FINAL ENVIRONMENTAL IMPACT ASSESSMENT (EIA) REPORT

FOR

THE PROPOSED 60TPH PALM OIL MILL PROJECT AT EXTENSION TWO IN OVIA-NORTHEAST LOCAL GOVERNMENT AREA, EDO STATE, NIGERIA

BY

OKOMU OIL PALM COMPANY PLC

FEBRUARY 2020

Environmental Impact Assessment (EIA) of the Proposed 60TPH Palm Oil Mill Project at Extension Two in Ovia- Northeast Local Government Area, Edo State, Nigeria

By

Okomu Oil Palm Company Plc

Submitted to.

Federal Ministry of Environment, Abuja

Final Report

Prepared by

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LIST OF ABBREVIATIONS AND ACRONYMS

AGO	-Automotive Gas Oil
ALARP	-As Low as Reasonably Practicable
ANC	-Antenatal Care
APHA	-American Public Health Association
BOD	-Biochemical Oxygen Demand
BS	-Base Saturation
BSR	-Basal Stem Rot
CBD	-Convention on Biological Diversity
CBR	-Crude Birth Rate
CEC	-Cation Exchange Capacity
CDR	-Crude Death Rate
CH_4	- Methane
CITES	-Convention on International Trade in Endangered Species of Wild Fauna and Flora
Cm	-Centimeter
CO	-Carbon Monoxide
CO_2	-Carbon dioxide
COD	-Chemical Oxygen Demand
CSR	-Corporate Social Responsibility
CPO	-Crude Palm Oil
CPKO	-Crude Palm Kernel Oil
dB(A)	-Decibel
DO	-Dissolved Oxygen
DOE	-Department of Environment
EC	-Electrical Conductivity
ECEC	-Effective Cation Exchange Capacity
EEA	-Environmental Evaluation Assessment
EFB	-Empty Fruit Bunch
EHS	-Environmental Health and Safety
EIA	-Environmental Impact Assessment
EMP	-Environmental Management Plan
EMS	-Environmental Management System
ERM	-Electrical Resistivity Method
ERP	-Emergency Response Plan
ESAs	-Environmentally Sensitive Areas
ESMP	-Environmental and Social Management Plans
ETPs	- Effluent Treatment Plants
FDS	-Foremost Development Services Limited
FEPA	-The Federal Environmental Protection Agency
FFA	-Free Fatty Acids

FFB	-Fresh Fruit Bunch
FMARD	-Federal Ministry of Agriculture and Rural Development
FMEnv	-Federal Ministry of Environment
FSC	-Forest Stewardship Council
GC-FID	-Gas Chromatography with flame ionization Detector
GHG	-Green House Gas
GPS	-Geographic Positioning System
Ha	-Hectare
HCVF	-High Conservation Value Forest
HIA	-Health Impact Assessment
HIV/AIDS	-Acquired Immune Deficiency Syndrome
Hr	- Hour
HRT	-Hydraulic Retention Time
HSE	-Health Safety and Environment
IEE	-Initial Environmental Examination
IFC	-International Finance Corporation
IUCN	-International Union for Conservation of Nature
KII	-Key Informant Interviews
LC	-Least Concern
LGA	-Local Government Area
MgO	-Magnesium Oxide
MOP	-Muriate of Potash
MOU	-Memoranda of Understanding
NCF	-Nigerian Conservation Foundation
NES	-Nigerian Environmental Society
NESREA	-National Environmental Standards and Regulations Enforcement Agency
NGO	-Non-Governmental Organization
NIFOR	-Nigerian Institute for Oil Palm Research
NIMET	-Nigeria Meteorological Agency
NOS	-Non Oily Solids
NPK	-Nitrogen Phosphorus Potassium fertilizer
NSE	-Nigeria Stock Exchange
OKM	-Okomu
OOPC	- Okomu Oil Palm Company
PAT	-Profit After Tax
P&C	-Principles & Criteria
PK	-Palm Kernel
PKC	-Palm Kernel Cake
PKO	-Palm Kernel Oil
POM	-Palm Oil Mill
POME	-Palm Oil Mill Effluent

POPs	-Persistent Organic Pollutants
PPE	-Personal Protective Equipment
PS	-Performance Standards
RAMSAR	-Convention on the Protection of Wetlands of International Importance
RBDPO	-Refined, Bleached and Deodorized Palm Oil
RSPO	-Roundtable on Sustainable Palm Oil
SFB	-Sterilized Fruit Bunches
SHOC	-Safe Handling of Chemicals
SIA	-Social Impact Assessment
SMP	-Social Management Plan
SPC	-Standard Plate Count
SPO	-Special Palm Oil
SPM	-Suspended Particulate Matter
SSP	-Single Super Phosphate
STD	-Sexually transmitted diseases
TCPC	-Technical committee on Privatization and Commercialization
TDS	-Total Dissolved Solid
THC	-Total Hydrocarbon Content
TN	-Total Nitrogen
TOC	-Total Organic Carbon
TOR	-Terms of Reference
UNCCD	-United Nation Convention on Combating Desertification
UNDP	-United Nation Development Programme
UNFCCC	-UN Framework Convention on Climate Change
US	-United State
VES	-Vertical Electrical Sounding
VOC	-Volatile Organic Compound
WHO	-World Health Organization
Yr	-Year

WEIGHTS AND MEASURES

kVA (kilovolt-ampere)	– 1,000 volt-amperes
kW (kilowatt)	– 1,000 watts
kWh (kilowatt-hour)	– 1,000 watts-hour
MW (megawatt)	– 1,000,000 watts
MT	- Metric Tonne
W (watt)	– unit of active power
T (Ton)	– 1,000 kilogram

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4. Ovia Northeast Local Government Area, Edo State
5. The Affected Communities.

EXECUTIVE SUMMARY (ES)

ES 1.0 The Proponent

The Okomu Oil Palm Company Plc (OOPC Plc) is an agricultural and food-processing company located at Okomu-Udo, Ovia Southwest Local Government Area, Edo State, Nigeria. The company specializes in plantation development and production of special palm oil, palm kernel oil and palm kernel cake and crump rubber. It started operation in 1976 as a Federal Government project and was privatized in 1990. The then Bendel State government granted the company a total concession of about 15,000 hectares within the Okomu forest reserve in 1978. The entire 15,000 hectares of the total concession at the main estate has been developed into oil palm and rubber plantations.

The company operates the Main Estate (a concession of 15,000 hectares) Extension One Estate (a concession of 6,000 hectares), and Extension Two Estate (a concession of 11,416.673 hectares) all located in Edo State. It supplies special palm oil, palm kernel oil, palm kernel cake and crump rubber.

The Company has over 12,000 individual and institutional shareholders, both Nigerian (40%) and foreign (60%). Currently, the company employs over 2000 permanent staff and several independent sub-contractors. All these have added up to place the Company on top in the burgeoning oil palm business and to position it as an emerging leader in rubber production.

ES 2.0 Project Justification

The company has just expanded it plantation holdings with additional oil palm plantation at another site in Ovia Northeast and Uhunmwonde LGA, called Extension Two. It is envisaged that the capacity of the palm oil mill at the main estate will not be able to absorb additional fresh fruit bunches coming from Extension Two as more of the new plantings at both extension Two and the main estate (including Extension One) become mature.

The bulk of the new plantings have attained the harvesting age and the acquired plantation has increasingly been producing FFB in the last five years. Given the existing mill capacity at the Main estate, company is faced with the following challenges as the bulk of the holdings attain full maturity:

- There is no neighbouring palm oil mill to absorb the excess FFB produced on the plantations.
- The risk of large quantities of FFB not being harvested and rotting on the trees.
- The cost of transporting FFB to the main estate for processing is very high

- Loss of value-added advantage.
- High prospects of loss of revenue.

In order to overcome these challenges, the Company proposes to establish a 60Tons FFB/hour palm oil mill at Extension Two to process the excess FFB being harvested from its plantations.

The operation of the palm oil mill would enhance the revenue base of the company and be of immense economic, social benefit to both proponent and Nigeria as a whole. Invariably, the proposed project will generate employment to the people directly or indirectly and assist to further meet its financial obligations and social responsibilities to host communities.

Nigeria is the fourth largest producer of palm oil in the world accounting for 3% of global production. The Nigerian Institute for Oil Palm Research (NIFOR) estimates that upstream palm oil production is 0.98 million tons.

Considering Nigeria’s population of about 194m [as per FAOSTAT] and per capita consumption of 12.5 kg per person per annum against the world average of about 20 kg per person per annum, estimated annual consumption is 2.4 million tons. Hence, Nigeria has deficit of 0.9 million tons worth of more than USD 800 million. The mechanisms to fulfill this gap are:

- Import of refined palm oil / vegetable oil is prohibited and there is a duty of 35% on the import of Crude Palm Oil / Crude Vegetable Oil.
- Creating an enabling environment for the establishment of Palm Oil Mills and Vegetable oil refineries across the country.

By adopting this policy, country is able to generate employment in manufacturing/refining industry and also supports oil palm plantation by protecting them with an additional margin of more than $300 per ton on and above sales price realized by Malaysia and Indonesia’s palm oil plantation."

The ongoing investments by the company, including the proposed 60tons FFB/Hour Palm Oil Mill Project could be seen as the company’s contribution and support aimed at meeting the goals of the Economic Recovery and Growth Plan (ERGP) of the Federal Republic of Nigeria.

ES 3.0 Project Description

The proposed palm oil mill at Extension Two will lie on about 10.4 hectares (400m x 260m) in Ovia Northeast Local Government Area. The proposed mill project has the capacity to process 60 tons Fresh Fruit Bunch (FFB) per hour. It lies between latitude $5^0$07.120' and $5^0$25.220'E and longitude $6^0$18.870' and $6^0$26.110'N.

The proposed project will involve six major civil and mechanical components namely: Reception Station; Sterilization Station (horizontal); Oil Mill Processing Line with all its components (for the extraction of palm oil from fresh fruit bunches through sterilization, bunch stripping, digestion, oil extraction and finally clarification and purifications), Boiler Station, Power generating units and Palm Oil Mill Effluent (POME) Treatment Ponds.

ES 4.0 EIA Study Procedure

The EIA study was carried out after due consultation with the Federal Ministry of Environment (FMEnv), and in accordance with the Ministry's Procedural Guidelines, and Terms of Reference (TOR) and scope of work, approved by the Ministry Edo State Ministry of Environment and Sustainability and Ovia Northeast Local Government were also carried along.

ES 5.0 Verification by the FMEnv

The FMEnv visited the proposed project site in March 2018 in order to verify the proposals and statements in the OOPC Plc's application for an environmental impact assessment (EIA) permit. The proposed project was classified as Category Two (2); requiring mandatory EIA Studies and a Technical Review Meeting.

ES 6.0 Period of EIA Study

The field data gathering for scientific studies of the existing environment started on 25 February to 5 March 2019 which was supplemented with data from Extension Two Oil Palm Development Project; Final EIA Report 2016.

ES 7.0 Consultations with and Participation by Stakeholders

The Stakeholders identified were: (i) Federal Ministry of Environment (FMEnv), (ii) Edo State Ministry of Environment and Sustainability; (iii) Ovia Northeast Local Government Council; (iv) Project's Affected Communities, namely; Agbanikaka, Owan, Uhiere, Odiguetue, Odighi, Ihrue, Oke, Ekpan, Umuokpe and Orhua Communities.

The objective of the consultation was to inform and educate stakeholders on details of the project, its justification, discuss the scope of study and the project's potential and associated environmental impacts, and obtain their views and comments. The summary of the community's assessment of the likely environmental impacts of the proposed project was that the proposed project would largely have insignificant adverse impacts but rather beneficial effects on the lives of the people.

ES 8.0 Alternative Considered and Envisaged Sustainability

In order to achieve the desirable sustainability of the proposed project, OOPC Plc will develop and operate the project based on industry best practices, applying especially the IFC Performance Standards and the Principles and Criteria of the Roundtable on Sustainable Palm Oil (RSPO) as follows.

Economic Sustainability: The planning and management of operations and production activities will aim at long-term financial and economic viability of the project. This will be achieved through sound industrial best practices with utmost safety measures to attain high productivity and premium quality of products.

Technical Sustainability: Technically, best hands and agricultural practices shall be employed to carry out the project to ensure its technical sustainability by relying on its foreign and local expertise and experience in the palm oil mill construction and operation in Edo State, other parts of Africa and Asia to ensure that the proposed project enjoys sound technical complements from design to implementation and operation.

Environmental Sustainability: This will be attained through the implementation of OOPC Plc Environmental Management System (EMS) that is already in place.

Social Sustainability: The Social action plan developed from the assessment of the social impact of the proposed project will be implemented to ensure that the desirable support and harmony is established between the project proponent and the communities.

Financial Sustainability: The project will be financed from the company's yearly turnover and profits which has been impressive and promising in the last five years. OOPC Plc is listed on the Nigerian Stock Exchange. The estimated cost of the project is about USD34million (1.2 Trillion Naira) while the life span of the project (oil mill) is about 30 years or more during which upgrades can be done.

Options and alternatives to the proposed project includes the no project option, delayed project option, and full development of the project as proposed.

- **Alternative Site**

  The option of alternative location means establishing a new palm oil mill at a different location. This option is undesirable because the prospect of acquiring new land is low. Moreover, establishing a new palm oil mill at a different location could mean that it would require travelling longer distances to transport FFB from its estates to this new location and this can be expensive. The advantage of synergy with the existing plantations will be lost

- **Alternative Project**
  This would mean the company embarking on other projects other than the palm oil mill establishment, given that the mill establishment is another developmental phase following the establishment of over 11,000ha oil palm plantation. This alternative would amount to a lack of vision and poor business strategy on the part of the company.

- **Alternative Technology**
  This means adopting a new, non-tested or trusted technology which could lead to the company incurring more cost in terms of procurement or technology failure especially considering the life span of the project.

- **No Project Option**
  This option would mean that the company should continue to operate without the option of increasing its CPO production capacity. This option is unacceptable when one considers the substantial net financial, economic and social benefits that will accrue to the company, the neighbouring communities and the national economy by operating the mill.

- **Delayed Project Option**
  This option would mean that the bulk of mature FFB coming from other plantation estates will not be processed, or sourcing for a high capacity oil mill in the neighborhood to process the FFB. This will lead to loss in company revenue, less employment generation and less quality assurance and control on products.

- **Do Project Option**
  The establishment of the 60TPH Palm Oil Mill within the Extension Two estate as proposed is the preferred option which will translate to financial, economic and social benefits to the company, neighbouring communities and country.

ES 9.0 Relevant Environmental Laws, Decrees, Regulations and Edicts

The following laws and regulations apply to the proposed project: (i) National Policy on Environment (FEPA, 1989), revised in 1999; (ii) EIA Act Cap E12 LFN, 2004; (iii) National Guidelines and Standards for Environmental Pollution Control in Nigeria, (FEPA,1991); (iv) National Effluent Limitations Regulations S.I.8 (FEPA,1991); (v) National Pollution Abatement in Industries and Facilities Generating Wastes Regulations S.I.9 (FEPA,1991); (vi) S. I. 15 National Environmental Protection (Management of Solid and Hazardous Wastes) Regulations 1991. (vii) National Environmental Standards and Regulations Enforcement Agency (NESREA), 2007. (viii) Edo State Ministry of Environment and Sustainability Environmental Pollution and Sanitation Act 2010; (ix) Edo State Environmental Waste Management Board Edicts/Mandate; (x) Ovia Northeast Local Government Area Mandate on environmental sanitation and solid waste management; (xi) Factories Act CAP F1 LFN 2004; (xii) Land Use Act Cap L5 LFN, 2004; (xiii) The Urban and Regional Planning Law Act No. 88 of 1992; (ix) Workmen Compensation Act, 1987 and Abandonment Guidelines 1995**.**

ES 10.0 Existing Baseline Environment

The biophysical socio-economic and health environments that might be impacted by the proposed project were ascertained from field data gathering within 10km spatial boundary of the study area, previous environmental studies and in-house environmental records of the company. A total of 18 sampling stations, geo-referenced with a GPS, were established.

10.1 Climate and Meteorology

Rainfall, temperature and sunshine hours (2010-2018),wind speed and direction, relative humidity and atmospheric pressure were obtained from Nigeria Institute for Oil Palm Research (NIFOR) Benin-City.

10.2 Air Quality and Noise Level

Automatic reading equipment was employed to determine air quality of the project site. The concentrations of SO_2, H2S, CO, CO_2, NOX, were all below the limits set by FMEnv; (CO, <1.0 ppm; CO_2, 0.30-0.32%; H2S, <0.1 ppm; HC, <0.1%, SO_2, <0.01 ppm; NO_2, <0.01ppm; O_2, 21% and Volatile Organic Compound, <0.01). The concentrations of particulates were also below the set limit of 250µg/m3 with values ranging from; (SPM, 70-110µg/m^3). These show clean, unpolluted ambient air at the locations.

The noise levels were also found to be below the FMEnv 8-hour exposure level of 90dBA with values ranging from 32.6 dB(A) to 52.4 dB(A).

10.3 Geology and Geomorphology

From the results and analysis as presented in **ES 7.0**, it was observed that the location for the proposed project is comprised mainly of both fines and sands with high to low plasticity. According to AASHTO and USSC soil classification systems, the soil was classed as A-7-6. This shows that the soil consists of both fines and sands, having low to high degree of plasticity.

In terms of strength, the allowable bearing capacity calculated using shear parameters obtained from laboratory triaxial tests revealed that the soil possesses great potential for an economic foundation.

From the analysis, it is evident that the location can provide economic foundation for most infrastructures, including the school that will be built on the site. Though bearing capacity computations from CPT showed that the bearing pressure at depth 2.0 to 6m is higher than 200kN/m^2, the value of 110kN/m^2 should be used as the design bearing pressure. With adequate scarification and compaction, the whole of the site will be put to good use construction-wise.

10.4 General Soil Properties and Interpretation

Characteristically, the soils had low silt and clay content and high sand contents. These soils had sand content that ranged in values between 70.60% and 93.20% .The surface horizons in most cases had higher sand content than the subsurface horizon but there was no consistent pattern of profile distribution of the sand particle size fraction. The values of silt content of the soils were comparatively lower than the values of the sand fractions and ranged in values from 1.40% and 13.40% in the surface soils, while the subsurface horizons had silt contents that ranged from 1.40% to 17.40%. The profile distribution of the silt particle size fraction did not follow any regular pattern of distribution within the profile. The clay contents of these soils increased with increasing soil depth in most profiles except in profile P.2Bwhere there was decrease in the clay content of the soil with increasing soil depth. However there was no strong evidence of clay illuviation in many of the profiles. Pedons P.2B, P.6B, P.157, P.177 and P.191 have no accumulation of clay in any part of the profile, while the remaining profiles show some weak evidence of argilluviation. The surface horizons had clay that ranged in value from 5.40% to 15.00% while the subsurface horizons had clay content that ranged from 5.40% to 28.00%.

The textures of these soils were predominantly sand to loamy sand in the epipedon while the subsurface horizons were predominately sand to sandy clay loam in texture. Three profiles (P.6B, P.177 and P.191) had no textural change with increasing soil depth. These profiles had sand textural class throughout the profile.

The soil structural classes of the soils ranged from weakly formed fine-crumbs in the surface horizons to moderately developed medium and coarse sub-angular blocky structures in the subsurface horizons. The consistencies were loose – friable in the surface and firm in the sub surface horizons.

10.5 Vegetation and Forestry

The vegetation at the proposed project site is presently covered by oil palm and with weed species typical of the lowland rain forest zone in Nigeria. The dominant plants include Guinea grass (*Panicum maximum), Trema orietalis, Alchornea cordifolia,* Siam weed (*Chromoleana odorata*) and *Sida* spp. However, there is a lake (06° 40' 27.4" N and 005° 49' 50.5" E) within the southern part of the plantation where the proposed project will be situated, with some aquatic plant species such as *Nymphaea lotus* and *Pistia stratiotes,Cyrtosperma.*

10.6 Terrestrial Fauna and Wildlife

These fauna animals fall within six (6) classes representing vertebrates and invertebrates. The invertebrates dominate the environment of the study area. The proportion of reptiles when compared with other vertebrates and invertebrates is naturally lower than the mammals and birds.

The species that were found in each site, especially within the plantation can be said to be those that found the area suitable and are able to meet their needs.

10.7 Surface and Groundwater Assessment

Water quality varied from one location to another within the proposed project area. The pH varied from 6.67–11.25, Conductivity 33.9–2,720(uscm-2), Turbidity 45-160, Total Suspended solids 1-98 mg/l, Dissolved oxygen 4.8-11.2mg/L, Biological oxygen demand 15.4-23.8mg/l, Alkalinity 9.6-60.7mg/L, Hardness <1-20mg/L, Salinity as Chloride 6.95-41.8mg/L, Phosphate 2.1-4.66, nitrate 0.14-0.22mg/l, Sulphate 10-26.0 mg/l, calcium <1.0-3.20mg/l, Magnesium <1.0-2.92/l. All the values determined for heavy metals in the water bodies occurred in low concentration (<0.01-<0.001mg/l), much below the recommended limits by FMENV and WHO (<1.0). Water temperature was 28.4ºC± 0.4. The speed of the water ranged from 0.5 to 0.7m/sec; with a mean of 0.603±0.054 m/sec. Secchi disc turbidity for Jemide River was 80cm.

The groundwater quality is good and free from pollution. Except for the pH that is generally low (5.20-5.84), thus making the water to be mildly acidic. All the water samples from the project’s water sources have all physico-chemical and microbiological parameters within the permissible limits recommended by WHO and FMENV for wholesome water. The pH of the water shall be raised to the recommended limit for drinking and portable water by adding soda lime (KCl).

10.8 Socio-Economic Environment

A quick appraisal of socioeconomic situation of the ten affected communities was carried out in March 2018 against what was reported in 2014 during Extension Two Oil Palm Plantation Development project. The proposed project was introduced to the affected communities when the study was conducted.

There are ten (10 Nos.) communities around the proposed project site, namely; Agbanikaka, Owan, Uhiere, Odiguetue, Odighi, Ihrue, Oke, Ekpan, Umuokpe and Orhua Communities.

From communities' sources, the cumulative population of all the affected communities is **25,500**. A dominant feature of the structure of the population of the proposed project affected communities is its significant level of young people with over 80% of the population below the age of 45 years. Adults in the age group 45 years and above constitute about 16% of the population. The male to female ratio is more or less even.

ES 11.0 Present Impacts and Significant Potential and Associated Environmental and Health Impacts

The summary of anticipated major/significant impacts arising from the proposed project were examined and considered at four phases but with more emphasis on three phases including: (i) Construction; (ii) Operation; (iii) Decommissioning and Abandonment.

The significant impacts of the proposed project include: 1.) Heavy machinery use; 2.) Installation of equipment; 3.) Generator use; 4.) Civil, electrical and mechanical works; 5.) Solid waste disposal; 6.) Transportation of FFB; 7.) Noise and Gaseous emissions; 8.) Palm Oil Mill Effluent (POME) disposal; 9.) Laying off staff and 10.) Palm Oil Mill abandonment.

The predicted residual effects were also considered for each Project phase (Pre-Construction, Construction, Operation, Decommissioning and Unplanned Events).

ES 12.0 Mitigation Measures

Mitigation measures were defined for the identified significant associated and potential impacts, so also the residual impacts based on the following criteria:

- **Prevention –** design and management measures for ensuring that significant potential impacts and risks do not occur,
- **Reduction –** operational and management measures for ensuring that the effects or consequences of those significant associated and potential impacts that cannot be prevented are reduced to a level as low as reasonably practical (ALARP).

- **Control -** Operational and management measures for ensuring that residual associated impacts are reduced to a level as low as reasonably practical (ALARP).

However, most of the significant environmental impacts that can likely arise from the construction and operation of the proposed proposed project can be mitigated once appropriate precautions are in place as defined in Table 6.1.

ES 13.0 Proposed Environmental and Social Management Plans, (EMP and SMP)

All mitigation measures will be adhered to by the Health, Safety and Environment (HSE) department of the company in conjunction with HSE committee and the company's environmental consultant; (i) Emissions testing, Laboratory analysis of groundwater and palm oil mill effluent (POME) will be carried out on quarterly basis and reporting will be done in accordance with the regulatory requirements and record submitted to FMEnv; (ii) Fire prevention precautions will be in place as required by the State Fire Service; (iii) All firefighting equipment will be inspected and maintained regularly; iv) Regular inspections will be conducted to verify the integrity of the fuel tanks. v) Written procedures governing the operation of the fuel tanks and precautions to be taken will be developed; (vi) The occupational health, safety and environmental policies shall be implemented; vii) Capacity building programme for mill staff including awareness, in-plant training, seminars, workshops and short courses shall be undertaken regularly to enhance the implementation of the EMP.

The environmental monitoring programme would cover a number of parameters including meteorology, ambient air quality, surface water quality, groundwater quality, palm oil mill effluent quality and noise levels. All these would be regularly monitored by OOPC.

The schedule of EMP detailing impacts, mitigation measures, actions to be taken and the persons responsible for mitigation actions has also been drawn. It will equally be monitored for compliance.

ES 14.0 Decommissioning

The approaches to the decommissioning of the proposed project would involve the combination of assets recovery, dismantling, demolition, decontamination and remediation.

ES 15.0 Conclusion

The EIA process demonstrates that the proposed project at OOPC extension two will fully comply with legislative requirements in Nigeria and other relevant international regulations applicable to the planned activities and operations.

The proposed project is an attestation to the sustainable growth of oil palm industry, which will result in substantial economic benefits for Nigeria through employment opportunities generation in particular during the construction and operation phases.

This EIA also indicates that discharges including wastewater and/or effluent, gaseous emissions and noise are expected from the operation of the proposed project. However, any such discharges, which can be considered as potential sources of adverse environmental effects, can be fully managed through preventive actions and mitigating measures. This means that no significant negative impact on the natural, health and social environmental sensitivities of the project area is expected to result from discharges.

The Project is environmentally and socially sound, and will promote balanced and environmentally sustainable operation of Okomu Oil Palm Company Plc (OOPC).

CHAPTER ONE

INTRODUCTION

1.1 History and Business of Okomu Oil Palm Company Plc

The proponent of the proposed 60tons FFB/Hr Palm Oil Mill project; The Okomu Oil Palm Company Plc (OOPC Plc) herein referred to as " The Company" is an agricultural and food-processing company located at Okomu-Udo, Ovia Southwest Local Government Area, Edo State, Nigeria. The company specializes in plantation development and production of crude palm oil, palm kernel oil and palm kernel cake.

The company was established in 1976 as a Federal Government pilot project aimed at rehabilitating oil palm production in Nigeria. At inception, the pilot project covered a surveyed area of 15,580 hectares out of which 12,500 hectares were planted with oil palm. It was incorporated on December 3, 1979 as a limited liability company.

In 1990 the Technical Committee on Privatization and Commercialization (TCPC) privatized the company on behalf of the Federal Government of Nigeria. At the turn of the millennium, the company acquired 6,000 hectares and 11,416.673ha property known as Extension One and Extension Two at Ovia southwest and Ovia Northeast/Uhunmwonde Local Government Areas respectively to further boost its available land holdings. The company now plans to establish a 60 tons/hr mill given the considerable progress of oil palm development at Extension Two.

The Company has since grown to become one of Nigeria's leading agricultural companies. Presently the company has over 10,000 ha of oil palm of which 8713 ha is mature and 7500 of rubber of which around 5000 ha is mature. It has also expanded its milling capacity from a meagre 1.5 tons FFB/hr in 1985 to 30 tons FFB/hr in 1992 and most recently an expansion of the existing mill to 60tons FFB/hr in 2018 thus making the company to operate one of the largest palm oil mill in Nigeria.

The privatization of the Company has been a great success and a huge encouragement for the Nigerian agricultural sector, with profound positive consequences of stable socio-economic growth for the region where it is located. The company has consistently posted profits in the last 15 years; a period during which most other similar establishment in the country have either folded up or performing sub-optimally.

What is most inspiring is not just the growth and profitability of the company, but the fact that it is the only agri-business in the NSE's top 18 companies with the largest turnovers.

Today, what is now known as The Okomu Oil Palm Company Plc has transformed into an economic success, earning presidential recommendation and recording over 300 percent rise in profit-after-tax (PAT). The company's activities and operations were recently certified by international bodies such as RSPO, ISO 14001, 19001 and 18001.

Just as the company is expanding in size, its corporate environment is also expanding. The Company has over 12,000 individual and institutional shareholders, both Nigerian (40%) and foreign (60%). Currently, the company employs over 2000 permanent staff and several independent sub-contractors. All these have added up to place the Company on top in the burgeoning oil palm business and to position it as an emerging leader in rubber production.

The Company benefits from the quality management provided by its main shareholders and technical partner, Socfinaf SA, with 62% shares in the company. Socfinaf SA is the biggest single shareholder that brings into the company a little under a century of sound acclaimed technical expertise in the world stage on tropical agriculture.

Socfinaf SA is a global player in the cultivation of oil palm, rubber, coffee and tropical flower. Socfinaf SA founded in 1912 was the first industrial company to plant oil palm in Africa and Indonesia. It has ongoing plantations in Cote D'ivoire, Liberia, Guinea, Cameroun, Indonesia, Kenya Sierra Leone and Congo.

1.2 Location and Access

The company headquarter is located at Okomu-Udo, within the Okomu Forest Reserve in Ovia Southwest Local Government Area of Edo State, Nigeria. The project site is accessible through a network of roads from Lagos and Benin City. It lies between geographic locations; top right $6^0$40'33.63"N and $5^0$48'43.58"E; top left $6^0$40'32.46"N and $5^0$48'29.41"E. Bottom right $6^0$40'22.44"N and $5^0$48'28.31"E; bottom left $6^0$40'20.79"N and $5^0$48'42.17"E (See Figure1.2)

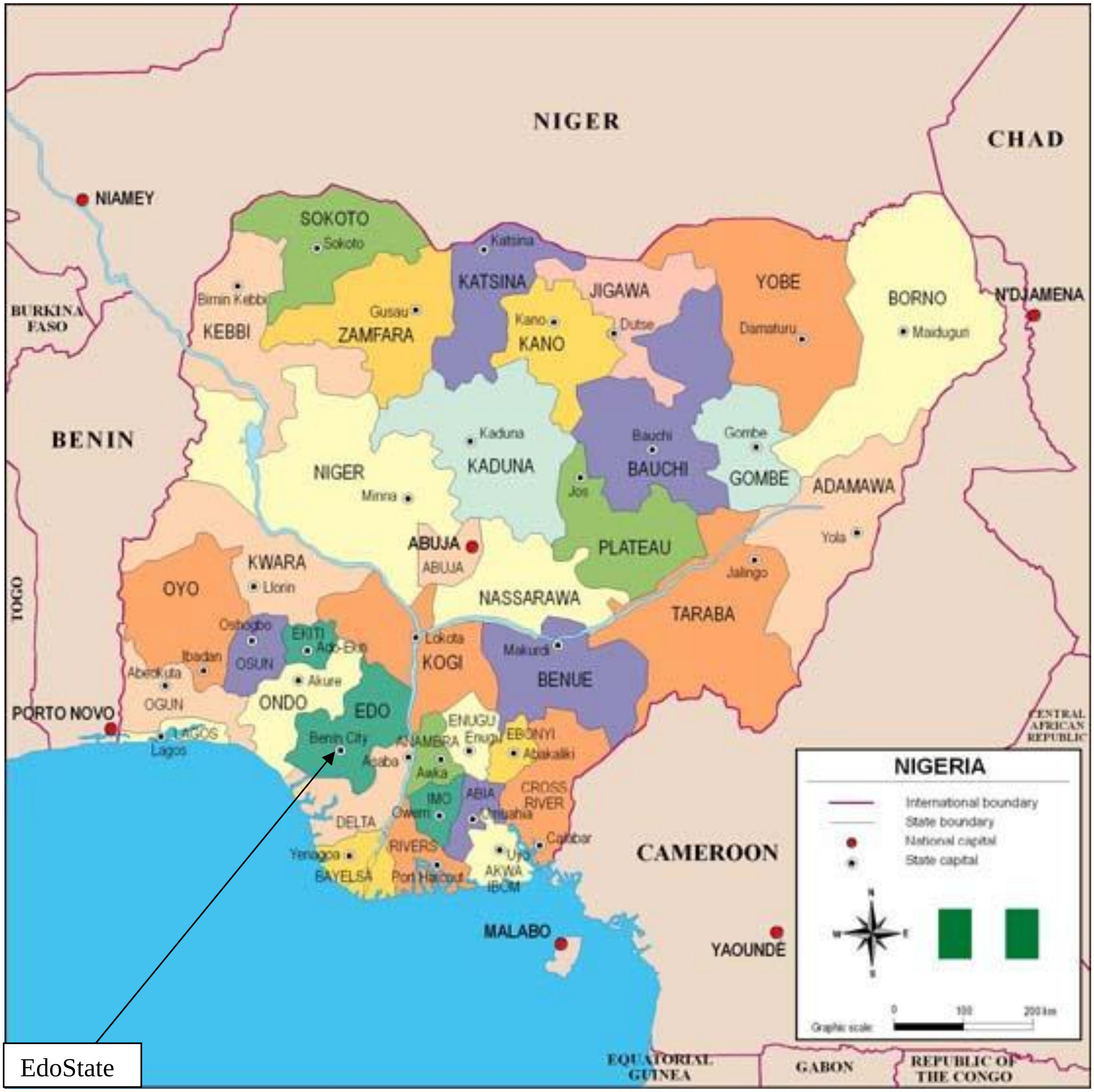


Figure 1.1: Map of Nigeria indicating Edo State

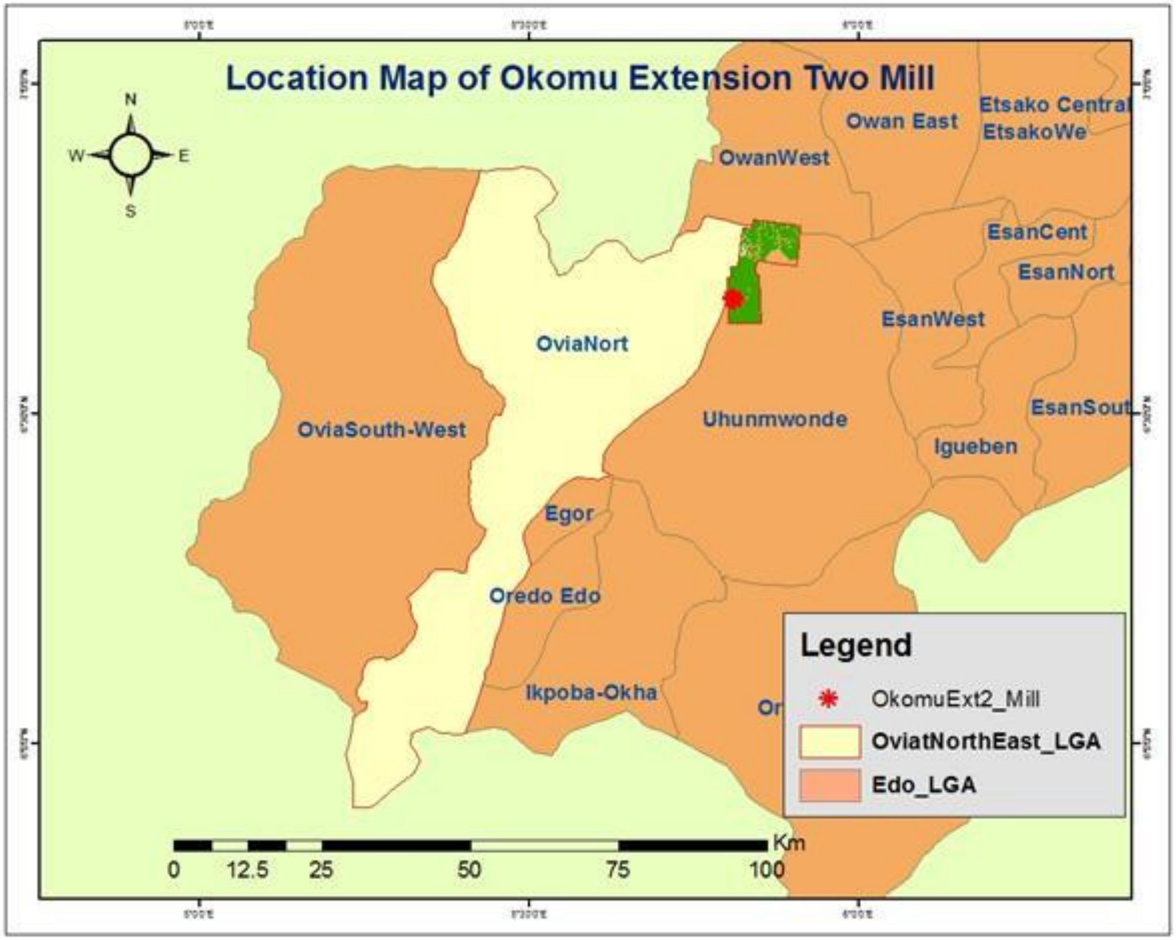


Figure 1.2: Map of Edo State Indicating the Proposed Mill in Ovia Northeast LGA

1.3 Activities

The company undertakes plantation agriculture involving the growing of oil palm (*Elaeis guineensis*) and the processing of Fresh Fruit Bunches (FFB) into crude palm oil (CPO). The company is also involved in the planting and tapping of rubber trees (*Hevea brasilenses*), and also the processing of cup lumps into crumb rubber. The major activities of the company include the oil palm plantation, palm oil mill, rubber plantation and rubber factory operations.

1.4 Mission Statement of The Okomu Oil Palm Company Plc

"To be Nigeria's leading agribusiness, through the efficient and effective management of our various plantations by a highly motivated workforce, working in harmony with other stakeholders, and continuously returning favourable results to our shareholders".

1.5 Literature Review on the Palm Oil

Fruit of oil palm tree

Palm oil is rich in carotenoids, (pigments found in plants and animals) from which it derives its deep red colour, and the major component of its glycerides is the saturated fatty acid palmitic; hence it is a viscous semi-solid, even at tropical ambient, and a solid fat in temperate climates.

Because of its economic importance as an high-yielding source of edible and technical oils, the oil palm is now grown as a plantation crop in most countries with high rainfall (minimum 1 600 mm/yr) in tropical climates within 10° of the equator. The palm bears its fruit in bunches varying in weight from 10 to 40 kg. The individual fruit, ranging from 6 to 20 gm, are made up of an outer skin (the exocarp), a pulp (mesocarp) containing the palm oil in a fibrous matrix; a central nut consisting of a shell (endocarp); and the kernel, which itself contains an oil, quite different to palm oil, resembling coconut oil.

Figure 1.3: Fresh Fruit Bunch (FFB)

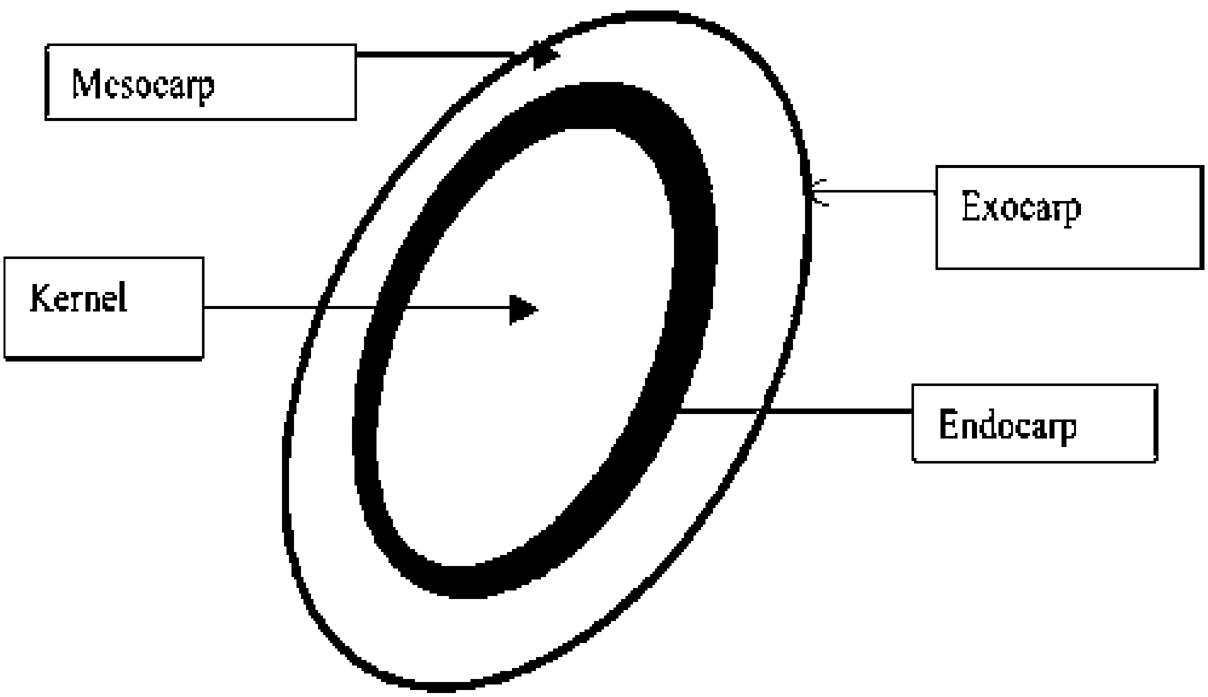


Figure 1.4: Structure of the palm fruit

The wild oil palm groves of Central and West Africa consists mainly of a thick-shelled variety with a thin mesocarp, called Dura. Breeding work, particularly crosses between Dura and a shell-less variety (Pisifera), have led to the development of a hybrid with a much thicker mesocarp and a thinner shell, termed Tenera. All breeding and planting programs now use this latter type, the fruits of which have a much higher content of palm oil than the native Dura.

Modern high-yielding varieties developed by breeding programs, under ideal climatic conditions and good management, are capable of producing in excess of 20 tonnes of bunches/ha/yr, with palm oil in bunch content of 25 percent. This is equivalent to a yield of 5 tonnes oil/ha/yr (excluding the palm kernel oil), which far outstrips any other source of edible oil.

Palm Oil

Palm oil (also known as dendê oil, from Portuguese) is an edible vegetable oil derived from the mesocarp (reddish pulp) of the fruit of the oil palms, primarily the African oil palm *Elaeis guineensis*, and to a lesser extent from the American oil palm *Elaeis oleifera* and the maripa palm *Attalea maripa*.

Palm oil is naturally reddish in color because of a high beta-carotene content. It is not to be confused with palm kernel oil derived from the kernel of the same fruit, or coconut oil derived from the kernel of the coconut palm (*Cocos nucifera*). The differences are in color (raw palm kernel oil lacks carotenoids and is not red), and in saturated fat content: Palm mesocarp oil is 41% saturated, while palm kernel oil and coconut oil are 81% and 86% saturated respectively.

Along with coconut oil, palm oil is one of the few highly saturated vegetable fats and is semi-solid at room temperature. Like most plant-based products, palm oil contains very little cholesterol.

Palm oil is a common cooking ingredient in the tropical belt of Africa, Southeast Asia and parts of Brazil. Its use in the commercial food industry in other parts of the world is widespread because of its lower cost and the high oxidative stability (saturation) of the refined product when used for frying.

1.6 Legal and Administrative Policy Framework

Nigeria has enacted a comprehensive policy and legal framework for environmentalassessment and management. The country has policies, legislation, and strategies in place tomanage the protected facilities, to satisfy its international obligations, and to protect thequality of the environment for the health and well-being of its citizens. The hierarchy ofpolicies and legislative provisions forenvironmental management in Nigeria is comprised of different enactments ranging from the Constitution to international treaties, and to environment andresource protection laws.

The Permit and Licence obtained from FMEnv will have reporting requirements and other obligations, which will need to be fulfilled. Other regulators such as the Edo State Ministry of Environment and Public Utilities, Edo State Waste Management Board and Federal Ministry of Labour and Employment will also have requirements. Persons who have to ensure that the obligations are fulfilled will need to be trained in the regulatory requirements.

A fundamental principle of the Nigerian environmental policy is that economicdevelopment must be in harmony with the extraction and utilization of natural resources andthat air, water, and soil pollution will be controlled.

The applicable Domestic environmental laws and regulations are as follows:

1.6.1 National Legislation

The National legislation applicable to this project includes:

- Environmental Impact Assessment (EIA) Act, Cap E12 LFN 2004
- The National Policy on Environment 1989 revised 1999.
- National Guidelines and Standards for Environmental Pollution Control in Nigeria, 1991
- Harmful waste (criminal provision) Act 42 of 1988
- S.I.8 National Environmental Protection (Effluent Limitations) Regulations, 1991
- S.I.9 National Environmental Protection (Pollution Abatement in Industries and Facilities Generating Wastes) Regulations, 1991
- S.I.15: National Environmental Protection (Management of Solid and Hazardous Waste) Regulations, 1991
- National Guidelines for Environmental Audit in Nigeria, 1999
- National Guidelines on Environmental Management System in Nigeria 1999.

- National Environmental Standards and Regulations Enforcement Agency (NESREA), 2007.
- Factories Act CAP F1 LFN 2004
- Land Use Act, CAP L5 LFN 2004
- The Urban and Regional Planning Law Act No. 88 of 1992
- National Policy on Renewable Energy Development
- The National Building Code (NBC)
- Workmen Compensation Act, 1987 and Abandonment Guidelines 1995

Environmental Impact Assessment Act CAP E12 LFN 2004,

EIA act was promulgated in 1992. It makes environmental impact assessment (EIA) mandatory for all new major projects. Therefore, an EIA permit is required for the proposed project.

National Guidelines and Standards for Environmental Pollution Control in Nigeria 1991

This schedule deals with the control of industrial effluent discharge, gaseous emissions and hazardous wastes, so also noise pollution control. This schedule established environmental guidelines and standards for the abatement and control of all forms of pollution.

The proposed project would therefore have to ensure that any discharges into the land, water and atmosphere are of acceptable quality to ensure that there are no legal repercussions under this schedule.

S. I. 8 National Environmental Protection (Effluent Limitation) Regulations 1991

These Regulations give the parameters in industrial gaseous emissions and wastewater (effluents) and their limitations, concentration and standards for discharge into land, atmosphere and receiving surface waters.

The proposed project would therefore have to ensure that any discharges into the land, water and atmosphere are of acceptable quality to ensure that there are no legal repercussions under this schedule.

S. I. 9 National Environmental Protection (Pollution Abatement in Industries and Facilities Generating Wastes) Regulations 1991

This regulation requires every industry to install anti-pollution/pollution abatement equipment to treat effluent discharges and gaseous emissions to the standards and limits prescribed in Regulation S.I.8, 1991.

S. I. 15 National Environmental Protection (Management of Solid and Hazardous Wastes) Regulations 1991.

This regulation requires that all steps that are necessary must be taken for the effective management of solid and hazardous wastes in order to safeguard public health, ensure that waste is collected, stored, transported, recycled, reused or disposed in an environmentally sound manner and promote safety standards in relation to such waste.

National Environmental (Sanitation and Waste Control) Regulations, 2009 (S.I.28)

The purpose of these regulations is the adoption of sustainable and environment friendly practices in environmental sanitation and waste management to minimize pollution. The provisions of the regulations state that a person in care, management or control of any industrial facility shall:

(a) Provide educational and pictorial signs to direct persons where they can drop waste.
(b) Provide receptacles for recyclable materials in appropriate and easily accessible locations.
(c) Keep the premises, drains and all public or private lands, street, lanes, walkways; beaches or docks within 5 meters of the boundary of the property free from litter at all times.
(d) Ensure that discarded materials are regularly collected and disposed of sanitarily.
(e) Ensure that recyclable materials are properly packed and neatly stacked.
(f) Ensure sorting and segregation of solid waste at source.

National Environmental (Noise Standards and Control) Regulations, 2009 (S.I.35)

The purpose of these regulations is to ensure maintenance of a healthy environment for all people in Nigeria, the tranquility of their surroundings and their psychological well-being by regulating noise levels and generally, to elevate the standard of living of the people. The regulations among others state the permissible noise levels to which a person may be exposed; control and mitigation of noise; permits for noise emissions in excess of permissible levels; and enforcement.

Factories Act CAP F1 LFN 2004

The regulations for Health, Safety and Welfare are under this act. This act also requires that: Before any person occupies or uses as a factory any premises which were not so occupied at the commencement of this Decree, he shall apply for the registration of such premises by sending to the Director of Factory an application containing the particulars set out in Schedule 1 to this Decree.

Any person who has not been issued a certificate of registration as aforesaid occupies or uses as a factory any premises that have not been registered as a factory shall be guilty of an offence.

Land Use Act, Cap L5, 2004

The Nigerian Land Use Act 1978 was promulgated in March 1978. It vests all land in each state of the federation (except land already vested in the Federal Government or its agencies) in the Governor of the state. It makes the state Government the authority for allocating land in all urban areas for residential, agricultural commercial and other purposes while it confers similar powers regarding non-urban areas on the Local Government in such area. The Governor of a state can revoke a Right of occupancy (statutory customary) for overriding public interest.

The Urban and Regional Planning Law Act No. 88 of 1992

Decree 88 of 1992 established a Development Control Department (DCD) charged with the responsibility for matters relating to development, control and implementation of physical development plans at Federal, State, and Local Government levels within their respective jurisdictions.

National Policy on Renewable Energy Development

The primary objective of the National Policy on Renewable Energy Development is to encourage the diversification of sources of energy supply through renewable energy, and as such improve the energy security of the country.

1.7 International Finance Corporation (IFC) Performance Standards (PS)

Other related international guidelines include IFC Performance Standards such as:

- PS 1– Assessment and Management of Environmental and social Risks and Impacts.
- PS 2- Labour and Working Conditions
- PS 3– Resource Efficiency and Pollution Prevention
- PS 4– Community Health, Safety and Security
- PS 5– Land Acquisition and Involuntary Resettlement
- PS 6– Biodiversity Conservation and Sustainable Management of Living Natural Resource
- PS 7 – Indigenous People
- PS 8– Cultural Heritage

1.8 Roundtable on Sustainable Palm Oil – Principles and Criteria

RSPO is a not-for-pro-t association that unites stakeholders from seven sectors of the palm oil industry - oil palm producers, palm oil processors or traders, consumer goods manufacturers, retailers, banks and investors, environmental or nature conservation NGOs and social or developmental NGOs - to develop and implement global standards for sustainable palm oil. This is achieved via eight principles as follows:

Principle 1: Commitment to transparency
Principle 2: Compliance with applicable laws and regulations
Principle 3: Commitment to long-term economic and financial viability
Principle 4: Use of appropriate best practices by growers and millers
Principle 5: Environmental responsibility and conservation of natural resources and biodiversity
Principle 6: Responsible consideration of employees, and of individuals and communities affected by growers and mills
Principle 7: Responsible development of new plantings
Principle 8: Commitment to continual improvement in key areas of activity

1.9 International Agreements and Protocols

Nigeria has acceded to a number of international environmental conventions and the keyones are presented in Table 1.1. The applicable international environmental agreements and protocols include:

- The Montreal Protocol
- The Basel Convention
- The Framework Convention on Climate Change
- The Convention for The Prevention of International Trade in Endangered Species (CITES)
- Convention on Biological Diversity (CBD)

The Montreal Protocol

This protocol discourages the use of substances that deplete the ozone layer and promotes the synthesis of new and environment-friendly products.

The Basel Convention

This convention deals with the control of Trans–boundary movement of Hazardous Waste and Substances among member countries.

The Framework Convention on Climate Change

This convention requires member countries to stabilize atmospheric concentrations of greenhouse gases at levels that will prevent human activities from interfering dangerously with the global climate change.

The Convention for the Prevention of International Trade in Endangered Species (CITES)

The trade involving certain wild animals and plants whose numbers are considered to be endangered is been regulated by this convention

Convention on Biological Diversity (CBD)

This convention deals with the conservation of biodiversity, the sustainable use of its component and the fair and equitable sharing of the resulting benefits.

Table 1.1: International Environmental Conventions Signed by Nigeria

Convention	Year of Accession
African Convention on the Conservation of Nature and Natural Resources	1968
Convention on Biological Diversity CBD)	1993
UN Framework Convention on Climate Change (UNFCCC)	1994
Kyoto Protocol	1999
UN Convention on Combating Desertification (UNCCD)	1996
Convention on the Protection of Wetlands of International Importance (RAMSAR)	1998
Vienna Convention for the Protection of the Ozone Layer	1996
Montreal Protocol (regulating substances that deplete the ozone layer)	1996
Convention on International Trade in Endangered Species of Fauna and Flora (CITES)	1996
Convention on Trans-boundary Movement of Hazardous Waste (BASEL)	1997
Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade	2000
Stockholm Convention on Persistent Organic Pollutants (POPs)	2004
World Heritage Convention	1990
Convention on the Conservation of Migratory Species of Wild Animals (BONN Convention)	1979
International Union for the Conservation of Nature and Natural Resources (IUCN)	1956
The Equator Principles III	2013

1.10 Institutions and Regulatory Agencies

- Federal Ministry of Environment
- National Environmental Standards and Regulations Enforcement Agency
- Edo State Ministry of Environment and Sustainability
- Edo State Environmental and Waste Management Board
- Ministry of Agriculture and Natural Resources, Edo State
- Ministry of Lands and Surveys, Edo State
- Edo State Fire Service
- Ministry of Health, Edo State
- Departments of Environment, Ovia Northeast Local Government Area of Edo State, Nigeria.
- Federal Ministry of Agriculture and Rural Development
- Agricultural Research council of Nigeria
- Nigerian Institute for Oil Palm Research

Federal Ministry of Environment

The Federal Ministry of Environment is the apex body with the broad mandate to regulate and protect the environment in Nigeria. In addition, Nigeria is party to some international agreements; protocols and conventions on Environment and is bound by their provisions and requirements.

National Environmental Standards and Regulations Enforcement Agency (NESREA)

NESREA is charged with the responsibility of enforcing all environmental laws, guidelines, policies, standards and regulations in Nigeria. It also has the responsibility to enforce compliance with provisions of international agreements, protocols, conventions and treaties on the environment.

Edo State Ministry of Environment and Sustainability

The Edo State Ministry of Environment and Sustainability is the arm of government responsible for regulating the environment in Edo State of Nigeria. Depending on certain peculiarities of the state, the Ministry has made and established its own laws and environmental standards, which are not inconsistent with Federal laws.

Edo State Environmental and Waste Management Board

This Board is under the Governor's Office with a mandate for waste management and environmental sanitation.

Department of Forestry and Natural Resources, Edo State

The Forestry Department of the Edo State Ministry of Environment and Sustainability has responsibility for forest resources management, forest reserves and wildlife conservation in the state.

Ministry of Lands and Surveys, Edo State

The Ministry of Lands and Surveys deals with land issues, plans and controls development, establishes residential, commercial and industrial layouts and execute in the state the Nigerian Urban and Regional Planning law.

Ovia Northeast Local Government Area

The Departments of Environment, Ovia Northeast Local Government Area of Edo State, Nigeria is the tier of government that is responsible for regulating and monitoring the environment at the local level especially the aspects of health and sanitation inspection of business premises to ensure that they conform to set standards.

Federal Ministry of Agriculture and Rural Development

The Ministry has the mandate to Grow Nigeria's agricultural sector and develop strategic partnerships to stimulate investments to drive a market-led agricultural transformation.

Agricultural Research council of Nigeria

To achieve significant improvements in agricultural productivity, marketing and competitiveness by generating appropriate technologies and policy options, promoting innovation, establishing a knowledge management capacity and strengthening the agricultural research system.

Nigerian Institute for Oil Palm Research

The formal mandate of the institute is to conduct research into the production and products of oil palm and other palms of economic importance and transfer its research findings to farmers.

1.11 Non-Governmental Organizations (NGOs)

- Nigerian Conservation Foundation (NCF)
- Nigerian Environmental Society (NES)
- Human Right and Rural Development Organisation of Nigeria
- Grassroot Development Initiative
- Vision 1 Health
- Women Empowerment and Development Network (WEDEN)

- Gender Development Action (GDA)

Nigerian Conservation Foundation (NCF)

The Nigerian Conservation Foundation (NCF) is Nigeria's foremost non-governmental organisation dedicated to the promotion of nature conservation. Formed in 1980 and registered in 1982 as a Charitable Trust (No. 1917), its ultimate goal is to stop and eventually reverse the accelerating degradation of Nigeria's natural environment and to help build a future in which humans live in harmony with nature.

Nigerian Environmental Society (NES)

The Nigerian Environmental Society (NES), with headquarters in Lagos, is incorporated in Nigeria as a professional, non-profit making, non-governmental Organisation which is committed to the protection, development and sustenance of the environment and to the promotion of the profession of Environmental Science and Engineering, both in theory and in practice. The NES has been in forefront of the vanguard of environmental protection and resource conservation.

1.12 General Environmental Impact Assessment Procedural Guidelines

In response to the promulgation of the EIA Act CAP E12 LFN 2004, an Environmental Impact Assessment Procedure for Nigeria was produced by the former Federal Environmental Protection Agency (FEPA, 1995). The procedure provides the steps to be followed from project conception to commissioning in order to ensure that the project is implemented with maximum consideration for the environment.

The procedure for EIA involves the project proposal stage where the project proponent notifies the Ministry of Environment of the proposed project in writing. The project proposal is to contain all relevant information on the project and a land-use map.

This stage is followed by the screening phase, when the Ministry will carry out an Initial Environmental Examination and assign the project into categories based on the following criteria: magnitude; extent or scope; duration and frequency; risk; significance; mitigation measures available for associated and potential environmental impacts. The location of the project in Environmentally Sensitive Areas is also an important criterion in the project categorization. The area categorized as Environmentally Sensitive Areas (ESA_S) include: coral reefs, mangrove swamps, small islands, tropical rain forests, areas with erosion prone soils, natural conservation areas, watersheds, wetlands etc.

There are three categories (I, II and III) in Ministry of Environment’s guidelines.

Category I projects are subjected to full scale EIA, and it consists among others: Petroleum projects such as Oil and Gas fields development; construction of offshore pipeline in excess of 50 kilometres in length; construction of Oil and Gas separation, processing, handling and storage facilities, and large scale construction of depots for storage of petroleum products.

Projects listed in category II may not require a full-scale EIA except when the project is located in an Environmentally Sensitive Area (ESA) and in this case the project will be assigned top category I. The requirement for category II projects is a partial EIA. Also, mitigation measures or changes in project design (depending on the nature and magnitude of the environmental impacts) as well as further actions, may be required from the proponent. Category II projects include reforestation/afforestation projects, land and soil management, small scale irrigation and drainage, mini hydro-power development, small-scale development of petroleum or related activities, etc.

Category III projects are expected to have essential beneficial impacts on the environment. For projects in this category, the Ministry of Environment will issue an Environmental Impact Statement (EIS). Projects in this category include; family program, institutional development, environmental awareness projects, etc.

Another stage of erstwhile FEPA’S EIA procedure is the scoping stage, the main feature of which is that the proponent will be required to submit a Terms of Reference (ToR) for the proposed EIA study. In some cases, the Ministry may demand a Preliminary Assessment Report, and any additional information from the proponent to assist in vetting the scope and the ToR of the proposed EIA study. This stage is followed by actual implementation of the EIA study; Preparation of Draft Final and Final Reports; Review process and Approval/Certification.The FMEnv process is shown in Figure 1.5 below.

The proposed project is a 60tons per hour Palm Oil Mill Project at Extension two estate of the company situated in Ovia Northeast LGA of Edo State. Upon site verification in March 2018 and screening by the Federal Ministry of Environment, it has been placed in Category Two; requiring mandatory EIA Studies and a Technical Review Meeting. The fieldwork for data gathering was approved for one (1) season to be supplemented with an Approved relevant EIA report.

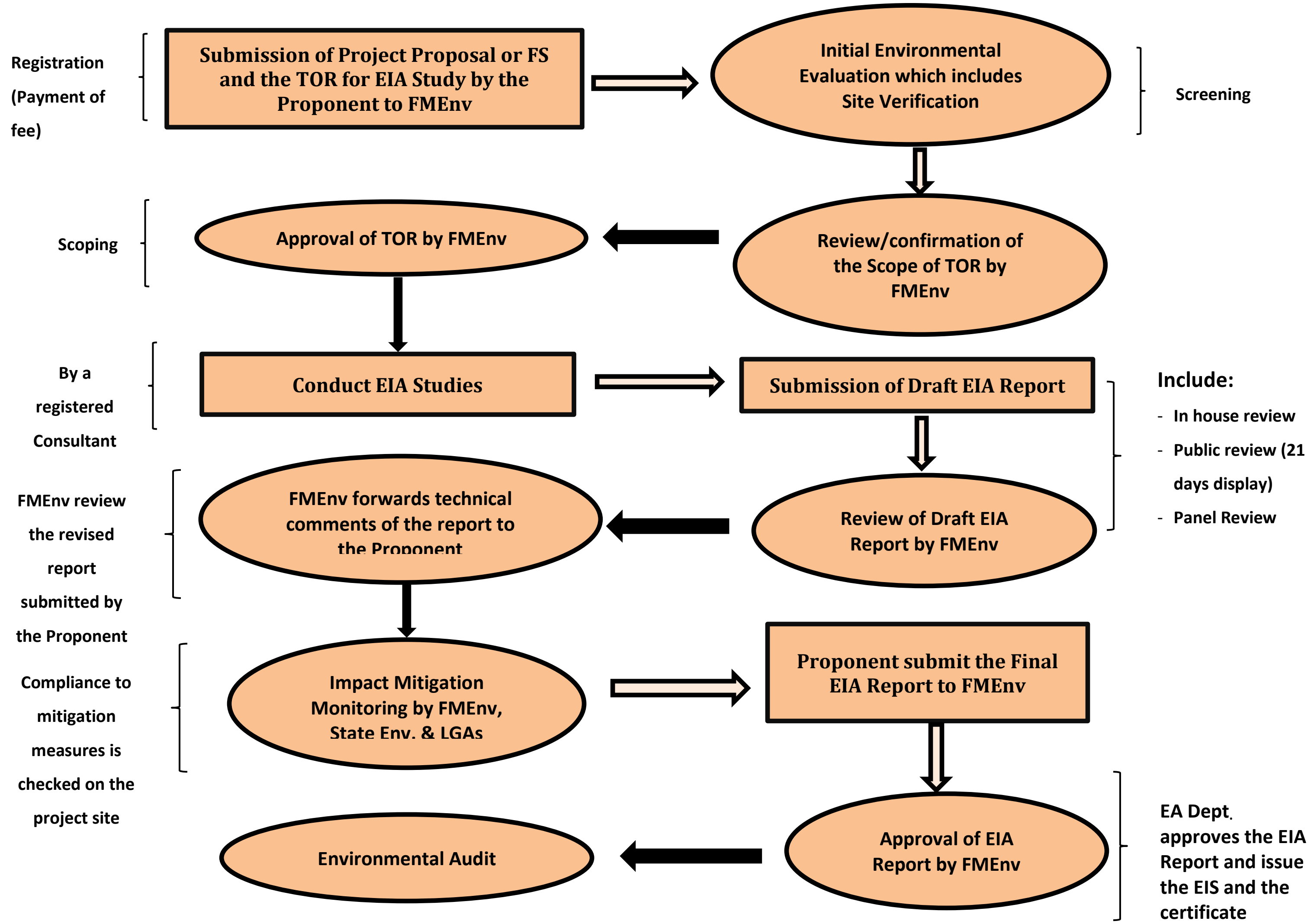


Figure 1.5: FMEnv EIA Procedure

Source: FMEnv Environmental Impact Assessment Procedural Guidelines (1995)

1.13 Okomu Oil Palm Company Plc IMS Policy

The **OKOMU OIL PALM COMPANY PLC** is committed to:

- Providing customers with high Quality products and services which meet requirements and are fit for their purpose.
- Compliance with all applicable laws, regulations, standards and other requirements related to our activities, products and services and their environmental aspects.
- Enhancing the skills of management and staff through review and actively pursuing an on-going training policy, the objective of which is to prepare staff to perform their work more effectively.
- Promoting the culture of continual improvement of the Quality and Environmental processes and the philosophy of getting things "right first time".
- Advocating the adoption of prudent Quality and Environmental principles to our vendors, suppliers and customers. Reduce and eliminate the generation of waste and emissions at the source and make all efforts to recycle when practical.
- Pledging ourselves to the prudent and sustainable use of the earth's resources and the protection of the natural environment while we strive to fulfil our corporate mission of contributing to enhance prosperity for all.
- Promoting the Integrated Management System and continually improving its effectiveness through the use of the Quality and Environmental Policy, Quality/Environmental objectives, audit results, analysis of data, corrective and preventive actions and management review.
- Communicating this policy to all persons working for or on behalf of the organization.

The Managing Director confirms the commitment and support, along with that of all employees and those working on behalf of the company, to the above policy statement and the effective application and continual improvement of the Integrated Management System.

1.14 Objectives of Environmental Impact Assessment

The main objective of the EIA is to principally identify the environmental consequences of the operations and activities of the proposed project and also to establish baseline data of the site to aid decision making process and serve as future reference. The EIA covers the whole environment from the biotic to abiotic (physical), socio-economic and health aspects of the resident company workers. In this circumstance therefore, and for the purposes of compliance with Federal Environmental Laws, it is required that the company as a responsible corporate organization should conduct an Environmental Impact Assessment on its proposed projects. This would serve to adequately analyse the sites, identify any environmental impacts and define framework for contingency plans and mitigation and abatement measures for impacts.

In Nigeria, the legal instruments relevant for the protection of the environment are contained in FEPA (now Federal Ministry of Environment) regulations. Some State governments also made few enactments that are not inconsistent with the Federal laws. In consonance with these laws, the company should:

- Develop, Implement and maintain an environmental policy that would enhance the environmental performance of its corporate activities.
- Aim and pursue compliance with existing environmental legislation, identify any non-compliance and endeavour to remedy such non-compliance.
- Develop and maintain environmental awareness of its employees, contractors and any such external parties involved in their corporate activities.
- Improve its corporate image through environmental responsibilities.
- Work in partnership with regulatory agencies for better environment.
- Pay special attention to sustainable development through incorporation of environmental concerns into any development projects.
- Minimize litigation that may arise from environmental non-performance of its projects’ activities.

1.15 Terms of Reference (ToR)

The detailed Terms of Reference as approved by the Federal Ministry of Environment are provided in Annexure I.

1.16 Justification of the EIA Report

Palm oil is the most consumed vegetable oil in the world and 80% of it is used in the food industry; a variety of other oils with different properties used various domains can be extracted from it. It is used primarily as a food product 77% of which is consumed. Some fatty substances are extracted from it and when mixed with other vegetable oils, produce good oil for frying.

Countries around the world produce billion pounds of vegetable oils each year. These domestic oils are extracted from the seeds of soybean, corn, cotton, sunflower, flax, and rapeseed plants, palm kernel, coconut, castor, tung and palm oil.

Although more than 12 billion pounds of these oils are used for food products such as shortenings, salad and cooking oils, and margarines, large quantities serve feed and industrial needs. The latter applications include chemicals such as plasticizers, which add pliability to plastics and other substances; stabilizers, which help other substances resist chemical change; emulsifiers, which enable the mixing of normally unmixable liquids; surfactants, which reduce the surface tension of liquids and are commonly used in detergents; and esters, nylons, and resins, which are basic ingredients in many industrial products. Besides detergents and plastics, products that contain chemicals derived from vegetable oils include lubricants, coatings, corrosion inhibitors, adhesives, cleaners, cosmetics, water repellants, and fuels.

Markets for these highly reactive oils are expected to grow with the increasing sophistication of consumers worldwide and with changing and more stringent product performance requirements.

Beyond these reasons, all projects in this sector worldwide are welcome as long as demand remains higher than supply and Nigeria is no exception to this rule. Beyond the economic, financial and social opportunities offered by the company, it is not without adverse consequences on the environment.

Thus, this report aims primarily to assess the potential environmental impact anticipated from the physical development and activities of the proposed project and the effects it could have on the totality of the project environment with a view to maximize the beneficial impacts and to mitigate the adverse impacts in order to facilitate the approval of the proposed project.

1.17 Structure of the Report

This report is presented in Preliminary sections and eight chapters as follows:

Preliminary pages (Cover Page, Table of Content, EIA Study Team and Preparers, Executive Summary and Acknowledgement)

Chapter One: Introduction
Chapter Two: Project Justification and the Project Alternatives,
Chapter Three: Project Description
Chapter Four: Description of the Project Environment
Chapter Five: Associated and Potential Impact
Chapter Six: Mitigation Measures
Chapter Seven: Environmental and Social Management Plan
Chapter Eight: Conclusion and Recommendations
References

1.18 Declaration

The Company as a corporate organization and the proponent of the proposed project on behalf of herself, the project contractors and other partners hereby declares her intention to undertake 60TPHR Palm Oil Mill Project, and in line with her corporate policy and compliance with all applicable national, state and local government laws, regulations and or bye-laws, the company takes full responsibility for the protection of the environment within the project area.

This EIA report has been prepared by **Foremost Development Services Limited** on behalf of **The Okomu Oil Palm Company Plc** in line with statutory requirements, guidelines, and standards for plantation crop development and the approved Terms of Reference, and the Federal Ministry of Environment is recognised as the sole regulatory authority on Environmental Impact Assessment in Nigeria.

CHAPTER TWO

PROJECT JUSTIFICATION

2.1 The Proposal

The Okomu Oil Palm Company Plc stated planting oil palm (*Elaeis*) at the main estate since 1979. The company later expanded it plantation holdings with additional oil palm plantation at another site in Ovia Northeast and Uhunmwonde LGA, called Extension Two. It is envisaged that the capacity of the palm oil mill at the main estate will not be able to absorb additional fresh fruit bunches coming from Extension Two as more of the new plantings at both extension Two and the main estate(including Extension One) become mature.

In order to address this problem of capacity limitation, the company proposes to establish 60tons/Hr palm oil mill at Extension Two. As a requirement of the environmental laws and regulations, a permit application and project description were submitted to the Federal Ministry of Environment. And based on the initial assessment by the Ministry, the proposed project was classified as Category Two requiring mandatory EIA studies and a Technical Review meeting.

2.2 Purpose and Need for the Project

The company in addition acquired an existing plantation of about 6000 hectares with both mature and immature trees in 2000. The bulk of the new plantings have attained the harvesting age and the acquired plantation has increasingly been producing FFB in the last five years. Furthermore to its expansion drive, the company acquired another 11,416.673ha (Extension two) in 2014 and since been developing the plantation. Given the existing mill capacity, company is faced with the following challenges as the bulk of the holdings attain full maturity:

- There is no neighbouring palm oil mill to absorb the excess FFB produced on the plantations.
- The risk of large quantities of FFB not being harvested and rotting on the trees.
- The cost of transporting FFB to the main estate for processing is very high
- Loss of value added advantage.
- High prospects of loss of revenue.

In order to overcome these challenges, the Company proposes to establish a 60Tons FFB/hour palm oil mill to process the excess FFB being harvested from its plantations.

The operation of the palm oil mill would enhance the revenue base of the company and be of immense economic, social benefit to both proponent and Nigeria as a whole. Invariably, the proposed project will generate employment to the people directly or indirectly and assist to further meet its financial obligations and social responsibilities to host communities.

This EIA is being conducted in accordance with the Terms of Reference approved by the FMEnv (See Annexure I). It covers the range of activities and undertakings at the different developmental stages of the project from construction to commissioning and decommissioning.

2.3 Project Justification

Nigeria is the fourth largest producer of palm oil in the world accounting for 3% of global production. The Nigerian Institute for Oil Palm Research (NIFOR) estimates that upstream palm oil production is 0.98 million tons.

Groundnut is second largest source of domestic edible oil. With the assumption of 1 million tons of unshelled groundnut crushed annually, estimated production and consumption of Groundnut oil per annum is 0.4 million tons. Other oils like Soybean, Cottonseed and Sesame oil, in total contribute to the production of maximum 0.1m MT. Total domestic edible oil production is estimated at about 1.5million tons.

Considering Nigeria's population of about 194m [as per FAOSTAT] and per capita consumption of 12.5 kg per person per annum against the world average of about 20 kg per person per annum, estimated annual consumption is 2.4 million tons (https://www.proshareng.com/news/Agriculture/Fact-File-on-Crude-Palm-Oil-(CPO)-in-Nig/39032). Hence, Nigeria has deficit of 0.9 million tons worth of more than USD 800 million. The mechanisms to fulfill this gap are.

- Import of refined palm oil / vegetable oil is prohibited and there is a duty of 35% on the import of Crude Palm Oil / Crude Vegetable Oil.
- Creating an enabling environment for the establishment of Palm Oil Mills and Vegetable oil refineries across the country.

The ongoing investments by the company, including the proposed 60tons FFB/Hour Palm Oil Mill Project could be seen as the company's contribution and support aimed at meeting the goals of the Economic Recovery and Growth Plan (ERGP) of the Federal Republic of Nigeria.

2.4 Cost of the Project

The cost of the proposed project is estimated at about USD34million. The cost covers capital and recurrent expenditures on building, mechanical and electrical installations.

A large proportion of this fund will be injected into the local economy through various contracts and subcontracts. In addition, employment opportunities at various phases of the project, for skilled, semi-skilled and unskilled labour would be available. The project will also bring about additional revenue generation to the government in terms of the various taxes and levies that will be paid into government coffers.

2.5 Benefits of the Project

The proposed project will complement considerably the economic recovery and growth plan (ERGP) of the country. Justification is therefore found for the proposed project in its potential to:

- Add value to the existing primary productions of the company
- Provide direct employment
- Create additional jobs
- Contribute to the socio-economic development of project area communities
- Increase revenue to the nation.
- Rise in the development of small/medium scale enterprises, especially in the project area.
- Foreign exchange savings
- Technological transfer

2.6 Envisaged Sustainability

Major factors for the sustainability of the proposed project include sustainable use of raw materials (Fresh Fruit Bunches), longevity of the products, local and international markets development, capacity building through trained local manpower, international collaborations and partnerships. In order to achieve the desirable sustainability of the proposed project, the company will develop and operate the project based on industry best practices, applying especially the International Finance Corporation (IFC) Performance Standards and the Principles and Criteria of the Roundtable on Sustainable Palm Oil (RSPO). In effect, the company will strive continually to implement its Health, Safety and Environment Policy. In so doing, the following aspects of the project sustainability are therefore predicted:

2.6.1 Economic Sustainability

The planning and management of operations and production activities will aim at long-term financial and economic viability of the project. This will be achieved through sound operational and management practices to attain high productivity and premium quality of products.

In addition, the project will be financed from the company's annual turnover and profits, which has been impressive and promising in the last five years. The company recorded a revenue of N8,655,718,000.00 with profit after tax of N1,454,320,000.00 in year 2014. The financial performance of the company has since improved considerably. For the year ended 31st December 2018, the revenue was N20,257,669,000.00, while the profit after tax was N8,239,903,000.00.The company is listed on the Nigerian Stock Exchange. The financial performance of the company over the years would enable it to execute and sustain the proposed project operations.

2.6.2 Technical Sustainability

The company will leverage on its foreign and local expertise and experience in palm oil mill construction and operation in Edo State, other parts of Africa and Asia to ensure that the proposed project enjoys sound technical complements from design to implementation and operation. Such practices will include adequate practices to safe handling of machines, equipment, minimizing emissions and in general operating in an environment friendly manner. They will also effectively protect the environment and its ecological system through a proper management of the POME generated. In addition, the construction material will be of the highest quality available. Essentially, best hands and best management practices will be employed to execute the project. Importantly, all staff and workers will be competent and adequately trained to ensure the technical sustainability of the proposed project.

2.6.3 Environmental Sustainability

The on and off-site impacts of the oil mill activities and operations will continually be assessed and managed. Continuous monitoring of environmental aspects around the proposed project area will be ensured and maintained through the implementation of the existing policy to monitor its operational area. In addition, POME will not be discharged into Surface water and other strategies to reduce air and water pollution will be implemented. Essentially, the bulk of the solid waste to be generated will be disposed by recycling in the plantation.

2.6.4 Social Sustainability

An assessment of the social impacts of the proposed project was carried out and the results and social action plan will be implemented to ensure that the desirable support and harmony is established between the project and the communities. Necessary mechanisms will be put in place to facilitate communication with the communities, including proper documentation and resolution of conflicts and grievances.

2.7 Project Alternatives and Options

The establishment of the proposed project essentially involves the construction and installation of equipment and facilities to achieve a 60MT FFB/HR capacity. In this section, alternatives and options to the proposed project are discussed.

2.7.1 Alternative Site

The option of alternative location means establishing a new palm oil mill at a different location. This option is undesirable because the prospect of acquiring new land is low. Moreover, establishing a new palm oil mill at a different location could mean that it would require travelling longer distances to transport FFB from its estates to this new location and this can be expensive. The advantage of synergy with the existing plantations will be lost

2.7.2 Alternative Project

This would mean the company embarking on other projects other than the palm oil mill establishment, given that the mill establishment is another developmental phase following the establishment of over 11,000ha oil palm plantation. This alternative would amount to a lack of vision and poor business strategy on the part of the company.

2.7.3 Alternative Technology

This means adopting a new, non-tested or trusted technology which could lead to the company incurring more cost in terms of procurement or technology failure especially considering the life span of the project.

2.7.4 No Project Option

This option would mean that the company should continue to operate without the option of increasing its CPO production capacity. This option is unacceptable when one considers the substantial net financial, economic and social benefits that will accrue to the company, the neighbouring communities and the national economy by operating the mill.

2.7.5 Delayed Project Option

This option would mean that the bulk of mature FFB coming from other plantation estates will not be processed, or sourcing for a high capacity oil mill in the neighbourhood to process the FFB. This will lead to loss in company revenue, less employment generation and less quality assurance and control on products.

2.7.6 Do Project Option

The establishment of the 60TPH Palm Oil Mill within the Extension Two estate as proposed is the preferred option which will translate to financial, economic and social benefits to the company, neighbouring communities and country.

CHAPTER THREE

PROJECT/PROCESS DESCRIPTION

3.1 Brief Project/Process Description

The proposed palm oil mill at Extension Two will lie on about 10.4 hectares (400m x 260m) in Ovia Northeast Local Government Area. The proposed project of 30MT expandable to 60MT FFB/hr capacity is within the existing Extension two plantation of Okomu Oil Palm Company Plc, Ovia Northeast/Uhunmwonde Local Government Areas of Edo State.

The proposed project will involve six major civil and mechanical components as follows:

i) **Reception Station:** The function of this station is to receive the FFB brought from the plantations in Lorries to the mill for onward delivery for processing.

ii) **Sterilization Station:** This is where sterilization of the FFB takes place. Sterilization inactivates the enzymes that promote the formation of Free Fatty Acid (FFA) and makes easy the fruits loosening from the bunch. It will also break oil cells in the mesocarp so that oil recovery will be easier.

iii) **Oil Mill Processing Line:** This will include the following

- ***Stripping/Threshing Station:*** This station is for separation of the fruits from the bunch using a rotary drum.
- ***Pressing Station:*** This is for extraction of oil. It comprises Digester unit, Screw press and conveying equipment.
- ***Clarification Station:*** This is for separation of crude palm oil and sludge to make pure oil.
- ***Kernel Recovery Station:*** This station is for nut processing to recover kernels. It is divided into three processes -
  - ✓ Depericarper - For separating fibre and Nut
  - ✓ Nut Cracking - For separation of kernel and shell
  - ✓ Kernel Drying - For drying wet kernels from about 20% to 1% moisture content to avoid deterioration while in storage.

iv) ***Boiler Station:*** Atmindo boilers of 2 Nos. 20Tons steam/Hour and 1 No. 40Tons steam/Hour will be installed for 60TPH palm oil mill. The boilers will run entirely on the solid waste of oil palm including empty fruit bunches (EFB), fibres, shells.

v) **Power Generation**: 2 Nos. 1200kW Shinko Steam Turbines will be installed to supply required (500mW) power to the proposed palm oil mill. Diesel Generators serving the existing residential quarters will serve as backup in case of turbine breakdown. The generator is about 500m away from the proposed palm oil mill location.

vi) ***Palm Oil Mill Effluent (POME) Treatment:*** The proposed system to treat POME is Biological treatment with open ponds before it is discharged in to the plantation field as irrigation water. Proposed sizes of ponds for 30 MT FFB/hr are,

- 1No. Cooling Pond- 92.5 x 53.5 x 2 mtrs deep
- 2Nos. Anaerobic Ponds- 219 x 126.25 x 5 mtrs deep
- 2Nos. Aerobic Ponds-219 x 125.87 x 1.5 mtrs deep

3.2 General Processes of Palm Oil Production

The following description was adapted from http://www.fao.org/docrep/005/y4355e/y4355e05.htm. Research and development work in many disciplines - biochemistry, chemical and mechanical engineering - and the establishment of plantations, which provided the opportunity for large-scale fully mechanized processing, resulted in the evolution of a sequence of processing steps designed to extract, from a harvested oil palm bunch, a high yield of a product of acceptable quality for the international edible oil trade. The oil winning process, in summary, involves the reception of fresh fruit bunches from the plantations, sterilizing and threshing of the bunches to free the palm fruit, mashing the fruit and pressing out the crude palm oil. The crude oil is further treated to purify and dry it for storage.

Large-scale plants, featuring all stages required to produce palm oil to international standards, are generally handling from 3 to 60 tonnes of FFB/hr. The large installations have mechanical handling systems (bucket and screw conveyers, pumps and pipelines) and operate continuously, depending on the availability of FFB. Boilers, fuelled by fibre and shell, produce superheated steam, used to generate electricity through turbine generators. The lower pressure steam from the turbine is used for heating purposes throughout the factory. Most processing operations are automatically controlled and routine sampling and analysis by process control laboratories ensure smooth, efficient operation. Although such large installations are capital intensive, extraction rates of 23 - 24 percent palm oil per bunch can be achieved from good quality Tenera.

Conversion of crude palm oil to refined oil involves removal of the products of hydrolysis and oxidation, color and flavour. After refining, the oil may be separated (fractionated) into liquid and solid phases by thermo-mechanical means (controlled cooling, crystallization, and filtering), and the liquid fraction (olein) is used extensively as a liquid cooking oil in tropical climates, competing successfully with the more expensive groundnut, corn, and sunflower oils.

Extraction of oil from the palm kernels is generally separate from palm oil extraction. The stages in this process comprise grinding the kernels into small particles, heating (cooking), and extracting the oil using an oilseed expeller or petroleum-derived solvent. The oil then requires clarification in a filter press or by sedimentation. Extraction is a well-established industry, with large numbers of international manufacturers able to offer equipment that can process from 10 kg to several tones per hour.

Alongside the development of these large-scale fully mechanized oil palm mills and their installation in plantations supplying the international edible oil refining industry, small-scale village and artisanal processing has continued in Africa. Ventures range in throughput from a few hundred kilograms up to 8 tones FFB per day and supply crude oil to the domestic market.

Palm oil processors of all sizes go through these unit operational stages. They differ in the level of mechanization of each unit operation and the interconnecting materials transfer mechanisms that make the system batch or continuous. The scale of operations differs at the level of process and product quality control that may be achieved by the method of mechanization adopted.

The general flow diagram is presented in Figure 3.1a below:

Palm Oil Processing Unit Operations

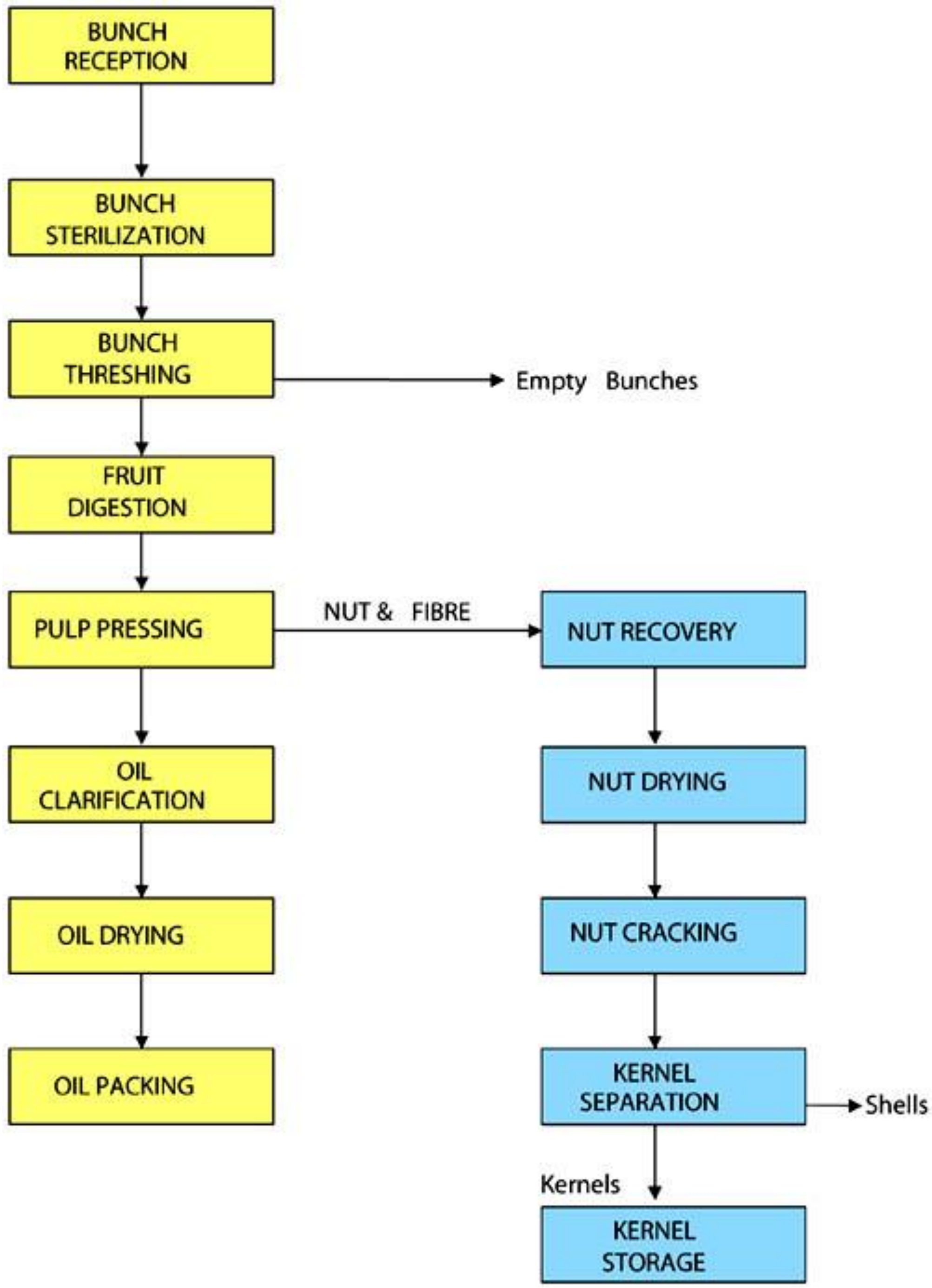


Figure 3.1a: General Palm Oil Flow Diagram

3.3 The proposed Oil Mill Processing Line (Process Flow chart

There are several stages of processing the extraction of palm oil from fresh fruit bunches. These include sterilization, bunch stripping, digestion, oil extraction and finally clarification and purifications; each process with its own unit operations.

The typical operations that take place during the processing of the EFB at the mill are described below.

3.3.1 Bunch reception

Post Harvesting

Fresh Fruits Bunches (FFB)/Loose fruits are taking to the reception bay waiting for processing. The waiting time is not up to 24hrs before they are conveyed to the ramp for immediate processing. The fresh fruit is normally emptied into wooden boxes suitable for weighing on a scale so that quantities of fruit arriving at the processing site may be checked. Large installations use weighbridges to weigh materials in trucks.

The quality standard achieved is initially dependent on the quality of bunches arriving at the mill. The mill cannot improve upon this quality but can prevent or minimize further deterioration.

The field factors that affect the composition and final quality of palm oil are genetic, age of the tree, agronomic, environmental, harvesting technique, handling and transport. Many of these factors are beyond the control of a small-scale processor. Perhaps some control may be exercised over harvesting technique as well as post-harvest transport and handling.

3.3.2 Threshing (removal of fruit from the bunches)

The fresh fruit bunch consists of fruit embedded in spikelet's growing on a main stem. Manual threshing is achieved by cutting the fruit-laden spikelet's from the bunch stem with an axe or machete and then separating the fruit from the spikelet by hand. Children and the elderly in the village earn income as casual laborers performing this activity at the factory site.

In a mechanized system a rotating drum or fixed drum equipped with rotary beater bars detach the fruit from the bunch, leaving the spikelet on the stem.

Most small-scale processors do not have the capacity to generate steam for sterilization. Therefore, the threshed fruits are cooked in water. Whole bunches which include spikelet's absorb a lot of water in the cooking process. High-pressure steam is more effective in heating bunches without losing much water. Therefore, most small-scale operations thresh bunches before the fruits are cooked, while high-pressure sterilization systems thresh bunches after heating to loosen the fruits.

Small-scale operators use the bunch waste (empty bunches) as cooking fuel. In larger mills the bunch waste is incinerated and the ash, a rich source of potassium, is returned to the plantation as fertilizer.

3.3.3 Sterilization of Bunches

Sterilization or cooking means the use of high-temperature wet-heat treatment to loose fruits. Cooking normally uses hot water; sterilization uses pressurized steam. The cooking action serves several purposes.

- Heat treatment destroys oil-splitting enzymes and arrests hydrolysis and autoxidation.
- For large-scale installations, where bunches are cooked whole, the wet heat weakens the fruit stem and makes it easy to remove the fruit from bunches on shaking or tumbling in the threshing machine.
- Heat helps to solidify proteins in which the oil-bearing cells are microscopically dispersed. The protein solidification (coagulation) allows the oil-bearing cells to come together and flow more easily on application of pressure.
- Fruit cooking weakens the pulp structure, softening it and making it easier to detach the fibrous material and its contents during the digestion process. The high heat is enough to partially disrupt the oil-containing cells in the mesocarp and permits oil to be released more readily.
- The moisture introduced by the steam acts chemically to break down gums and resins. The gums and resins cause the oil to foam during frying. Some of the gums and resins are soluble in water. Others can be made soluble in water, when broken down by wet steam (hydrolysis), so that they can be removed during oil clarification. Starches present in the fruit are hydrolyzed and removed in this way.
- When high-pressure steam is used for sterilization, the heat causes the moisture in the nuts to expand. When the pressure is reduced the contraction of the nut leads to the detachment of the kernel from the shell wall, thus loosening the kernels within their shells. The detachment of the kernel from the shell wall greatly facilitates later nut cracking operations. From the foregoing, it is obvious that sterilization (cooking) is one of the most important operations in oil processing, ensuring the success of several other phases.

However, during sterilization it is important to ensure evacuation of air from the sterilizer. Air not only acts as a barrier to heat transfer, but oil oxidation increases considerably at high temperatures; hence oxidation risks are high during sterilization. Over-sterilization can also lead to poor bleach ability of the resultant oil. Sterilization is also the chief factor responsible for the discoloration of palm kernels, leading to poor bleach ability of the extracted oil and reduction of the protein value of the press cake.

3.3.4 Digestion of the Fruit

Digestion is the process of releasing the palm oil in the fruit through the rupture or breaking down of the oil-bearing cells. The digester commonly used consists of a steam-heated cylindrical vessel fitted with a central rotating shaft carrying a number of beater (stirring) arms. Through the action of the rotating beater arms the fruit is pounded. Pounding, or digesting the fruit at high temperature, helps to reduce the viscosity of the oil, destroys the fruits' outer covering (exocarp), and completes the disruption of the oil cells already begun in the sterilization phase. Unfortunately, for reasons related to cost and maintenance, most small-scale digesters do not have the heat insulation and steam injections that help to maintain their contents at elevated temperatures during this operation.

Contamination from iron is greatest during digestion when the highest rate of metal wear is encountered in the milling process. Iron contamination increases the risk of oil oxidation and the onset of oil rancidity.

3.3.5 Pressing (Extracting the palm oil)

There are two distinct methods of extracting oil from the digested material. One system uses mechanical presses and is called the 'dry' method. The other called the 'wet' method uses hot water to leach out the oil.

In the 'dry' method the objective of the extraction stage is to squeeze the oil out of a mixture of oil, moisture, fibre and nuts by applying mechanical pressure on the digested mash. There are a large number of different types of presses but the principle of operation is similar for each. The presses may be designed for batch (small amounts of material operated upon for a time period) or continuous operations.

3.3.6 Batch Presses

In batch operations, material is placed in a heavy metal 'cage' and a metal plunger is used to press the material. The main differences in batch press designs are as follows: a) the method used to move the plunger and apply the pressure; b) the amount of pressure in the press; and c) the size of the cage.

The plunger can be moved manually or by a motor. The motorized method is faster but more expensive.

Different designs use either a screw thread (spindle press) or a hydraulic system (hydraulic press) to move the plunger. Higher pressures may be attained using the hydraulic system but care should be taken to ensure that poisonous hydraulic fluid does not contact the oil or raw material. Hydraulic fluid can absorb moisture from the air and lose its effectiveness and the plungers wear out and need frequent replacement. Spindle press screw threads are made from hard steel and held by softer steel nuts so that the nuts wear out faster than the screw. These are easier and cheaper to replace than the screw.

The size of the cage varies from 5 kg to 30 kg with an average size of 15 kg. The pressure should be increased gradually to allow time for the oil to escape. If the depth of material is too great, oil will be trapped in the center. To prevent this, heavy plates' can be inserted into the raw material. The production rate of batch presses depends on the size of the cage and the time needed to fill, press and empty each batch.

Hydraulic presses are faster than spindle screw types and powered presses are faster than manual types. Some types of manual press require considerable effort to operate and do not alleviate drudgery.

3.3.7 Continuous Systems

The early centrifuges and hydraulic presses have now given way to specially designed screw-presses similar to those used for other oilseeds. These consist of a cylindrical perforated cage through which runs a closely fitting screw. Digested fruit is continuously conveyed through the cage towards an outlet restricted by a cone, which creates the pressure to expel the oil through the cage perforations (drilled holes). Oil-bearing cells that are not ruptured in the digester will remain unopened if a hydraulic or centrifugal extraction system is employed. Screw presses, due to the turbulence and kneading action exerted on the fruit mass in the press cage, can effectively break open the unopened oil cells and release more oil. These presses act as an additional digester and are efficient in oil extraction.

Moderate metal wear occurs during the pressing operation, creating a source of iron contamination. The rate of wear depends on the type of press, method of pressing, nut-to-fibre ratio, etc. High pressing pressures are reported to have an adverse effect on the bleach ability and oxidative conservation of the extracted oil.

The advantages of the screw press over the hydraulic press are detailed below:

- Continuous operation – hence, less labour required; the screw press was a 'batch' process;
- Higher throughput – hence, less investment in buildings and machinery;
- Less power required for a given throughput;
- Nut/fiber separation is easier because of the lower oil content after pressing;
- Screw presses can handle a wide range of throughput rates.

3.3.8 Clarification and Drying of Oil

The main point of clarification is to separate the oil from its entrained impurities. The fluid coming out of the press is a mixture of palm oil, water, cell debris, fibrous material and 'non-oily solids'. Because of the non-oily solids the mixture is very thick (viscous). Hot water is therefore added to the press output mixture to thin it. The dilution (addition of water) provides a barrier causing the heavy solids to fall to the bottom of the container while the lighter oil droplets flow through the watery mixture to the top when heat is applied to break the emulsion (oil suspended in water with the aid of gums and resins). Water is added in a ratio of 3:1.

The diluted mixture is passed through a screen to remove coarse fibre. The screened mixture is boiled from one or two hours and then allowed to settle by gravity in the large tank so that the palm oil, being lighter than water, will separate and rise to the top. The clear oil is decanted into a reception tank. This clarified oil still contains traces of water and dirt. To prevent increasing FFA through autocatalytic hydrolysis of the oil, the moisture content of the oil must be reduced to 0.15 to 0.25 percent. Re-heating the decanted oil in a cooking pot and carefully skimming off the dried oil from any engrained dirt removes any residual moisture. Continuous clarifiers consist of three compartments to treat the crude mixture, dry decanted oil and hold finished oil in an outer shell as a heat exchanger.

The wastewater from the clarifier is drained off into nearby sludge pits dug for the purpose. No further treatment of the sludge is undertaken in small mills. The accumulated sludge is often collected in buckets and used to kill weeds in the processing area.

3.3.9 Oil Storage

In large-scale mills the purified and dried oil is transferred to a tank for storage prior to dispatch from the mill. Since the rate of oxidation of the oil increases with the temperature of storage the oil is normally maintained around 50°C, using hot water or low-pressure steam-heating coils, to prevent solidification and fractionation. Iron contamination from the storage tank may occur if the tank is not lined with a suitable protective coating.

Small-scale mills simply pack the dried oil in used petroleum oil drums or plastic drums and store the drums at ambient temperature.

3.3.10 Kernel Recovery

The residue from the press consists of a mixture of fibre and palm nuts. The nuts are separated from the fibre by hand in the small-scale operations. The sorted fibre is covered and allowed to heat, using its own internal exothermic reactions, for about two or three days. The fibre is then pressed in spindle presses to recover a second grade (technical) oil that is used normally in soap-making. The nuts are usually dried and sold to other operators who process them into palm kernel oil. The sorting operation is usually reserved for the youth and elders in the village in a deliberate effort to help them earn some income.

Large-scale mills use the recovered fibre and nutshells to fire the steam boilers. The super-heated steam is then used to drive turbines to generate electricity for the mill. For this reason it makes economic sense to recover the fibre and to shell the palm nuts. In the large-scale kernel recovery process, the nuts contained in the press cake are separated from the fibre in a depericarper. They are then dried and cracked in centrifugal crackers to release the kernels. The kernels are normally separated from the shells using a combination of winnowing and hydro cyclones. The kernels are then dried in silos to a moisture content of about 7 percent before packing.

During the nut cracking process some of the kernels are broken. The rate of FFA increase is much faster in broken kernels than in whole kernels. Breakage of kernels should therefore be kept as low as possible, given other processing considerations.

3.3.11 Traditional Method of Palm Oil Processing

The village traditional method of extracting palm oil involves washing pounded fruit mash in warm water and hand squeezing to separate fibre and nuts from the oil/water mixture. A colander, basket or a vessel with fine perforated holes in the bottom is used to filter out fibre and nuts. The wet mixture is then put on the fire and brought to a vigorous boil. After about one or two hours, depending on the volume of material being boiled, the firewood is taken out and the boiled mixture allowed to cool. Herbs may be added to the mixture at this point just before reducing the heat. On cooling to around blood temperature, a calabash or shallow bowl is used to skim off the palm oil. Because of the large quantities of water used in washing the pulp this is called the ‘wet’ method.

3.3.12 Processing and Use

Refining

After milling, various palm oil products are made using refining processes. First is fractionation, with crystallization and separation processes to obtain solid (stearin), and liquid (olein) fractions. Then melting and degumming removes impurities. Then the oil is filtered and bleached. Physical refining removes smells and coloration to produce "refined, bleached and deodorized palm oil" (RBDPO) and free sheer fatty acids which are used in the manufacture of soaps, washing powder and other products. RBDPO is the basic palm oil product sold on the world's commodity markets. Many companies fractionate it further to produce palm olein for cooking oil, or process it into other products.

Red palm oil

Since the mid-1990s, red palm oil has been cold-pressed and bottled for use as cooking oil, and blended into mayonnaise and salad oil.

Antioxidants

Red palm oil antioxidants like tocotrienols and carotenes are added to foods and cosmetics because of their purported health benefits.

Butter and Trans Fat Substitute

The highly saturated nature of palm oil renders it solid at room temperature in temperate regions, making it a cheap substitute for butter or trans fats in uses where solid fat is desirable, such as the making of pastry dough and baked goods. A recent rise in the use of palm oil in the food industry has partly come from changed labelling requirements that have caused a switch away from using trans fats. Palm oil has been found to be a reasonable replacement for trans fats; however, a small study conducted in 2009 found that palm oil may not be a good substitute for trans fats for individuals with already-elevated LDL levels.

Biomass and Bio-energy

Palm oil is used to produce both methyl ester and hydro deoxygenated biodiesel. Palm oil methyl ester is created through a process called Trans-esterification. Palm oil biodiesel is often blended with other fuels to create palm oil biodiesel blends. Palm oil biodiesel meets the European EN 14214 standard for biodiesels.

The organic waste matter that is produced when processing palm oil, including oil palm shells and oil palm fruit bunches can also be used to produce energy. This waste material can be converted into pellets that can be used as a biofuel. Additionally, palm oil that has been used to fry foods can be converted into methyl esters for biodiesel. The used cooking oil is chemically treated to create a biodiesel similar to petroleum diesel.

Kernel Drying

Fresh kernels have a moisture content of about 20% and cannot be stored without deterioration. Drying is usually done in a silo. The fresh kernels are fed in at the top, warm air is blown upwards from below and dry kernels (7% moisture) are removed at the base. The kernels can also be steam-sterilized for 5-6 minutes before drying and the FFA of the kernel oil will then remain below 1% after storage for 6 months or more.

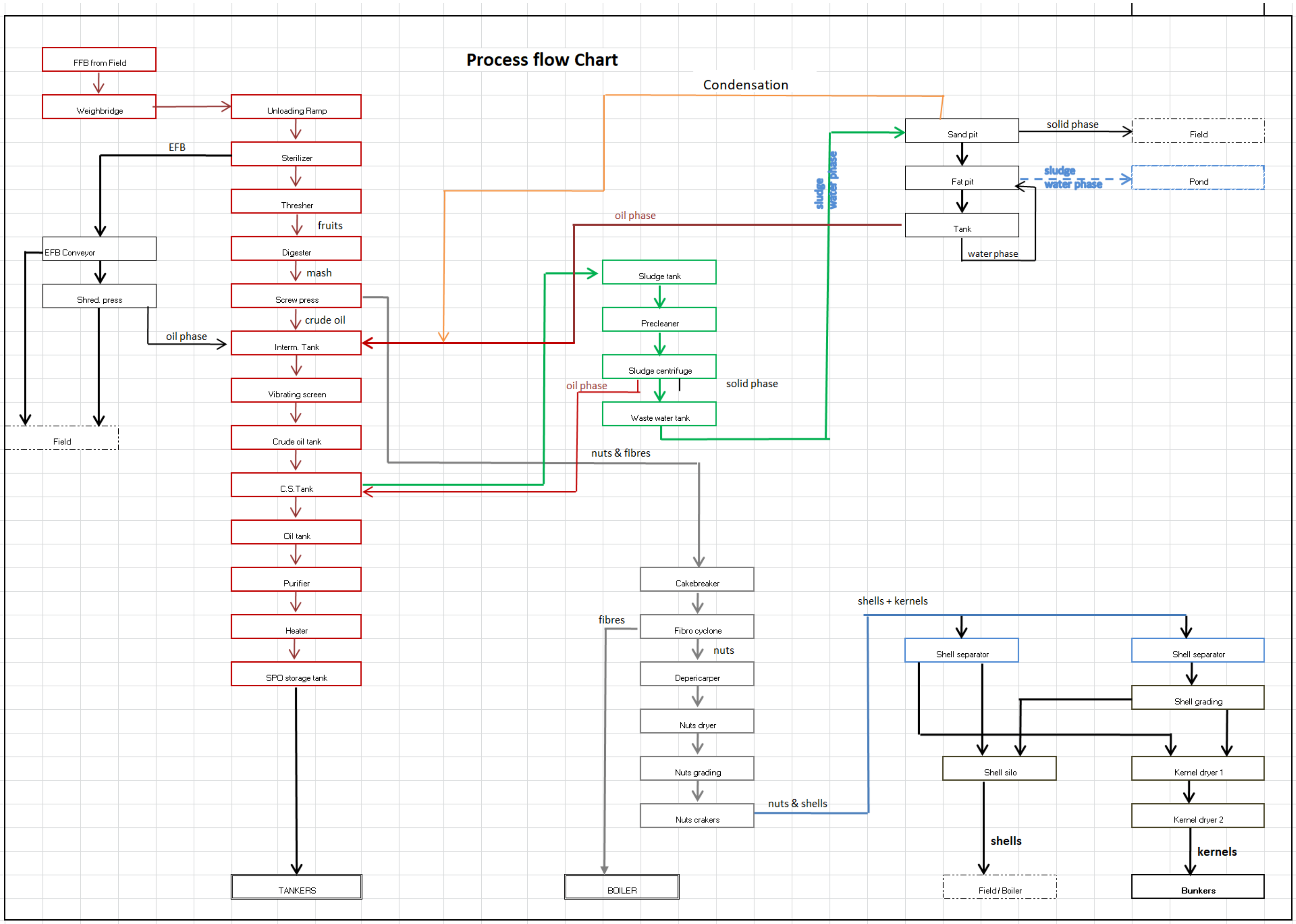


Figure 3.1b: Flowchart for the Proposed Extraction of Crude Palm Oil

3.4 The Proposed Palm Oil Mill

The design, manufacture, supply, installation and commissioning of the proposed palm oil mill of capacity 30MT expandable to 60MT FFB/hr with conventional type double door horizontal sterilizers is by **Besteel Berhad**, Malaysia.

The plant is designed for a useful life of about 30 years once it is operated and maintained according to the manufacturers' instructions.

The technical drawings of the proposed palm oil mill are presented in Table 3.2 to Table 3.8 below.

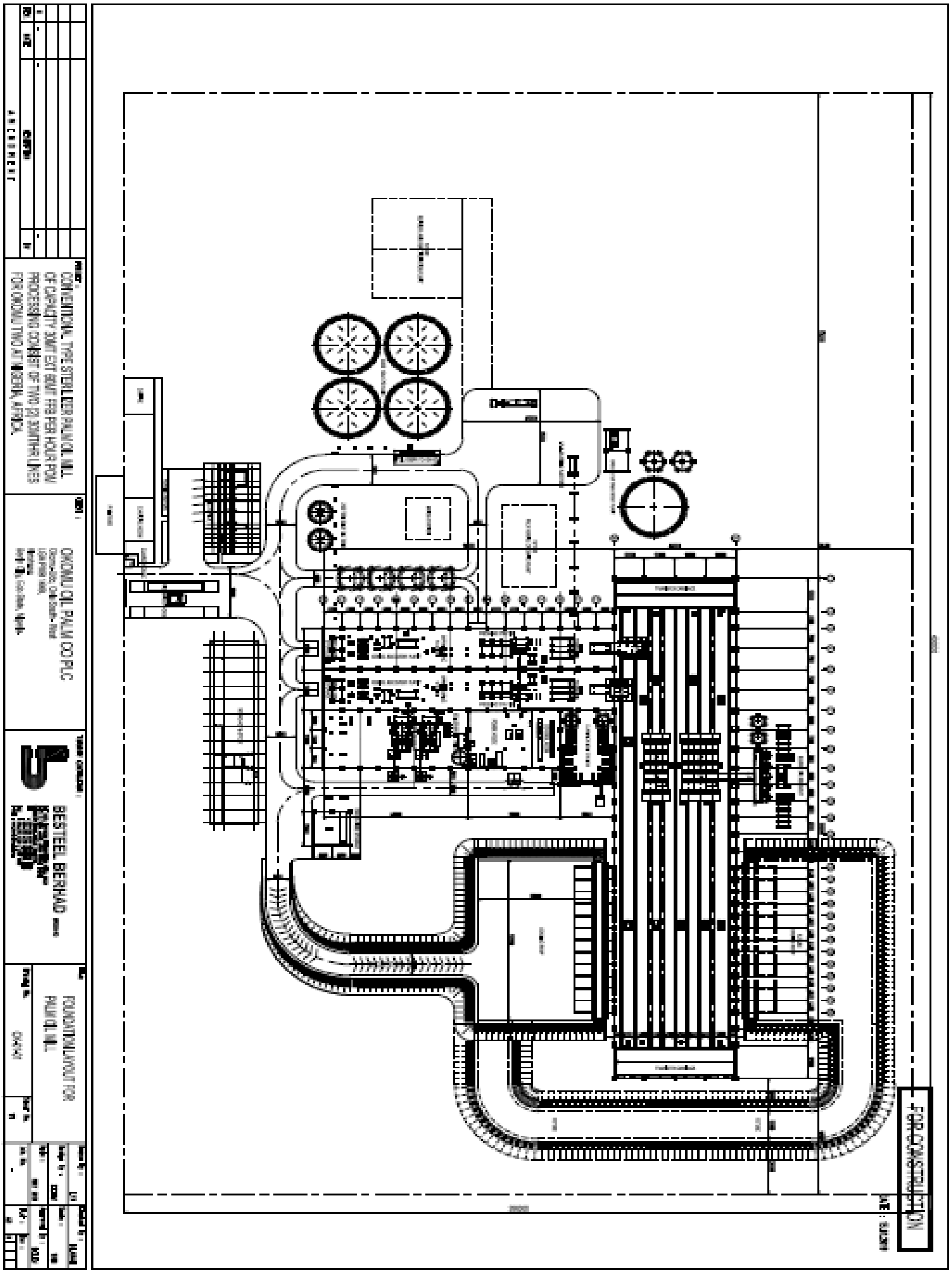


Figure 3.2: Foundation Layout for Palm Oil Mill

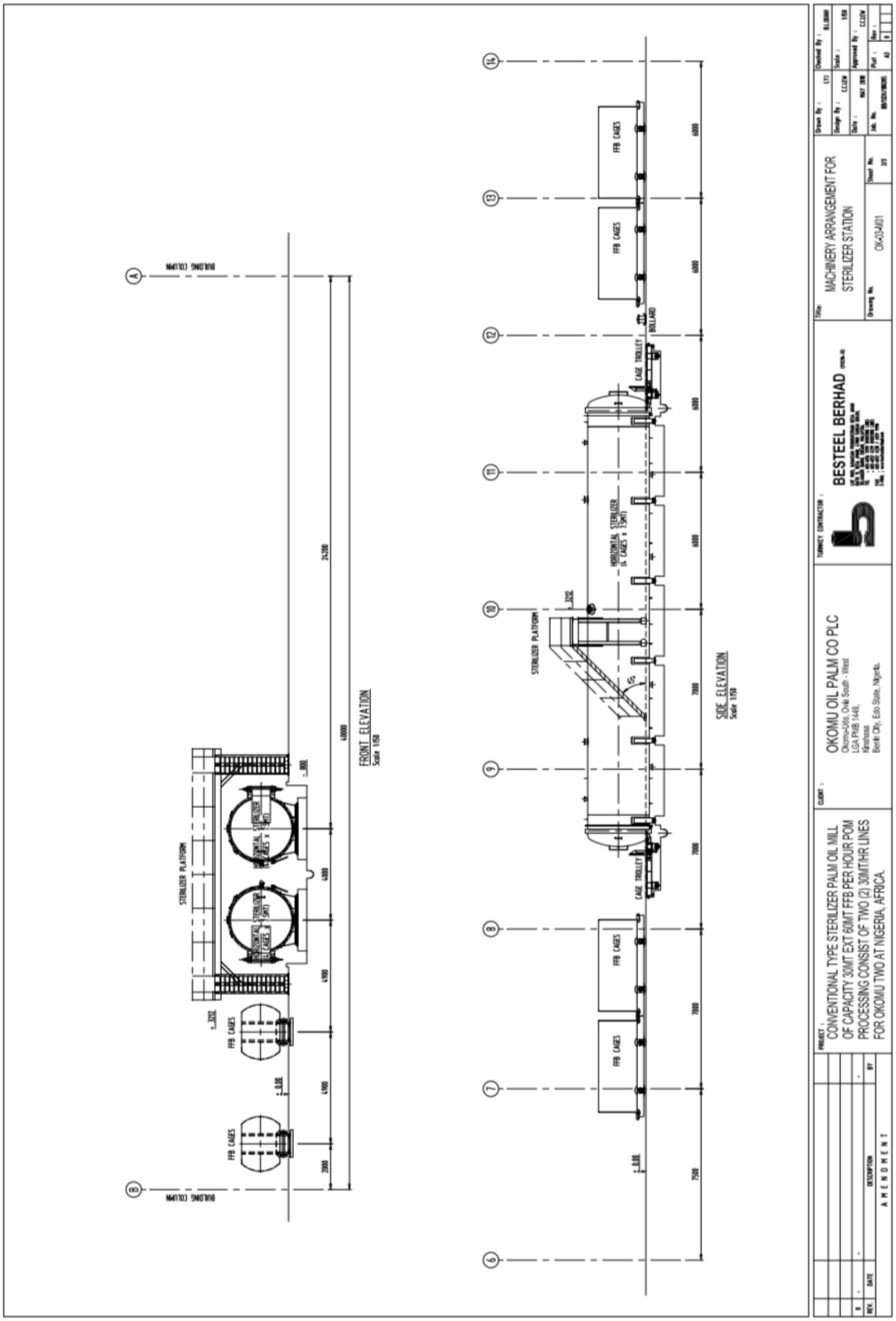


Figure 3.3: Machinery Arrangement for Sterilizer Station

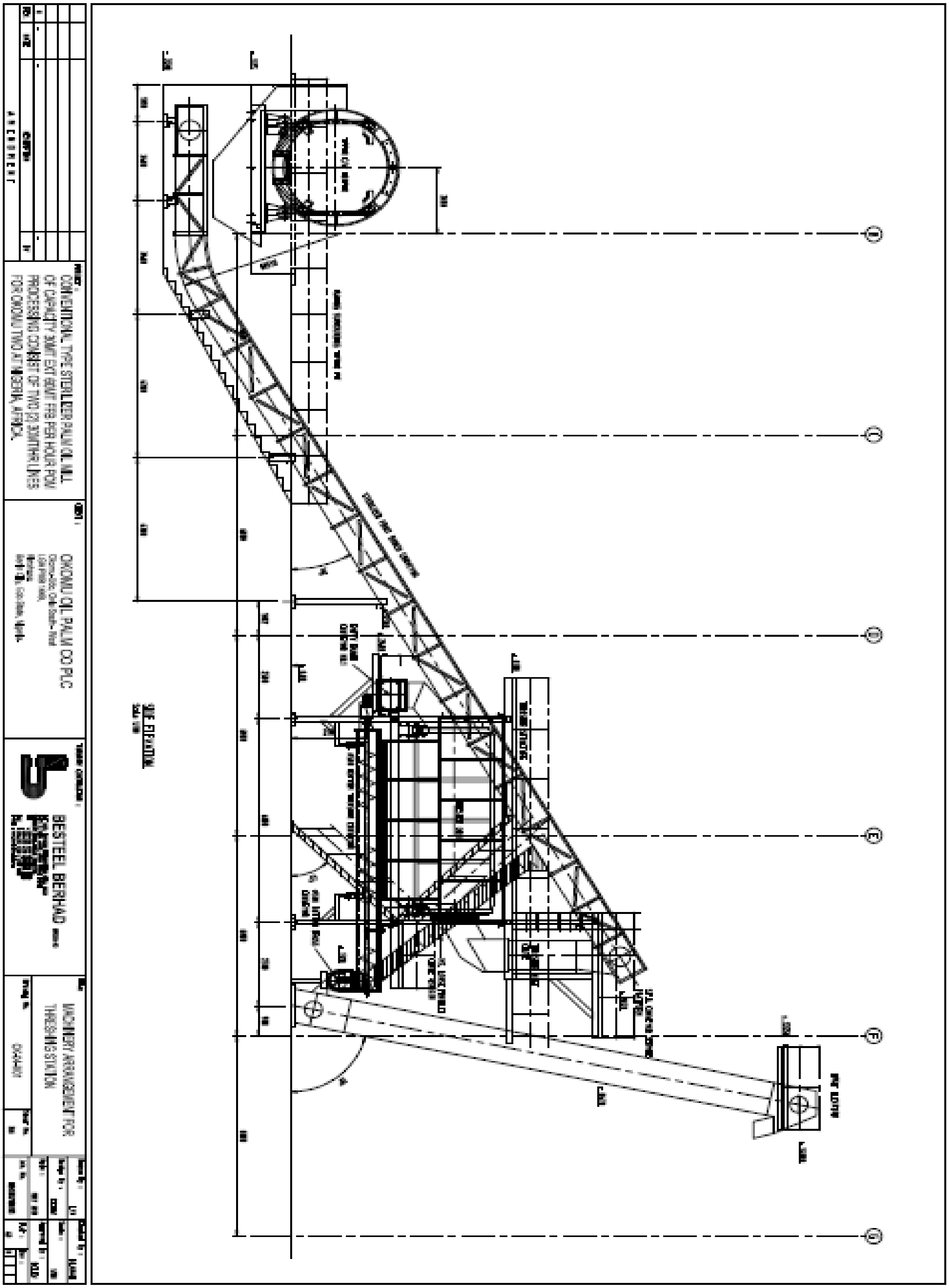


Figure 3.4: Machinery Arrangement for Threshing Station

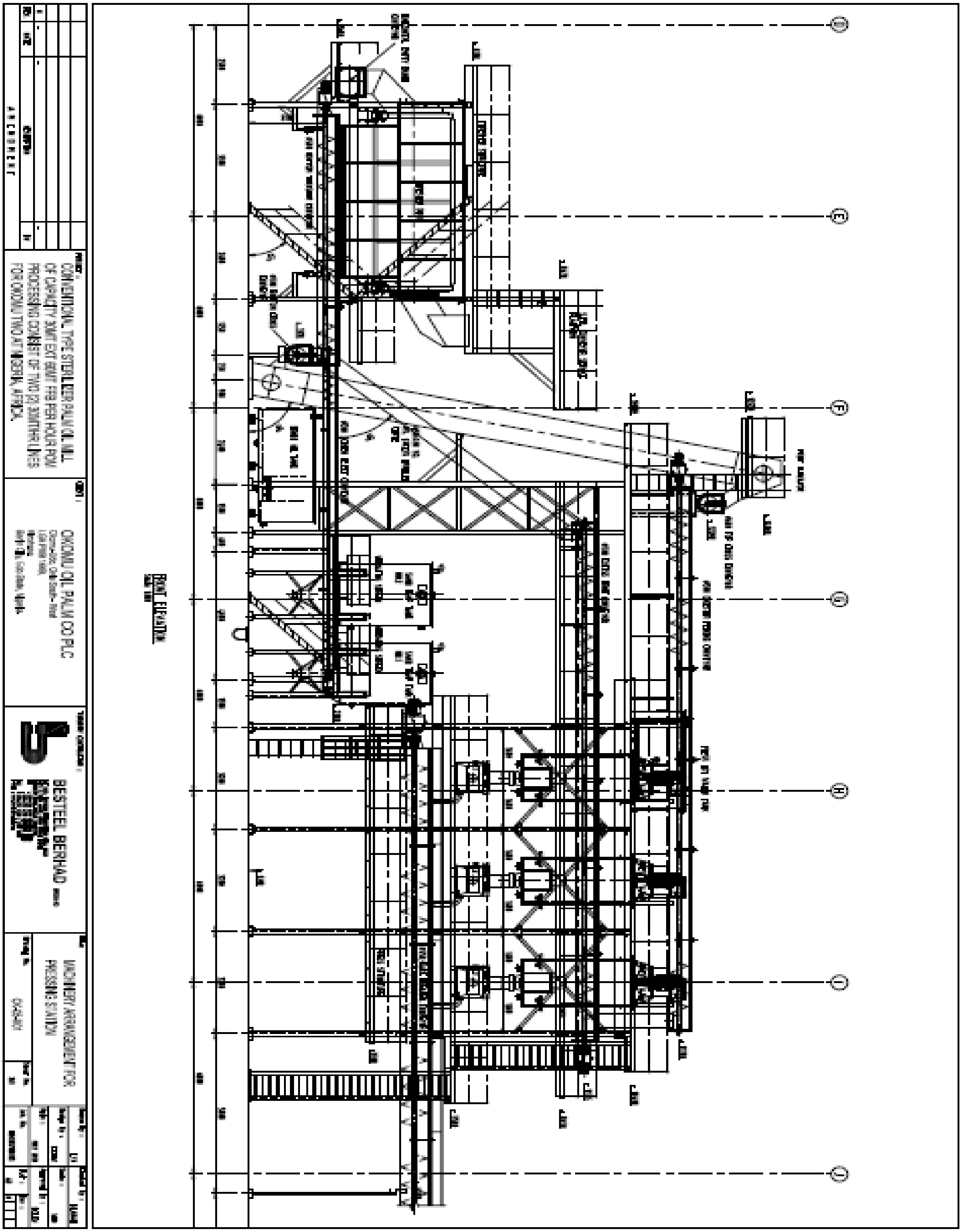


Figure 3.5: Machinery Arrangement for Pressing

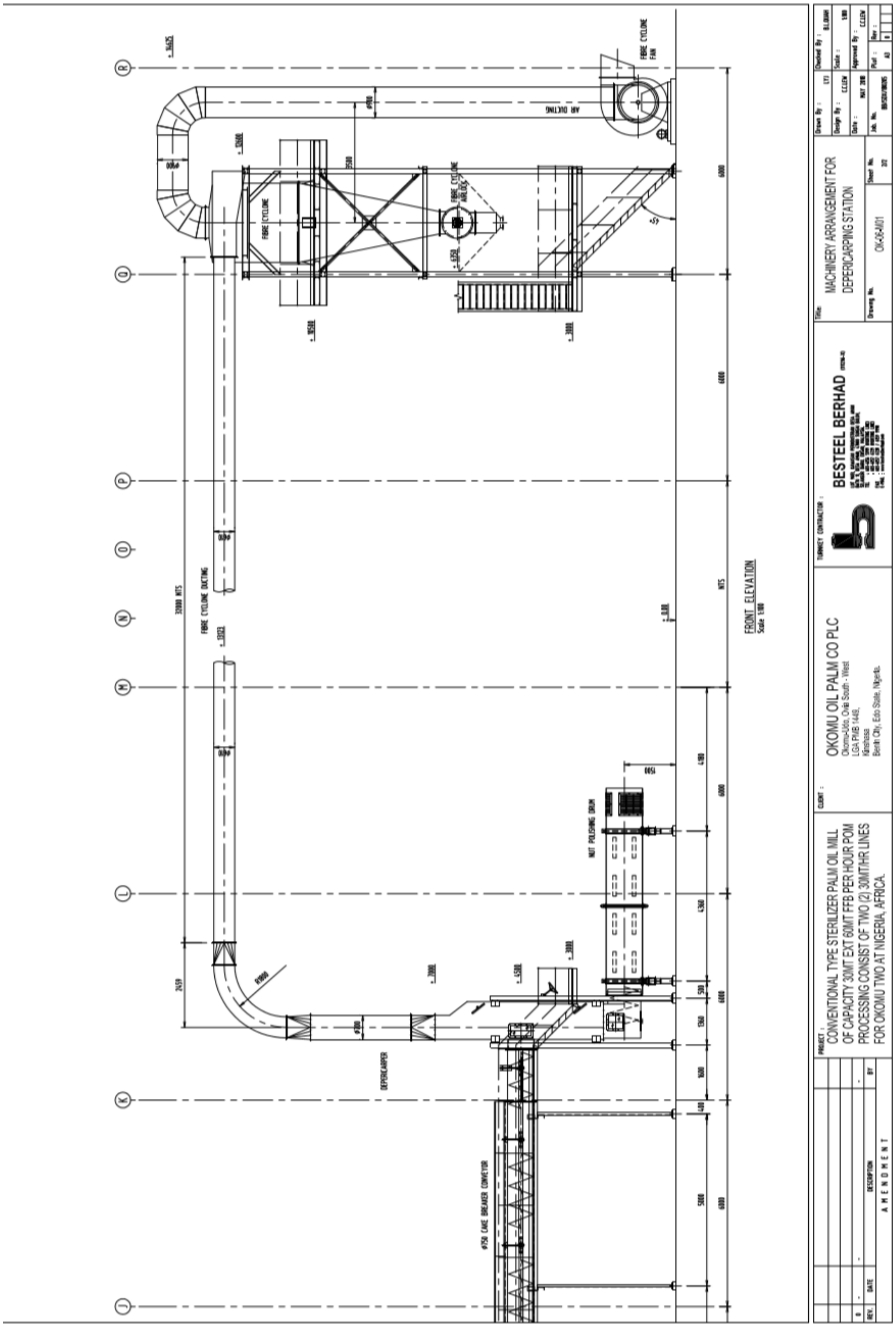


Figure 3.6: Machinery Arrangement for Depricarping Station

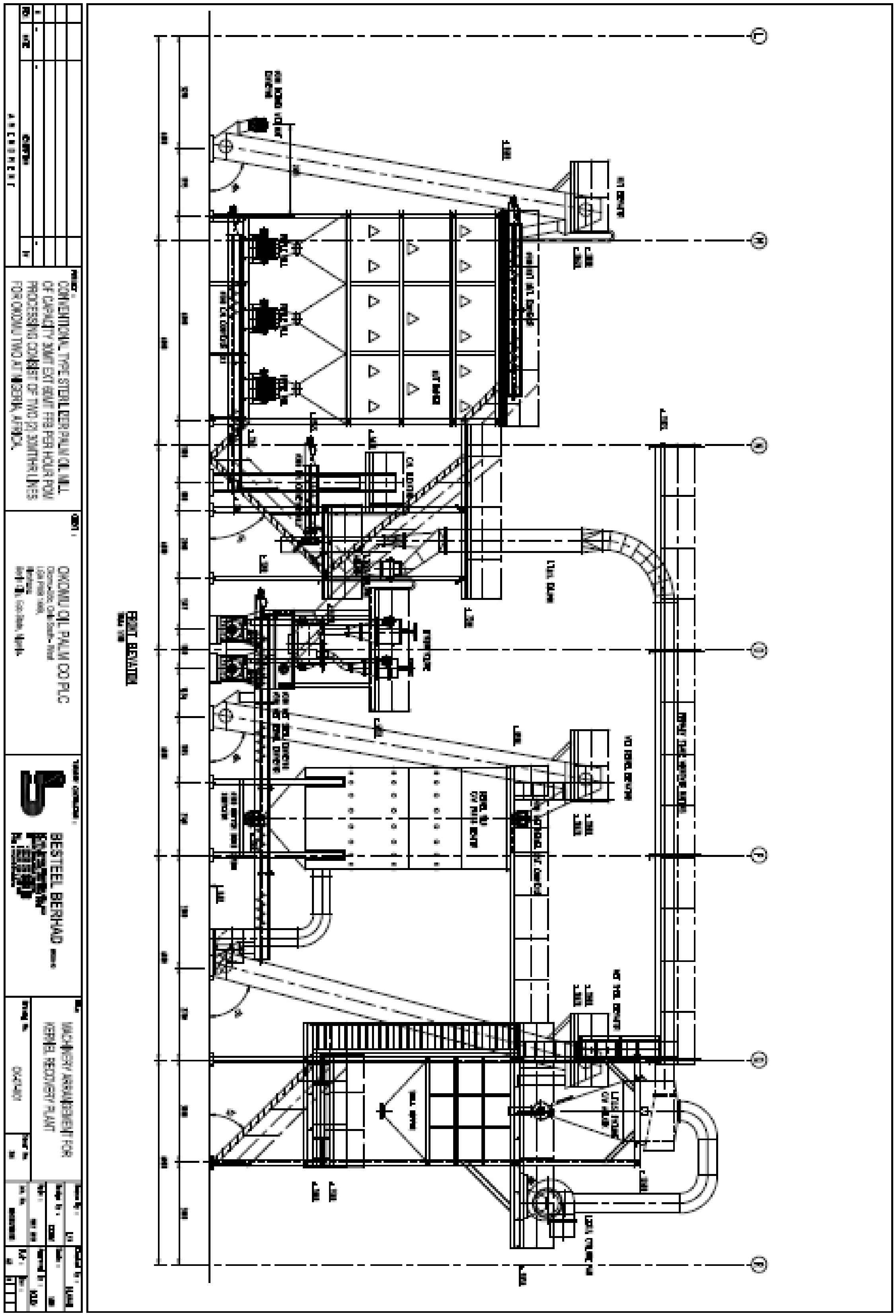


Figure 3.7: Machinery Arrangement for Kernel Plant

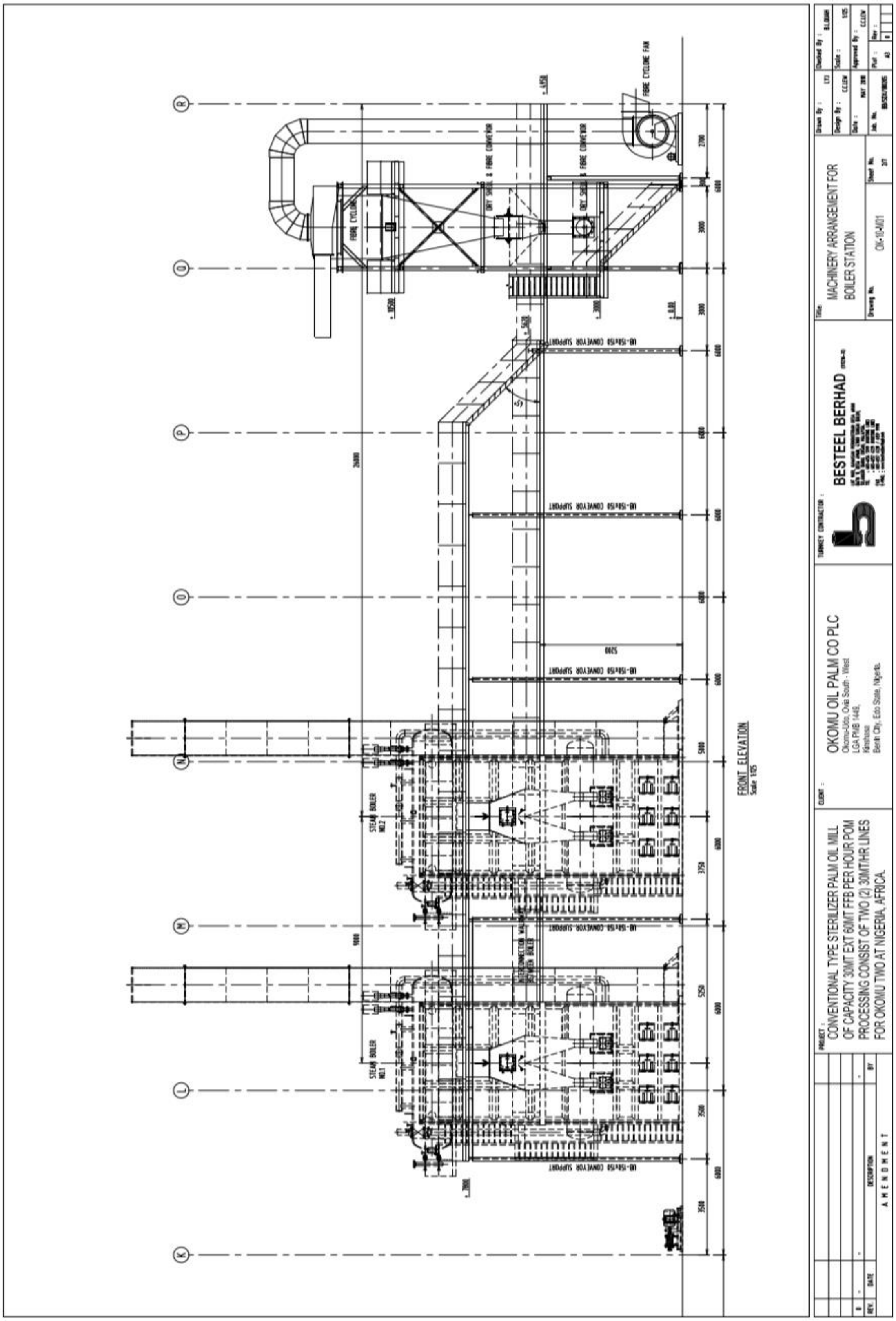


Figure 3.8: Machinery Arrangement for Boiler Station

3.5 Mill Processing Line Mechanical Components

The mechanical components of the proposed mill processing line are presented in Table 3.1 below.

Table 3.1: Processing Line Mechanical Components

item	Description	Specification
LR	**FRUIT RECEPTION STATION**	
LR 1	Weighbridge	80 T X 2 Nos.
LR 2.a	FFB Loading Ramp c/w Hydraulic System	12 bay x 24 door with power pack
LR 3	FFB cages	7.5 Ton each x 60nos
LR 4	Transfer carriage	2 Nos
LR 5 &6	Capstan /Winch & Bollard	11nos
LR 7	Transfer carriage pit pump	5M3,2.2Kw x 2
LR 8	Rail track System	9 sets as per drawing
LR 9	Dirt Conveyor below FFB conveyor	300mm dia x 63000mm long
ST	**STERILIZATION STATION**	
ST 1	Horizontal sterilizer	2700mm dia x 18400mm long X 4Nos.
ST 2	Sterilizer manual control	As per Drawing
ST 3	Blow-down chamber	2nos, as per drawing
ST 4	Sterilizer Pit Pump	$5m^3$/hr at 10m head, 2.2kw
ST 5	Sterilized Condensate Collection Pump	$35m^3$/hr at 30m head, 7.5kw
ST 6	All interconnection Platform & Staircase	As per drawing
ST 7	Cage trolley	1no
TH	**THRESHING STATION**	
TH 1	Sterilized Fruit Bunch (SFB) Conveyor	1.2M (W) x 32.0M
TH 2	Thresher Drum	Ø 2.0m x 5.86m(L) Shaftless Type x 2
TH 3	Bottom Thresher Conveyor	Ø 500mm x 9000mm (L) X2
TH 4	Bottom cross conveyor	Ø 500mm x 9000mm (L)
TH 5	Horizontal Empty Bunch Conveyor	750mm (W) x 36.0M (L)
TH 6	Inclined Empty Bunch Conveyor	750mm (W) x 62.0M (L)
TH 7	Empty Bunch Conveyor structure & chute	1 set
TH 8	Thresher Structures & Platform	For install 2 unit thresher drum
TH 9	Tippler c/w Hopper & shuttle door	As per Spec Sheets
TH 10	Tippler pit pump	$5m^3$/hr at 10m head, 2.2kw
PS	**PRESSING STATION**	
PS 1	Fruit Elevator	800WD x 14.0m (L) x2
PS 2	Top Cross Conveyor	Ø 600mm x 7000mm (L)
PS 3	Digesters Feeding Conveyor c/w manual rack & pinion	Ø 500mm x 17000mm (L)
PS 4	Excess fruitlet chutes	M.S 500 S.QX8000mm L
PS 5	Excess Fruit Conveyor/Return Conveyor	Ø 500mm x 16000mm (L)
PS 6	Digester	4.0 m3 X3
PS 7	Screw Press	P 15 (Modiplam) x3
PS 8	Press Hot Water Tank	M.S 6mmt ($6m^3$)
PS 9	“V” Notch Dilution Tank	M.S 4.5mmt (200 Litre)

PS 10	Crude Oil Gutter	S.S 304 Sch10 Ø 250 Pipe x 0.0M (L)
PS 11	Sand Trap Tank	M.S 6mmt (7m^3) x2
PS 12	Vibrating Screen	Ø 60" Double Deck x2
PS 13	Screen Reject Conveyor	Ø 250mm x 10000mm x(L)
PS 14	Crude Oil Tank	M.S 6mmt (10m^3)
PS 15	Crude Oil Pump	35m^3/hr at 30m head, 7.5kw x2
PS 16	Crude Oil Vibrating Screen Platform	To install 2 units
PS 17	Pressing Station Structures & Platform	To install 3 units
DS	**DEPERICARPING STATION**	
DS 1	Cake Breaker Conveyor c/w Steam Jacket, Steam trap and Catwalk	Ø 750m x 24000mm (L)
DS 2	Depericarper	As per Drawing
DS 3	Nut Polishing Drum	Shaftless Ø 1.0m x 6.0m (L)
DS 4	Pneumatic Fibre Transport Ducting	As per drawing
DS 5	Fibre Cyclone	Ø 2300mm
DS 6	Fibre Cyclone Fan & Ducting	As per Drawing
DS 7	Fibre Cyclone Airlock	Ø 750mm
DS 8	Inclined Wet Nut Conveyor	Ø 300mm x 7000mm (L)
DS 9	Fibre/Shell Cyclone Supporting Structure	As per Drawing
KS	**KERNEL RECOVERY PLANT**	
KS 1	Wet Nut Elevator	400mm (W) x 9000mm (L)
KS 2	Nut Hopper c/w Fan and heater	M.S 3 compartments X 30M3 each
KS 3	Ripple Mills	6 Ton /HrX3
KS 4	Cracked Mixture Conveyor No.1 (Below Ripple Mill)	Ø 300mm x 8000mm (L)
KS 5	Cracked Mixture Conveyor No.2	Ø 300mm x 8000mm (L)
KS 6	Cracked Mixture Elevator	450mm (W) x 12800mm (L)
KS 7	Primary Stage Winnower Cyclone	6MT cracked mixture/hr
KS 8	Primary Stage Winnower Fan & Ducting	6MT cracked mixture/hr
KS 9	Primary Stage Winnower Airlock	Ø 400mm x2
KS13	Hydrocyclones	2 stage
KS 14	Wet Kernel conveyor	300mmdia x 6000mm (L)
KS 15	Kernel elevator	400mm (W) x 10000mm (L)
KS 16	Kernel distributing conveyor	Ø 300mm x 9000mm (L)
KS 17	Kernel Drying Silos c/w Fan & Heater	M.S (45m^3 each) x2
KS 18	Bottom Dried Kernel Conveyor	Ø 300mm x 10000mm (L)
KS 19	Dried Kernel Transport System	3mt dried kernel/hr
KS 20	Top distribution Dried Kernel Conveyor	Ø 300mm x 12000mm (L)
KS 21	Kernel Bulk Silo c/w Support Roofing	M.S 300T eachX2
KS 22	Kernel Recovery Station Structure and Platform	As per drawing
KS 23	Wet shell Conveyor	Ø 300mm x 13000mm (L)
KS 24	Wet shell Elevator	450mm (W) x 10000mm (L)
CS	**CLARIFICATION STATION**	
CS 1	Crude Oil Buffer Tank	M.S 6mmt
CS 2	Oil Clarifier	M.S (120m^3)
CS 3	Pure Oil tank	M.S (30m^3)

CS 4	Pure Oil Pump	30m^3/hr at 70m head, 11kw X2
CS 6	Atmospheric Drier c/w Pump sets	As per Drawing
CS 7	Oil Production Pump	15m^3/hr at 70m head, 7.5kw
CS 8	Sludge Tank	M.S (30m^3)
CS 9	Pre-cleaner Pump	30m^3/hr at 30m head , 7.5kwX3
CS 10	Pre-cleaner	45M3/hr
CS 11	Pre-cleaner Sand Collection Tank	M.S 6mmt
CS 12	Overhead Sludge Buffer tank	M.S 6mmt
CS 15	Sludge centrifuge	6000L/hr X3
CS 16	Light Phase Recycle Tank	M.S 6mmt
CS 17	Light Phase Pump	35m^3/hr at 30m head, 7.5kw x2
CS 18	Reclaim Oil Tank	M.S 6mmt (6m^3)
CS 19	Reclaim Oil Pump (to crude oil buffer tank)	35m^3/hr at 30m head, 7.5kw x2
CS 21	Sludge Drain Tank	M.S 6mmt, 14m^3
CS 22	Fat pit tank	MS 8mmt
CS 23	Fat pit pump	35m^3/hr at 30m head, 7.5kw x2
CS 24	Structure and Platform support	As per Drawing
SB	**SHELL BUNKER**	
SB 1	Shell Hopper	M.S (30m^3)
SB 2	Dry Shell &fibre Conveyor	Ø 600mm x 19000mm (L)
BH	**Boiler Station**	
BH 1	Fuel distribution conveyor	750mm (W) x 36000mm (L)
BH 2	Platform for the above	As per Drawing
BH 3	Excess fuel conveyor	600mm (W) x 44000mm (L)
BH 4	Excess fuel recycled conveyor	750mm (W) x 48000mm (L)
BH 5	Steam Boiler, Atmindo	20T.hrX2
BH 6	Cation & Anion Exchanger	30m3/hr
BH 7	Demin booster pump	30m^3/hr at 25m head, 5.5kw x2
BH 8	Feed water tank	MS 100m3
BH 10	Vacuum deaerator c/w chemical dozing	As per Drawing
PH	**Power House**	
PH 1	Steam Turbine	1200KW x2
PH 2	Steam Separator	As per Drawing
PH 3	Back pressure vessel	MSØ 1200mm x 6000mm (L)
PH 4	Diesel Generator 1	1500KVA
PH 5	Diesel Generator 2	150KVA
PH 6	Diesel skid tank	MS 20,000ltrs
PH 7	Diesel Day tank	MS 2m3
PH 8	Diesel skid pump	3m^3/hr at 5m head, 1.5Kw
RW	**RAW WATER TREATMENT PLANT**	
RW 2	Reservoir pipe work	GI 500mtrs
RW 3	Raw water chemical dosing system	0.25 kw (Dosing) 0.18kw (Stirrer) x2
RW 4	Water clarifier tanks	M.S (120m^3/hr)
RW 5	Clarified water storage tank	M.S 3000m^3
RW 6	Pressure sand filters	As per Drawing
RW 7	Pressure sand filters pumps	60m^3/hr at 20m head, 11kw x2

RW 8	Interconnection piping c/w valve	Dosing, drain and filter
RW 11	Main water pump	$30m^3$/hr at 25m head, 5.5kw x2
ET	**Effluent Treatment**	
ET 1	Sludge pit pump	$35m^3$/hr at 35m head, 7.5kw x2
ET 2	Sludge recovery tank	M.S $100m^3$
ET 3	Effluent Piping	HDPE, 500mtrs
OS	**Oil Storage Despatch Area**	
OS 1	Oil storage tank 1	Ms 3000Mt X2
OS 2	Oil storage tank2 (Day oil Tank)	Ms 200MTX2
OS 3	Oil despatch pump	$100m^3$/hr at 25m head, 18.5kw x2
OS 4	Oil recycle pump	$20m^3$/hr at 30m head, 5.5kw
PW	**PIPING AND VALVES WORK FOR PROCESSING**	
PW 1	Water- Cold and Hot	G.I / SGP Pipe
PW 2	Steam- High, Low pressure and Condensate	API Pipe
PW 3	Crude Oil and Sludge and Oil	S.S 304 , API/ SGP Pipe
PW 4	Diesel	API / SGP Pipe
PW 5	Compressed Air	API / SGP Pipe
PW 6	Oil Recycle	S.S 304 / API / SGP Pipe
AW	**ANCILLARY WORK**	
AW 1	Insulation	As per drawing
AW 2	Painting	As per drawing
AW 3	Lubricant	As per drawing
AW 4	Motor cover and base motor frame	As per drawing
AW 5	Inter connection station platform	As per drawing
FF	**FIRE FIGHTING SYSTEM**	
FF 1	Firefighting diesel pump set	$100m^3$/hr at 40m head, 30kw
FF 2	Hose reel, quick coupling and plain jet	As per Spec Sheets
FF 3	Hydrant Piping System	As per Spec Sheets
FF 4	Fire Extinguisher	As per Spec Sheets
WI	**BOREHOLE WATER INTAKE**	
WI 2	Pipeline	6”dia HDPE,1000M

3.6 Safety Devices

There are two safety switches on each machine including the sterilizer. The first can be used manually as a safety button to stop the machine and the ancillary machines. The second one is triggered off automatically by the machine if the operations limits are exceeded. Also, on each critical machine a reverse button is installed. Some of the critical machines have safety provisions as follows:

Oil Mill Machines and Component:

Sterilizer	Emergency switch
Tipper	Emergency switch
Thresher	Emergency switch
Press	Emergency switch
Clarification Machine	Emergency switch

3.7 Steam Boiler

A boiler can be defined as a closed vessel in which water or other fluid is heated under pressure. This fluid is then circulated out of the boiler for use in various processes or power generation. In the case of power generation, steam is taken out of the steam boiler at very high pressure and temperature.

Steam boilers are used where steam and hot steam is needed. Hence, steam boilers are used as generators to produce electricity in the energy business. Besides, steam boilers are used in many different application areas in the industry, for example in heating systems or for cement production, steam boilers are also used in agriculture as well for soil steaming.

Boiler Types

Boiler systems are classified in a variety of ways. They can be classified according to the end use, such as foe heating, power generation or process requirements. Or they can be classified according to pressure, materials of construction, size tube contents (for example, waterside or fireside), firing, heat source or circulation. Boilers are also distinguished by their method of fabrication. Accordingly, a boiler can be packaged or field erected. Sometimes boilers are classified by their heat source. For example, they are often referred to as:

- Coal fired boilers
- Oil fired boilers
- Gas fired boilers
- Multi-fuel fired
- Industrial waste fired boilers
- Biomass fired boilers

The proposed steam boilers are Atmindo boiler of 2X20 tons per hour capacity. It is a waste fired steam boiler. The boiler would comprise Atmindo Bi-drum Model SFBW 20-SH-PG Air cooled Fix Pinhole Grate boiler having the capacity to evaporate 2X20,000 kg/hr at 22 bar (g) MCR, 280°C steam when fired with palm waste fuel and drum working pressure of 25 bar (g).

The pressure parts of the boiler would be carried in a substantial structural steel frame to support the boiler fabric with due provision for thermal expansion between the pressure parts and supporting structure and the refractory and brickwork setting. The name and address of the manufacturers are as follows:

PT AtmindoTbk
J1.Sei Belumai Km.2,4 No 30-40
Desa Dagang Kelambir
Tanjung Morawa 20362,
North Sumantera,
Indonesia.

The specific technical information on the boiler is presented in Table 3.2.

Table 3.2: Steam Boiler Technical Information

Description	Details
Boiler Data	SFBW 20-SH-PG
Application	1+1 (W+S)
Installation	In the premise of the oil mill processing line
Quality	Designed to operate under tropical conditions, i.e. hot, 25-40°C, and humid, 80-90%
Electric Motors	Tropicalized
Induced Drought Fan	Frequency converter to limit the start Amps
Mass Flow	4523 kg/hr
Pressure MCR	22 bar (g)
Steam Pressure	25 bar (g)
Steam Output	20 ton/hr
Temperature	280^0C

3.8 Civil Structures

The major civil structures of the palm oil mill Project are listed in Table 3.3 below.

Table 3.3: Major Equipment and Structures of the project

S/No.	Item	Specification
1	FFB Reception Station	RCC/Steel Structure
2	Sterilizer Station	Steel Structure
3	Processing Line	Steel structure
4	Boiler House	Steel Structure
5	Water Treatment House	Steel Structure
6	Empty bunch yard	RCC
7	Storage tanks	RCC/Steel Structure
8	Ash Yard	Open Field
9	Effluent Lagoon	Earth Pond with lining

3.9Mill Features and Facilities

The main mill features and facilities are described in Table 3.4 below.

Table 3.4: Mill Features and Facilities

Component	Description
FFB Storage	The 12 bay FFB hoppers with hydraulic doors (24) for the 1500MT storage of FFB prior to processing
Workshop	The workshop provides back-up repairs and maintenance services for the mill plant and machinery.
Power Supply	The power requirement of the mill will be produced in house and back up with industrial diesel generators i) Turbine – 1200kW x 2nos ii) Diesel Generator – 1500 kVA – To generate a total of 1.5mW iii) Diesel Generator – 150 kVA
Water Supply	The process water requirement is $0.7 m^3$ per ton of FFB will be sourced from 4 Nos. boreholes in the mill complex. The water supply system involves the extraction of water from the bore holes with electrical pumps. The raw water is pumped into an overhead water tank. The water tank is also equipped with an automatic level switch, which turns on and off to maintain a constant water level. Water is fed into the processing line by gravity. The storage tank is also equipped with a flow meter to monitor and record water use and safety ladder for ease of maintenance.
Weighbridge	Proposing two (2 Nos.) weighbridge of 80 Tons capacity each with features including computers and control panels.
Laboratory/Admin Office	The laboratory/Admin office building is proposed within the mill office building. The building provides accommodation for the quality control laboratory and offices for the mill administration. The laboratory performs essentially quality control and quality assurance operations and is equipped with

Component	Description
	the appropriate equipment, machines and apparatus. The major laboratory equipment includes oil extractor and centrifuge.
Tank Farm	The finished product (CPO) will be stored in the Tank Farm. Two (2 Nos.) storage tanks of 3000 tons each were proposed.
Communication	Proposing four communication systems to facilitate operations and handle emergencies as follows: **Local Intranet** – for internal communication (between the different offices) **VHF Handset**– for internal communication **Internet System** – for external communication **GSM** – for both internal and external communication.
Safety Devices	For the proposed project, all the machines would have their dangerous parts protected. Each machine would also have two safety switches including manual stop button and automatic stop button. In addition, critical machines will have reverse buttons installed.

3.10 Sizing of the Palm Oil Mill

3.10.1 Quantity of FFB to be processed

The proposed capacity of the existing mill is 30 MT FFB/hour. The capacity utilization will rise gradually, as more plantation area becomes mature. The proposed sizing of the mill is based on the following:

3.10.2 Throughput

- 60 tons FFB/hour
- 1200 tons/day [Average 20 h/d]
- 220,000 tons/year

3.02.3 Capacity Utilization per Year

- 2021 : 200,000 tons FFB
- 2022 : 220,000 tons FFB
- 2023 : 268,000 tons FFB

3.10.4 Finished Products

CPO

- 2021 : 42,000 tons
- 2022 : 46,000 tons
- 2023 : 56,000 tons

PK

- 2021 : 8,000 tons
- 2022 : 8,800 tons
- 2023 : 11,000 tons

3.11 Installation & Commissioning

The equipment manufacturers and suppliers will be responsible for setting up and commissioning the mill plant and machinery. These activities include:

- Providing detailed drawings of mill's pre-installation requirements for foundations, structures, elevations, layout etc.
- General arrangements for all the plant and machinery in the processing hall together with installation pre-requirements
- On-site testing
- Instructions and training to users and maintenance technicians

3.11.1 Plant Installation and Construction Engineers

The installation and construction engineering companies are:

- Kalleen-Tech Nigeria Limited
  km 20, Benin-Sapele Rd,
  Benin City,
  Edo State.
- Fredson Global Ventures.
  5, Alhaji Street, Ladega B/stop,
  Ikorodu, Lagos.
- Wilka Associates
  6, Akpakpava Rd.,
  Benin City, Edo State
- BesteelBerhad
  Lot 968, Kawasan Perindustrian,
  Desa Aman, 47000,
  Sungai Buloh, Malasia.

3.12 Description of the Site

The proposed project is to be constructed in extension 2 plantation area near Tango 1 Gate. Effluent ponds are also proposed besides the project.

3.13 Water Treatment Process

The water treatment process (Water treatment plant) is designed to ensure the desirable water quality for boiler feed water and auxiliary quality water needs. The existing water treatment source will service the proposed boiler.

3.14 Water Supply and Drainage System Facility

Water supply and drainage system facility will be designed in relation to water source; circulating water system; make-up water system; service water system; water supply and drainage of the entire mill complex.

Domestic water supply system is fed from domestic water supply system. Water supply and drainage systems include: domestic water supply; storm water drainage, domestic sewage and wastewater drainage.

3.15 Firefighting System

The existing fire prevention and control system includes water firefighting system, hydrant, as well as fire extinguishers installations. Water firefighting system is responsible for the firefighting of the mill, oil tank area, auxiliary and associated buildings.

3.16 Emissions Control Facilities

All emission control facilities will be provided, especially at the steam boiler. Such facilities will include:

- Electrostatic Precipitator (ESP)
- SO_2 Removal Facility
- NOx Control Equipment

3.17 Civil Engineering

The civil engineering design will be sound to ensure well organized operation within the mill complex.
In addition, fire prevention and evacuation; sanitary facilities; drainage of floors and roofs; lighting and ventilation; decoration and finishingrequirements will be considered in the designs.

Civil engineering designs will be completed in full consideration of the major technical parameters and safety standards.

3.18 Current Situation of Energy Supply

Existing 500kVA diesel generators will be used for construction.

3.19 Training

3191.1Plant Operation

Training will also be provided by the manufacturer/supplier of the mill plant and machinery regarding their operations and maintenance requirements. Persons who should participate in this training include:

- The Mill Manager in charge of Engineering (Operations and Maintenance)
- The personnel that will operate the mill plant and machinery

Training of staff and services contractor in waste management practices of the mill is critical. Training programmes will include:

- Basic training in waste handling procedures for all new staff
- In-service training to revise and update the knowledge of mill and waste handling staff.

Pamphlets and signs are all useful materials to complement the formal training activities and they act as reminder for staff.

3.20 Environmental Considerations

3.20.1 Treatment of Solid Waste Products

In a well-run palm oil mill, it is expected that each 100 tonnes of FFB processed yields 20 to 24 tonnes of crude palm oil and about 4 tonnes of palm kernels. Thus between 72 to 76 percent of the FFB comes out at various stages of the process as waste.

The solid wastes that result from the milling operations are:

- Empty fruit bunches,
- Palm fibre, and
- Palm kernel shell.

In the large- and medium-scale mills the above-mentioned waste products are all put to economically useful purpose. They could therefore be referred to as by-products rather than waste products.

Wet, empty bunches are partly dried in the sun and later used as fuel. Another economic use for the empty bunches is to return them to the plantation as a mulch to enhance moisture retention and organic matter in the soil.

The palm kernel shell is also used as a source of fuel for the boilers. Unfortunately the shell contains silicates that form a scale in the boilers if too much shell is fed to the furnace, thus limiting the amount of shell that can be utilized in the boilers. Residual shell is disposed of as gravel for plantation roads maintenance. Blacksmiths also buy the shells to use as fuel material in their casting and forging operations.

The fibre recovered from the nut/fibre separation stage is a good combustible material and finds ready use as fuel to boil the fruit. The fibre constitutes the bulk of material used to fire the large boilers used to generate superheated steam to drive turbines for electrical power generation in large-scale plants.

Boiler ash is recycled as fertilizer and factory floor cleaning agent. The potash in the ashes reacts with the oil to form a weak potash soap that is washed away with water.

Small-scale mills also use the fibre and bunch waste as fuel material. Most small-scale mills do not undertake the shelling of recovered palm nuts. The nuts are sold to palm kernel processors.

Small-scale palm kernel processors use clay baths to separate kernels from shells. The shells are normally left in a pile to dry. Some of the shells are used for fuel but there are always residual amounts found around the palm kernel processing centres. Periodically the pile is removed and used as landfill.

Wood consumption of small-scale operations is relatively small because of the recycling of the fibre and bunch waste as the main fuel source. The medium-scale operators tend to supplement their internally generated solid waste fuel sources with wood for firing their boilers. The impact on the local tree population is significant enough to cause factories to close while foraging for wood supplies.

3.20.2 Treatment of Aqueous Effluent

Large- and medium-scale mills produce copious volumes of liquid waste from the sterilizer, clarifying centrifuges and hydro cyclones. This effluent must be treated before discharge to avoid serious environmental pollution.

Liquid waste treatment involves anaerobic fermentation followed by aerobic fermentation in large ponds until the effluent quality is suitable for discharge. In some of the mills the treated effluent is used on the farm as manure and source of water for irrigation. The sludge accumulating in the fermentation ponds is periodically removed and fed to the land.

To manage the amount of oil entrained in the effluent, while at the same time improving the efficiency of oil recovery, the large mills use de-watering and decanting centrifuges at various locations in the process line.

When it comes to liquid waste management most traditional processors and small-scale palm oil processors do not adhere to any environmental protection practices. The environmental awareness level of the operators in this industrial area is low. Indeed much is desired of the hygiene of most facilities. Traditional processors operate so close to nature that they simply return liquids to the surrounding bushes. The discharged quantities are so small that the ground easily absorbs the waste matter and the operators have not yet seen their activities as injurious to their surroundings.

However in the more organized intermediate technology mills sludge from the clarifying tanks are carried in buckets or rudimentary gutters to sludge pits dug in the nearby bushes. When the sludge pit begins to give off a bad odour the pit is filled in and another one dug for the purpose. Charcoal from the cooking fires is dumped into the pits to absorb some of the odour.

Sometimes the oil in the sludge pit is recovered and mixed with fibre to make a fire-starting cake called ‘flint’.

It has been observed that when the small-scale mill operators empty their sludge on the surrounding bushes the bushes slowly die. Operators say they use the sludge as a herbicide to clear their surroundings. It is, however, time to develop simple inexpensive aqueous pollution control systems for small-scale operators.

Environmental pollution considerations in small-scale palm oil milling need concentrated attention as this industrial segment assumes greater importance. It is hoped that as more educated people come into the industry they will bring increased awareness and a greater commitment to adopt improved environmental management practices in their operations.

3.21 Waste Management

Okomu Oil Palm Company Plc has put in place detailed waste management plans covering a comprehensive description of activities and waste handling at preconstruction, construction, operational and abandonment phases of this project. During site visits, the waste management practices were observed and the company's internal environmental management system (EMS) was ascertained.

Palm oil processing is carried out using large quantities of water in mills where oil is extracted from the palm fruits. During the extraction of crude palm oil from the fresh fruits, about 50% of the water results in palm oil mill effluent (POME). It is estimated that for 1 tonne of crude palm oil produced, 5-7.5 tonnes of water ends up as POME (Ahmed et al, 2003).

The solid waste products that result from the milling operation are empty fruit bunches, palm fibre and palm kernel. In both traditional and modern milling settings, these solid waste products are all put to economic use such as fuel material and mulch in agriculture. It is the POME that is usually discharged into the environment, either raw or treated.

Raw POME consisting of complex vegetative matter is thick, brownish, colloidal slurry of water, oil and solids including about 2% suspended soils originating mainly from cellulose fruit debris that is palm mesocarp (Bek Nelsen et al, 1999). The raw or partially treated POME has an extremely high content of degradable organic matter which is due in part to the presence of unrecovered palm oil (Ahmad et al, 2003).

This highly polluting wastewater can, therefore, cause pollution of waterways due to oxygen depletion and other related effects as reported by Ahmad et al. (2003). Thus, while enjoying a most profitable commodity, palm oil, the adverse environmental impact from the palm oil industry cannot be ignored.

Large and medium scale mills produce copious volumes of liquid waste (POME) from the processing lines, (Sterilizers, clarifying centrifuges and hydro cyclones) where POME is produced on a large and commercial level. However effective the system of oil recaptured from the sludge may be; the POME discharged from an oil mill is objectionable and could pollute streams, rivers or surrounding land (Hartley, 1988). While mills were comparatively few and mostly beside large fast flowing rivers, the problem was not a serious one but the situation in many countries including Nigeria is quite different with much attention being recently given to the subject of effective disposal and protection of the environment. Apart from the sludge water itself, which amounts to about 300 kg per tonne of bunches milled (or about 1.5 tonne per tonne of palm oil), there are also about 175 kg of sterilizer condensate and between 40 and 140 kg of POME from the hydrocyclone or clay bath separators/tonne of bunches (Hartley, 1988). The total amounts of POME is therefore more than a tonne/tonne bunches/hour, more than 200 tonnes of POME may be discharged over 24 hours and this may contain up to 1 tonne of oil and 9 tonnes of dissolved or suspended solids (Hartley, 1988).

POME is generated in the sterilization, digestion and clarification phases in the palm oil mills. POME has remained one of the largest liquid wastes generated in agro-industrial activities in Nigeria. Studies have shown (Ohimian, 2014) that Nigeria produces 3.950 to 4.650 million tonnes of FFB producing 790,000 to 930,00 metric tonnes of crude palm oil using 24.687 to 29.062 million tonnes of water for processing and generating 15.923 to 18.745 million tonnes POME in the past 10 years (2004–2014). The FFB production reached 4,650,000 crude palm oil, while utilizing 29,062,500 tonnes of water and releasing 18,745,312.5 metric tonnes of POME.

3.21.1 Ash Handling

Ash handing system is designed to consider ash quantity produced by the boiler; fly ash conveying system; bottom ash conveying system; and ash transportation off the site.

The bottom ash handling system will be used to collect and transport bottom ash from the furnace of boiler. The bottom ash from the furnace will be removed continuously by bottom ash coolers, after cooled, then discharged to bottom ash bin, it will further be transported by truck to the ash disposal yard east of the mill complex.

3.21.2 Ash Yard

The ash dumps of the existing operation are situated east of the mill complex. The available space is large and it has the capacity to accommodate the boiler ash to be generated from the proposed steam boiler. Trucks will be used for transporting ash to the ash yard. Seepage control (including concrete flooring and protective ground cover) and other environmental protection measures will be considered for the extra ash dumping.

3.21.3 Overall Waste Management

No waste shall be discharged into any surface river or wetland without adequate treatment. Table 3.5 shows the proposed waste management plan to be put in place.

Table 3.5: Summary of Okomu Oil Palm Company Plc Waste Management Plan.

Type of Waste	Waste From	Waste Management Option			Disposal	
		Reduce	Re-use	Recycle	Forest/	Land
Gaseous	Heavy duty machines (Land Preparation), Methane	Installation of appropriate filters to the exhaust pipe			-	-
Noise	Machinery and generators,	Installation of appropriate noise Reducing devices			-	-
Liquid	Office Areas (Wastewater)	-	-	-	None	Soak-away pits attached to buildings.
	Sanitary from Toilets	-	Used in the field	-	None	Appropriately designed Septic tanks
	Oil traps				None	Trapping of oil using retention trays
	Palm Oil Mill Effluent	-	Used in the field as irrigation water	-	-	Discharge in the treatment ponds for biological (natural) treatment.
Solid	Domestic waste, mill, workshop	Collected and taken to the dumpsite. Used as fuel for the mill boiler				-
	EFB, fibre, ash, plantation field, shrubs, palm fronds, tree back.	Retained in the field as manure				-
	Hazardous wastes such as empty agrochemical containers	Taken away by the manufacturers and/or suppliers as part of agreement deal.				-

None: Not discharged into/disposed off in the habitat − Not Applicable

3.21.3.1 Waste Classification

The wide range of waste that will be generated by the proposed project during construction and operation phases are classified into solid waste, liquid waste and gaseous emissions.

3.21.4 Waste Generation and Sources

Solid, liquid and gaseous wastes will be generated during construction and operational phases of the project. The waste profile is presented in Table 3.6 below.

Table 3.6: Waste Profile of the proposed mill

Project Phase	**Waste Class**		
	Solid	**Liquid**	**Gaseous**
Construction	❑ Soil and vegetation ❑ Cement bags ❑ Wood scraps ❑ Steel Scraps ❑ Rubble ❑ Food Waste ❑ Glass and Plastic Bottles ❑ Dust	❑ Wastewater ❑ Engine oil ❑ Spent oil	❑ Fugitive Dust ❑ Suspended Particulate ❑ Carbon dioxide ❑ Carbon monoxide ❑ Greenhouse Gases
Operation *(Mill)*	❑ EFB ❑ Sludge ❑ Paper ❑ Glass & Plastic Bottles ❑ Boiler ash ❑ Palm kernel shell	❑ Palm Oil Mill Effluent ❑ Wastewater ❑ Spent Oil	❑ Fugitive Dust ❑ Suspended Particulate ❑ Carbon dioxide ❑ Carbon monoxide ❑ Greenhouse Gases
Operation *(Laboratory)*	❑ Reagent bottles & cans ❑ Papers/plastics/glass	❑ Wastewater	❑ Carbon dioxide ❑ Carbon monoxide
Operation *(Offices)*	❑ Papers/plastics/glass ❑ Scrap office equipment	❑ Wastewater	❑ Carbon dioxide ❑ Carbon monoxide ❑ Fumes
Operation *(Workshop)*	❑ Metal scraps ❑ Empty cans ❑ Electric cables	❑ Spent oil ❑ Spilled Oil ❑ Wastewater ❑ Fuel ❑ Solvents	❑ Carbon dioxide ❑ Carbon monoxide ❑ Fume
Operation *(Offices)*	❑ Papers/plastics/glass ❑ Scrap office equipment	❑ Wastewater	❑ Carbon dioxide
Operation *(Powerhouse)*	❑ Plastics ❑ Empty cans ❑ Electric cables	❑ Wastewater ❑ Spilled Oil ❑ Spent Oil	❑ Suspended Particulate ❑ Carbon dioxide ❑ Carbon monoxide ❑ Greenhouse Gases
Operation *(Fuel Storage)*	❑ Plastic/metal Containers ❑ Papers	❑ Wastewater ❑ Spilled fuel	❑ Carbon dioxide ❑ Carbon monoxide ❑ Fume

3.21.4.1 Solid Waste Handling

Storage: At all the points of waste generation, waste bins will be provided for the immediate storage of solid waste. Provision would also be made for sorting and segregation of all solid waste at the point of generation. There are waste management plans where wealth shall be generated from wastes as much as practicable.

Collection and Transfer: Waste collection and transfer would include the provision of a truck to collect and transport the collected waste to a designated dumpsite.

Disposal: The solid waste collected would be transported and disposed of at the solid waste dumpsite within the plantation.

3.21.4.2 Liquid Waste Handling

Wastewater: Wastewater will be channelled into soak-away pits of varying dimensions attached to the mill facilities.

Storm water: Rainstorm water will be collected in channels and led into natural drainage lines and vegetation.

Palm Oil Mill Effluent: Palm Oil Mill Effluent (POME) and wastewater will be channelled into cooling pond followed by anaerobic and Aerobic ponds for treatment via a stainless steel pipe. The ponds are located just besides the plant.

3.21.5 Waste Re-use/Re-cycling

As much as possible, waste will be minimized. There is an existing yard already designated for keeping all reusable waste.

3.22 Waste Manifest and Tracking

A manifest system will be established and record kept appropriately ensuring that the mill waste is tracked from “cradle to grave”.

3.23 Effluent Treatment Facility

The discharge of untreated POME though creates adverse impact to the environment, the notion of nurturing POME and its derivatives as valuable resources should not be dismissed. Below are types of POME treatment.

3.23.1 Anaerobic Digestion System

Generally, Palm oil mill effluent treatment plants (ETPs) are operated on two-phase anaerobic digestion process followed by extended aeration process. In the anaerobic digestion process, the raw POME is first converted into volatile fatty acids by acid forming bacteria. The volatile acids are then converted into methane and carbon dioxide. The advantages of anaerobic digestion system are:

- The two phase system allows greater control of digester environmental conditions.
- Long solid retention times allow better biodegradation efficiencies.
- Additional settling of liquor ensures minimum loading to the aerobic process.
- There is capability to cope with full effluent load, regardless of fluctuation.

Anaerobic digestion also consists of breaking down of organic materials in the absence of oxygen. These materials are broken down biologically by a complex group of acid-forming and methanogenic bacteria which obtain their energy from the oxidation of organic compounds converting them into end products consisting of water, gases (mainly methane and carbon dioxide) and stabilized solids, (singh et al, 1999).

3.23.2 Extended Aerobic Process

In the extended aerobic system, the anaerobic liquor is aerated to further reduce the BOD content. In addition to providing oxygen, the floating aerators also ensure complete mixing is achieved and the pod contents are always in suspension. In this process, levels of beneficial micro-organisms are increased which in turn hasten the conversion of pollutants into carbon dioxide, water and energy. The aerobic suspension is allowed to settle in a settling tank to ensure production of a fairly clean supernatant. The main advantages of extended aerobics systems are its high BOD removal efficiency and low solid yield.

3.23.3 Ponding System

This is by far the most popular treatment system adopted by more than 85 percent of the palm oil mills in the country (Chooi 1984). Various design and configurations of raw effluent is treated using a ponding system comprising of three phases involved anaerobic, facultative, and aerobic processes. Although the system takes a longer retention time of 90 days, it Is less sensitive to environment changes, stable, efficient and could guarantee excellent pollutant biodegradation efficiency of above 95%. Dominion square SdnBhd is one of is also one of the crude palm oil suppliers that use this kind of treatment for their palm oil mill effluent treatment before it can be released to the water system and comply with the standard B by the department of environmental.

Microorganism or microbe is any organism too small to be seen by the naked eye and can only be seen under a microscope. Categories of microorganisms include Algae, Bacteria, Fungi, Protozoa, Viruses or Sub-viral agents. Effective microorganism (EM) technology has now become a major science, assisting in the creation of sustainable practices for agriculture, animal husbandry, nature farming, environmental stewardship, construction, human health and hygiene, industrial, community activities and more. Specially-cultured microbes are used in the biological treatment of sewage and Industrial waste effluent, a process known as bio augmentation. Treatment of POME involve the biodegrading by thermophilic and mesophilic anaerobic microbe. Lifecycle of microbe involved in the reduction of POME directly related to the temperature of the effluent. That is one of the parameters that is going to be investigated in this experiment. Some studies of the structure of mesophilic and thermophilic granules and biofilms have already been made. The structure of mesophilic granular sludge has been described as consisting of three distinct layers. The outer layer consists mainly of a heterogeneous population of acidogenic bacteria, the middle layer of syntrophic cocci- and rod-shaped bacteria, and the center of densely packed *Methanothrix with* many gas cavities. Such a structure would enable substrate to pass through the biomass, being degraded by the various types of bacteria to reach the methanogens that produce biogas. This could then diffuse outward via gas channels. Morganet et al used sequential staining to examine the internal architecture of mesophilic granules treating paper mill and sugar refinery effluents. Both types of granule had a heterogenous surface population of bacteria, with an abundance of *Methanothrix* being found internally. (Quarmby and Forster).

Chan (1982) and Chooi (1984) have reported that ponding system is reliable, stable and is capable of producing good quality discharge with BOD less than the DOE standard and meet the regulatory watercourse discharge standard. Ponding system is cheap to construct but requires a large land area. The anaerobic ponds are usually 5-7 meter deep while the facultative ponds are 1-1.5 meter in depth. The hydraulic retention times (HRT) for this system is 1, 4, 45 and 16 days for de-oiling tank, acidification, anaerobic and facultative ponds respectively.

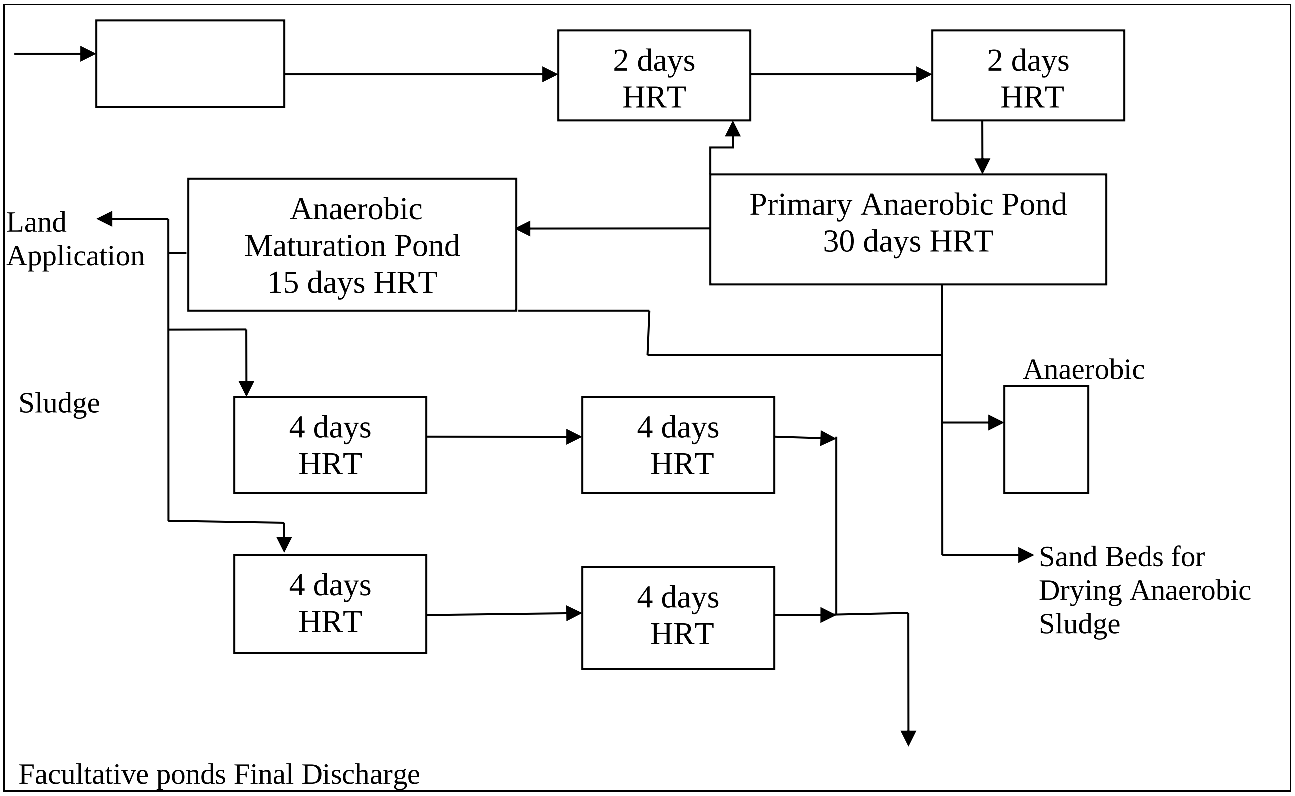


Figure 3.9: Schematic Flow Diagram for Ponding System
Source: Chooi (1984)

Ponding system is normally operated at very low rate. The organic loading varies from 0.2 to 0.35kg BOD/m^3/day. Because of the size and configuration of the ponds, the processes are relatively difficult to control and monitor. Furthermore, there is no mechanical mixing in the ponds. Limited mixing is achieved through the bubbling of biogas generated during the anaerobic digestion process. Also, the rising biogas will bring along with it the fine suspended solid to the surface of the pond. If it is allowed to accumulate, it will develop into scum. Consequently, it is not uncommon to find discrete islands floating on the surface of the pond resulting in the dead spots and short circulating in the ponds. Another feature of the ponding system is the build-up of solids at the bottom of the pond. If these solids are allowed to accumulate to excessive levels, they together with the scum at the top will effectively reduce digester capacity and shorten the HRT. This will adversely affect the treatment efficiency of the process. Regular desludging (solid removal) is therefore recommended.

Energy required to operate the ponding system is minimum. It is only required to run the pumps. Gravity flow is exploited wherever possible. For a 30-tonne FFB/hour mill, the energy demand to operate the ponding system is about 20kwh. Figure 3.10 showed the schematic flow diagram for DDSB wastewater ponding treatment process use in DSSB.

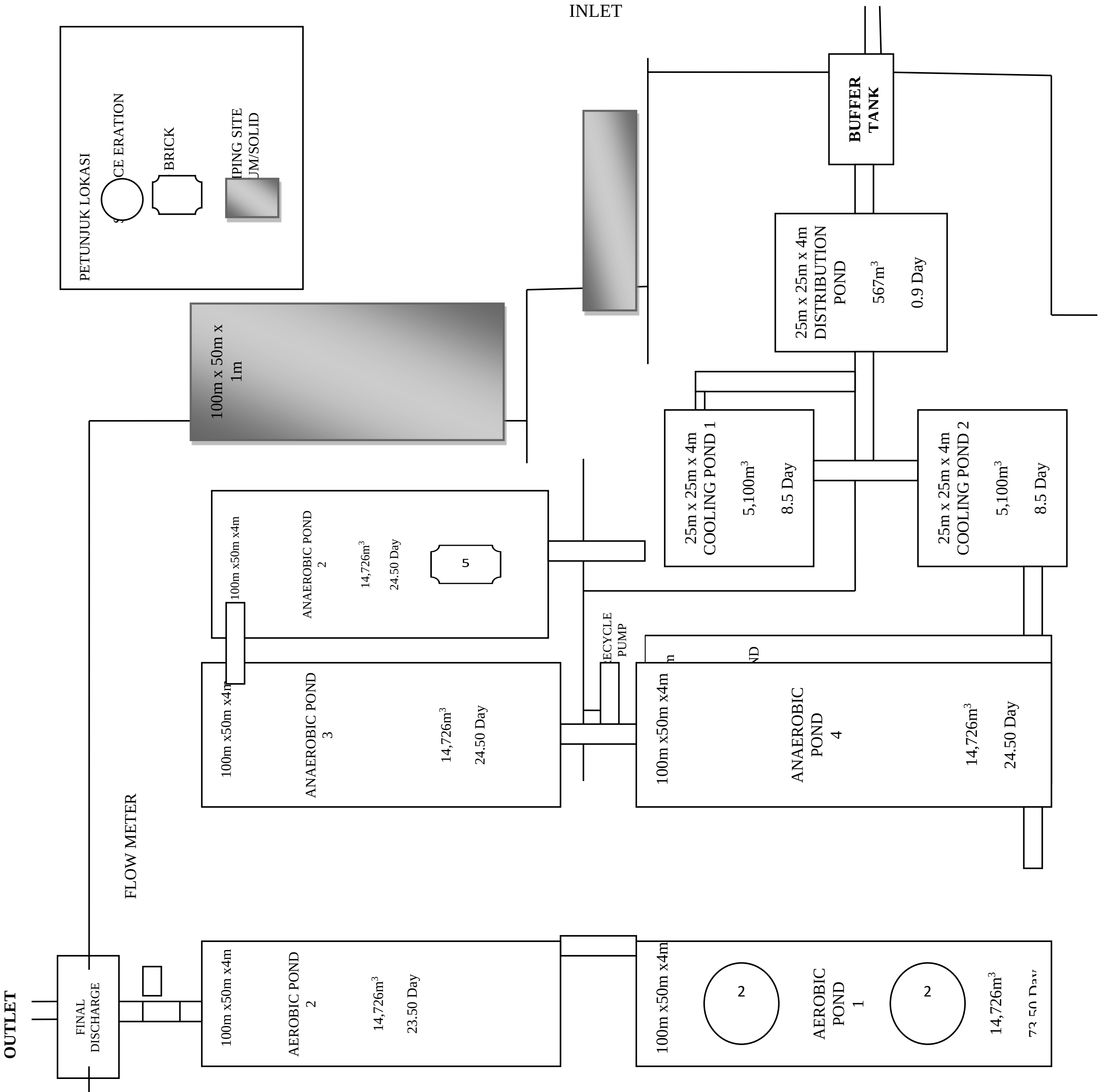


Figure 3.10: DSSB Schematic Flow Diagram for Ponding System

3.23.4 Lagoon System

It is no wonder that one of the most popular methods of wastewater treatment around the world is also of the simplest and least expensive. Lagoon systems use natural and energy-efficient processes to provide low-cost wastewater treatment. They are one of the most cost-effective wastewater treatment options for many homes and communities.

In the U.S, most wastewater treatment lagoons are found in small and rural communities. Lagoons are especially well-suited to small communities because they can cost less to construct, operate and maintain than other systems. They also require more land than other wastewater treatment methods, and land is more likely to be available and inexpensive in rural areas. Lagoons can also be designed to serve individual households. They are sometimes good option for homes on large lots in areas where other onsite systems or sewers are too costly or otherwise impractical. Lagoons also work well for many seasonal rental properties and recreational areas, because they are able to handle intermittent periods of both light and heavy use.

There are several different types and names for lagoons and many possible system designs. Lagoon systems include one or more pond-like bodies of water or basins designed to receive, hold, and treat wastewater for a predetermined period of time. Lagoons are constructed and lined with material, such as clay or an artificial liner that will prevent leaks to the groundwater below. While in the lagoon, wastewater receives treatment through a combination of physical, chemical and biological processes. Much of the treatment occurs naturally, but some systems are designed to also use aeration devices that increase the amount of oxygen in the wastewater. Aeration makes treatment more efficient, so that less land area is necessary, and aerators can be used to upgrade some existing systems to treat more wastewater. Every lagoon system must be individually designed to fit its specific site and use. Designs are based on such factors as the type of soil, the amount of land area available, the climate, and the amount of sunlight and wind in an area. Other important design considerations for lagoon systems include the amount and type of wastewater to be treated and the level of treatment required by state and local regulations. Depending on local standards and the final method of disposal chosen, wastewater leaving lagoon systems often requires additional treatment, or "polishing," to remove disease causing organisms or nutrients from the wastewater before it can be returned to the environment.

Lagoons are not all the same, some employ different biological, chemical and physical processes to treat the wastewater, while others may play a different role in overall treatment. Some lagoon designs provide adequate treatment for certain methods of discharge, while others should be used in combination with other lagoons or with additional treatment.

Complicating matters further, there can be several different names for the same type of lagoon, for example, the terms *lagoon and pond* are often used interchangeably, and names, such as *polishing, stabilization and maturation,* can refer to lagoons particular role in treatment. This can be very confusing for community leaders and home owners trying to evaluate lagoon systems. The following is a brief overview of some of the more common types of lagoons and some of the terms used for them.

Anaerobic Lagoons

The word anaerobic means without oxygen, which describes the conditions inside this type of lagoon. Anaerobic lagoons are most often used to treat animal wastes from dairies and pig farms, commercial or industrial wastes, or as the first treatment step in systems using two or more lagoons in a series. Typically, anaerobic lagoons are designed to hold and treat wastewater from 20 to 50 days. They are relatively deep (usually 8 to 15 feet) and work much like septic tanks. Inside an anaerobic lagoon, solids in the wastewater separate and settle into layers. The top layer consists of grease, scum and other floating materials. This layer keeps oxygen out, allowing bacteria and other organisms that thrive in anaerobic conditions to work to treat the wastewater. As with septic tanks and most other lagoon designs, the layer of sludge that settles at the bottom of an anaerobic lagoon eventually accumulates and must be removed periodically. Also similar to a septic tank, the wastewater that leaves an anaerobic lagoon always requires further treatment. Odor can be a problem with anaerobic lagoons. However, in many cases odor can be managed through a variety of methods, such as adding sodium nitrate, recirculating pond effluent, and through regular maintenance.

Aerobic Lagoons

Dissolved oxygen is present throughout much of the depth of aerobic lagoons. They tend to be much shallower than other lagoons, so sunlight and oxygen from air and wind can better penetrate the wastewater. In general, they are better suited for warm, sunny climates, where they are less likely to freeze. Wastewater usually must remain in aerobic lagoons from 3 to 50days to receive adequate treatment. Wastewater treatment takes place naturally in aerobic lagoons with the aid of aerobic bacteria and algae. Because they are so shallow, their bottoms needs to be either paved or lined with materials that will prevent weeds from growing in them. Sometimes, wastewater in aerobic lagoons needs to be mixed to allow sunlight to reach all of the algae and to keep it from forming a layer that blocks out the air and sun completely.

Aerated Lagoons

Aerated lagoons are very common in small communities. These systems use aerators to mix the contents of the pond and add oxygen to the wastewater. They are sometimes referred to as partial-mix or complete-mix lagoons depending on the extent of aeration. Partial-mix aerated lagoons that have been adapted and upgraded to receive more wastewater. With the exception of wind-driven designs, most aerators require energy to operate. However, energy costs are almost always considerably less than those for other mechanical community treatment systems. Aeration makes treatment more efficient, which offsets energy costs in some cases. Aerated lagoons require less land area and shorter detention times for wastewater than other lagoons.

Facultative Lagoons

Both aerobic and anaerobic conditions exist in facultative lagoons, which also are called stabilization ponds, oxidation ponds, photosynthetic ponds, and aerobic-anaerobic ponds. They are the most common type of wastewater treatment lagoon used by small communities and individual households. Facultative lagoons can be adapted for use in most climates, require no machinery, and treat wastewater naturally, using both aerobic and anaerobic processes.

3.24 Palm Oil Mill Effluent (POME) Ponds for the Proposed Project

The proposed POME treatment system for this project is biological (natural) method with open ponding system before it is discharged into the plantation field as irrigation water. Proposed sizes of treatment ponds for 60 MT FFB/hr. are:

- Cooling Pond **-** 92.5 x 53.5 x 2 metres deep
- Anaerobic Ponds **-** 219 x 126.25 x 5 metres deep
- Aerobic Ponds**-** 219 x 125.87 x 1.5 metres deep

3.24.1 Palm Oil Mill Effluent Quality and Monitoring

The lagoon system working efficiently treats and improves the quality of the wastewater to acceptable international levels for the critical elements. The characteristics of water leaving the outlet point of lagoon system with both National and International Norm requirements for wastewater discharge onto land are presented in Table 3.7.

Table 3.7: Characteristics of wastewater leaving the Pond with both National and International Required Norms

Parameters	Expected Results After Treatment	FMEnv., (Nigerian, standards)	Indonesia Standards	Malaysia Standards
pH	9	6-9	6-9	6-9
COD ppm	< 225	80	472	216
BOD ppm	< 100	30	137	93

Source: Chan (1982) and Chooi (1984)

The quality of the effluent will be monitored routinely (quarterly basis) to ensure that it conforms to regulatory (FMEnv) standards. This means that the discharge quality at points of discharge must not exceeds the FMEnv and/or International recommended values for discharge into the environment. In addition to routine monitoring of effluent, quarterly monitoring of groundwater and monitoring well at about 150 radius to the treatment ponds will also be carried out to assess any changes in quality that may arise due to effluent discharge and seepage.

3.24.2 Technical Specifications

One solution to treat the POM effluents is to reject them in ponds respecting residence time to let occur biological decomposition with or without oxygen of the organic material. Experience shows that we must have 5 ponds respecting specifically the depths to encourage the anaerobic or aerobic decomposition:

Table 3.8: Decomposition Time of POME in Various Ponds

Ponds	Retention Time	Depth
1 Cooling pond	5 days	2
2 Anaerobic pond	70 days	5
3 Anaerobic pond	70 days	5
4 Anaerobic Pond	22 days	1.5
5 Aerobic Pond	22 days	1.5

- The purpose of the first pond is to cool down the effluents before to reject them in the anaerobic ponds. It helps to reach a favourable temperature for the anaerobic decomposition.
- The purpose of the second and third ponds is to decompose the organic material with bacteria living in a anaerobic environment.
- The purpose of the fourth and fifth ponds is to decompose the remaining organic material with the dissolved oxygen or by the algae photosynthesis.

Considering these parameters, that the OOPC POM is producing 1,2 m^3/tFFB of effluent and its capacity is 60 t/h, the ponds could be designed as presented in Table 3.9 below:

Table 3.9: Capacity of Individual Ponds

Title	Volume		Size	
	Quantity	Unit	Quantity	Unit
Effluent Production	1200	m^3/t FFB		
Palm Oil Mill (POM) Capacity	60	t/h m^3/h		
Effluent Production Peak	72	m^3/t FFB		
1 Cooling pond Volume	8,640	m^3	4,320	m^2
2 Anaerobic pond Volume	120,960	m^3	24,192	m^2
3 Anaerobic pond Volume	120,960	m^3	24,192	m^2
4 Anaerobic Pond Volume	38,016	m^3	25,344	m^2
5 Aerobic Pond Volume	38,016	m^3	25,344	m^2

The company has designated a location to install the effluent treatment between the road G33/34,G34/41 and FG road, at about 1km from the proposed palm oil mill. A topographical survey was made in this area. Considering these information, the five ponds were designed and located as in the following drawings:

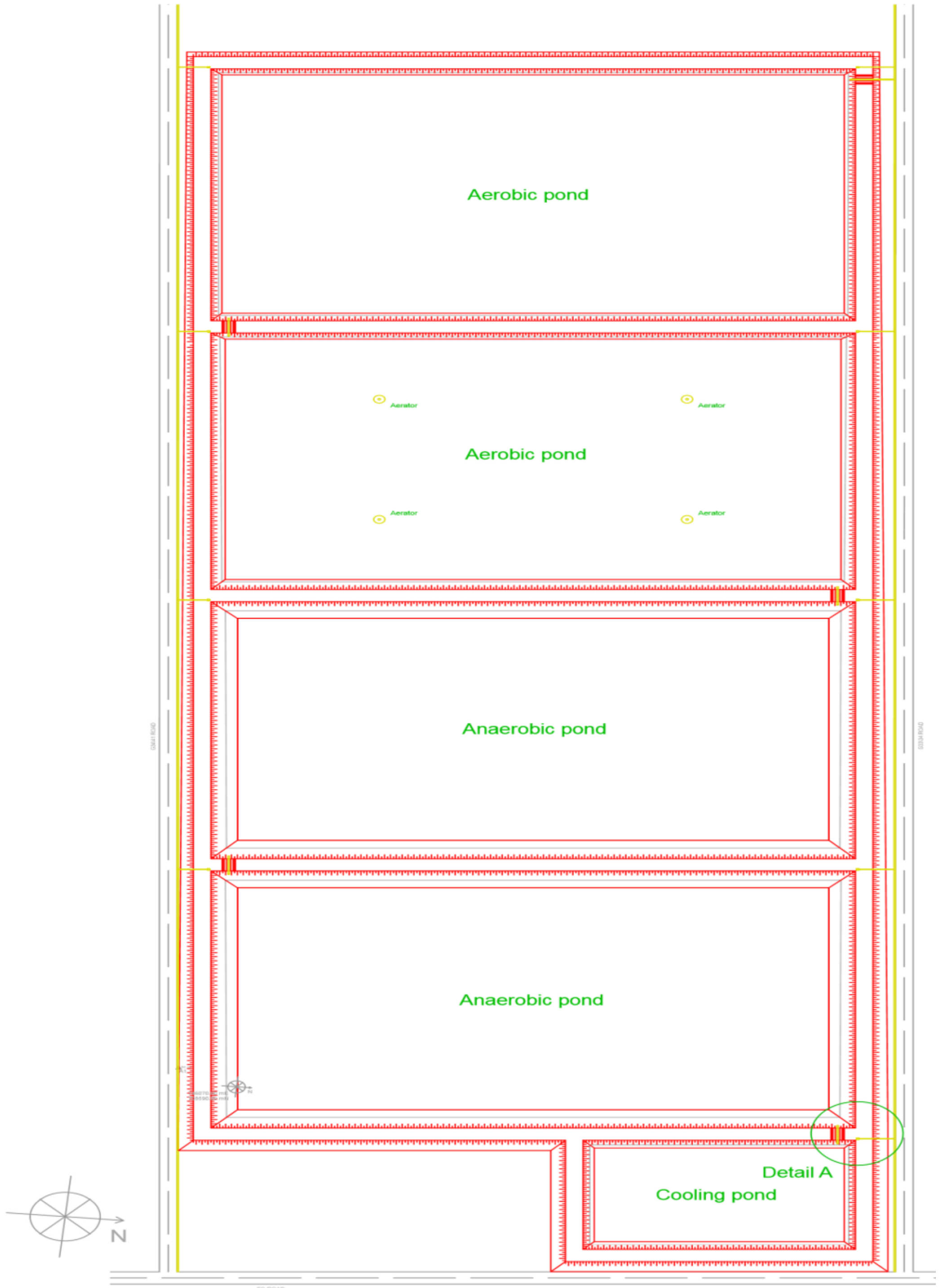


Figure 3.11: Drawings of the Proposed Palm Oil Mill Effluent Treatment Ponds

The ponds are designed to have earthworks balance, between the excavated earth and the embankment, to reduce the quantity of earth that has to be evacuated. To separate the ponds, a 6m wide road is designed on the top of the embankment to let vehicle circulate and to ease the maintenance operations. The embankments are made with a slope of 2 by 3. It's important and advisable that the earthworks are done during the dry season. Here are the ponds dimensions:

Table 3.10: Dimensions of Various Treatment Ponds

Title	Length (m)	Width (m)	Depth (m)
1 Cooling pond	92.5	53.5	2
2 Anaerobic pond	219	126.25	5
3 Anaerobic pond	219	126.25	5
4 Aerobic pond	219	125.87	1.5
5 Aerobic pond	219	12.87	1.5
Road between ponds	-	6	-

The ponds are designed to let the flow of effluents from a pond to another pond by gravity. To do this, each consecutive pond are connected by 4 PVC pipes with a diameter of 100mm and each pond is lower than the one before. The connections are arranged in quincunx to force the effluent to take the longest way and to be sure that the residence time is respected.

The bottom of the ponds is covered with one layer of withe felt geotextile that is covered by an EPDM liner to make them watertight. Both membranes are anchored at the top of the embankment with a trench full of gravel. These trenches are also used as a rain drain that is evacuated at both sides of the ponds in earth drains.

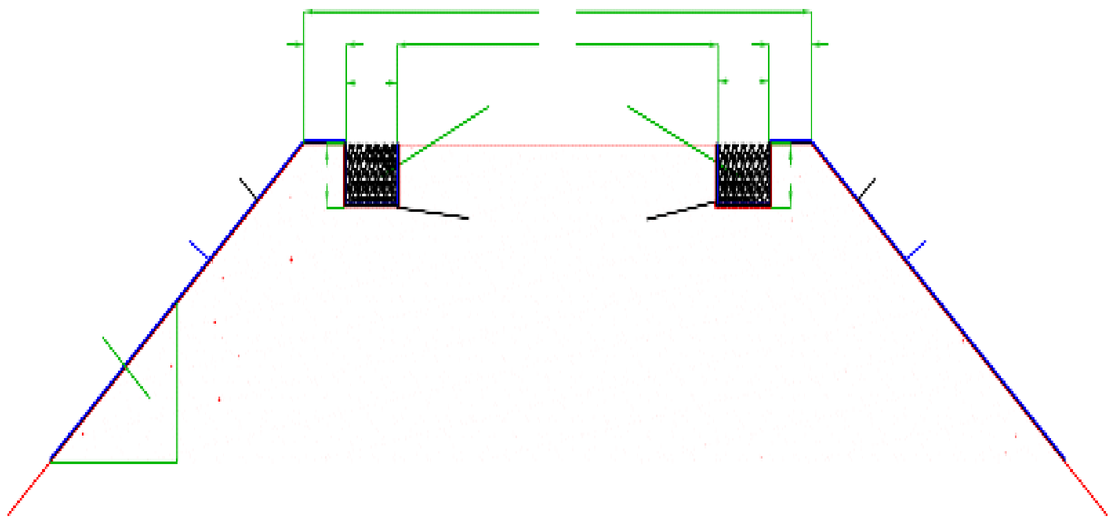


Figure 3.12: Drawings of the Trenches at POME Treatment Ponds

To ensure that the effluent at the outlet of the last pond reaches the COD and BOD standard values, 4 aerators will be installed in the 4th aerobic pond. They will increase the oxygen in the water and help to decompose remaining organic material. The whole system works by itself, but daily analyses must be done to control if the ponds are working correctly.

With this design, the experience show us that we can achieve a COD of 225 ppm and a BOD of 100 ppm from an effluent coming out of the Palm Oil Mill with a COD of 50 000 ppm and a BOD of 25,000 ppm.

Table 3.11: Effluent Quality from POM and Expected Quality after Treatment

Title	Effluents Quality directly at the outlet of the POM	Expected Effluents Quality after ponds treatment
BOD (ppm)	25,000	< 100
COD (ppm)	50,000	< 225

The advantage is that this system needs few maintenance, only the aerators need to be maintained and need electricity which means the operation cost is low.

The disadvantage of this system is that the methane produced during the organic decomposition is released in the atmosphere and not recovered as energy. However, trapping the methane gas will solve the problem of electricity generation in future.

3.25 Greenhouse Gas (GHG Emission)

Table 3.12: Estimation of Baseline Emission (for 30 and 60tons/hour capacity mill):

Effluent produced	30t/hr mill	60t/hr mill
Max production per day	600 tons FFB	1200 tons FFB
Effluent produced per day	300 tons POME	600 tons POME
Maximum expected production per year	110,000 tons FFB	220,000 tons FFB
Effluent produced per year	55,000 ton POME	110,000 ton POME

Source: Extension Two EIA Field work 2018 (OOPC Palm Oil Mill Department)

1 tonne FFB = 0.5 tonne POME
1 ton POME = 28 m^3 biogas (65% CH_4, 35% CO_2)

- 65% CH_4 = 18.72m^3 or 18720 liters
- 35% $C0_2$= 10.08m^3 or 10080 liters

Base on the above calculations:
55,000 tons POME = 1,540,000 (65% CH_4, 35% CO_2)
• 65% CH_4 = 1,001,000m^3
• 35% $C0_2$= 539,000m^3

While;
110,000 tons POME = 3,080,000 (65% CH_4, 35% CO_2)

- 65% CH_4 = 2,002,000m^3
- 35% $C0_2$ = 1,078,000m^3

- total baseline emission = 1,540,000m^3/year for 30tons/hr capacity
- total baseline emission = 3,080,000m^3/year for 60tons/hr capacity

The proposed project has the potential of emitting GHG equivalent to 1,001,000m^3 methane; 539,000m^3 CO_2 and 2,002,000m^3 methane; 1,078,000m^3 CO_2 for 30tons/hr and 60tons/hr mill capacities respectively equivalent per annum as shown in Table 3.15 below.

Table 3.13: Baseline GHG Emission from the Effluent Ponds of the Proposed Project

Item	Unit/Year	2020 (for 30 tons/hour Capacity Mill)	2022 (for 60 tons/hour Capacity Mill)
Emission of CH_4	Cubic Meters CH_4 eq/yr	1,001,000	2,002,000
Emission of CO_2	Cubic Meters CO_2 eq/yr	539,000	1,078,000
Total Emission (65% CH_4, 35% CO_2)	Cubic Meters GHG eq/yr	1,540,000	3,080,000

3.26 GHG Emission Monitoring and Verification

For the evaluation of the effect of POME discharge from this project activity, Table 3.16 below presents the types of data collection and monitoring plan that shall be performed.

Table 3.14: Data to be collected in order to monitor emission from the project activity

No	Data variable	Data Unit	Measured (m), calculated (c) or estimated (e)	Recording frequency	Proportion of Data to be monitored	For how long is archived data to be kept	Comment
1	FFB reception from plantation	t/year	m	Every FFB reception by truck	100%	15 years (project period)	Data will be aggregated monthly and yearly
2	FFB reception from other producers	t/year	m	Every FFB reception by truck	100%	15 years (project period)	Data will be aggregated monthly and yearly
3	POME yield from CPO produced	m^3 POME/tons FFB	m	Once a day	100%	15 years (project period)	Data will be aggregated monthly and yearly

3.27 Decommissioning and Abandonment

Palm Oil Mill exists for many decades. The ownership of the mill may change but total abandonment is not frequent. However, the several factors that may cause decommissioning and abandonment include:

- Lack of experience and knowledge of operational activities
- Use of outdated management principles and practices
- Financial malpractices
- Non-payment of workers' salaries

3.28 Facilities that will be Decommissioned or Abandoned:

A. Equipment:

- Ramp
- Mill processing line building
- Sterilizer
- Machine components
- Platforms

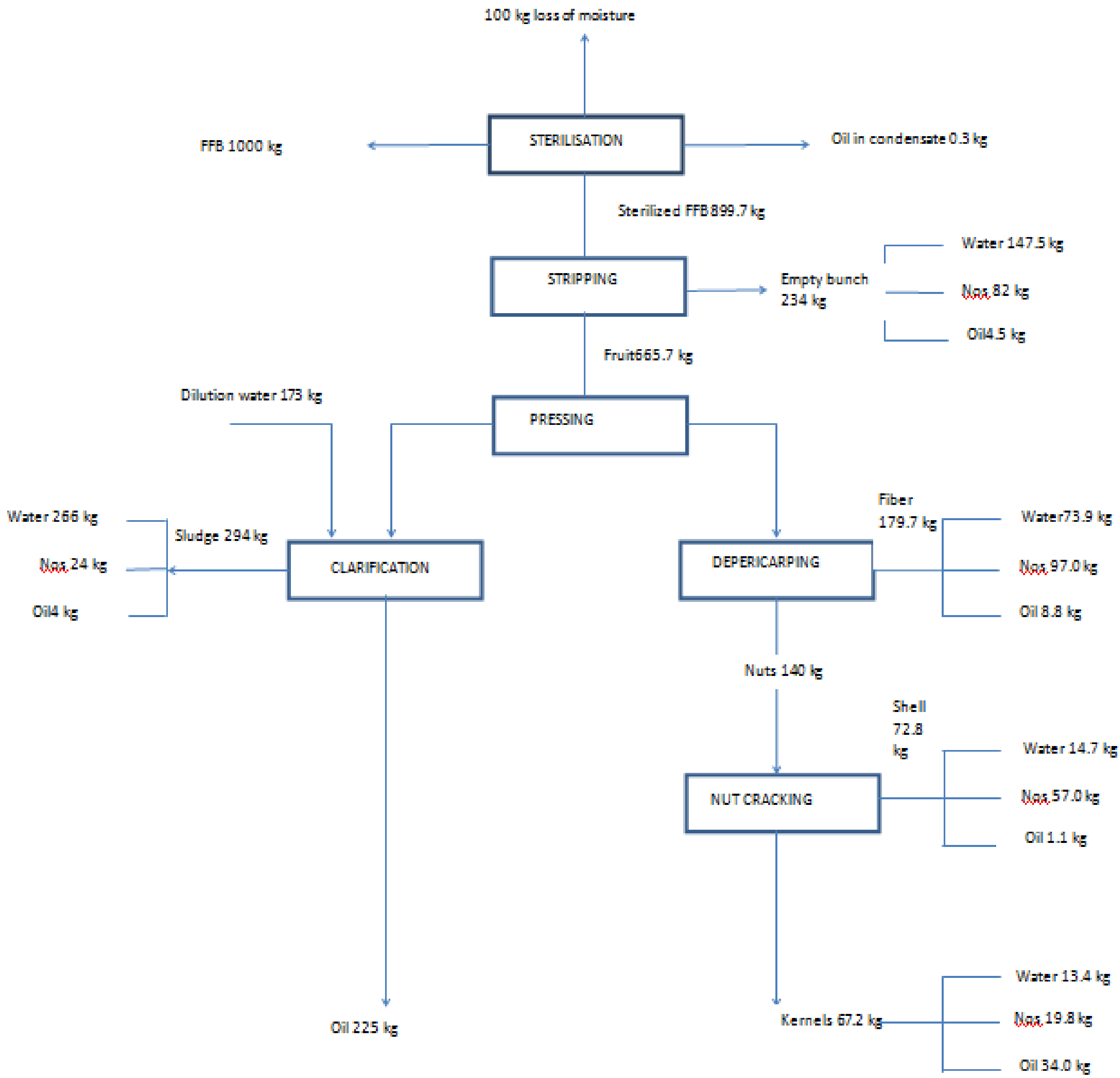
B. Chemicals, mainly laboratory:

- Hezene
- Pepton-22
- Hydochloric Acid
- Tetraoxosulphate –vi- acid

C. Infrastructure:

- Workers' housing
- Tank Farm
- Powerhouse
- Workshop
- Water pipes
- Quality assurance laboratory equipment
- Earth roads
- Palm Oil Mill Effluent Pond

3.29 Material Balance for the Proposed Project



MATERIAL BALANCE FOR MILL PROCESSING

3.30 Project Schedule

Some of the activities to be carried out from first quarter 2019 to 4th quarter 2022 are provided in Chapter 5. The schedule and timing of the critical project activities are illustrated in Table 3.14 below.

Table 3.15: Schedule and Timing of Critical Project Activities

Phase	**Activities**	**2019**	**2020**	**2021**	**2022**
Pre-Construction	EIA Process				
	(Mobilisation)				
Construction	(Heavy Machinery Use, Civil, Electric and Mechanical Work				
	Machine Installation				
Commissioning	Operation and Maintenance				

CHAPTER FOUR

DESCRIPTION OF THE EXISTING ENVIRONMENT

4.1 Location

The proposed palm oil mill project is to be situated within Okomu Extension Two oil palm plantation. The proposed mill project has the capacity to process 60 tons Fresh Fruit Bunch (FFB) per hour. There are going to be two processing lines of 30 Tons FFB/hour each.

4.2 Methodology

4.2.1 Data Acquisition from Literature and Previous Studies

The preliminary information on the study area was obtained as follows:

a. Background information on the oil palm industry in Nigeria was obtained from the Nigerian Institute for Oil Palm Research (NIFOR) and other technical notes from the Plantation department of Okomu Oil Palm Company (OOPC) Plc.
b. The relevant institutional, legal and regulatory framework was obtained from publications by the regulatory agencies and ministries.
c. The most recent relevant meteorological records were obtained from OOPC Plc
d. The OOPC Extension 2 Final EIA Report 2016 (Approved by FMENv, Abuja)
e. The OOPC Palm Oil Mill Expansion Project Final EIA Report 2017 (Approved by FMENv, Abuja)
f. Other data sourced from literature.
g. The company's environmental audit and environmental monitoring reports in the last five years.

4.3 Field Data Gathering

The field data gathering started on 25 February to 5 March 2019 which was supplemented with data from the Final EIA Report 2016 of oil palm development project at extension two.

4.3.1 Sampling Points and Control

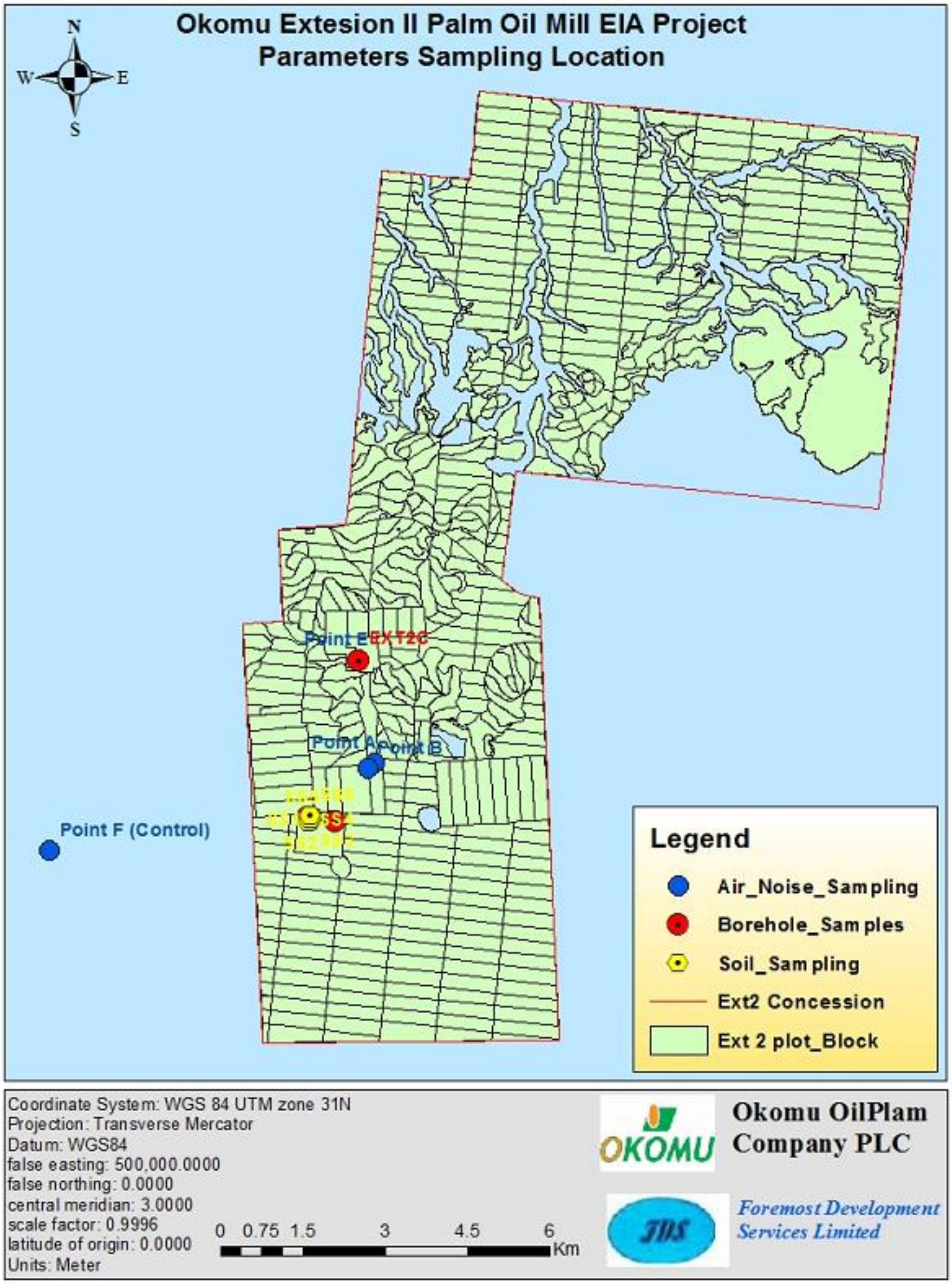
Sampling and observation points were established around the proposed palm oil mill project area. At each sampling location, the GPS location was taken and all the relevant environmental parameters including water quality, air quality, noise level, temperature, soil, vegetation type were sampled or observed.

The sampling points with their coordinates are presented in Table 4.1 and Map 4.1 below.

Table 4.1: Sampling Points and Control Locations

Sample Location	Coordinates – 31N			Environmental Component
	(UTM Easting)	(UTM Northing)	Elevation (m)	
Point 1	0811194	0738659	291	Groundwater
Point 2	0810677	0738734	285	Groundwater
Point 3 CTRL	**0811604**	**0741609**	**254**	**Groundwater**
River Jemide	N06^{0}41’41.8”	E005^{0}52’44.2”	upstream	**Surface River**
Stream I	N06^{0}45’56.1”	E005^{0}50’50.4”	upstream	**Surface River**
Stream I	N06^{0}47’35.41”	E005^{0}51’11.04”	downstream-	**Surface River**
Point A	0811895	0739708	258	Air Quality & Noise Measurement
Point B	0811767	0739617	252	Air Quality & Noise Measurement
Point C	0810755	0738737	285	Air Quality & Noise Measurement
Point D	0811193	0738659	291	Air Quality & Noise Measurement
Point E	0811604	0741609	214	Air Quality & Noise Measurement
Point F (Odigiemute Community)_CTRL	**0805970**	**0738130**	**260**	**Air Quality & Noise Measurement**
Point G	0810756	0738740	286	Soil
Point H	0810751	0738673	285	Soil
Point I	0810724	0738669	284	Soil
Point J	0810716	0738646	283	Soil
Point K	0810733	0738698	286	Soil
Point L - CTRL	**0810740**	**0738759**	**289**	**Soil**

Source: OOPC; Extension Two Mill EIA Field Work, February 2019



Map 4.1: OOPC Plantation Map showing the Sampling Points at the Proposed Project Site at Extension Two.

4.3.2 Study Approach

The purpose of this environment description is to provide qualitative and quantitative baseline information on the existing status of the proposed project area against which future studies and the proposed project will be weighed.

Quality Assurance/Control Procedure: The Quality Assurance/Control for laboratory analysis is in accordance with FMEnv recommended methods and it includes blank analysis to establish analytical level, duplicate analysis to establish analytical precision, spiked and blank sample analyses to determine analytical accuracy. It covers all aspects of the study, and includes sample collection, handling, laboratory analysis, data coding and manipulation, statistical analysis, presentation and communication of results. Sample chain of custody form was used for the registration and tracking of sample from the field to the laboratory. The name of laboratory used for all the analyses is on page xiii.

Sample Collection and Handling: This was carried out in accordance with Federal Ministry of Environment guidelines and standards (sampling and handling of samples). Where logistic and safety considerations precluded strict compliance with the above guidelines and standards, other proven, scientifically acceptable methods of sample collection and handling were used.

Laboratory Analysis: The methods of analysis used were as specified in the Federal Ministry of Environment guidelines and standards and other International Analytical Standards methods of analysis such as APHA for water quality. Trace metal analysis was done using Atomic Absorption spectrophotometer dully calibrated using standards, physicochemical parameters were determined using Thermoelectric Genesys 10 VIS Spectrophotometer and Orion ISE Meter Model 710A, dully calibrated with standards, as well as Flame Photometer.

Statistical Analysis: Errors in field data include those resulting from the instrument and those introduced by the observer. With proper sustained calibration of the instrument and the use of standardized observational procedures equipment errors were brought to acceptable minimum. However, other errors arise from the method of sampling. Errors often arise from two-stage sampling or sub sampling, or even from the fact that the samples collected are not representative samples of the medium. There are also spatial variations for the same medium, e.g., soil and water. Thus, it is taken, so as to establish a reasonable level of confidence in the results obtained. A good result is obtained when the variance is within 5% of the mean.

Data Coding and Manipulation: To ensure preservation of the integrity of data collected, data coding forms for use in the field, were designed in such a way that field data could be directly entered into computer data sheets. Since their analyses may be required in legal proceedings, it is essential to establish sample authenticity. Samples must be properly sealed and labelled. All data collected were labelled and the following information provided among others:

- Identification code or sample number
- Date and time of sampling
- Description of sample
- Methods of sampling
- Particulars of any photographs taken

All movements of the samples were included on the samples record. Basic information was recorded together with results of analysis, in a register.

4.4 Air Quality and Noise Level

a) Air Temperature

For air temperature and humidity of ambient conditions, a digital thermometer and Fisher Scientific Hygrometer were used respectively.

b) Gases

In-situ determination of the gases was carried out using portable gas analyzers. The ambient air was monitored using GasTech GT402 to measure the concentration of CO, O_2, Non-methane hydrocarbons, and H_2S. BWT Gas Alert was used to determine the concentration of NO_2 and Ogawa Passive Air Samplers were used for the sampling of SO_2 and subsequently analysed in the laboratory to determine the concentration of the gases.

c) Suspended Particulate Matter, (SPM)

PPM 1055 Hand-held Aerosol Monitor was used to determine Suspended Particulate Matter (SPM).

d) Noise level measurement

Sound level was measured at same point as that for air quality. A CEL-254 Sound level meter was first calibrated and re-checked before determining the sound level. The reading was allowed to stabilize before recording in decibel units {dB(A)}.

4.5 Ambient Environment

4.5.1 Climate

The project site falls within the rain forest region of south-western Nigeria which experiences a hot and humid tropical climate. The climate is characterized by seasonal rainfall, high temperatures and high relative humidity. The environment is noted for two distinct seasons of rainy and dry periods in a year, characterized by the southwest moisture laden monsoon wind and the northeast dry cold harmattan wind respectively. The Southwest trade wind predominates over the area, usually between March and November, while the northeast trade wind has greater influence between December and February/March. The Southwest monsoon wind originates from the Atlantic Ocean; hence it is moisture laden, warm and brings rain to the area. The north east trade wind is characterized by cold, dry and dusty weather, often referred to as harmattan. The occurrence of these trade winds is determined by the North-South migration of the zone of demarcation between them, known as Inter-Tropical Discontinuity (ITD). The movement is usually gradual, steady and consistent, hence, the regular pattern of rainfall and dry periods in the year. It directly and indirectly controls other climatic parameters apart from rain like temperature, relative humidity, cloud cover, wind direction and speed, etc. These in turn moderate and determine crops to be grown, farming systems and operations, etc.

According to Muller-Samanu *et al.* (1994), the area falls between humid and semi humid climate zone of the tropics with about 8-9 months of rainfall, and having an average of 8.5 humid months in a year. The rainfall is more than 1,500 mm per annum for most years, and the driest months have less than 60 mm of rain.

Rainfall

The rainfall pattern (amount, intensity and distribution) is greatly influenced by the movement of ITD. The annual total rainfall for the area ranges from 1595 – 2127.2mm (NIFOR meteorological station). The rains are said to have been established when at least 100mm have fallen in a year. Thus, for most years, this is not attained until April. The amount of rainfall increases from April through to June/July when it peaks and then reduces during the month of August before it peaks again in the months of September/October. Thereafter, it tapers-out towards the end of the year.

The total amount of rainfall, its distribution and intensity are very important factors in determining the suitability or otherwise of a land, apart from the quality of soil for any particular agricultural enterprise. The host communities of the project site are essentially agrarian, hence highly influenced by the pattern of rainfall in their activities. The rains, usually, at the onset of the season are noted for thunderstorms which at times can be destructive, traveling at very high speed exceeding 48km/hr. These are torrential and windy rains, usually referred to as line squall. It should be noted that the amount of rainfall in a month can vary widely from one year to another. This is not unconnected to the global phenomenon of climate change which is becoming more and more apparent in recent years as presented in Table 4.2, while the graphical illustration is shown in Figures 4.1.

Table 4.2: Monthly Rainfall in mm (2010 – 2018)

Rainfall in mm

Month/Yrs	2010	2011	2012	2013	2014	2015	2016	2017	2018
January	0	0	65.4	22.9	21.5	17.8	0	0	0
February	57.5	116.2	34.4	31.9	6.7	38.2	7	2	0
March	38.7	84.9	45.4	45.4	108.7	133.1	155.1	113.8	81.7
April	219.9	118.3	162.4	221.3	132.7	38.7	84.6	132.8	75.1
May	125.4	264	188.8	199.3	154.6	157.4	133.3	275.9	165.5
June	174.6	275.2	265.2	190.5	208.5	320	178.9	178.1	231.3
July	257.8	430.3	396.9	284.6	139	289.7	200.6	246.1	260.3
August	455.8	277.8	139.9	69.3	437.2	157.3	208.2	338.9	230.4
September	282.1	250.9	317.5	469.6	246	271.6	175	252.7	269.4
October	373.8	240.8	178.9	153.5	116.6	273.3	19.7	157.7	177.1
November	109	68.8	46.9	70.7	125	7	6	58.8	28.2
December	0	0	0	13	0.6	0	3.6	31.1	0
Total	**2094.9**	**2127.2**	**1814.7**	**1772**	**1697.1**	**1704.1**	**1172**	**1787.9**	**1519**
Mean	**174.6**	**177.3**	**151.2**	**147.7**	**141.4**	**142**	**97.7**	**149**	**126.6**

Source: NIFOR Meteorological Station 2019

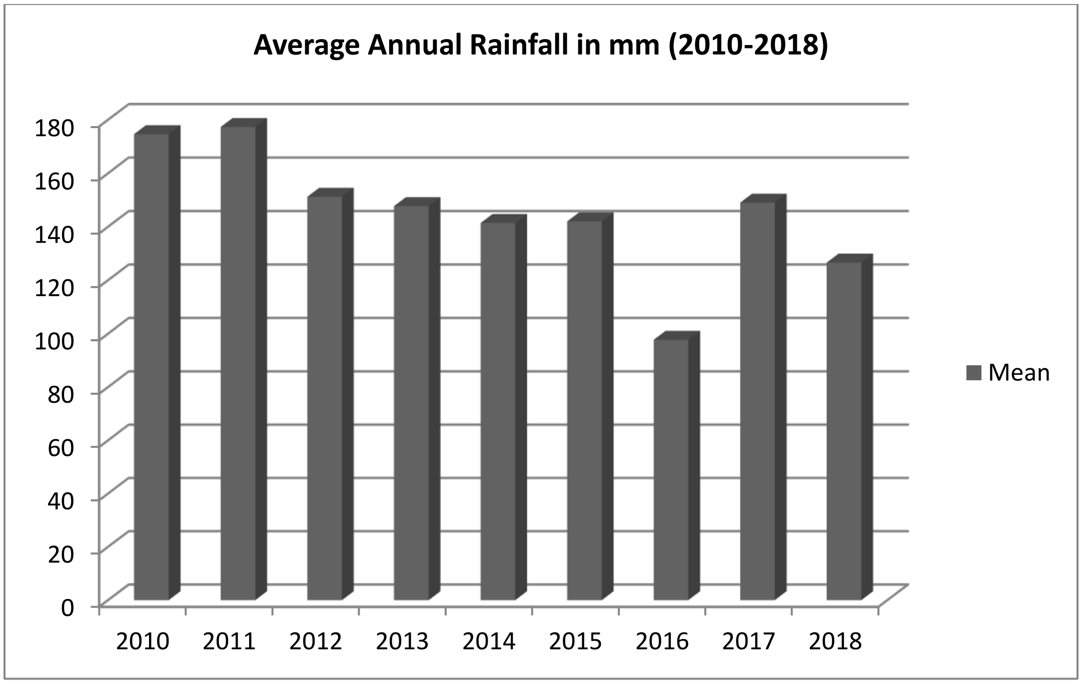


Figure 4.1: Average Annual Rainfall of Study Area and Environs

Temperature

The mean air temperature of the project area, like most of the tropical environment is generally high throughout the year. It is characterized by minimal fluctuations, usually less than 5°C throughout the year. It is referred to as isohyperthermic temperature regime. The highest mean monthly temperatures are recorded in the months of February and March 34.57°C to 33.76°C, while the lowest mean air temperatures are 20.83°C to 20.97°C in the months of January and July respectively. The average annual (2010-2018) data of temperature at NIFOR weather station range from 20.6^{0}C to 33.9^{0}C as presented in Table 4.3, while the graphical illustration is shown in Figure 4.2 below.

Table 4.3: Monthly Temperatures in ^{0}C (2010 – 2018)

Months/Yrs	2010		2011		2012		2013		2014		2015		2016		2017		2018	
	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
January	**34.2**	**24.5**	**33.2**	**18.9**	**33.9**	**18.2**	**32.6**	**22.1**	32.4	24.7	32.5	24.3	35	22.4	32.7	23.3	33.9	22
February	35.1	24.4	33.5	22	33.4	21.7	31.1	20.1	32.5	24.5	34.1	24.9	34.7	22.6	35	23.9	33.3	24.2
March	34.8	25.4	34.2	22.7	35.1	22.3	32.3	22	32.9	24.3	34.3	24.4	33.5	22.2	34.9	24.8	32.7	23.1
April	32	22.8	32.9	22	33.4	21.5	31.3	21.3	32.1	23.6	32.7	24.2	34	23.9	38.6	24.2	32.6	22.4
May	33.4	23.5	32.8	21.6	32.5	20.3	31.2	21.5	32.3	23.3	32.5	24	32.2	22.3	33.9	23.9	33.2	23.3
June	31.4	22.6	31.2	21.5	31.2	20	29.5	20.5	31.2	23.3	30.6	23.6	30.4	22.9	30.7	23.3	32	23.2
July	29.8	21	29.3	20.3	28.8	20.9	27.8	18.9	29.2	22.9	29	23.5	28.6	21.3	33.3	23.5	30.5	23.4
August	28.5	21.5	28.5	20.9	28	20.7	29.2	20.8	28.6	22.4	28.5	23.6	29.3	22.3	34.8	23.1	30.5	23.1
September	30.2	21.5	30.1	20.4	29.8	21.1	29	22.8	30.3	23.3	29.3	24.1	30.4	20.8	31.6	23.1	30.8	23.1
October	31.3	21.9	31.4	21.3	31.5	20.9	31.2	23.6	30.3	23.1	31.9	25	32	23	34	23.6	32.3	22.9
November	32.6	21.9	33.3	21.5	33	21.4	31.3	22.5	31.6	23.1	32.2	23.4	33	23	33.6	24	32.8	23.8
December	33.5	20.8	34.2	19	33	18	31.5	21.9	33.8	23.7	33.3	19	33.7	23.2	33.6	24.1	33	22
Total	**386.8**	**271.8**	**384.6**	**252.1**	**383.6**	**247**	368	258	**377.2**	**282.2**	**380.9**	**284**	**386.8**	**269.9**	**406.7**	**284.8**	**388**	**276.5**
Mean	**32.2**	**22.7**	**32.1**	**21**	**32**	**20.6**	**30.6**	**21.5**	**31.4**	**23.5**	**31.7**	**23.7**	**32.2**	**22.5**	**33.9**	**23.7**	**32**	**23**

Source: NIFOR Meteorological Station 2019

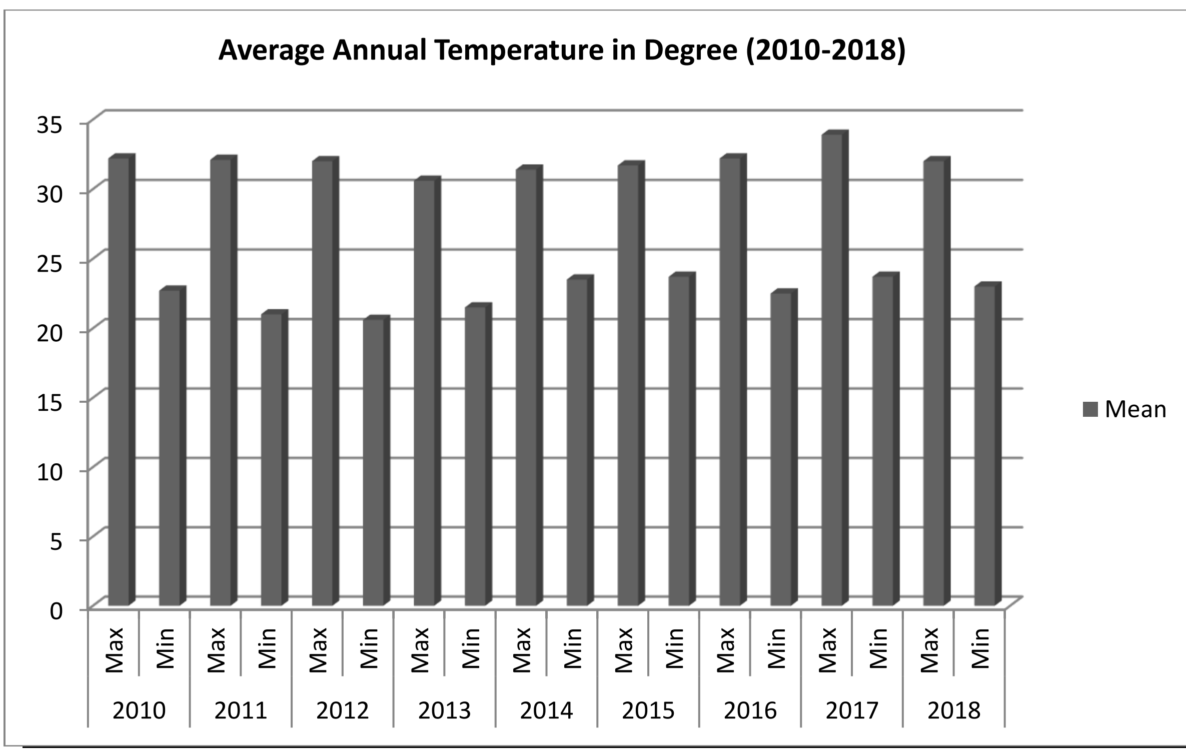


Figure 4.2: Average Annual Temperature of Study Area and Environs

Sunshine Hours

The mean annual sunshine hour at the proposed project site and environs for the period 2010 to 2018 range between 3.4 hours to 4.7 hours as presented in Table 4.4, while the graphical illustration is shown in Figure 4.3.

Table 4.4: Monthly Sunshine (Hr) (2010 - 2018)

Month/Yrs	2010	2011	2012	2013	2014	2015	2016	2017	2018
January	5.2	5.4	5.4	5.5	6.4	5.2	4.6	3.4	2.9
February	5.2	5.9	4.9	4.1	4.6	5.3	2.2	2	3.1
March	3.3	6.1	5.4	5.7	5.6	4.4	4.3	3	4.3
April	5.8	5.1	5.7	5.6	5.8	4.7	5.7	5	4.3
May	5.3	5.6	5.1	5.9	5.8	5.2	5.1	6.1	4.2
June	3.8	3.3	3.8	4.3	4.5	3	4.3	4.2	4.3
July	2.9	2.4	1.7	2.7	2.5	2.1	4.2	2.2	2.9
August	2.4	1.6	2.6	2.1	1.5	1.6	2.8	2	2.9
September	3.6	2.5	3.6	2.8	1.8	2.5	2.2	2.5	3.1
October	5.5	4.4	4.7	4.7	3.7	5.2	4.9	3.3	4.7
November	6	7	6.3	6.1	5.9	6.8	5.5	4.4	5.2
December	7.1	7.3	7.6	6.5	6.2	8.8	4.4	2.5	4.3
Total	**56.1**	**56.6**	**56.8**	**56**	**54.3**	**54.8**	**50.2**	**40.6**	**46.2**
Mean	**4.7**	**4.7**	**4.7**	**4.6**	**4.5**	**4.6**	**4.2**	3.4	**3.9**

Source: NIFOR Meteorological Station 2019

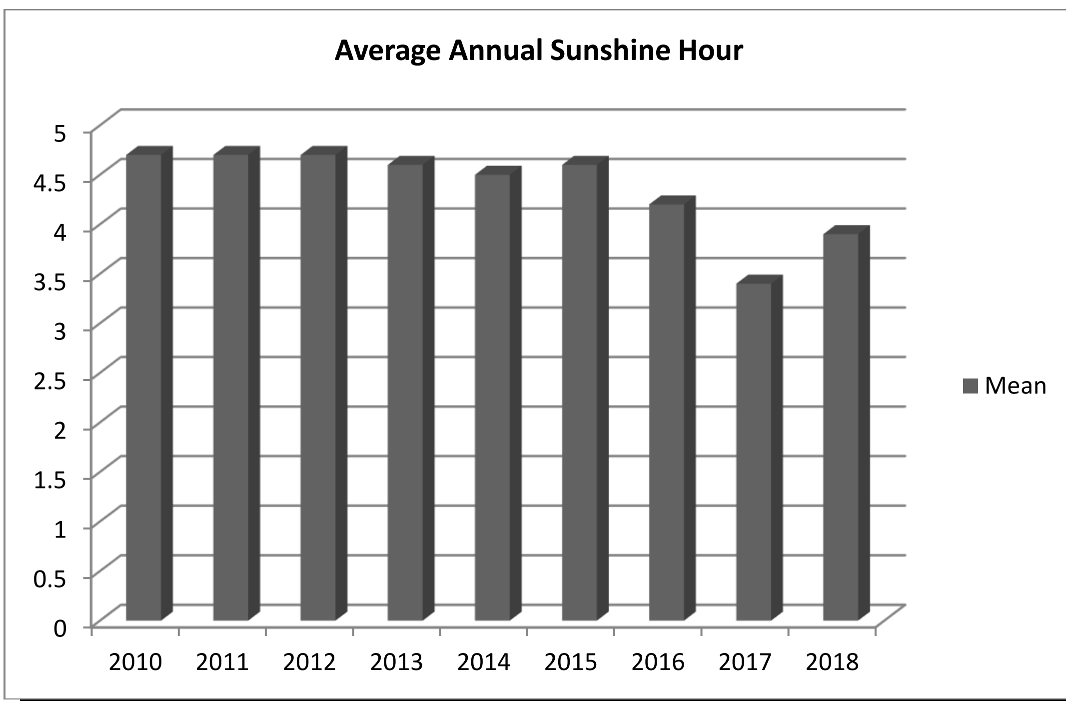


Figure 4.3: Average Annual Temperature of Study Area and Environs

Relative Humidity.

In the tropical environment, there is a good correlation between the temperature/rainfall and relative humidity. The relative humidity of the atmosphere in the environment is generally high throughout the year. The highest values are recorded at the height of rainy season (June and September), while the lowest are expected during the drier months of December and January as presented in Table 4.5 and Figure 4.4 below.

Table 4.5: Monthly Relative Humidity in % (2010 – 2018)

Month/Yrs	2010		2011		2012		2013		2014		2015		2016		2017		2018	
	10am	4pm	10am	4pm	10am	4pm	10am	4pm	10am	4pm	10am	4pm	10am	4pm	10am	4pm	10am	4pm
January	80.4	52.5	62.9	43.8	80.5	58.3	77.1	56.7	82.7	59.4	80.7	74.4	58.3	44.3	80.4	55.5	77.9	74.3
February	80	58	81.3	58.5	83.8	63.7	77.4	64	77.1	60.3	82.9	58	76.7	48.2	79.6	62.3	82.2	78.2
March	82.9	60.5	83.5	61.1	79.8	58.1	75.3	69.6	80.4	63.2	82.5	61.2	78.4	63.3	81.3	65.8	83.9	80
April	78	64.7	82.4	67.3	80.6	68.5	77.3	73.8	81.9	66.3	80.9	63.8	81.8	66.7	83.9	71.7	83.2	77.6
May	81.4	69.9	83	72.9	83.2	71.6	77.5	74.2	79.1	69.5	81	69.4	95.4	70.1	82.6	73.1	83.5	74.8
June	84.6	72.6	86.3	77.3	87.2	75.3	83.1	77	84.2	73.3	85	80.1	81.8	77.6	87.9	78.4	82.8	73.9
July	87.7	80.5	87	78.6	82.2	73	84.8	80.7	88.8	80.4	87.3	84.3	85	81.3	88.8	81.8	85	81
August	90	84.1	90.1	81.7	89.7	78	84	81	88.7	84.5	86.5	85	84.4	80.5	88.6	84.9	87.2	80.7
September	87.7	80	87.8	80.2	86.7	75.7	83.3	75	84.4	80	85.3	78.8	80.7	80.2	87.5	83.8	90.1	79.9
October	84.9	75.3	81.9	76	85.1	74.5	82.1	71.2	86.2	79.9	83.6	71.7	81.6	75.1	84.9	77.5	83.7	70.5
November	83.1	70.1	78.7	69.5	83	68.4	83	68	84.5	75.1	81.5	59.3	83	64.8	84.7	77.5	83.4	69.5
December	77.4	55.3	76.1	5.2	83.3	68.3	73	66	79.2	62.9	61.5	45	76.3	61.8	82.6	79.3	79	66
Total	**998.1**	**823.5**	**981**	**771.9**	**1005.1**	**833.4**	**957.9**	**857.2**	**997.2**	**854.8**	**978.7**	**831**	**963.4**	**815.9**	**1012.8**	**891.6**	**1001.9**	**906.4**
Mean	**83.2**	**68.6**	**81.8**	**64.3**	**83.8**	**69.5**	**79.8**	**71.4**	**83.1**	**71.2**	**81.5**	**69.2**	**80.2**	**67.8**	**84.4**	**74.3**	**83.5**	**75.5**

Source: NIFOR Meteorological Station 2019

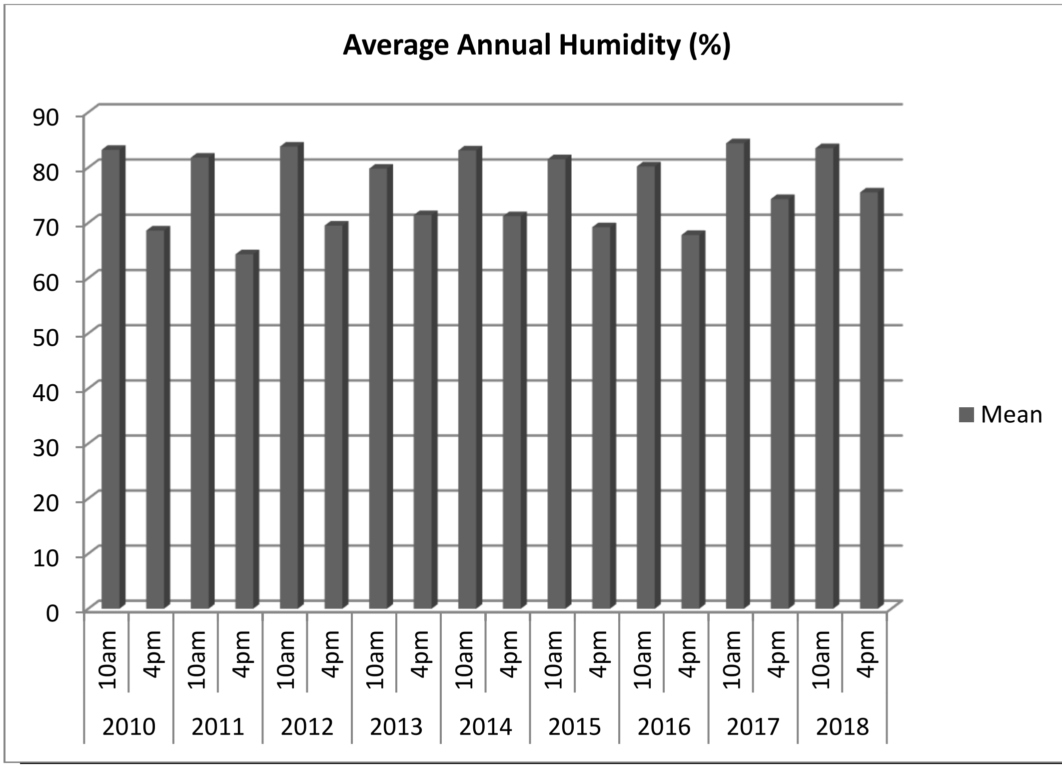


Figure 4.4: Average Annual Humidity of Study Area and Environs

4.5.2 Groundwater Quality

The groundwater quality is good and free from pollution. Except for the pH that is generally low, thus making the water mildly acidic. All the water samples from the project's water sources have all physico-chemical and microbiological parameters within the permissible limits recommended by WHO and FMENV for wholesome water. The low pH can be raised by adding soda lime ($CaHNaO_2$).

The results of laboratory analyses of three groundwater and control samples collected from the proposed project site are presented in Table 4.6 while the secondary data is presented in Table 4.7.

S/N	Sample Code	Description of Location	Coordinates	
1.	BH1	Okomu Extension 2 Borehole 1	N06^{0}42'03.4"	E005^{0}49'08.8"
2.	BH2	Okomu Extension 2 Borehole 2	N06^{0}41'11.7"	E005^{0}49'55.4"
3.	**BH3 (CTRL)**	**Okomu Extension 2 Borehole 3**	**N06^{0}40'30.6"**	**E005^{0}48'36.6"**

Source: OOPC: Proposed Palm Oil Mill at Extension Two; EIA Field Work, March 2019

Table 4.6: Results of Physico-Chemical Laboratory Analysis of Groundwater Samples at OOPC Plc

PARAMETER/UNIT	FMENV: 2015	Method, APHA, 23Ed.	BH1	BH2	BH3 (CTRL)
Appearance	Clear & colourless		Clear & colourless liquid		
Odour	Unobjectionable		Unobjectionable		
Taste	Unobjectionable		Unobjectionable		
pH	6.5-8.5	4500-HB	5.25	5.20	5.84
Temperature, °C	Ambient	-	31.8	31.2	31.1
Conductivity, µS/cm	1000	2500-B	50	40	60
Colour, Pt-Co	15	2120-C	2	<1	<1
Turbidity, NTU	5	2130-B	4	6	1
Total Solids, mg/L	-	2540B	26.2	22	30
Total Dissolved solids, mg/L	500	2540-D	25.2	20	30
Total Suspended Solids, mg/L	-	2540-C	1	2	<1
Total Hardness, mg/L		2340-C	4	4	12
Total Alkalinity, mg/L	-	2320-B	23	19.2	21.1
Total acidity, mg/L	-	2310-B	24.4	27.8	13.9
Calcium, mg/L	-	3500-B	1.6	1.6	3.6
Magnesium, mg/L	20	3500-B	<1	<1	0.7
Chloride, mg/L	250	4500-B	1.4	6.2	6.2
Nitrate, mg/L	50	4500-NO_3^--E	0.10	0.5	0.9
Nitrite, mg/L	0.2	4500-NO_2^--B	<0.01	<0.01	<0.01
Sulphate, mg/L	100	4500-SO_4-E	9	12	11
Phosphate, mg/L	-	4500-E	<0.1	<0.1	<0.1
Free carbon dioxide, mg/L	-	4500-CO2-C	21.4	24.5	12.2
Iron (total), mg/L	0.3	3500-B	<0.01	0.01	0.01
Fluoride, mg/L	1.5	4500-F^-C	<0.10	<0.1	<0.1
Lead, mg/L	0.01	3500 -Pb-B	<0.001	<0.001	<0.001
Arsenic, mg/L	0.01	3500 -As-B	<0.001	<0.001	<0.001
Manganese, mg/L	0.2	3500 -Mn-B	<0.001	<0.001	<0.001
Copper, mg/L	1.0	3500 -Cu-B	<0.001	<0.001	<0.001
Cadmium, mg/L	0. 03	3500 -Cd-B	<0.001	<0.001	<0.001
Hydrogen Sulphide, mg/L	0.05	4500-S^{2-}H	0	0	0
Chemical Oxygen Demand, mg/L	80	5220-D	<1	<1	<1
Biochemical Oxygen Demand, mg/L	30	5210-B	<1	<1	<1
Oil and Grease, mg/L	10	4500-G	<1	<1	<1
Salinity as Chloride, mg/L	200	4500-B	<0.01	<0.01	<0.01
Total coliform count, CFU/mL	10	9225-D	0	0	0
Faecal coliform (E.coli), CFU/100 mL	Nil	9222-D	0	0	0
Clostridium perfringens, CFU/100 mL	Nil	AOAC 973.30	0	0	0
Salmonella/Shigella sp., CFU/100 mL	Nil	9260-E	0	0	0
Staphylococcus sp. , CFU/100 mL	Nil	AOAC 995.12	0	0	0
Pseudomonas aureus, CFU/100 mL	Nil	9213-E	0	0	0
Total plate count, CFU/100 mL	10^2	9215-B	6	4	8

Source: OOPC: Proposed Palm Oil Mill at Extension Two; EIA Field Work, March 2019

Table 4.7: Results of Physico-Chemical Laboratory Analysis of Groundwater Samples (Secondary Data)

Parameter/Unit	Reference Standard NIS554:2007	Sample 1 (UTM 31N) E807370.44 ; N743794.01		Sample 2 (UTM 31N) E811678.31 ; N741640.71		Control Sample (UTM 31N) E814753.24 ; N739975.42	
		Dry Season	Wet Season	Dry Season	Wet Season	Dry Season	Wet Season
Appearance	Clear and colourless liquid	Clear and Colourless liquid	Clear and Colourless liquid	Clear and Colourless liquid	Clear and Colourless liquid	Clear and Colourless liquid	Clear and Colourless liquid
Odour	Unobjectionable	Unobjectionable	Unobjectionable	Unobjectionable	Unobjectionable	Unobjectionable	Unobjectionable
Taste	Unobjectionable	Unobjectionable	Unobjectionable	Unobjectionable	Unobjectionable	Unobjectionable	Unobjectionable
pH @27.5 ^oC	6.5-8.5	7.07	5.20	6.8	5.8	5.6	6.7
Temperature, ^oC	Ambient	29.9	27.5	28.5	27.8	28.9	26.7
Conductivity, µS/cm	1000	29.9	36.3	31.2	22.2	30.0	33.4
Electrode Potential, mV	-	109	114	110	116	116	112
Colour, Pt-Co	15	<1.0	14.0	2.0	11.0	2.0	4.0
Turbidity, NTU	5	<1.0	5.0	1.0	3.0	0.9	2.0
Total Solids, mg/L	-	15.0	21.3	12.0	17.0	13.0	18.0
Total Dissolved solids, mg/L	500	15.0	18.1	9.0	11.0	10.0	16.0
Total Suspended Solids, mg/L	-	<1.0	3.0	2.0	6.0	1.0	4.0
Total Hardness, mg/L $CaCO_3$	150	5.0	11.0	3.0	8.08	4.0	10.0
Total Alkalinity, mg/L	-	9.20	3.12	10.30	4.43	9.6	3.4
Total acidity, mg/L	-	6.96	26.35	2.14	21.75	5.45	24.78
Calcium, mg/L as Ca	-	0.8	1.2	1.1	2.02	0.9	1.3
Magnesium, mg/L as Mg	2.0	0.73	1.94	0.24	0.74	0.21	0.72
Chloride, mg/L	250	4.43	4.42	1.92	1.70	1.9	1.72
Residual chlorine, mg/L	0.2-0.25	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Fluoride, mg/L	1.5	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Nitrate, mg/L	50	0.12	0.49	0.13	0.49	0.22	0.45
Nitrite, mg/L	0.2	0.02	0.08	0.20	0.21	0.14	0.25
Sulphate, mg/L	100	4	5.0	<1.0	<1.0	<1.0	<1.0
Phosphate, mg/L	-	<0.1	0.3	<0.1	<0.1	<0.1	<0.1
Free carbon dioxide, mg/L	-	6.12	23.19	3.60	19.1	7.4	22.11
Iron (total), mg/L	0.3	<0.01	0.11	<0.1	0.1	0.1	0.1
Lead, mg/L	0.01	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Arsenic, mg/L	0.01	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Manganese, mg/L	0.2	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Copper, mg/L	1.0	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Cadmium, mg/L	0. 03	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Chromium, mg/L	0.05	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Hydrogen Sulphide, mg/L	0.05	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Total coliform count*	10	0	0	0	0	0	0
Faecal coliform (E.coli)	Nil	0	0	0	0	0	0
Clostridium perfringens,	Nil	0	0	0	0	0	0
Salmonella/Shigella sp.	Nil	0	0	0	0	0	0
Staphylococcus sp.	Nil	0	0	0	0	0	0
Pseudomonas aureus	Nil	0	0	0	0	0	0
Total plate count,	10^2	4	2	2	2	2	2

Source: Extension Two Oil Palm Development Project; EIA Final Report December 2016 (Secondary Data)

4.5.3 Ambient Air Quality Measurements

4.5.3.1 In-situ Measurements

In-situ determination of the gases was carried out using portable gas analyzers. The ambient air was monitored using Mattheson IQ-1000 gas analyzer (with mega and electrochemical sensors) to measure the concentrations of carbon monoxide, Oxygen, Non-methane hydrocarbons, hydrogen sulphide, Sulphur dioxide. BWT Gas Alert was used to determine the concentration of NO_2. PPM 1055 Handheld Aerosol Monitor was used to determine Suspended Particulate Matter (SPM). Fisher Scientific Hygrometer was used to determine the temperature and humidity of ambient conditions during the sampling period.

4.5.3.2 Results of Ambient Air Quality Measurements

The results of ambient air quality determinations at six different locations plus the control location are presented in Tables 4.8a and 4.8b. The results show that the ambient air quality is good with all the quality parameters within acceptable regulated limits.

Table 4.8a: Results of Air Quality at the Proposed Project Site

Coordinate	**Point A**	**Point B**	**Point C**	**Point D**	**Point E**	**Point F (Odigiemute Community) - CTRL**	**FMEnv. Limit**
	31N 0811895	**31N 0811767**	**31N 0810755**	**31N 0811193**	**31N 0811604**	**31N 0805970**	
	E0739708	**E0739617**	**E0738737**	**E0738659**	**E0741609**	**E0738130**	
Elevation, m	258m	252m	285m	291m	214m	260m	
SPM (μg/m^3)	80	110	110	80	70	70	**250**
Humidity (%)	51.7	41.5	45.4	44.2	39.6	45.6	**Ambient**
Temperature (^{0}C)	29.0	31.6	31.2	31.8	33.7	31.1	**Ambient**
Carbon monoxide, ppm	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	**10-20**
Carbon dioxide, %	0.32	0.31	0.30	0.32	0.31	0.32	**Ambient**
Hydrogen sulphide, ppm	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	**-**
Hydrocarbon, %	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	**-**
Oxygen, %	21.0	21.0	21.0	21.0	21.0	21.0	**21.0**
Sulphur dioxide, ppm	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	**0.01**
Nitrogen dioxide, ppm	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	**0.4-0.06**
VOC, ppm	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	

Source: OOPC: Proposed Palm Oil Mill at Extension Two; EIA Field Work, February 2019

Table 4.8b: Results of Air Quality and Noise Measurements– Secondary Data

LOCATION	Powerhouse /Residential Area	Control	Odighi Community	Owan Community	Uhiere Community	Odiguetue Community	Agbanikaka Community	Orhua Community	Umuokpe Community	Ekpan Community	Irhue Community	FMEnv. Limit
Coordinate	N06.701270	N06.72450	N06.64316	N06.76092	N06.73056	N06.67075	N06.78252	N06.64316	N06.76092	N06.73056	N06.67075	-
	E005.818770	E005.821410	E005.764470	E005.768670	E005.788640	E005.770260	E005.777240	E005.764470	E005768670	E005.788640	E005.770260	-
SPM(μg/m^3)	32	29	27	27	28	28	28	22	22	22	24	**250**
Temperature, ^oC	36.9	38.9	38.9	37.8	38.9	42.8	42.8	35.8.4	32.7	31.0	33.3	**Ambient**
Humidity,%	31.2	31	28	26	24	20	21	60	68	60	56	
Carbon monoxide, ppm	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	**10-20**
Carbon dioxide, %	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.01	0.01	**Ambient**
Hydrogen sulphide, ppm	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	-
VOC, mg/m^3	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	
Oxygen,%	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	20.9	21.0	21.0	**21.0**
Sulphure dioxide, ppm	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	**0.01**
Nitrogen oxides, ppm	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	**0.04-0.06**

Source: OOPC – Extension Two Oil Palm Development Project; Final EIA Report 2016 (Secondary Data)

4.5.4 Noise Level Measurement

Sound level was measured at same point as that for air quality. A CEL-254 Sound level meter was first calibrated and re-checked before determining the sound level. The reading was allowed to stabilize before recording in decibel units dB(A).

4.5.4.1 Results of Noise Level Measurements

Generally, the proposed project area and its environs are serene with no abnormal noise level recorded except at the existing mill complex. A digital sound level meter was used to measure the noise levels at different locations in the proposed project site. The measurement taken at different locations of the proposed project site showed that the noise levels range from 32.6 dB(A) to 52.4 dB(A). The noise levels are within Federal Ministry of Environment permissible limit of 90 dB(A) for 8 hours exposure as presented in Table 4.9 below.

Table 4.9: Noise Levels Measurements around the Project Area

Facility/ Workplace	**Point A**	**Point B**	**Point C**	**Point D**	**Point E**	**Point F (Odigiemute Community) - CTRL**
Coordinate (UTM 31N)	31N 0811895	31N 0811767	31N 0810755	31N 0811193	31N 0811604	31N 0805970
	0739708	0739617	0738737	0738659	0741609	0738130
Elevation (m)	258m	252m	285m	291m	214m	260m
Noise, dB(A) Dry Season, 28 February 2019	32.6	36.0	44.4	40.5	52.4	47.8
FMEnv Limits (8-hr. Exposure)	**90dB(A)**					

Source: OOPC – Proposed Palm Oil Mill at Extension Two; EIA Field Work, February 2019

4.5.5 Aquatic Biology

This section focuses on the water and bottom sediment characteristics within the area. This component of the study is aimed at monitoring surface water and bottom sediment parameters which, when altered, can easily affect the ability of the concerned attributes to perform their natural functions. Although there is no surface river close to the proposed project site, it is about 10km away from the proposed site.

The area is drained by two perennial water bodies, Jemide and Owan Rivers, which are tributaries of the *Osse* River that originates from the Idanre hills and drains into the Benin River into the Atlantic Ocean. Other water body sampled within the area was Stream 1 (06° 44' 30.4" N, 005° 49' 05.7" E). The major water body is the Jemide River (N 6° 45' 42.1" N, 005° 52' 43.9" E) which is over 12km to the proposed project area.

4.5.5.1 Surface Water Quality

In-situ physio-chemical parameters measured were pH, Electrical conductivity, Dissolved Oxygen, salinity and temperature as presented in Table 4.10 below.

4.5.5.2 Methodology

Field and laboratory studies were carried out, in addition to literature studies. During the fieldwork, present situation of salient environmental parameters with regards to water resources quality was carried out. Sampling and laboratory analyses of water were aimed at determining the magnitude and pattern of variation of appropriate physico-chemical and microbiological parameters within the study area.

One (1No.) representative sample each of surface water was collected from stream 1 and Jemide River (upstream and downstream) and then taken to the laboratory for analysis.

4.5.5.3 Field Work

At each sampling station, water samples were collected and stored in 2 liter polyethylene bottles, and pre-treated as suggested by Battley and Gardner (1977). Samples for heavy metal determinations were fixed with concentrated H_2SO_4 and refrigerated. Samples for microbiological analyses were stored in sterile Macarthy bottles and also refrigerated. In-situ measurements for pH, DO, Conductivity, Salinity, TDS and Temperature were determined using various digital meters.

4.5.5.4 Laboratory Analysis

a) **Biochemistry of Water Sample:**
The parameters determined, were Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD). Tests for these parameters were conducted using the incubation method recommended by the American Public Health Association (APHA).

b) **Chemistry:**
The following physico-chemical parameters were determined:

i. **Water temperature**: Water temperature was determined in-situ using mercury-in-glass floating thermometer calibrated in ^{0}C

ii. **Hydrogen ion concentration (PH):** pH was determined in-situ using Hatch water analysis test kit model FF1A Cat. No. 2430-02.

iii. **Dissolved oxygen (DO):** the DO concentration was measured using the standard winkers method (Boyd, 1979) and Mackereth *et al*, (1978)

iv. **Conductivity:** Electrical conductivity was determined using conductivity meter Karl Kolb SE 1000 table conductivity meter at room temperature.

v. **Ammonia:** Ammonia in water samples was determined by Nelslerization method (Emerson *et al.*, 1972) in-situ using Hatch water analysis test kit model FF1A Cat. No. 2430-02.

vi. **Nitrite**: Nitrite was determined on the field using Hatch water analysis test kit model FF1A Cat. No. 2430-02.

vii. **Alkalinity**: Alkalinity was determined on the field using Hatch water analysis test kit model FF1A Cat. No. 2430-02.

viii. **Total dissolved solid (TDS)**: TDS in water samples was determined by the method described by Boyd (1979).

ix. Heavy **Metal in water**. The following heavy metals; Copper, Zinc, Cadmium, Arsenic, Iron, Manganese, lead and Nickel, were determined in water samples according to standard method using atomic absorption spectrophotometer (AAS) (APHA, 1992).

x. **Chlorine** was determined by argentiometric titration according to Swindle (1979)

xi. **Total Solids, Total Suspended Solid (CTSS) and Total dissolved solid** were estimated by gravimetric method.

xii. The total, **calcium and magnesium hardness** was carried out using EDTA titration method.

xiii. **Sulphate** was measured using turbidimetric method while **nitrate** was estimated using the flame photometer.

xiv. **Magnesium and calcium** was determined by EDTA titration method.

All other physico-chemical parameters were determined according to APHA, 23Ed. (2005).

c) **Microbiological analysis**

The coliform count test was carried out following standard procedure (APHA, 2005). 'Presumptive', 'confirmed' and 'complete' tests were carried out following the principle that except for many coliforms only a few bacteria will ferment lactose with simultaneous production of acid and gas. The ultimate aim was to narrow down the identification of the coliform to *Escharichia coli* or rule it out.

Sampling Locations

S/N	Code	Description	**Coordinate**	
1.	$OKMEXT2_G$	River Jemide (upstream)	$N06^0 41'41.8''$	$E005^0 52'44.2''$
2.	$OKMEXT2_{H1}$	Stream I (upstream)	$N06^0 45'56.1''$	$E005^0 50'50.4''$
3.	$OKMEXT2_{H2}$	Stream I (downstream-by G1-West)	$N06^0 47'35.41''$	$E005^0 51'11.04''$

Source: OOPC: Proposed Palm Oil Mill at Extension Two; EIA Field Work, March 2019

Table 4.10: Physico-chemical Analysis Result of Jemide and Stream 1 Upstream and Downstream Water Samples at the Proposed Project Area.

PARAMETER/UNIT	METHOD, APHA (21^{st} Edn.)	OKMEXT2G	OKMEXT2H1	OKMEXT2H2	FMEnv. Limit
		Jemide Upstream	Stream 1 Upstream	Stream 1 Downstream	
Appearance	Visual	Faint brown with tiny floc	Clear liquid with trace particles		
pH	Electrometric	6.67	11.25	8.80	**6-9**
Temperature, ^{O}C	Thermometer	28.4	28.7	28.5	**Ambient**
Conductivity, μS/cm	2510-B	63.9	71.20	57.20	**2000**
Colour, Pt-Co	2120-C	<1	2860	320	**7.0**
Turbidity, NTU	2130-B	45	117	160	**10**
Total Solids, mg/L	2540-B	17.9	1045	118.6	**-**
Total Dissolved solids,	2540-D	16.9	980	20.6	**1000**
Total Suspended Solids,	2540-C	1	65	98	**30**
Total Hardness, mg/L	2340-C	4	<1	20	**-**
Total Alkalinity, mg/L	2320-B	9.6	60.7	23.04	**-**
Total acidity, mg/L	2310-B	6.96	<1.0	6.96	**-**
Calcium, mg/L as Ca	3500-B	0.80	<1.0	3.20	**-**
Magnesium, mg/L as Mg	3500-B	0.49	<1.0	2.92	-
Salinity as Chloride, mg/L	4500-B	27.79	41.8	6.95	**200**
Nitrate, mg/L	4500-NO_3^- -B	0.22	0.19	0.14	**50**
Nitrite, mg/L	4500-NO_2^- -B	0.09	0.07	0.03	**0.3**
Sulphate, mg/L	4500-E	17	26.0	10	**250**
Phosphate, mg/L	4500-C	2.1	4.66	3.65	**-**
Iron (total), mg/L	3500-B	0.88	2.58	0.20	**20**
Lead, mg/L	3500 -Pb-B	<0.001	<0.001	<0.001	**<1.0**
Copper, mg/L	3500 -Cu-B	<0.001	<0.001	<0.001	**<1.0**
Manganese, mg/L	3500 -Mn-B	<0.001	<0.001	<0.001	**0.10**
Cadmium, mg/L	3500 -Cd-B	<0.01	<0.01	<0.01	**<1.0**
Nickel, mg/L	3500 -Ni-B	<0.01	<0.01	<0.01	**<1.0**
Cobalt, mg/L	3500 -Co-B	<0.01	<0.01	<0.01	**<1.0**
Arsenic, mg/L	3500 -As-B	<0.01	<0.01	<0.01	**<1.0**
Chem. Oxygen Demand,	5220-D	34	25	22	**80**
Biochem. Oxygen Demand, mg/L	5210-B	23.8	17.5	15.4	**30**
Dissolved Oxygen, mg/L	4500-G	6.8	11.2	4.8	**>2.0**
Total Hydrocarbon, mg/L	Spectrophotometer	<0.01	<0.01	<0.01	
Pesticides, mg/L	Screening	<0.01	<0.01	<0.01	
Total coliform count, MPN/mL	9225-D	6	2	3	**10^2**

Faecal coliform, E.coli; CFU/mL	9222-D	Nil	Nil	Nil	-
Total plate count,	9215-B	72	1.0 x 10^2	1.0 x 10^2	**10^4**

Source: OOPC: Proposed Palm Oil Mill at Extension Two; EIA Field Work, March 2019

4.5.5.5 Results and Discussions

Water quality varied from one location to another within the proposed project area. The pH varied from 6.67–11.25, Conductivity 33.9–2,720(uscm-2), Turbidity 45-160, Total Suspended solids 1-98 mg/l, Dissolved oxygen 4.8-11.2mg/L, Biological oxygen demand 15.4-23.8mg/l, Alkalinity 9.6-60.7mg/L, Hardness <1-20mg/L, Salinity as Chloride 6.95-41.8mg/L, Phosphate 2.1-4.66, nitrate 0.14-0.22mg/l, Sulphate 10-26.0 mg/l, calcium <1.0-3.20mg/l, Magnesium <1.0-2.92/l. All the values determined for heavy metals in the water bodies occurred in low concentration (<0.01-<0.001mg/l), much below the recommended limits by FMENV and WHO (<1.0). Water temperature was 28.4ºC± 0.4. The speed of the water ranged from 0.5 to 0.7m/sec; with a mean of 0.603±0.054 m/sec. Secchi disc turbidity for Jemide River was 80cm.

Colour

The apparent surface water colour is as a result of upward scattering of light after it passes through the water columns at various depths and undergoing selective attenuation *enroute*. From this study, the colour of the surface water ranged from <1 to 2860 Hazen units in all the locations sampled. The study showed that areas with high dissolved organic matter and biological activities have high water colour values which may be rightly linked to presence of human, livestock and agricultural activities. The values obtained for ground water in all location fell within FMEnv limit of 15 Hazen.

Conductivity

The measure of the ionic richness of the surface water is best reflected through the conductivity test. The conductivity indicates the freshness or otherwise of the water. The conductivity results obtained in this study ranged between 57.20 and 71.20 µS/cm**.** These values are typical of fresh water bodies which is further collaborated by the observations recorded for TDS (Mustapha, 2009, Ibrahim *et al*., 2009). This is attributed to evapo-transpiraton and mineralization of organic matter. The values obtained however fell within the conductivity range of 50 – 2,000 µS recommended for freshwater (Boyd, 1979).

Turbidity

Turbidity measures the ability of water to transmit the light that restricts light penetration and limit photosynthesis. Turbidity in water is caused by suspended solids (organic and inorganic) which is a major concern in aquatic systems where most aquatic organisms especially filter feeders cannot tolerate appreciable concentrations of inorganic particulate matter. The surface water turbidity in the study site varies from 45 to 160NTU. The values obtained did not comply with the FMEnv limit of 10 NTU. The high level of turbidity obtained may be attributed to low level of water which allow for adequate light penetration and consequent increase in the level of photosynthesis and also, due to increase in the level of allochthonous substances that find their ways into the surface waters relative to the volume of water available during the dry season (Ikomi *et al*., 2003; Oso and Fagbuaro, 2008).

Total Dissolved Solids

Total Dissolved Solids is the total amount of mobile charged ions, including minerals, salts or metals dissolved in a given volume of water. Total Dissolved Solids, TDS is directly related to the purity of water and the quality of water purification systems and affects everything that consumes, lives in, or uses water, whether organic or inorganic, whether for better or for worse. The TDS for the surface water samples ranged from 16.9 to 980mg/L during this period. These values reflected that erosion and perturbation may be low during the period of sampling. These values are however generally lower than the FMEv limit of 1000mg/l for surface water and 500-1500mg/l WHO limits for drinking water.

P^H

The water bodies during the study were slightly neutral or slightly alkaline and had pH values varying from 6.67 to 8.80 with an average of 7.97. All values fell within the tolerable limits of pH 6 –9 stipulated by FMEv for surface waters except. This pH range was in agreement with range obtained by Idowu and Ugwumba (2005); Atobatele *et al.,*(2009), pH between 6.2 to 8.5 is ideal for biological productivity (Boyd, 1998).

Total Alkalinity (HCO_3)

Alkalinity refers to the capacity of water to neutralise acid. Alkalinity (expressed as HCO_3) ranged from 50.1 to 62.4mg/l with an average of 68.1mg/l. Alkalinity in water is due to any dissolved substance, usually weak anions that can accept and neutralise protons. Most freshwaters contain bicarbonate alkalinity. The alkalinity values are generally good when compared with the optimum range of 50 to 300mg/l recommended by Boyd (1998). This could account for the low acidity encountered in the water samples.

Total Suspended Solids

These are solid materials, including organic and inorganic, that are suspended in the water which include silt, plankton and industrial wastes. High concentrations of suspended solids can lower water quality by absorbing light. Waters then become warmer and lessen the ability of the water to hold oxygen necessary for aquatic life. The TSS values for surface water samples vary from 1 to 98 mg/l during the study in February 2019. The range of values obtained was higher than the FMEnv limits of 30mg/l. This implies that the water is turbid and could hinder photosynthetic activities.

Anions

Monovalent, divalent and tetravalent anions were determined and occurred in varying amounts at all sampling stations. These are NO_3-N, NO_2-N and NH_4 +-N (which are different forms of nitrogen in the aquatic ecosystem), phosphates, sulphates and chlorides. Ammonia is toxic to aquatic organisms in its unionized form. In water, some ammonia usually combines with water molecules to produce the non-toxic ionized form known as Ammonium (NH_4). Compounds of nitrogen and especially those of phosphorus are major cellular components of organisms. They are highly dynamic in the aquatic ecosystem. In general, there is a moderately high level of NH_4 +-N, which is expected, for the flora and fauna presence in the sampling stations. Of all forms of nitrogen, the most stable and easily utilized is the nitrate derived from the oxidation of nitrite. The nitrate levels in the surface water were between 0.14 to 0.22mg/L with an average of 0.18. This is less than 10 to 50mg/l limit by WHO and FMEnv. Aquatic organisms need nitrates as essential nutrient for primary productivity and thus its value couple with that of phosphate gives a true indication of species abundance and activity of aquatic life. The nitrite levels were significantly low during this study (<0.01 – 0.1mg/l) in all the sample monitored. The values obtained fall below 0.3mg/l FMEnv limit.

Phosphorus is a basic element in living matter and occurs in natural waters and wastewaters almost solely as phosphates. This major component of agricultural fertilizers is a limiting nutrient in many river systems. The phosphate values recorded from the study area varied from 2.1 to 4.66mg/l with an average of 3.47 mg/L. The values are generally below the limit of 3.50 and 5.0mg/l by WHO and FMEnv.

Sulphate values recorded were quite low and ranged from 10 to 26.0 mg/L with an average of 53.0 mg/L. Beauchamp (1953) had reported that African inland waters are generally deficient in this anion, which is due to its low concentration in the non-sedimentary rock of drainage areas. Chloride anions were the most abundant anion reported; they ranged from 6.95 to 41.8 mg/L during the sampling. The chloride values observed were basically of the freshwater bracket. All values reported were lower than the recommended limits of 200 mg/l set by FMEnv.

Chemical Oxygen Demand (COD)

The Chemical Oxygen Demand (COD) is an expression of the reducing capacity that measures the oxygen equivalent of the organic matter content of a sample that is susceptible to oxidation by a strong chemical oxidant. The COD values ranged from 22 to 34 mg/l with an average of 27 mg/L. These values were all below the 80 mg/l limit recommended for surface waters by FMEnv.

Exchangeable Cations

The major cations dissolved in natural freshwaters are calcium, magnesium, sodium and potassium, and of these, calcium and sodium are normally dominant. This observation was made by Willoughby (1976) and Chukwunogo (1990) and was also confirmed in this study. Calcium was the most abundant of all the cations during this study with a range of <1.0 to 3.20 mg/l. Magnesium concentrations ranged from <0.1mg/l to 2.92mg/l. The high values of Ca and Mg reported are attributable to the geomorphology of the area. The total concentration of calcium and magnesium expressed as their $CaCO_3$ equivalent denotes the total hardness of waters. The presence of a generous amount of dissolved calcium makes the water “hard”. All values reported were lower than the recommended limits of <2000mg/l set by FMEnv.

Heavy Metals

Some of these heavy metals are highly toxic when present beyond the recommended limit. The sources of these heavy metals may be associated with industrial process such as electroplating, Smelting, Engraving and Battery manufacturing. Also inorganic fertilizer such as phosphate fertilizer and Sewage used in Agricultural land could be a source.

The results of the heavy metals analysed show that all the metals occurred in trace levels or very minute quantities far below recommended limits set by FMEnv. The values were lower than that reported for Nigerian inland and coastal waters (Egborge, 1991). The iron content measured in the surface water ranges from 0.20 to 2.58mg/L, while the cadmium value was <0.01 (Table 4.10).

The lead content measured in the surface water <0.001 mg/l. Major sources of this metal are atmospheric deposition of exhaust from vehicles, disposal of batteries, sewage discharge, highway run-off and agricultural run-off from field fertilized with sewage sludge. Nickel and Arsenic levels in the surface water samples are generally <0.01mg/l and <0.01mg/l, respectively for all the water sampled. Copper levels were <0.001 mg/L for all the water samples.

Microbiological Characteristics of Ground water and Surface water

Pure water is completely free from micro-organisms such as bacteria, viruses, fungi and so on. Good quality water should be free from disease-causing organisms such as pathogenic bacteria, viruses, protozoa, or parasitic worms [Akpata and Ekundayo, 1978]. The presence or absence of living organisms in water can be one of the most useful indicators of its quality. In streams, rivers and lakes, the diversity of fish and insects species provides a measure of the biological balance or health of the aquatic environment. A wide variety of different species of organisms usually indicates that the stream or lake is unpolluted. The disappearance of certain species and overabundance of other groups of organisms could indicate level of pollution. A very important biological indicator of water quality and pollution used in environmental technology is the group of bacteria called coliforms. Consequently, water that has been recently contaminated with sewage will always contain coliforms (APHA, 1998). A particular species of coliforms found in domestic sewage is called *Eschericha coli* (E. Coli). Coliform bacteria are organisms that hardly survive in water longer than most pathogens and are also relatively easy to detect. In general, it can be stated that if a sample of water is found not to contain coliforms, then there has not been recent sewage pollution and the presence of pathogens is therefore extremely unlikely. On the other hand, if coliforms are detected, there is a possibility of recent sewage pollution. However, additional tests would be required to confirm that the coliforms are from sewage and not from other sources [WHO/UNICEF, 1986 and UNEP, 1996]. A total coliform test is particularly applicable to the analysis of drinking water to determine its sanitary quality. Drinking water must be free from coliforms of any kind. On the other hand, a feacal coliform test is more appropriate for monitoring pollution of natural surface water or groundwater, since a total coliform count would be inconclusive in this case.

In this study, the coliform count was far below recommended limit of 10^2 by FMEnv.

Fisheries

Fishing activities were not noticeable in all the surface water within the proposed project coverage areas. However, the list of few fish species identified during the study and those reported to be available by members of the community but not sighted during the course of sampling. Generally, fish diversity within the proposed project area is very low. This could be attributed to low volume of surface water sampled and possibly the alternative usage of most of the water bodies make it less productive for fish to thrive.

The results obtained from the study showed that all investigated physico-chemical parameters were within desirable limits for growth, survival and production of fish as well as for public consumption.

Regular monitoring of the physical, chemical and biological properties of both surface and ground water within the proposed project area is canvassed to quickly remediate any parameters going beyond tolerable limits before havoc is wrecked.

4.5.6 Sediment Studies

4.5.6.1 Methodology

Two (2Nos.) sediment samples were taken during fieldwork exercise, Sediment samples were taken at location where water sample was collected. The sediment samples were taken using a Van-Veen type grab sampler and sediment samples for Total Hydrocarbon estimations, Poly Aromatic Hydrocarbons and phenols were stored in aluminum foils and refrigerated prior to laboratory analyses, while samples for microbiological analyses were stored in sterile Teflon bags and equally refrigerated. Samples for others were stored in labeled polyethylene bags prior to laboratory analysis.

4.5.6.2 Laboratory Analysis

The collected sediment samples were used for the laboratory analyses at Environmental Laboratory Services, 28 Apaola Street, off Aladelola Ikosi Ketu, Lagos State. The analyses undertaken were as follows:

a. **Physico-chemical Characteristics:**

- Particle size, soil texture, moisture content and organic content. Particle size was determined using the standard Bouycous hydrometer, while organic content were determined using sodium hexametaphosphate solution method.
- Major and trace metals Mg^{2+}, Ca^{2+}, Na^{+}, Zn^{2+}, K^{+}) were determined using the X-Ray Fluorescence (XRF) method.
- Heavy metal (Cu, Fe, Pb, Cd, V, Ni, Hg, etc) were determined using atomic absorption spectrophotometery method.
- pH, oil and grease, Total Hydrocarbon Content (THC) using standard methods.

b. Geotechnical Studies:

Geotechnical studies were conducted for engineering characteristics of the sediments. In order to achieve this, the following classification tests were conducted using standard engineering methods.

- Moisture content determination
- Grain size analysis
- Specific gravity
- Permeability
- Bulk density
- Strength test

c. Microbiology:

Soil and bottom sediment samples were subjected to microbiological tests as follows:

- Total heterotrophs, were isolated using the standard plate count (SPC) technique.
- Total pathogens were isolated using three (3) selective media (MacConkey agar, blood agar and decoxycholocate agar.
- Fungi were isolated using minimal salts agar.
- Hydrocarbon utilizing micro-organisms were determined using minimal salt agar, and a single source of carbon (crude petroleum) according to the method described by Raymond et al (1976).

d. Identification of Micro Organisms

Hydrocarbon utilizing bacteria was first purified to obtain a pure culture, stained by grain staining technique to differentiate gram positive from gram negative organisms. The organisms were then passed through series of biochemical tests which include glucose/gas production, lusive/omitare, hydrogen sulfide and indole, oxidize, adonitol, arabinose, sorbitol, ducitol, motility, phenyl alanine, urea, citate utilization. All these reagents were packaged in three sets.

1. BBL minitech for identification of gram positive organisms.
2. BBL. Enterotubes I and H for identification of gram negative bacteria (oxidize negative).
3. BBL oxiferm tubes I and H for identification of gram negative, oxidize positive bacteria.

The BBL identification kit is latest technology in numerical identification of microorganisms. It is packaged by Becton Dickinson Microbiology Systems, USA. The bicode manual used for identification is the 1993 version. Fungal and yeast identification was at specie level by microscopic examination and sugar fermentation.

e. Total Hydrocarbon Contents

Sampling and subsequent laboratory analyses of sediment samples were aimed at checking if the proposed site area has been impacted. At each sampling point, sediment was collected in aluminum foil and kept in a refrigerator prior to the time of analysis. The hydrocarbon content of the samples was extracted using the Soxhlet apparatus with methylene chloride under reflux for a minimum of 6 hours as suggested by Brown et al (1983). The extract, which was concentrated with a rotary evaporator was analyzed by Gas Chromatography with flame ionization Detector (GC-FID) and quantified by comparison with the appropriate THC standard.

4.5.6.3 Results and Discussions

The planktonic community was represented by 25 species of phyto-planktons and 2 species of zooplankton. The phytoplankton consist of Bacillariohyta (7 species), Chlorophyta (9 species) Euglenophyta (4 species) Cyanophyta (1 species), and Dinophyta (7 species) while the zooplankton was up of 2 species of Cladocera and Copepoda. There was no evidence of eutrophication (alga bloom).

The benthic fauna of the Jemide river and stream 1 is made up of eleven (11) species; decapods, crustacean and larval forms of Coleoptera, Diptera, Tricoptera and Odonata. These species are indicative of the absence of organic pollution.

Ichthyofauna

Ichthyofauna (fishes) information revealed that the fish comprised mainly members of the family Cichlidae (*Oreochromis niloticus*, *Sarotherodon galilaeus*), Clariidae (*Clarias gariepinus* and *Heterobranchus longifilis*), Hepstidae (*Hepsetus odoe*) and Gymnarchidae (*Gymnarchus niloticus*).

Table 4.11: Checklist of Phtoplankton Species Recorded from the Water Bodies around the Project Area

	TAXA	Stream 1	Jemide Downstream	Jemide Upstream
	BACILLARIOPHYTA			
1	*Baccillaria paradoxa*		19	16
2	*Flagillaria sp*	32	15	15
4	*Bidulphia regia*	1	5	1
5	*Melosira granulata*		1	
6	*Synedra acus*	17	11	10
7	*Synedra ulna*	16	4	14
	CHLOROPHYTA			
8	*Melosira granulata*	1		1
9	*Volvox africana*	1		
10	*Spirogyra sp*	18	8	22
11	*Spirogyra majuscula*	10	4	
12	*Pandorina morum*	21		11
13	*Pandorina sp*	60	17	
14	*Closterium gracile*		1	
15	*Closterium pseudonulula*			1
16	*Sirogonium melanosporum*	8	7	3
17	*Scenedesmus sp.*			1
	EUGLENOPHYTA			
18	*Euglena spirogyra*		1	
19	*Phacus Curvicauda*	1		
20	*Phacus acuminatus*		1	
21	*Euglena sp*	7	15	32
	CYANOPHYTA			
22	*Coelosphaerium pallidum*		2	
	DINOPHYTA			
23	*Gymnodinium fusum*	11	2	4
24	*Merisbmospeida elegans*			3
25	*Microcystis aeruginosa*		14	4
	ZOOPLANKTON			
	ARTHROPODA			
	CRUSTACEA			
	CLADOCERA			
	SIDIDAE			
26	*Diaphanosoma excisum*		1	
	COPEPODA			
	ORDER CYCLOPOIDA			
27	Mesocyclops bodanicola	6	2	3

Source: OOPC: Proposed Palm Oil Mill at Extension Two; EIA Field Work, March 2019

Table 4.12: List of benthic fauna Recorded from the Water Bodies around the Project Area

	TAXA	STREAM 1	JAMIDE UPSTREAM	JAMIDE DOWN STREAM
	DECAPODA			
1	*Desmocaris trispinosa*	5		2
2	*Caridina gabonesis*	2	2	6
	DIPTERA			
	Chironomidae			
3	*Chironomus sp*	5		1
4	*Chironomus fractilobus*	2		
5	*Tarnypus sp*		5	3
6	*Culex sp*		1	
	COLEOPTERA			
7	*Hydrophilus sp*		1	1
	EPHEMEROPTERA			
8	*Elassoneura candida*		2	
9	*Cloeon sp*		12	4
10	*Baetis sp*		3	
	TRICHOPTERA			
11	*Trichoptera* larvae		2	
	ODONATA			
12	Anisoptera			
13	*Aphyla sp*	2		
14	*Libellula sp*		3	

Source: OOPC: Proposed Palm Oil Mill at Extension Two; EIA Field Work, March 2019

Bottom Sediments

The results of the laboratory analyses of the bottom sediment samples collected during the field exercise are presented in Table 4.13. The pH value of the sediment samples was within the range of 6.50 and 6.74 with an average of 6.62. Results of grain size analyses showed that the sediment samples were predominantly made up of sand with an average content value of 85.0% followed by silt having an average content value of 2.15% and lastly clay with 2.0% average content value.

Table 4.13: Bottom Sediment Analysis Result

Sample Code	pH	E.C (µS/cm)	O.C (%)	THC (mg/kg)	SAND (%)	CLAY (%)	SILT (%)
September 2015							
SP1	6.50	678.50	0.03	0.001	85.00	2.00	2.15
SP2	6.74	760.80	0.05	0.002	85.00	2.00	2.15

Source: Extension Two Oil Palm Development Project; EIA Final Report December 2016

4.5.7 Soil Characteristics

Using Dutch Soil Auger and Mussel Soil Colour Chart, the morphological characteristics of the soils were examined from the soil surface to a depth of 120cm.

4.5.7.1 Soil Profile:

The soil profiles were described according to the FAO guideline (2010). The soil characteristics and morphological properties were described for each of the identified horizons (layers) in the profiles. The soil colour was evaluated with the aid of Munsell Soil Colour Charts; texture was determined on the field by hand feel method, at moist state. Structure, concretions, roots and boundary forms were described using visual assessment. The soil consistence was determined at dry, moist and wet states on the field.

After the description of the sites and soil profiles, samples were taken from each of the soil profiles, starting from lowest horizon upward. The samples were put into polythene bags and labelled for laboratory analyses.

4.5.7.2 Laboratory Analytical Methods

The soil samples collected were air dried at room temperature and sieved through a 2mm sieve. The resulting soil samples were analysed for their physical and chemical properties as follows: Particle size was determined by hydrometer method (Gee and Boulder, 1986). Available Phosphorous (P) was determined by Bray P-I method (Anderson and Ingram, 1993). Total Nitrogen (TN) was determined by macro-kjedhal method (Brookes *et al.*, 1985). Soil pH was determined in a 1:2 soil to water suspension using a pH meter (Maclean, 1982). Exchangeable bases were extracted using NH_40AC buffered at pH 7.0 (Thomas, 1982). While Potassium (K) and Sodium (Na) were read from a flame photometer, Exchangeable Calcium (Ca) and Magnesium (Mg) was determined using atomic absorption spectrophotometer. Total Exchangeable acidity ($H^+ + Al^{3+}$) was by titration method (Anderson and Ingram, 1993) while effective cations exchange capacity was determined by summation of exchangeable cations and exchangeable acidity (Tan, 1996).

The gravel portion (> 2mm diameter), of the soil samples were weighed and the ratio of gravel to fine earth calculated. Thus, the gravel content was calculated as a percentage of total air-dried soil. The proportion or gravel content goes a long way to influence, soil physical properties like bulk density, porosity, compatibility, shearing index, infiltration and hydraulic conductivity rates, etc.

4.5.8 General Soil Properties and Interpretation

4.5.8.1 Particle Size Distribution

Characteristically, the soils had low silt and clay content and high sand contents (Table 4.14). These soils had sand content that ranged in values between 70.60% and 93.20% .The surface horizons in most cases had higher sand content than the subsurface horizon but there was no consistent pattern of profile distribution of the sand particle size fraction. The values of silt content of the soils were comparatively lower than the values of the sand fractions and ranged in values from 1.40% and 13.40% in the surface soils, while the subsurface horizons had silt contents that ranged from 1.40% to 17.40%. The profile distribution of the silt particle size fraction did not follow any regular pattern of distribution within the profile. The clay contents of these soils increased with increasing soil depth in most profiles except in profile P.2Bwhere there was decrease in the clay content of the soil with increasing soil depth. However there was no strong evidence of clay illuviation in many of the profiles. Pedons P.2B, P.6B, P.157, P.177 and P.191 have no accumulation of clay in any part of the profile, while the remaining profiles show some weak evidence of argilluviation. The surface horizons had clay that ranged in value from 5.40% to 15.00% while the subsurface horizons had clay content that ranged from 5.40% to 28.00%.

The textures of these soils were predominantly sand to loamy sand in the epipedon while the subsurface horizons were predominately sand to sandy clay loam in texture. Three profiles (P.6B, P.177 and P.191) had no textural change with increasing soil depth. These profiles had sand textural class throughout the profile.

The soil structural classes of the soils ranged from weakly formed fine-crumbs in the surface horizons to moderately developed medium and coarse sub-angular blocky structures in the subsurface horizons. The consistencies were loose – friable in the surface and firm in the sub surface horizons.

4.5.8.2 Bulk Density, Porosity and Soil Gravimetric Water Content

The soil bulk density (ρ_b) varied from one part of the surveyed site to the other and from one mapping unit to the other but was lower generally in the soil surface compared with the deeper soil layers and thus majorly increased with increasing soil depth while the soil total porosity (P_t)was higher at the uppermost layers (0-25 cm) of the soil than the underlying layers. The gravimetric water content (θ_g) also, increased with increasing soil depth in most parts of the surveyed soil. The high bulk density values recorded as the profiles depth increases, according to Mbagwu *et al*. (1984) could be caused by translocation of clay from eluvial horizon, with simultaneous loss of structure and closer packing of sand grains in the eluvial horizon. Other authors such as Rasool *et al*., (2007); Singh *et al*., (2007); Busari *et al*. (2012a); Busari *et al*., (2012b) have reported increase in bulk density with increasing soil depth because of influence of soil organic matter which was higher in the upper horizon than the lower horizons (Salako *et al*., 2006).

With exception of some parts of mapping unit 6 (P.2b and P.6B), the range of bulk density, total porosity and θ_g from all the mapping units portend no hindrance to oil palm cultivation. These ranges of bulk density and θ_g are a reflection of the various land uses, vegetation and topography of the different parts of the surveyed site. For instance, in the SMU 2 of the surveyed land around profile pit P.001 the low range of ρ_b and high range of θ_g is attributable to densely vegetated *Chromoleana odorata* (Siam weeds) with less human impacts and a nearly flat land terrain.

Table 4.14: Soil Particle Size Analysis of Representative Soil Profiles

S/Code	H-Depth	Sand %	Silt %	Clay %	Soil texture
P.001	0-20	93.20	1.40	5.40	Sand
	20-66	77.20	17.40	5.40	loamy sand
	66-142	79.20	15.40	5.40	loamy sand
	142-200	75.20	2.80	22.00	Sandy clay loam
P.011	0-15	89.20	4.80	6.00	Sand
	15-35	89.20	4.80	6.00	Sand
	35-83	91.20	2.80	6.00	Sand
	83-146	75.20	1.40	23.40	sandy clay loam
	146-200	75.20	1.40	23.40	sandy clay loam
P.040	0-5	75.20	13.40	11.40	sandy loam
	5--49	83.20	4.30	12.50	loamy sand
	49-97	76.20	4.40	19.40	sandy loam
	97-160	76.60	3.40	20.00	sandy clay loam
P.091	0-21	92.60	1.40	6.00	Sand
	21-71	82.60	5.40	12.00	loamy sand
	71-115	76.60	3.40	20.00	sandy clay loam
	115-163	70.60	1.40	28.00	sandy clay loam
P.095	0-49	90.60	3.40	6.00	Sand
	49-73	82.60	3.40	14.00	sandy loam
	73-121	85.60	8.80	5.40	loamy sand
	121-160	91.80	2.80	5.40	Sand
P.111	0-9	91.80	2.80	5.40	Sand
	9--49	85.80	8.50	5.70	loamy sand
	49-91	83.80	10.50	5.70	loamy sand

	91-180	75.80	3.80	20.40	sandy clay loam
P.117	0-8	91.80	0.80	7.40	Sand
	8--54	91.20	3.40	5.40	Sand
	54-139	75.20	4.40	20.40	sandy clay loam
	137-170	75.20	2.40	22.40	sandy clay loam
P.137	0-11	93.20	1.40	5.40	Sand
	11--41	90.40	4.20	3.86	Sand
	41-119	79.20	5.40	15.40	sandy loam
	119-200	75.20	5.40	19.40	sandy loam
P.157	0-13	93.20	1.40	5.40	Sand
	13-36	93.30	1.40	5.40	Sand
	36-90	91.20	1.40	7.40	Sand
	90-170	89.20	1.40	9.40	loamy sand
	170-200	89.20	1.40	9.40	loamy sand
P.159	0-10	93.20	1.40	5.40	Sand
	10--37	91.80	1.80	6.40	Sand
	37-80	91.80	2.80	5.40	Sand
	80-170	83.20	3.40	13.40	sandy loam
P.177	0-12	89.20	5.40	5.40	Sand
	12--45	92.60	2.00	5.40	Sand
	45-103	90.60	4.00	5.40	Sand
	103-182	88.00	6.60	5.40	Sand
P.191	0-13	88.00	6.60	5.40	Sand
	13-48	88.00	6.60	5.40	Sand
	48-112	90.60	4.00	5.40	Sand
	112-170	90.00	4.60	5.40	Sand
P.196	0-20	92.60	1.40	6.00	Sand
	20-48	92.60	1.40	6.00	Sand
	48-120	78.60	5.40	16.00	sandy loam
	120-180	84.60	1.40	14.00	loamy sand
P.2B	0-16	85.60	2.40	12.00	loamy sand
	16-61	85.60	2.40	12.00	loamy sand
	61-150	91.20	2.80	6.00	Sand
	150-200	93.20	0.80	6.00	Sand
P.6B	0-20	91.20	2.80	6.00	Sand
	20-49	89.20	4.80	6.00	Sand
	49-145	89.20	4.80	6.00	Sand
	145-190	91.20	2.80	6.00	Sand

Source: Extension Two Oil Palm Plantation Development Project, Final EIA Report 2016

Table 4.15: Some Soil Physical Properties of the Representative Soil Profiles

Profile No	Depth (cm)	Bulk density (g cm^{-3})	Total Porosity (%)	Gravimetric water content (%)
PT.001	0-25	0.89	65.40	16.09
	25-50	1.32	48.29	14.62
	50-75	1.68	34.37	12.12
	75-100	1.25	51.08	17.07
PT.011	0-25	1.76	31.19	11.56
	25-50	2.07	19.26	15.27
	50-75	1.98	22.84	20.62
	75-100	1.97	23.24	21.76
PT.040	0-25	1.47	42.72	11.11
	25-50	1.69	33.97	10.24
	50-75	1.93	24.43	14.21
	75-100	1.91	25.22	16.49
PT.091	0-25	1.71	33.18	11.90
	25-50	1.94	24.03	8.38
	50-75	1.89	26.02	13.98
	75-100	1.77	30.79	16.67
PT.095	0-25	0.91	64.45	10.38
	25-50	1.19	53.46	17.35
	50-75	1.62	36.76	27.61
	75-100	1.45	43.52	20.42
PT.111	0-25	1.00	61.02	10.20
	25-50	1.07	58.24	15.24
	50-75	1.02	60.23	16.00
	75-100	1.31	48.69	13.95
PT.117	0-25	1.85	27.61	6.04
	25-50	2.15	16.08	8.53
	50-75	1.94	24.03	11.52
	75-100	1.98	22.84	15.46
PT.137	0-25	1.21	52.67	5.88
	25-50	1.15	55.05	9.73
	50-75	1.20	53.07	11.02
	75-100	1.43	44.32	12.14
PT.157	0-25	1.26	50.68	2.42
	25-50	1.30	49.09	4.69
	50-75	1.20	53.07	5.08
	75-100	1.35	47.10	6.02
PT.159	0-25	1.42	44.53	2.32
	25-50	1.57	38.67	3.76

	50-75	1.66	35.16	3.89
	75-100	1.92	25.00	5.01
PT.177	0-25	1.23	51.87	3.31
	25-50	1.39	45.51	5.11
	50-75	1.33	47.90	5.34
	75-100	1.36	46.70	6.72
PT.191	0-25	1.24	51.48	2.46
	25-50	1.33	47.90	3.05
	50-75	1.28	49.88	7.94
	75-100	1.27	50.28	5.60
PT.196	0-25	0.95	63.01	6.45
	25-50	1.11	56.65	6.42
	50-75	1.37	46.30	1.48
	75-100	1.47	42.72	1.39
PT.2B	0-25	1.85	27.61	3.85
	25-50	2.03	20.85	4.52
	50-75	2.23	12.89	5.94
	75-100	2.10	18.06	6.80
PT.6B	0-25	1.69	33.97	4.22
	25-50	1.86	27.21	3.83
	50-75	1.81	29.20	8.43
	75-100	1.48	42.33	8.97

Source: Extension Two Oil Palm Plantation Development Project, Final EIA Report 2016

4.5.9 Soil Chemical Characteristics

The soils had reaction ranging from strongly acid to slightly alkaline (5.10 - 7.40). The exchangeable acidity (H + Al) values of the soils were low and ranged from 0.03 to 0.09cmol kg^{-1} (Table 4.16).

The exchange sites of these soils were dominated by exchangeable calcium and magnesium. The exchangeable calcium (Ca^{2+}) ranged in values from 3.17cmol kg^{-1} to 16.85cmol kg^{-1}. In most profiles, the highest Ca value was observed in the first surface horizon. The Magnesium (Mg^{2+}) contents of the soils varied from 0.48cmol kg^{-1} to 2.30cmol kg^{-1}. Exchangeable K^+ content of the soils was low and ranged from 0.02cmol $kg^{-1}$to 0.48cmol kg^{-1}.

The subsoil had values of K^+ that was lower than 0.10cmol kg^{-1}in most cases. Apart from Ca and Mg which were moderate in all the pedons, the values of exchangeable K and Na within the rooting zones (0- 100 cm) were well below the suggested critical requirements for most arable crops grown in the agro-ecological zone of the project site. This means that apart from $Ca^{2+}$and Mg^{2+}which are adequate in supply, the quantity of the other exchangeable bases will limit crop production in these soils.

The suggested soil critical levels of exchangeable Mg (0.28cmol kg^{-1}) showed that the Mg^{2+} status of the soil will not limit the yield of oil palm grown on these soils. Soils with exchangeable K less than 0.13cmol kg^{-1} have been classified as being poor in K, and those that contained between 0.13cmol kg^{-1} to 0.31cmol kg^{-1} as being moderately endowed with K, while those having exchangeable K that is greater than 0.31cmol kg^{-1} were regarded as being adequate in K.

In Nigeria, the recommended critical K level for oil palm ranged between 0.18cmol kg^{-1} and 0.35cmol kg^{-1}. Based on the above recommendation, the supply of K is expected to limit the production of oil palm on these soils. Also, the low K^+: Ca^{2+} or K^+: Ca^{2+} + Mg^{2+}ratio is likely to aggravate the problem of K^+ uptake. Kirkman *et al.* (1994) noted that the displacement of K^+ by Ca^{2+}+(Mg^{2+}) was particularly important in the soils because of selective adsorption of Ca^{2+} which resulted in leaching of K^+. Parfitt (1992) also reported that a high solution concentration of Ca^{2+} led to complementary ion effect occurring between Ca^{2+} and K^+ and that this led to reduced K^+ uptake by plants. Application of K fertilizer will be a critical requirement for sustainable use of these soils for oil palm production.

The effective cation exchange capacity (ECEC) of the soils was low in pedon P.001 but moderate in all other pedons. The ECEC in pedon P.001 ranged from 4.71cmol $kg^{-1}$to 7.66cmol kg^{-1} while those of the remaining pedons ranged from 10.05cmol kg^{-1} to 18.64cmolkg^{-1}. Percentage base saturation (BSat) values ranged between 98.96% and 99.75%. In most of the profiles, the sum of Ca^{2+} and Mg^{2+} accounted for more than 80% of the TEB and ECEC.

Table 4.16: Soil Chemical Properties of the Representative Soil Profiles

Profile No.	H-Depth	pH	N (%)	Org C (%)	Al+H	Ca	Mg	K	Na	ECEC	CEC clay	B-Sat	ESP	Av. P	Mn	Fe	Cu	Zn	EC
					cmol kg^{-1}									mg kg^{-1}					
P.001	0-20	5.60	0.09	1.02	0.08	5.99	1.12	0.18	0.29	7.66	7.00	98.96	3.79	2.15	22.15	12.75	0.65	2.05	70.50
	20-66	5.51	0.04	0.61	0.06	4.23	1.19	0.15	0.21	5.84	5.44	98.97	3.60	2.99	25.06	13.83	0.75	1.65	56.40
	66-142	5.61	0.02	0.33	0.06	3.42	1.16	0.02	0.05	4.71	4.50	98.73	1.06	3.06	23.90	12.80	0.60	1.55	28.20
	142-200	5.61	0.02	0.11	0.05	3.66	1.36	0.04	0.07	5.18	5.16	99.03	1.35	1.81	13.47	14.38	0.55	1.75	28.20
P.2B	0-16	5.46	0.09	0.08	0.07	3.17	1.26	0.04	0.14	4.68	4.66	98.50	2.99	2.92	9.10	15.05	0.50	1.65	28.20
	16-61	5.36	0.01	0.14	0.07	9.41	1.48	0.03	0.11	11.10	11.06	99.37	0.99	4.81	12.35	21.46	0.45	1.55	14.41
	61-150	5.41	0.17	2.02	0.06	12.23	1.42	0.26	0.49	14.46	13.28	99.59	3.39	6.04	19.05	19.30	0.35	2.85	84.60
	150-200	5.36	0.02	0.16	0.07	10.10	1.12	0.12	0.24	11.65	11.56	99.40	2.06	5.04	3.00	17.10	0.50	1.80	56.40
P.6B	0-20	5.77	0.08	0.75	0.08	10.18	1.22	0.18	0.35	12.01	11.57	99.33	2.91	6.37	10.25	14.35	0.45	1.95	42.30
	20-49	5.72	0.02	0.27	0.08	11.33	1.51	0.03	0.07	13.02	12.86	99.39	0.54	5.37	7.65	12.98	0.55	1.60	14.10
	49-145	5.56	0.01	0.12	0.05	12.53	1.62	0.03	0.11	14.34	14.27	99.65	0.77	4.26	2.60	13.80	0.60	1.80	14.10
	145-190	5.41	0.01	0.13	0.06	13.28	1.73	0.07	0.13	15.27	15.19	99.61	0.85	4.78	5.85	18.72	0.25	3.65	28.20
P.011	0-15	5.70	0.17	2.27	0.08	15.58	2.42	0.19	0.37	18.64	17.32	99.57	1.98	2.26	93.10	12.70	0.35	6.90	112.80
	15-35	5.41	0.05	0.34	0.06	11.63	1.47	0.07	0.13	13.36	13.16	99.55	0.97	2.17	16.05	24.85	0.80	3.40	42.30
	35-83	5.31	0.02	0.16	0.07	10.55	1.39	0.05	0.11	12.17	12.08	99.42	0.90	1.96	9.40	20.18	0.65	5.05	14.10
	83-146	5.80	0.01	0.14	0.07	12.02	1.20	0.04	0.09	13.42	13.40	99.48	0.67	3.61	12.65	19.85	0.75	3.75	14.10
	146-200	5.76	0.01	0.12	0.06	11.48	1.10	0.04	0.11	12.79	12.77	99.53	0.86	3.33	15.50	24.30	0.70	2.75	28.20
P.040	0-5	5.60	0.09	0.71	0.07	13.28	1.16	0.41	0.71	15.63	15.41	99.55	4.54	4.87	14.35	23.20	0.75	2.40	56.40
	5-49	5.20	0.03	0.19	0.04	8.99	0.98	0.07	0.13	10.21	10.16	99.61	1.27	6.03	13.85	15.65	0.90	2.50	14.10
	49-97	4.90	0.03	0.28	0.03	10.15	1.02	0.04	0.09	11.33	11.28	99.74	0.79	2.70	14.60	13.86	0.80	2.35	28.20
	97-160	4.80	0.01	0.10	0.05	9.33	0.56	0.04	0.07	10.05	10.03	99.50	0.70	2.08	16.66	16.05	0.65	1.75	28.20
P.091	0-21	6.40	0.10	1.24	0.07	12.55	1.14	0.08	0.16	14.00	13.28	99.50	1.14	5.56	16.70	4.00	0.85	4.25	56.40
	21-71	5.60	0.04	0.35	0.06	10.63	0.89	0.03	0.05	11.66	11.56	99.49	0.43	4.37	22.30	8.95	0.95	5.50	28.20

	71-115	5.66	0.02	0.15	0.06	12.38	1.17	0.04	0.07	13.72	13.69	99.56	0.51	2.89	16.50	10.63	1.25	4.00	28.20
	115-163	5.60	0.01	0.04	0.07	10.78	0.75	0.03	0.05	11.68	11.68	99.40	0.43	3.98	18.45	17.54	1.50	2.55	14.10
P.095	0-49	5.20	0.22	3.00	0.08	14.88	1.06	0.36	0.62	17.00	15.25	99.53	3.65	5.19	50.75	18.75	1.65	2.35	112.80
	49-73	4.80	0.12	1.00	0.05	11.83	0.68	0.08	0.15	12.79	12.54	99.61	1.17	12.87	3.05	13.90	2.30	1.75	14.10
	73-121	4.70	0.21	3.29	0.08	11.40	0.62	0.26	0.47	12.83	10.70	99.38	3.66	15.31	3.25	16.10	2.15	2.65	112.80
	121-160	4.90	0.02	0.10	0.06	9.44	0.69	0.02	0.02	10.23	10.17	99.41	0.20	7.41	6.00	12.87	1.05	1.85	28.20
P.111	0-9	5.56	0.11	0.92	0.05	9.36	0.62	0.08	0.13	10.24	9.64	99.51	1.27	4.36	17.75	20.15	0.55	2.85	56.40
	9-49	4.91	0.03	0.32	0.09	13.19	1.82	0.02	0.05	15.17	14.97	99.41	0.33	7.00	10.80	14.63	0.65	2.25	28.20
	49-91	6.00	0.01	0.05	0.07	`13.06	1.91	0.02	0.07	2.07	2.04	96.62	3.38	3.33	8.50	13.19	0.50	3.00	28.20
	91-180	6.40	0.01	0.09	0.07	14.23	1.94	0.04	0.11	16.39	16.37	99.57	0.67	3.30	7.75	8.44	0.35	4.05	14.10
P.117	0-8	6.10	0.15	2.20	0.08	16.46	1.63	0.27	0.49	18.93	17.89	99.58	2.59	5.54	6.60	6.10	0.30	4.56	141.00
	8-54	6.10	0.09	0.80	0.06	12.23	1.14	0.12	0.20	13.75	13.23	99.56	1.45	2.84	14.00	9.30	0.95	1.95	28.20
	54-139	4.90	0.02	0.09	0.06	11.35	1.08	0.05	0.16	12.70	12.68	99.53	1.26	2.80	9.55	5.36	0.70	2.15	28.20
	137-170	6.90	0.01	0.08	0.07	9.43	1.08	0.03	0.07	10.68	10.67	99.34	0.66	1.27	5.50	4.85	1.00	2.00	14.10
P.137	0-11	5.46	0.22	2.90	0.08	14.95	2.30	0.23	0.38	17.94	16.06	99.55	2.12	2.64	49.55	11.55	0.90	5.95	141.00
	11-41	5.66	0.04	0.26	0.06	14.11	2.11	0.05	0.13	16.46	16.22	99.64	0.79	0.82	41.87	9.75	0.60	3.55	28.20
	41-119	5.76	0.01	0.07	0.04	12.88	1.81	0.03	0.07	14.83	14.81	99.73	0.47	0.55	50.10	7.66	0.80	4.55	28.20
	119-200	5.76	0.01	0.06	0.05	13.52	2.00	0.03	0.07	15.67	15.66	99.68	0.45	0.94	35.75	10.12	0.90	2.50	28.20
P.157	0-13	5.10	0.07	0.53	0.04	10.55	0.86	0.05	0.13	11.63	11.29	99.66	1.12	1.27	10.55	12.15	0.30	2.30	56.40
	13-36	4.90	0.02	0.15	0.04	13.11	1.05	0.02	0.07	14.29	14.19	99.72	0.49	0.94	4.20	10.86	0.50	3.05	28.20
	36-90	4.70	0.01	0.07	0.05	10.93	0.77	0.02	0.05	11.82	11.79	99.58	0.42	1.52	3.85	15.65	0.40	2.00	14.10
	90-170	4.60	0.04	0.34	0.04	11.42	0.63	0.01	0.05	12.15	12.02	99.67	0.41	2.58	5.62	14.82	0.60	4.20	28.20
	170-200	5.10	0.01	0.06	0.06	10.96	0.84	0.01	0.05	11.92	11.90	99.50	0.42	1.96	3.95	18.71	0.45	2.75	14.10
P.159	0-10	5.20	0.07	0.63	0.09	11.03	0.78	0.11	0.20	12.21	11.80	99.26	1.64	3.19	4.70	17.35	0.55	1.45	70.50
	10-37	4.90	0.01	0.13	0.08	9.87	0.67	0.04	0.07	10.73	10.66	99.25	0.65	1.42	2.75	19.42	0.65	1.65	28.20
	37-80	4.60	0.01	0.13	0.09	11.83	0.48	0.04	0.11	12.55	12.47	99.28	0.88	1.37	5.50	29.20	0.50	1.50	28.20

	80-170	4.70	0.01	0.11	0.07	10.51	0.61	0.02	0.05	11.26	11.23	99.38	0.44	2.82	12.30	24.55	0.65	5.10	14.10
P.177	0-12	7.40	0.10	0.83	0.08	13.76	1.16	0.31	0.55	15.86	15.32	99.50	3.47	5.71	15.00	25.65	0.50	6.05	70.50
	12-45	5.20	0.01	0.12	0.05	10.55	0.59	0.23	0.42	11.84	11.76	99.58	3.55	1.91	21.50	22.15	0.85	5.85	14.10
	45-103	5.50	0.01	0.06	0.06	11.40	1.23	0.47	0.84	14.00	13.96	99.57	6.00	1.83	18.45	11.29	0.80	5.60	28.20
	103-182	5.56	0.01	0.05	0.05	11.29	1.46	0.03	0.09	12.92	12.89	99.61	0.70	1.24	16.90	13.33	0.95	7.85	28.20
P.191	0-13	5.61	0.09	0.74	0.06	12.17	1.18	0.12	0.22	13.75	13.27	99.56	1.60	2.40	25.35	9.86	0.70	6.70	14.10
	13-48	5.81	0.01	0.04	0.04	14.30	1.78	0.02	0.07	16.21	16.18	99.75	0.43	2.25	15.60	10.25	0.60	9.15	28.20
	48-112	5.91	0.01	0.06	0.03	14.18	1.47	0.02	0.07	15.77	15.73	99.81	0.44	1.82	19.28	7.85	0.55	11.25	28.20
	112-170	5.61	0.01	0.05	0.06	13.78	1.84	0.05	0.13	15.86	15.83	99.62	0.82	1.49	27.42	6.21	0.65	7.50	28.20
P.196	0-20	5.81	0.16	2.14	0.05	16.85	2.20	0.26	0.47	19.83	18.58	99.75	2.37	2.85	83.90	6.15	0.50	8.50	84.60
	20-48	5.76	0.03	0.22	0.04	12.77	1.96	0.05	0.15	14.97	14.84	99.73	1.00	3.13	42.55	6.83	1.25	8.00	28.20
	48-120	5.71	0.02	0.21	0.05	13.46	2.08	0.14	0.29	16.02	15.97	99.69	1.81	5.43	38.75	8.29	1.10	5.75	28.20
	120-180	5.56	0.01	0.10	0.06	13.27	2.12	0.10	0.20	15.75	15.73	99.62	1.27	8.14	45.56	10.11	0.95	6.75	14.10

Source: Extension Two Oil Palm Plantation Development Project; Final EIA Report 2016

The organic carbon content of the soils was moderate to high in the surface of all the pedons except pedon P.2B (where OC value was 0.08%). However, the OC content of the subsurface horizons were very low except in pedons P.2B and P.095 (where OC values were 2.02% and 3.29% in the third horizon respectively). Organic carbon content of the surface soils ranged from 0.53% and 3.00% while the subsurface horizons had organic carbon contents that ranged from 0.05% to 0.35%. In all the profiles the organic carbon content of the horizons deeper than 30 cm were below the critical requirement of 0.8% recommended for sustainable production of oil palm.

The total Nitrogen (TN) status of the soils varied linearly with the soil organic carbon content. Thus the TN content of the soil was moderate in the surface horizons with moderate OC contents and very low in the subsurface horizons where the OC content was low. The surface horizons had TN that ranged from 0.08% to 0.22% while the subsurface horizons have TN that ranged from 0.01 – 0.21. In most cases, the surface horizons had the highest TN content.

Available P was low in the surface and subsurface horizons of the soils. Available P in these soils ranged from 2.15 mg kg^{-1} and 6.37 mg kg^{-1} in the surface horizons while the subsurface horizons had values of available P between 1.27 mg kg^{-1} and 15.31 mg kg^{-1}. In most cases, the surface horizons had higher content of available P than the subsurface horizons. All the pedons were deficient in available P and thus application of P fertilizer will be required for sustainable production of oil palm.

4.5.9.1 Micro-Nutrient Status of the Soils

The values of available Fe in the soils were very high and ranged from 4.00 to 29.20 mg kg^{-1} (Table 4). These values are higher than values reported for most soils in Nigeria (Adesanwo, 2002). Available Fe is generally high in tropical soils, although localized deficiencies of Fe are known to occur (Enwezor *et al*., 1990; Adesanwo, 2002). At low nutrient level, even 30 mg kg^{-1}, Fe has been reported to be toxic (Moorman and Van Breemen, 1978).

Apart from its direct effect on crops, high level of Fe in the soil can also have serious negative effect on availability of P for plant uptake. However, at high soil pH (pH > 6.0) both the uptake of Fe and its influence on availability of P may not be significant. Therefore, any step taken to bring down the soil pH from neutrality will improve the activity of soil Fe with its likely negative effects on P availability.

The contents of available copper ranged from 0.25 to 2.30 mg kg^{-1}, with a mean of 0.67 mg kg^{-1}. The mean value of Cu obtained in this study is lower than the critical value of 0.75 mg kg^{-1} suggested for EDTA-extractable Cu (Haque *et al.*, 2010). However, pedons P.040, P.091, P.095 and P.196 had mean Cu content higher than this suggested critical value. This result suggests that external input of Cu inform of fertilizer will be for sustainable use of the land for oil palm production.

The values of available Mn ranged from 2.60 to 93.10 mg kg^{-1} with a mean of 20.65 mg kg^{-1}. The values of Mn obtained in this study were higher than the critical values suggested by several authors (Borggaard, 1976; Kociał kowski *et al.*, 1999) and higher than values reported for most parts of Nigeria.

The available Zn ranged from 1.50 to 11.25 mg kg^{-1} with a mean of 4.62 mg kg^{-1}. Chude and Obigbesan (1982) reported mean Zn values that ranged from 2.50 to 42.50 mg kg^{-1} for soils on sedimentary deposits and a range of 5.80–22.50 mg kg^{-1} for soils developed on igneous and metamorphic deposits in southwestern Nigeria. Haque *et al*., (2010) suggested a critical range of 1.40 – 3.00 mg kg^{-1} for EDTA-extracted Zn. A critical range of 1.0–5.0 mg kg^{-1} has been reported elsewhere (Sims and Johnson, 1991; Deb and Sakal, 2002). The values obtained from this study are lower than those reported by Chude and Obigbesan (1982). From the result obtained in this study, Zn may not be limiting to sustain good oil palm yield.

4.6 Geology, Geotechnical/Hydrogeology Studies

4.6.1Geophysical Investigation

The geophysical investigation at the proposed project site was done in June 2018 for the economic design of the foundation structure of the proposed mill to carry surface load in line with the proposed project's objectives for the site location.

4.6.2 Objective of Geotechnical Investigation

The objectives of the geotechnical investigation included the following:

(i) To investigate and give details about the soil profile to a maximum depth of about 15 m below the natural ground level

(ii) To determine the index and strength properties of the soil required for foundation design

(iii) To collect disturbed and undisturbed samples of the soil by drilling ten boreholes to 15.0 m depth and three road points to depths of 1.5m each for laboratory testing and analysis

(iv) To carry out Dutch Cone Penetrometer Testing (CPT) to depth of refusal or anchorage

(v) Recommendation for further improvement of the geotechnical properties of the investigated site soil where necessary.

4.6.3 Methodology and Scope of Work

The scope of work includes the following:

1. Mobilization of equipment and personnel to site
2. Drilling of ten (10) boreholes to 15 m depths at each test point using the Shell and Augar Technique with a Percussion Rig mounted equipment and also collect samples from three road points at depths 1.5m each.
3. Laboratory testing of recovered soil samples from the location. The laboratory test shall include:
   i. Specific gravity test
   ii. Sieve analysis test
   iii. Consistency test
   iv. Compaction test
   v. Undrained Triaxial test
   vi. California Bearing ratio
4. Cone penetrometer tests
5. Bearing capacity calculations at specific depths
6. Analysis of the tests results with recommendation for improvement and economic design
7. Preparation and submission of detailed Geotechnical Report with Appendices.

Materials

The equipment and materials used for soil exploration includes:

1. Pilcon Drilling Equipment
2. Measuring Tapes and Steel Rule
3. Dutch Cone Penetrometer
4. Shovels

4.6.4 Soil Exploration

Soil samples were drilled from ten deep boreholes up to a depth of 15 m and to depths of 1.5m for the road samples. Water table was not reached in the course of this investigation. The recovered soil samples were then taken to the Geotechnical and Highway Materials Testing Laboratory of the University of Benin for testing and analysis.

4.6.5 Cone Penetrometer Tests

The field work also involved the execution of three Cone Penetrometer Tests. The apparatus consisted of a cylindrical probe of 1000 mm^2 cross sectional area, and a conic head of apex angle of 60^o. The probe was forced down through the soil at a steady rate of about 20 mm/s in the closed position by exerting pressure force on outer sounding tube. The point resistance and the resistance to side friction were measured separately from the attached gauge.

4.6.6 Description of Soil Samples by Visual Inspection

Both soil description and classification require knowledge of grading and plasticity. Grading and plasticity can be assessed using a rapid procedure which involves personal judgments based on the appearance and feel of the soil.

Most of the soil samples collected was dark to light reddish brown in colouration depicting lateritic nature. A table showing a complete description of the soil samples obtained at the various depths investigated is shown below in Table 4.17.

Most of the samples are smooth when rubbed between fingers indicating a lower size limit for coarse soils and is also evident on sight when moist. The soils could easily be moulded to a firm mass when some amount of water is added indicating its cohesiveness and could deform without severely cracking or crumbling.

Table 4.17: Detailed Soil Description by Visual Inspection

Location	Borehole ID	Depth (m)	Physical Description
Okomu Road	Point 1	1.5	Dark reddish brown fine grained silty clay
	Point 2	1.5	Reddish brown coarse grained silty clay
	Point 3	1.5	Reddish brown coarse grained silty clay
		1.0	Reddish brown fine grained sandy silt
		3.0	Reddish brown fine grained sandy silt
		6.0	Reddish brown fine grained sandy silt
		9.0	Reddish brown fine grained sandy silt
		12.0	Reddish brown fine grained sandy silt
		15.0	Reddish brown fine grained sandy silt
Okomu Power House	BHII	2.0	Reddish brown fine grained silty clay
		5.0	Reddish brown fine grained sandy silt
		8.0	Reddish brown fine grained sandy silt
		11.0	Reddish brown fine grained sandy silt
		15.0	Reddish brown fine grained silty clay
Okomu Clarification Station	BHIII	2.5	Reddish brown fine grained sandy silt
		5.5	Reddish brown fine grained sandy silt
		8.5	Reddish brown fine grained sandy silt
		11.5	Reddish brown fine grained sandy silt
		14.5	Reddish brown fine grained sandy silt
Okomu Sterilizer	BHIV	0.5	Reddish brown fine grained silty clay
		3.5	Reddish brown fine grained sandy silt
		6.5	Reddish brown fine grained silty clay
		9.5	Reddish brown fine grained silty clay
		12.5	Reddish brown fine grained silty sand
		15.0	Reddish brown coarse grained silty sand
Okomu Pressing Station	BHV	1.5	Reddish brown fine grained silty clay
		4.5	Reddish brown coarse grained silty clay
		7.5	Reddish brown fine grained silty clay
		10.5	Reddish brown fine grained silty clay
		14.5	Reddish brown fine grained silty clay
Okomu Storage Tank	BHVI	1.0	Reddish brown fine grained silty clay
		4.0	Reddish brown fine grained silty clay
		7.0	Reddish brown fine grained silty clay
		10.0	Reddish brown fine grained silty clay
		13.0	Reddish brown fine grained silty clay
		15.0	Reddish brown fine grained silty clay

Table 4.17 cont'd: Detailed Soil Description by Visual Inspection

Location	Borehole ID	Depth (m)	Physical Description
Okomu Weigh Bridge	BHVII	1.0	Reddish brown fine grained sandy silt
		4.0	Reddish brown fine grained sandy silt
		7.0	Reddish brown fine grained sandy silt
		10.0	Reddish brown fine grained sandy silt
		13.0	Reddish brown fine grained sandy silt
		15.0	Reddish brown fine grained silty sand
Okomu Water Tank	BHVIII	3.0	Reddish brown coarse grained silty sand
		6.0	Reddish brown coarse grained silty sand
		9.0	Reddish brown coarse grained silty sand
		12.0	Reddish brown coarse grained silty sand
		15.0	Reddish brown coarse grained silty sand
Okomu Ramp I	BHIX	2.0	Reddish brown fine grained silty clay
		5.0	Reddish brown coarse grained silty sand
		8.0	Reddish brown coarse grained silty sand
		11.0	Reddish brown fine grained sandy silt
		14.0	Reddish brown fine grained sandy silt
Okomu Ramp II	BHX	1.5	Reddish brown fine grained sandy silt
		4.5	Reddish brown fine grained sandy silt
		7.5	Reddish brown fine grained sandy silt
		10.5	Reddish brown fine grained sandy silt
		13.5	Reddish brown fine grained sandy silt
		15.0	Reddish brown fine grained sandy silt

Source: OOPC: Proposed Palm Oil Mill at Extension Two; EIA Field Work, June 2018

Laboratory Testing

All the laboratory tests were done in accordance with the general specification given in the British standard specification BS EN 1997-1-2004 and BS EN 1997-2-2007, Geotechnics Designs (General Rules and Ground Investigation and testing respectively).

Disturbed samples were selected for standard laboratory classification and other tests which included the following:

- Specific Gravity Test
- Particle Size Analysis Test
- Atterberg Limit Test
- Compaction Test
- Undrained Triaxial Test

4.6.6.1 Specific Gravity Test.

Specific gravity tests were carried out on samples recovered from specified depths of borehole. The tests were performed as per procedures laid out in *BS EN 1997-1-2004 and BS EN 1997- 2-2007, Geotechnics Designs (General Rules and Ground Investigation and testing respectively).*

The specific gravity of a soil is the ratio of the weight or mass of a volume of the material to the weight or mass of an equal volume of water. For soils, it is specified to use one litre gas jar fitted with a rubber bung and a mechanical shaker apparatus which rotates the jar at a constant rate. An oven dried sample was placed into the gas jar along with some 500 ml of water. The jar was sealed and shaken. Subsequently, following established procedures, specific gravity of the soil can be calculated.

4.6.6.2 Particle Size Analysis

This test is to determine the percentage quantity of individual grain sizes as they occur in a particular soil layer. British Standard Sieves (BS – Sieves) were used on the mechanical sieve shaker to separate these grains into their various sizes. These were then weighed and their percentage weights calculated. The result of this test is of value when used for classification purposes and it enables soil groupings to be delineated and their properties inferred. Further tests to determine the size of the grain particle was undertaken with the aid of the Hydrometer tests. These were carried out in accordance with *BS EN 1997-2-2007*.

4.6.6.3 Atterberg/ Consistency Tests

Atterberg limits were determined on soil specimens with very fine particles, i.e. the clay samples. The Atterberg limits are boundaries between the liquid limit and plastic states (Liquid Limit, LL), and between the plastic and brittle states (Plastic Limit, PL). They are expressed as water content, in percentage.

The liquid limit is the water content at which a part of soil placed in a standard cup and cut by a groove of standard dimensions flow together at the base of the groove, when the cup is subjected to 25 standard shocks. The one-point liquid test was carried out. Distilled water was added during soil mixing to achieve the required consistency. The plastic limit is the water content at which a soil can no longer be deformed by rolling into 3 mm diameter threads without crumbling. The range of water contents over which a soil behaves plastically is the Plasticity Index, Ip. This is the difference between the liquid limit and the plasticity limit (WL-WP). The Reference test standard used for this test was *BS EN 1997-2-2007.*

4.6.6.4 Compaction Tests

Compaction is the process of increasing the density of a soil by packing the particles of the soil closer together, with a reduction in the volume of air. Two parameters are usually obtained from this test – optimum moisture content (OMC) and maximum dry density (MDD). The compaction tests were carried out in accordance with *BS EN 1997-2-2007.*

4.6.6.5 Undrained Triaxial Tests

This test was used were to obtain the drained shear parameters (i.e. c’ and ’) of the sand layers in the investigation. It involves the shearing of a cylindrical column of soil obtained in- situ to determine its resistance to pressure. Triaxial machine is used, from where two important parameters namely; angle of internal friction and cohesion are obtained. With these, the bearing capacity of the soil is calculated. The test was carried out in accordance with BS 1377:75 Test 13.

4.6.6.6 California Bearing Ratio Test

The CBR test was conducted using the compaction energy as for compaction test. The California Bearing Ratio test was carried out in accordance with *BS EN 1997-1-2004 and BS EN 1997-2-2007, Geotechnics Designs (General Rules and Ground Investigation and Testing respectively).*

4.6.6.7 Presentation of Results

The recovered samples from the sites were taken to the Geotechnical Engineering Laboratory in the Civil Engineering Department of the University of Benin. The following laboratory tests and analysis were conducted alongside the in situ cone penetrometer test (CPT):

- Specific gravity test
- Particle size analysis
- Atterberg limit test
- Compaction
- Unconsolidated Undrained Triaxial test

4.6.6.8 Specific Gravity Test Results

The Average Specific Gravity (A.GS) values for the deep borehole (BH) are presented in Table 4.18.

Table 4.18: Specific Gravity Test Results

S/N	LOCATION	BOREHOLE ID	DEPTH (m)	AGs
1	**Okomu Road**	Point 1	1.5	2.57
2		Point 2	1.5	2.55
3		Point 3	1.5	2.42
4	**Okomu Boiler**	BHI	1.0	2.34
5			3.0	2.46
6			6.0	2.50
7			9.0	2.44
8			12.0	2.52
9			15.0	2.43

Table 4.18 cont'd: Specific Gravity Test Results

S/N	LOCATION	BOREHOLE ID	DEPTH (m)	Ags
10	**Okomu Power House**	BHII	2.0	2.47
11			5.0	2.56
12			8.0	2.43
13			11.0	2.50
14			15.0	2.47
15	**Okomu Clarification Station**	BHIII	2.5	2.44
16			5.5	2.51
17			8.5	2.42
18			11.5	2.44
19			14.5	2.36
20	**Okomu Sterilizer**	BHIV	0.5	2.38
21			3.5	2.30
22			6.5	2.30
23			9.5	2.11
24			12.5	2.21
25			15.0	2.23
26	**Okomu Pressing Station**	BHV	1.5	2.28
27			4.5	2.24
28			7.5	2.28
29			10.5	2.34
30			14.5	2.51
31		BHVI	1.0	2.47

Table 4.18 cont'd: Specific Gravity Test Results

S/N	LOCATION	BOREHOLE ID	DEPTH (m)	Ags
32	**Okomu Storage Tank**	BHVI	4.0	2.47
33			7.0	2.35
34			10.0	2.17
35			13.0	2.42
36			15.0	2.28
37	**Okomu Weigh Bridge**	BHVII	1.0	2.40
38			4.0	2.44
39			7.0	2.19
40			10.0	2.23
41			13.0	2.18
42			15.0	2.25
43	**Okomu Water Tank**	BHVIII	3.0	2.22
44			6.0	2.49
45			9.0	2.47
46			12.0	2.50
47			15.0	2.46
48	**Okomu Ramp I**	BHIX	2.0	2.31
49			5.0	2.33
50			8.0	2.36
51			11.0	2.37
52			14.0	2.37
53	**Okomu Ramp II**	BHX	1.5	2.24

Table 4.18 cont'd: Specific Gravity Test Results

S/N	LOCATION	BOREHOLE ID	DEPTH (m)	Ags
54	**Okomu Ramp II**	BHX	4.5	2.52
55			7.5	2.35
56			10.5	2.36
57			13.5	2.42
58			15.0	2.42

4.6.6.9 Particle Size Distribution Tests Results

The tests were conducted to determine the percentage quantity of individual grain sizes as they occur in particular soil layers. The test results are presented in Table 4.19 and Appendix II. Mechanical sieving was carried out up to 0.075mm sieve.

Table 4.19: Sieve Analysis Test Results

S/N	LOCATION	BOREHOLE ID	DEPTH(m)	PERCENTAGE PASSING SIEVE NO.		
				1.18mm	**0.425mm**	**0.075mm**
1	**Okomu Road**	Point 1	1.5	99.24	78.00	44.12
2		Point 2	1.5	98.50	82.00	60.52
3		Point 3	1.5	97.97	81.00	57.64
4	**Okomu Boiler**	BHI	1.0	97.89	72.85	47.75
5			3.0	98.37	82.60	63.31
6			6.0	98.22	83.53	60.40
7			9.0	97.71	81.64	56.69
8			12.0	98.43	86.63	64.66
9			15.0	98.29	92.29	67.98

Table 4.19 cont'd: Sieve Analysis Test Results

S/N	LOCATION	BOREHOLE ID	DEPTH(m)	PERCENTAGE PASSING SIEVE NO.		
				1.18mm	0.425mm	0.075mm
10	Okomu Power House	BHII	2.0	98.49	79.35	55.91
11			5.0	98.11	81.60	58.98
12			8.0	98.58	85.17	63.56
13			11.0	98.24	85.05	63.50
14			15.0	98.40	85.21	62.82
15	Okomu Clarification Station	BHIII	2.5	97.88	79.23	54.02
16			5.5	98.42	84.54	61.61
17			8.5	98.22	83.22	53.89
18			11.5	98.08	82.46	56.82
19			14.5	98.13	83.00	56.21
20	Okomu Sterilizer	BHIV	0.5	98.64	75.15	43.64
21			3.5	97.94	78.50	53.02
22			6.5	97.99	80.74	55.49
23			9.5	97.74	80.85	52.77
24			12.5	98.02	81.71	53.43
25			15.0	98.29	81.61	57.31
26	Okomu Pressing Station	BHV	1.5	98.78	78.34	48.57
27			4.5	98.11	83.33	61.53
28			7.5	97.48	81.56	50.86
29			10.5	98.08	83.62	53.97

Table 4.19 cont'd: Sieve Analysis Test Results

S/N	LOCATION	BOREHOLE ID	DEPTH(m)	PERCENTAGE PASSING SIEVE NO.		
				1.18mm	**0.425mm**	**0.075mm**
30	**Okomu Storage Tank**	BHVI	14.5	97.43	79.25	49.12
31			1.0	98.28	79.23	51.11
32			4.0	97.91	81.69	55.45
33			7.0	98.03	82.39	54.61
34			10.0	97.08	77.91	49.07
35			13.0	98.38	84.54	60.22
36			15.0	98.05	84.11	58.56
37	**Okomu Weigh-Bridge**	BHVII	1.0	98.51	80.57	54.55
38			4.0	98.50	85.03	64.05
39			7.0	95.51	80.57	54.55
40			10.0	97.65	81.40	52.78
41			13.0	98.29	83.44	59.45
42			15.0	98.20	84.12	57.55
43	**Okomu Water Tank**	BHVIII	3.0	97.68	78.90	51.92
44			6.0	97.35	79.06	53.39
45			9.0	98.27	83.99	55.83
46			12.0	98.51	83.18	57.53
47			15.0	97.97	82.64	60.51
48	**Okomu Ramp I**	BHIX	2.0	98.43	76.66	47.32
49			5.0	98.69	73.77	40.11

Table 4.19 cont'd: Sieve Analysis Test Results

S/N	LOCATION	BOREHOLE ID	DEPTH(m)	PERCENTAGE PASSING SIEVE NO.		
				1.18mm	0.425mm	0.075mm
50	Okomu Ramp I	BHIX	8.0	98.60	76.55	49.19
51			11.0	97.49	75.05	47.17
52			14.0	97.30	73.20	48.95
53	Okomu Ramp II	BHX	1.5	98.97	80.96	51.98
54			4.5	98.67	69.82	35.01
55			7.5	98.34	73.89	43.18
56			10.5	97.88	76.93	55.73
57			13.5	98.17	78.08	52.83
58			15.0	98.29	78.27	47.49

4.6.6.10 Atterberg/Consistency Limits Test Results

The tests carried out under this heading includes Liquid Limit (LL), Plastic Limit (PL), Plasticity Index (PI) and Linear shrinkage (LS), all of which make up the Atterberg Limit test. The results of these tests are presented in Table 4.20.

Table 4.20: Atterberg Limit Test Results

LOCATION	BOREHOLE ID	DEPTH (m)	ATTERBERG LIMIT TESTS			
			LL (%)	PL (%)	PI (%)	PLASTICITY
Okomu Road	Point 1	1.5	36.46	22.03	16.43	CI
	Point 2	1.5	56.85	28.61	28.25	CH
	Point 3	1.5	52.88	27.77	25.12	CH
Okomu Boiler	BHI	1.0	50.15	27.44	22.71	MH
		3.0	52.13	27.79	24.33	MH
		6.0	49.32	25.47	23.85	MH
		9.0	54.48	28.48	25.66	MH
		12.0	52.48	29.94	22.54	MH
		15.0	54.19	25.86	28.33	MH
Okomu Power House	BHII	2.0	49.29	23.37	25.92	CI
		5.0	48.97	27.80	21.17	MI
		8.0	53.43	28.16	25.27	MH
		11.0	50.65	27.78	22.86	MH
		15.0	45.23	25.69	22.54	CI
Okomu Clarification Station	BHIII	2.5	47.28	27.97	20.31	MI
		5.5	53.87	27.02	26.85	MH
		8.5	51.06	27.24	23.82	MH
		11.5	51.85	27.22	24.64	MH
		14.5	52.51	30.23	22.27	MH

Table 4.20 cont'd: Atterberg Limit Test Results

Okomu Sterilizer	BHIV	0.5	45.34	24.55	20.80	CI
		3.5	29.50	27.03	2.47	ML
		9.5	53.35	27.22	26.13	CH
		12.5	45.34	24.55	20.80	CI
Okomu Pressing Station	BHV	7.5	53.32	26.85	26.46	CH
		14.5	51.30	28.67	22.63	MH
Okomu Storage Tank	BHVI	10.0	54.13	25.74	28.39	CH
Okomu Weigh Bridge	BHVII	7.0	52.37	28.09	24.30	MH
		15.0	54.79	29.11	25.69	MH
Okomu Water Tank	BHVIII	6.0	50.87	30.87	20.28	MH
		9.0	49.79	26.38	23.41	CI
		12.0	51.21	27.97	23.24	MH
		15.0	51.41	26.16	25.26	MH
Okomu Ramp I	BHIX	2.0	54.63	27.44	27.19	CH
		5.0	56.70	31.28	25.43	MH
		8.0	56.17	28.50	27.67	MH
		11.0	48.41	27.23	21.18	MI
Okomu Ramp II	BHX	1.5	48.14	28.19	19.95	MI
		7.5	49.50	28.46	21.04	MI
		10.5	48.85	27.23	21.63	MI
		13.5	55.34	25.62	29.73	MH

C=CLAY, M= SILT (M-SOIL), I= INTERMEDIATE PLASTICITY, L= LOW PLASTICITY, H=HIGH PLASTICITY

4.6.6.11 Compaction Tests Results

Compaction tests is used to determine the density beyond which any increment in water content will not have effect on the strength of the soil. From the test, the optimum moisture content and maximum dry densities were obtained as shown below in Table 4.21 for the samples that were tested.

Table 4.21: Compaction Test Results

LOCATION	BOREHOLE ID	DEPTH (m)	MDD (g/cm^3)	OMC (%)
Okomu Road	Point 1	1.5	1.74	13.40
	Point 2	1.5	1.51	21.90
	Point 3	1.5	1.47	25.30
Okomu Boiler	BHI	1.0	1.51	22.50
		3.0	1.48	24.0
		6.0	1.50	23.40
		9.0	1.48	20.60
		12.0	1.44	24.70
		15.0	1.48	23.40
Okomu Power House	BHII	2.0	1.47	20.60
		5.0	1.49	20.10
		8.0	1.49	19.40
		11.0	1.53	24.30
		15.0	1.44	24.80
Okomu Clarification Station	BHIII	2.5	1.51	22.30
		5.5	1.52	22.30
		8.5	1.58	22.30
		11.5	1.49	21.90
		14.5	1.51	22.60
Okomu Sterilizer	BHIV	0.5	1.58	18.90
		3.5	1.48	21.70
		6.5	1.61	18.90
		9.5	1.50	21.60
		12.5	1.55	21.40
		15.0	1.51	21.20
Okomu Pressing Station	BHV	1.5	1.56	19.20
		4.5	1.47	21.60
		7.5	1.55	21.40
		10.5	1.52	23.50
		14.5	1.58	22.00

Table 4.21 cont'd: Compaction Test Results

LOCATION	BOREHOLE ID	DEPTH (m)	MDD (g/cm^3)	OMC (%)
Okomu Storage Tank	BHVI	1.0	1.47	19.60
		4.0	1.48	20.80
		7.0	1.50	21.20
		10.0	1.51	24.90
		13.0	1.49	21.90
		15.0	1.58	21.80
Okomu Weigh Bridge	BHVII	1.0	1.50	20.00
		4.0	1.52	23.50
		7.0	1.49	22.30
		10.0	1.46	24.70
		13.0	1.46	25.30
		15.0	1.55	23.40
Okomu Water Tank	BHVIII	3.0	1.48	26.40
		6.0	1.48	26.40
		9.0	1.49	23.20
		12.0	1.48	21.70
		15.0	1.58	21.80
Okomu Ramp I	BHIX	2.0	1.57	19.20
		5.0	1.68	16.50
		8.0	1.52	19.9
		11.0	1.54	17.80
		14.0	1.51	21.60
Okomu Ramp II	BHX	1.5	1.58	18.70
		4.5	1.73	15.00
		7.5	1.65	17.90
		10.5	1.54	18.90
		13.5	1.62	19.30
		15.0	1.56	20.50

4.6.6.12 Undrained Triaxial Tests Results

The results obtained from Undrained Triaxial Test performed on U2 soil samples recovered from specific depths are presented in Table 4.22.

Table 4.22: Shear Strength Test Results

Location	Borehole ID	Depth(m)	Φ' (°)	C' (KN/m^2)
Okomu Boiler	BH1	3.0	4.00	11.0
		6.0	10.68	37.0
		9.0	6.73	29.0
		15.0	5.88	38.0
Okomu Power House	BH2	2.0	12.68	12.0
		5.0	6.66	58.0
		15.0	9.93	17.0
Okomu Clarification Station	BH3	2.5	12.48	46.0
		8.5	11.49	38.0
		14.5	10.36	37.0
Okomu Sterilizer	BH4	0.5	6.46	18.0
		6.5	7.57	15.0
		12.5	6.16	5.0
Okomu Pressing Station	BH5	7.5	15.64	9.0
		10.5	11.62	18.0
		14.5	10.28	5.0
Okomu Storage Tank	BH6	1.0	13.71	3.0
		7.0	6.22	22.5
		15.5	3.43	46.0
Okomu Weigh Bridge	BH7	4.0	7.97	15.0
		13.0	3.94	24.0
		15.0	22.64	13.0
Okomu Water Tank	BH8	3.0	12.64	45.0
		9.0	5.94	45.0
		12.0	5.0	11.43
Okomu Ramp I	BH9	2.0	20.34	20.0
		8.0	9.15	4.0
		11.0	9.29	35.0
Okomu Ramp II	BH10	1.5	7.93	15.50
		7.5	3.61	24.0
		13.5	10.20	50.0

4.6.6.13 Bearing Capacity Computation Using Parameters from Undrained Triaxial Test The ultimate bearing capacity was calculated for a 1m square pad footing using Meyerhof's equations as shown below:

ˁ 1 cot Ø (3)

ˁ 1 tan 1.4Ø (4)

1 0.2+, /. (5)

1 0.1+, /. (6)

— 1 0.2/+, / (7)

— 1 0.1/+, / (8)

+, !"# 45 Ø/2 (9)

Where;

qult = Ultimate bearing capacity c = Cohesion
Φ = Angle of internal friction
c = Cohesion
Nc, Nq, Nϒ = Bearing capacity factors
sc, sq, sϒ = Shape correction factors
dc, dq, dϒ = Depth correction factors

Table 4.23 below shows the allowable bearing capacity computed at various depths using a factor of safety of 3.5, which is suitable for light industrial projects.

Table 4.23: Computed Allowable Bearing Capacities at Various Depths

Location	Borehole ID	Depth (m)	Ultimate bearing	Allowable bearing capacity (q,all)
Okomu Boiler	BH1	3.0	252	72
		9.0	1453	415
		15.0	1579	451
Okomu Power House	BH2	2.0	402	115
		5.0	1376	393
		15.0	2948	842
Okomu Clarification Station	BH3	2.5	1153	329
		8.5	2403	687
		14.5	3915	1119
Okomu Sterilizer	BH4	0.5	195	56
		6.5	805	230
		12.5	1218	348
Okomu Pressing Station		7.5	1758	502
		10.5	2202	629
		14.5	2326	665
Okomu Storage Tank	BH6	1.0	143	41
		7.0	939	268
		15.5	2575	736
Okomu Weigh-Bridge	BH7	4.0	500	143
		15.0	6284	1795
Okomu Storage Tank	BH8	3.0	1274	364
		9.0	1764	504
		12.0	1882	538
Okomu Ramp I	BH9	8.0	849	243
		11.0	2495	713
Okomu Ramp II	BH10	1.5	273	78
		7.5	839	240
		13.5	4132	1181

4.6.6.14 Dutch Cone Penetrometer Test Results

Cone penetrometer test was carried out at three (3) points. The cone penetration resistance (qc) obtained at specific depths for the three points are shown in Table 4.24.

Several correlations have been drawn to relate ultimate bearing capacity to cone penetration resistance. Meyerhof (1976) suggested a direct method for estimating qult from cone resistance as follows:

3 (10)

—— $\bar{0}$ 1 $_{12.2}$ ^{2} 11 2

Where

q,ult = Ultimate bearing capacity in kN/m^2

$\bar{q}c$ = Arithmetic average of qc values in a zone including footing base and 1.5B beneath footing, in kN/m^2

B = Width of footing, in m Df = Depth of footing, in m

The computed allowable bearing capacities for the specific depths shown in Table 4.23 above are presented in Table 4.25 below, for a 1m square footing. It should be noted that depth was not corrected for, and that a factor of safety of 3.5 was used in the calculations.

Table 4.24: Cone Resistance Obtained at Specific Depths for Points 1, 2 and 3

Depth (m)	CPT1 (kg/cm^2)	CPT2 (kg/cm^2)	CPT3 (kg/cm2)
1.0	25.0	65.0	47.0
2.0	50.0	200.0	65.0
3.0	55.0	220.0	68.0
4.0	64.0	205.0	70.0
5.0	83.0	220.0	75.0
6.0	110.0	250.0	92.0
7.0	130.0	-	105.0
8.0	150.0	-	135.0
9.0	175.0	-	180.0
10.0	200.0	-	220.0
11.0	230.0	-	-

Table 4.25a: Bearing Capacity Computation from CPT from Test Point 1

Depth (m)	Ave. qc(MN/m^2)	qult (kN/m^2)	qall (kN/m^2)
1.0	2.45	402.05	114.87
2.0	4.91	1206.15	344.61
3.0	5.39	1769.00	505.43
4.0	6.28	2573.12	735.18
5.0	8.14	4004.41	1144.12
6.0	10.79	6191.56	1769.02
7.0	12.75	8362.62	2389.32
8.0	14.72	10855.33	3101.52
9.0	17.17	14071.72	4020.49
10.0	19.62	17690.16	5054.33

Table 4.25b: Bearing Capacity Computation from CPT from Test Point 2

Depth (m)	Ave. qc (MN/m^2)	qult (kg/cm^2)	qall (kN/m^2)
1.0	6.38	1045.33	298.67
2.0	19.62	4824.59	1378.45
3.0	21.58	7076.07	2021.73
4.0	20.11	8242.01	2354.86
5.0	21.58	10614.10	3032.60
6.0	24.53	14071.72	4020.49

Table 4.25c: Bearing Capacity Computation from CPT from Test Point 3

Depth (m)	Ave. qc (MN/m^2)	qult (kg/cm^2)	qall (kN/m^2)
1.0	4.61	755.85	215.96
2.0	6.38	1567.99	447.99
3.0	6.67	2187.15	624.89
4.0	6.87	2814.34	804.09
5.0	7.36	3618.44	1033.84
6.0	9.03	5178.39	1479.54
7.0	10.30	6754.43	1929.84
8.0	13.24	9769.79	2791.37
9.0	17.66	14473.77	4135.36
10.0	21.58	19459.18	5559.77

4.6.6.15 California Bearing Ratio Test Result

The California Bearing Ratio test is a depth penetration test for determining the mechanical strength of subgrade beneath new carriageway construction. The CBR test is described in ASTM Standards D1883-05 (for soils place in field), and AASTO T193. The CBR Test is fully described in BS 1377: Soils for civil engineering purposes: Part 4, compaction related tests, and in Part 9: In-situ tests. The California bearing ratio test results for samples tested are presented in Table 4.26 below.

Table 4.26: CBR Tests Results

S/N	Location	Sampling Depth	Pressure Layer	Unsoaked		Soaked	
				2.5mm	5.0mm	2.5mm	5.0mm
1.	Point 1	0.5m	BOTTOM	8.67	8.06	6.44	5.86
			TOP	6.69	6.90	5.53	5.86
2.	Point 2	0.5m	BOTTOM	12.30	10.96	7.52	8.88
			TOP	11.81	11.07	7.59	8.49
3.	Point 3	0.5m	BOTTOM	8.84	10.47	8.59	8.49
			TOP	10.24	10.79	5.45	8.27

4.6.6.16 General Discussion of Index Properties and Soil Classification

Geotechnical investigation to understand the subsurface at the proposed location showed that the site passed most of the criteria that characterises a suitable soil for Civil Engineering construction.

4.6.6.16.1 Specific Gravity

The specific gravity results from the boreholes presented in Table 4.1 ranged from 2.34 to 2.52 for borehole 1, 2.47 to 2.56 for borehole 2, 2.36 to 2.51 for borehole 3, 2.11 to 2.38 for borehole 4, 2.28 to 2.51 for borehole 5, 2.17 to 2.47 borehole 6, 2.18 to 2.44 for borehole 7, 2.22 to 2.50 for borehole 8, 2.31 to 2.37 for borehole 9 and 2.24 to 2.52 for borehole 10 while the road points have specific gravity values ranging from 2.42 to 2.57. The highest specific value of 2.57 was recorded in road point 1, 1.5m .These results obtained from the specific gravity tests indeed show the suitability of the soils as a construction material especially as subgrade materials with respect to the road points.

4.6.6.16.2 Particle Size Distribution

Particle size distribution tests carried out on the Auger Samples showed that the soils have many similarities irrespective of depth. The range of the soil passing the 0.075 mm sieve for borehole I is , borehole II IS 55.91% to 63.56%, borehole III IS 53.89% to 61.61% , borehole IV is 43.64% to 55.49%, borehole V is 48.57% to 61.53% , borehole VI is 49.07% to 60.22%, borehole VII is 52.78% to 64.05 , borehole VIII is 51.92% to 60.51% , borehole IX is , borehole X is 47.49% to 53.77% .For the road points: point I, point II and point III have maximum of 44.92%, 60.52% and 57.64% passing through 0.075 mm sieve. This indicates that the soils contain both fines and sands. According to the American Association of State Highway and Transportation Officials (AASHTO), these soils can be classified as A-7-6.

4.6.6.16.3 Consistency Limit Tests

The extent of fine material in the soil mix was also ascertained using the consistency or Atterberg limit tests. The results obtained showed that the soils from all the boreholes ranges within intermediate to high plasticity silty clay/ sandy silty soil with a maximum plasticity index of 29.73% and liquid limit of 56.85%.

4.6.6.16.4 Compaction Tests

The maximum dry density (MDD) and optimal moisture content (OMC) values which are used to determine the dry unit weight of the soil were obtained from the standard proctor compaction tests carried out on recovered soil samples from specific depths for all the borehole locations. The results show that the range of maximum dry density and optimum moisture content values for road points is 1.47 g/cm^3 to 1.74 g/cm^3 and 13.40% to 25.30% , borehole 1 is 1.44 g/cm^{3}to 1.51 g/cm^3 and 20.60% to 24.70%, borehole 2 is 1.44 g/cm^3 to 1.49 g/cm^3 and 19.40% to 24.80%, borehole 3 is 1.49 g/cm^3 to 1.58 g/cm^3 and 21.90% to 22.60 %, borehole 4 is 1.48 g/cm^3 to 1.58 g/cm^3 and 18.90% to 21.70%, borehole 5 is 1.47 g/cm^3 to 1.58 g/cm^3 and 19.20% to 23.50%, borehole 6 is 1.47 g/cm^3 to 1.58 g/cm^3 and 19.60% to 24.90%, borehole 7 is 1.46 g/cm^3 to 1.55 g/cm^3 and 20.00% to 25.30%, borehole 8 is 1.48 g/cm^3 to 1.58 g/cm^3 and 21.70% to 26.40%, borehole 9 is 1.51 g/cm^3 to 1.68 g/cm^3 and 16.50% to 21.60% while borehole 10 maximum dry density values range from 1.54 g/cm^3 to 1.65 g/cm^3 with optimum moisture content values from 15.0% to 20.50%. Their compaction curves are typical for sandy silt soils and silty clay soils with high plasticity clay as obtained in literature.

4.6.6.17 General Discussion of Strength Results

The allowable bearing capacity of the soil was determined using shear parameters obtained from laboratory triaxial tests and cone penetration resistance obtained from in situ cone penetrometer test (CPT), both of which are shown in Tables 4.24 and 4.25a - 4.25c respectively. It should be noted that the calculations were done assuming a 1m x 1m square footing and a factor of safety of 3.5. In the foundation analysis and design, actual sizes of footings should be used alongside the shear parameters to obtain the adequate bearing capacity.

Comparing the allowable bearing capacities shown in Table 4.24 to those in Table 4.25a – 4.25c, it can be seen that both agree to certain levels. However, the values obtained via calculation using the shear parameters obtained from laboratory tests appear to be more conservative and should therefore be used in the foundation analysis and design. In general, the results of the bearing capacity showed that the soil is relatively firm and high strength foundation can be obtained with a minimum bearing capacity of 110 kN/m^2 at depth 2.0m and factor of safety of 3.5 employed.

4.6.6.18 California Bearing Ratio Results

The result of California Bearing Ratio (CBR) test revealed that the sub-surface strength varies along the road as could be seen in Table 4.26. These should be further checked with moving load of vehicles that will use this route for adequacy as subgrade material.

It was observed that both the unsoaked CBR values and the soaked CBR values were less than 15%, although the unsoaked CBR values recorded higher values than the soaked CBR values. The soaked CBR values were used in this analysis of which the highest value was taken as the CBR value for each chainage. Table 4.26 shows the minimum value of soaked CBR for various road pavement layer. For a subgrade layer, the minimum is between 5 – 11% which is the focal point of this report. Any value found below this range will be subject to capping or subgrade treatment. Recommendations for capping and sub-base layer have been presented in Table 4.27. This fill material should be appropriately compacted by roller compactor after spreading.

4.6.6.19 Conclusion and Recommendation

4.6.6.19.1 Conclusion

From the results and analysis, it was observed that the location for the proposed project is comprised mainly of both fines and sands with high to low plasticity. According to AASHTO and USSC soil classification systems, the soil was classed as A-7-6. This shows that the soil consists of both fines and sands, having low to high degree of plasticity.

In terms of strength, the allowable bearing capacity calculated using shear parameters obtained from laboratory triaxial tests revealed that the soil possesses great potential for an economic foundation.

4.6.6.20 Recommendation

From the analysis, it is evident that the location can provide economic foundation for most infrastructures, including the school that will be built on the site. Though bearing capacity computations from CPT showed that the bearing pressure at depth 2.0 to 6m is higher than 200kN/m^2, the value of 110kN/m^2 should be used as the design bearing pressure. With adequate scarification and compaction, the whole of the site will be put to good use construction-wise.

4.6.6.20.1 Sub-grade Treatment

In exceptional circumstances where the CBR value falls below 2%, a value below which the sub-grade would deform under construction traffic, there are several options open to the designer:

The material can be removed and replaced with a more suitable material. The thickness replaced should be between 0.5m and 1.0m. Irrespective of the quality of the new material a CBR value of just below 2% should be assumed for the sub-grade.

With these soils having cohesive properties, it may be possible to treat the soils using lime. The sub-base and capping is again designed assuming a sub-grade CBR of just below 2%.

For sub-grades with CBR values of 15% and above, the sub-base should have a standard thickness of 150mm, a value determined as the minimum practical for spreading and compaction. This is in accordance with the Design Manual for Roads And Bridges, HD 23/99, Road Note RD/GN/ 042 (Pavement Design for Carriageway Construction), Federal ministry of works, Highway manual and the AASHTO 1993 (Design of Pavement Structures). This is summarised in Table 4.25 for the chainages tested. For sub-grade of elastic modulus below 50 MPa or 5% CBR, strengthening measures are required in order to provide a strong and uniform support for the pavement and to allow road construction vehicles to pass over the sub-grade without damaging the layer. This can be achieved by providing a thick layer of sub-base on the sub-grade but it may be more economical to provide a capping layer of selected materials. The provision of a capping layer over a weak sub-grade avoids the necessity of an extraordinarily thick sub-base, and provides an adequate working platform for sub-base compaction as well as reduces the risk of damage to the sub-grade during construction. The CBR value of the capping layer shall be of at least 15%.

The recommended thicknesses of the capping layer for various CBR values of subgrade for flexible and rigid pavements are shown in Table 4.27. The capping layer can be specified as granular fill material in accordance with Section 6 of the General Specification for Civil Engineering Works.

4.6.6.20.2 Sub - Base

Sub-base shall be specified as granular material in accordance with Section 9 of the General Specification for Civil Engineering Works. Lean concrete is generally not recommended for sub- base application. For flexible pavements, localised shrinkage cracks developed in the lean concrete sub-base would likely propagate upwards through the bituminous surfacing causing reflective cracking at the pavement surface, which reduces the service life of pavement. For rigid pavements, the high rigidity and flexural strength of concrete itself contribute to most of the load bearing function, resulting in very small deflections and pressures induced by vehicular loading on the sub-layers. The purpose of sub-base on rigid pavements is primarily for controlling pumping, which can be achieved by using granular materials.

The thickness of the sub-base layer is determined primarily from the strength of the sub-grade, i.e. the CBR value. The recommended thicknesses and type of sub-base for flexible and rigid pavements are shown in Table 4.27 below.

Table 4.27: Sub-Grade Strength Class and Recommended Minimum Thickness for Capping and Granular Sub-Base

Location	Depth of Sampling (m)	PI (%)	CBR %	Capping Layer (mm)	Granular Sub-Base Layer (mm)	Subgrade Strength Class
Point 1	1.5	16.43	6.44	N/A	200	S3
Point 2	1.5	28.25	8.88	N/A	200	S4
Point 3	1.5	25.12	8.59	N/A	200	S4

4.7 Ecological Environment

4.7.1 Current Status

The vegetation at the proposed project site is presently covered by oil palm and with weed species typical of the lowland rain forest zone in Nigeria. The dominant plants include Guinea grass (*Panicum maximum), Trema orietalis, Alchornea cordifolia,* Siam weed (*Chromoleana odorata*) and *Sida* spp. However, there is a lake (06° 40' 27.4" N and 005° 49' 50.5" E) within the southern part of the plantation where the proposed project will be situated, with some aquatic plant species such as *Nymphaea lotus* and *Pistia stratiotes,Cyrtosperma.*

The results of the biodiversity study indicate the presence of about fourteen (14) fauna species of animal, while about twenty-one (21) Flora species of plants were found as shown in Tables 4.28 and 4.30.

Table 4.28: List of Encountered Fauna Species in the Study Area

S/N	Common Name	Scientific Name	Family Name
1	Tree squirrel	*Protexerus spp*	Sciuridae
2	Giant rat	*Cricetomys gambianus*	Cricetidae
3	Bush fowl	*Francolinus bicalcaratus*	Phasianidae
4	Water snail	*Lymnea spp*	Mollusca
5	Giant land snail	*Archatina archatina*	Mollusca
6	Butterfly	*Paplio spp*	Papilionidae
7	Earthworm	*Lumbricus terrestris*	Lumbricidae
8	Village weaver bird	*Ploceus calcullatus*	Ploceidae
9	Side stripe brown snake	*Bothropthalmus lineatum*	Colubridae
10	Millipede	*Spirostepus aseniansis*	Spirostreptidae
11	Centipede	*Hoxodesmos plaz*	Scolopendridae
12	Honey bee	*Apis milifera*	Apidae
13	Lizard buzzard	*Kalpifalco monogrammicus*	Accipitridae
14	Grass cutter	*Thyronomys swinderianus*	Thronomydae

Source: OOPC – Proposed Mill EIA at Extension Two; Field work, February-March 2019

These fauna animals fall within six (6) classes representing vertebrates and invertebrates. The invertebrates dominate the environment of the study area. The proportion of reptiles when compared with other vertebrates and invertebrates is naturally lower than the mammals and birds.

The species that were found in each site, especially within the plantation can be said to be those that found in the area suitable and are able to meet their needs.

Table 4.29: Population Estimates, Proportions and Diversity Indices of Animal Species Encountered in the Study Area

S/N	Name of animal	Plantation Population estimates/field	Proportion (p)
1	Tree squirrel	59.20	0.0575
2	Giant rat	10.40	0.0101
3	Bush fowl	16.00	0.0155
4	Water snail	0.80	0.0008
5	Giant land snail	1.60	0.0016
6	Butterfly	6.40	0.0119
7	Earthworm	180.00	0.3338
8	Village weaver bird	12.80	0.0237
9	Side stripe brown snake	0.80	0.0008
10	Millipede	20.80	0.0386
11	Centipede	20.80	0.0386
12	Honey bee	3.52	0.0030
13	Lizard buzzard	0.80	0.0008
14	Grass cutter	13.60	0.0252
15	Crab	20.80	0.0386

Total No of Species: 15
Total Population: 368.32
Site Diversity Index: 0.5118

It was also noticed that the floor of the plantation is covered by dry brown litter fall, which may not be able to camouflage reptiles.

The plant species found in all the sample fields of the blocks revealed that *Euphorbia hirta, Eupatorium odoratum, Centrocema spp, Pueraria spp, Ipomea spp, Commelina spp, Pennisetum purpureum and Ludigwa spp* are the most common flora plants that are noticeable in all the block sampled.

The flora found in all the sample plots represents different classes of plants that were grouped into 13 families. The *Solanaceae leguminaceae* dominate the environment of the study area.

The species of plants found at the sample plots show that the environments of the study area are really recuperating from the destruction of vegetation that occurred during the clearing stage. There were no IUCN Red-listed categories of threatened, endangered, rare and endemic plants, medicinal and economic crops at or near the project area.

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Table 4.30: List of Encountered Flora Species in the Study Area

S/N	Common Name	Scientific Name	Family Name
1	Capsicum	*Capsicum spp*	Solanaceae
2	Pawpaw	*Carica papaya*	Cacaceae
3	Goat weed	*Ageratum conyzoldes*	Compositae
4	N.A	*Combretum peniculatum*	Combretaceae
5	Garden egg	*Solanum nigrum*	Solanaceae
6	Pepper	*Capsicum frutescens*	Solanaceae
7	Lemmon grass	*Cymbopogon citratus*	Papilionaceae
8	Water leaf	*Talinium triangulare*	Portulacaceae
9	Mushroom	*Termitomyces spp*	Agaricaceae
10	Awolowo weed	*Chromolaena odorata*	Asteraceae
11	Cats hair	*Euphorbia hirta*	Euphobiaceae
12	Giant grass	*Imperata cylindrica*	Poaceae
13	Giant star grass	*Axonopus compressus*	Giramineae
14	Osetura	*Sida acuta*	Mimosaceae
15	Odukun	*Ipomea batas*	Convolvulaceae
16	Ope	*Elaeis guineensis*	Oil palm
17	Black night shade	*Solanum nigruum*	Solanaceae
18	African allophylus	*Allophyllus Africana*	Sapindaceae
19	Asofeyese (yor)	*Rauwolfia amygdalina*	Apocynaceae
20	Bitter leaf	*Vernonia amygdalina*	Asteraceae
21	Garden egg	*Solanum nigrum*	Solanaceae

Source: OOPC – Proposed Mill at Extension Two; EIA Field work, 2019

4.7.2 Secondary Data on Biodiversity from Similar Project Site (Proposed Extension Two Oil Palm Development Project EIA Final Report December 2016)

The secondary data on biodiversity for the proposed project was obtained from the recent Final EIA report of the same location in 2016. Suffice to say that it is enough for the purpose of the proposed project. The study was conducted on a large expanse of land (11,200 hectares) of which the proposed project site was included. The vegetation type, plant form/species, terrestrial fauna particularly invertebrate species and Wildlife, especially large mammals recorded are presented below.

4.7.2.1 Flora and Fauna Composition

4.7.2.1.1 Flora

The vegetation in the northern part of the proposed site consists of a mosaic of fallow lands, farms, and riparian wetlands along the streams located within the site. The commonest crops under cultivation in the farms include *Manihot esculenta* (cassava), *Musa sapientum* (Plantain), *Zea mays* (corn), and *Dioscorea alata* (yams). The fallow lands are covered by a variety of weeds including *Commelina nodiflora*, *Panicum repens, Indigofera suffruticosa, Chromoleana odorata, Tridax procumbens, Panicum maximum, Axonopus compressus, Ageratum conyzoides, Ipomoea involucrata, Sida acuta, Abuliton* sp., *Costus afer, Smilax anceps, Manniophyton fulvum, Solanumtorvum Ipomoea hirta* and *Cyperus* spp.

Trees within the fallow area of the northern region of the proposed project area include *Baphia nitida, Trema orientalis, Pycnanthus angolensis, Musanga cecropioides, Alchornea cordifolia, Alstoni aboonei, Milicia excelsia,Nauclea spp., Voacanga spp, Terminalia ivorensis,Ricinodendron africanum ,Irvingia gabonensis* and *Bombax* spp. The riparian wetland areas along the streams and *Jemide*River are dominated by swamp loving plants such as *Hallea ciliata, Ancistrophyllum seccundiflorum, Uapaca spp., Musanga cropioides, Anthostema aubryanum, Danielia ogea, Pandanus togoensis,* and *Alchornea cordifolia.* Riparian wetlands area areas of high conservation value as they contain sensitive biota. Aquatic macrophytes encountered include *Cyrtosperma senegalense, Ipomoea aquatica, Leersia hexandra, Crinum sp.* and *Jussiea repens.* The vegetation is generally healthy. The cassava mosaic disease is however prevalent in the study area.

The vegetation in the Southern part of the study area is also similar to that of the northern part but a portion of it is presently covered by oil palm plantation, farmlands, forest regrowth and with weed species typical of the lowland rain forest zone in Nigeria. The dominant plants include Guinea grass (*Panicum maximum), Trema orietalis,* *Alchornea cordifolia*, Siam weed (*Chromoleana odorata*) and *Sida* spp. However, there is a lake (06° 40' 27.4" N and 005° 49' 50.5" E) within the southern part of the proposed project area, with some aquatic plant species such as *Nymphaea lotus* and *Pistia stratiotes,Cyrtosperma.*


Plate 4-1a: Luxuriant growth of cassava in the study area


Plate 4-1b: Part of a plantain farm


Plate 4-1c: A new plantain farm by one of the streams


Plate 4-1d: Part of a yam farm


Plate 4-1e: Part of the fallow land colonised by various weeds, shrubs and trees


Plate 4-1f: A riparian forest is well developed along one of the streams.


Plate 4-1g: River Jemide with emergent aquatic species


Plate 4-1h:The southern part with mainly weed spec

Plate 4-1a to 4-1h: Different Types of Vegetation Recorded at Extension Two

Forest Stratification

Forest stratification was observed in large patches. There were three tree strata, consisting of emergents, canopy and under-storey layers. Other life forms associated with trees were epiphytes and climbers.

Emergent

These are the tallest trees (>35m) scattered within the forest. Their crowns do not touch as they are far apart and tower above the canopy trees. Emergent species encountered during the survey included *Triplochiton scleroxylon*, *Ceiba pentandra*, *Khaya ivorensis*, *Terminalia superba*, *Piptadeniastrum africanum* and *Milicia excelsa*. A *Terminalia sp* tree was above 50m in height and 5m in girth. As these are timber species of value, these forest fragments are susceptible to assault by timber merchants and their collaborators.

Plate 4.2: Emergent vegetation

Canopy Layer

The trees in this layer have their crown touching one another so they form a complete cover (canopy) over the forest, thus casting shade upon the species below. Species found in this layer included *Trema guineensis*, *Antiaris toxicaria*, *Trilepisium madagascariense*, *Malacantha alnifolia*, *Hallea ciliata*, *Alstonia boonei* and *Dacryodes edulis*.

Plate 4.3: Canopy trees

Under-Storey Layer

The trees in this layer are adapted to the little amount of light that filters through the canopy layer. They are smaller in size and some notable characteristics include buttresses at the bases of the stems, relatively thin barks, and drip tips of leaves. Species found included *Olax subscorpioidea*, *Celtis phillipensis*, *Cola millenii*, *Campylospermum flavum*, and *Pycnanthus angolensis*.

The canopies of trees in this layer were infested with epiphytes such as lichens, mosses and ferns, and some vascular plants including *Culcasia scandens* and a variety of orchids. The shrub layer had species like *Abrus precatorius*, *Cnestis ferruginea*, and *Connarus staudtii*. *Paullinia pinnata* occurred at the edge of the forests where there is illumination.

Plate 4.4: Understory Trees with Epiphytes

4.7.2.1.2 Composition of the Fauna

The terrestrial wildlife fauna of the region consist of mammals, birds, reptiles, amphibians and invertebrates.

Mammals

Table 4.31 gives a summary of the mammalian fauna recorded from the study area. A total of 27 species of mammals (excluding bats) were recorded in the area during the period of study. These species belong to 6 mammalian Orders, 16 Families, and 24 Genera. They include the rodents (Rodentia), primates (Primates), pangolins (Pholidota), carnivores (Carnivora), insectivores (Insectivora), and ungulates (Artiodactyla). The rodents were the most dominant mammalian group, excluding bats, constituting about 40% of the total number of mammalian species recorded. Except for the Giant rats, the rodents are small mammals and are very varied in pelage coloration and patterning (Happold, 1987). They are mostly terrestrial and live in burrows, being mostly nocturnal. Because of their large numbers they are neither threatened nor endangered by the proposed project but rather considered a pest to field crops and stored products. They are listed as Least Concert (LC) by the 2014 IUCN Red list.

The primates include the monkeys, galagos and pottos. Monkeys were sighted along the watershed forest in Grid 11, 17 and 18. Mona monkeys (*Cercopithecus mona*) and the White-throated monkeys were seen recently but their population is declining as a result of habitat loss through deforestation for timber and conversion of forest to agricultural land. These monkeys are now restricted to the watershed forest of the Jemide River. The White Throated Monkey is listed in the IUCN Red list (2014) as Vulnerable and will need special attention for protection when clearing and farm operations commence. Pottos and galagos have been reported by trappers and hunters. Although their population is declining, they were considered as Least Concern by the IUCN Red list.

The carnivores are represented by small to medium-sized species of civet, genet and mongoose. They are all rare and may be threatened by habitat loss and over-exploitation by humans for food. They were considered as Least Concern by the IUCN Red list.

Amongst the Artiodactyla (even-toed ungulates) only the antelopes (family Bovidae) and bush pigs (family Suidae) were reported to occur in the area. They are commonly found in the area and may not be threatened immediately by the project. However, as the forest becomes more accessible to hunters/trappers due to the project, these wildlife species will be seriously threatened. The buffalo was reported to be present in the past but this species has not been recorded in the area in the last 5 years and may be locally extinct. All the Artiodactyla are considered as Least Concern by the IUCN Redlist.

The pangolins (Order Pholidota) were represented by a single species of tree pangolin, or White-bellied Pangolin *Manis tricuspis* = *Phataginus tricuspis*. This species is considered as Vulnerable by the IUCN Red list. Table 4.31 gives a checklist of all the mammalian fauna found in the area of study.

Table 4.31: Number of Species, Genera and Families of Mammals (Excluding bats)

Order	**Family**	**Genera**	**Species**
Rodentia	6	6	11
Primates	3	4	4
Artiodactyla	2	3	4
Carnivora	2	5	5
Insectivora	2	2	2
Pholidota	1	1	1
Total	**16**	**21**	**27**

Source: Extension Two Oil Palm Development Project; EIA Final Report December 2016

Birds (Avifauna)

The avifauna of the region represents the diverse habitat types in the region. The habitats include secondary forest at various successional stages, farmlands (including cassava, yam) and freshwater swamp forest in the northern part of the concession and oil palm plantation in the south. A total of 49 species were recorded. Birds' characteristic of primary forest or old growth secondary forest such as hornbills, turacos, various bulbuls, flycatchers, and eagles were found in the primary forest fragment near the *Jemide River*.

Seed and insect eating birds dominated the farmlands and oil palm plantation in the southern part of the concession within the proposed project area. They include bulbuls, barn swallows, swift, wagtails, waxbills, pin-tailed whydahs, common thrush, kingfishers and sunbirds. These species gives a clear indication of habitat change.

Common raptors in the proposed project area include hawks, hawk-sparrow, kites, buzzards, palmnut vultures and martial eagles.

Moreover, only a few species restricted to the Guinea-Congo Forest Biome, were identified during the assessment. These include the White-Thighed Hornbill (*Bycanistes albotibialis*), African Emerald Cuckoo (*Chrysococcyx cupreus*), Yellow-Crested Woodpecker (*Thripias xantholophus*) and White-Breasted Negro finch (*Nigrita fusconotus*). Plate 4.5 shows some of the bird species recorded from the proposed project area.

The proposed project area is not located within any Important Bird Area (IBA) as defined by Birdlife International. The nearest being the Okomu National Park, approximately 60 km, in Ovia Southwest Local Government Area, Edo State, Nigeria.

Table 4.32: A Checklist of Avifauna of the Proposed Project Area

Family	Scientific Name	Common Name	IUCN Status
Accipitridae	*Gypohierax angolensis*	Palm-Nut Vulture	Least concern
Accipitridae	*Polyboroides radiatus*	Harrier Hawk	LC
Accipitridae	*Polemaetus bellicosus*	Martial Eagle	LC
Accipitridae	*Milvus migrans*	Black Kite	LC
Accipitridae	*Kaupifalco monogrammicus*	Lizard Buzzard	LC
Alcedinidae	*Halcyon malimbica*	Blue-Breasted kingfisher	LC
Alcedinidae	*Halcyon senegalensis*	Woodland Kingfisher	LC
Alcedinidae	*Alcedo cristata*	Malachite kingfisher	LC
Apodidae	*Cypsiurus parvus*	African Palm-swift	LC
Ardeidae	*Bubulcus ibis*	Cattle Egret	LC
Bucerotidae	*Bycanistes subcylindricus*	Black-and-White Casqued Hornbill	LC
Bucerotidae	*Tockus fasciatus*	African Pied hornbill	LC
Capitonidae	*Pogoniulus bilineatus*	Yellow-Rumped Tinkerbird	LC
Capitonidae	*Pogoniulus subsulphureus*	Yellow-Throated Tinkerbird	LC
Cisticolidae	*Cisticola erythrops*	Chattering Cisticola	LC
Columbidae	*Turtur tympanistria*	Tambourine Dove	LC
Columbidae	*Streptopelia senegalensis*	Laughing Dove	LC
Columbidae	*Streptopelia semitorquata*	Red eyed Dove	LC
Coraciidae	*Eurystomus glaucurus*	Broad-Billed Roller	LC
Columbidae	*Turtur afer*	Blue-spotted Wood dove	LC
Corviidae	*Corvus albus*	Pied Crow	LC
Cuculidae	*Centropus senegalensis*	Senegal Coucal	LC
Cuculidae	*Centropus grilli*	Black Coucal	LC
Cuculidae	*Chrysococcyx caprius*	Didric cuckoo	LC
Estrildidae	*Nigrita fusconotus*	White Breasted Negrofinch	LC
Estrildidae	*Lonchura cucullata*	Bronze Mannikin	LC
Estrildidae	*Nigrita canicapillus*	Grey-Headed Negrofinch	LC
Estrildidae	*Lonchura bicolor*	Black and White Mannikin	LC
Hirundinidae	*Hirundo nigrita*	White-Throated Blue Swallow	LC
Hirundinidae	*Hirundo aethiopica*	Ethiopian Swallow	LC
Meropidae	*Merops pusilus*	LittleBee-Eater	LC
Meropidae	*Merops albicollis*	White-throated bee-eater	LC
Motacillidae	*Motacilla flava*	Yellow Wagtail	LC
Motacillidae	*Macronyx croceus*	Yellow-Throated Longclaw	LC
Nectariniidae	*Hedydipna collaris*	Collared Sun-bird	LC
Nectariniidae	*Cinnyris cupreus*	Copper Sun-bird	LC
Nectariniidae	*Cinnyris superbus*	Superb Sunbird	LC
Numididae	*Numida meleagris*	Helmented Guinea Fowl	LC
Passeridae	*Passer griseus*	Northern Grey-Headed Sparrow	LC
Picidae	*Dendropicos goertae*	Grey Woodpecker	LC

Picidae	*Dendropicos gabonensis*	Gabon Woodpecker	LC
Ploceidae	*Ploceus cucullatus*	Village Weaver	LC
Pycnonotidae	*Pycnonotus barbatus*	Common Bulbul	LC
Pycnonotidae	*Andropadus virens*	Little Greenbul	LC
Pycnonotidae	*Thescelocichla leucopleura*	Swamp Palm Bulbul	LC
Sylviidae	*Hylia prasina*	Green Hylia	LC
Turdidae	*Turdus pelios*	African Thrush	LC
Viduidae	*Vidua macroura*	Pin-Tailed whydah	LC

Plate 4.5a: White-throated Bee-eater, *Merops albicollis*

Plate 4.5b: Little Bee-eater, *Merops pusillus*

Plate 4.5c: Red-eyed Dove, *Streptopelia vinacea*

Plate 4.5d: Pied Crow

Plate 4.5a-5d: Bird Species Recorded at Project Site

Source: Extension Two Oil Palm Development Project; EIA Final Report December 2016

Plate 4.6: Different Bird nests in the project area

Source: Extension Two Oil Palm Development Project; EIA Final Report December 2016

Invertebrates: Arthropods and Molluscs

Arthropods collected were represented mainly by the Lepidoptera (butterflies), Coleoptera (beetles), Isoptera (termites), Orthoptera (grasshoppers), Hemiptera (bugs) and Diptera (flies). Land molluscs were represented by over thirty species of snails belonging to the families Achatinidae, Streptaxidae, Subulinidae, urocyclidae, and Veronicellidae.

Plate 4-7a: Butterflies

Plate 4-7b: Prey mantis,

Plate 4-7c: Dragonfly

Plate 4.7a to 4-7c: Arthropods from the proposed project area

Source: Extension Two Oil Palm Development Project; EIA Final Report December 2016

Amphibians and Reptiles

The reptiles were represented by chameleons, geckos, monitor lizards, agama lizards, snakes, skinks, and tortoises. There are reports of the presence of the long snouted crocodiles in the lake within the southern part of the project area. However, none was sighted during the study. A total of 14 species of reptiles and ten (10) amphibian species were recorded in the proposed project area. Apart from the crocodiles and the royal python most reptilian and amphibian species are neither endangered nor threatened. The amphibians were represented mainly by different types of frogs and toads including the African Tree frogs and the Tongueless frogs. A checklist of the amphibian and reptilian species found or reported is listed in Table 4.33 below.

Table 4.33: Checklist of Reptiles and Amphibians Reported from the Proposed Project Area

Order	Family	Common name	Scientific name	Abundance	IUCN status
Chelonia	Testudinidae	Tortoise			
		Serrate Hinge-back tortoise	*Kinixys erosa*	Rare	LC
Crocodilia	Crocodylidae				
		Dwarf Crocodile	*Osteolaemus tetraspis*	Rare	V
Squamata	Agamidae	Agama lizard	*Agama agama*	Abundant	LC
	Gekkonidae	Wall Gecko	*Hemidactylus brooki*	Abundant	LC
	Scincidae	Skinks	*Mabuya sp*	Abundant	LC
			Lygosoma sp	Abundant	LC
			Melanoceps sp.	Abundant	LC
	Varanidae	Nile Monitor	*Varanus niloticus*	Rare	LC
	Boidae	Royal Python	*Python regius*	Rare	LC
	Colubridae	Common Snakes			
		Common Nigerian File Snake	*Mehelya crossi*	Abundant	LC
		The Lined House Snake	*Boaedon lineatus*	Abundant	LC
		the Common Hedge Snake	*Philothamnus irregularis*	Abundant	LC
	Elapidae	Black Cobra	*Naja melanoleuca*	Abundant	LC
	Viperidae	common vipers	*Vipera sp.*	Abundant	LC
Amphibians	Bufonidae	Toads	*Amietophrynus maculates*	Abundant	LC
	Dicroglossidae	True frogs	*Hoplobrachus occipitalis*	Abundant	LC
	Arthroleptidae		*Leptopelis hyloides*	Rare	LC
	Phrynobatrachidae		*Phrynobatracus sp*	Abundant	LC
	Hyperoliidae	Treefrogs	*Afrixalus dorsalis*	Rare	LC
			Hyperiolius fusciventris	Rare	LC
	Ptychadenidae		*Ptychadena longirostris*	Abundant	LC
			Ptychadena oxyrynchus	Abundant	LC
			Ptychadena pumlio	Abundant	LC
			Chiromantis rufescens	Rare	LC

Source: Extension Two Oil Palm Development Project; EIA Final Report December 2016

4.8 Socioeconomic and Social Impact Assessment

A quick appraisal of socioeconomic situation of the ten affected communities was carried out in March 2018 against what was reported in 2014 during Extension Two Oil Palm Plantation Development project. The proposed project was introduced to the affected communities when the study was conducted. The Extract of the study in 2014 is thus presented as follows:

4.8.1 Communities

There are ten communities surrounding the proposed project. The respective locations of the communities in relation to the proposed project are as follows:

4.8.1.1 Agbanikaka Community

Agbanikaka, which translates to "The Land of Peace", is an Uhobe community in Ovia North East Local Government Area in Edo State, Nigeria. The community is in the North-West of the Extension and shares boundaries with Sabogida, Ijagba, Owan, and Sobe in the North, South, East and West respectively.

4.8.1.2 Owan Community

Owan, which translates to "The land that protects its children", is an Uhebe community in Ovia North East Local Government Area in Edo State, Nigeria. The community is in the North-West of Extension Two, and shares boundaries with Sabongida, Ofutebe, Uhiere, and Agbanikaka in the North, South, East and West respectively.

4.8.1.3 Uhiere Community

Uhiere, which translates to "The Land of Peace", is an Ishan community in Ovia North East Local Government Area in Edo State, Nigeria. The community is in the West of the project site and shares boundaries with Oke, Ofutebe, Odiguetue and Owan in the North, South, East and West respectively.

4.8.1.4 Odiguetue Community

Odiguetue, which translates to "The Land of dignity", is an Edo community in Ovia North East Local Government Area in Edo State, Nigeria. The community is in the South-West of the project site and shares boundaries with Okokhuo, Oke, Uhiere and Odighi in the North, South, East and West respectively.

4.8.1.5 Odighi Community

Odighi, which translates to "The Land of honey", is an Ozoguo community in Ovia North East Local Government Area in Edo State, Nigeria. The community is in the South-West of the project site and shares boundaries with Idunmowo, Oke, Osasinmwonoba, and Uhiere in the North, South, East and West respectively.

4.8.1.6 Ihrue Community

Ihrue, which translates to “The Land of evil blood”, is a Benin community in Uhunmwonde Local Government Area in Edo State, Nigeria. The community is in the East of the project site and shares boundaries with Oke, Iruekpe, Ekpan and Ikhuo in the North, South, East and West respectively.

4.8.1.7 Oke Community

Oke, translates to “The Land surrounded by hills”, is a Benin community in Uhunmwonde Local Government Area in Edo State, Nigeria. The community is in the East of the project site and is one of the oldest communities based on oral history.

4.8.1.8 Ekpan Community

Ekpan, which translates to “The Land of Peace”, is a Benin community in Uhunmwonde Local Government Area in Edo State, Nigeria. The community is in the East of the project site. The community which is about 2 square kilometers in size (in-dwelling) is made up of four quarters namely Dumeso, Idueke, Ukpoka and Egohie. It shares boundaries with Isa West, Owan, Irhue and Umuokpe-Irhua in the North, South, East and West respectively.

4.8.1.9 Umuokpe Community

Umuokpe, which translates to “The Land of Prosperity”, is a Benin community in Uhunmwonde Local Government Area in Edo State, Nigeria. The community is in the North-East of Extension Two. It is about 2 square kilometers in size (in-dwelling) and is made up of three quarters and seven compounds. The community shares boundaries with Orhua, Ekpan, Isan West and Owan in the North, South, East and West respectively.

4.8.1.10 Orhua Community

Orhua, which translates to “The Land of humility”, is a combination of Ishan and Benin community in Uhunmwonde Local Government Area in Edo State, Nigeria. The community is in the North-East of the project site and shares boundaries with Iruekpen, Umuokpe, Isan West and Owan in the North, South, East and West respectively.

4.8.2 Study Approach and Methodology

Methodology adopted for the study in the affected communities involved triangulation of various sources of data with the use of tools relevant to Participatory Rural Appraisal (PRA) and Socio-Economic Assessment.

The following steps were undertaken at ensuring the successful outcome of the study:

- Formal stakeholders' meetings with the ten local communities of the proposed project at Extension Two (FGD)
- Scoping: This is the process of identifying, defining and prioritizing the social components to be addressed in the social assessment. The impact of the proposed project was assessed in terms of the following impact criteria:

  - ✓ *Scale*: Physical scale/areas which the impact would be felt (local or regional).
  - ✓ *Duration*: Length of time the impact would likely be felt (short term, medium term and long term).
  - ✓ *Severity*: The intensity of the impact.
  - ✓ *Direction*: Whether the impact would be positive (beneficial) or negative (adverse).

4.8.2.1 Data collection

To facilitate accurate information dissemination from each community,

- Structured check-lists were used to enlist information and data in the ten communities as well as other internal and external stakeholders of the respective communities such as community executives, Local Government representatives, CBOs and NGOs, and so on.
- Interview of key informants in each community to obtain divergent views on the issues at stake and how to address them.

4.8.2.2 Review of relevant document

Secondary data were gathered from journals, archives, publications and internet. The gathering and review of published and unpublished baseline/project data were not left out.

4.8.2.3 Field Work

Socio-economic survey and SIA of the proposed project communities were concurrently conducted as outlined in Table 4.34 below.

Table 4.34: Schedule of Socioeconomic and SIA exercise

Communities	SIA Field Exercise	Attendance	Checklist authentication
Agbanikaka	18th March, 2014	27	Ikpefuran Sunday - 08038157678
Owan	19th March, 2014	28	Elder Clement Ugboiyobo
Uhiere	20th March, 2014	35	Francis Obanor - 08182731748
Odigwetue	20th March, 2014	36	John Ehigia - 08182401090
Odighi	24th March, 2014	27	Flamingo Dajide - 08077220988
Oke- Irhue	20th March, 2014	53	Ohiengbe Sylvester - 08134266005
Ihrue	24th March, 2014	15	Samuel Alohan (08031259221)
Umuokpe	25th March, 2014	15	(Community Secretary - 08086792306)
Epkan	24th March, 2014	13	Matthew Omoniyi (07031259895)
Orhua	25th March, 2014	10	O.C. District Forest Chairman - 08066318167

Source: Extension Two Oil Palm Development Project EIA Final Report December 2016

4.8.2.4 Duration of Study

The socioeconomic and social impact assessment study including data collection and fieldwork in the ten communities was conducted between March and May 2014.

4.8.3 General Baseline Socioeconomic Conditions

4.8.3.1 Household Demographics

From communities sources the demographic data are summarized in Table 4.35 below while the cumulative population of all the affected communities is **25,500**. A dominant feature of the structure of the population of the Extension Two affected communities is its significant level of young people with over 80% of the population below the age of 45 years. Adults in the age group 45 years and above constitute about 16% of the population. The male to female ratio is more or less even.

Table 4.35: Demographic Data

S/No.	Community	Children	Youth	Adult	Total	LGA	Male	Female
1	AGBANIKAKA	1,200	800	300	2,300	OVIA NORTH EAST	1,300	1,000
2	OWAN	1,500	1,000	500	3,000	OVIA NORTH EAST	1,400	1,600
3	UHIERE	600	1,200	200	2,000	OVIA NORTH EAST	1,000	1,000
4	ODIGWETUE	1,500	2000	1000	4,500	OVIA NORTH EAST	2,200	2,300
5	ODIGHI	1,000	1500	500	3,000	OVIA NORTH EAST	1,400	1,600
	SUB-TOTAL	**5,800**	**6500**	**2500**	**14,800**		**7,300**	**7,500**
6	IHRUE	400	800	300	1,500	UHUNWONDE	800	700
7	OKE-IHRUE	2,000	1600	400	4,000	UHUNWONDE	2,100	1,900
8	EKPAN	500	700	300	1,500	UHUNWONDE	700	800
9	UMUOKPE	400	600	200	1,200	UHUNWONDE	500	700
10	ORHUA	600	1,600	300	2,500	UHUNWONDE	1,300	1,200
	SUB-TOTAL	**3,900**	**5,300**	**1500**	**10,700**		**5,400**	**5300**
	GRAND TOTAL	**9,700**	**11,800**	**4,000**	**25,500**		**12,700**	**12,800**

Source: Extension Two Oil Palm Development Project EIA Final Report December 2016

The population distribution is skewed towards youth and the implication is that unless they are productively engaged in proposed Extension Two project, they may constitute a social/security risk as soon as their farmland is taken over by the project.

4.8.3.2 Housing

Housing is one of the three essential things of life and the housing pattern of the people in the ten affected communities of proposed Okomu Extension Two project is below MDG goals with only 29% living in cement block houses. Table 4.36 shows the housing summary on community basis.

Table 4.36: Housing Patterns of affected Communities

S/N		Thatched roof (%)	Shed for relaxation (%)	Zinc roof (%)	Mud house (%)	Block & Cement (%)
1	Agbanikaka	3	10	12	50	25
2	Owan	3	7	20	60	10
3	Uhiere	1	2	2	80	15
4	Odiguetue	1	2	2	10	85
5	Odighi	1	5	14	60	25
6	Ihrue	4	3	8	50	35
7	Oke- Ihrue	1	4	5	70	20
8	Umuokpe	1	3	6	70	20
9	Orhua	4	3	3	65	25
10	Ekpan	5	5	10	45	35
	AVERAGE	**2**	**5**	**8**	**56**	**29**

Source: Extension Two Oil Palm Development Project; EIA Final Report December 2016

4.8.3.3 Infrastructure

It was obvious that all the ten communities of the proposed project lack virtually all the desirable basic infrastructural facilities. There are four (4) abandoned reticulated water & three (3) neighbourhood water schemes which are malfunctioning therefore, no portable water for most population in the affected communities.

Plate 4.8: Umuokpe Malfunction Water Scheme

Plate 4.9: New Water Scheme Project at Umuokpe Community By OOPC

Plate 4.10: Odiguetue Abandoned Water Scheme

Plate 4.11: First Borehole Project at Odiguetue by OOPC

Plate 4.12: Town Hall Project at Odiguetue Community by OOPC

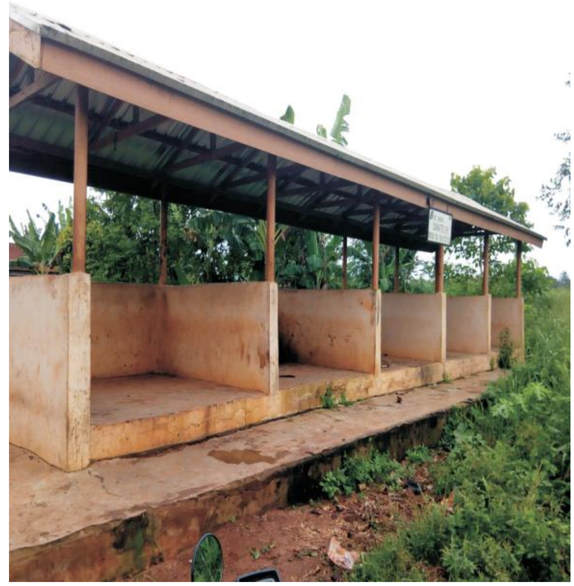


Plate 4.13: New Market Stalls at Odiguetue Community by OOPC

Oke-Irhue community is one of the oldest communities based on oral history, and till date the little infrastructure there, such as road, health centre care all dilapidated. Odighi community has some infrastructural facilities, which are mostly non-functional.

Plate 4.14: New Borehole at Irhue Community By OOPC

Plate 4.15: New Market Stalls at Irhue Community By OOPC

Plate 4.16: New Town Hall at Irhue Community By OOPC

4.8.3.4 Agriculture and Household Nutrition

Farming and agricultural activities are rain fed and on subsistence level. Men are more into farming (usually with the assistance of children/youth) than women. A wide range of crops is cultivated especially cocoa, plantain/banana, maize, cassava, vegetables and root/stem crops. Apart from being one of the main traditional occupations of the people, it is also practiced mostly by the natives due to the community's land ownership structures.

The assets used in agricultural activities are as follows:

Human Assets: The people employ traditional farming skills such as:

- Land management skills, like rotational bush fallowing, in cultivation of crops
- Maintenance of local farm tools
- Fairly good marketing skills but growth and opportunity in the commodity value chains have not been used to their advantage.

Natural Assets: These include farmland, soil and topography and favorable climate.
Physical Assets: Farmers own hoes, cutlass, spades, wheelbarrow, basins, basket and other equipment.

Social Assets: There is low level of social cooperation due to subsistence level of farming practice as well as poverty.

The rainy season (March/April to September/October is associated with peak cropping seasons especially arable crop cultivation whilst the dry season is used for harvesting, marketing and land preparation for the next farming season.

The level of poverty in all the communities is pretty high as the standard of living is really low. Though the communities are rich in agricultural produce, due to the lack of processing facilities, most of their crops get spoilt early because of lack of storage facilities for these produce as was reported in 2014.

4.8.3.5 Education

There is no marked discrimination in access to education gender-wise, although the only few primary schools and two secondary schools in the Extension Two communities have positive correlation with the school enrolment rate. The informal education facilities and the adult learning programmes are non-existent in all the communities. It is worth mentioning that the educational attainment / literacy level amongst the community people is below average. There is however skewed literacy rate in favor of men compared to women.

4.8.3.6 Health

All the four (4) health centres in the communities need staffing, equipment and drugs as reported in 2014 (see Plate 4.17 and Plate 4.18) while the new clinic and equipment donated by Okomu Oil Palm Company Plc to Odighi community is depicted in Plate 4.19 to Plate 4.22 below.

Plate 4.17: Odiguetue Health Centre with Old beds

Plate 4.18: Umokpe Nursing Home

Plate 4.19: Her Excellency Lara Oshiomole Commissioning Odighi Clinic

Plate 4.20: Odighi Clinic Built By Ovia North East L.G.A and Equiped By OOPC

Plate 4.21: Some of the Hospital Beds Donated By OOPC

Plate 4.22: Gen Set at Odighi Clinic Donated By OOPC

4.8.3.7 Livelihood Strategies

Economic activities of Extension Two communities are relatively diverse although on small and medium scales. Traditional occupations of the people of the affected communities include subsistence farming, lumbering and agro-based trading. These livelihoods are practiced alongside other gainful non-traditional economic activities such as commercial transportation, civil service, contracting and artisans. There are fertile soils for farming; rivers for fishing & water transport, timber for lumbering as well as forest products as natural resource use in the most of the affected communities.

4.8.3.8 Income and Expenditure

The measurement of income level is generally a major problem in Nigeria because of the reluctance of respondents to give accurate information on their real income. Moreover, there are problems in quantifying the real income of the rural working population because a good proportion of their produce is consumed directly and does not enter the market.

There are various forms of social capital available to households in the community notably family support, exchange of labour, group activities, association and cooperative groups. The main sources of income of households and individuals are from occupations / activities like farming, trading and rendering of various services. Generally, there is poor income security in virtually all the communities.

4.8.3.9 Belief Systems and Sacred Sites

Sacred sites are places within the landscape that have a special significance under Aboriginal tradition. Hills, rocks, waterholes, trees, plains and other natural features may be sacred sites. In coastal and sea areas, sacred sites may include features which lie both above and below water. There are sacred sites in some of the communities such as Agbanikaka and Odighi. In Agbanikaka, there are two shrines that is, Osun Shrine and a sacred shrine called Ose River Shrine. It was said that Odiguetue community has a lake called Odighi Lake and they have a shrine beside the lake. The locations of these sacred sites in Extension Two land are in the South West and North West.

Some belief systems are localized while some cut across the ten communities. Uhiere has two main rivers (Ikpesira and Abumeri). The Ikpesira River has great law guiding it like; no one is allowed to visit it at night, no woman in her period is allowed to visit it, it forbids fishing and the pouring of oil on it; while the Abumeri River forbids the killing of its fishes only.

The community frowns greatly at having sex with married women (another man's wife), the use of "juju" is a taboo and also no use of gun or cutlass when fighting, and stealing is also a taboo. The Oke River is one of their main sources of water but the River forbids the washing of oil and killing of the fish.

4.9 Social Impact Assessment

4.9.1 Baseline Social Situation

A baseline assessment provides information on the situation the study aims to change. It provides a critical reference point for assessing changes and impact, as it establishes a basis for comparing the situation before and after an intervention, and for making inferences as to the effectiveness of the program. Baseline assessments should be conducted before the actual programme intervention starts so as to serve as a benchmark for examining what change is triggered by the intervention. The baseline situation information was obtained through direct observation and local talent and knowledge of communities. The direct observation is nothing less than "Visual inspection" which is the quickest and best way to check issues of location, scale and proximity that determine many impacts. Stakeholders and local communities have local knowledge that you need. And, impacts depend on what those that are affected value and need!

The results of baseline situation as related to the people of the communities to be affected by the proposed Extension Two project are presented as follows:

People's way of life: Based on the empirical data gathered from the FGD and key informants from the various communities it is obvious that the people are majorly farmers with a few into some forms of trade. They tend to be more bounded by the common interests they share as farmers. Apart from Odiguetue and Oke that have internal crisis among themselves and the SIA team identified them as social hot spots, other communities are peaceful and are receptive to strangers. During the study of the various communities we were informed that some criminals from Oke went to the bush and killed a young man from Uhiere who attempted to run when he was about to be robbed. Few days later we also heard that another person was shot dead at Oke due to conflict among groups of youths. Even during pre-entry visit to the community some members of Oke community presented such a high level of antagonism that neither the study team nor the company is welcomed. Other communities such as Owan, Odighi, Agbanikaka, Uhiere are very harmonious in their day to day live, and tend to work for the overall interest of the community members.

Their culture: The ten communities have similar culture in the way of greetings, marriage, tradition and other norms and values. Some of their traditions or community dos and don'ts include – no fighting in the bush and with dangerous weapon; no love making in the bush; no sexual advances from any man to a married woman. But a community like Owan places emphasis on no usage of charms against any other person the community. It is their belief that River Owan is not friendly to strangers – hence, it is advised that strangers beware. The Owan, Agbanikaka and Uhiere are a multi ethnic communities but the predominant language among them is Owan language; for Oke, Umopke, Epkan and Orhua the dialect is basically Ishan. But Odiguetue, Odighi and Irhue are Benin speaking people. Odighi and Uhiere both have sacred rivers that are not accessible.

***Their environment*:** On the general perspective their environment is clean and habitable. No exposures to hazardous and dangerous chemicals; no epidemic outbreak whatsoever. The air is generally clean. However, the pathetic condition of their source of portable water can lead to water borne diseases. Owan River demands an urgent attention due to some community members who deposit waste substances therein or use chemical to kill fish from the river.

One of the major problems in some of the communities is erosion and flooding. During the peak of rainy season the western part of Owan land is cut off from the community for about three months. To the extent that the two major rivers around Ose and Owan meet at some point and making the major road to Benin partially impassable for about two to three days. Likewise at Irhue – the only security outfit Nigerian police Force was forced out of the location because of flooding.

The physical safety of most of the communities is threatened at a particular period of the year because of the activities of Fulani herdsmen armed with sophisticated rifles and who without regard enter into farmlands with their cattle, when challenged for this provoking action they either attack the males or rape the females in the communities.

Their Health and Wellbeing: The health status is average as in a normal Nigerian community setting. But the people are majorly affected by malaria and typhoid fever. The lack of healthcare facilities in most of the communities also place the community members at risk most especially pregnant and nursing mothers.

Their Level of Education: Although no educational status related questions were asked but from our observation most men can express themselves either in pidgin or simple English but the case is different with women. However, there are some graduates from various institutions and some other persons with vocational skills. There is opportunity to develop capacity and competencies even further most especially in the agricultural sector.

Their Personal and Property Rights: The land use and ownership of the proposed Extension Two project communities is mainly for farming and gathering of forest products and there is no case of share-croppers in the community at present.

4.9.2 Mitigating Adverse Social Impacts

Impacts are matched to mitigation actions. Mitigation is the implementation of measures designed to reduce the undesirable effects of a proposed action on the people and/or environment. The types of mitigation measures are contained in the Table 4.37 below.

Table 4.37: Types of Mitigation Measure

Type of mitigation measure	**How it works**
Prevention and control measures	Fully or partially prevent an impact/reduce a risk by: -Changing means or technique -Changing or adding design elements -Changing the site -Specifying operating practices
Compensatory measures	Offset adverse impacts in one area with improvements elsewhere.
Remediation measures	Repair or restore the environment after damage is done.

4.9.3 Summary of SIA

Based upon the findings, the proposed project at Extension Two showed generally positive social consequences in the affected communities. However, there are considerable adverse social impacts enumerated by community stakeholders and perceived by the study team, which require urgent attention and mitigation measures in order for Okomu Oil Palm Company Plc to achieve social security in the project area.

Table 4.38 below is the status of the management and mitigation measures proposed in 2016 for adoption and implementation to address the significant potential social and environmental impacts in order to make the proposed project socially acceptable and beneficial:

Table 4.38: The Proposed Management and Mitigation Measures for the Communities in 2016 and Current Situation in 2019

S/No.	Proposed Management and Mitigation Measures	Present Situation in 2018	Remarks
1.	Implement FPIC	FPIC Process concluded 2016.	FPIC Agreements with the communities signed 29, July 2016 which were late notarized and delivered to the communities.
2.	Develop and implement community engagement plan	The company has developed a Stakeholders Engagement Procedure	
3.	Avoidance of displacement of communities and people.	No community and people were displaced	
4.	Identification, demarcation and appropriate management of traditional conservation areas and other high conservation values in the landscape.	All identified HCV's are presently being conserved	High Conservation Values (HCV's) were identified and being conserved
5.	Prevention of pollution of water resources.	Ongoing	Quarterly water monitoring is being conducted
6.	Ensuring proper participatory disengagement and payment of compensation to farmers using the land.	Done	Compensation duly paid by former owner (A & Hatman)
7.	Fire prevention programmes and zero or controlled burning.	No burning is being done	
8.	Corporate social services to communities.	On going	
9.	Provision of healthcare services and HIV prevention.	Equipping of Odighi Community clinic	
10.	Diligent implementation of social impact management plan	Implementation Ongoing	

Table 4.39: List of Communities in Extension 2 with Projects and the Year of Execution

S/N	COMMUNITIES	PROJECTS	YEAR
1	**OKE**	BOREHOLE PROJECT AT OKE COMMUNITY	2017
		CORPERS LODGE AT OKE COMMUNITY	2017
		SECOND BOREHOLE AT OKE COMMUNITY	2017
		RENOVATION OF SCHOOL	2016
		THIRD BOREHOLE AT OKE COMMUNITY	2018
		OKE COMMUNITY TOWN HALL	2018
		CONSTRUCTION OF DOUBLE SEATER DESK & CHAIRS(40NOS)	2017
2	**UHIERE**	BOREHOLE PROJECT AT UHIERE COMMUNITY	2015
		RENOVATED MATERNITY AT UHIERE COMMUNITY	2016
		MARKET STALLS AT UHIERE COMMUNITY	2016
		RENOVATED TEACHERS QUARTER AT UHIERE COMMUNITY	2017
		SECOND BOREHOLE AT UHIERE COMMUNITY	2018
3	**AGBANIKAKA**	FIRST BOREHOLE PROJECT AT AGBANIKAKA COMMUNITY	2018
		MARKET STALLS AT AGBANIKAKA COMMUNITY	2018
		SECOND BOREHOLE PROJECT AT AGBANIKAKA(UNDER CONSTRUCTION)	2019
		AGBANIKAKA TOWN HALL	2017
4	**IRHUE**	MARKET STALLS AT IRHUE COMMUNITY	2017
		TOWN HALL AT IRHUE COMMUNITY	2017
		FIRST BOREHOLE AT IRHUE COMMUNITY	2017
		GRADING OF ROADS DURING DRY SEASON	2016-TILL DATE
		CASSAVA PROCESING MACHINE	2018
		CONSTRUCTION OF POLICE STATION	2018
		SECOND BOREHOLE PROJECTS(UNDER CONSTRUCTION)	2019
5	**UMOKPE**	FIRST BOREHOLE PROJECT AT UMOKPE COMMUNITY	2017
		SECOND BOREHOLE PROJECT AT UMOKPE COMMUNITY	2017
		GRADING OF ROADS DURING DRY SEASON	2016-TILL DATE
		CASSAVA PROCESSING MACHINE	2018
6	**ODIGHI**	EQUIPPING OF ODIGHI CLINIC	2016
		GEN SET AT ODIGHI CLINIC	2016
		FIRST MARKET STALL (5ROOMS)	2016
		RENOVATION OF ENOJIE PALACE	2016

		RENOVATION OF ODIONWERE'S HOUSE	2016
		SECOND MARKET STALL(5ROOMS)	2017
7	**OWAN**	POLICE STATION AT OWAN COMMUNITY	2017
		FIRST BOREHOLE PROJECT AT OWAN COMMUNITY	2017
		PROVISION OF SCHOOL CHAIRS AND DESKS (40NOS)	2016
8	**ODIGUETUE**	TOWN HALL PROJECT AT ODIGUETUE COMMUNITY	2016
		MARKET STALLS AT ODIGUETUE COMMUNITY	2016
		FIRST BOREHOLE PROJECT AT ODIGUETUE COMMUNITY	2015
		SECOND BOREHOLE PROJECT AT ODIGUETUE	2017
		TOWN HALL COMPLETED BY OKOMU AT ODIGUETUE	2016
		RENOVATION OF ODIONWERE'S HOUSE	2017
		MARKET STALL(5ROOMS)	2015
		THIRD BOREHOLE PROJECT AT ODIGUETUE	2018
		GRADING OF ROADS DURING DRY SEASON	2016-TILL DATE
9	**EKPAN**	TOWN HALL PROJECT AT EKPAN COMMUNITY	2017
		MARKET STALLS (5ROOMS)AT EKPAN COMMUNITY	2017
		GRADING OF ROADS DURING DRY SEASON	2016-TILL DATE
10	**ORHUA**	BOREHOLE PROJECT AT ORHUA COMMUNITY	2018
		GRADING OF ROADS DURING DRY SEASON	2016-TILL DATE
11	**EKIADOLOR**	FENCING OF POLICE STATION	2017
12	**EHOR**	FENCING OF POLICE STATION	2017

4.10 Consultation with and Participation By Stakeholders

4.10.1 Introduction

In the EIA process, consultation with and participation by stakeholders is a very important activity. EIA is not EIA without consultation and participation by stakeholders. It is a continuous activity in the EIA process, taking place in early stages prior to the decision on the action to be taken on the project. The decision may be made by the proponent (e.g. choices between various alternatives), jointly by the proponent and the decision-making and environmental regulators (screening and scooping decisions) and the public on whether or not to allow the project or proposal proceed (Wood, 1996).

The stakeholders include the adjoining communities to the proposed project location, environmental regulatory agencies, governmental ministries and parastatals, local governments, non-governmental organizations (NGOs) and persons having interest and concerns on the conservation of the areas where development will take place (Figure 4.5).

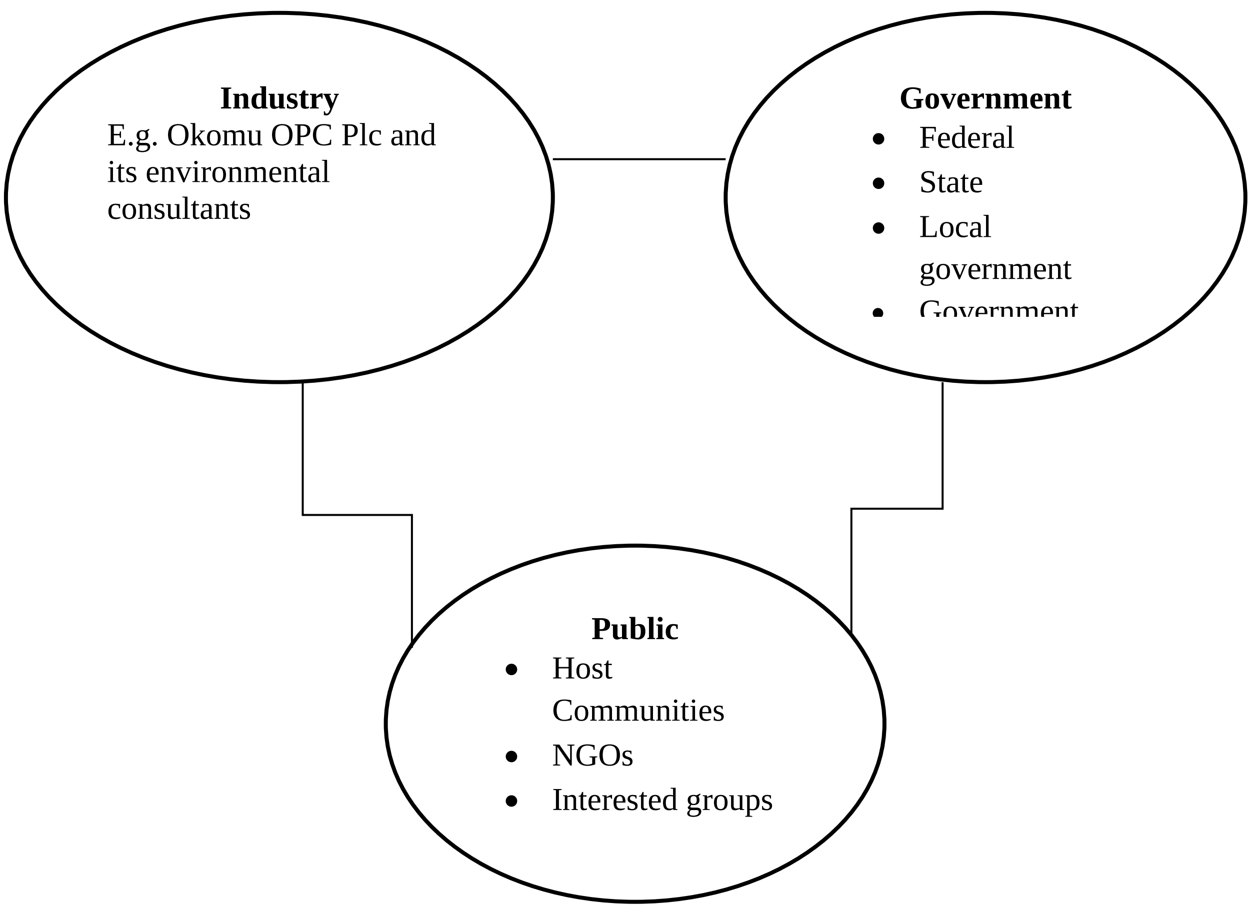


Figure 4.5: Stakeholders' Interrelationship in the Activities for an EIA Study

4.10.2 Objectives

The specific objectives of the consultation and participation process are to:

- Inform and educate stakeholders about the project
- Obtain stakeholders view on the project as it may affect the existing conditions of the environment of the area
- Assist in scoping of activities to be included in the study
- Resolve conflicts relating to the project
- Identify problems, concerns and needs of adjoining communities
- Establish a coordinal link between the proponent (Okomu Oil Palm Co Plc) and the affected communities

4.10.3 Consultations with Stakeholders

4.10.3.1 Institutional

Federal Ministry of Environment, FMEnv

The Federal Ministry of Environment, FMEnv, at Abuja was consulted in screening process or initial environmental examination (IEE) in order to categorize the project. Also an application for an EIA study by the Company, the Terms of Reference and Scope of the study to be carried out, were submitted 04 December 2017 to the FMEnv for vetting and approval. The FMEnv carried out a site verification visit in January 2018 and subsequently approved the TOR for the EIA study. Regular contacts were made with the FMEnv at Abuja and sometimes with the Edo state Zonal office in Benin City.

In similar vein contacts and consultations were made with the following government agencies:

a. Ministry of Environment and Sustainability, Benin City.
b. Ministry of Agriculture and Natural Resources, Benin City
c. Ovia Northeast Local Government Area of Edo State, Nigeria

4.10.3.2 Communities

OOPC Plc used its FPIC process and mechanism to hold meetings with the ten affected communities. The community engagement meetings presented the opportunity for the EIA consultants to present and explain the proposed project to the understanding of the communities. The outcome of the engagement meetings is what has culminated to Notarized FPIC Agreements signed by a representative from each community and the Company. The FPIC report is attached in Appendix II.

4.10.4 Levels of Community Representatives and Organizations Consulted

4.10.4.1 Affected Communities

In all the communities, meetings and consultations were held with representatives including individuals, community heads and leaders. Others included community development associations and community based organizations. The meetings and consultations usually held at either their town hall or at the quarters of the community heads and the communities had representations including the youth association members. The schedule of the meetings is shown below, while photo illustrations are provided in Plate 4.23.

Communities	Attendance	Reference Contact
Agbanikaka	27	Ikpefuran Sunday - 08038157678
Owan	28	Elder Clement Ugboiyobo
Uhiere	35	Francis Obanor - 08182731748
Odiguetue	36	John Ehigia - 08182401090
Odighi	27	Flamingo Dajide - 08077220988
Oke- Irhue	53	Ohiengbe Sylvester - 08134266005
Ihrue	15	Samuel Alohan - 08031259221
Umuokpe	15	Community Secretary - 08086792306
Epkan	13	Matthew Omoniyi - 07031259895
Orhua	10	O.C. District Forest Chairman - 08066318167


Agbanikaka Community with Study Team


Uhiere Community with Study Team


Irhue Community with Study Team


Odighi Community Leaders with OOPC Management Team


Odiguetue Community with OOPC Management Team


A & Hatman Workers with OOPC Management Team

Plate 4.23: Photos of Community Meetings

CHAPTER FIVE

ASSOCIATED AND POTENTIAL ENVIRONMENTAL IMPACT

5.1 Introduction

The primary intention of this Environmental Impact Assessment (EIA) is to identify the associated and potential impacts of the proposed project and to develop options for mitigating the negative impacts that have been so identified.

The primary objectives of the impact assessment process are to:

- Establish the significance of identified potential impacts that may occur as a result of a project activity being undertaken.
- Differentiate between those impacts that are insignificant (i.e. can be sustained by natural systems) and those that are significant (i.e. cannot be sustained by natural systems).
  Unacceptable negative impacts will require additional mitigation measures to complement those incorporated in the project design. Potential cumulative impacts are also considered. The significance of an impact is determined by:

    - Determining the environmental consequence of the activity;
    - Determining the likelihood of occurrence of the activity and
    - Subsequently calculating the product of these two parameters.

This chapter basically identified the potential environmental impacts by considering the anticipated effects of the proposed project on the existing physical, chemical, biological conditions of the environment.

At an earlier stage in this study, an environmental screening and scoping exercise was carried out, the process employed was a combination of desk study, site visitation, and consultations with stakeholders. From this, an overview of the potential impacts, the choice of the appropriate field analysis and likely mitigation measures and the monitoring programme were examined.

This chapter presents an overview of the impact assessment methodology as well as results of impact screening followed by detailed qualitative and quantitative impact assessments. Their inclusion does not mean they would necessarily occur or cannot be successfully mitigated.
The boundaries (temporal and spatial) of this EIA study were determined through the scoping process involving consultations with stakeholders, social, economic and

health studies. The project activities that would impact on the environment were identified as:

- Pre-construction activities
- Construction
- Operation and maintenance
- Decommissioning

5.1.1 Social and Environmental Impacts

Social Impacts

The palm oil industry has had both positive and negative impacts on workers, indigenous peoples and residents of palm oil-producing communities. Palm oil production provides employment opportunities, and has been shown to improve infrastructure, social services and reduce poverty. However, in some cases, oil palm plantations have developed lands without consultation or compensation of the indigenous people occupying the land, resulting in social conflict. The use of illegal immigrants in Malaysia has also raised concerns about working conditions within the palm oil industry.

Some social initiatives use palm oil cultivation as part of poverty alleviation strategies. Examples include the UN Food and Agriculture Organization's hybrid oil palm project in Western Kenya, which improves incomes and diets of local populations, and Malaysia's Federal Land Development Authority and Federal Land Consolidation and Rehabilitation Authority, which both support rural development.

The use of palm oil in the production of biodiesel has led to concerns that the need for fuel is being placed ahead of the need for food, leading to malnourishment in developing nations. This is known as the food versus fuel debate. According to a 2008 report published in the *Renewable and Sustainable Energy Reviews*, palm oil was determined to be a sustainable source of both food and biofuel. The production of palm oil biodiesel does not pose a threat to edible palm oil supplies. According to a 2009 study published in the *Environmental Science and Policy* journal, palm oil biodiesel might increase the demand for palm oil in the future, resulting in the expansion of palm oil production, and therefore an increased supply of food.

Environmental Impacts

Oil palm cultivation has been criticized for impacts on the natural environment, including deforestation, loss of natural habitats, which has threatened critically endangered species such as the orangutan and Sumatran tiger, and increased greenhouse gas emissions. Many oil palm plantations are built on top of existing peat bogs, and clearing the land for palm oil cultivation may contribute to greenhouse gas emissions.

Efforts to portray palm oil cultivation as sustainable have been made by organizations including the Roundtable on Sustainable Palm Oil, an industry group, and the Malaysian government, which has committed to preserve 50 percent of its total land area as forest. According to research conducted by the Tropical Peat Research Laboratory, a group studying palm oil cultivation in support of the industry, oil palms plantations act as carbon sinks, converting carbon dioxide into oxygen and, according to Malaysia's Second National Communication to the United Nations Framework Convention on Climate Change, the plantations contribute to Malaysia's status as a net carbon sink.

Environmental groups such as Greenpeace and Friends of the Earth oppose the use of palm oil biofuels, claiming that the deforestation caused by oil palm plantations is more damaging for the climate than the benefits gained by switching to biofuel and utilizing the palms as carbon sinks.

5.2. Methodology of impact assessment

5.2.1 Overall methodology

The overall methodology comprises five steps as follows:

Step 1

- Identification and description of project phase.
- Associated activities and their possible interactions with environmental, social and health components.

Step 2

Preliminary identification of potential impacts on environmental, social and health components

Step 3

- Screening for impact significance
- Elimination of activity of environmental interactions producing no effect;
- Selection of focus impacts for further assessments

Step 4

Detailed assessment of selected focus impacts in terms of:

- Nature- positive or negative, direct or indirect
- Magnitude-qualitative and quantitative
- Areal extent-qualitative and quantitative
- Frequency
- Receptor sensitivity
- Duration including reversibility
- Cumulative effects

Step 5

- Final assessment and assignment of overall impact significance levels based on step 4 results and application of objective impact severity criteria and likelihood;
- Identification of impacts requiring mitigation.

The analysis of impacts covers the aspects of the project activities described in Chapter Three.

For each activity, potentially affected environmental media are identified and the nature of the effects are qualified and quantified.

5.2.2 Preliminary Identification and Screening

In accordance with recommended impact assessment approaches (FMEHUD, 1995; UNEP, 1996; Canter, 1996; Lohani et al 1997) the first level of impact assessment involves the preliminary identification and screening of potential environmental impacts by anticipating activity – environment interactions. This requires a thorough understanding of the project activities (project description), the project setting (the environmental description), and the interaction with environmental components. A modified Leopold matrix (Leopold, 1971) was used for the identification and screening. The matrix shows project activities against environmental (biophysical, social and health) components, and supports a methodical, comprehensive, and objective identification of the impacts each project activity may have on each biophysical, social, and health component.

Impact identification is based on Wathern (1988), who defines an impact as “having both spatial and temporal components and can be described as the change in an environmental parameter over a specified period within a defined area, resulting from a particular activity compared with the situation which would have occurred had the activity not been initiated”.

To further guide the identification and screening of impacts using the matrix, established environmental impact indicators or indices are developed for each of the environmental interaction categories. Impact indicators are the observable or measurable parameters of each environmental component that can be directly or indirectly linked to changes in environmental conditions.

The integrated impact assessment is conducted with consideration of environmental, social and health elements, some procedures specific to each element were used in the process as relevant to the study.

5.3 Checklist of Environmental Indicators

(a) Biophysical (Natural and Physical)

The major indicators are:

- Climate and meteorology
- Air quality
- Noise travel
- Ground water
- Surface River
- Geology and geomorphology
- Soil
- Drainage pattern/flooding
- Unique physical features/aesthetics
- Terrestrial fauna and wildlife
- Fisheries

(b) Socio-Economic

- Community population and ethnicity
- Employment and income
- Culture and religion
- Infrastructure provision
- Health
- Education
- Traditional administration
- Community

Each of the environmental indicators above was also evaluated to ascertain the present situation and extent of damage and/or degradation as presented in Chapter Four.

5.4 Project and Associated Activities of the Proposed Project at Extension Two

The major activities at the proposed mill expansion site will be:

a. Pre-construction stage
   - Contract Award
   - Mobilization

b. Construction Stage - The activities include:
   - Heavy machinery use during foundation construction
   - Installation of equipment
   - Generator use
   - Civil, Electrical and Mechanical works
   - Solid waste generation and disposal

c. Operation Phase
   - Transportation of FFB to the mill
   - Palm oil processing/production
   - Noise and gaseous emission
   - Solid waste generation and disposal
   - Palm Oil Mill Effluent generation and disposal

d. Decommissioning and Abandonment
   - Laying off workers
   - Abandonment of equipment and vehicles
   - Solid and Liquid waste generation and disposal

5.5 Screening Project – Environmental Interactions Criteria

The criteria used in categorizing the various impacts are shown in Table 5.1.

Table 5.1: Impact Type

Type	**Positive/Beneficial or Negative/Adverse**
Severity	Minor/very low/insignificant, moderate, high/major/very significant
Prevalence	Likely extent of the impact
Duration	Long term (>12 months), short term (<12 months or intermittent)
Importance	Economic, social and cultural values attached to the undisturbed project

Severity is classified as shown in Table 5.2 below.

Table 5.2: Criteria for Rating Magnitude, Duration and Severity of Environmental Impacts

Severity of Impact	Description/Quantification
1. Impact on Sensitive Habitats e.g. wetlands; forest reserve	
Very High, 5 points	Very severe long term adverse effects; more than 20% of the habitat area will be destroyed or damaged.
High, 4 points	Major long term adverse effects: 1 – 2% of the habitat area will be destroyed or damaged
Moderate, 3 points	Moderate adverse effects: 0.25 – 1% of the habitat area will be destroyed or damaged
Low, 2 points	Minor adverse effects: 0.02 – 0.025% of the habitat area will be destroyed or damaged
Very Low, 1 point	Negligible to minor adverse effects: 0.02% of the habitat area will be destroyed or damaged
2. Impacts on Water Quality (Rivers and Streams)	
Very High	Water quality parameters change significantly by several orders of magnitude: toxic trace metals or hydrocarbons exceed FMEnv’s safe levels; changes persist for months or longer.
High	Water quality parameters change significantly by one or two orders of magnitude: toxic trace metals or hydrocarbons exceed FMEnv’s safe levels; changes persist for months or longer.
Moderate	Statistically significant changes in water quality parameters which persists for several weeks.
Low	Some measures of water quality deviate significantly from ambient measures but are quickly (within 1-2 days) restored to normal.
Very Low	Normal measures of water quality such as dissolved oxygen content, salinity, temperature, trace metal concentrations and hydrocarbon levels show no statistically significant changes from ambient conditions.
3. Impacts on Air Quality and Noise	
Very High	Significant increase in levels of criteria pollutants. Significant effects on public health and welfare are expected.
High	Increase in levels of criteria pollutants likely to pose hazards to public health and welfare.
Moderate	Increase in levels of criteria pollutants moderate and unlikely to pose hazards to public health and welfare.
Low	Increase in levels of criteria pollutants unlikely to pose hazards to public health and welfare.
Very Low	Increase in levels of criteria pollutants does not pose hazards to public health and welfare.
4. Impacts on Cultural/Archaeological Resources	
Very high	An interaction between a cultural resource/archaeological site and an impact producing factor occurs and results in the loss of unique cultural/archaeological information.

Moderate	The interaction occurs and results in the loss of cultural/archaeological data that are not significant.
Low	The results are temporary and reversible.
Very Low	Little damaging interaction between an impact producing factor and cultural resource/archaeological site occurs.
5. Impacts on Local Employment, Income, and Population	
Very High	10% or greater annual growth in employment, payroll, population.
High	7-9% annual growth in employment, payroll, population.
Moderate	4-6% annual growth in employment, payroll, population.
Low	2-3% annual growth in employment, payroll, population.
Very Low	1% or less annual growth in employment, payroll, population.
6. Impacts on Community Infrastructure	
Very High	Potentially major long-term effects on community services and facilities indicated by a 10% or more increase in the infrastructure.
High	The effect is indicated by a 3-9.9% increase/decrease
Moderate	The effect is indicated by a 1.5-2.9% increase/decrease
Low	Minor effects on community services and facilities: indicated by a 0.5-1.4% increase/decrease
Very Low	Negligible to minor effects on community services and facilities: indicated by a less than 0.5% increase/decrease,
7. Impacts on Wildlife/Forestry	
Very High	A specie, population, community or assemblage of wildlife will be harmed, as a result of habitat area destroyed or disturbed, to the extent that recovery of that particular entity may not occur.
High	A significant interference with ecological relationships. This usually involves the mortality or alteration of a noticeable segment of the population, community or assemblage.
Moderate	A short-term interference with ecological relationships. Although some species may sustain substantial losses, other species will sustain low losses, and the ecological mix will not be altered.
Low	A few species may sustain low losses, but any interference with ecological relationships will not be evident.
Very Low	Loss of a few individuals but no interference with ecological relationships.

5.6 Leopold Matrix Screening

The modified Leopold impact matrix consists of a horizontal list of biophysical, social and health environmental components that could be affected by the proposed project activities versus a vertical list of project activities, which represent environmental aspects, or "sources of impact", associated with each project phase. Environmental aspects are elements of an activity that can or will interact with the biophysical, social and health conditions within the area of influence.

Entries in the matrix cells represent the nature and preliminary ranking of the severity of the impact. Ranking of the severity is based on the following scale and symbols:

- Major: 2
- Minor: 1
- Negligible or no effect: - (a dash)
- Positive: +

Table 5.3 gives the criteria for rating an impact and the scores awarded to each criterion/severity category and Table 5.4 gives the matrix obtained.

Table 5.3: Scores Awarded to Magnitude, Duration and each Severity Category

EFFECTS	SCORES
A major long term effect (Very high)	points (in a square)
A major short term effect (High)	4 points
A moderate long term effect (Moderate)	3 points
A moderate short term effect (Low)	2 points
A minor effect in magnitude and duration (Very Low)	1 point (in a square)
No impact/interaction	0 point/Blank square
Positive impact	+ added in front of a number
Negative impact	- added in front of a number

For this preliminary impact assessment stage, the impacts are defined as follows:
A Major impact is one that would affect a large (higher than 40%) amount of a resource/receptor and or have a relatively large footprint and persist for a long time or is irreversible;

A Minor impact is one that could either affect a large (as defined above) or moderate (less than 40%) amount of an affected resource/receptor, has a mid to long term effect (1 to 10 years) but is most likely reversible.

A Negligible impact is one that may occur but based on experience, available scientific information and expert knowledge will have no measurable effect on the environmental component;

A Positive impact is one that adds a measurable benefit to the immediate and larger project environment including its social, cultural and health dimensions.

All number entries denote negative impacts. Cells with both positive sign (+) and numbers indicate that the specific activity and environmental interaction will potentially result in both positive and negative impact. All potential impacts, whether likely or unlikely are also considered at this stage. The likelihood of an impact is further assessed in the detailed impact evaluation. The identification of and screening of an impact relies on the following:

- Available knowledge of product activity
- Documented impacts of similar projects in similar environment
- Consultation with experts
- Professional judgment
- Result of earlier environmental studies carried out in the Lagos lagoon area.

Spatial boundaries of interaction were decided based on specialist knowledge and documented experience of the specific activity on environmental interaction.

5.7 Detailed Assessment of Impact

The preliminary identification and screening of environmental impact resulted in a group of focus impacts (impacts ranked 1 and 2) which were further assessed in terms of severity and significance. Impact severity and significance criteria used at this next stage relied on a number of resources and tools including the following:

- FMEnv Environmental Assessment guidelines;
- Overlaying project component on maps of existing conditions to identify potential impact areas and issues
- Environmental baseline studies
- Results of earlier studies carried out in the area; experience from similar projects in Nigeria and elsewhere.
- Published and unpublished documents (such as the World Bank environmental assessment source book; relevant IFC performance standards, and other authoritative texts on performing environmental impact assessment) providing guidance on performing impact analysis for industrial development activities;

5.8 Impact Severity and Significance Evaluation

The overall methodology for assessing impacts of activities associated with the proposed project involves establishing impact indicators, and evaluating the potential effects of project activities on each project specific impact indicator. Impacts may be positive (beneficial) or adverse (detrimental). Impact indicators are easily identifiable environmental or socio-economic components that would readily indicate changes in environmental or socio-economic conditions. For the purpose of this project, the impact indicators selected are shown in Table 5.4.

In order to facilitate the process of impact assessment, a tabular checklist was developed from information provided by the client, to highlight the major activities and the key concerns in the project location.

5.9 Impact Severity Evaluation Criteria

To objectively review those issues warranting consideration as potential impacts (previously identified as focus areas) and to determine the likely significance of those impacts when compared to baseline conditions, certain significance criteria were developed. This EIA uses the significance criteria to evaluate impacts, which enables systematic identification and focus on those resources and receptors most likely to be impacted by the proposed project. These significance criteria were applied to all potential impacts initially identified during the screening process to determine whether they would likely be Positive, Negligible, Minor, Moderate, or Major. Those issues determined to be inconsequential or not applicable based on the significance criteria were eliminated or "screened out" from further consideration. This impact severity assessment takes into account three main areas of significance criteria: temporal factors, areal extent, and magnitude of the impact. The components of each of these primary criteria are described below, i.e., temporal factors include duration, frequency, and reversibility. In addition to the three main significance criteria, supplementary factors were considered as part of the overall impacts severity assessment, sensitivity of the receptor, indirect or secondary influences, and Cumulative effects.

Eligible is used in some instances and a negligible rating should be considered in deriving the overall impact severity. The term is omitted from the impact assessment matrix table that follows this section, but the criteria are described in the preceding text. The following describes the severity rating criteria.

5.10 Magnitude

Magnitude is defined as the quantitative intensity of the impact, and can be measured as the percentage of a resource or a population within the area of influence that may be affected by an impact. The definitions of “high”, “medium”, and “low” with respect to magnitude may vary depending upon the specific receptor. The magnitude of an impact is characterized as follows:

- High – large amount of the resources or population is affected; easily observable and measurable effect;
- Medium – moderate amount of the resource or population is affected; generally measurable and observable effect;
- Low – small amount of the resource or population is affected; low magnitude impact may be within the range of normal variation of background conditions:
- Negligible – amount of resource or population affected is unnoticeable or immeasurably small.

Magnitude may also be defined with respect to quantitative or semi – quantitative criteria, if available and applicable, (e.g., level of noise as decibels). The magnitude of an impact is characterized as follows:

- High –greater than the quantitative or semi – quantitative criteria
- Medium – at the quantitative or semi – quantitative criteria
- Low – less than the quantitative or semi – quantitative criteria
- Negligible – impact not detected or at background levels.

5.11 Duration

Duration is defined as the time that is estimated for a population or resource to return to pre – impact/baseline conditions. The duration is calculated from the time the impact begins, which may coincide with the start of the activity that caused the impact.

The duration of an impact is characterized as follows:

- High – long –term impact (recovery would not occur within ten years)
- Medium – moderate –term impact (recovery time between one year and ten years)
- Low – short –term impact (recovery time within less than one year)
- Negligible – impact or recovery time is very short or immediate characterization of the duration of an impact as low, medium, or high includes consideration of the degree of reversibility of the impact. Impacts for which the duration is classified as high, as defined above, are considered irreversible impacts

5.12 Frequency

Frequency is defined as the number of times an impact is expected to occur over the life of the project, the frequency of an impact is characterized as follows:

- High-impact will occur continuously throughout the life of the project (e.g, continuous transportation of FFB to the mill)
- Medium-impact will occur intermittently over the life of the project (e.g, operations and maintenance)
- Low-impact will occur rarely or a very limited number of times (e.g. construction impacts – civil work during mill construction

There is no "negligible" category for frequency because impacts with no frequency would not occur, and were screened out.

5.13 Extent

Areal Extent refers to the potential geographic range of an impact and quantified in units of area affected (e.g. hectares). The areal extent is classified as follows:
High-impact has influence well beyond the project environment to the regional or even global environment.

Medium-impact limited to the general vicinity of the project site/study area.
Low-impact limited to the immediate area of the activity of occurrence.
Negligible-impact limited to a very small part of the activity area.

5.14 Sensitivity

Sensitivity refers to economic, social, and/or environmental/ecological relevance of the receptor, including the intrinsic sensitivity of the resource, reliance on the receptor by people for sustenance, livelihood, cultural significance or economic activity, and to the importance of direct impacts to persons associated with the resource.

The sensitivity criterion also refers to potential impacts to Environmentally Sensitive Areas (ESAs) and impacts on species, with effects including loss of endangered species introduction of invasive species, and similar environmental/ecological impacts. The intrinsic sensitivities of a receptor species and actions that after then function of the receptor are also considered. Sensitivity is characterized as follows:

High – receptor is of high economic, social, and/or environmental relevance and or has an intrinsic sensitivity (including vulnerability and exposure) to the specific impact (e.g. water resources).

Medium- receptor is of moderate economic, social, and/or environmental relevance and is not particularly vulnerable and/or exposed to the impact.
Negligible –receptor is not of economic, social and/or environmental relevance or is not sensitive to impact.

5.15 Impact Significance

The following section describes the method by which the overall impact severity rating and associated impact significance is derived.

Impact Severity Rating

To reach an overall impact severity rating for each impact assessed, the five impact severity criteria above are aggregated using impact severity matrices. Aggregation is at three levels.

First, magnitude and areal extent are combined to arrive at a rating for the Impact Quantum while duration and frequency are aggregated to give the overall temporal effects.

Impact Quantum and Temporal Effects are then combined and their resulting aggregate assessed in terms of sensitivity to arrive at the overall impact severity.

Impact Likelihood

To further assess the significance of the severity associated with each potential negative impact identified in the previous section, a likelihood criterion is applied to each negative impact. The likelihood criteria are used to determine whether negative impacts can be prevented or mitigated or if they are unavoidable.

It should be noted that the likelihood criteria are applied to the likelihood of the impact occurring and not of the activity occurring. Thus the overall severity rating (significance) of a negative environmental impact is a function of its severity as earlier defined and the likelihood of occurrence as defined in the table.

Overall Impact Significance

The overall impact significance is indicated by the position on the impact significance matrix. Impacts with a high likelihood of occurrence and consequence have a high significance rating. These high-significance impacts become high priority for further evaluation or management action (e.g. design, change or mitigation). Impacts that are moderate are of medium priority; there are also activities with low impacts. Other impacts are positive or beneficial impacts. The criteria and severity matrix set forth in this section are applicable to all the types of events and impacts identified.

Table 5.4: Matrix for Identification of Significant Activity Impacts of the Proposed Project on the Environment at Extension Two Estate

ENVIRONMENTAL COMPONENTS	Project Activity Phases													
	Pre-Construction		Construction				Operation and Maintenance					Decommission and Abandonment		
	Contracts Award	Mobilisation	Heavy Machinery Use	Generator Use	Civil, Electric and Mechanical works	Solid Waste Disposal	Trucks Carrying FFB	Generators and Machine: Noise and Gaseous Emission	Palm Oil Mill Effluent (POME) Disposal	Solis Waste Disposal	Methane Emission	Laying off Staff	Mill Abandonment	Equipment and Chemicals Abandonment
Air Quality			-2	-2	-2			-3	-3		-5			
Noise level		-2	-2	-2	-2			-3						
Vegetation								-2	-2		-3			
Terrestrial Inverts								-2	-2		-3			
Wildlife								-2			-3			
Groundwater					-2				-3					
Surface River					-2	-2			-4	-2				-1
Soil/Land Pollution		-1			-2	-2	-2		-4	-2				
Drainage														
Demography					-1									
Employment/Income	+3	+3			+3				+2					
Culture/Religion									-3					
Occupational Health/Accidents		-3	-3	-1	-2	-2	-2	-3	-3	-2			-2	-2
Infrastructure														
Community Relations	+3											-3	-2	
Economic loss											-3	-3	-2	
Corporate Image									-2	-2		-3	-2	-3

KEY: + Positive impact   No impact = Blank Square
- Negative impact   Minor effect, (very low) = 1 point in square

Moderate short term effect (Low) = 2 points
Moderate long term effect (Moderate) = 3 points
Major short term effect (High) = 4 points
Major long term effect (Very high) = 5 points

5.16 Description of Impacts

5.16.1 Significant Impacts

The proposed project by OOPC Plc offers a number of potential beneficial impacts to the people of the project site and area beyond. These effects shall be enhanced throughout the duration of the project. Improved and more secured palm oil mill would benefit a broad range of individuals and businesses throughout Nigeria. The project will substantially improve agricultural development by improving palm oil production that will continuously provide job opportunities for teeming youths in Nigeria.

In addition, the project will contribute to achieving some of the objectives of the Federal Ministries of Agriculture & Rural Development and Trade &Investment, which include securing the social and economic benefits of an efficient Agricultural and Investment sector; considerably increasing Palm oil production to meet its annual requirement in the country.

More importantly, the proposed project is the company's contribution and support aimed at meeting the goals of the Economic Recovery and Growth Plan (ERGP) of the Federal Republic of Nigeria.

Moreover, the proposed project will provide employment opportunities for qualified Nigerians (skilled, semi –skilled and unskilled) from the immediate project area and beyond. The employment opportunity will lead to acquisition of new skills and introduction of all manners of income generating spill over effects.

Other potential benefits of the project include:

- Increase the life span of the oil palm plantation
- Add values to the FFB produced on the plantation
- Increase in the revenue base of the company
- Provide direct employment
- Create additional jobs
- Contribute to the socio-economic development of the neighbouring communities
- Increase the revenue base of both Edo State Government and Federal Government of Nigeria

5.16.2 Significant Negative Impacts

In this section, only activity-receptor relationships resulting in impact significance above 'low' are presented and discussed to understand how additional mitigation measures beyond those incorporated in the project design could help bring down the residual impacts to 'low' in the least. In the analysis, the environmental receptors are considered singly or collectively along with the corresponding project activities.

5.16.2.1 Evaluation of Potential Impacts of Project Activities

5.16.2.1.1 Adverse Impact of Loss of vegetation

There will be complete loss of vegetation in the main land area that is going to contain the discharged POME especially mature oil palm. Considering the large volume of POME that is going to be discharged especially during optimal capacity production level of the palm oil mill, large land area would be lost to POME treatment ponds.

5.16.2.1.2 Palm Oil Mill Effluent (POME) disposal

The discharge of the raw and untreated POME to the open land area although undesirable, has beneficial impact on the adjoining soils as follows.

Soil Nutrient Enrichment: The recent study has revealed that the levels of both essential macro and micronutrient elements needed for plant growth and development were increased following the open discharge of the POME in the soil. Specifically, there were notable increases in the levels of exchangeable cations of potassium and magnesium, and corresponding elevation in the values of available phosphorus, organic carbon and total nitrogen content of the soils containing POME. Also, the amount of iron, zinc, manganese and copper increased in these soils. Proper and effective management of the soils could lead to increase in crop yield and productivity.

Hydrocarbon and Oil/Grease Contaminants: The increase in the amount of these contaminants in the soil could have adverse effect in the functionality and productivity capacity of the soils. Relatively high levels of THC and Oil/Grease in the soil receiving POME can reduce the microbial activity of the soil thereby making potentially available nutrients unavailable for plant uptake.

Heavy Metals Enrichment: Enrichment of the POME soil with heavy metals such as lead, cadmium, chromium, nickel and vanadium as determined in the present study would have adverse effects or impacts on soil quality. This is because, under favourable soil conditions of pH, texture and moisture regimes, these metals could be made available for plant uptake, especially when the soil is used for the cultivation of vegetables and shallow rooting crops.

5.16.2.1.3 Harvesting and Transportation of Fresh Fruit Bunches

During harvesting, fronds are pruned. This helps to give easy access to the ripe fruit bunches as well as keep the oil palm stem clean of hanging dead and decaying leaves. The fronds are left on the ground to add organic matter to the soil. The pruning of fronds, harvesting and collection of fruit bunches are activities which provide employment for more workers.

5.16.2.1.4 Decommissioning and Abandonment

- Permanent and casual workers will be laid off resulting in loss of employment and income. This can itself give rise to strained relations between workers/community and the company.
- The palm oil mill will no longer be regularly and properly serviced and maintained. There will be great economic loss to company, shareholders and the nation. There will be no facility to process FFB harvested from the plantation thereby making the fruits to get rotten.
- Equipment and Materials Abandonment, Abandoned trucks and other mill machinery will blight the workshop and mill premises. This is also an economic loss to the Company and its shareholders.

5.16.3 Significant Impact Producing Activities

Based on a score of 3 points and above as shown in Table 5.4 (Matrix for Identification of Significant Activity Impacts of the Proposed Project) above, the significant impact producing activities (IPA$_S$) are as follow:

- Palm Oil Mill Effluent (POME) may contaminate and/or pollute groundwater thereby causing health problem to the public.
- Laying off workers/Severance Payment
- Palm Oil Mill Abandonment
- Gaseous Emission
- Decommissioning and abandonment have three main activities, which will produce adverse impacts as listed in section *5.16.2.1.4 above*.

5.16.4 Cumulative Impacts

Cumulative impacts are changes to the environment that are caused by an activity in combination with other past, present and future human activities (GSI, 2003). The concept of cumulative effects is an important one. It holds that, while impacts may be small individually, the overall impact of all environmental changes affecting the receptors taken together can be significant. When a resource is nearing its tolerance threshold, a small change can push it over. The objective of the cumulative impact assessment is to identify those environmental and/or socio-economic aspects that may not on their own constitute a significant impact but when combined with impacts from past, present or reasonably foreseeable future activities associated with this and/or other projects, result in a larger and more significant impact[s].

5.16.4.1 Project Specific Cumulative Effects' Assessment

This section evaluates the cumulative effects of the individual impacts evaluated in the preceding sections.

5.16.4.1.1Land Based Traffic

It is envisioned that land based traffic will also increase as a result of the proposed project. Land based traffic is expected to increase mainly during the operation phase to allow the FFB collected in the field to be processed at the proposed mill. Activities at the project site during construction will however be varied and limited to the construction phase. The proposed project will result in a negligible impact on traffic, circulation and parking at the project site and its vicinity. It would be unlikely that the rate of motor vehicle accidents would increase due to the project. No additional cumulative transportation impacts would result from the proposed action. Therefore, it is anticipated that no long-term environmental impact will be forthwith in considering the land-based traffic.

5.16.4.1.2 Public Services

There would be no impact to public services under the proposed project. The project will not introduce any additional long-term population or employment into the area, and thus, would not result in any additional demand for police or fire services or the need for new or altered facilities. No damage to roadways is expected beyond that which would be considered normal wear and tear. Therefore, the proposed project would result in negligible impact on public utilities.

5.16.4.1.3 Employment Opportunities

There will be some beneficial impacts that are cumulative that are in the employment sector. During the operational phase of the proposed project, the company will employ workers – all Nigerian. Positive cumulative social benefits include gainful employment and tax being paid to government coffers.

5.16.4.1.4 Abandonment/Laying off staff

There will be serious negative impacts that are cumulative that are also in the employment sector. During the abandonment/decommissioning phase of the project, the company will lay off workers. Negative cumulative social impacts include loss of employment and thereby adding to the unemployment status of the region in particular and the nation in general.

5.17 Health Impact Assessment (HIA) of the Proposed Project

The health impact assessment of the proposed project is a rapid appraisal of the likely health impacts the project might have on the totality of the environment. The assessment will consist simply of a summary table and a conclusion. The summary table shall list the intermediate factors and their likely impacts with minimal qualification.

5.17.1 Identifying Intermediate Factors that Impact on Health

Many proposals that are not intended to affect health directly have indirect effects on health and well-being; often these indirect effects have not been recognized. Proposals may affect things such as employment, income, air quality or housing which in turn affect health. These factors which are not health indicators but do influence health are referred to as intermediate factors. (They may also be called determinants of health).

Some of the identified intermediate factors of the proposed project are:

- Air Quality
- Water Quality and Hydrology
- Noise and Vibration
- Health and Safety
- Traffic and transport
- Waste Management
- Workers' Welfare
- Social cohesion
- Corporate Image

Table 5.5: Summary of Health Impacts of the Proposed Project

Intermediate Factor	Affected Group	Health Impact	Action to be Taken
Air quality Dust and gaseous emissions from land preparation and palm oil mill and vehicular emission leading to high suspended particulates in the atmosphere.	All	- Allergy - Eye irritation Nose irritation - Respiratory Tract Infections	**The Company** will ensure the following: - Low-emission/high efficiency engines shall be used. - Regular maintenance of vehicles to ensure optimal performance. - Movement of men and materials shall be properly coordinated to optimize vehicle use and resultant emissions. - Dust and particulate barriers shall be used during operation. - Avoid burning in the oil mill (i.e. zero burning).
Noise and vibration Noise emissions generated by heavy duty vehicles and palm oil mill	All	- Hearing impairment, hypertension, annoyance, sleep disturbance of site workers. - Hand-Arm Vibration Syndrome (HAVS)	**The Company** will ensure the following: - Noise attenuation measures such as installation of acoustic mufflers on large engines and equipment; - Hearing protection shall be provided and usage enforced for workers on site.
Water Quality and Hydrology Increased receiving water body turbidity from runoff. Improper storage and handling of, hydrocarbons, fuel and other chemicals would inevitably result in spillage during construction activities.	All	- Illnesses including Typhoid, Cholera, Dysentery, Polio, Hepatitis	**The Company** will ensure the following: - Stack demolition materials properly to reduce turbidity effect on surface runoffs; **The Company** will ensure the following: - Put in place adequate contingency measures to curtail accidental spills and ensure spill containment equipment shall be available at the construction site - In order to reduce ground contamination, an impervious sump or container shall be placed

			under the spigots of fuel drums to collect drippings. - Re-fuelling and maintenance of heavy construction vehicles at the site, shall be done at specified areas or makeshift "depots" where measures are in place to deal with spillages and temporary storage of oily waste. Preferably these depots shall be located in an area that would ultimately be permanently paved (e.g. parking lots) thereby covering any contaminated soil. - A thick layer of sawdust or absorbent would be used to absorb any spillages. Subsequently, this layer shall be removed for proper disposal. In the event of a large spill, the latter will be cleaned up immediately by excavating the contaminated soil and removing it in a secure vehicle to an approved disposal site.
Solid Waste - Solid waste constituting aesthetic nuisance - Sewage nuisance	All	- Improper solid waste handling can lead to the following: - **-** Creating conditions favourable to the survival and growth of microbial pathogens - **-** Causing infectious and chronic diseases especially the waste workers.	**The Company** shall ensure the following: - Waste is contained and removed regularly through its own waste management system already in place.
Hostility Industrial disputes	Workers and communities	- Youth restiveness - Persistence conflicts between community and company - Hostages	**The Company** shall ensure the following: - Grievance and conflict resolution mechanism is instituted. - Employ as much local labour as possible. - Adequate stakeholders forum and information shall be given to stakeholders. - Adequate compensation shall be paid to

			permanent workers in case of any eventualities.
Health and Safety - Accidents, Vehicular, slips, falls, trips etc - Hearing impairment due to exposure to noise of heavy machineries - Improper storage and handling of hazardous materials (e.g. lubricants, fuels, etc), are potential health hazards workers Carcinogenic/Toxic/Chemical hazards: corrosive substances - Poor chemical handling - Asphyxiating atmosphere - Road Traffic Accident - Wrong use of PPE - Inadequate PPE - Inadequate equipment/surface guard on equipment - Low awareness	All	Health hazards that can arise from poor health and safety include: - Occupational health problems such as terminal diseases and/or prolonged ill health - Permanent Loss Injury - Temporary Loss Injury -	**The Company** will ensure the following: Wearing of ear protection. - Safe storage areas shall be identified and retaining structures constructed prior to the arrival of material. - Hazardous materials (e.g. fuels) shall be properly stored in appropriate containers and shall be safely locked away. - Conspicuous warning signs (e.g. 'No Smoking') shall be posted around hazardous waste storage and handling facilities. **The Company** will ensure the following: - Guideline on safe handling of chemicals (SHOC) and appropriate PPE are provided. - Guideline on traffic control to ensure best traffic safety practices on the road. **The Company** shall ensure: - Awareness training - Sufficient PPE are provided **The Company** will ensure: - Equipment specifications are made available. - Provision of adequate training to workers. - Provision of warning signs to workers and commuters.
Waste Management - Wastes constitute aesthetic and pollution issues for the project area	All	Health hazards associated with poor waste management include: - Skin and blood infections	**The Company** will ensure the following: - A site waste management plan although already in place shall be prepared prior to project commencement. This shall include

- Accumulated waste could lead to contamination of soil/groundwater and breeding grounds for vectors and rodents		resulting from direct contact with waste. - Different diseases such as intestinal infections that result from poor waste management. Reduction in aquatic food supply - Disruption of food chain	designation of appropriate waste storage areas, collection and removal schedule, identification of approved disposal sites, and system for supervision and monitoring. - Preparation and implementation of the plan shall be the responsibility of **OOPC** with the system being monitored independently. - Waste shall be properly contained to avoid contamination of groundwater.
Sewage - Faecal aesthetic issues for the project area. - Spillage of septic liquor	Workers	- Cholera - Dysentery - Infectious and chronic diseases	**The Company** will ensure the following: - Onsite toilets shall be made available for use.
Socio-economics - Promiscuity - Sexual harassment - Youth Militancy - Unemployment - Grievances	All	- Sexually transmitted diseases (STDs) - HIV/AIDS - Population explosion	**The Company** will ensure the following: - Public enlightenment about potential health risks (STDs). - Facilitate education/enlightenment about the project and its nature. - Appropriate policies.
Workers' Welfare Especially when workers leave the organization and/or layoff.	Workers	- Depression - Hypertension - Workers' restiveness	**The Company** will ensure that: - Workers receive their full benefits when leaving the organization.
Corporate Image The negative corporate image arising from day-to-day activities of the organization,	Company/All	- Annoyance - Depression	**The Company** will always ensure that its day-to-day activities and operations do not portend bad image about the organization to the general public and therefore operate according to the best industry standards and practice.

***Note: "All" in the Affected Group column means, "Totality of the Environment" including flora and fauna and humans.**

Table 5.6: Checklist for Health Impact Assessment of the Proposed Project

Environmental Component	Effect on Health		
	Good	None	Bad
Employment	✓		
Income	✓		
Workplace	✓		
Housing	✓		
Transport	✓		
Built Environment		✓	
Air Pollutants			✓
Water pollutants			✓
Noise			✓
Amenity		✓	
Lifestyle	✓		
Social Cohesion		✓	
Parenting		✓	
Education	✓		
Use of health services	✓		
Other cause of public concern		✓	

5.18 Conclusion

The main negative impacts are health and safety. However, mitigation measures will be put in place for health and safety through the provision of adequate and appropriate PPE.

As a result of the above provisions and measures, the net health impact of the proposed project is positive.

CHAPTER SIX

MITIGATION MEASURES

6.1 Introduction

The rationale for impact quantification and significance has earlier been discussed in the previous chapter. The results have indicated that various components would be impacted positively or negatively. In order to preserve the present integrity of the environment, certain steps have been recommended to mitigate or control the major negative impacts identified in this study. The control/mitigation measures have been based on the baseline conditions with regards to the biophysical environment, socio-economic and health status of the supposed host communities. Also considered were the project activities and their envisaged impacts and concerns of stakeholders during consultation meetings and socio-economic/health status of the host communities. However, mitigation measures are defined for the identified significant present impacts and associated and/or potential impacts based on the following criteria:

- **Prevention –** design and management measures for ensuring that significant potential impacts and risks do not occur.
- **Reduction –** operational and management measures for ensuring that the effects or consequences of those significant associated and potential impacts that cannot be prevented are reduced to a level as low as reasonably practical (ALARP).
- **Control -** Operational and management measures for ensuring that residual associated impacts are reduced to a level as low as reasonably practical (ALARP).
- **Corrective/Precaution –** Operational and management measures for correcting the identified impacts emanating from previous operations and also taking appropriate precautions to preventing reoccurrence

Most of the significant environmental impacts that can likely arise from the construction and operation of the proposed project can be mitigated once appropriate precautions are in place.

Table 6.1 below define the identified and potential environmental and social impacts, their sources and the recommended mitigation measures.

Table 6.1: Summary of Impact, Mitigation Measures and Residual Impacts

Activity Phase	Environmental Aspects	Type of Impact	Mitigation measures	Residual Impacts
Pre-Construction Phase	**Mobilization to Site**	- Risk of road accidents and congestion - Air pollution leading to global warming and increase in carbon footprint. - Generation and spillage of small amount of toxic or hazardous materials (lubricating oils, hydraulic fluids and insulating fluids)	- safe driving under speed limitation - Well maintained vehicles of appropriate engine capacity will be used - Necessary precautions to avoid leaks and training on oil spill containment procedures	None
Construction Phase	**Air quality and Climate**	Dust and gaseous emissions from mill construction and vehicular emission leading to high suspended particulates in the atmosphere.	- Low-emission/high efficiency engines shall be used. - Regular maintenance of vehicles to ensure optimal performance - Movement of men and materials shall be properly coordinated to optimize vehicle use and resultant emissions. - Dust and particulate barriers shall be used during operation. - Avoid burning in the oil mill (i.e. zero burning).	There would be emitted gaseous substances in the ambient air environment
	Noise and vibration	Noise emissions generated by heavy duty vehicles and workers activities and resultant hearing impairment on site workers.	- Noise attenuation measures such as installation of acoustic mufflers on large engines and equipment; - Hearing protection shall be provided and usage enforced for workers on site to reduce noise level below 85dB(A).	None

Table 6.1 Cont'd: Summary of Impact, Mitigation Measures and Residual Impacts

Activity Phase	Environmental Aspects	Type of Impact	Mitigation measures	Residual Impacts
Construction Phase	Traffic, Access and Transport	- Safety issues associated with the movement of abnormal loads on the road network associated with the Proposed Development - Increased intimidation of pedestrians and cyclists.	- Construction vehicles to use approved Site access routes only. - Movement of abnormal loads to take place outside of peak flow hours and warning signs and traffic management to control abnormal load movements	Negligible
	Landscape	Change in land use and visual effect	Ornamental trees and flowers will be planted which will minimize aesthetic impacts of land clearing.	Minimal disturbance of natural landscape and visual appearance
	Solid Waste	- Solid waste constituting aesthetic nuisance - Sewage nuisance - Solid waste generated (packaging, construction and domestic waste)	- Waste is contained and removed regularly through its own waste management system already in place. - All practical measures will be taken to avoid, minimize and recycle wastes.	Significant amount of construction waste will be reused onsite. While domestic waste generated will be recycled
	Job Creation	Creation of employment	-	-
	Water Resources and Hydrology	Increased receiving water body turbidity from runoff from the palm oil mill.	-	None

Table 6.1 Cont'd: Summary of Impact, Mitigation Measures and Residual Impacts

Activity Phase	Environmental Aspects	Type of Impact	Mitigation measures	Residual Impacts
Operation Phase	Traffic, Access and Transport	Increased intimidation of pedestrians and cyclists. A Traffic Management Plan is proposed.	Standard traffic management measures will be implemented during operational phase, particularly for the use of cranes, and will be set out in the Traffic Management Plan.	Negligible
	Air quality and Climate	- Stack emission - Fugitive emissions from tanks used to store petroleum and other hydrocarbon products. - Combustion emissions from exhausts of machines e.g. pumps power generating sets - Air pollution from transport during the decommissioning phase.	- All flanges and vents shall be properly tightened to reduce fugitive emissions. - All systems shall be properly checked to ensure there are no leakages or losses. - All machinery and vehicles for the project shall have high efficiency burner to reduce emission of noxious gases. - Well maintained vehicles will be used to reduce air pollution -	There would be present of emitted gaseous substances in the ambient air environment
	Solid waste and sewage and POME	- Waste runoff flowing into the surface waters. - Solid waste constituting aesthetic nuisance. - Sewage nuisance. - GHG emission - Weeds and long grass - Blue-green algae	- Waste is contained and removed regularly through its own waste management system already in place. - Efficient POME treatment system. - Pond banks would be mowed and weeded regularly.	None Green House Gas (GHG) Emission

Table 6.1 Cont'd: Summary of Impact, Mitigation Measures and Residual Impacts

Activity Phase	Environmental Aspects	Type of Impact	Mitigation measures	Residual Impacts
Operation Phase	**Solid waste, Sewage and POME**	- Algae blooms	- Unlike green algae, this algae is stringy and can clump, block sunlight, and cause short-circuiting. It can dominate the ponds when conditions are poor, when pH is low, or when protozoa eat all of the green algae. Blue-green algae can be physically removed like duckweed.	Insignificant
		- Odors	- After periods of cloudy weather or abrupt temperature changes, algae can multiply quickly and then die-off. Matted algae on the surface can block sunlight and cause foul odors. - There would be proper operation and maintenance- to help prevent odors.	
		- Sludge accumulation	- Sludge in the bottom of POME treatment ponds shall be removed as needed.	Inefficient functioning of the POME treatment ponds
	Water Resources and Hydrology	Increased receiving water body turbidity from runoff from the proposed mill.	-	None

Table 6.1 Cont'd: Summary of Impact, Mitigation Measures and Residual Impacts

Activity Phase	Environmental Aspects	Type of Impact	Mitigation measures	Residual Impacts
Operation Phase	**Health and Safety**	- Chemical and toxic hazards: corrosive substances - Poor chemical handling - Asphyxiating atmosphere - Road Traffic Accident - Ponds can attract children, pets and unsuspecting adults, who may think they look like good places to play and even swim - Wrong use of PPE - Inadequate PPE - Inadequate equipment/surface guard on equipment - Low awareness	- Guideline on safe handling of chemicals (SHOC) and appropriate PPE are provided. - Guideline on traffic control to ensure best traffic safety practices on the road. - Ponds to be cordon off by bund walls and have warning signs clearly posted. - All OOPC occupational safety practices and standards by anyone working near a body of water would be observed. - Awareness training - Sufficient PPE are provided - Equipment specifications are made available. - Provision of adequate training to workers. - Provision of warning signs to workers and commuters.	None None None
	Oil/Fuel Spills	- Oil/fuel can enter the drainage system and contaminate the land and water. - Oil spills can occur within and outside the powerhouse, and the fuel and lubricant storage area. - Effluent pipe leakages	- The fuel storage tanks will be surrounded by a bund wall to contain up to 1.5 times the total storage capacity in case of a spill. - All wash down from inside the powerhouse will be directed to a sump equipped with an oil/water separator to trap and filter oil from wastewater before it is discharged to the drains. - Arrangements for the proper disposal of the waste oil collected in the oil/water separator will be made. - An emergency response plan will be developed with detailed procedures for preventing and handling spills.	None

Table 6.1 Cont'd: Summary of Impact, Mitigation Measures and Residual Impacts

Activity Phase	Environmental Aspects	Type of Impact	Mitigation measures	Residual Impacts
Operation Phase	**Workers' Welfare**	Payment of severance to permanent workers	- Workers will receive their full benefits when leaving the organization.	None
	Hostility	Conflicts between the communities and the company.	- Conflict resolution mechanism is instituted. - Employ as much local labour as possible. - Adequate stakeholders' forum and information shall be given to stakeholders. - Adequate compensation shall be paid to permanent workers in case of any eventualities.	Insignificant
	Socio-economics	- Sexual laxity disruption - Youth Militancy/unemployment/grievances	- Public enlightenment about potential health risks (STDs). - Facilitate education/enlightenment about the project and its nature.	None
	Corporate Image	The negative corporate image arising from day-to-day activities of the organization.,	- Ensure that its day-to-day activities and operations do not portend bad image about the organization to the general public and therefore operate according to the best industry standards and practice.	None
Decommissioning Phase	**Air Quality and Climate**	Air pollution from transport during the decommissioning phase.	Well maintained vehicles will be used to reduce air pollution	Insignificant Impact

In addition to the mitigation measures for environmental impacts and social issues above, the following management and mitigation measures are also proposed for adoption and implementation to address the significant residual social and environmental impacts in order to make the proposed project operations environmentally and socially acceptable and beneficial:

- Develop and implement community engagement plan
- Prevention of pollution of water resources.
- Preparation of a Traffic Management Plan
- Fire prevention programmes and zero or controlled burning.
- Corporate social services to communities.
- Provision of healthcare services and HIV prevention.
- Diligent implementation of social impact management plan

6.2 Residual Effects Assessment Summary

Residual impacts refer to those environmental effects predicted to remain after the application of mitigation outlined in Table 6.1. The predicted residual effects are considered for each project phase (Pre-Construction, Construction, Operation, Decommissioning and Unplanned Events). As per the criteria established in Section 5.5 (Impact Significance) of this EIA report, the significance has been determined for each residual adverse effect in Table 6.2 (no significance rating was established for positive effects).

6.2.1 Residual Impacts

The residual impacts of the proposed project, following the implementation of the environmental mitigation measures are listed below in Table 6.2.

Table 6.2: Residual Impacts Associated with the Proposed Project

Activity Phase	Environmental Aspects	Type of Impact	Nature of Impact (Adverse, Beneficial or Negligible)	Significance (Minor, Moderate, Major)
Pre-Construction Phase	**Mobilization to Site**	- Risk of road accidents and congestion	Negligible	-
		- Air pollution leading to global warming and increase in carbon footprint.	Adverse	Moderate to Major
		- Generation and spillage of small amount of toxic or hazardous materials (lubricating oils, hydraulic fluids and insulating fluids)	Negligible	-
Construction Phase	**Air quality and Climate**	Dust and gaseous emissions from palm oil mill construction and vehicular emission leading to high suspended particulates in the atmosphere.	Negligible	-
	Noise and vibration	Noise emissions generated by heavy duty vehicles and workers activities and resultant hearing impairment on site workers.	Not Significant	-

Table 6.2 Cont'd: Residual Impacts Associated with the Proposed Project

Activity Phase	Environmental Aspects	Type of Impact	Nature of Impact (Adverse, Beneficial or Negligible)	Significance (Minor, Moderate, Major)
Construction Phase	**Traffic, Access and Transport**	- Safety issues associated with the movement of abnormal loads on the road network associated with the Proposed Development - Increased intimidation of Pedestrians and Cyclists.	Negligible Negligible	- -
	Landscape	Change in land use and visual effect	Adverse.	Moderate
	Solid Waste	- Solid waste constituting aesthetic nuisance - Sewage nuisance - Constitutes an eye sore	Negligible Negligible Negligible	- - -
	Job Creation	Creation of employment	Beneficial	Minor
	Water Resources and Hydrology	Impact on receiving water body	Adverse	Minor/Negligible

Table 6.2 Cont'd: Residual Impacts Associated with the Proposed Project

Activity Phase	Environmental Aspects	Type of Impact	Nature of Impact (Adverse, Beneficial or Negligible)	Significance (Minor, Moderate, Major)
Operation Phase	Traffic, Access and Transport	Increased intimidation of pedestrians and cyclists. A Traffic Management Plan is proposed.	Negligible	-
	Air quality and Climate	- Stack emission	Negligible	-
		- Fugitive emissions from tanks used to store petroleum and other hydrocarbon products.	Negligible Negligible	- -
		- Combustion emissions from exhausts of machines e.g. pumps power generating sets	Negligible	-
		- Air pollution from transport during the operation.	Negligible	-
	Solid waste and sewage and POME	- Waste runoff flowing into the surface waters.	Negligible	-
		- Solid waste constituting aesthetic nuisance.	Negligible	-
		- Sewage nuisance.	Negligible	-
		- GHG emission	Adverse	Major
		- Weeds and long grass	Adverse	Minor
		- Blue-green algae	Adverse	Minor

Table 6.2 Cont'd: Residual Impacts Associated with the Proposed Project

Activity Phase	Environmental Aspects	Type of Impact	Nature of Impact (Adverse, Beneficial or Negligible)	Significance (Minor Moderate, Major)
Operation Phase	**Solid waste and sewage and POME**	- Algae blooms	Adverse	Minor
		- Odors	Negligible.	-
		- Sludge accumulation	Adverse	Minor
	Water Quality and Hydrology	Increased receiving water body turbidity from runoff from the palm oil mill.	Adverse	Minor

Table 6.2 Cont'd: Residual Impacts Associated with the Proposed Project

Activity Phase	Environmental Aspects	Type of Impact	Nature of Impact (Adverse, Beneficial or Negligible)	Significance (Minor, Moderate, Major)
Operation Phase	**Health and Safety**	- Chemical and toxic hazards: corrosive substances	Negligible	-
		- Poor chemical handling	Negligible	-
		- Road Traffic Accident	Negligible	-
		- Ponds can attract children, pets and unsuspecting adults, who may think they look like good places to play and even swim	Negligible	-
		- Wrong use of PPE	Negligible	-
		- Inadequate PPE	Negligible	-
		- Inadequate equipment/surface guard on equipment	Negligible	-
		- Low awareness	Negligible	-
	Oil/Fuel Spills	- Oil/fuel can enter the drainage system and contaminate the land and water.	Negligible	-
		- Oil spills can occur within and outside the powerhouse, and the fuel and lubricant storage area.	Negligible	-
		- Effluent pipe leakages	Negligible	-

Table 6.2 Cont'd: Summary of Impact, Mitigation Measures and Residual Impacts

Activity Phase	Environmental Aspects	Type of Impact	Nature of Impact (Adverse, Beneficial or Negligible)	Significance (Minor, Moderate, Major)
Operation Phase	**Workers' Welfare**	Payment of severance to permanent workers	Beneficial	-
	Hostility	Conflicts between the communities and the company.	Adverse	Major
	Socio-economics	- Sexual laxity disruption - Youth Militancy/unemployment/grievances	Negligible Adverse	- Minor
	Corporate Image	The negative corporate image arising from day-to-day activities of the organization.,	Negligible	-
Decommissioning Phase	**Air Quality and Climate**	Air pollution from transport during the decommissioning phase.	Negligible	-

6.3 Conclusions

On the basis of the assessment of potential impacts and the recommended mitigation measures, overall, the proposed project is not likely to impose many significant adverse effects on the environment. As summarised in Table 6.1, the majority of impacts on the environment are either negligible in nature (and therefore significance) or of minor adverse significance.

The EIA has, however, identified some potentially moderate/major adversely significant effects, largely surrounding the POME discharge impacts of the proposed project during operation. Impacts on POME discharge and potentially sensitive receptor points in the surrounding area are considered to be potentially major adverse in significance.

Conversely, the implementation of mitigation measures to reduce the significance of potential impacts has allowed for some beneficial environmental impacts to be identified, such as to the socio-economics. Further, the economic benefits of job creation during the entire lifespan of the proposed project are considered a positive effect.

6.4 Cost Implications Associated with Mitigation Measures

6.4.1 Construction

The mitigation measures for the proposed project (construction phase) would be included as line items in the Bills of Quantities in the tender document so that the bidders are sure to cost these items and can be held accountable for them during construction. It is not possible to estimate these costs as they will vary depending on the contractor, the number of workers to be used.

6.4.2 Operation (FFB Processing)

The activities and equipment that will have costs associated with them are listed below in Table 6.3 below.

Table 6.3: Cost Implications Associated with Mitigation Measures

Mitigation Measures	**Cost Implications**
Pollution abatement equipment.	This cost will be included in the cost of the project.
Construction of ramp, sterilizer, processing line, boiler and ponding system	Cost will be included as a line item in the Bills of Quantities for the project build-up.
All the necessary mill operation equipment	Not possible to estimate these costs.
Personal Protective Equipment (PPE) for the persons handling hazardous materials.	This cost will be part of the running cost of the proposed palm oil mill and cannot be determined at this point. All contracts relating to supply, handling and management of hazardous materials must have provisions for this, i.e. personnel being kitted with PPE.
Correction of all inherited impacts from previous activities and operation.	Costs will be decided and implemented by the management.

CHAPTER SEVEN

ENVIRONMENTAL AND SOCIAL MANAGEMENT PLANS (ESMP)

Environmental monitoring will be required to monitor the effectiveness of the mitigation measures and to report to the regulatory agencies. Through sound environmental management, many avoidable adverse impacts from the construction and operation of the proposed project can be prevented.

The Environment Management Plan (EMP) consists of all mitigation measures for each component of the environment due to the activities increased during the construction, operation, decommissioning and the entire life cycle to minimize adverse environmental impacts resulting from the activities of the project. It would also delineate the environmental monitoring plan for compliance of various environmental regulations. It states the steps to be taken in case of emergency such as accidents at the sites including fire. The detailed EMP for the complex is given below.

7.1 Environmental Management Plan

The Environment Management Plan (EMP) is a site specific plan developed to ensure that the project is implemented in an environmental sustainable manner where all contractors and subcontractors, including consultants, understand the potential environmental risks arising from the project and take appropriate actions to properly manage that risk. EMP also ensures that the project implementation is carried out in accordance with the design by taking appropriate mitigation actions to reduce adverse environmental impacts during its life cycle. The plan outlines existing and potential problems that may adversely impact the environment and recommends corrective measures where required. Also, the plan outlines roles and responsibility of the key personnel and contractors who will be in-charge of the responsibilities to manage the project site.

The components of the environmental management plan, potential impacts arising, from the project and remediation measures are summarized below in Table 7.1.

Table 7.1: Summary of Potential Impacts and Remedial Measures

S/No.	Environmental components	Potential Impacts	Potential Source of Impact	Controls Through EMP & Design	Impact Evaluation	Remedial Measures
1.	Groundwater Quality	Ground Water Contamination	Construction Phase Wastewater generated from temporary labor tents.	No surface accumulation will be allowed. Mobile toilets will be provided.	No significant impact as majority of labours would be locally deployed	
			Operation Phase Sewage from the project	Toilets will be built inside the mill complex for workers	No negative impact on ground water quality envisaged.	
			Effluent discharges	Ponding system will be used for effluent treatment.	Not significant.	Monitoring Borehole will be dug at 150m Radius
2.	Ground Water Quantity	Ground Water Depletion	Construction Phase Groundwater aquifer depletion.	Industrial borehole will be constructed for construction purpose	No significant impact on ground water quantity envisaged.	
			Operation Phase The source of water during operation phase is Boreholes (4 in number).	Industrial borehole will be constructed for construction purpose. Awareness Campaign to reduce the water consumption	No significant impact on ground water quantity envisaged from the project.	In an unlikely event of non-availability of water supply, water will be brought using tankers.

3.	Surface Water Quality	Surface water contamination	<u>Construction Phase</u> Surface runoff from site during construction activity.	Surface water is over 8 km away from the project site.	No significant impact on surface water envisaged from the project.	
			<u>Operation Phase</u> Discharge of wastewater/effluent to the environment.	Wastewater/effluent will be channelled to 5 serial ponds for biological treatment.	No significant impact on surface water envisaged	
4.	Air Quality	Dust Emissions	<u>Construction Phase</u> All heavy construction activities	• During construction phase the contractors are advised to facilitate nose masks for the workers. • Water sprinklers will be used for suppression of dust during construction phase.	Not significant because dust generation will be temporary and will settle fast due to dust suppression techniques.	

		Emissions of SPM, SO_2, NO_2 and CO	<u>Construction Phase</u> Operation of Construction equipment and vehicles during site development.	• Rapid on-site construction and improved maintenance of equipment • Use of Personal Protective Equipment (PPE) like earmuffs and earplugs during construction activities	Not significant.	Regular monitoring of emissions and control measures will be taken to reduce the emission levels.
			<u>Operation Phase</u> • Power generation by generator set • Emission from vehicular traffic in use	• Use of low sulphur diesel if available • Stack height of generator would be adequate. • Providing Footpath and pedestrian ways within the site for the employees and visitors	Not significant. No significant increase in ambient air quality level is expected from the project's activities. There are no sensitive receptors located within the vicinity of site.	The vegetation cover (oil palm) at the proposed site will help trap greenhouse gases to be emitted.

5.	Noise Environment		Operation Phase • Noise from vehicular movement • Noise from generator set operation	• Green Belt Development • Development of speed breakers to check the traffic movement • Provision of noise shields near the heavy construction, operations and acoustic enclosures for generator set. • Construction activity will be limited to day time only	No significant impact	
6.	Land Environment	Soil contamination	Construction Phase • Disposal of construction debris	Construction debris will be collected and suitably used on site	No significant impact. Impact will be local, as waste generated will be reused for filling of low lying areas etc.	
			Operation Phase • Generation of solid waste • Used oil generated from generator set	• It is proposed that the solid waste generated will be managed as per ESWMB Rules. • Collection, segregation, transportation and disposal will be done as per ESWMB Rules. • Used oil generated will be sold to authorized recyclers	Since solid waste is handled by the authorized agency, waste dumping is not going to be allowed. Not significant. Negligible impact	

7.	Biological Environment (Flora and Fauna)	Displacement of Flora and Fauna on site	<u>Construction Phase</u> Site Development during construction	Landscaping is being carried out.		
			<u>Operation Phase</u> Increase in green covered area	Suitable green belts will be developed as per landscaping plan in and around the site using local flora	Beneficial impact.	
8.	Socio-Economic Environment	Population displacement and loss of income	<u>Construction Phase</u> • There is no displacement due to the construction.		No negative impact.	
			<u>Operation Phase</u> Site operation	Project will provide employment opportunities to the local people in terms of labor during construction and service personnel (guards, securities, gardeners etc) during operations .	Beneficial impact	

9.	Traffic Pattern	Increase of vehicular traffic	<u>Construction Phase</u> • Heavy Vehicular movement during construction	• Adequate parking facility will be provided • The peak hour will be avoided for transportation of materials.	No negative impact Beneficial Impact	
			<u>Operation Phase</u> • Traffic due to people once the project is operational	• Vehicular movement will be regulated inside the project area with adequate roads and parking lots.	No major significant impact	
10.	Occupational Safety	Accidents from heavy machinery movement and assemblage	<u>Construction and Operation Phases</u> Influx of machine and material movement into the site	• Operators must wear PPE • Traffic control into/out of site.	In case there is a violation of PPE usage.	Persuasion will first be adopted followed by sanction.
11.	Effluent and/or POME	Water/Land Pollution from POME.	<u>Construction Phase</u> Effluent and/or POME will not be discharged during construction activity.	Not Applicable	No significant impact on effluent/POME discharge is expected.	

7.1.1 EMP for Air Environment

Construction Phase

To mitigate the impacts of suspended particulate matter during the construction phase of the project, the following measures are recommended for implementation:

- A dust control plan
- Procedural changes to construction activities

Dust Control Plan

The most cost-effective dust suppressant is water because water is easily available on construction site. Water can be applied using water trucks, handled sprayers and automatic sprinkler systems. Furthermore, incoming loads could be covered to avoid loss of material in transport, especially if material is transported off-site.

Procedural Changes to Construction Activities

Idle time reduction: Construction equipment is commonly left idle while the operators are on break or waiting for the completion of another task. Emission from idle equipment tends to be high, since catalytic converters cools down, thus reducing the efficiency of hydrocarbon and carbon monoxide oxidation. Existing idle control technologies comprises of power saving mode, which automatically off the engine at preset time and reduces emissions, without intervention from the operators.

Improved Maintenance: Significant emission reductions can be achieved through regular equipment maintenance. Contractors will be asked to provide maintenance records for their fleet as part of the contract bid, and at regular intervals throughout the life of the contract. Incentive provisions will be established to encourage contractors to comply with regular maintenance requirements.

Reduction of On-Site Construction Time: Rapid on-site construction would reduce the duration of traffic interference and therefore, will reduce emissions from traffic delay.

Operation Phase

To mitigate the impacts of pollutants from generators and vehicular traffic during the operational phase of the Project, the following measures are recommended for implementation:

- Generator emission control measures
- Vehicular emission controls and alternatives
- Greenbelt development

Diesel Generator Set Emission Control Measures

Adequate stack height will be maintained to disperse the air pollutants generated from the operation of the generators to dilute the pollutants concentration within the immediate vicinity coupled with vegetation growth around the proposed project site. Hence no additional emission control measures have been suggested.

Vehicle Emission Controls and Alternatives

During construction, vehicles will be properly maintained to reduce emission.

Greenbelt Development

Increased vegetation in the form of greenbelt is one of the preferred methods to mitigate air and noise pollution. Plants serve as a sink for pollutants, act as a barrier to break the wind speed as well as allow the dust and other particulates to settle on the leaves. It also helps to reduce the noise level to a large extent. There exists vegetation growth (oil palm) around the proposed project site to take care of this impact.

7.1.2 EMP for Noise Environment

Construction Phase

To mitigate the impacts of noise from construction equipment during the construction phase on the site, the following measures are recommended for implementation.

Time of Operation: Noisy construction equipment will not be allowed to be use at night time.

Job Rotation and Hearing Protection: Workers employed in high noise areas are not employed on shift basis. Hearing protection such as earplugs/muffs will be provided to those working very close to the noise generating machinery.

Operation Phase

To mitigate the impacts of noise from diesel generator set during operational phase, the following measures are recommended:

- Adoption of Noise emission control technologies
- Greenbelt development

Noise Emission Control Technologies

Source of noise in the operational phase will be from generator sets (which is the main source of power for the propose project) and pumps & motors. All the machinery will be of highest standard of reputed make and will comply with standard i.e. The generator set room will be provided with acoustic enclosure to have maximum 90 dB(A) insertion loss or for meeting the ambient noise standard whichever is on higher side as per FMENV standard for 8 hour exposure limit.

7.1.3 EMP for Water Environment

Construction Phase

To prevent degradation and to maintain the quality of the water source, adequate control measures have been proposed. To check the surface run-off as well as uncontrolled flow of water into any water body is proposed. The following management measures are suggested to protect the water source being polluted during the construction phase:

- Avoid excavation during raining season
- Care has will be taken to avoid soil erosion
- Common toilets has been constructed on site during construction phase and the sewage would be channelized to the septic tanks in order to prevent sewage to enter into the water bodies
- To prevent surface and ground water contamination by oil and grease, the floors of oil and grease handling area will be kept effectively impervious. Any wash off from the oil and grease handling area or workshop will be drained through imperious drains
- Collection and settling of storm water, prohibition of equipment wash downs and prevention of soil loss and toxic release from the construction site are necessary measure to be taken to minimize water pollution

Operation Phase

In the operation phase of the project, water conservation and development measures will be taken, including all possible potential for rain water harvesting. Following measures will be adopted:

- Minimizing water consumption.
- Promoting reuse of water after treatment and development of closed loop systems for different water streams.

Minimizing Water Consumption

Consumption of fresh water will be minimized by combination of water saving devices and other domestic water conservation measures. Further, to ensure ongoing water conservation, an awareness program will be introduced for employees not to excessively use or waste water.

Wastewater Treatment Method

It is expected that the project will generate approx 300 tons/day of effluent. The effluent will be treated in the 5 Nos. serial ponds for biological treatment before being discharged into the oil palm plantation for irrigation.

Storm Water Management

Most of the storm water produced on site will be harvested for ground water recharge. Thus proper management of this resource is a must to ensure that it is free from contamination.

Contamination of Storm Water is possible from the following sources:

- Diesel and oil spills in the diesel power generator and fuel storage area
- Waste spills in the solid / hazardous waste storage area
- Oil spills and leaks in vehicle parking lots
- Silts from soil erosion in gardens
- Spillage of palm oil from palm oil mill processing line

A detailed storm water management plan will be developed which will consider the possible impacts from above sources. The plan will incorporate best management practices which will include following:

- Regular inspection and cleaning of storm drains
- Clarifiers or oil/separators will be installed in all the parking areas. Oil/grease separators installed around parking areas. Both clarifiers and oil/water separators will be periodically pumped in order to keep discharges within limits
- Covered waste storage areas
- Secondary containment and dykes in fuel/oil storage facilities
- Conducting routine inspection to ensure cleanliness
- Provision of slit traps in storm water drains
- Good housekeeping in the above areas

7.1.4 EMP for Land Environment

Construction Phase

The waste generated from construction activity includes construction debris, biomass from land clearing activities, waste from the temporary make shift tents for the labour's and hazardous waste.

Construction Debris

Construction debris is bulky and heavy and re-utilization and recycling is an important strategy for management of such waste. As concrete constitutes the majority of waste generated, recycling of this waste by conversion to aggregate can offer benefits of reduced landfill space and reduced extraction of raw material for new construction activity. This is particularly applicable to the project site as the construction is to be completed in a phased manner.

Metal scrap from structural steel, piping, concrete reinforcement and sheet metal work will be removed from the site by construction contractors. A significant portion of wood scrap will be reused on site. Recyclable wastes such as plastics, glass fibre insulation, roofing etc shall be sold to recyclers.

Hazardous waste

Construction sites are sources of many toxic substances such as paints, solvents wood preservatives, adhesives and sealants. Hazardous waste generated during construction phase shall be stored in sealed containers and disposed as per The S.I.15 - National Environmental Protection (Management of Solid and Hazardous Wastes) Regulations 1991.

Some management practices to be developed are:

- Paintbrushes and equipment for water and oil based paints shall be cleaned within a contained area and has not been allowed to contaminate site soils, water courses or drainage systems.
- Provision of adequate hazardous waste storage facilities. Hazardous waste collection containers will be located as per safety norms and designated hazardous waste storage areas will be away from storm drains or watercourses
- Segregation of potentially hazardous waste from non-hazardous construction site debris
- Well labelled all hazardous waste containers with the waste being stored and the date of generation
- Instruct employees and subcontractors in identification of hazardous and solid waste.

Even with careful management, some of these substances are released into air, soil and water and many are hazardous to workers. With these reasons, we will try as much as practically possible to avoid their use by using low-toxicity substitutes and low VOC (Volatile Organic Compound) materials.

Waste from Temporary Makes Shift Tents for Labours

Wastes generated from temporary make shift labour tents will mainly comprise of household domestic waste, which will be managed by the contractor on the site. The sewage generated will be channelized to the septic tank.

<u>Operation Phase</u>

In the operation phase of the project, effluent/POME will be discharged into five (5) serial ponds for biological treatment before discharge into the plantation as irrigation water. The following measures will be adopted to monitor both the quality of the effluent and also the impact on groundwater:

- Effluent sample (treated) will be collected from the last pond discharge point (pond No. 5) and taken to the laboratory for analysis to know if it conforms to FMENV limit for land application.
- Sample of monitoring well located at about 150 radius to the effluent treatment ponds will be collected and taken to the laboratory for analysis. This will inform us of contamination potential of groundwater.

Top Soil Management

To minimize disruption of soil and for conservation of top soil, the contractor will keep the top soil cover separately and stockpile it. After the construction activity is over, top soil will be utilized for landscaping activity. Other measures, which would be followed to prevent soil erosion and contamination include:

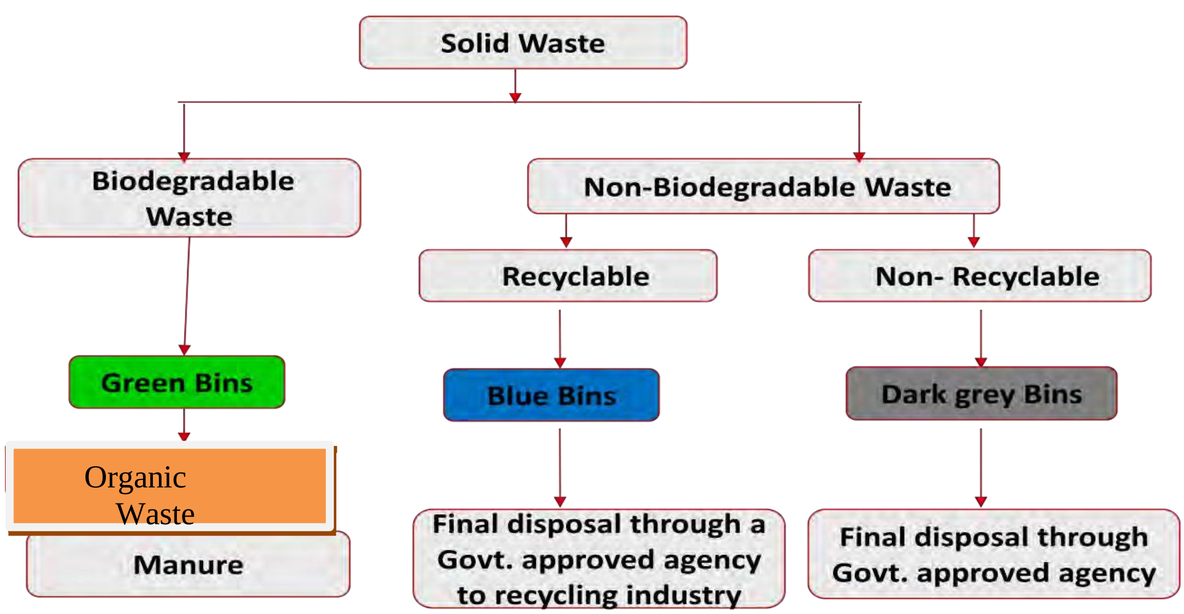
- Maximize use of organic fertilizer for landscaping.
- To prevent soil contamination by oil/grease, leak-proof containers will be used for storage and transportation of oil/grease and wash off from the oil/grease handling area will be drained through impervious drains and treated appropriately before disposal.
- Working in a small area at a point of time (phase wise construction)
- Construction of erosion prevention troughs/berms.

Operational Phase

The philosophy of solid waste management at the proposed mill complex will be to encouraging the four R's of waste i.e. **R**eduction, **R**euse, **R**ecycling and **R**ecovery (materials & energy). The company will leverage on its present waste management Plan for proper segregation and storage techniques. The Environmental Management Plan for the solid waste focuses on three major components during the life cycle of the waste management system i.e., collection and transportation, treatment or disposal and closure and post-closure care of treatment/disposal facility.

Collection and Transportation

- During the collection stage, the solid waste of the project will be segregated into biodegradable waste and non-biodegradable. Biodegradable waste and non-biodegradable waste will be collected in separate bins. Biodegradable waste will be composted and returned to the plantation field as organic manure. Proper segregation of waste will be carried out as follows:
- To minimize littering and odour, waste will be stored in well-designed containers/ bins that will be located at strategic locations to minimize disturbance in traffic flow
- Care would be taken such that the collection vehicles are well maintained and generate minimum noise and emissions. During transportation of the waste, it will be covered to avoid littering.



Disposal

With regards to the disposal/treatment of waste, the management will take the services of the authorized agency for waste management and disposal of the same on the project site during its operational phase.

7.1.5 EMP for Ecological Environment

Construction activity changes the natural environment. But the proposed project also creates a built environment for its inhabitants. The project requires the implementation of following choices exclusively or in combination.

Construction Stage

- Restriction of construction activities to defined project areas, which are ecologically sensitive
- Restrictions on location of temporary labour tents and offices for project staff near the project area to avoid human induced secondary additional impacts on the flora and fauna species
- Cutting, uprooting, coppicing of trees or small trees if present in and around the project site for cooking, burning or heating purposes by the labors is prohibited.
- Conservation plots of High Conservation Value forest had been set aside before the construction of this project

Operation Stage

Improvement of the current ecology of the project site will entail the following measures:

- Oil Palm Plantation and Landscaping
- Conservation Plots of HCV

7.1.6 EMP for Socio-Economic Environment

The social management plan has been designed to take proactive steps and adopt best practices, which are sensitive to the socio-cultural setting of the region. The Social Management Plan for the proposed project focuses on the following components:

Income Generation Opportunity during Construction and Operation Phase

The project would provide employment opportunity during construction and operation phase. There would also be a wide economic impact in terms of generating opportunities for secondary occupation within and around the complex. The main principles considered for employment and income generation opportunities are out lined below:

- Employment strategy will provide for preferential employment of local people
- Conditions of employment would address issues like minimum wages and medical care for the workers. Contractors would be required to abide to employment priority towards locals and abide by the labour laws regarding standards on employee terms and conditions.

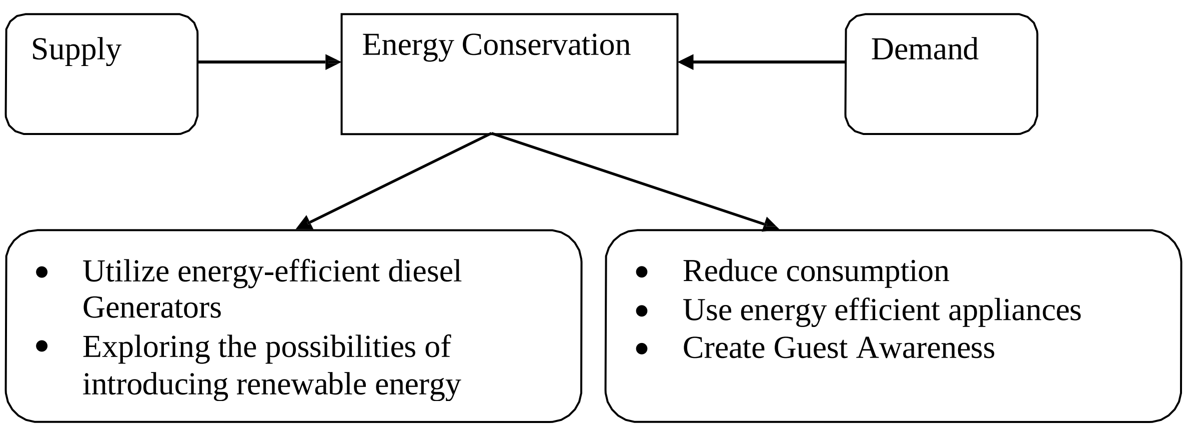
Improved Working Environment for Employees

The project would provide safe and improved working conditions for the workers employed at the facility during construction and operation phase. With the ambience and facilities provided, the proposed project will provide a new experience in living and recreations. Following measures would be taken to improve the working environment of the area:

- Developing a proper interface between the work and the human resource through a system of skill improvement
- Measures to reduce the incidence of work related injuries, fatalities and diseases
- Maintenance and beautifications of the project site

7.1.7 EMP for Energy Conservation to Reduce Greenhouse Gas Emission

Energy conservation program will be implemented through measures taken both on energy demand and supply.



Energy conservation will be one of the main focuses during the project planning and operation stages. The conservation efforts would consist of the following:

Architectural design

- Maximize the use of natural lighting through design.
- The orientation of the buildings will be done in such a way that maximum daylight is available.

Energy Saving Practices

- The company has already put in place an energy conservation plan which includes switching off all electrical appliances when not in use or when going on break.
- Constant monitoring of energy consumption and defining targets for energy conservation.
- Adjusting the settings and illumination levels to ensure minimum energy used for desired comfort levels.

Behavioural Change on Consumption

- Promoting workers awareness on energy conservation
- Training staff on methods of energy conservation and to be vigilant to such opportunities.

7.1.8 EMP at Decommissioning Phase

Activity Phase	Potential Impact	Action that shall be taken	Responsibility for Mitigating Action	Monitoring of Mitigation/Impacts	
				Activity to be Monitored	Timing & Frequency
Decommissioning Phase	***Air Pollutants*** Generation of dust during mill components destruction and also residues retained on the inner surface of the machinery may pose a health risk to the persons dismantling the components and its ancillary facilities. This risk could spread to the residences if particulates and PM_{10} in the residues are allowed to become airborne through a failure to contain the contaminated parts. Pollutants of particular concern in the residues include PCBs, dioxins and heavy metals.	Decontamination will be done according to procedure that will be approved beforehand by FMEnv	HSE Department/HSE Committee	Contamination and pollution of the soil	During decommissioning exercise
	Noise The dismantling and demolition of the mill components will generate minimal noise.	Decontamination will be done according to procedure that will be approved beforehand by FMEnv	HSE Department/HSE Committee	Contamination and pollution of the soil	During decommissioning exercise
	Wastewater Though quantities of wastewater may be small, this needs to be appropriately contained to prevent release into any nearby waterways or leaching into soil.	Decontamination will be done according to procedure that will be approved beforehand by FMEnv	HSE Department/HSE Committee	Contamination and pollution of the soil	During decommissioning exercise

Activity Phase	Potential Impact	Action that shall be taken	Responsibility for Mitigating Action	Monitoring of Mitigation/Impacts	
				Activity to be Monitored	**Timing & Frequency**
Decommissioning Phase	***Solid Waste*** Large quantities of steel, metal, wooden and concrete waste will be accumulated after demolition and dismantling of the machinery may be contaminated with residues of PCBs, dioxins and heavy metals.	Decontamination will be done according to procedure that will be approved beforehand by FMEnv	HSE Department/HSE Committee	**C**ontamination and pollution of the soil	During decommissioning exercise
	Air Pollutants Generation of dust during mill components destruction and also residues retained on the inner surface of the machinery may pose a health risk to the persons dismantling the components and its ancillary facilities. This risk could spread to the residences if particulates and PM_{10} in the residues are allowed to become airborne through a failure to contain the contaminated parts. Pollutants of particular concern in the residues include PCBs, dioxins and heavy metals.	Decontamination will be done according to procedure that will be approved beforehand by FMEnv	HSE Department/HSE Committee	**C**ontamination and pollution of the soil	During decommissioning exercise

Table 7.2: Social Impact Management Plan (SIMP)

Mitigation Target: To Minimize Influx of Plantation Workers and its Implications on Communities' Family Structures and Social Networks		
Priority is given to affected communities for all categories of workers to be recruited provided they have the requisite qualification and expertise.	Okomu Oil Palm Company Plc and communities	Throughout the project's life.
Develop database of local service providers and ensure they are informed of opportunities and tenders.	Okomu Oil Palm Company Plc	Within the first 3 years of project implementation.
Undertake orientation and induction on local communities' culture, tradition and values for workers from outside of the communities.	Okomu Oil Palm Company Plc and Community Liaison Officer (CLO)	Throughout the project's life.
Mitigation Target: To Minimize Water Pollution due to POME		
Proper treatment of POME before discharge into the environment.	Okomu Oil Palm Company Plc	Throughout project life.
Secure POME treatment facility by enough posting of the area with safety warnings	Okomu Oil Palm Company Plc	Throughout project life.
Mitigation Target: To Avoid or Minimize the Exposure of Workers and Local Communities to Health and Safety Risk including HIV Aids		
Conduct risk assessment for all tasks and provide personal protective clothing to all workers.	Okomu Oil Palm Company Plc	At the commencement of operation.
Provide decent and adequate toilet and sanitation facilities for workers at the mill complex	Okomu Oil Palm Company Plc	During operation phase.
Develop and implement waste management plans.	Okomu Oil Palm Company Plc	Throughout the project life.
Undertake regular medical check-up for workers.	Okomu Oil Palm Company Plc	Throughout the project life.
Formulate and release HIV/AIDS policy for workplace.	Okomu Oil Palm Company Plc and Workers Unions	Throughout the project life.
Design and implement health education programmes for workers.	Okomu Oil Palm Company Plc	Throughout the project life.

Establish an in-plant clinic to provide healthcare services to workers and their families.	Okomu Oil Palm Company Plc	At commencement of project implementation.
Mitigation Target: To Minimize Impacts of Operations on Public Facilities and Structures		
Ensure that damage caused to public facilities are appropriately fixed and within reasonable timeframe.	Okomu Oil Palm Company Plc and contractors	Soon after damage is identified.
Identify and develop guidelines for key activities that have the potential to impact on public facilities	Okomu Oil Palm Company Plc	Before commencement of project implementation.
Regular and effective monitoring of operation's impacts on public facilities and infrastructure	Okomu Oil Palm Company Plc	To be part of monitoring.
Support to the development of public facilities and infrastructure (e.g. schools, roads, electricity, etc.)	Okomu Oil Palm Company Plc	Throughout project life.
Mitigation Target: To Maximize Local Employment and Ensure Reasonable Quality of Life and Working Conditions of Workers at Palm Oil Mill		
Ensure workers' conditions of service including salaries and wages compare favorable as applicable in the oil palm industry in Nigeria.	Okomu Oil Palm Company Plc, service providers and contractors	Throughout project life.
Dialogue, engage regularly and communicate effectively with workers union.	Okomu Oil Palm Company Plc and Workers Union	Throughout project life.
Ensure workers have appropriate and safe means of transport to and from work site.	Okomu Oil Palm Company Plc	Throughout project life.
Adopt and implement mechanism for disputes and grievance resolution.	Okomu Oil Palm Company Plc	Throughout project life.
Mitigation Target: To Avoid/Minimize Potential Impacts of Pollution, Safety, Noise and Dust and Damage to Roads caused by Heavy Vehicles and Construction Activities		
Ensure all vehicles are roadworthy and drivers receive road safety trainings.	Okomu Oil Palm Company Plc and contractors	Throughout project life.

Institute safe driving culture including sanctions for violators both inside and outside of the estate.	Okomu Oil Palm Company Plc, customers and contractors	Throughout project life.
Maintain access roads to the palm oil mill.	Okomu Oil Palm Company Plc	Throughout project life.
Undertake a noise mapping of the mill and workshop to identify areas with more than 90 decibels and monitor regularly.	Okomu Oil Palm Company Plc	Throughout project life.
Provide appropriate personal protective equipment (PPE) for all workers especially at the workshop palm oil mill.	Okomu Oil Palm Company Plc	Throughout project life.
Mitigation Target: To Avoid Pollution or Destruction of Water Bodies		
Implement the environmental management plan (EMP) as approved by Federal Ministry of Environment.	Okomu Oil Palm Company Plc	Throughout the project life.
Comply with regulations relating to pollution	Okomu Oil Palm Company Plc and contractors	Throughout the project life.
Avoid environmental pollution at all workplaces.	Okomu Oil Palm Company Plc and contractors	Throughout the project life.
Obtain permits from regulatory bodies for effluent discharges and solid waste disposal.	Okomu Oil Palm Company Plc	Throughout project life.
Monitoring:		
Monitoring of operations impacts on local communities and population.	Okomu Oil Palm Company Plc	3 Years after commencement, then bi-annual.
Implement the approved social impact monitoring programme.	Okomu Oil Palm Company Plc	Annually.

7.2 Environmental Management System and Monitoring Plan

The company has put in place an effective Environmental Management system (EMS) to ensure consistent functioning of the project. The EMS would include the following:

- An Environmental management committee.
- Environmental Monitoring.
- Personnel Training.
- Regular Environmental audits and Correction measures.
- Documentation – standards operation procedures Environmental Management Plan and other records.

7.3 Health, Safety and Environment (HSE Department/HSE Committee)

Apart from having an Environmental Management Plan, it is also proposed to have a permanent organizational set up charged with the task of ensuring its effective implementation of mitigation measures and to conduct environmental monitoring. The major duties and responsibilities of HSE department with HSE Committee shall be as given below:

- To implement the environmental management plan.
- To assure regulatory compliance with all relevant rules and regulations.
- To ensure regular operation and maintenance of pollution control devices.
- To minimize environmental impact of operations as by strict adherence to the EMP.
- To initiate environmental monitoring as per approved schedule.
- Review and interpretation of monitored results and corrective measures in case monitored results are above the specified limit.
- Maintain documentation of good environmental practices and applicable environmental laws for a ready reference.
- Maintain environmental related records.
- Coordination with regulatory agencies and external consultants
- Maintenance of log of public complaints and the action taken.

7.4 Hierarchical Structure of Environmental Management Committee

Normal activities of the EMP cell would be supervised by HSE department together with the site manager/coordinator of the project. The hierarchical structure of HSE department/HSE Committee is presented in Figure 7.1 below.

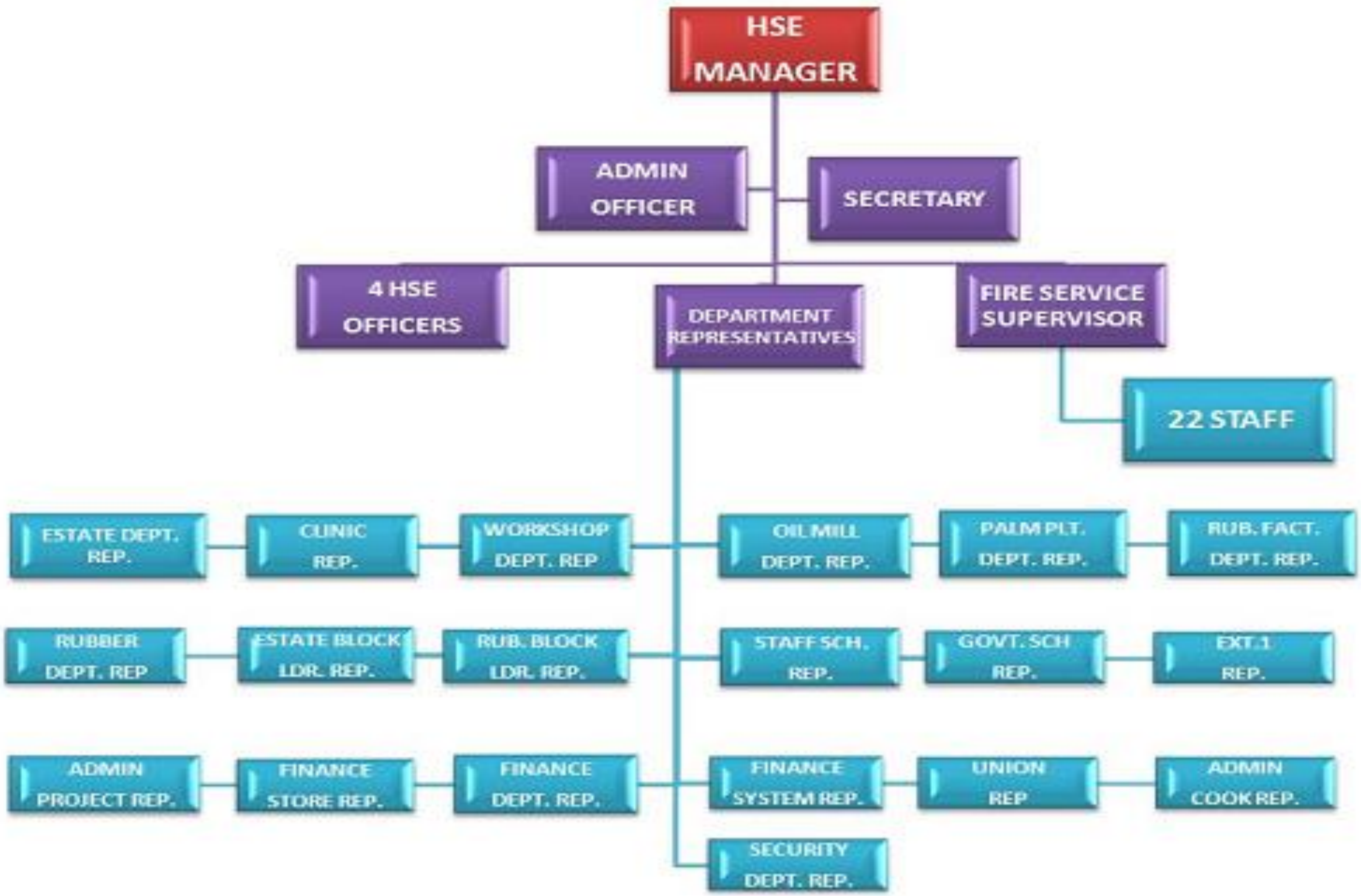


Figure 7.1: HSE Department/Committee Structure

7.5 Environmental Monitoring

The purpose of environmental monitoring is to evaluate the effectiveness of implementation of Environmental Management Plan (EMP) by periodic monitoring. The important environmental parameters within the impact area are selected so that any adverse effects are detected and timely action can be taken. The project proponent will monitor ambient air Quality, Ground Water Quality and effluent/wastewater Quality and ambient noise level in accordance with an approved monitoring schedule.

Table 7.3: Suggested Monitoring Program for the Proposed Project

S. No.	Type	Locations	Parameters	Period and Frequency
1.	Meteorology	At the proposed project site	Rainfall, temperatures, Wind Speed, Sunshine Hours	Daily
2.	Ambient Air Quality	Project Site	Criteria Pollutants: SO2, NO2, SPM, CO, CO_2, VOC etc	Quarterly
3.	Groundwater (Portability testing)	Project site	Drinking water parameters as per FMENV/WHO Standard such as pH, BOD, COD, Microbiology.	Quarterly
4.	Effluent/Wastewater Quality	Effluent Ponds	FMENV Limit for Land Application such as pH, BOD, COD, TSS, Oil and Grease, Microbiology.	Quarterly
5.	Ambient Noise	Noise Generating Facilities	FMENV Limit for 8-hour Exposure {dB (A)} levels.	Monthly
6.	Health	Facility Clinic	Occupational diseases and/or Medical statistics	Every 6 months

7.6 Awareness and Training

Training and human resource development is an important link to achieve sustainable operation of the facility and environment management. For successful functioning of the project, relevant EMP would be communicated to:

7.6.1 Company Staff and Contractors

Workers must be made aware of the importance of waste segregation and disposal, water and energy conservation. The awareness would be communicated through posters and notices in a bill board. They would be informed of their responsibilities.

7.6.2 Environmental Audits and Corrective Action Plans

To assess whether the implemented EMP is adequate, periodic environmental audits will be conducted by the project proponent's HSE department. These audits will be followed by Correction Action Plan (CAP) to correct various issues identified during the audits.

7.7 Emergency Response Plan

An emergency is any unplanned occurrence caused by either natural or man-made events which can lead to deaths, significant injuries, cessation of operations, physical or environmental damage and economic losses. Numerous events can lead to emergencies. These include:

- Fires
- Floods
- Communications failure
- Chemical spills
- Oil Spills
- Structural failure
- Civil disturbance

Emergency management is therefore critical to planning, mitigating, responding and recovering from the potential impacts of these events. The emergency management process however is very site specific and varies according to type of operations, geographic location, proximity to neighbouring communities and the history of such occurrences. Therefore, one of the first stages in developing an Emergency Response Plan (ERP) would be the identification of the potential hazards or threats to the facility, organisation or operation based on the above mentioned factors.

The Emergency Response Plan must be documented and cover all the areas mentioned above. In addition;

- The plan must identify the person(s) responsible for Emergencies and Safety. This person will keep the documentation updated (at least annually) and ensure that it is disseminated to all relevant persons.
- The plan must speak to the preparatory actions that must be taken in case of emergencies with forewarning such as hurricanes and responsibilities must be assigned.
- The plan should include actions that must be taken when a spill, riot or fire occurs. A safe area (muster) must be designated for persons to congregate during an emergency.
- A system must be in place to account for all staff members in an emergency with the appropriate responsibilities assigned.
- Drills must be conducted on a specified frequency (for example 3 times in the year for fire).

The plan must include for firefighting equipment to be checked on a specified

- frequency by a competent entity.
- The plan must address clean-up measures after the emergency.

The Emergency Response Plan must be developed in consultation with FMEnv to ensure that it meets their requirements. The Emergency Response Plan for the mill expansion will form a part of the overall Emergency Response Plan for the company.

7.7 Decommissioning

7.7.1 Decommissioning of a Palm Oil Mill

The approaches to the decommissioning of a palm oil mill would involve the combination of the following activities/options:

7.7.1.1 Asset Recovery

This would be achieved through a reputable decommissioning services company. The company would offer to purchase the complete asset units or sale of the entire palm oil mill. Assets recovery would be done such as to achieve maximum return for the assets within the specified time.

7.7.1.2 Dismantling

This is applicable to either the removal of installations or the 'un-building' of structures. Dismantling is generally achieved by a careful reversal of the construction process. Dismantling will be done to optimize asset recovery.

7.7.1.3 Demolition

Demolition usually applies to structures and plant which have reached the end of their working life, and must be carried out with a high degree of knowledge and expertise. The demolition techniques used include conventional, remote mechanical and the use of controlled explosive charges.

7.7.1.4 Decontamination

Contamination and pollution of the soil and buildings can often be a major problem for those decommissioning industrial premises. The contamination may be in various forms i.e. solid, liquid, vapour, gas or powder. This contamination can be present in the air or on surfaces such as plant items or building fabric. Decontamination will be done according to procedure that will be approved beforehand by FMEnv.

7.7.1.5 Remediation

Ground remediation, rehabilitation and regeneration package will form an integral part of the services to be performed by the company to be appointed for decommissioning.

7.8 Decommissioning Procedure

A decommissioning service company will be contracted to undertake the decommissioning. The company will prepare and submit a manual articulating the procedure and methodology of decommissioning, including approach, type of waste and disposal method. The procedure will be such as to minimize the adverse impacts associated with decommissioning and will be approved by FMEnv before commencement of decommissioning.

CHAPTER EIGHT

CONCLUSION

This project is an attestation to the sustainable growth of palm oil processing which will result in substantial economic benefits for Nigeria through employment opportunities generation in particular during the construction and operation phases.

This EIA also indicates that discharges including wastewater discharge, gaseous emissions and noise are expected from the operation of the palm oil mill. However, any such discharges, which can be considered as potential sources of adverse environmental effects, can be fully managed through preventive actions and mitigating measures. This means that no significant negative impact on the natural, health and social environmental sensitivities of the project area is expected to result from discharges.

The assessment has gathered and analysed the present situation which shall form the basis for baseline data. The data seem adequate and have assisted to determine the present and socio-economic status of the project environment and the kinds of effects and responses that may result from the interaction of the mill operation. However, the proposed project is not expected to have significant adverse effects on the natural, cultural, environmental and socioeconomic life in the project area.

The assessment further demonstrates that the proposed project will fully comply with legislative requirements in Nigeria and other relevant international regulations applicable to the planned operations much as in the case of the existing one at the proponent headquarters known as Main estate.

The existing environmental management programme of OOPC Plc has put in place good solid waste management system, which will fully complement the waste management requirement of the proposed project.

An EMP involving environmental management and supervision organizations, and environmental monitoring has been established to ensure the environmental performance of the Project. To ensure successful implementation of these measures, the EMP covers major relevant aspects such as institutional arrangement for environmental management and supervision and environmental monitoring. With implementation of the mitigation measures defined in the EIA and EMP, all the likely adverse environmental impacts associated with the proposed project will be prevented, eliminated, or minimized to environmentally and socially acceptable levels.

It is clear that the proposed project will be sustainable if all the identified and potential environmental and social impacts are adequately mitigated.

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ANNEXURE I

APPROVED TERMS OF REFERENCE (ToR)

FEDERAL MINISTRY OF ENVIRONMENT

Environment House

Independence Way South, Central Business District, Abuja - FCT.
Tel: 09-2911 337 www.environment.gov.ng, ea-environment.org

ENVIRONMENTAL ASSESSMENT DEPARTMENT

FMEnv/EA/EIA/4539/Vol.1/
11th April, 2018

The Managing Director,
Okomu Oil Palm Company PLC,
Okomu-Udo, Edo State.

RE: ENVIRONMENTAL IMPACT ASSESSMENT (EIA) OF THE PROPOSED 60 TONS FFB/HR PALM OIL MILL EXTENSION II, IN OVIA NORTH-EAST LGA, EDO STATE BY OKOMU OIL PALM COMPANY PLC.

Please refer to your letter dated 29th November, 2017 and the Ministry's letter Ref: **FMEnv/EA/EIA/4539/Vol.1/17** dated 14th December, 2017 on the above subject.

2. Following the conclusion of the EIA Site Verification Exercise, the Ministry has placed the project in Category two (2) requiring Mandatory EIA studies and a Technical Review meeting. Please be informed that the issues considered significant by Stakeholders during the scoping workshop must be addressed in the EIA Study. Please note that this is a condition for the approval of the Terms of Reference (TOR) submitted to the Ministry.

3. The field data gathering for the EIA study and laboratory analysis of the environmental component of the study will be One (1) season data gathering which will be supplemented with an approved relevant EIA report and should include the following as minimum. Sampling points shall be geo-referenced with coordinates.

S/N	ENVIRONMENTAL COMPONENTS.	COMPONENT DETAILS	NUMBER OF SAMPLES/ DISTRIBUTION	PARAMETERS TO BE MONITORED.
1.	Meteorology	Microclimate/ regional climatic features	In-situ measurement, secondary data	Temp (max. and min.), rainfall pattern (seasonal patterns, intensity), relative humidity (wet and dry bulb), pollutant dispersal patterns, seasonal variation in climate conditions, climate zone characterization, tidal patterns, wind speed and direction, visibility etc.
2.	Topography		Descriptive	Drainage patterns, slope angles & orientation, prominent features, elevation (maximum and minimum, prominent features), identification of creeks, rivers, water access routes, operation areas, terrain conditions, major access routes to project sites.
3.	Groundwater	Physiochemistry/ Microbiology	3 Nos (within the extension ii area/nearby communities) + control samples	Depth to water table, and thickness of acquifers, hydraulics, groundwater flow regime and rates, volumes, recharge sources and rates, areas of groundwater/surface water interactions, recharge and, uses. **General**- BOD, COD, DO, THC, TDS, TSS, Alkalinity, Color, pH, Turbidity, Salinity, hardness, temperature, hydrodynamics **Exchangeable cations** - Na, K, Mg and Ca **Exchangeable anions** – sulphate, nitrate, nitrite, ammonium, nitrogen and chloride. **Heavy metals** – Cu, Cd, Ba, Pb, Fe, Al, Cr, Mn, CN, V, K, Hg, Mo, Ni, Ti, Zn. **Microbiology** – (faecal coli form, total coliform, total plate), water body depth and width, total hydrocarbon utilizing Fungi, total heterotrophic fungi counts, coliform counts, other pathogens detected, hydrocarbon degrading bacteria ,fungi.
4.	Soil	Physical	6 Nos. (within the extension ii area) + control samples	Particle size distributions, Profile (depth, type) colour, permeability, porosity, bulk density, texture, total organic content, pH, total nitrogen, conductivity.

		Chemical	6 Nos. (within the extension ii area) + control samples	Heavy metals (V, Ni, Fe, Pb, Cu, Zn, As, Hg, Mg, Cr, Ba, Cd). Exchangeable anions (sulphate, nitrate, nitrite, ammonium nitrogen, chloride).
		Soil Microbiology	6 Nos. (within the extension ii area) + control samples	Total heterogenic bacteria (total hydrocarbon, T. fungi, total hydrocarbon bacteria (THB), faecal coliform. Agricultural potential
5.	**Ambient air**		6 Nos. (in-situ @ different elevations within the extension ii area) + control samples	Suspended Particulate Matter, background radiation, NO_2, SO_2, CO_2, CO, VOCs, H_2S, NH_3. HC(methane and non-methane HC). Greenhouse Gases(GHGs)
6.	**Noise and Vibration**	Noise level	6 Nos. (in-situ within the extension ii area) + control samples	Point source and non-point sources (Db).
7.	**Vegetation**			Density frequency, relative importance, economic/medicinal plant species which may be used as indicators of environmental effects, tissue analysis for heavy metals, wetland & other conservation areas.
8.	**Land Use**	Land cover	-	Characterization of main land uses and land types including harvesting periods.
9.	**Waste Inventory/Management**			Identification of various sources of waste generation, waste management practice, waste disposal sites, waste recycling facilities and techniques.
10.	**Geology/Geotechnical/hydrogeology studies**			Stratigraphy, structure, fracture patterns, aquifer level, lithological regional geology, stratigraphic properties.
11.	**Traffic study/safety & Traffic management plan**			Vehicular volume count/ destination survey.
12.	**Socio-Economics**		Oral interviews, structured questionnaires.	Impacts of project on socio-economic indices, education, culture, distribution of livelihoods, land use types, taboos, religious beliefs, festivals, shrines, etc. with structured questionnaire administration.
13.	**Health Impact Assessment**			Health status and prevalent diseases in the community.
14.	**Climate Change Issues**			Carbon dioxide emissions, transportation heat and electricity generation, waste resources and flooding risk increase.

4. The laboratory analysis of the samples must be carried out in an FMEnv accredited Laboratory and witnessed by officials of the Ministry. You are also to ensure full quality assurance/quality control (QA/QC) measures for the laboratory analysis in line with standard practices and notify us in good time to enable us plan our participation in the exercise.

5. The following should be forwarded to the Federal Ministry of Environment before submission of the **draft** EIA report.

i. Evidence of accreditation of the Federal Ministry of Environment for the Laboratory where the sample analysis would be carried out.
ii. Chain of Custody.
iii. Certificate of Analysis duly stamped and signed by the Laboratory Manager.
iv. Evidence of Laboratory witnessing by the Federal Ministry of Environment.

6. Upon completion of the EIA studies, the proponent are to submit to the Ministry Ten (10) hard copies along with two (2) electronic copies of the draft EIA report and also email a copy to eia@ead.gov.ng

7. Thank you for your co-operation.

K. A. Ihebinike
For: Honourable Minister

APPENDIX I

LABORATORY ANALYSIS RESULTS

ENVIRONMENTAL Laboratories Ltd
(Environmental Consultants & Public Analysts)

MOLAJ HOUSE:
15A, Niyi Ayeye Street, Off Channels TV Avenue,
OPIC Estate, (Via Berger), Isheri, Ogun State
Tel: 234(0)7647923, (0)8052059768.
E-mail:info@environlabsng.com, els@environlabsng.com
Website:www.environlabsng.com

Analyst's Certificate

№: 1903007

[Institute of Public Analysts of Nigeria Decree 100 of 1992]

Name of Sample:	Extension 2 Groundwater samples	**Project**: Extension 2 POM EIA
Client:	Foremost Development Services Limited *For:* OKOMU Nig. PLC Benin City, Edo State.	
Submission Date:	4 March 2019	**Lab No.:**EL/W/1903/31803-31805

Methodology:

Samples of water collected from all the sites were analyzed using Standard methods of water and wastewater analysis (APHA, 23rdedition) and HACH methods of analysis of water (12th edition). The parameters examined are as contained in the result Table.

Sampling Locations

S/N	Sample Code	Description of Location	Coordinates	
1.	BH1	Okomu Extension 2 Borehole 1	N06^{0}42'03.4"	E005^{0}49'08.8"
2.	BH2	Okomu Extension 2 Borehole 2	N06^{0}41'11.7"	E005^{0}49'55.4"
3.	**BH3 (CTRL)**	**Okomu Extension 2 Borehole 3**	**N06^{0}40'30.6"**	**E005^{0}48'36.6"**

Result of Analysis

The result of on-site measurements and laboratory analyses carried out on the water samples collected from OKOMU Oil Palm Extension II while in the same condition as submitted to us is presented in Table 1:

Comments

Based on the result of analysis conducted on the samples, all the physico-chemical and microbiological qualities of the water samples conformed to the Standard except for slight acidic content.

I, the undersigned Public Analyst, OYEDIRAN, L.O. (IPAN NO. 00155®), make this certification, as witnessed my hand this 11thday of March, 2019.

FEMI OYEDIRAN
INSTITUTE OF PUBLIC ANALYSTS OF NIG.
(ESTABLISHED BY DECREE No. 100 OF 1992)
PRACTICE LICENCE No: 00155

TABLE 1: EXTENSION 2 GROUNDWATER SAMPLES — Ex.: OKOMU Oil Palm Plc

PARAMETER/UNIT	FMENV: 2015	Method, APHA, 23Ed.	BH1	BH2	BH3 (CTRL)
Appearance	Clear & colourless		Clear & colourless liquid		
Odour	Unobjectionable		Unobjectionable		
Taste	Unobjectionable		Unobjectionable		
pH	6.5-8.5	4500-HB	5.25	5.20	5.84
Temperature, °C	Ambient	-	31.8	31.2	31.1
Conductivity, µS/cm	1000	2500-B	50	40	60
Colour, Pt-Co	15	2120-C	2	<1	<1
Turbidity, NTU	5	2130-B	4	6	1
Total Solids, mg/L	-	2540B	26.2	22	30
Total Dissolved solids, mg/L	500	2540-D	25.2	20	30
Total Suspended Solids, mg/L	-	2540-C	1	2	<1
Total Hardness, mg/L		2340-C	4	4	12
Total Alkalinity, mg/L	-	2320-B	23	19.2	21.1
Total acidity, mg/L	-	2310-B	24.4	27.8	13.9
Calcium, mg/L	-	3500-B	1.6	1.6	3.6
Magnesium, mg/L	20	3500-B	<1	<1	0.7
Chloride, mg/L	250	4500-B	1.4	6.2	6.2
Nitrate, mg/L	50	4500-NO_3^--E	0.10	0.5	0.9
Nitrite, mg/L	0.2	4500-NO_2^--B	<0.01	<0.01	<0.01
Sulphate, mg/L	100	4500-SO_4-E	9	12	11
Phosphate, mg/L	-	4500-E	<0.1	<0.1	<0.1
Free carbon dioxide, mg/L	-	4500-CO2-C	21.4	24.5	12.2
Iron (total), mg/L	0.3	3500-B	<0.01	0.01	0.01
Fluoride, mg/L	1.5	4500-F^-C	<0.10	<0.1	<0.1
Lead, mg/L	0.01	3500 -Pb-B	<0.001	<0.001	<0.001
Arsenic, mg/L	0.01	3500 -As-B	<0.001	<0.001	<0.001
Manganese, mg/L	0.2	3500 -Mn-B	<0.001	<0.001	<0.001
Copper, mg/L	1.0	3500 -Cu-B	<0.001	<0.001	<0.001
Cadmium, mg/L	0. 03	3500 -Cd-B	<0.001	<0.001	<0.001
Hydrogen Sulphide, mg/L	0.05	4500-S^{2-}H	0	0	0
Chemical Oxygen Demand, mg/L	80	5220-D	<1	<1	<1
Biochemical Oxygen Demand, mg/L	30	5210-B	<1	<1	<1
Oil and Grease, mg/L	10	4500-G	<1	<1	<1
Salinity as Chloride, mg/L	200	4500-B	<0.01	<0.01	<0.01
Total coliform count, CFU/mL	10	9225-D	0	0	0
Faecal coliform (E.coli), CFU/100 mL	Nil	9222-D	0	0	0
Clostridium perfringens, CFU/100 mL	Nil	AOAC 973.30	0	0	0
Salmonella/Shigella sp., CFU/100 mL	Nil	9260-E	0	0	0
Staphylococcus sp. , CFU/100 mL	Nil	AOAC 995.12	0	0	0
Pseudomonas aureus, CFU/100 mL	Nil	9213-E	0	0	0
Total plate count, CFU/100 mL	10^2	9215-B	6	4	8

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Analyst’s Certificate

№:008219

[Institute of Public Analysts of Nigeria Decree 100 of 1992]

Name of Sample:	Extension 2 Surface River samples	**Project:** OOPC Ext. 2 Mill EIA
Client:	Foremost Development Services Limited For: OKOMU Nig. Plc Benin City, Edo State.	**BC REF:** 31977 - 31984
Submission Date:	5 March 2019	**Lab No.:** EL/W/1809/056-063

A. Methodology:

Samples of water collected from all the sites were analyzed using Standard methods of water and wastewater analysis (APHA) (21st edition) and HACH methods of analysis of water (12th edition). The parameters examined are as contained in the result Table.

B. Sampling Locations

S/N	Code	Description	Coordinate	
1.	OKMEXT2$_{G}$	River Jemide (upstream)	N06^{0}41’41.8”	E005^{0}52’44.2”
2.	OKMEXT2$_{H1}$	Stream I (upstream)	N06^{0}45’56.1”	E005^{0}50’50.4”
3.	OKMEXT2$_{H2}$	Stream I (downstream-by G1-West)	N06^{0}47’35.41”	E005^{0}51’11.04”

C. Result of Analysis

The result of on-site measurements and laboratory analysis carried out on the samples collected from Extension 2 area of OKOMU Oil Palm Plc while in the same condition as submitted to us is presented in Table 1:

D. Comments:

Based on the result of analysis conducted on the samples

- The pH of the samples conformed to the standard
- The aesthetic quality of sample **OKMEXT2$_{H}$** as shown by the results of colour, turbidity and suspended solids differ from the limits
- Other physico-chemical and microbiological qualities of the samples conformed to the Standard.

I, the undersigned Public Analyst, OYEDIRAN, L.O. (IPAN NO. 00155®), make this certification, as witnessed my hand this 14th day of March, 2019.

Table 1: Result of Analysis of Surface Water Samples at Extension 2

PARAMETER/UNIT	METHOD, APHA (21^{st} Edn.)	Jemide River Upstream	Stream 1 Upstream	Stream 1 Downstream	FMEnv.
Appearance	Visual	Faint brown with tiny floc	Clear liquid with trace particles		
pH	Electrometric	6.67	8.46	8.80	6-9
Temperature, ^{o}C	Thermometer	28.4	28.7	28.5	Ambient
Conductivity, µS/cm	2510-B	63.9	71.20	57.20	2000
Colour, Pt-Co	2120-C	<1	2860	320	7.0
Turbidity, NTU	2130-B	45	117	160	10
Total Solids, mg/L	2540-B	17.9	1045	118.6	-
Total Dissolved solids,	2540-D	16.9	980	20.6	1000
Total Suspended Solids,	2540-C	1	65	98	30
Total Hardness, mg/L	2340-C	4	<1	20	-
Total Alkalinity, mg/L	2320-B	50.1	60.7	62.4	-
Total acidity, mg/L	2310-B	6.96	<1.0	6.96	-
Calcium, mg/L as Ca	3500-B	0.80	<1.0	3.20	-
Magnesium, mg/L as Mg	3500-B	0.49	<1.0	2.92	-
Salinity as Chloride, mg/L	4500-B	27.79	41.8	6.95	200
Nitrate, mg/L	4500-NO_3^--B	0.22	0.19	0.14	10-50
Nitrite, mg/L	4500-NO_2^--B	<0.01	0.01	0.1	0.3
Sulphate, mg/L	4500-E	17	26.0	10	250
Phosphate, mg/L	4500-C	2.1	4.66	3.65	-
Iron (total), mg/L	3500-B	0.88	2.58	0.20	20
Lead, mg/L	3500 -Pb-B	<0.001	<0.001	<0.001	<1.0
Copper, mg/L	3500 -Cu-B	<0.001	<0.001	<0.001	<1.0
Manganese, mg/L	3500 -Mn-B	<0.001	<0.001	<0.001	0.10
Cadmium, mg/L	3500 -Cd-B	<0.01	<0.01	<0.01	<1.0
Nickel, mg/L	3500 -Ni-B	<0.01	<0.01	<0.01	<1.0
Cobalt, mg/L	3500 -Co-B	<0.01	<0.01	<0.01	<1.0
Arsenic, mg/L	3500 -As-B	<0.01	<0.01	<0.01	<1.0
Chem. Oxygen Demand,	5220-D	34	25	22	80
Biochem. Oxygen Demand, mg/L	5210-B	23.8	17.5	15.4	30
Dissolved Oxygen, mg/L	4500-G	6.8	11.2	4.8	>2.0
Total Hydrocarbon, mg/L	Spectrophotometer	<0.01	<0.01	<0.01	
Pesticides, mg/L	Screening	<0.01	<0.01	<0.01	
Total coliform count,	9225-D	6	2	3	10^2
Faecal coliform, E.coli; CFU/mL	9222-D	Nil	Nil	Nil	-
Total plate count,	9215-B	72	1.0 x 10^2	1.0 x 10^2	10^4

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Analyst's Certificate

№: *19227*

[Institute of Public Analysts of Nigeria Decree 100 of 1992]

Name of Sample	Proposed 60Tons FFB/Hr Palm Oil Mill Project at Extension II	
Client	Foremost Development Services Limited	
	For: OKOMU Oil plc, Benin-City, Edo State.	
Sampling Date	28 February 2019	Season: DRY

Methodology and result

Sampling and measurement of air quality and noise level were carried out using portable analyzers. Gaseous components of the air were monitored using Mattheson Model IQ 1000 Gas Analyzer to measure the concentration of carbon monoxide (CO), carbon dioxide (CO_2), Sulphur dioxide (SO_2), oxygen, hydrogen sulphide (H_2S) and volatile organic compounds (HNU-PID Monitor). Nitrogen oxides, NOx, were determined using BWT gas alert meter. Handheld Aerosol Monitor PPM1055 was used for the measurement of suspended particulate matter. Quest 2500 Sound Level Meter was used to measure the noise level within and around the facility.

The result of on-site measurements carried out on the ambient air at the facility is presented in Table 1:

The result of measurements conducted around the site showed that:

- The baseline ambient air quality was within the regulatory limits as shown by the concentration of particulate matter and gases present in the air;
- The noise level at all the locations also fell within the standard for 8-hour exposure.

I, the undersigned Public Analyst, OYEDIRAN, L.O. (IPAN NO. 00155®), make this certification, as witnessed my hand this 1st day of March 2019.

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Table 1: Result of air quality measurement and noise level at Extension II Project site

Coordinate	Point A	Point B	Point C	Point D	Point E	Point F (Odigiemute Community) - CTRL	FMEnv. Limit
	31N 0811895	**31N 0811767**	**31N 0810755**	**31N 0811193**	**31N 0811604**	**31N 0805970**	
	0739708	**0739617**	**0738737**	**0738659**	**0741609**	**0738130**	
Elevation, m	258m	252m	285m	291m	214m	260m	
Noise, dB(A)	32.6	36.0	44.4	40.5	52.4	47.8	**90**
SPM (µg/m^3)	80	110	110	80	70	70	**250**
Humidity (%)	51.7	41.5	45.4	44.2	39.6	45.6	**Ambient**
Temperature (^{0}C)	29.0	31.6	31.2	31.8	33.7	31.1	**Ambient**
Carbon monoxide, ppm	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	**10-20**
Carbon dioxide, %	0.32	0.31	0.30	0.32	0.31	0.32	**Ambient**
Hydrogen sulphide, ppm	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	**-**
Hydrocarbon, %	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	**-**
Oxygen, %	21.0	21.0	21.0	21.0	21.0	21.0	**21.0**
Sulphur dioxide, ppm	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	**0.01**
Nitrogen dioxide, ppm	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	**0.04 – 0.06**
VOC, ppm	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	**-**

VOC = Volatile organic compounds; SPM = Suspended particulate matter

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APPENDIX II

GEOTECHNICAL AND SOIL REPORTS

REPORT OF GEOTECHNICAL INVESTIGATION FOR OKOMU EXTENSION II MILL, BENIN CITY

GEOTECHNICAL ENGINEERING CONSULTANTS:

JEFFA GEOSURVEYS & TECHNICAL SERVICES LIMITED,
248 UGBOWO-LAGOS ROAD,
BENIN CITY, EDO STATE.

JUNE, 2018

REPORT OF GEOTECHNICAL INVESTIGATION FOR PROPOSED OKOMU EXTENSION II MILL, BENIN CITY

FIELD & LAB TECHNICIAN	**MR. UWAILA N. G.**
SOIL SPECIALIST	**ENGR. E. IZILIEN**
GEOTECH ANALYST	**ENGR. DR. O. R. OGIRIGBO**
QC VERIFIED BY:	**PROF. EHIOROBO J.O.**
REVISION	**REV-0.00**
DATE	**MAY, 2018**

TABLE OF CONTENT

CHAPTER ONE

1.0 INTRODUCTION

Jeffa Geosurveys and Technical Services Ltd was commissioned by the proprietors of **OKOMU MILL PLC** to carryout geotechnical investigation on the proposed site for **Okomu Extension Mill II**. Exploration works was conducted in the site in the month of May, 2018. This investigation was conducted during the wet season of the year.

The output from this investigation will be employed for the economic design of the foundation structure to carry surface load in line with client's developmental objectives for the site location.

The output from this investigation will also be employed for the economic design of the foundation structure to carry surface load in line with client's developmental objectives for the site location.

1.2 OBJECTIVE OF GEOTECHNICAL INVESTIGATION

The objectives of the geotechnical investigation included the following:

(i) To investigate and give details about the soil profile to a maximum depth of about 15 m below the natural ground level
(ii) To determine the index and strength properties of the soil required for foundation design
(iii) To collect disturbed and undisturbed samples of the soil by drilling ten boreholes to 15.0 m depth and three road points to depths of 1.5m each for laboratory testing and analysis
(iv) To carry out Dutch Cone Penetrometer Testing (CPT) to depth of refusal or anchorage
(v) Recommendation for further improvement of the geotechnical properties of the investigated site soil where necessary.

1.3 SCOPE OF WORK

The scope of work includes the following:

1. Mobilization of equipment and personnel to site

2. Drilling of ten (10) boreholes to 15 m depths at each test point using the Shell and Augar Technique with a Percussion Rig mounted equipment and also collect samples from three road points at depths 1.5m each.
3. Laboratory testing of recovered soil samples from the location. The laboratory test shall include:
   I. Specific gravity test
   II. Sieve analysis test
   III. Consistency test
   IV. Compaction test
   V. Undrained Triaxial test
   VI. California Bearing ratio
4. Cone penetrometer tests
5. Bearing capacity calculations at specific depths
6. Analysis of the tests results with recommendation for improvement and economic design
7. Preparation and submission of detailed Geotechnical Report with Appendices.

CHAPTER TWO

2.0 FIELDWORK

2.1 EQUIPMENT FOR SOIL EXPLORATION

The equipment deployed to the site for soil exploration includes:

1. Pilcon Drilling Equipment
2. Measuring Tapes and Steel Rule
3. Dutch Cone Penetrometer
4. Shovels

2.2 SOIL EXPLORATION

Soil samples were drilled from ten deep boreholes up to a depth of 15 m and to depths of 1.5m for the road samples. Water table was not reached in the course of this investigation. The recovered soil samples were then taken to the Geotechnical and Highway Materials Testing Laboratory of the University of Benin for testing and analysis.

2.3 CONE PENETROMETER TESTS

The field work also involved the execution of three Cone Penetrometer Tests. The apparatus consisted of a cylindrical probe of 1000 mm^2 cross sectional area, and a conic head of apex angle of 60^o. The probe was forced down through the soil at a steady rate of about 20 mm/s in the closed position by exerting pressure force on outer sounding tube. The point resistance and the resistance to side friction were measured separately from the attached gauge.

2.4 DESCRIPTION OF SOIL SAMPLES BY VISUAL INSPECTION

Both soil description and classification require knowledge of grading and plasticity. Grading and plasticity can be assessed using a rapid procedure which involves personal judgements based on the appearance and feel of the soil.

Most of the soil samples collected were dark to light reddish brown in colouration depicting lateritic nature. A table showing a complete description of the soil samples obtained at the various depths investigated is shown below in Table 2.1.

Most of the samples are smooth when rubbed between fingers indicating a lower size limit for coarse soils and is also evident on sight when moist. The soils could easily be moulded to a firm mass when some amount of water is added indicating its cohesiveness and could deform without severely cracking or crumbling.

Table 2.1: Detailed Soil Description by Visual Inspection

Location	Borehole ID	Depth (m)	Physical Description
Okomu Road	Point 1	1.5	Dark reddish brown fine grained silty clay
	Point 2	1.5	Reddish brown coarse grained silty clay
	Point 3	1.5	Reddish brown coarse grained silty clay
Okomu Boiler	BHI	1.0	Reddish brown fine grained sandy silt
		3.0	Reddish brown fine grained sandy silt
		6.0	Reddish brown fine grained sandy silt
		9.0	Reddish brown fine grained sandy silt
		12.0	Reddish brown fine grained sandy silt
		15.0	Reddish brown fine grained sandy silt
Okomu Power House	BHII	2.0	Reddish brown fine grained silty clay
		5.0	Reddish brown fine grained sandy silt
		8.0	Reddish brown fine grained sandy silt
		11.0	Reddish brown fine grained sandy silt
		15.0	Reddish brown fine grained silty clay

Location	Borehole ID	Depth (m)	Physical Description
Okomu Clarification Station	BHIII	2.5	Reddish brown fine grained sandy silt
		5.5	Reddish brown fine grained sandy silt
		8.5	Reddish brown fine grained sandy silt
		11.5	Reddish brown fine grained sandy silt
		14.5	Reddish brown fine grained sandy silt
Okomu Sterilizer	BHIV	0.5	Reddish brown fine grained silty clay
		3.5	Reddish brown fine grained sandy silt
		6.5	Reddish brown fine grained silty clay
		9.5	Reddish brown fine grained silty clay
		12.5	Reddish brown fine grained silty sand
		15.0	Reddish brown coarse grained silty sand
Okomu Pressing Station	BHV	1.5	Reddish brown fine grained silty clay
		4.5	Reddish brown coarse grained silty clay
		7.5	Reddish brown fine grained silty clay
		10.5	Reddish brown fine grained silty clay
		14.5	Reddish brown fine grained silty clay
Okomu Storage Tank	BHVI	1.0	Reddish brown fine grained silty clay
		4.0	Reddish brown fine grained silty clay
		7.0	Reddish brown fine grained silty clay
		10.0	Reddish brown fine grained silty clay
		13.0	Reddish brown fine grained silty clay
		15.0	Reddish brown fine grained silty clay

Location	Borehole ID	Depth (m)	Physical Description
Okomu Weigh Bridge	BHVII	1.0	Reddish brown fine grained sandy silt
		4.0	Reddish brown fine grained sandy silt
		7.0	Reddish brown fine grained sandy silt
		10.0	Reddish brown fine grained sandy silt
		13.0	Reddish brown fine grained sandy silt
		15.0	Reddish brown fine grained silty sand
Okomu Water Tank	BHVIII	3.0	Reddish brown coarse grained silty sand
		6.0	Reddish brown coarse grained silty sand
		9.0	Reddish brown coarse grained silty sand
		12.0	Reddish brown coarse grained silty sand
		15.0	Reddish brown coarse grained silty sand
Okomu Ramp I	BHIX	2.0	Reddish brown fine grained silty clay
		5.0	Reddish brown coarse grained silty sand
		8.0	Reddish brown coarse grained silty sand
		11.0	Reddish brown fine grained sandy silt
		14.0	Reddish brown fine grained sandy silt
Okomu Ramp II	BHX	1.5	Reddish brown fine grained sandy silt
		4.5	Reddish brown fine grained sandy silt
		7.5	Reddish brown fine grained sandy silt
		10.5	Reddish brown fine grained sandy silt
		13.5	Reddish brown fine grained sandy silt
		15.0	Reddish brown fine grained sandy silt

CHAPTER THREE

3.0 LABORATORY TESTING

All the laboratory tests were done in accordance with the general specification given in the British standard specification BS EN 1997-1-2004 and BS EN 1997-2-2007, Geotechnics Designs (General Rules and Ground Investigation and Testing respectively).

Disturbed samples were selected for standard laboratory classification and other tests which included the following:

- Specific Gravity Test
- Particle Size Analysis Test
- Atterberg Limit Test
- Compaction Test
- Undrained Triaxial Test

3.1 Specific Gravity Test.

Specific gravity tests were carried out on samples recovered from specified depths of borehole. The tests were performed as per procedures laid out in *BS EN 1997-1-2004 and BS EN 1997-2-2007, Geotechnics Designs (General Rules and Ground Investigation and testing respectively).*

The specific gravity of a soil is the ratio of the weight or mass of a volume of the material to the weight or mass of an equal volume of water. For soils, it is specified to use one litre gas jar fitted with a rubber bung and a mechanical shaker apparatus which rotates the jar at a constant rate. An oven dried sample was placed into the gas jar along with some 500 ml of water. The jar was sealed and shaken. Subsequently, following established procedures, specific gravity of the soil can be calculated.

3.2 Particle Size Analysis

This test is to determine the percentage quantity of individual grain sizes as they occur in a particular soil layer. British Standard Sieves (BS – Sieves) were used on the mechanical sieve shaker to separate these grains into their various sizes. These were then weighed and their percentage weights calculated. The result of this test is of value when used for classification purposes and it enables soil groupings to be delineated and their properties inferred. Further tests to determine the size of the grain particle was undertaken with the aid of the Hydrometer tests. These were carried out in accordance with *BS EN 1997-2-2007*.

3.3 Atterberg/ Consistency Tests

Atterberg limits were determined on soil specimens with very fine particles, i.e. the clay samples. The Atterberg limits are boundaries between the liquid limit and plastic states (Liquid Limit, LL), and between the plastic and brittle states (Plastic Limit, PL). They are expressed as water content, in percentage.

The liquid limit is the water content at which a part of soil placed in a standard cup and cut by a groove of standard dimensions flow together at the base of the groove, when the cup is subjected to 25 standard shocks. The one-point liquid test was carried out. Distilled water was added during soil mixing to achieve the required consistency. The plastic limit is the water content at which a soil can no longer be deformed by rolling into 3 mm diameter threads without crumbling. The range of water contents over which a soil behaves plastically is the Plasticity Index, Ip. This is the difference between the liquid limit and the plasticity limit (WL-WP). The Reference test standard used for this test was *BS EN 1997-2-2007.*

3.4 Compaction Tests

Compaction is the process of increasing the density of a soil by packing the particles of the soil closer together, with a reduction in the volume of air. Two parameters are usually obtained from this test – optimum moisture content (OMC) and maximum dry density (MDD). The compaction tests were carried out in accordance with *BS EN 1997-2-2007.*

3.5 Undrained Triaxial Tests

This test was used were to obtain the drained shear parameters (i.e. c' and ϕ') of the sand layers in the investigation. It involves the shearing of a cylindrical column of soil obtained in-situ to determine its resistance to pressure. Triaxial machine is used, from where two important parameters namely; angle of internal friction and cohesion are obtained. With these, the bearing capacity of the soil is calculated. The test was carried out in accordance with BS 1377:75 Test 13.

3.6 California Bearing Ratio Test

The CBR test was conducted using the compaction energy as for compaction test. The California Bearing Ratio test was carried out in accordance with *BS EN 1997-1-2004 and BS EN 1997-2-2007, Geotechnics Designs (General Rules and Ground Investigation and Testing respectively).*

CHAPTER FOUR

4.0 PRESENTATION OF RESULTS

The recovered samples from the sites were taken to the Geotechnical Engineering Laboratory in the Civil Engineering Department of the University of Benin. The following laboratory tests and analysis were conducted alongside the in situ cone penetrometer test (CPT):

- Specific gravity test
- Particle size analysis
- Atterberg limit test
- Compaction
- Unconsolidated Undrained Triaxial test

4.1 Specific Gravity Test Results

The Average Specific Gravity (A.GS) values for the deep borehole (BH) are presented in Table 4.1 and in Appendix I.

Table 4.1: Specific Gravity Test Results

S/N	LOCATION	BOREHOLE ID	DEPTH (m)	AGs
1	**Okomu Road**	Point 1	1.5	2.57
2		Point 2	1.5	2.55
3		Point 3	1.5	2.42
4	**Okomu Boiler**	BHI	1.0	2.34
5			3.0	2.46
6			6.0	2.50
7			9.0	2.44
8			12.0	2.52
9			15.0	2.43

S/N	LOCATION	BOREHOLE ID	DEPTH (m)	AGs
10	**Okomu Power House**	BHII	2.0	2.47
11			5.0	2.56
12			8.0	2.43
13			11.0	2.50
14			15.0	2.47
15	**Okomu Clarification Station**	BHIII	2.5	2.44
16			5.5	2.51
17			8.5	2.42
18			11.5	2.44
19			14.5	2.36
20	**Okomu Sterilizer**	BHIV	0.5	2.38
21			3.5	2.30
22			6.5	2.30
23			9.5	2.11
24			12.5	2.21
25			15.0	2.23
26	**Okomu Pressing Station**	BHV	1.5	2.28
27			4.5	2.24
28			7.5	2.28
29			10.5	2.34
30			14.5	2.51
31		BHVI	1.0	2.47

S/N	LOCATION	BOREHOLE ID	DEPTH (m)	AGs
32	**Okomu Storage Tank**	BHVI	4.0	2.47
33			7.0	2.35
34			10.0	2.17
35			13.0	2.42
36			15.0	2.28
37	**Okomu Weigh Bridge**	BHVII	1.0	2.40
38			4.0	2.44
39			7.0	2.19
40			10.0	2.23
41			13.0	2.18
42			15.0	2.25
43	**Okomu Water Tank**	BHVIII	3.0	2.22
44			6.0	2.49
45			9.0	2.47
46			12.0	2.50
47			15.0	2.46
48	**Okomu Ramp I**	BHIX	2.0	2.31
49			5.0	2.33
50			8.0	2.36
51			11.0	2.37
52			14.0	2.37
53	**Okomu Ramp II**	BHX	1.5	2.24

S/N	LOCATION	BOREHOLE ID	DEPTH (m)	AGs
54	**Okomu Ramp II**	BHX	4.5	2.52
55			7.5	2.35
56			10.5	2.36
57			13.5	2.42
58			15.0	2.42

4.2 Particle Size Distribution Tests Results

The tests were conducted to determine the percentage quantity of individual grain sizes as they occur in particular soil layers. The test results are presented in Table 4.2 and Appendix II. Mechanical sieving was carried out up to 0.075mm sieve.

Table 4.2: Sieve Analysis Test Results

S/N	LOCATION	BOREHOLE ID	DEPTH(m)	PERCENTAGE PASSING SIEVE NO.		
				1.18mm	**0.425mm**	**0.075mm**
1	**Okomu Road**	Point 1	1.5	99.24	78.00	44.12
2		Point 2	1.5	98.50	82.00	60.52
3		Point 3	1.5	97.97	81.00	57.64
4	**Okomu Boiler**	BHI	1.0	97.89	72.85	47.75
5			3.0	98.37	82.60	63.31
6			6.0	98.22	83.53	60.40
7			9.0	97.71	81.64	56.69
8			12.0	98.43	86.63	64.66
9			15.0	98.29	92.29	67.98

S/N	LOCATION	BOREHOLE ID	DEPTH(m)	PERCENTAGE PASSING SIEVE NO.		
				1.18mm	0.425mm	0.075mm
10	Okomu Power House	BHII	2.0	98.49	79.35	55.91
11			5.0	98.11	81.60	58.98
12			8.0	98.58	85.17	63.56
13			11.0	98.24	85.05	63.50
14			15.0	98.40	85.21	62.82
15	Okomu Clarification Station	BHIII	2.5	97.88	79.23	54.02
16			5.5	98.42	84.54	61.61
17			8.5	98.22	83.22	53.89
18			11.5	98.08	82.46	56.82
19			14.5	98.13	83.00	56.21
20	Okomu Sterilizer	BHIV	0.5	98.64	75.15	43.64
21			3.5	97.94	78.50	53.02
22			6.5	97.99	80.74	55.49
23			9.5	97.74	80.85	52.77
24			12.5	98.02	81.71	53.43
25			15.0	98.29	81.61	57.31
26	Okomu Pressing Station	BHV	1.5	98.78	78.34	48.57
27			4.5	98.11	83.33	61.53
28			7.5	97.48	81.56	50.86
29			10.5	98.08	83.62	53.97

S/N	LOCATION	BOREHOLE ID	DEPTH(m)	PERCENTAGE PASSING SIEVE NO.		
				1.18mm	0.425mm	0.075mm
30			14.5	97.43	79.25	49.12
31	**Okomu Storage Tank**	BHVI	1.0	98.28	79.23	51.11
32			4.0	97.91	81.69	55.45
33			7.0	98.03	82.39	54.61
34			10.0	97.08	77.91	49.07
35			13.0	98.38	84.54	60.22
36			15.0	98.05	84.11	58.56
37	**Okomu Weigh Bridge**	BHVII	1.0	98.51	80.57	54.55
38			4.0	98.50	85.03	64.05
39			7.0	95.51	80.57	54.55
40			10.0	97.65	81.40	52.78
41			13.0	98.29	83.44	59.45
42			15.0	98.20	84.12	57.55
43	**Okomu Water Tank**	BHVIII	3.0	97.68	78.90	51.92
44			6.0	97.35	79.06	53.39
45			9.0	98.27	83.99	55.83
46			12.0	98.51	83.18	57.53
47			15.0	97.97	82.64	60.51
48	**Okomu Ramp I**	BHIX	2.0	98.43	76.66	47.32
49			5.0	98.69	73.77	40.11

S/N	LOCATION	BOREHOLE ID	DEPTH(m)	PERCENTAGE PASSING SIEVE NO.		
				1.18mm	0.425mm	0.075mm
50	**Okomu Ramp I**	BHIX	8.0	98.60	76.55	49.19
51			11.0	97.49	75.05	47.17
52			14.0	97.30	73.20	48.95
53	**Okomu Ramp II**	BHX	1.5	98.97	80.96	51.98
54			4.5	98.67	69.82	35.01
55			7.5	98.34	73.89	43.18
56			10.5	97.88	76.93	55.73
57			13.5	98.17	78.08	52.83
58			15.0	98.29	78.27	47.49

4.3 Atterberg/Consistency Limits Test Results

The tests carried out under this heading includes Liquid Limit (LL), Plastic Limit (PL), Plasticity Index (PI) and Linear shrinkage (LS), all of which make up the Atterberg Limit test. The results of these tests are presented in Table 4.3 and Appendix III.

Table 4.3: Atterberg Limit Test Results

LOCATION	BOREHOLE ID	DEPTH (m)	ATTERBERG LIMIT TESTS			
			LL (%)	PL (%)	PI (%)	PLASTICITY
Okomu Road	Point 1	1.5	36.46	22.03	16.43	CI
	Point 2	1.5	56.85	28.61	28.25	CH
	Point 3	1.5	52.88	27.77	25.12	CH
Okomu Boiler	BHI	1.0	50.15	27.44	22.71	MH
		3.0	52.13	27.79	24.33	MH
		6.0	49.32	25.47	23.85	MH
		9.0	54.48	28.48	25.66	MH
		12.0	52.48	29.94	22.54	MH
		15.0	54.19	25.86	28.33	MH
Okomu Power House	BHII	2.0	49.29	23.37	25.92	CI
		5.0	48.97	27.80	21.17	MI
		8.0	53.43	28.16	25.27	MH
		11.0	50.65	27.78	22.86	MH
		15.0	45.23	25.69	22.54	CI
Okomu Clarification Station	BHIII	2.5	47.28	27.97	20.31	MI
		5.5	53.87	27.02	26.85	MH
		8.5	51.06	27.24	23.82	MH
		11.5	51.85	27.22	24.64	MH
		14.5	52.51	30.23	22.27	MH

Okomu Sterilizer	BHIV	0.5	45.34	24.55	20.80	CI
		3.5	29.50	27.03	2.47	ML
		9.5	53.35	27.22	26.13	CH
		12.5	45.34	24.55	20.80	CI
Okomu Pressing Station	BHV	7.5	53.32	26.85	26.46	CH
		14.5	51.30	28.67	22.63	MH
Okomu Storage Tank	BHVI	10.0	54.13	25.74	28.39	CH
Okomu Weigh Bridge	BHVII	7.0	52.37	28.09	24.30	MH
		15.0	54.79	29.11	25.69	MH
Okomu Water Tank	BHVIII	6.0	50.87	30.87	20.28	MH
		9.0	49.79	26.38	23.41	CI
		12.0	51.21	27.97	23.24	MH
		15.0	51.41	26.16	25.26	MH
Okomu Ramp I	BHIX	2.0	54.63	27.44	27.19	CH
		5.0	56.70	31.28	25.43	MH
		8.0	56.17	28.50	27.67	MH
		11.0	48.41	27.23	21.18	MI

Okomu Ramp II	BHX	1.5	48.14	28.19	19.95	MI
		7.5	49.50	28.46	21.04	MI
		10.5	48.85	27.23	21.63	MI
		13.5	55.34	25.62	29.73	MH

C=CLAY, M= SILT (M-SOIL), I= INTERMEDIATE PLASTICITY, L= LOW PLASTICITY, H=HIGH PLASTICITY

4.4 Compaction Tests Results

Compaction tests is used to determine the density beyond which any increment in water content will not have effect on the strength of the soil. From the test, the optimum moisture content and maximum dry densities were obtained as shown below in Table 4.4 and Appendix IV for the samples that were tested.

Table 4.4: Compaction Test Results

LOCATION	BOREHOLE ID	DEPTH (m)	MDD (g/cm^3)	OMC (%)
Okomu Road	Point 1	1.5	1.74	13.40
	Point 2	1.5	1.51	21.90
	Point 3	1.5	1.47	25.30
Okomu Boiler	BHI	1.0	1.51	22.50
		3.0	1.48	24.0
		6.0	1.50	23.40
		9.0	1.48	20.60
		12.0	1.44	24.70
		15.0	1.48	23.40

LOCATION	BOREHOLE ID	DEPTH (m)	MDD (g/cm^3)	OMC (%)
Okomu Power House	BHII	2.0	1.47	20.60
		5.0	1.49	20.10
		8.0	1.49	19.40
		11.0	1.53	24.30
		15.0	1.44	24.80
Okomu Clarification Station	BHIII	2.5	1.51	22.30
		5.5	1.52	22.30
		8.5	1.58	22.30
		11.5	1.49	21.90
		14.5	1.51	22.60
Okomu Sterilizer	BHIV	0.5	1.58	18.90
		3.5	1.48	21.70
		6.5	1.61	18.90
		9.5	1.50	21.60
		12.5	1.55	21.40
		15.0	1.51	21.20
Okomu Pressing Station	BHV	1.5	1.56	19.20
		4.5	1.47	21.60
		7.5	1.55	21.40
		10.5	1.52	23.50
		14.5	1.58	22.00

LOCATION	BOREHOLE ID	DEPTH (m)	MDD (g/cm³)	OMC (%)
Okomu Storage Tank	BHVI	1.0	1.47	19.60
		4.0	1.48	20.80
		7.0	1.50	21.20
		10.0	1.51	24.90
		13.0	1.49	21.90
		15.0	1.58	21.80
Okomu Weigh Bridge	BHVII	1.0	1.50	20.00
		4.0	1.52	23.50
		7.0	1.49	22.30
		10.0	1.46	24.70
		13.0	1.46	25.30
		15.0	1.55	23.40
Okomu Water Tank	BHVIII	3.0	1.48	26.40
		6.0	1.48	26.40
		9.0	1.49	23.20
		12.0	1.48	21.70
		15.0	1.58	21.80
Okomu Ramp I	BHIX	2.0	1.57	19.20
		5.0	1.68	16.50
		8.0	1.52	19.9

LOCATION	BOREHOLE ID	DEPTH (m)	MDD (g/cm^3)	OMC (%)
		11.0	1.54	17.80
		14.0	1.51	21.60
Okomu Ramp II	BHX	1.5	1.58	18.70
		4.5	1.73	15.00
		7.5	1.65	17.90
		10.5	1.54	18.90
		13.5	1.62	19.30
		15.0	1.56	20.50

4.5 Undrained Triaxial Tests Results

The results obtained from Undrained Triaxial Test performed on U2 soil samples recovered from specific depths are presented in Table 4.5 and Appendix V.

Table 4.5: Shear Strength Test Results

Location	Borehole ID	Depth(m)	Φ' (°)	C' (KN/m^2)
Okomu Boiler	BH1	3.0	4.00	11.0
		6.0	10.68	37.0
		9.0	6.73	29.0
		15.0	5.88	38.0
Okomu Power House	BH2	2.0	12.68	12.0
		5.0	6.66	58.0
		15.0	9.93	17.0

Location	Borehole ID	Depth(m)	Φ' (°)	C' (KN/m^2)
Okomu Clarification Station	BH3	2.5	12.48	46.0
		8.5	11.49	38.0
		14.5	10.36	37.0
Okomu Sterilizer	BH4	0.5	6.46	18.0
		6.5	7.57	15.0
		12.5	6.16	5.0
Okomu Pressing Station	BH5	7.5	15.64	9.0
		10.5	11.62	18.0
		14.5	10.28	5.0
Okomu Storage Tank	BH6	1.0	13.71	3.0
		7.0	6.22	22.5
		15.5	3.43	46.0
Okomu Weigh Bridge	BH7	4.0	7.97	15.0
		13.0	3.94	24.0
		15.0	22.64	13.0
Okomu Water Tank	BH8	3.0	12.64	45.0
		9.0	5.94	45.0
		12.0	5.0	11.43
Okomu Ramp I	BH9	2.0	20.34	20.0
		8.0	9.15	4.0
		11.0	9.29	35.0

Location	Borehole ID	Depth(m)	Φ' (°)	C' (KN/m^2)
Okomu Ramp II	BH10	1.5	7.93	15.50
		7.5	3.61	24.0
		13.5	10.20	50.0

4.6 Bearing Capacity Computation Using Parameters from Undrained Triaxial Test:

The ultimate bearing capacity was calculated for a 1m square pad footing using Meyerhof's equations as shown below:

$$q_{ult} = cN_c s_c d_c + \gamma D N_q s_q d_q + 0.5\gamma B N_\gamma s_\gamma d_\gamma \qquad (1)$$

$$N_q = \exp(\pi \tan \emptyset) tan^2(45° + \frac{\emptyset}{2}) \qquad (2)$$

$$N_c = (N_q - 1)\cot \emptyset \qquad (3)$$

$$N_\gamma = (N_\gamma - 1)\tan(1.4\emptyset) \qquad (4)$$

$$s_c = 1 + 0.2K_p B/L \qquad (5)$$

$$s_q = s_\gamma = 1 + 0.1K_p B/L \qquad (6)$$

$$d_c = 1 + 0.2\sqrt{K_p} D/B \qquad (7)$$

$$d_q = d_\gamma = 1 + 0.1\sqrt{K_p} D/B \qquad (8)$$

$$K_p = tan^2(45 + \emptyset/2) \qquad (9)$$

Where

q_{ult} = Ultimate bearing capacity

c = Cohesion

Φ = Angle of internal friction

N_c, N_q, N_γ = Bearing capacity factors

s_c, s_q, s_γ = Shape correction factors

d_c, d_q, d_γ = Depth correction factors

Table 4.6 shows the allowable bearing capacity computed at various depths using a factor of safety of 3.5, which is suitable for light industrial projects.

Table 4.6: Computed allowable bearing capacities at various depths

Location	Borehole ID	Depth (m)	Ultimate bearing capacity ($q_{,ult}$) kN/m^2	Allowable bearing capacity ($q_{,all}$) kN/m^2
Okomu Boiler	BH1	3.0	252	72
		9.0	1453	415
		15.0	1579	451
Okomu Power House	BH2	2.0	402	115
		5.0	1376	393
		15.0	2948	842
Okomu Clarification Station	BH3	2.5	1153	329
		8.5	2403	687
		14.5	3915	1119
Okomu Sterilizer	BH4	0.5	195	56
		6.5	805	230
		12.5	1218	348
Okomu Pressing Station	BH5	7.5	1758	502
		10.5	2202	629
		14.5	2326	665

Okomu Storage Tank	BH6	1.0	143	41
		7.0	939	268
		15.5	2575	736
Okomu Weight Bridge	BH7	4.0	500	143
		15.0	6284	1795
Okomu Storage Tank	BH8	3.0	1274	364
		9.0	1764	504
		12.0	1882	538
Okomu Ramp I	BH9	8.0	849	243
		11.0	2495	713
Okomu Ramp II	BH10	1.5	273	78
		7.5	839	240
		13.5	4132	1181

4.6 Dutch Cone Penetrometer Test Results

Cone penetrometer test was carried out at three (3) points. The cone penetration resistance (q_c) obtained at specific depths for the three points are shown in Table 4.7. The complete results are shown in Appendix VI.

Several correlations have been drawn to relate ultimate bearing capacity to cone penetration resistance. Meyerhof (1976) suggested a direct method for estimating q_{ult} from cone resistance as follows:

$$q_{ult} = \bar{q}_c \left(\frac{B}{12.2}\right)\left(1 + \frac{D_f}{B}\right) \tag{10}$$

Where

$q_{,ult}$ = Ultimate bearing capacity in kN/m^2

$\bar{q}_c$ = Arithmetic average of q_c values in a zone including footing base and 1.5B beneath footing, in kN/m^2

B = Width of footing, in m

D_f = Depth of footing, in m

The computed allowable bearing capacities for the specific depths shown in Table 4.7 are presented in Table 4.8, for a 1m square footing. It should be noted that depth was not corrected for, and that a factor of safety of 3.5 was used in the calculations.

Table 4.6: Cone resistance obtained at specific depths for points 1, 2 and 3

Depth (m)	CPT1 (kg/cm^2)	CPT2 (kg/cm^2)	CPT3 (kg/cm2)
1.0	25.0	65.0	47.0
2.0	50.0	200.0	65.0
3.0	55.0	220.0	68.0
4.0	64.0	205.0	70.0
5.0	83.0	220.0	75.0
6.0	110.0	250.0	92.0
7.0	130.0	-	105.0
8.0	150.0	-	135.0
9.0	175.0	-	180.0
10.0	200.0	-	220.0
11.0	230.0	-	-

Table 4.8a: Bearing capacity computation from CPT from test point 1

Depth (m)	Ave. q_c(MN/m^2)	q_{ult} (kN/m^2)	q_{all} (kN/m^2)
1.0	2.45	402.05	114.87
2.0	4.91	1206.15	344.61
3.0	5.39	1769.00	505.43
4.0	6.28	2573.12	735.18
5.0	8.14	4004.41	1144.12
6.0	10.79	6191.56	1769.02
7.0	12.75	8362.62	2389.32
8.0	14.72	10855.33	3101.52
9.0	17.17	14071.72	4020.49
10.0	19.62	17690.16	5054.33

Table 4.8b: Bearing capacity computation from CPT from test point 2

Depth (m)	Ave. q_c (MN/m^2)	q_{ult} (kg/cm^2)	q_{all} (kN/m^2)
1.0	6.38	1045.33	298.67
2.0	19.62	4824.59	1378.45
3.0	21.58	7076.07	2021.73
4.0	20.11	8242.01	2354.86
5.0	21.58	10614.10	3032.60
6.0	24.53	14071.72	4020.49

Table 4.8c: Bearing capacity computation from CPT from test point 3

Depth (m)	Ave. q_c (MN/m^2)	q_{ult} (kg/cm^2)	q_{all} (kN/m^2)
1.0	4.61	755.85	215.96
2.0	6.38	1567.99	447.99
3.0	6.67	2187.15	624.89
4.0	6.87	2814.34	804.09
5.0	7.36	3618.44	1033.84
6.0	9.03	5178.39	1479.54
7.0	10.30	6754.43	1929.84
8.0	13.24	9769.79	2791.37
9.0	17.66	14473.77	4135.36
10.0	21.58	19459.18	5559.77

4.7 CALIFORNIA BEARING RATIO TEST RESULT

The California Bearing Ratio test is a depth penetration test for determining the mechanical strength of subgrade beneath new carriageway construction. The CBR test is described in ASTM Standards D1883-05 (for soils place in field), and AASTO T193. The CBR Test is fully described in BS 1377: Soils for civil engineering purposes: Part 4, compaction related tests, and in Part 9: Insitu tests. The California bearing ratio test results for samples tested are presented in Table 4.9 below and Appendix VI.

Table 4.9: CBR Tests Results

S/N	LOCATION	SAMPLING DEPTH	PRESSURE LAYER	UNSOAKED		SOAKED	
				2.5mm	5.0mm	2.5mm	5.0mm
1	POINT 1	0.5m	BOTTOM	8.67	8.06	6.44	5.86
			TOP	6.69	6.90	5.53	5.86
2	POINT 2	0.5m	BOTTOM	12.30	10.96	7.52	8.88
			TOP	11.81	11.07	7.59	8.49
3	POINT 3	0.5m	BOTTOM	8.84	10.47	8.59	8.49
			TOP	10.24	10.79	5.45	8.27

CHAPTER FIVE

5.0 DISCUSSION

5.1 General Discussion of Index Properties and Soil Classification

Geotechnical investigation to understand the subsurface at the proposed location showed that the site passed most of the criteria that characterises a suitable soil for Civil Engineering construction.

1. ***Specific Gravity***

The specific gravity results from the boreholes presented in Table 4.1 ranged from 2.34 to 2.52 for borehole 1, 2.47 to 2.56 for borehole 2, 2.36 to 2.51 for borehole 3, 2.11 to 2.38 for borehole 4, 2.28 to 2.51 for borehole 5, 2.17 to 2.47 borehole 6, 2.18 to 2.44 for borehole 7, 2.22 to 2.50 for borehole 8, 2.31 to 2.37 for borehole 9 and 2.24 to 2.52 for borehole 10 while the road points have specific gravity values ranging from 2.42 to 2.57. The highest specific value of 2.57 was recorded in road point 1, 1.5m .These results obtained from the specific gravity tests indeed show the suitability of the soils as a construction material especially as subgrade materials with respect to the road points.

2. ***Particle Size Distribution***

Particle size distribution tests carried out on the Auger Samples showed that the soils have many similarities irrespective of depth. The range of the soil passing the 0.075 mm sieve for borehole I is , borehole II IS 55.91% to 63.56%, borehole III IS 53.89% to 61.61% , borehole IV is 43.64% to 55.49%, borehole V is 48.57% to 61.53% , borehole VI is 49.07% to 60.22%, borehole VII is 52.78% to 64.05 , borehole VIII is 51.92% to 60.51% , borehole IX is , borehole X is 47.49% to 53.77% .For the road points: point I, point II and point III have maximum of 44.92%, 60.52% and 57.64% passing through 0.075 mm sieve. This indicates that the soils contain both fines and sands. According to the American Association of State Highway and Transportation Officials (AASHTO), these soils can be classified as A-7-6.

3. ***Consistency Limit Tests***

The extent of fine material in the soil mix was also ascertained using the consistency or Atterberg limit tests. The results obtained showed that the soils from all the boreholes ranges within intermediate to high plasticity silty clay/ sandy silty soil with a maximum plasticity index of 29.73% and liquid limit of 56.85%.

4. ***Compaction Tests***

The maximum dry density (MDD) and optimal moisture content (OMC) values which are used to determine the dry unit weight of the soil were obtained from the standard proctor compaction tests carried out on recovered soil samples from specific depths for all the borehole locations. The results show that the range of maximum dry density and optimum moisture content values for road points is 1.47 g/cm^3 to 1.74 g/cm^3 and 13.40% to 25.30% , borehole 1 is 1.44 g/cm^3 to 1.51 g/cm^3 and 20.60% to 24.70%, borehole 2 is 1.44 g/cm^3 to 1.49 g/cm^3 and 19.40% to 24.80%, borehole 3 is 1.49 g/cm^3 to 1.58 g/cm^3 and 21.90% to 22.60 %, borehole 4 is 1.48 g/cm^3 to 1.58 g/cm^3 and 18.90% to 21.70%, borehole 5 is 1.47 g/cm^3 to 1.58 g/cm^3 and 19.20% to 23.50%, borehole 6 is 1.47 g/cm^3 to 1.58 g/cm^3 and 19.60% to 24.90%, borehole 7 is 1.46 g/cm^3 to 1.55 g/cm^3 and 20.00% to 25.30%, borehole 8 is 1.48 g/cm^3 to 1.58 g/cm^3 and 21.70% to 26.40%, borehole 9 is 1.51 g/cm^3 to 1.68 g/cm^3 and 16.50% to 21.60% while borehole 10 maximum dry density values range from 1.54 g/cm^3 to 1.65 g/cm^3 with optimum moisture content values from 15.0% to 20.50%. Their compaction curves are typical for sandy silt soils and silty clay soils with high plasticity clay as obtained in literature.

5.2 General Discussion of Strength Results

The allowable bearing capacity of the soil was determined using shear parameters obtained from laboratory triaxial tests and cone penetration resistance obtained from in situ cone penetrometer test (CPT), both of which are shown in Tables 4.6 and 4.8a - 4.8c respectively. It should be noted that the calculations were done assuming a 1m x 1m square footing and a factor of safety of 3.5. In the foundation analysis and design, actual sizes of footings should be used alongside the shear parameters to obtain the adequate bearing capacity.

Comparing the allowable bearing capacities shown in Table 4.6 to those in Table 4.8a – 4.8c, it can be seen that both agree to certain levels. However, the values obtained via calculation using the shear parameters obtained from laboratory tests appear to be more conservative and should therefore be used in the foundation analysis and design. In general, the results of the bearing capacity showed that the soil is relatively firm and high strength foundation can be obtained with a minimum bearing capacity of 110 kN/m^2 at depth 2.0m and factor of safety of 3.5 employed.

5.3 California Bearing Ratio Results

The result of California Bearing Ratio (CBR) test revealed that the sub-surface strength varies along the road as could be seen in Table 6.1. These should be further checked with moving load of vehicles that will ply this route for adequacy as subgrade material.

It was observed that both the unsoaked CBR values and the soaked CBR values were less than 15%, although the unsoaked CBR values recorded higher values than the soaked CBR values. The soaked CBR values were used in this analysis of which the highest value was taken as the CBR value for each chainage. Table 5.1 shows the minimum value of soaked CBR for various road pavement layer. For a subgrade layer, the minimum is between 5 – 11% which is the focal point of this report (see Table 5.1). Any value found below this range will be subject to capping or subgrade treatment. Recommendations for capping and sub-base layer have been presented in Table 6.1. This fill material should be appropriately compacted by roller compactor after spreading.

CHAPTER SIX

6.0 CONCLUSION AND RECOMMENDATION

6.1 CONCLUSION

From the results and analysis, it was observed that the location for the proposed school is comprised mainly of both fines and sands with high to low plasticity. According to AASHTO and USSC soil classification systems, the soil was classed as A-7-6. This shows that the soil consists of both fines and sands, having low to high degree of plasticity.

In terms of strength, the allowable bearing capacity calculated using shear parameters obtained from laboratory triaxial tests revealed that the soil possesses great potential for an economic foundation.

6.2 RECOMMENDATIONS

From the analysis, it is evident that the location can provide economic foundation for most infrastructures, including the school that will be built on the site. Though bearing capacity computations from CPT showed that the bearing pressure at depth 2.0 to 6m is higher than 200kN/m^2, the value of 110kN/m^2 should be used as the design bearing pressure. With adequate scarification and compaction, the whole of the site will be put to good use construction-wise.

6.2. 1 Subgrade Treatment

In exceptional circumstances where the CBR value falls below 2%, a value below which the subgrade would deform under construction traffic, there are several options open to the designer:

The material can be removed and replaced with a more suitable material. The thickness replaced should be between 0.5m and 1.0m. Irrespective of the quality of the new material a CBR value of just below 2% should be assumed for the subgrade.

With these soils having cohesive properties, it may be possible to treat the soils using lime. The sub-base and capping is again designed assuming a subgrade CBR of just below 2%.

For subgrades with CBR values of 15% and above, the sub-base should have a standard thickness of 150mm, a value determined as the minimum practical for spreading and compaction. This is in accordance with the Design Manual for Roads And Bridges, HD 23/99, Road Note RD/GN/ 042 (Pavement Design for Carriageway Construction), Federal ministry of works, Highway manual and the AASHTO 1993 (Design of Pavement Structures). This is summarised in Table 6.1 for the chainages tested. For subgrade of elastic modulus below 50 MPa or 5% CBR, strengthening measures are required in order to provide a strong and uniform support for the pavement and to allow road construction vehicles to pass over the subgrade without damaging the layer. This can be achieved by providing a thick layer of sub-base on the subgrade but it may be more economical to provide a capping layer of selected materials. The provision of a capping layer over a weak subgrade avoids the necessity of an extraordinarily thick sub-base, and provides an adequate working platform for sub-base compaction as well as reduces the risk of damage to the subgrade during construction. The CBR value of the capping layer shall be of at least 15%.

The recommended thicknesses of the capping layer for various CBR values of subgrade for flexible and rigid pavements are shown in Table 6.1. The capping layer can be specified as granular fill material in accordance with Section 6 of the General Specification for Civil Engineering Works.

6.2.2 Sub - Base

Sub-base shall be specified as granular material in accordance with Section 9 of the General Specification for Civil Engineering Works. Lean concrete is generally not recommended for sub-base application. For flexible pavements, localised shrinkage cracks developed in the lean concrete sub-base would likely propagate upwards through the bituminous surfacing causing reflective cracking at the pavement surface, which reduces the service life of pavement. For rigid pavements, the high rigidity and flexural strength of concrete itself contribute to most of the load bearing function, resulting in very small deflections and pressures induced by vehicular loading on the sub-layers. The purpose of sub-base on rigid pavements is primarily for controlling pumping, which can be achieved by using granular materials.

The thickness of the sub-base layer is determined primarily from the strength of the subgrade, i.e. the CBR value. The recommended thicknesses and type of sub-base for flexible and rigid pavements are shown in Table 6.1.

Table 6.1: Subgrade strength class and recommended minimum thickness for capping and granular sub-base

LOCATION	DEPTH OF SAMPLING (m)	PI (%)	CBR %	CAPPING LAYER (mm)	GRANULAR SUB-BASE LAYER (mm)	SUBGRADE STRENGTH CLASS
POINT 1	1.5	16.43	6.44	N/A	200	S3
POINT 2	1.5	28.25	8.88	N/A	200	S4
POINT 3	1.5	25.12	8.59	N/A	200	S4

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APPENDICES

APPENDIX I

DETERMINATION OF SPECIFIC GRAVITY OF SOIL PARTICLES
(Standard Laboratory Method)

OPERATOR:
LOCATION: **OKOMU**
SOIL NO:
DATE: **08-06-2018**

S/N	LOCATION	DEPTH	BN	B+W	B+S+W	B+S	B	Ad. W	WWAS	WS	WOWDS	Gs	AGs
1	**ROAD, POINT 1**	1.5m	RA	76.82	91.89	48.04	23.18	53.64	43.85	24.86	9.79	2.54	2.57
			TT	73.50	88.24	44.98	21.07	52.43	43.26	23.91	9.17	2.61	
2	**ROAD, POINT 2**	1.5m	EI	76.62	90.05	44.29	22.26	54.36	45.76	22.03	8.60	2.56	2.55
			TN	74.84	89.53	44.30	20.02	54.82	45.23	24.28	9.59	2.53	
3	**ROAD, POINT 3**	1.5m	TT	73.40	88.20	46.50	21.00	52.40	41.70	25.50	10.70	2.38	2.42
			RA	76.70	91.80	48.70	23.30	53.40	43.10	25.40	10.30	2.47	
4	**BH1 BOILER**	1.00	RK	77.10	92.50	47.90	20.70	56.40	44.60	27.20	11.80	2.31	2.34
			MO	74.80	90.10	48.60	22.10	52.70	41.50	26.50	11.20	2.37	
5		3.0m	FO	74.71	89.49	47.77	22.74	51.97	41.72	25.03	10.25	2.44	2.46
			EJ	77.13	92.86	48.86	22.55	54.58	44.00	26.31	10.58	2.49	
6		6.0m	MI	73.93	90.52	48.27	20.65	53.28	42.25	27.62	11.03	2.50	2.50
			RP	76.18	91.39	48.01	22.67	53.51	43.38	25.34	10.13	2.50	
7		9.0m	RW	76.30	94.60	51.60	21.00	55.30	43.00	30.60	12.30	2.49	2.44
			RD	73.00	91.30	50.50	19.00	54.00	40.80	31.50	13.20	2.39	
8		12.0m	I3I4	37.19	45.50	24.74	10.95	26.24	20.76	13.79	5.48	2.52	2.52
			UB	37.49	44.77	24.09	12.06	25.43	20.68	12.03	4.75	2.53	
9		15.0m	TO	74.21	87.59	44.27	21.65	52.56	43.32	22.62	9.24	2.45	2.43
			RW	76.26	92.05	47.80	20.88	55.38	44.25	26.92	11.13	2.42	
10	**BH2 POWER HOUSE**	2.0m	VP	75.85	91.57	48.38	22.01	53.84	43.19	26.37	10.65	2.48	2.47
			EF	77.56	93.60	48.31	21.26	56.30	45.29	27.05	11.01	2.46	
11		5.0m	TQ	75.75	91.78	47.82	21.56	54.19	43.96	26.26	10.23	2.57	2.56
			RD	73.53	89.97	46.08	19.01	54.52	43.89	27.07	10.63	2.55	
12		8.0m	RL	75.73	91.44	48.10	21.48	54.25	43.34	26.62	10.91	2.44	2.43
			RV	75.33	88.82	45.46	22.50	52.83	43.36	22.96	9.47	2.42	
13		11.0m	EB	73.65	88.05	44.66	20.77	52.88	43.39	23.89	9.49	2.52	2.50
			RK	77.47	91.86	44.91	20.87	56.60	46.95	24.04	9.65	2.49	
14		15.0m	RQ	75.34	88.85	45.14	22.30	53.04	43.71	22.84	9.33	2.45	2.47
			RD	75.93	91.93	48.61	21.85	54.08	43.32	26.76	10.76	2.49	
15	**BH3 CLARIFICATION STATION**	2.5m	EB	73.50	88.90	47.20	20.80	52.70	41.70	26.40	11.00	2.40	2.44
			QJ	76.60	92.40	48.50	22.00	54.60	43.90	26.50	10.70	2.48	
16		5.5m	QJ	76.73	92.63	48.55	22.06	54.67	44.08	26.49	10.59	2.50	2.51
			MO	74.91	88.31	44.29	22.08	52.83	44.02	22.21	8.81	2.52	
17		8.5m	VH	67.92	85.53	48.22	17.20	50.72	37.31	31.02	13.41	2.31	2.42
			VE	74.00	86.45	43.41	22.80	51.20	43.04	20.61	8.16	2.53	
18		11.5m	IZ	38.00	47.86	28.22	11.40	26.60	19.64	16.82	6.96	2.42	2.44
			VR	38.26	47.49	28.76	13.20	25.06	18.73	15.56	6.33	2.46	
19		14.5m	RL	75.60	93.40	52.50	21.40	54.20	40.90	31.10	13.30	2.34	2.36
			RV	75.40	92.60	52.00	22.40	53.00	40.60	29.60	12.40	2.39	
20	**BH4 STERILIZER**	0.5m	VW	70.61	86.80	47.40	19.60	51.01	39.40	27.80	11.61	2.39	2.38
			JO4	69.65	84.30	45.70	20.30	49.35	38.60	25.40	10.75	2.36	
21		3.5m	UP	66.00	82.80	44.70	14.80	51.20	38.10	29.90	13.10	2.28	2.30
			MB	68.55	86.60	49.40	17.70	50.85	37.20	31.70	13.65	2.32	
22		6.5m	VZ	73.89	88.60	49.20	23.10	50.79	39.40	26.10	11.39	2.29	2.30
			GS	68.44	85.10	48.70	19.30	49.14	36.40	29.40	12.74	2.31	
23		9.5m	I9Z0	39.00	47.70	28.30	11.50	27.50	19.40	16.80	8.10	2.07	2.11
			S6	39.62	48.10	28.70	12.80	26.82	19.40	15.90	7.42	2.14	
24		12.5m	GC	67.80	82.50	44.70	18.00	49.80	37.80	26.70	12.00	2.23	2.21
			PH	70.34	86.00	49.40	20.60	49.74	36.60	28.80	13.14	2.19	
25		15.0m	III2	39.09	46.50	26.70	12.70	26.39	19.80	14.00	6.59	2.12	2.23
			7B	39.10	47.60	26.50	11.60	27.50	21.10	14.90	6.40	2.33	
26	**BH5 PRESSING STATION**	1.5m	Q8	45.20	56.50	34.80	14.50	30.70	21.70	20.30	9.00	2.26	2.28
			Q1	48.70	60.50	39.10	18.20	30.50	21.40	20.90	9.10	2.30	
27		4.5m	MZ	71.64	84.60	44.10	20.90	50.74	40.50	23.20	10.24	2.27	2.24
			GP	68.67	80.80	41.00	18.80	49.87	39.80	22.20	10.07	2.20	
28		7.5m	DA	73.06	86.90	46.50	22.30	50.76	40.40	24.20	10.36	2.34	2.28
			ZIZZ	69.20	84.70	47.70	19.60	49.60	37.00	28.10	12.60	2.23	
29		10.5m	EI	76.60	94.10	53.10	22.30	54.30	41.00	30.80	13.30	2.32	2.34
			EJ	77.30	93.50	50.50	22.40	54.90	43.00	28.10	11.90	2.36	
30		14.5m	Q5	47.20	54.50	28.70	16.50	30.70	25.80	12.20	4.90	2.49	2.51
			Q7	45.40	54.10	31.50	17.10	28.30	22.60	14.40	5.70	2.53	
31	**BH6 STORAGE TANK**	1.0m	JQ	75.52	89.30	44.70	21.60	53.92	44.60	23.10	9.32	2.48	2.47
			RD	75.70	90.90	47.30	21.70	54.00	43.60	25.60	10.40	2.46	
32		4.0m	EF	77.40	91.50	44.40	21.30	56.10	47.10	23.10	9.00	2.57	2.47
			VP	75.26	89.00	45.70	22.00	53.26	43.30	23.70	9.96	2.38	
33		7.0m	IZ	38.10	46.50	25.80	11.30	26.80	20.70	14.50	6.10	2.38	2.35
			UR	38.50	45.40	25.30	13.20	25.30	20.10	12.10	5.20	2.33	
34		10.0m	RQ	75.20	92.00	54.00	22.40	52.80	38.00	31.60	14.80	2.14	2.17
			TN	74.80	92.80	52.90	20.00	54.80	39.90	32.90	14.90	2.21	
35		13.0m	I3I4	69.12	82.20	42.90	20.50	48.62	39.30	22.40	9.32	2.40	2.42
			C	68.72	82.60	42.70	19.10	49.62	39.90	23.60	9.72	2.43	
36		15.0m	EE	77.80	92.70	49.70	22.90	54.90	43.00	26.80	11.90	2.25	2.28
			TZ	77.20	93.00	48.80	20.90	56.30	44.20	27.90	12.10	2.31	

37		1.0m	I3I4	37.25	45.60	25.10	10.80	26.45	20.50	14.30	5.95	2.40	2.40
			UB	37.72	45.70	25.80	12.10	25.62	19.90	13.70	5.72	2.40	
38		4.0m	RP	76.10	90.50	47.00	22.50	53.60	43.50	24.50	10.10	2.43	2.44
			TO	74.40	88.90	46.20	21.70	52.70	42.70	24.50	10.00	2.45	
39		7.0m	VH	68.14	84.50	47.80	17.20	50.94	36.70	30.60	14.24	2.15	2.19
	BH7 WEIGH BRIDGE		VE	74.26	90.60	52.60	22.90	51.36	38.00	29.70	13.36	2.22	
40		10.0m	CV	75.20	89.30	48.70	23.40	51.80	40.60	25.30	11.20	2.26	2.23
			VI	77.60	91.30	47.40	22.20	55.40	43.90	25.20	11.50	2.19	
41		13.0m	FO	70.36	85.10	47.00	20.30	50.06	38.10	26.70	11.96	2.23	2.18
			DI	70.12	85.40	48.30	19.50	50.62	37.10	28.80	13.52	2.13	
42		15.0m	MI	73.90	90.00	49.40	20.50	53.40	40.60	28.90	12.80	2.26	2.25
			FO	74.50	89.90	50.40	22.70	51.80	39.50	27.70	12.30	2.25	
43		3.0m	BZ	73.08	90.60	52.50	21.60	51.48	38.10	30.90	13.38	2.31	2.22
			GZ	73.08	90.40	53.00	20.30	52.78	37.40	32.70	15.38	2.13	
44		6.0m	EC	73.60	87.10	43.00	20.10	53.50	44.10	22.90	9.40	2.44	2.49
			RN	75.00	90.10	47.50	22.60	52.40	42.60	24.90	9.80	2.54	
45	BH8 WATER TANK	9.0m	OG	75.90	92.90	51.60	22.80	53.10	41.30	28.80	11.80	2.44	2.47
			CD	77.10	92.10	48.20	23.20	53.90	43.90	25.00	10.00	2.50	
46		12.0m	JO	76.25	89.00	44.10	22.50	53.75	44.90	21.60	8.85	2.44	2.50
			CO	75.30	91.70	46.90	20.00	55.30	44.80	26.90	10.50	2.56	
47		15.0m	E	67.23	81.50	40.80	16.80	50.43	40.70	24.00	9.73	2.47	2.46
			VR	67.65	83.50	44.30	17.60	50.05	39.20	26.70	10.85	2.46	
48		2.0m	Q2	48.80	61.30	37.30	15.60	33.20	24.00	21.70	9.20	2.36	2.31
			Q4	49.30	60.60	37.60	17.30	32.00	23.00	20.30	9.00	2.26	
49		5.0m	BED	37.99	47.80	28.30	11.70	26.29	19.50	16.60	6.79	2.44	2.33
			BOB	38.75	48.10	28.90	11.90	26.85	19.20	17.00	7.65	2.22	
50	BH9 RAMP I	8.0m	BA	72.57	90.90	53.90	22.20	50.37	37.00	31.70	13.37	2.37	2.36
			Z3Z4	72.46	88.90	50.50	21.80	50.66	38.40	28.70	12.26	2.34	
51		11.0m	EK	74.40	89.00	46.70	20.70	53.70	42.30	26.00	11.40	2.28	2.37
			RM	76.40	88.20	40.80	20.90	55.50	47.40	19.90	8.10	2.46	
52			RY	73.30	87.90	44.80	19.80	53.50	43.10	25.00	10.40	2.40	2.37
		14.0m	RS	79.50	93.20	49.00	25.00	54.50	44.20	24.00	10.30	2.33	
53		1.5m	RC	74.20	89.30	45.20	17.90	56.30	44.10	27.30	12.20	2.24	2.24
			TW	77.20	93.10	50.80	22.10	55.10	42.30	28.70	12.80	2.24	
54		4.5m	EJ	76.50	95.80	54.40	22.40	54.10	41.40	32.00	12.70	2.52	2.52
			EH	75.40	95.20	55.90	23.00	52.40	39.30	32.90	13.10	2.51	
55		7.5m	HP	76.12	92.90	51.80	22.70	53.42	41.10	29.10	12.32	2.36	2.35
	BH10 RAMP II		DP	75.50	91.10	48.90	21.70	53.80	42.20	27.20	11.60	2.34	
56		10.5m	PA	69.58	84.10	44.60	19.80	49.78	39.50	24.80	10.28	2.41	2.36
			VY	70.23	86.30	47.30	19.00	51.23	39.00	28.30	12.23	2.31	
57			A	48.21	59.20	37.10	18.20	30.01	22.10	18.90	7.91	2.39	2.42
		13.5m	B	50.80	63.60	41.00	19.40	31.40	22.60	21.60	8.80	2.45	
58			S2	73.60	92.00	53.00	21.40	52.20	39.00	31.60	13.20	2.39	2.42
		15.0m	EA	77.20	93.30	49.80	22.50	54.70	43.50	27.30	11.20	2.44	

B+W = Wt. of Bottle + Water (full) W4
B+S+W = Wt. of Bottle + Soil+ Water W3
B+S = Wt. of Bottle + Soil W2
B = Wt. of Bottle W1
Ad.W = Wt. of Added Water (full) (W4-W1)
WWAS = Wt. of Water added to Soil (W3-W2)
WS = Wt. of Soil (W2-W1)
WOWDS = Wt. of Water Displaced by Soil (W4-W1)-(W3-W2) = W
GS = Specific Gravity (W2-W1)/W

APPENDIX II

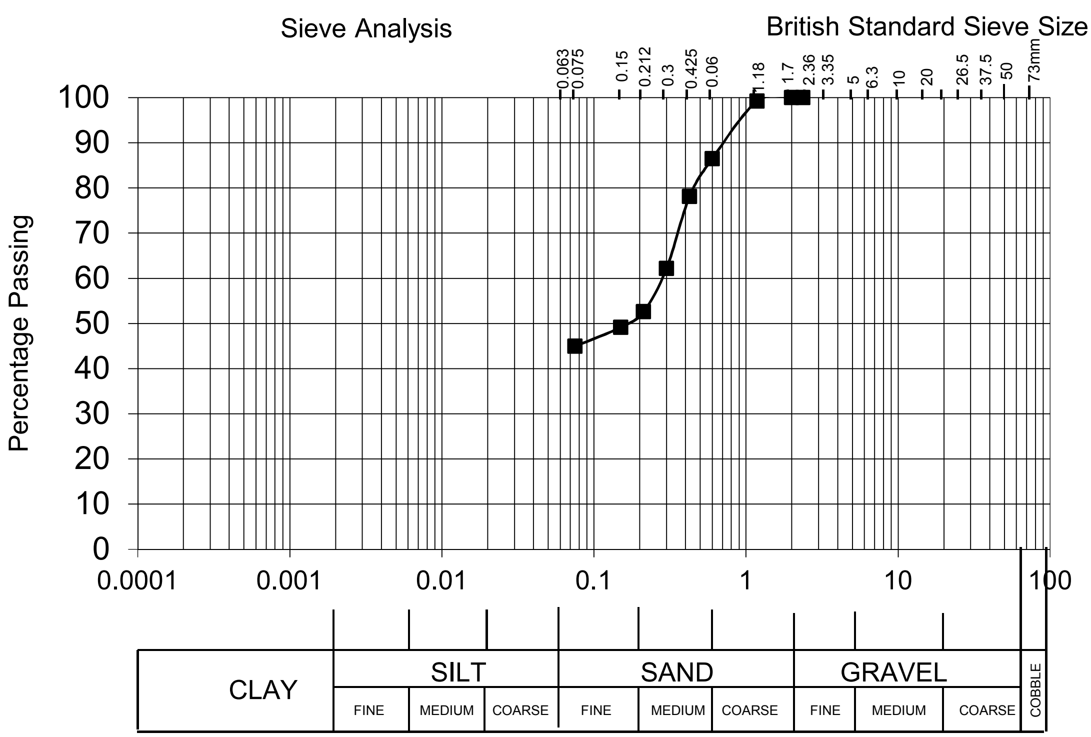
UNIBEN GEOTECH RESEARCH
GRAIN SIZE ANALYSIS BY WET-SIEVING

SITE: … **OKOMU** **JOB:............**

LOCATION: ROAD POINT 1... DATE**: 08-06--2018**………

DEPTH: **……. 1.5m……** TESTED BY:……**WET SIEVE**………

SIEVE NO.				
APPROX IMPERIAL EQUIV (Seive No.)	BRITISH STANDARD SIEVE SIZES (mm)	RETAINED IN gm	PASSING IN gm	PASSING IN (%)
3	75			
2 ½				
2	50			
1 ½	37.5			
1	26.5			
¾	20			
½	14			
⅜	10			
¼	6.3			
3/16	5			
⅛	3.35		100	100
7	2.36		100	100
10	2		100	100
14	1.18	0.76	99.24	99.24
25	0.6	12.78	86.46	86.46
36	0.425	8.35	78	78
52	0.3	15.97	62.14	62.14
72	0.212	9.55	52.59	52.59
100	0.15	3.44	49.15	49.15
200	0.075	4.23	44.92	44.92



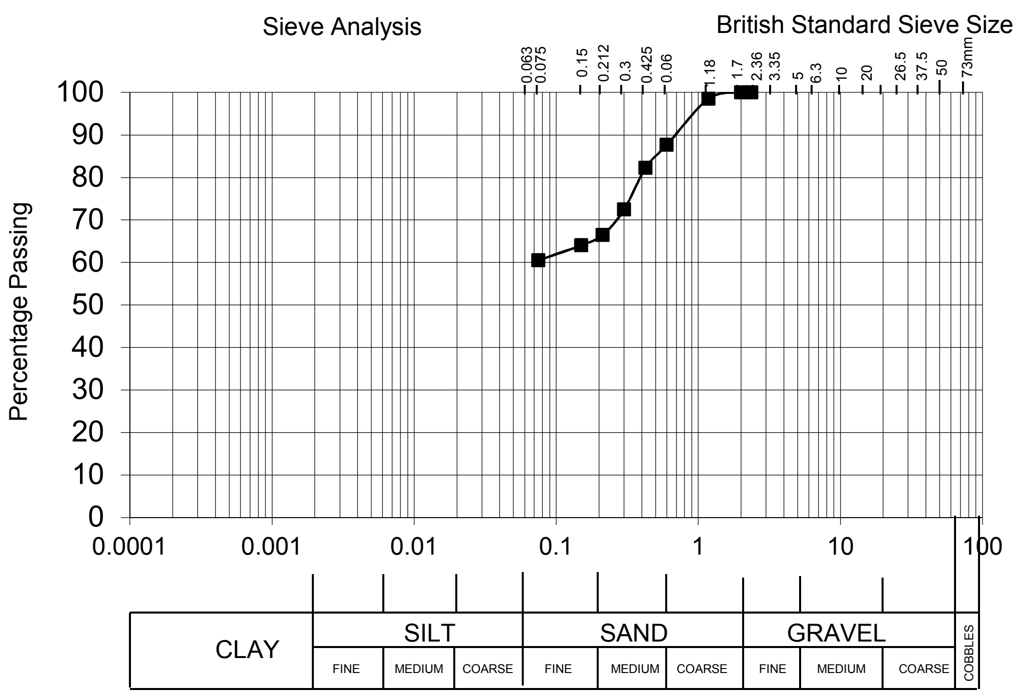
UNIBEN GEOTECH RESEARCH
GRAIN SIZE ANALYSIS BY WET-SIEVING

SITE: **… OKOMU** JOB:**............**

LOCATION: .ROAD POINT 2. DATE**: 08-06--2018**………

DEPTH: **……. 1.5m……** TESTED BY:……**WET SIEVE**………

SIEVE NO.				
APPROX IMPERIAL EQUIV (inches)	BRITISH STANDARD SIEVE SIZES (mm)	RETAINED IN gm	PASSING IN gm	PASSING IN (%)
3	75			
2 ½				
2	50			
1 ½	37.5			
1	26.5			
¾	20			
½	14			
⅜	10			
¼	6.3			
3/16	5			
⅛	3.35		100	100
7	2.36		100	100
10	2		100	100
14	1.18	1.5	98.5	98.5
25	0.6	10.85	87.65	87.65
36	0.425	5.43	82	82
52	0.3	9.78	72.44	72.44
72	0.212	6.02	66.42	66.42
100	0.15	2.39	64.03	64.03
200	0.075	3.51	60.52	60.52



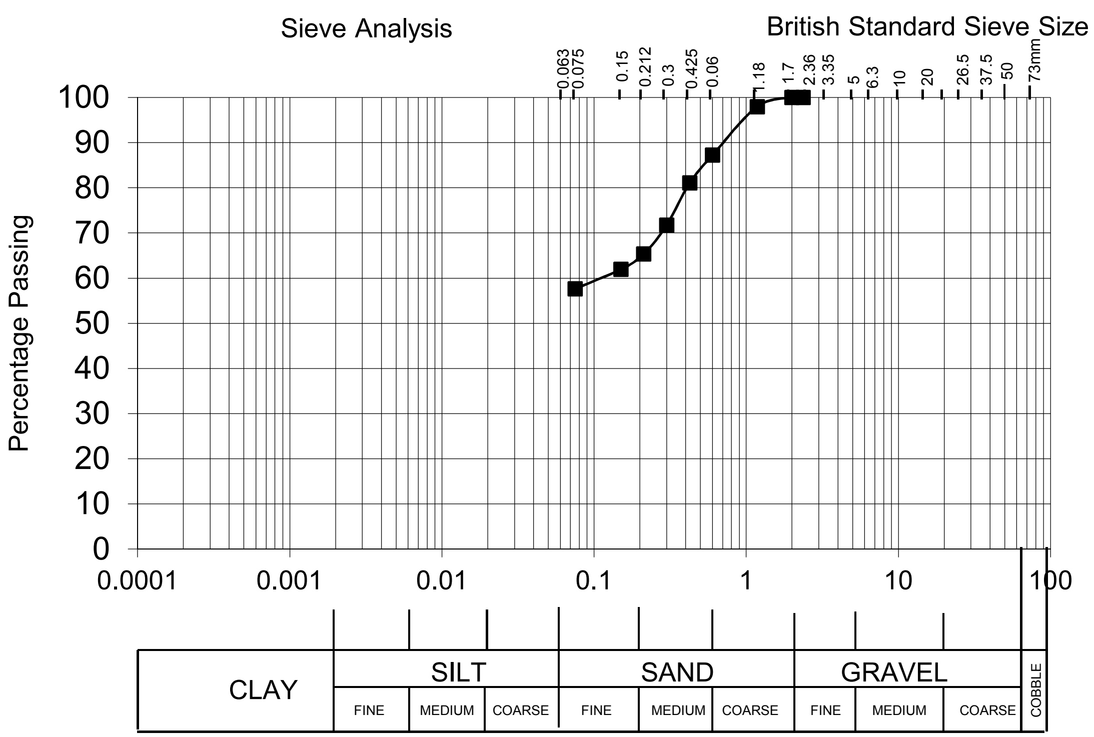
UNIBEN GEOTECH RESEARCH
GRAIN SIZE ANALYSIS BY WET-SIEVING

SITE: ... **OKOMU** **JOB:............**

LOCATION: .ROAD POINT 3. DATE**: 08-06--2018**.........

DEPTH: **....... 1.5m......** TESTED BY:......**WET SIEVE**.........

SIEVE NO.				
APPROX IMPERIAL EQUIV (Seive No.)	BRITISH STANDARD SIEVE SIZES (mm)	RETAINED IN gm	PASSING IN gm	PASSING IN (%)
3	75			
2 ½				
2	50			
1 ½	37.5			
1	26.5			
¾	20			
½	14			
⅜	10			
¼	6.3			
3/16	5			
⅛	3.35		100	100
7	2.36		100	100
10	2		100	100
14	1.18	2.03	97.97	97.97
25	0.6	10.75	87.22	87.22
36	0.425	6.17	81	81
52	0.3	9.33	71.72	71.72
72	0.212	6.37	65.35	65.35
100	0.15	3.41	61.94	61.94
200	0.075	4.3	57.64	57.64



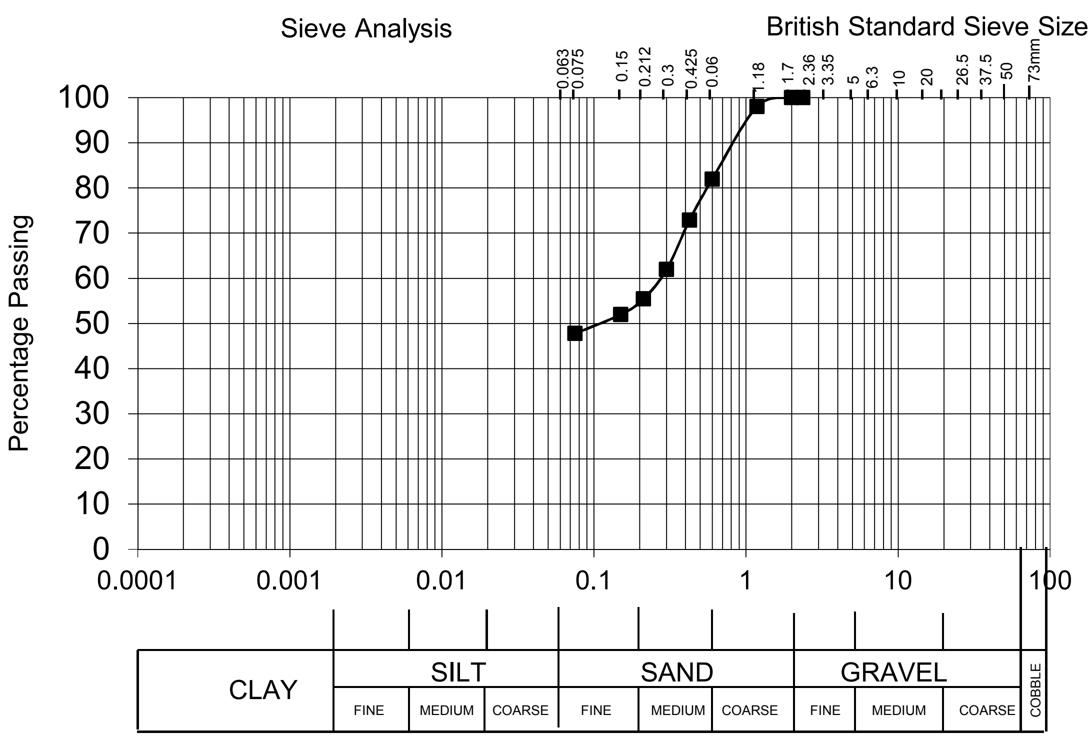
UNIBEN GEOTECH RESEARCH
GRAIN SIZE ANALYSIS BY WET-SIEVING

SITE: ... **OKOMU** **JOB:............**

LOCATION: .....BOILER , BH1. DATE: **08-06--2018**.........

DEPTH: **....... 1.0m......** TESTED BY:......**WET SIEVE**.........

SIEVE NO.				
APPROX IMPERIAL EQUIV (Seive No.)	BRITISH STANDARD SIEVE SIZES (mm)	RETAINED IN gm	PASSING IN gm	PASSING IN (%)
3	75			
2 ½				
2	50			
1 ½	37.5			
1	26.5			
¾	20			
½	14			
⅜	10			
¼	6.3			
3/16	5			
⅛	3.35		100	100
7	2.36		100	100
10	2		100	100
14	1.18	2.01	97.99	97.99
25	0.6	16.05	81.94	81.94
36	0.425	9.09	72.85	72.85
52	0.3	10.93	61.92	61.92
72	0.212	6.49	55.43	55.43
100	0.15	3.46	51.97	51.97
200	0.075	4.22	47.75	47.75



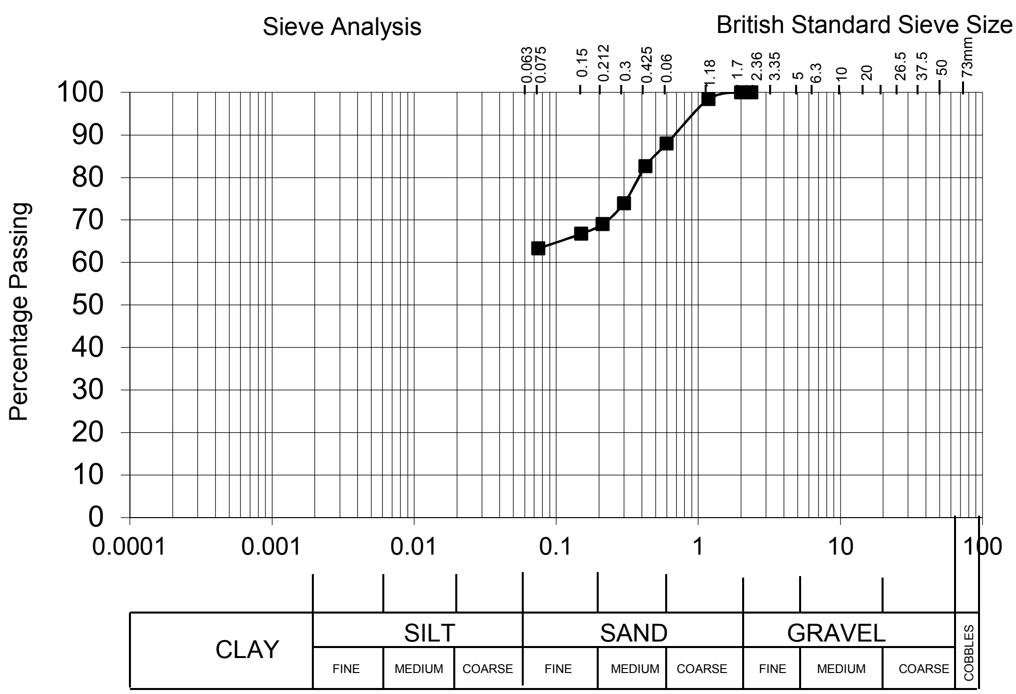
UNIBEN GEOTECH RESEARCH
GRAIN SIZE ANALYSIS BY WET-SIEVING

SITE: **… OKOMU** **JOB:.............**

LOCATION: .....BOILER , BH1. DATE**: 08-06--2018**………

DEPTH: **……. 3.0m……** TESTED BY:……**WET SIEVE**………

SIEVE NO.				
APPROX IMPERIAL EQUIV (Seive No.)	BRITISH STANDARD SIEVE SIZES (mm)	RETAINED IN gm	PASSING IN gm	PASSING IN (%)
3	75			
2 ½				
2	50			
1 ½	37.5			
1	26.5			
¾	20			
½	14			
⅜	10			
¼	6.3			
3/16	5			
⅛	3.35		100	100
7	2.36		100	100
10	2		100	100
14	1.18	1.63	98.37	98.37
25	0.6	10.43	87.94	87.94
36	0.425	5.34	82.60	82.60
52	0.3	8.7	73.9	73.9
72	0.212	4.88	69.02	69.02
100	0.15	2.29	66.73	66.73
200	0.075	3.42	63.31	63.31



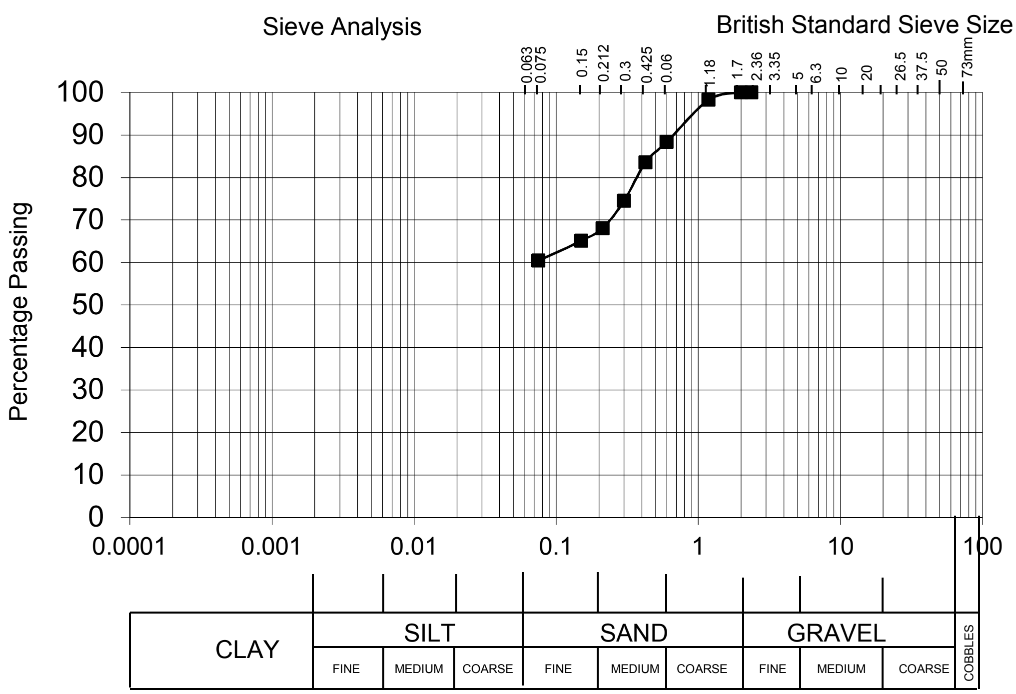
UNIBEN GEOTECH RESEARCH
GRAIN SIZE ANALYSIS BY WET-SIEVING

SITE: **… OKOMU** **JOB:………….**

LOCATION: …..BOILER , BH1. DATE**: 08-06--2018**………

DEPTH: **……. 6.0m……** TESTED BY:……**WET SIEVE**………

SIEVE NO.				
APPROX IMPERIAL EQUIV (Seive No.)	BRITISH STANDARD SIEVE SIZES (mm)	RETAINED IN gm	PASSING IN gm	PASSING IN (%)
3	75			
2 ½				
2	50			
1 ½	37.5			
1	26.5			
¾	20			
½	14			
⅜	10			
¼	6.3			
3/16	5			
⅛	3.35		100	100
7	2.36		100	100
10	2		100	100
14	1.18	1.78	98.22	98.22
25	0.6	9.87	88.35	88.35
36	0.425	4.82	83.53	83.53
52	0.3	9.05	74.48	74.48
72	0.212	6.43	68.05	68.05
100	0.15	2.95	65.1	65.1
200	0.075	4.7	60.4	60.4



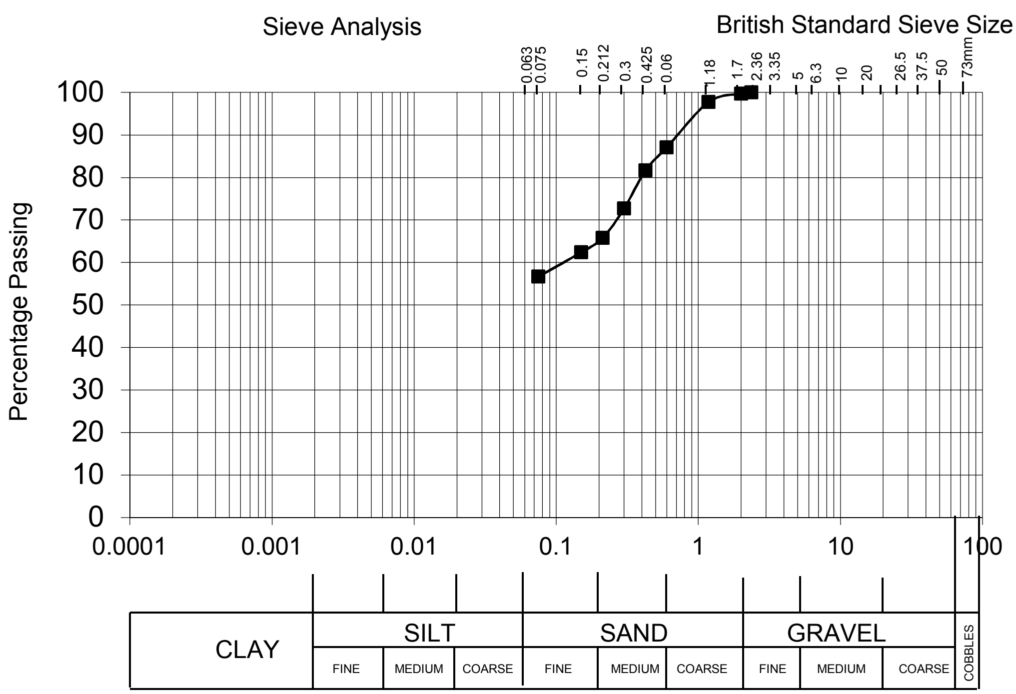
UNIBEN GEOTECH RESEARCH
GRAIN SIZE ANALYSIS BY WET-SIEVING

SITE: **… OKOMU** **JOB:.............**

LOCATION: .....BOILER , BH1. DATE**: 08-06--2018**………

DEPTH: **……. 9.0m……** TESTED BY:……**WET SIEVE**………

SIEVE NO.				
APPROX IMPERIAL EQUIV (inches)	BRITISH STANDARD SIEVE SIZES (mm)	RETAINED IN gm	PASSING IN gm	PASSING IN (%)
3	75			
2 ½				
2	50			
1 ½	37.5			
1	26.5			
¾	20			
½	14			
⅜	10			
¼	6.3			
3/16	5			
⅛	3.35		100	100
7	2.36		100	100
10	2	0.32	99.68	99.68
14	1.18	1.97	97.71	97.71
25	0.6	10.63	87.08	87.08
36	0.425	5.44	81.64	81.64
52	0.3	8.97	72.67	72.67
72	0.212	6.93	65.74	65.74
100	0.15	3.35	62.39	62.39
200	0.075	5.7	56.69	56.69



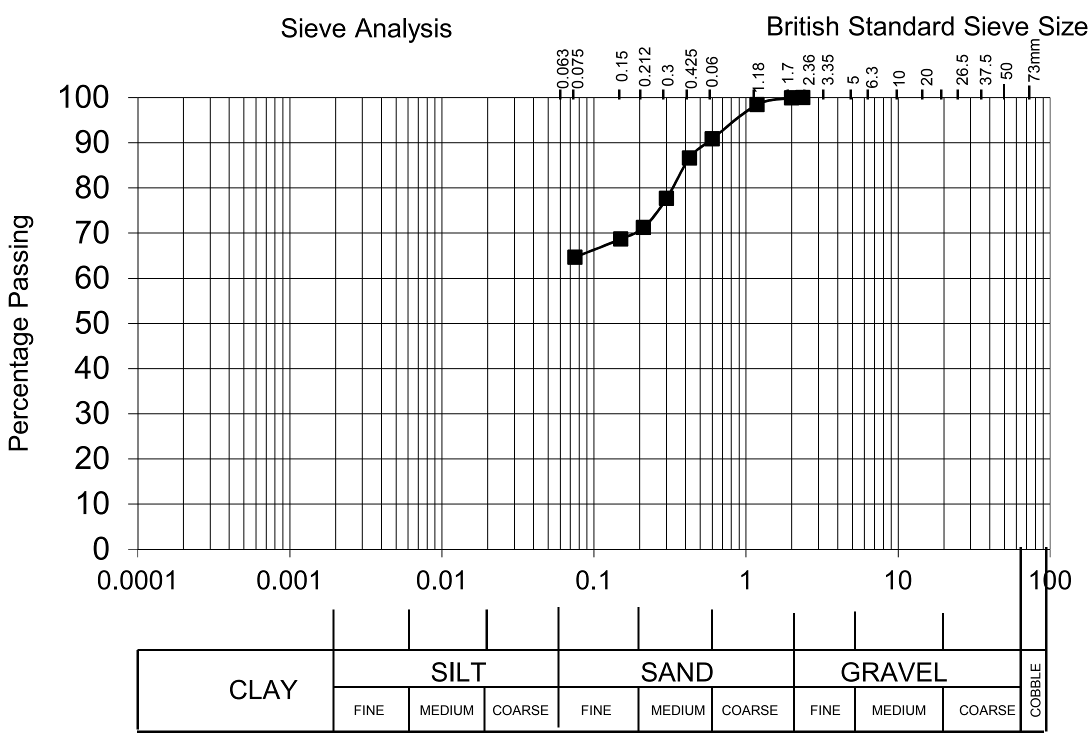
UNIBEN GEOTECH RESEARCH
GRAIN SIZE ANALYSIS BY WET-SIEVING

SITE: ... **OKOMU** **JOB:............**

LOCATION: .....BOILER , BH1. DATE: **08-06--2018**.........

DEPTH: **....... 12.0m......** TESTED BY:......**WET SIEVE**.........

SIEVE NO.				
APPROX IMPERIAL EQUIV (Seive No.)	BRITISH STANDARD SIEVE SIZES (mm)	RETAINED IN gm	PASSING IN gm	PASSING IN (%)
3	75			
2 ½				
2	50			
1 ½	37.5			
1	26.5			
¾	20			
½	14			
⅜	10			
¼	6.3			
3/16	5			
⅛	3.35		100	100
7	2.36		100	100
10	2	0.09	99.91	99.91
14	1.18	1.48	98.43	98.43
25	0.6	7.57	90.86	90.86
36	0.425	4.23	86.63	86.63
52	0.3	8.98	77.65	77.65
72	0.212	6.42	71.23	71.23
100	0.15	2.54	68.69	68.69
200	0.075	4.03	64.66	64.66



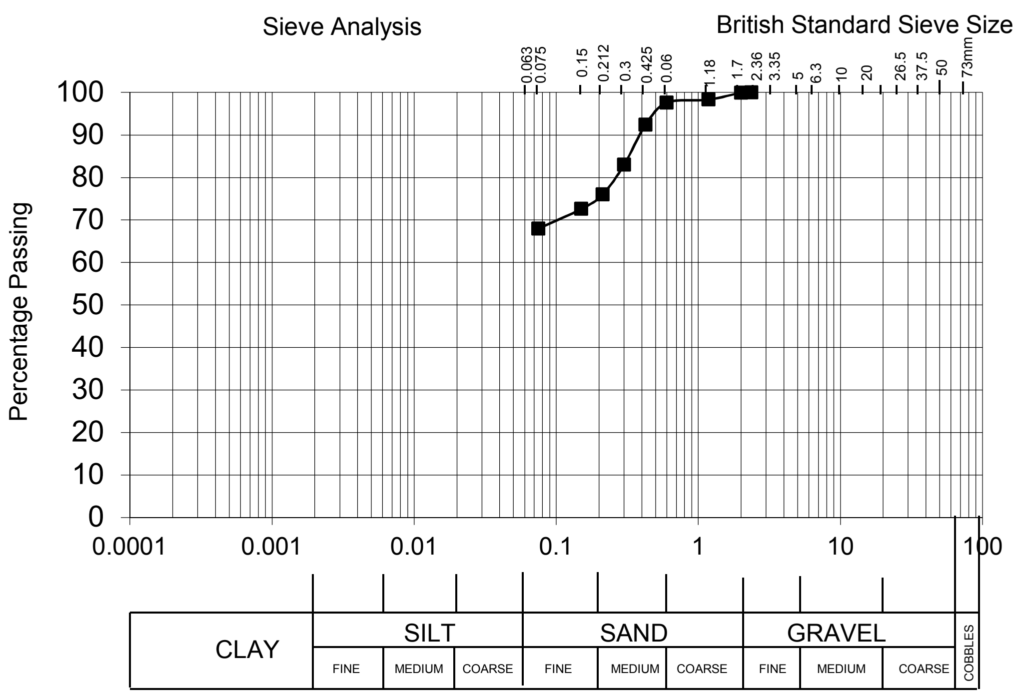
UNIBEN GEOTECH RESEARCH
GRAIN SIZE ANALYSIS BY WET-SIEVING

SITE: **… OKOMU** **JOB:.............**

LOCATION: .....BOILER , BH1. DATE**: 08-06--2018**………

DEPTH: **……. 15m……** TESTED BY:……**WET SIEVE**………

SIEVE NO.				
APPROX IMPERIAL EQUIV (Sieve No.)	BRITISH STANDARD SIEVE SIZES (mm)	RETAINED IN gm	PASSING IN gm	PASSING IN (%)
3	75			
2 ½				
2	50			
1 ½	37.5			
1	26.5			
¾	20			
½	14			
⅜	10			
¼	6.3			
3/16	5			
⅛	3.35		100	100
7	2.36		100	100
10	2	0.07	99.93	99.93
14	1.18	1.64	98.29	98.29
25	0.6	0.71	97.58	97.58
36	0.425	5.23	92.35	92.35
52	0.3	9.4	82.95	82.95
72	0.212	6.99	75.96	75.96
100	0.15	3.39	72.57	72.57
200	0.075	4.59	67.98	67.98



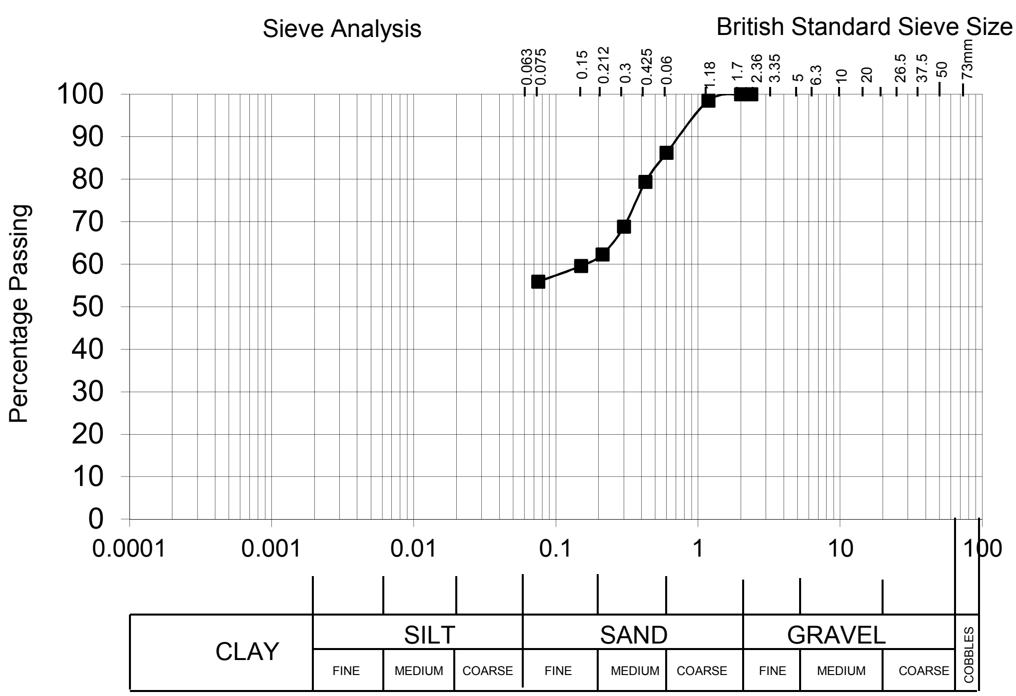
UNIBEN GEOTECH RESEARCH
GRAIN SIZE ANALYSIS BY WET-SIEVING

SITE: **… OKOMU** **JOB:.............**

LOCATION: .....POWER HOUSE , BH2. DATE**: 08-06--2018**………

DEPTH: **……. 2.0m……** TESTED BY:……**WET SIEVE**………

SIEVE NO.				
APPROX IMPERIAL EQUIV (Seive No)	BRITISH STANDARD SIEVE SIZES (mm)	RETAINED IN gm	PASSING IN gm	PASSING IN (%)
3	75			
2 ½				
2	50			
1 ½	37.5			
1	26.5			
¾	20			
½	14			
⅜	10			
¼	6.3			
3/16	5			
⅛	3.35		100	100
7	2.36		100	100
10	2		100	100
14	1.18	1.51	98.49	98.49
25	0.6	12.26	86.23	86.23
36	0.425	6.88	79.35	79.35
52	0.3	10.53	68.82	68.82
72	0.212	6.48	62.34	62.34
100	0.15	2.73	59.61	59.61
200	0.075	3.7	55.91	55.91



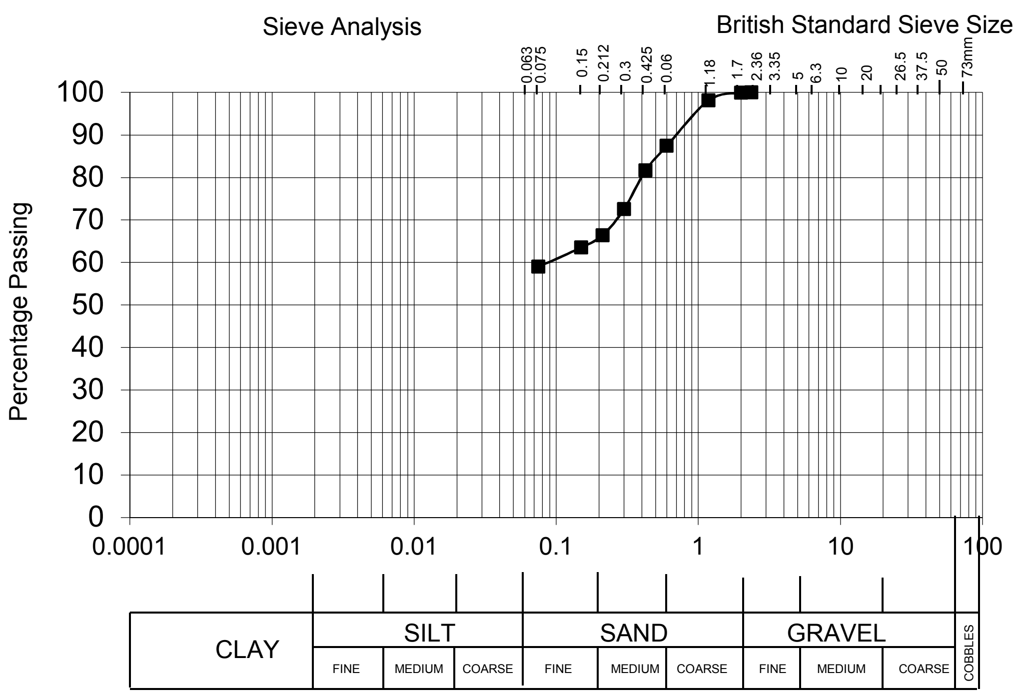
UNIBEN GEOTECH RESEARCH
GRAIN SIZE ANALYSIS BY WET-SIEVING

SITE: **… OKOMU** **JOB:.............**

LOCATION: .....POWER HOUSE , BH2. DATE**: 08-06--2018**………

DEPTH: **……. 5.0m……** TESTED BY:……**WET SIEVE**………

SIEVE NO.				
APPROX IMPERIAL EQUIV (Seive No.)	BRITISH STANDARD SIEVE SIZES (mm)	RETAINED IN gm	PASSING IN gm	PASSING IN (%)
3	75			
2 ½				
2	50			
1 ½	37.5			
1	26.5			
¾	20			
½	14			
⅜	10			
¼	6.3			
3/16	5			
⅛	3.35		100	100
7	2.36		100	100
10	2	0.08	99.92	99.92
14	1.18	1.81	98.11	98.11
25	0.6	10.7	87.41	87.41
36	0.425	5.81	81.60	81.60
52	0.3	9.04	72.56	72.56
72	0.212	6.17	66.39	66.39
100	0.15	2.86	63.53	63.53
200	0.075	4.55	58.98	58.98



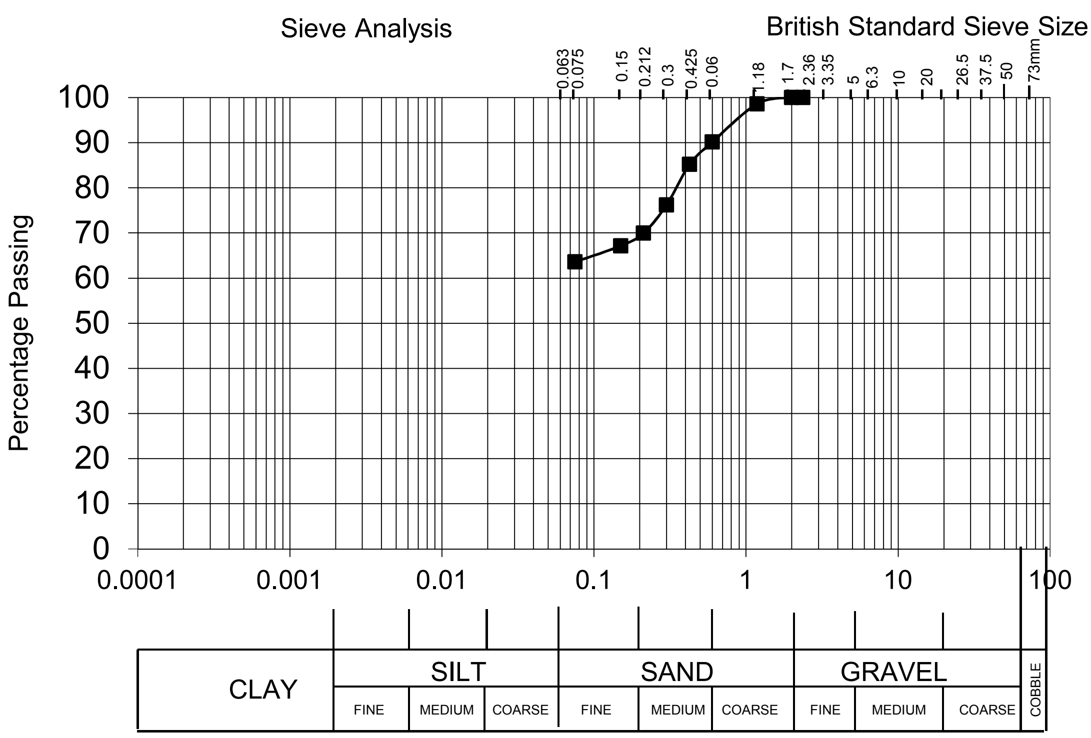
UNIBEN GEOTECH RESEARCH
GRAIN SIZE ANALYSIS BY WET-SIEVING

SITE: ... **OKOMU** **JOB:............**

LOCATION: .....POWER HOUSE , BH2. DATE**: 08-06--2018**.........

DEPTH: **....... 8.0m......** TESTED BY:......**WET SIEVE**.........

SIEVE NO.				
APPROX IMPERIAL EQUIV (Seive No.)	BRITISH STANDARD SIEVE SIZES (mm)	RETAINED IN gm	PASSING IN gm	PASSING IN (%)
3	75			
2 ½				
2	50			
1 ½	37.5			
1	26.5			
¾	20			
½	14			
⅜	10			
¼	6.3			
3/16	5			
⅛	3.35		100	100
7	2.36		100	100
10	2		100	100
14	1.18	1.42	98.58	98.58
25	0.6	8.45	90.13	90.13
36	0.425	4.96	85.17	85.17
52	0.3	8.95	76.22	76.22
72	0.212	6.24	69.98	69.98
100	0.15	2.83	67.15	67.15
200	0.075	3.59	63.56	63.56



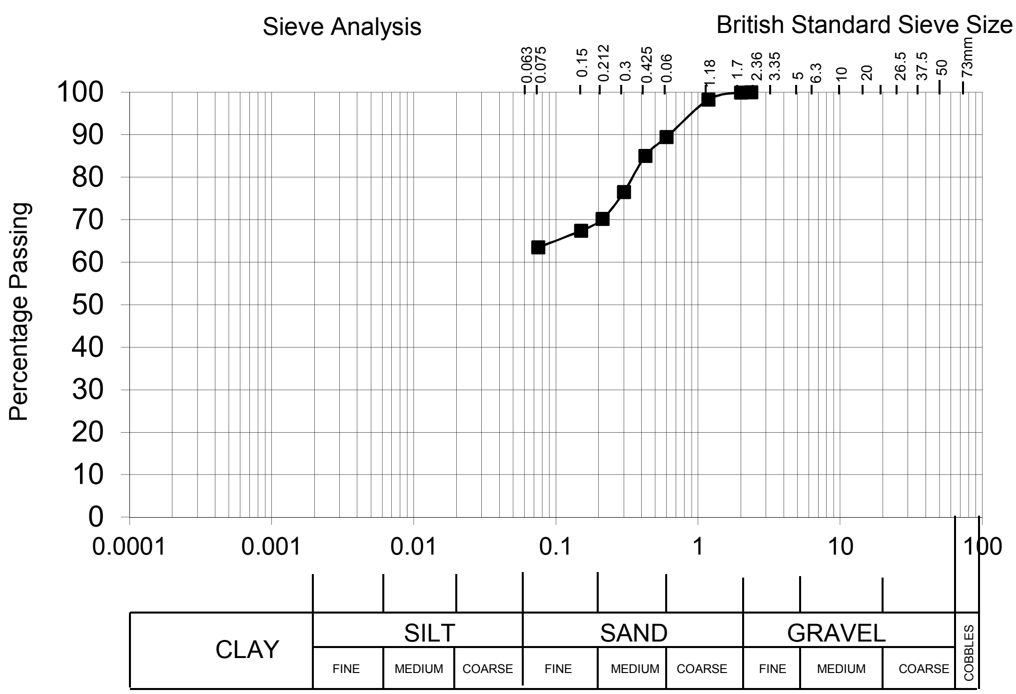
UNIBEN GEOTECH RESEARCH
GRAIN SIZE ANALYSIS BY WET-SIEVING

SITE: **… OKOMU** **JOB:.............**

LOCATION: .....POWER HOUSE , BH2. DATE**: 08-06--2018**………

DEPTH: **……. 11.0m……** TESTED BY:……**WET SIEVE**………

SIEVE NO.				
APPROX IMPERIAL EQUIV (Seive No.)	BRITISH STANDARD SIEVE SIZES (mm)	RETAINED IN gm	PASSING IN gm	PASSING IN (%)
3	75			
2 ½				
2	50			
1 ½	37.5			
1	26.5			
¾	20			
½	14			
⅜	10			
¼	6.3			
3/16	5			
⅛	3.35		100	100
7	2.36		100	100
10	2	0.07	99.93	99.93
14	1.18	1.69	98.24	98.24
25	0.6	8.76	89.48	89.48
36	0.425	4.43	85.05	85.05
52	0.3	8.52	76.53	76.53
72	0.212	6.32	70.21	70.21
100	0.15	2.77	67.44	67.44
200	0.075	3.94	63.5	63.5



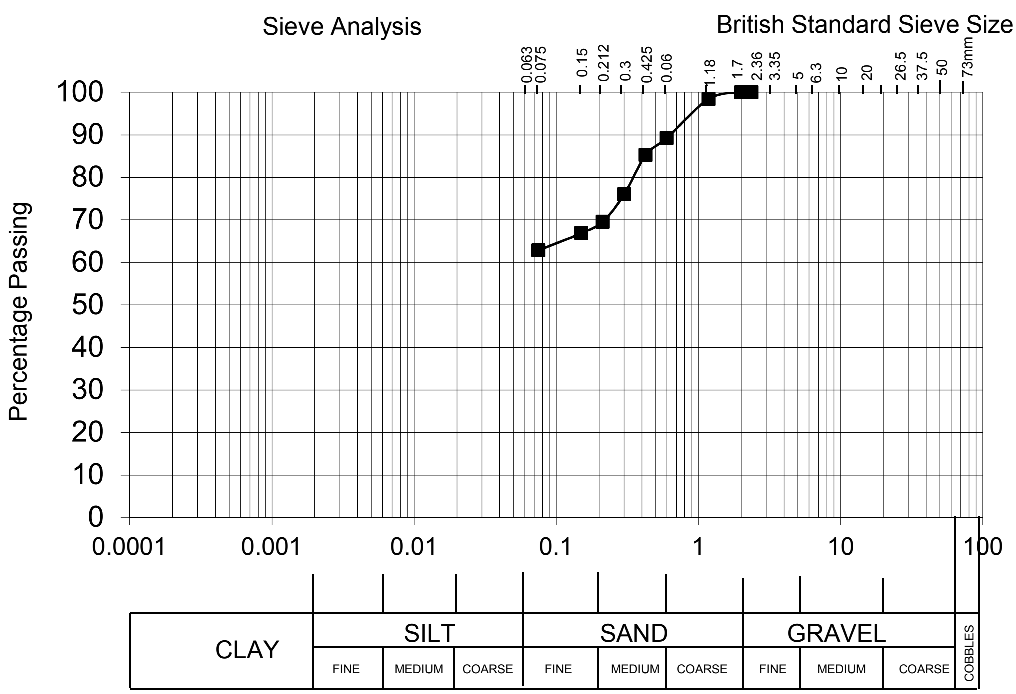
UNIBEN GEOTECH RESEARCH
GRAIN SIZE ANALYSIS BY WET-SIEVING

SITE: **… OKOMU** **JOB:.............**

LOCATION: .....POWER HOUSE , BH2. DATE**: 08-06--2018**………

DEPTH: **……. 15.0m……** TESTED BY:……**WET SIEVE**………

SIEVE NO.				
APPROX IMPERIAL EQUIV (Seive No.)	BRITISH STANDARD SIEVE SIZES (mm)	RETAINED IN gm	PASSING IN gm	PASSING IN (%)
3	75			
2 ½				
2	50			
1 ½	37.5			
1	26.5			
¾	20			
½	14			
⅜	10			
¼	6.3			
3/16	5			
⅛	3.35		100	100
7	2.36		100	100
10	2	0.04	99.96	99.96
14	1.18	1.56	98.4	98.4
25	0.6	9.15	89.25	89.25
36	0.425	4.04	85.21	85.21
52	0.3	9.24	75.97	75.97
72	0.212	6.41	69.56	69.56
100	0.15	2.7	66.86	66.86
200	0.075	4.04	62.82	62.82



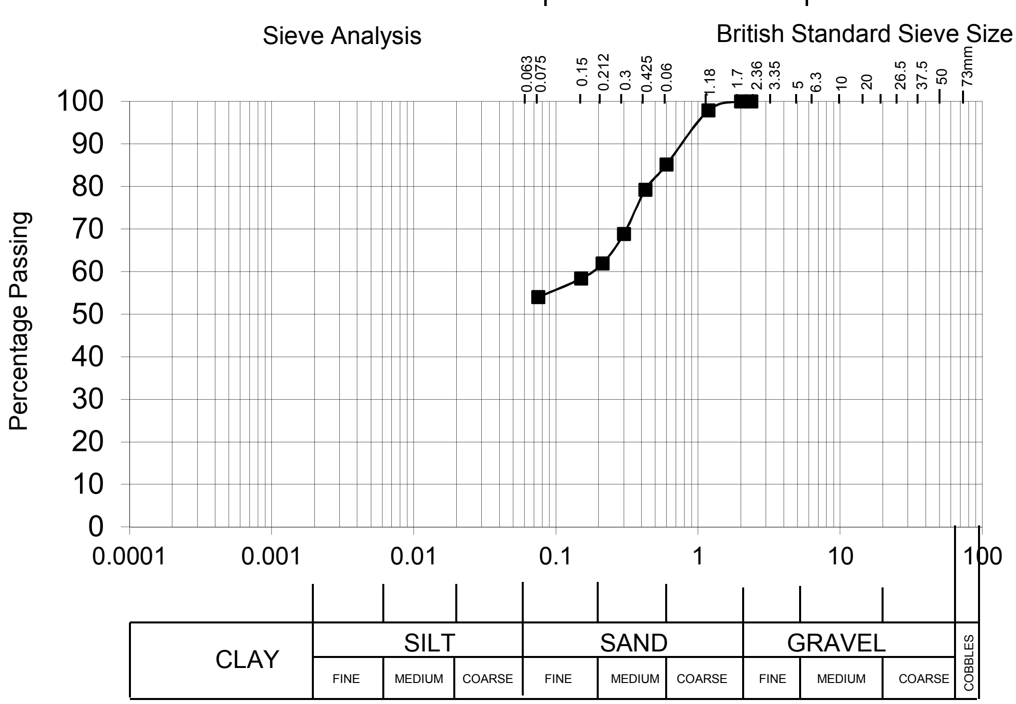
UNIBEN GEOTECH RESEARCH
GRAIN SIZE ANALYSIS BY WET-SIEVING

SITE: **... OKOMU** **JOB:.............**

LOCATION: .CLARIFICATION STATION, BH3. DATE**: 08-06--2018**.........

DEPTH: **....... 2.5m......** TESTED BY:......**WET SIEVE**.........

SIEVE NO.				
APPROX IMPERIAL EQUIV (Seive No.)	BRITISH STANDARD SIEVE SIZES (mm)	RETAINED IN gm	PASSING IN gm	PASSING IN (%)
3	75			
2 ½				
2	50			
1 ½	37.5			
1	26.5			
¾	20			
½	14			
⅜	10			
¼	6.3			
3/16	5			
⅛	3.35		100	100
7	2.36		100	100
10	2		100	100
14	1.18	2.12	97.88	97.88
25	0.6	12.73	85.15	85.15
36	0.425	5.92	79.23	79.23
52	0.3	10.37	68.86	68.86
72	0.212	6.93	61.93	61.93
100	0.15	3.57	58.36	58.36
200	0.075	4.34	54.02	54.02



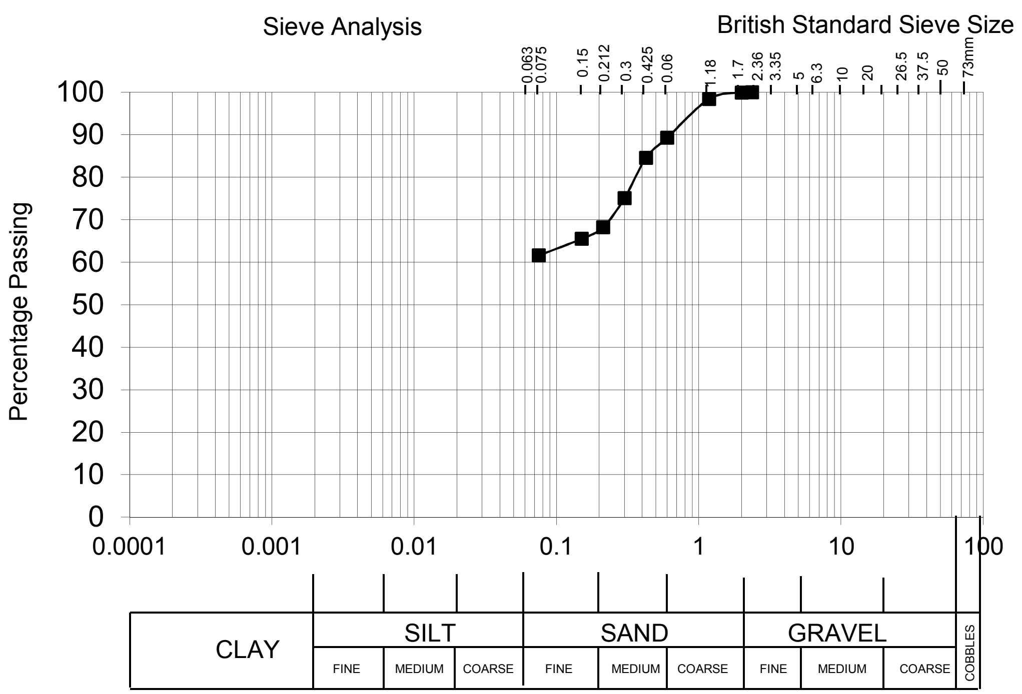
UNIBEN GEOTECH RESEARCH
GRAIN SIZE ANALYSIS BY WET-SIEVING

SITE: **… OKOMU** **JOB:………….**

LOCATION: CLARIFICATION STATION, BH3. DATE**: 08-06--2018**………

DEPTH: **……. 5.5m……** TESTED BY:……**WET SIEVE**………

SIEVE NO.				
APPROX IMPERIAL EQUIV (Seive No.)	BRITISH STANDARD SIEVE SIZES (mm)	RETAINED IN gm	PASSING IN gm	PASSING IN (%)
3	75			
2 ½				
2	50			
1 ½	37.5			
1	26.5			
¾	20			
½	14			
⅜	10			
¼	6.3			
3/16	5			
⅛	3.35		100	100
7	2.36		100	100
10	2	0.06	99.94	99.94
14	1.18	1.52	98.42	98.42
25	0.6	9.09	89.33	89.33
36	0.425	4.79	84.54	84.54
52	0.3	9.48	75.06	75.06
72	0.212	6.81	68.25	68.25
100	0.15	2.73	65.52	65.52
200	0.075	3.91	61.61	61.61



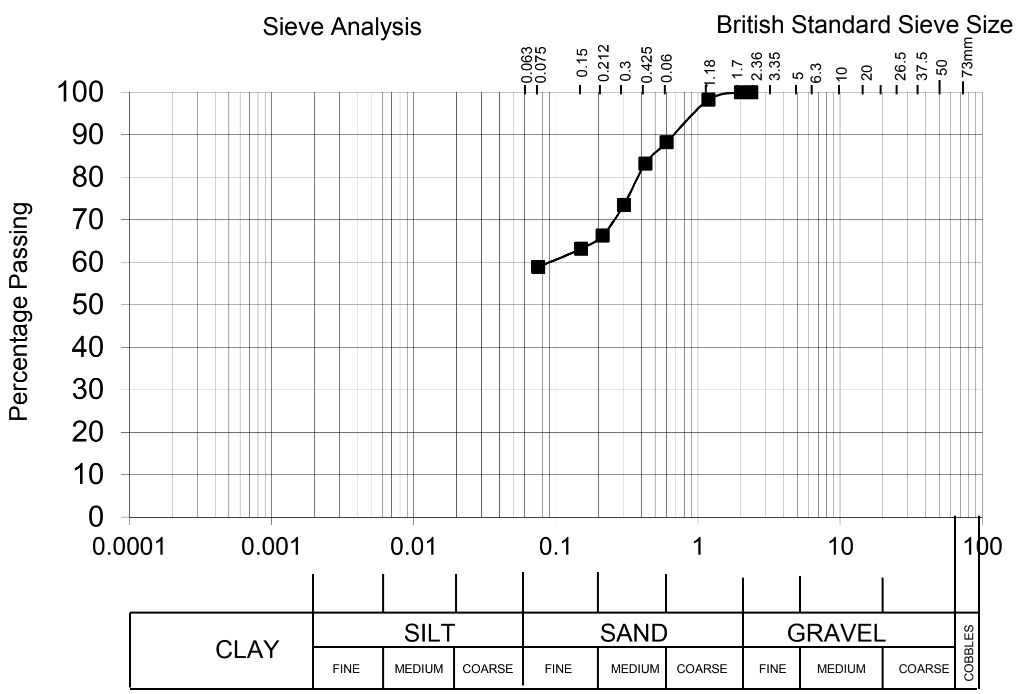
UNIBEN GEOTECH RESEARCH
GRAIN SIZE ANALYSIS BY WET-SIEVING

SITE: **… OKOMU** **JOB:.............**

LOCATION: CLARIFICATION STATION, BH3. DATE**: 08-06--2018**………

DEPTH: **……. 8.5m……** TESTED BY:……**WET SIEVE**………

SIEVE NO.				
APPROX IMPERIAL EQUIV (Seive No.)	BRITISH STANDARD SIEVE SIZES (mm)	RETAINED IN gm	PASSING IN gm	PASSING IN (%)
3	75			
2 ½				
2	50			
1 ½	37.5			
1	26.5			
¾	20			
½	14			
⅜	10			
¼	6.3			
3/16	5			
⅛	3.35		100	100
7	2.36		100	100
10	2		100	100
14	1.18	1.78	98.22	98.22
25	0.6	9.99	88.23	88.23
36	0.425	5.01	83.22	83.22
52	0.3	9.69	73.53	73.53
72	0.212	7.25	66.28	66.28
100	0.15	3.09	63.19	63.19
200	0.075	4.3	58.89	58.89



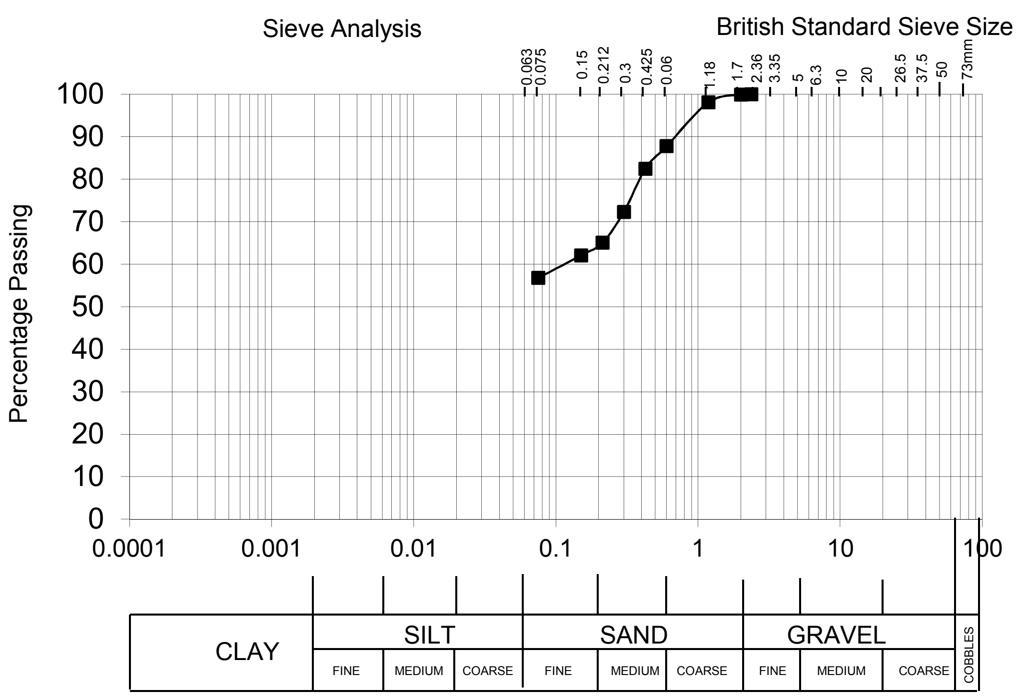
UNIBEN GEOTECH RESEARCH
GRAIN SIZE ANALYSIS BY WET-SIEVING

SITE: **… OKOMU** **JOB:.............**

LOCATION: CLARIFICATION STATION, BH3. DATE**: 08-06--2018**………

DEPTH: **……. 11.5m……** TESTED BY:……**WET SIEVE**………

SIEVE NO.				
APPROX IMPERIAL EQUIV (Seive No.)	BRITISH STANDARD SIEVE SIZES (mm)	RETAINED IN gm	PASSING IN gm	PASSING IN (%)
3	75			
2 ½				
2	50			
1 ½	37.5			
1	26.5			
¾	20			
½	14			
⅜	10			
¼	6.3			
3/16	5			
⅛	3.35		100	100
7	2.36		100	100
10	2	0.1	99.9	99.9
14	1.18	1.82	98.08	98.08
25	0.6	10.3	87.78	87.78
36	0.425	5.32	82.46	82.46
52	0.3	10.15	72.31	72.31
72	0.212	7.23	65.08	65.08
100	0.15	2.99	62.09	62.09
200	0.075	5.27	56.82	56.82



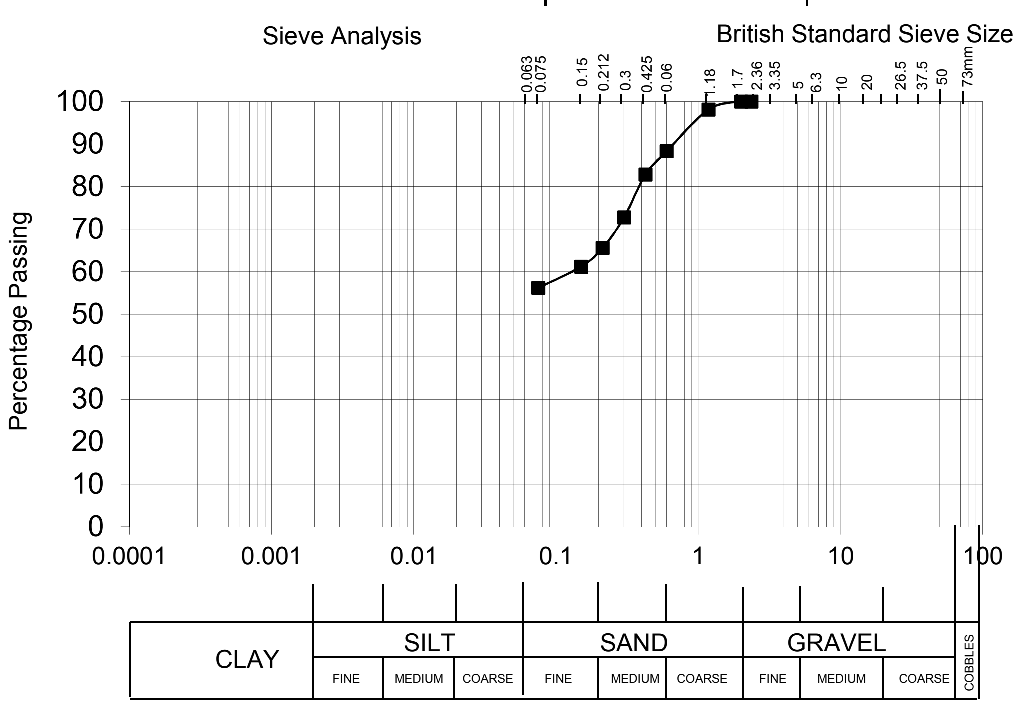
UNIBEN GEOTECH RESEARCH
GRAIN SIZE ANALYSIS BY WET-SIEVING

SITE: **… OKOMU** **JOB:.............**

LOCATION: CLARIFICATION STATION, BH3. DATE**: 08-06--2018**………

DEPTH: **……. 14.5m……** TESTED BY:……**WET SIEVE**………

SIEVE NO.				
APPROX IMPERIAL EQUIV (Seive No.)	BRITISH STANDARD SIEVE SIZES (mm)	RETAINED IN gm	PASSING IN gm	PASSING IN (%)
3	75			
2 ½				
2	50			
1 ½	37.5			
1	26.5			
¾	20			
½	14			
⅜	10			
¼	6.3			
3/16	5			
⅛	3.35		100	100
7	2.36		100	100
10	2		100	100
14	1.18	1.87	98.13	98.13
25	0.6	9.81	88.32	88.32
36	0.425	5.49	83	83
52	0.3	10.11	72.72	72.72
72	0.212	7.13	65.59	65.59
100	0.15	4.38	61.21	61.21
200	0.075	5	56.21	56.21



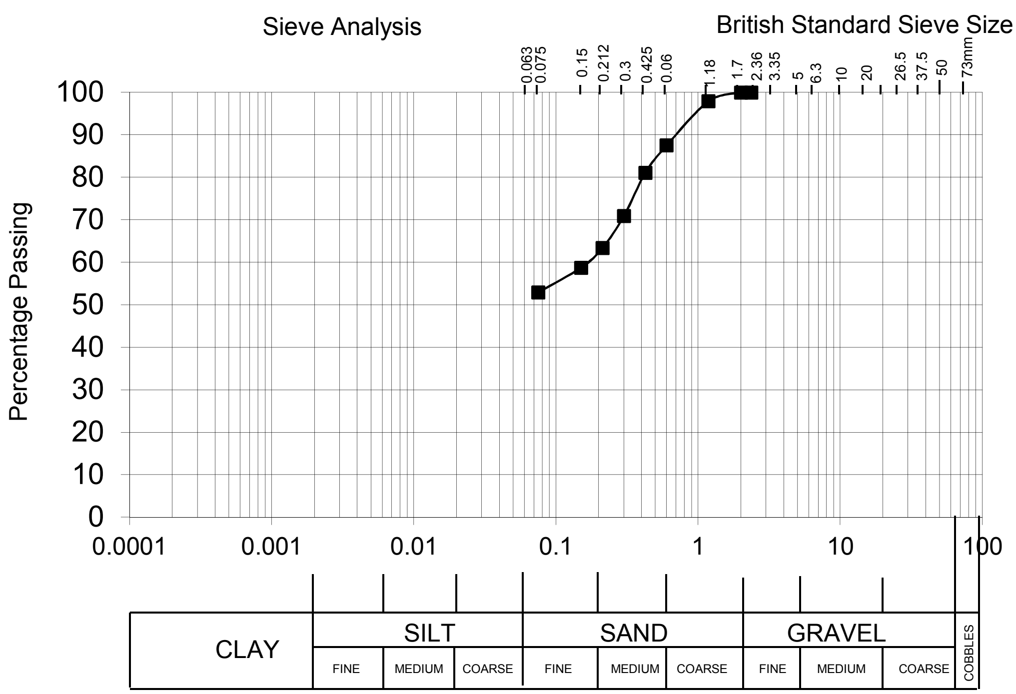
UNIBEN GEOTECH RESEARCH
GRAIN SIZE ANALYSIS BY WET-SIEVING

SITE: **… OKOMU** **JOB:.............**

LOCATION: ...STERILIZER , BH4. DATE**: 08-06--2018**………

DEPTH: **……. 15.0m……** TESTED BY:……**WET SIEVE**………

SIEVE NO.				
APPROX IMPERIAL EQUIV (Seive No)	BRITISH STANDARD SIEVE SIZES (mm)	RETAINED IN gm	PASSING IN gm	PASSING IN (%)
3	75			
2 ½				
2	50			
1 ½	37.5			
1	26.5			
¾	20			
½	14			
⅜	10			
¼	6.3			
3/16	5			
⅛	3.35		100	100
7	2.36	0.06	99.94	99.94
10	2	0.07	99.87	99.87
14	1.18	2.03	97.84	97.84
25	0.6	10.36	87.48	87.48
36	0.425	6.42	81.06	81.06
52	0.3	10.19	70.87	70.87
72	0.212	7.49	63.38	63.38
100	0.15	4.65	58.73	58.73
200	0.075	5.79	52.94	52.94



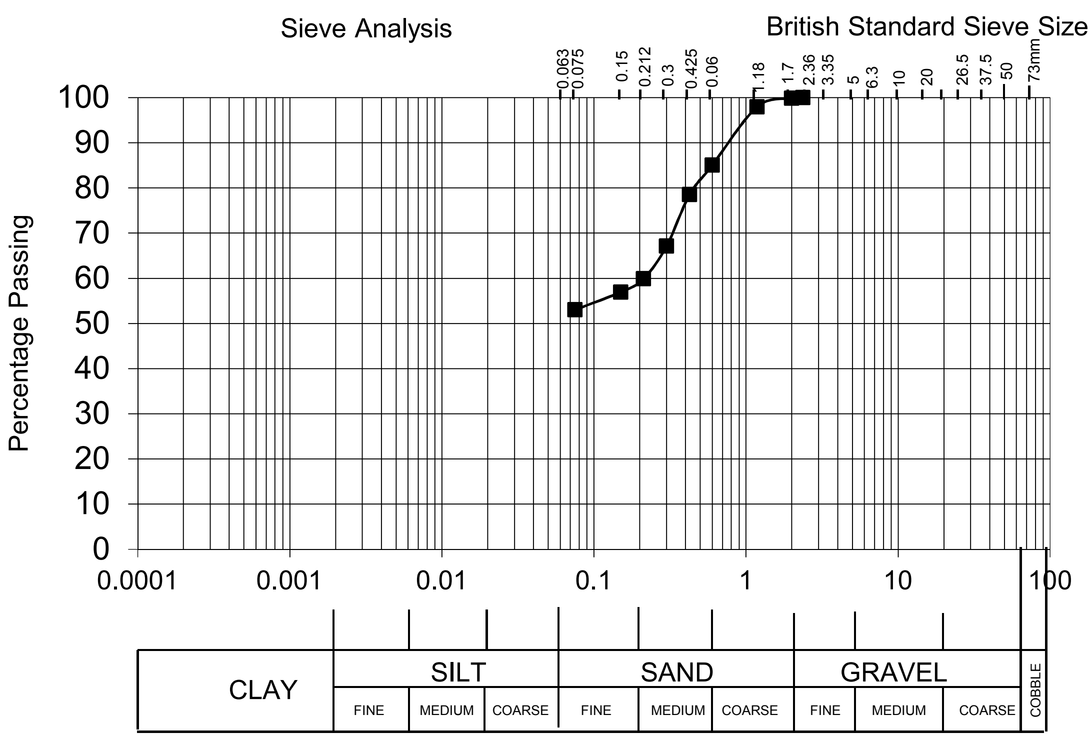
UNIBEN GEOTECH RESEARCH
GRAIN SIZE ANALYSIS BY WET-SIEVING

SITE: … **OKOMU** **JOB:............**

LOCATION: ...STERILIZER , BH4. DATE**: 08-06--2018**………

DEPTH: **……. 3.5m……** TESTED BY:……**WET SIEVE**………

SIEVE NO.				
APPROX IMPERIAL EQUIV (Seive No.)	BRITISH STANDARD SIEVE SIZES (mm)	RETAINED IN gm	PASSING IN gm	PASSING IN (%)
3	75			
2 ½				
2	50			
1 ½	37.5			
1	26.5			
¾	20			
½	14			
⅜	10			
¼	6.3			
3/16	5			
⅛	3.35		100	100
7	2.36		100	100
10	2	0.14	99.86	99.86
14	1.18	1.92	97.94	97.94
25	0.6	12.9	85.04	85.04
36	0.425	6.54	78.50	78.50
52	0.3	11.39	67.11	67.11
72	0.212	7.22	59.89	59.89
100	0.15	2.97	56.92	56.92
200	0.075	3.9	53.02	53.02



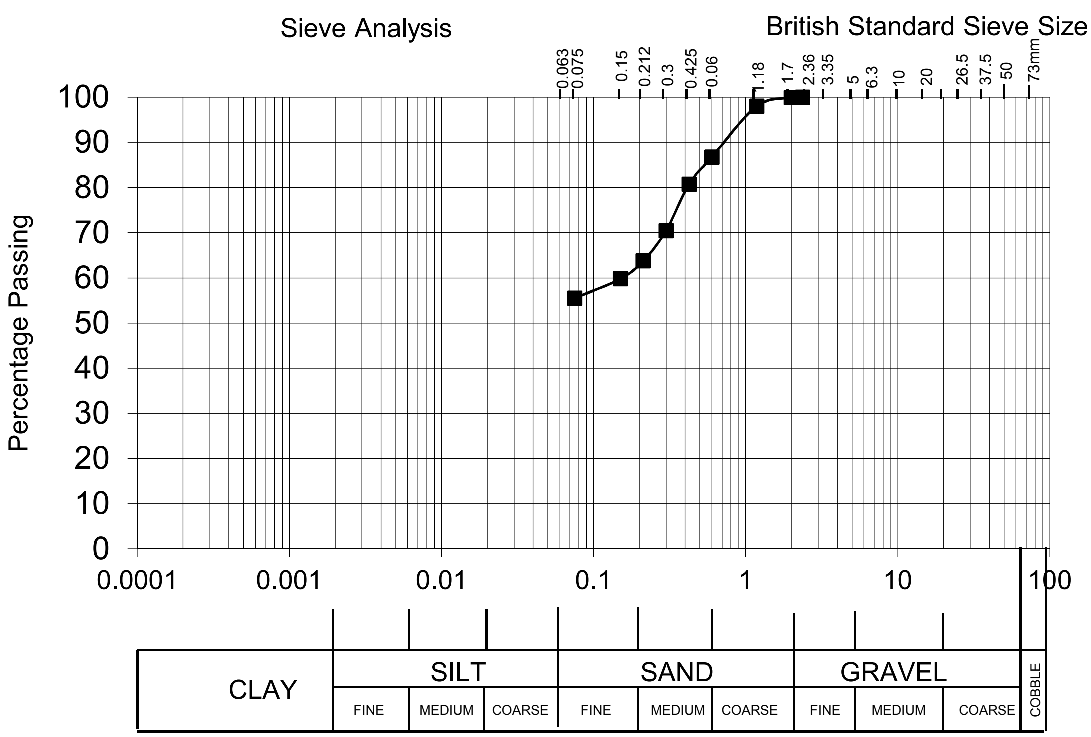
UNIBEN GEOTECH RESEARCH
GRAIN SIZE ANALYSIS BY WET-SIEVING

SITE: ... **OKOMU** **JOB:............**

LOCATION: ...STERILIZER , BH4. DATE**: 08-06--2018**.........

DEPTH: **....... 6.5m......** TESTED BY:......**WET SIEVE**.........

SIEVE NO.				
APPROX IMPERIAL EQUIV (Seive No.)	BRITISH STANDARD SIEVE SIZES (mm)	RETAINED IN gm	PASSING IN gm	PASSING IN (%)
3	75			
2 ½				
2	50			
1 ½	37.5			
1	26.5			
¾	20			
½	14			
⅜	10			
¼	6.3			
3/16	5			
⅛	3.35		100	100
7	2.36		100	100
10	2	0.09	99.91	99.91
14	1.18	1.92	97.99	97.99
25	0.6	11.23	86.76	86.76
36	0.425	6.02	80.74	80.74
52	0.3	10.27	70.47	70.47
72	0.212	6.71	63.76	63.76
100	0.15	3.96	59.8	59.8
200	0.075	4.31	55.49	55.49



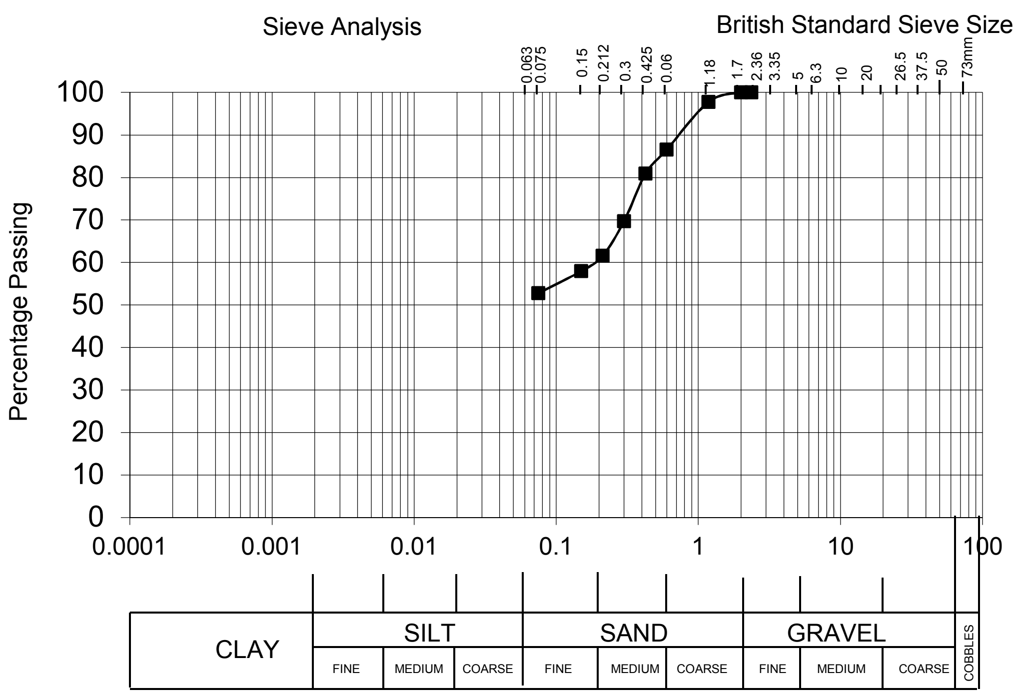
UNIBEN GEOTECH RESEARCH
GRAIN SIZE ANALYSIS BY WET-SIEVING

SITE: **… OKOMU** **JOB:………….**

LOCATION: ...STERILIZER , BH4. DATE**: 08-06--2018**………

DEPTH: **……. 9.5m……** TESTED BY:……**WET SIEVE**………

SIEVE NO.				
APPROX IMPERIAL EQUIV (Seive No.)	BRITISH STANDARD SIEVE SIZES (mm)	RETAINED IN gm	PASSING IN gm	PASSING IN (%)
3	75			
2 ½				
2	50			
1 ½	37.5			
1	26.5			
¾	20			
½	14			
⅜	10			
¼	6.3			
3/16	5			
⅛	3.35		100	100
7	2.36		100	100
10	2		100	100
14	1.18	2.26	97.74	97.74
25	0.6	11.19	86.55	86.55
36	0.425	5.7	80.85	80.85
52	0.3	11.16	69.69	69.69
72	0.212	8.13	61.56	61.56
100	0.15	3.6	57.96	57.96
200	0.075	5.19	52.77	52.77



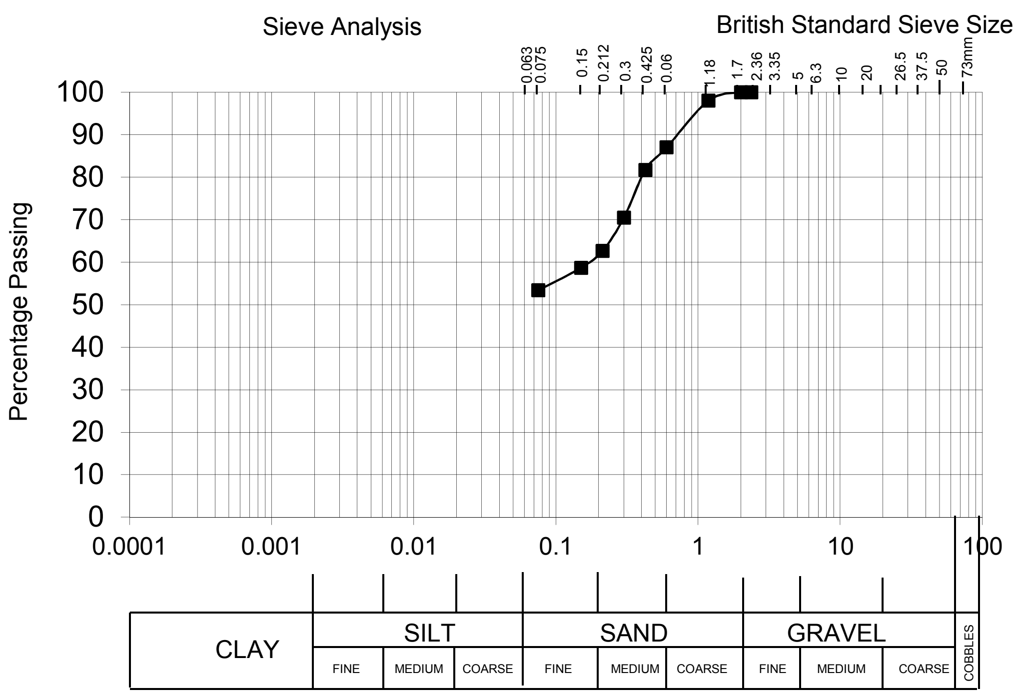
UNIBEN GEOTECH RESEARCH
GRAIN SIZE ANALYSIS BY WET-SIEVING

SITE: **… OKOMU** **JOB:………….**

LOCATION: ...STERILIZER , BH4. DATE**: 08-06--2018**………

DEPTH: **……. 12.5m……** TESTED BY:……**WET SIEVE**………

SIEVE NO.				
APPROX IMPERIAL EQUIV (Seive No.)	BRITISH STANDARD SIEVE SIZES (mm)	RETAINED IN gm	PASSING IN gm	PASSING IN (%)
3	75			
2 ½				
2	50			
1 ½	37.5			
1	26.5			
¾	20			
½	14			
⅜	10			
¼	6.3			
3/16	5			
⅛	3.35		100	100
7	2.36		100	100
10	2		100	100
14	1.18	1.98	98.02	98.02
25	0.6	11	87.02	87.02
36	0.425	5.31	81.71	81.71
52	0.3	11.24	70.47	70.47
72	0.212	7.79	62.68	62.68
100	0.15	3.96	58.72	58.72
200	0.075	5.29	53.43	53.43



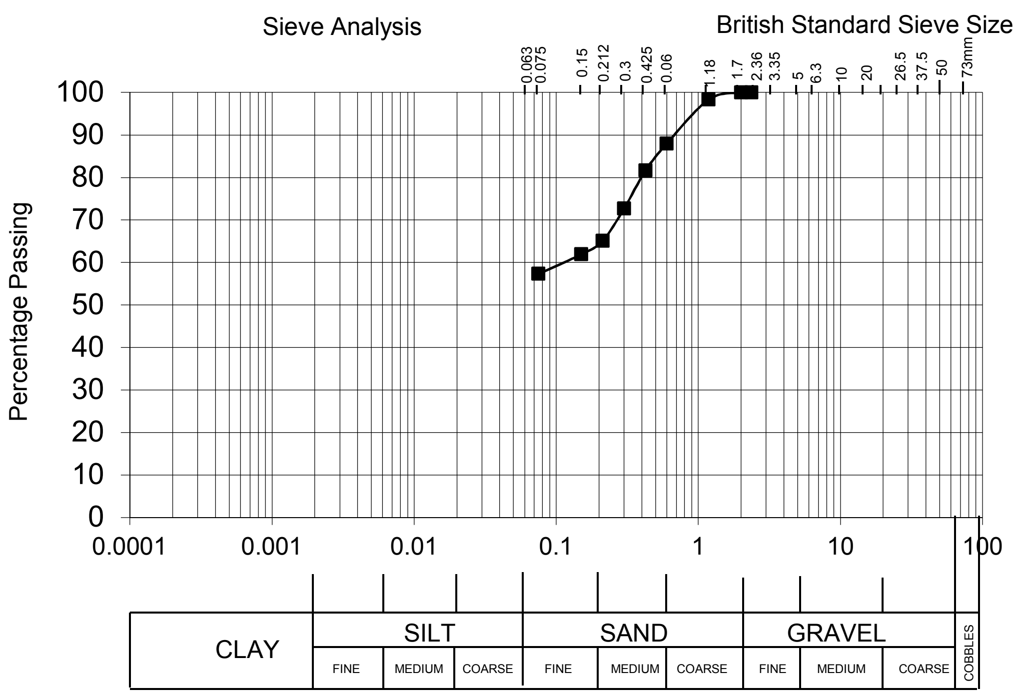
UNIBEN GEOTECH RESEARCH
GRAIN SIZE ANALYSIS BY WET-SIEVING

SITE: **… OKOMU** **JOB:............**

LOCATION: ...STERILIZER , BH4. DATE**: 08-06--2018**………

DEPTH: **……. 15.0m……** TESTED BY:……**WET SIEVE**………

SIEVE NO.				
APPROX IMPERIAL EQUIV (inches)	BRITISH STANDARD SIEVE SIZES (mm)	RETAINED IN gm	PASSING IN gm	PASSING IN (%)
3	75			
2 ½				
2	50			
1 ½	37.5			
1	26.5			
¾	20			
½	14			
⅜	10			
¼	6.3			
3/16	5			
⅛	3.35		100	100
7	2.36		100	100
10	2		100	100
14	1.18	1.71	98.29	98.29
25	0.6	10.32	87.97	87.97
36	0.425	6.36	81.61	81.61
52	0.3	8.95	72.66	72.66
72	0.212	7.58	65.08	65.08
100	0.15	3.18	61.9	61.9
200	0.075	4.59	57.31	57.31



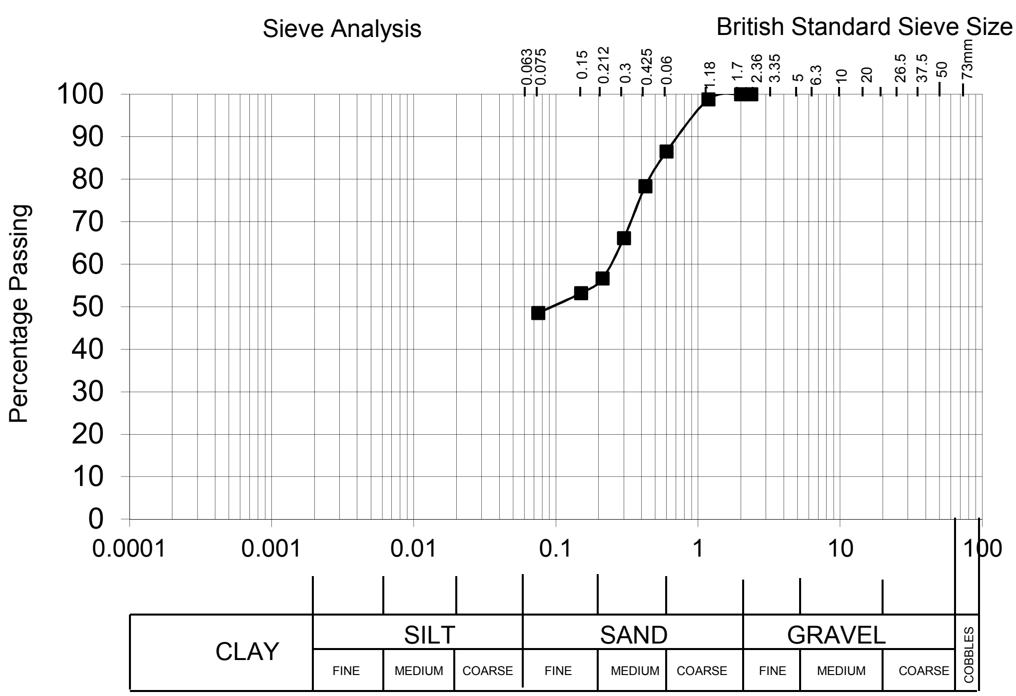
UNIBEN GEOTECH RESEARCH
GRAIN SIZE ANALYSIS BY WET-SIEVING

SITE: **… OKOMU** **JOB:.............**

LOCATION: .....PRESSING STATION , BH5. DATE**: 08-06--2018**………

DEPTH: **……. 1.5m……** TESTED BY:……**WET SIEVE**………

SIEVE NO.				
APPROX IMPERIAL EQUIV (Seive No.)	BRITISH STANDARD SIEVE SIZES (mm)	RETAINED IN gm	PASSING IN gm	PASSING IN (%)
3	75			
2 ½				
2	50			
1 ½	37.5			
1	26.5			
¾	20			
½	14			
⅜	10			
¼	6.3			
3/16	5			
⅛	3.35		100	100
7	2.36		100	100
10	2		100	100
14	1.18	1.22	98.78	98.78
25	0.6	12.27	86.51	86.51
36	0.425	8.17	78.34	78.34
52	0.3	12.19	66.15	66.15
72	0.212	9.52	56.63	56.63
100	0.15	3.39	53.24	53.24
200	0.075	4.67	48.57	48.57



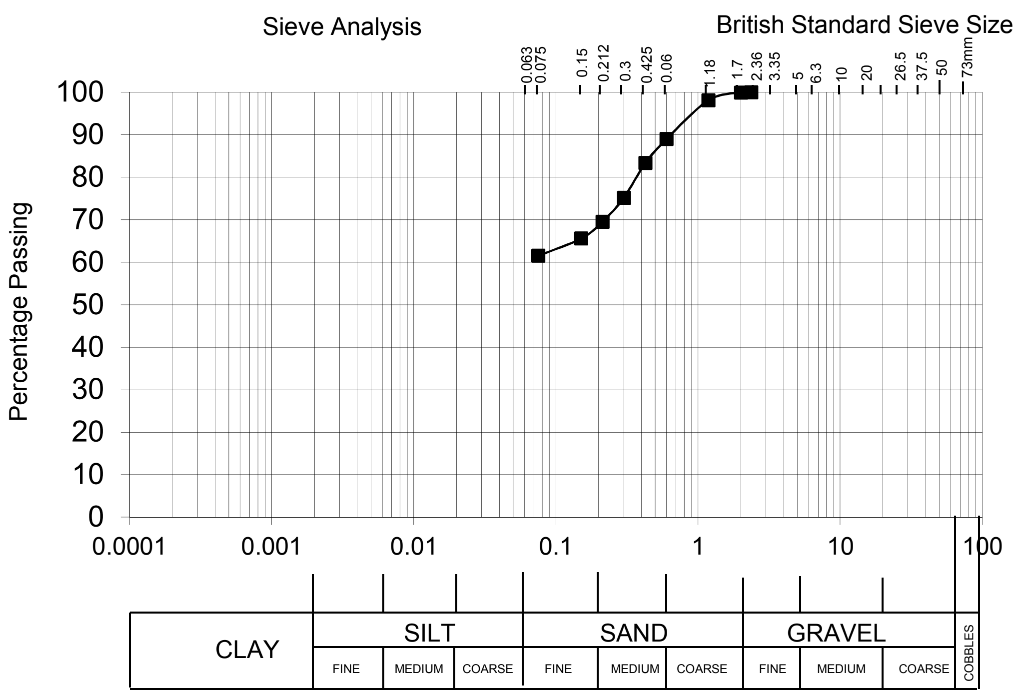
UNIBEN GEOTECH RESEARCH
GRAIN SIZE ANALYSIS BY WET-SIEVING

SITE: **… OKOMU** **JOB:………….**

LOCATION: …..PRESSING STATION , BH5. DATE**: 08-06--2018**………

DEPTH: **……. 4.5m……** TESTED BY:……**WET SIEVE**………

SIEVE NO.				
APPROX IMPERIAL EQUIV (Seive No.)	BRITISH STANDARD SIEVE SIZES (mm)	RETAINED IN gm	PASSING IN gm	PASSING IN (%)
3	75			
2 ½				
2	50			
1 ½	37.5			
1	26.5			
¾	20			
½	14			
⅜	10			
¼	6.3			
3/16	5			
⅛	3.35		100	100
7	2.36		100	100
10	2	0.06	99.94	99.94
14	1.18	1.83	98.11	98.11
25	0.6	9.12	88.99	88.99
36	0.425	5.66	83.33	83.33
52	0.3	8.15	75.18	75.18
72	0.212	5.65	69.53	69.53
100	0.15	3.95	65.58	65.58
200	0.075	4.05	61.53	61.53



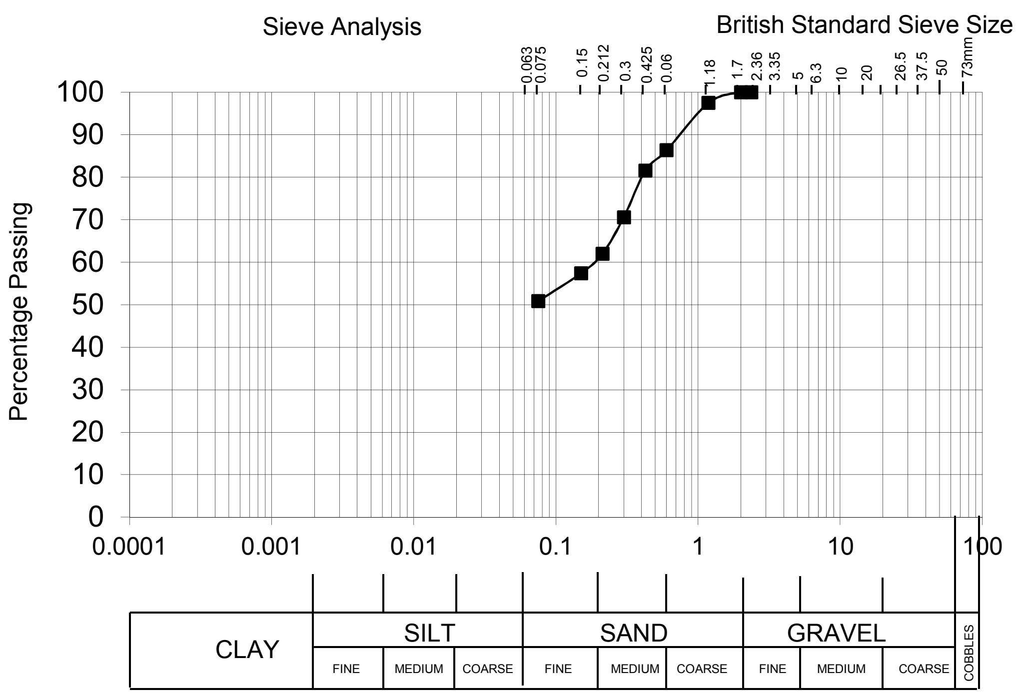
UNIBEN GEOTECH RESEARCH
GRAIN SIZE ANALYSIS BY WET-SIEVING

SITE: **… OKOMU** **JOB:.............**

LOCATION: .....PRESSING STATION , BH5. DATE**: 08-06--2018**………

DEPTH: **……. 7.5m……** TESTED BY:……**WET SIEVE**………

SIEVE NO.				
APPROX IMPERIAL EQUIV (Seive No.)	BRITISH STANDARD SIEVE SIZES (mm)	RETAINED IN gm	PASSING IN gm	PASSING IN (%)
3	75			
2 ½				
2	50			
1 ½	37.5			
1	26.5			
¾	20			
½	14			
⅜	10			
¼	6.3			
3/16	5			
⅛	3.35		100	100
7	2.36		100	100
10	2		100	100
14	1.18	2.52	97.48	97.48
25	0.6	11.14	86.34	86.34
36	0.425	4.78	81.56	81.56
52	0.3	10.95	70.61	70.61
72	0.212	8.62	61.99	61.99
100	0.15	4.55	57.44	57.44
200	0.075	6.58	50.86	50.86



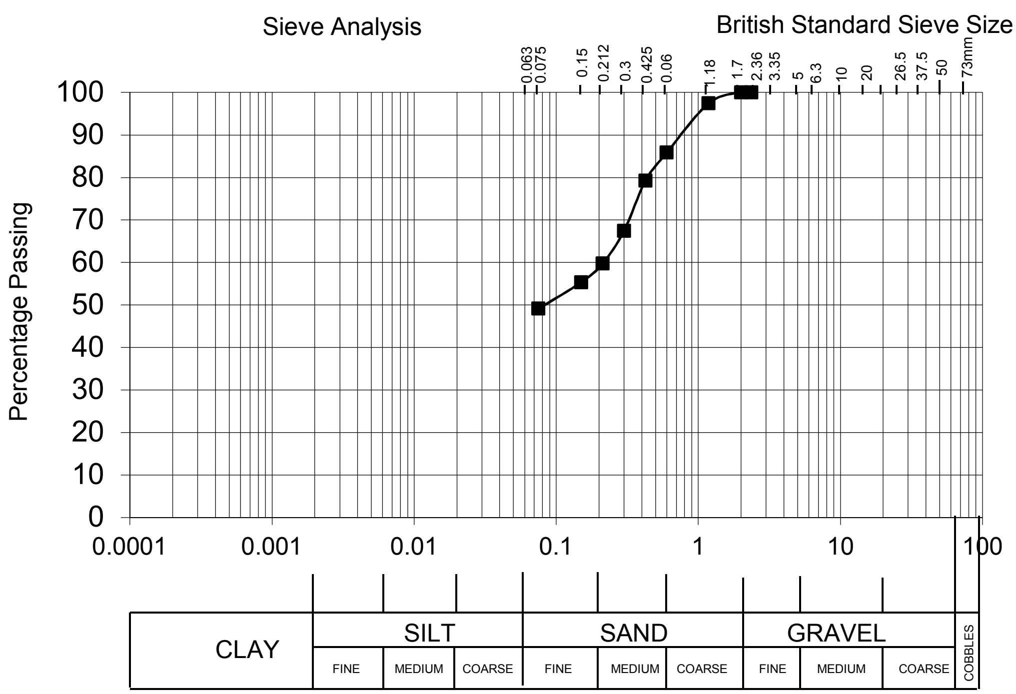
UNIBEN GEOTECH RESEARCH
GRAIN SIZE ANALYSIS BY WET-SIEVING

SITE: **… OKOMU** **JOB:............**

LOCATION: .....PRESSING STATION , BH5. DATE**: 08-06--2018**………

DEPTH: **……. 14.5m……** TESTED BY:……**WET SIEVE**………

SIEVE NO.				
APPROX IMPERIAL EQUIV (Seive No.)	BRITISH STANDARD SIEVE SIZES (mm)	RETAINED IN gm	PASSING IN gm	PASSING IN (%)
3	75			
2 ½				
2	50			
1 ½	37.5			
1	26.5			
¾	20			
½	14			
⅜	10			
¼	6.3			
3/16	5			
⅛	3.35		100	100
7	2.36		100	100
10	2		100	100
14	1.18	2.57	97.43	97.43
25	0.6	11.61	85.82	85.82
36	0.425	6.57	79.25	79.25
52	0.3	11.82	67.43	67.43
72	0.212	7.72	59.71	59.71
100	0.15	4.37	55.34	55.34
200	0.075	6.22	49.12	49.12



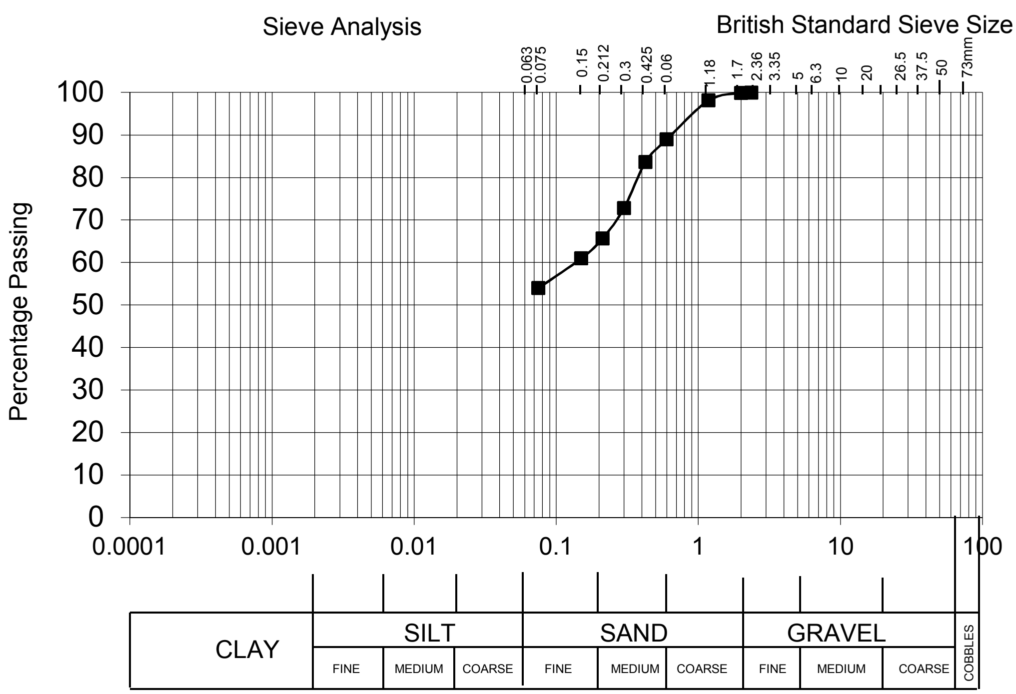
UNIBEN GEOTECH RESEARCH
GRAIN SIZE ANALYSIS BY WET-SIEVING

SITE: **… OKOMU** **JOB:.............**

LOCATION: .....PRESSING STATION , BH5. DATE**: 08-06--2018**………

DEPTH: **……. 10.5m……** TESTED BY:……**WET SIEVE**………

SIEVE NO.				
APPROX IMPERIAL EQUIV (Seive No.)	BRITISH STANDARD SIEVE SIZES (mm)	RETAINED IN gm	PASSING IN gm	PASSING IN (%)
3	75			
2 ½				
2	50			
1 ½	37.5			
1	26.5			
¾	20			
½	14			
⅜	10			
¼	6.3			
3/16	5			
⅛	3.35		100	100
7	2.36	0.08	99.92	99.92
10	2	0.06	99.86	99.86
14	1.18	1.78	98.08	98.08
25	0.6	9.15	88.93	88.93
36	0.425	5.31	83.62	83.62
52	0.3	10.85	72.77	72.77
72	0.212	7.12	65.65	65.65
100	0.15	4.72	60.93	60.93
200	0.075	6.96	53.97	53.97



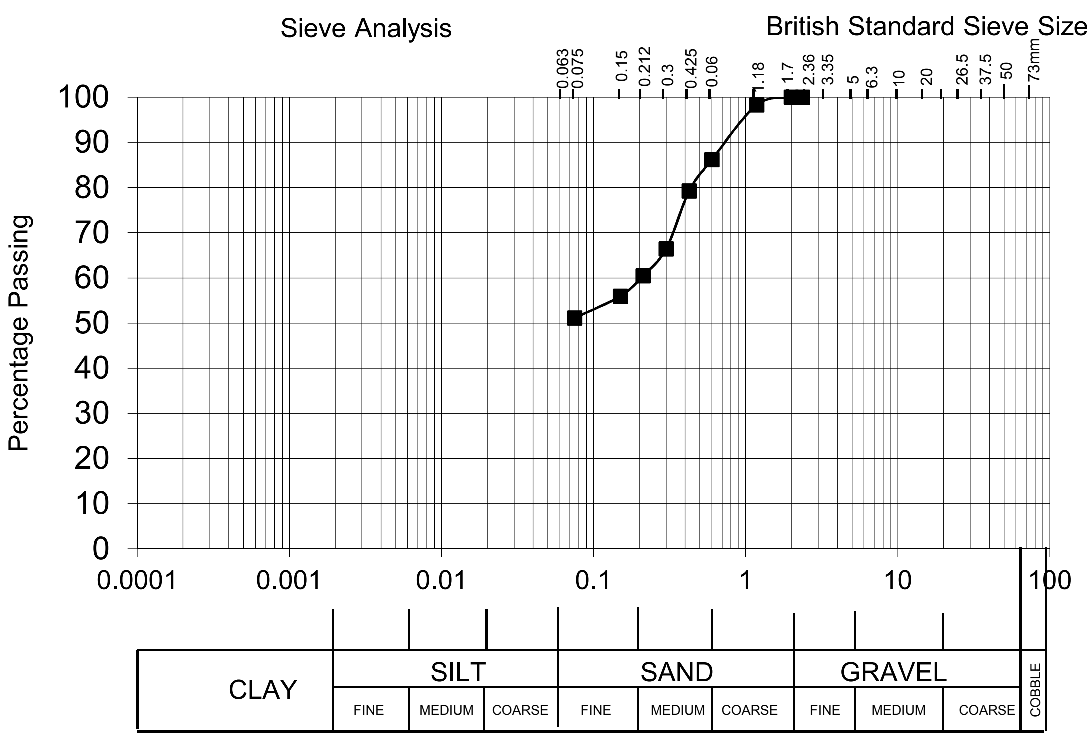
UNIBEN GEOTECH RESEARCH
GRAIN SIZE ANALYSIS BY WET-SIEVING

SITE: … **OKOMU** **JOB:............**

LOCATION: .....STORAGE TANK , BH6. DATE**: 08-06--2018**………

DEPTH: **……. 1.0m……** TESTED BY:……**WET SIEVE**………

SIEVE NO.				
APPROX IMPERIAL EQUIV (Seive No.)	BRITISH STANDARD SIEVE SIZES (mm)	RETAINED IN gm	PASSING IN gm	PASSING IN (%)
3	75			
2 ½				
2	50			
1 ½	37.5			
1	26.5			
¾	20			
½	14			
⅜	10			
¼	6.3			
3/16	5			
⅛	3.35		100	100
7	2.36		100	100
10	2		100	100
14	1.18	1.72	98.28	98.28
25	0.6	12.1	86.18	86.18
36	0.425	6.95	79.23	79.23
52	0.3	12.79	66.44	66.44
72	0.212	5.95	60.49	60.49
100	0.15	4.54	55.95	55.95
200	0.075	4.84	51.11	51.11



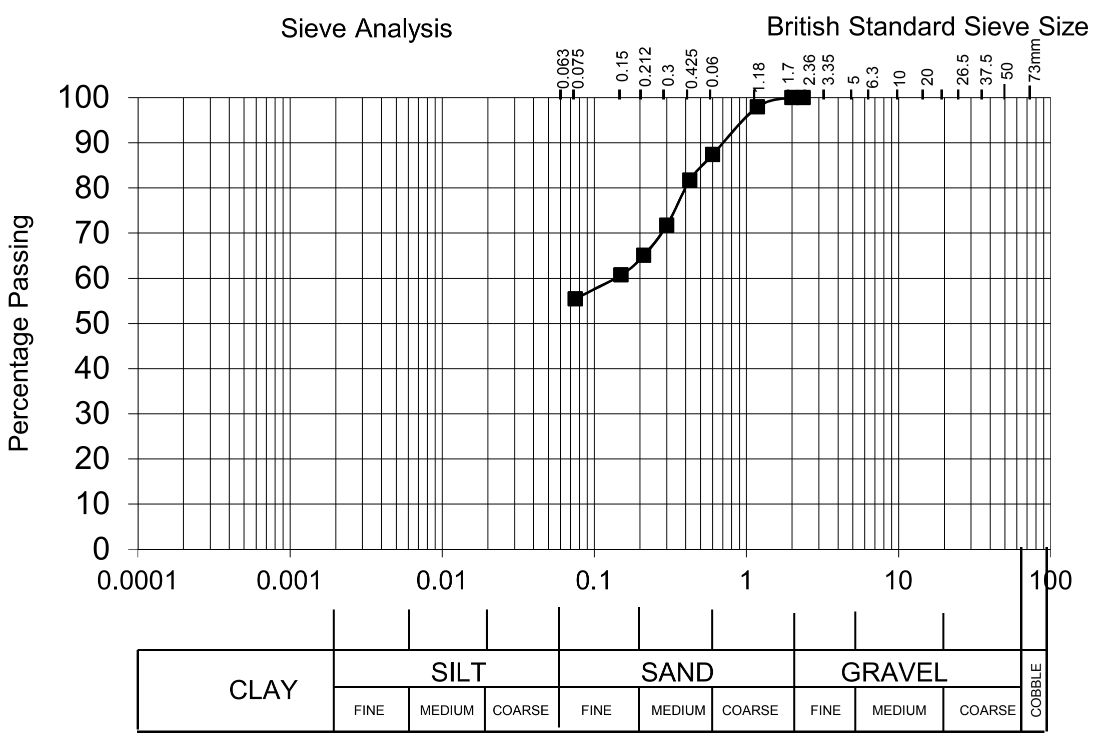
UNIBEN GEOTECH RESEARCH
GRAIN SIZE ANALYSIS BY WET-SIEVING

SITE: ... **OKOMU** **JOB:............**

LOCATION: .....STORAGE TANK , BH6. DATE**: 08-06--2018**………

DEPTH: **……. 4.0m……** TESTED BY:……**WET SIEVE**………

SIEVE NO.				
APPROX IMPERIAL EQUIV (Seive No.)	BRITISH STANDARD SIEVE SIZES (mm)	RETAINED IN gm	PASSING IN gm	PASSING IN (%)
3	75			
2 ½				
2	50			
1 ½	37.5			
1	26.5			
¾	20			
½	14			
⅜	10			
¼	6.3			
3/16	5			
⅛	3.35		100	100
7	2.36		100	100
10	2		100	100
14	1.18	2.09	97.91	97.91
25	0.6	10.55	87.36	87.36
36	0.425	5.67	81.69	81.69
52	0.3	9.94	71.75	71.75
72	0.212	6.66	65.09	65.09
100	0.15	4.34	60.75	60.75
200	0.075	5.3	55.45	55.45



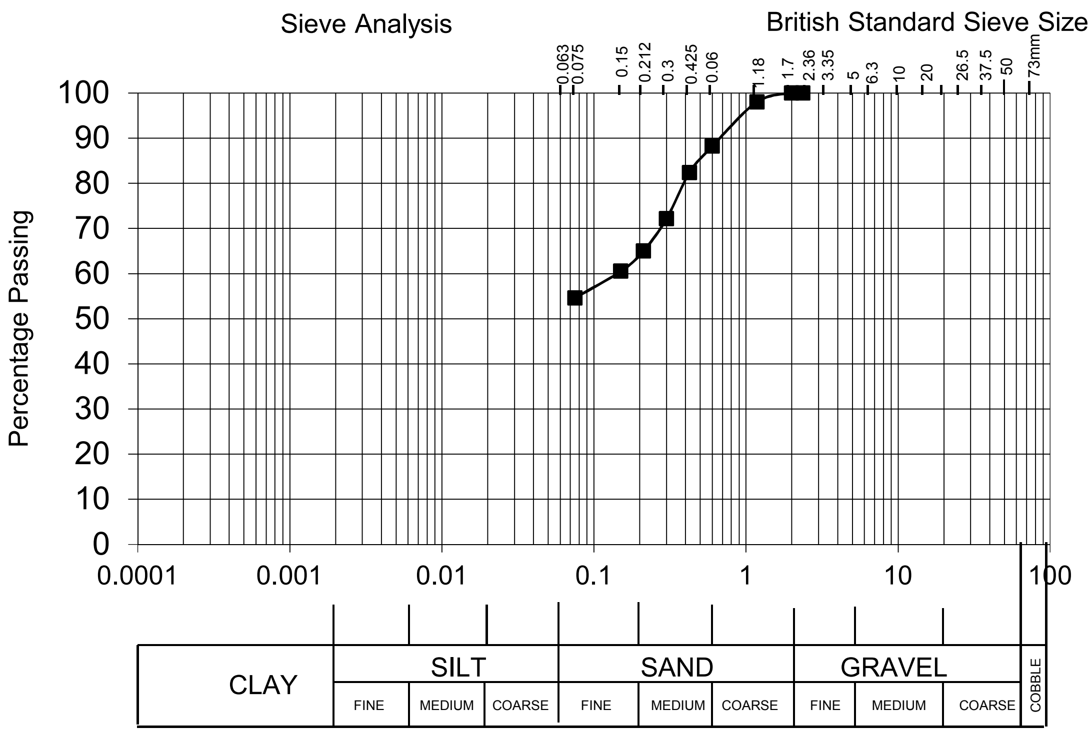
UNIBEN GEOTECH RESEARCH
GRAIN SIZE ANALYSIS BY WET-SIEVING

SITE: … **OKOMU** **JOB:............**

LOCATION: .....STORAGE TANK , BH6. DATE**: 08-06--2018**………

DEPTH: **……. 7.0m……** TESTED BY:……**WET SIEVE**………

SIEVE NO.				
APPROX IMPERIAL EQUIV (Seive No.)	BRITISH STANDARD SIEVE SIZES (mm)	RETAINED IN gm	PASSING IN gm	PASSING IN (%)
3	75			
2 ½				
2	50			
1 ½	37.5			
1	26.5			
¾	20			
½	14			
⅜	10			
¼	6.3			
3/16	5			
⅛	3.35		100	100
7	2.36		100	100
10	2		100	100
14	1.18	1.97	98.03	98.03
25	0.6	9.79	88.24	88.24
36	0.425	5.85	82.39	82.39
52	0.3	10.21	72.18	72.18
72	0.212	7.16	65.02	65.02
100	0.15	4.52	60.5	60.5
200	0.075	5.89	54.61	54.61



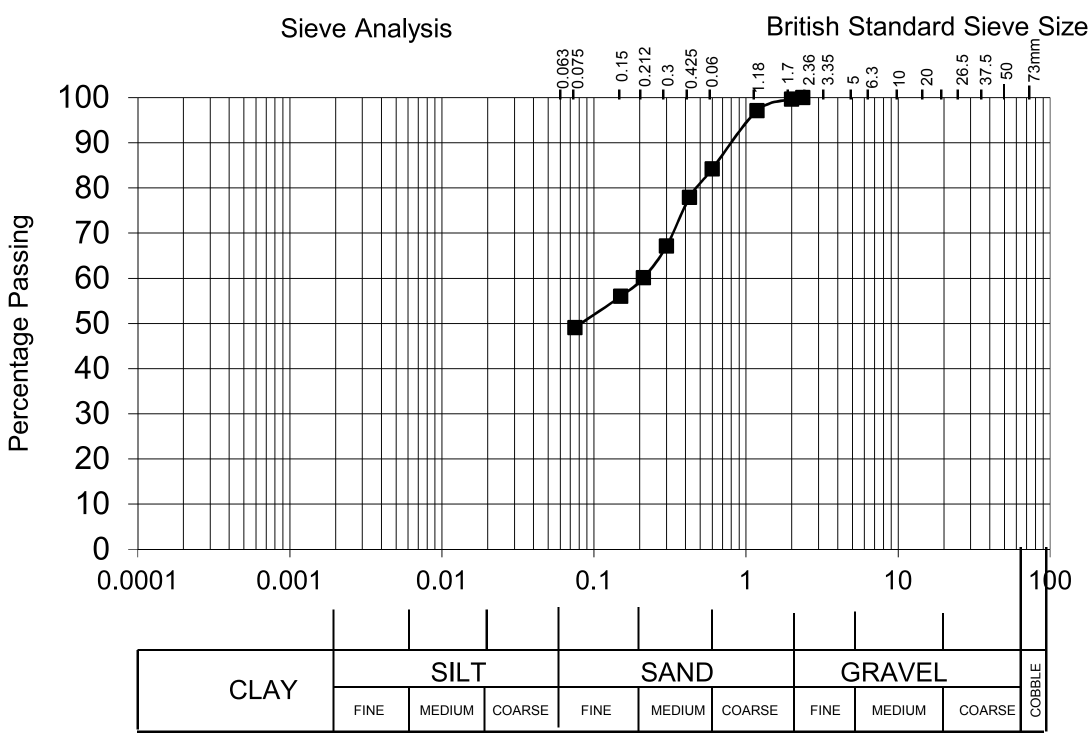
UNIBEN GEOTECH RESEARCH
GRAIN SIZE ANALYSIS BY WET-SIEVING

SITE: ... **OKOMU** JOB:.............

LOCATION: .....STORAGE TANK , BH6. DATE: **08-06--2018**.........

DEPTH: **....... 10.0m......** TESTED BY:......**WET SIEVE**.........

SIEVE NO.				
APPROX IMPERIAL EQUIV (Seive No.)	BRITISH STANDARD SIEVE SIZES (mm)	RETAINED IN gm	PASSING IN gm	PASSING IN (%)
3	75			
2 ½				
2	50			
1 ½	37.5			
1	26.5			
¾	20			
½	14			
⅜	10			
¼	6.3			
3/16	5			
⅛	3.35		100	100
7	2.36		100	100
10	2	0.36	99.64	99.64
14	1.18	2.56	97.08	97.08
25	0.6	12.85	84.23	84.23
36	0.425	6.32	77.91	77.91
52	0.3	10.78	67.13	67.13
72	0.212	7.02	60.11	60.11
100	0.15	4.1	56.01	56.01
200	0.075	6.94	49.07	49.07



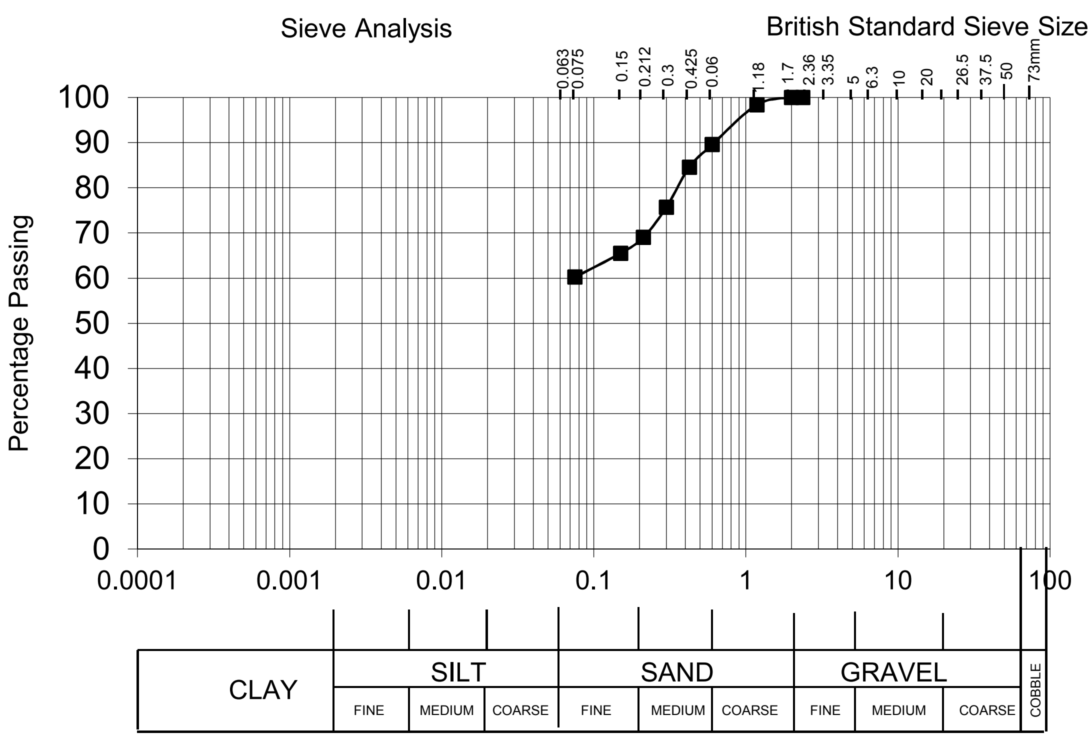
UNIBEN GEOTECH RESEARCH
GRAIN SIZE ANALYSIS BY WET-SIEVING

SITE: ... **OKOMU** **JOB:............**

LOCATION: .....STORAGE TANK , BH6. DATE**: 08-06--2018**.........

DEPTH: **....... 13.0m......** TESTED BY:......**WET SIEVE**.........

SIEVE NO.				
APPROX IMPERIAL EQUIV (Seive No.)	BRITISH STANDARD SIEVE SIZES (mm)	RETAINED IN gm	PASSING IN gm	PASSING IN (%)
3	75			
2 ½				
2	50			
1 ½	37.5			
1	26.5			
¾	20			
½	14			
⅜	10			
¼	6.3			
3/16	5			
⅛	3.35		100	100
7	2.36		100	100
10	2		100	100
14	1.18	1.62	98.38	98.38
25	0.6	8.82	89.56	89.56
36	0.425	5.02	84.54	84.54
52	0.3	8.87	75.67	75.67
72	0.212	6.62	69.05	69.05
100	0.15	3.54	65.51	65.51
200	0.075	5.29	60.22	60.22



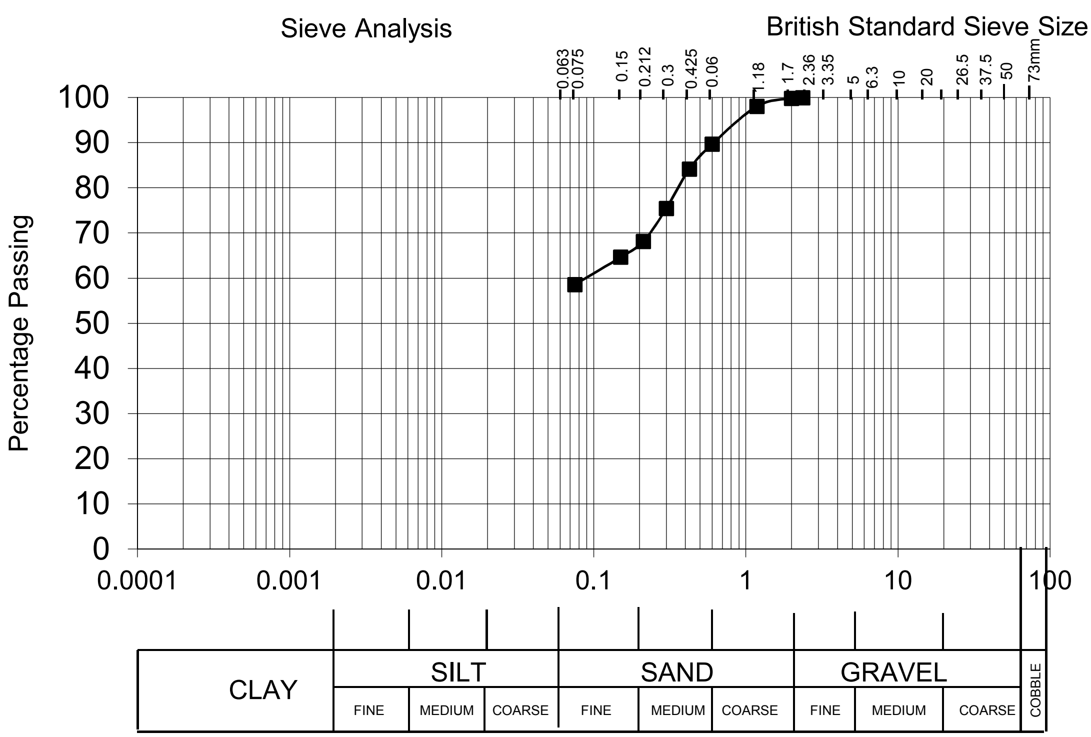
UNIBEN GEOTECH RESEARCH
GRAIN SIZE ANALYSIS BY WET-SIEVING

SITE: ... **OKOMU** **JOB:.............**

LOCATION: .....STORAGE TANK , BH6. DATE**: 08-06--2018**.........

DEPTH: **....... 15.0m......** TESTED BY:......**WET SIEVE**.........

SIEVE NO.				
APPROX IMPERIAL EQUIV (Seive No.)	BRITISH STANDARD SIEVE SIZES (mm)	RETAINED IN gm	PASSING IN gm	PASSING IN (%)
3	75			
2 ½				
2	50			
1 ½	37.5			
1	26.5			
¾	20			
½	14			
⅜	10			
¼	6.3			
3/16	5			
⅛	3.35		100	100
7	2.36	0.09	99.91	99.91
10	2	0.1	99.81	99.81
14	1.18	1.76	98.05	98.05
25	0.6	8.39	89.66	89.66
36	0.425	5.55	84.11	84.11
52	0.3	8.67	75.44	75.44
72	0.212	7.29	68.15	68.15
100	0.15	3.53	64.62	64.62
200	0.075	6.06	58.56	58.56



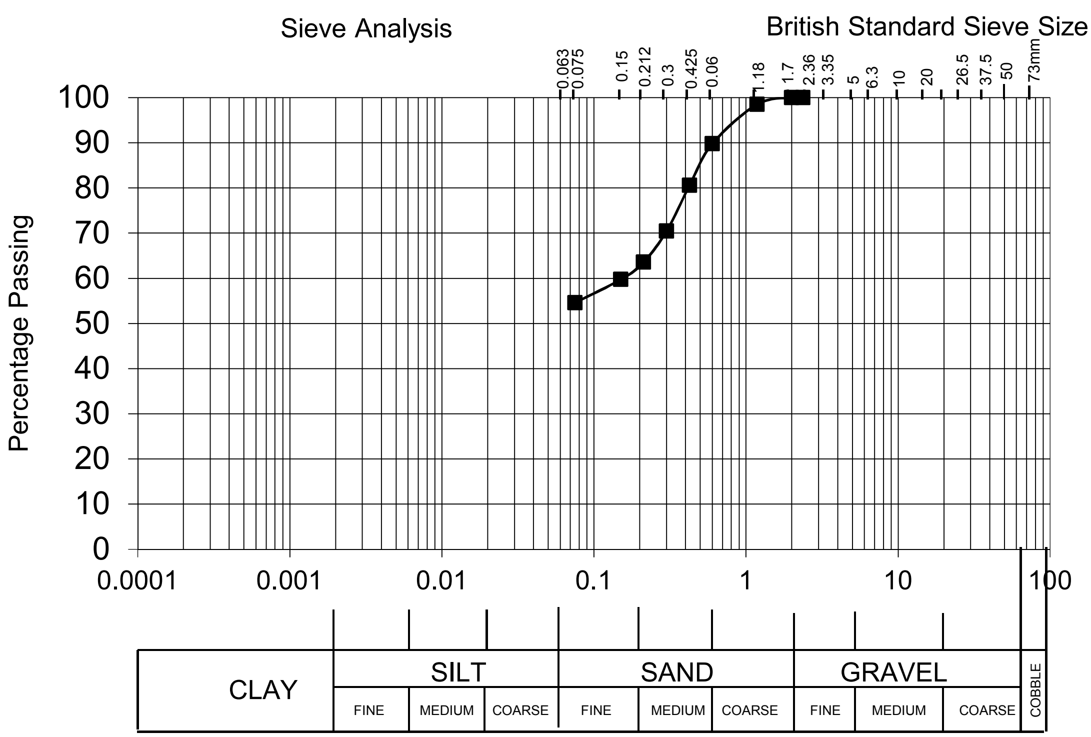
UNIBEN GEOTECH RESEARCH
GRAIN SIZE ANALYSIS BY WET-SIEVING

SITE: ... **OKOMU** **JOB:............**

LOCATION: .....WEIGH BRIDGE , BH7. DATE**: 08-06--2018**.........

DEPTH: **....... 7.0m......** TESTED BY:......**WET SIEVE**.........

SIEVE NO.				
APPROX IMPERIAL EQUIV (Seive No.)	BRITISH STANDARD SIEVE SIZES (mm)	RETAINED IN gm	PASSING IN gm	PASSING IN (%)
3	75			
2 ½				
2	50			
1 ½	37.5			
1	26.5			
¾	20			
½	14			
⅜	10			
¼	6.3			
3/16	5			
⅛	3.35		100	100
7	2.36		100	100
10	2		100	100
14	1.18	1.49	98.51	98.51
25	0.6	8.73	89.78	89.78
36	0.425	9.21	80.57	80.57
52	0.3	10.12	70.45	70.45
72	0.212	6.9	63.55	63.55
100	0.15	3.82	59.73	59.73
200	0.075	5.18	54.55	54.55



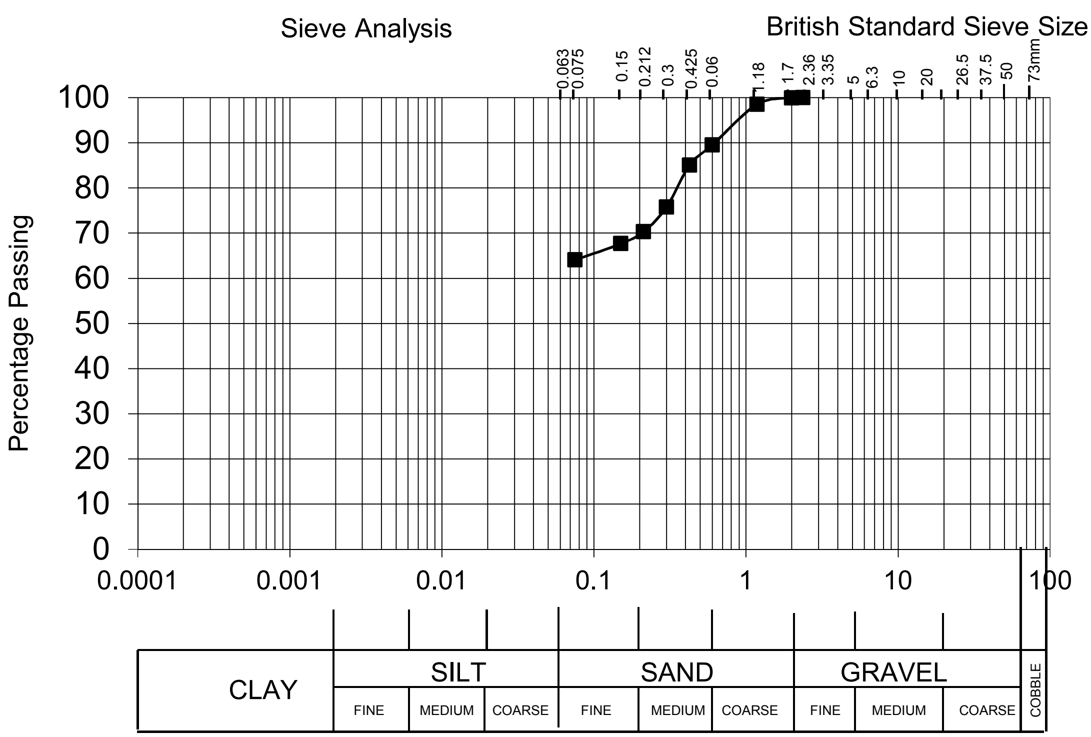
UNIBEN GEOTECH RESEARCH
GRAIN SIZE ANALYSIS BY WET-SIEVING

SITE: ... **OKOMU** **JOB:............**

LOCATION: .....WEIGH BRIDGE , BH7. DATE**: 08-06--2018**.........

DEPTH: **....... 4.0m......** TESTED BY:......**WET SIEVE**.........

SIEVE NO.				
APPROX IMPERIAL EQUIV (Seive No.)	BRITISH STANDARD SIEVE SIZES (mm)	RETAINED IN gm	PASSING IN gm	PASSING IN (%)
3	75			
2 ½				
2	50			
1 ½	37.5			
1	26.5			
¾	20			
½	14			
⅜	10			
¼	6.3			
3/16	5			
⅛	3.35		100	100
7	2.36		100	100
10	2	0.04	99.96	99.96
14	1.18	1.46	98.5	98.5
25	0.6	8.98	89.52	89.52
36	0.425	4.49	85.03	85.03
52	0.3	9.23	75.8	75.8
72	0.212	5.48	70.32	70.32
100	0.15	2.66	67.66	67.66
200	0.075	3.61	64.05	64.05



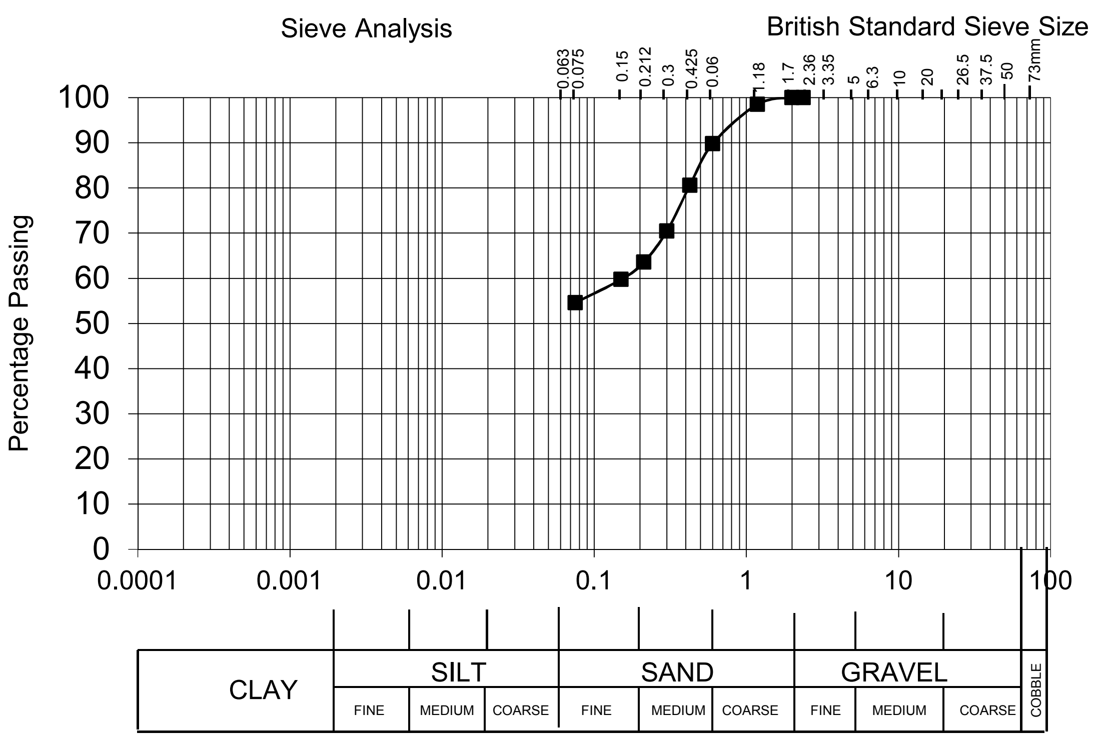
UNIBEN GEOTECH RESEARCH
GRAIN SIZE ANALYSIS BY WET-SIEVING

SITE: … **OKOMU** **JOB:………….**

LOCATION: …..WEIGH BRIDGE , BH7. DATE**: 08-06--2018**………

DEPTH: **……. 7.0m……** TESTED BY:……**WET SIEVE**………

SIEVE NO.				
APPROX IMPERIAL EQUIV (Seive No.)	BRITISH STANDARD SIEVE SIZES (mm)	RETAINED IN gm	PASSING IN gm	PASSING IN (%)
3	75			
2 ½				
2	50			
1 ½	37.5			
1	26.5			
¾	20			
½	14			
⅜	10			
¼	6.3			
3/16	5			
⅛	3.35		100	100
7	2.36		100	100
10	2		100	100
14	1.18	1.49	98.51	98.51
25	0.6	8.73	89.78	89.78
36	0.425	9.21	80.57	80.57
52	0.3	10.12	70.45	70.45
72	0.212	6.9	63.55	63.55
100	0.15	3.82	59.73	59.73
200	0.075	5.18	54.55	54.55



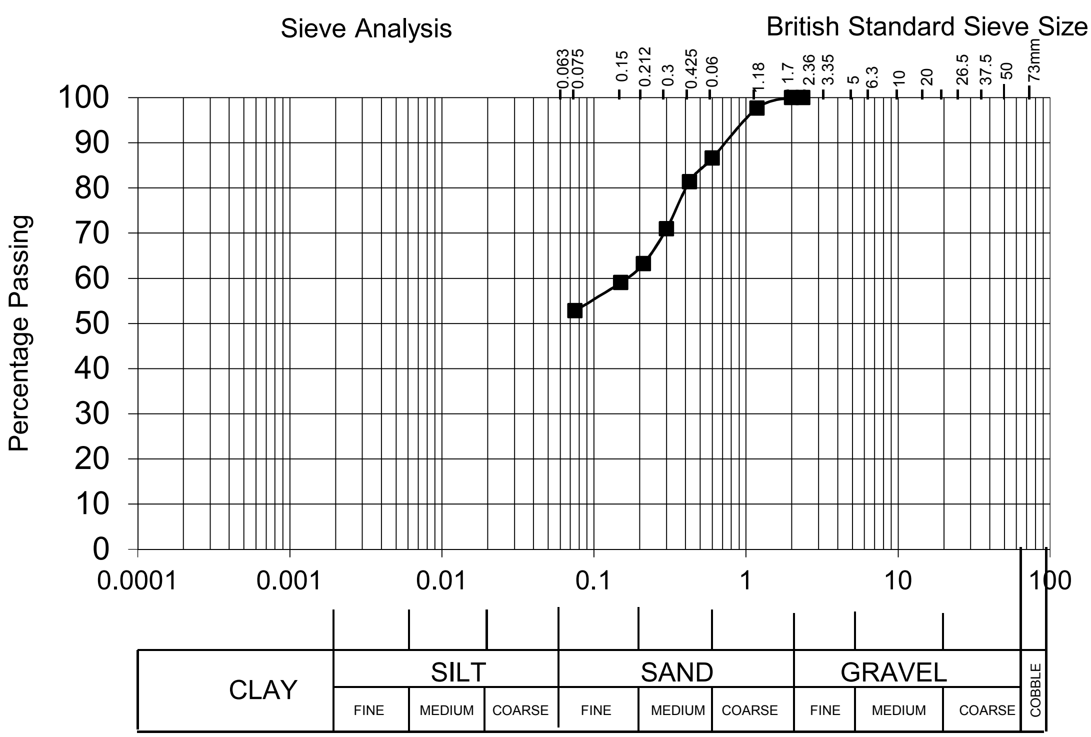
UNIBEN GEOTECH RESEARCH
GRAIN SIZE ANALYSIS BY WET-SIEVING

SITE: … **OKOMU** **JOB:............**

LOCATION: .....WEIGH BRIDGE , BH7. DATE**: 08-06--2018**………

DEPTH: **……. 10.0m……** TESTED BY:……**WET SIEVE**………

SIEVE NO.				
APPROX IMPERIAL EQUIV (Seive No.)	BRITISH STANDARD SIEVE SIZES (mm)	RETAINED IN gm	PASSING IN gm	PASSING IN (%)
3	75			
2 ½				
2	50			
1 ½	37.5			
1	26.5			
¾	20			
½	14			
⅜	10			
¼	6.3			
3/16	5			
⅛	3.35		100	100
7	2.36		100	100
10	2		100	100
14	1.18	2.35	97.65	97.65
25	0.6	11.02	86.63	86.63
36	0.425	5.23	81.40	81.40
52	0.3	10.47	70.93	70.93
72	0.212	7.71	63.22	63.22
100	0.15	4.18	59.04	59.04
200	0.075	6.26	52.78	52.78



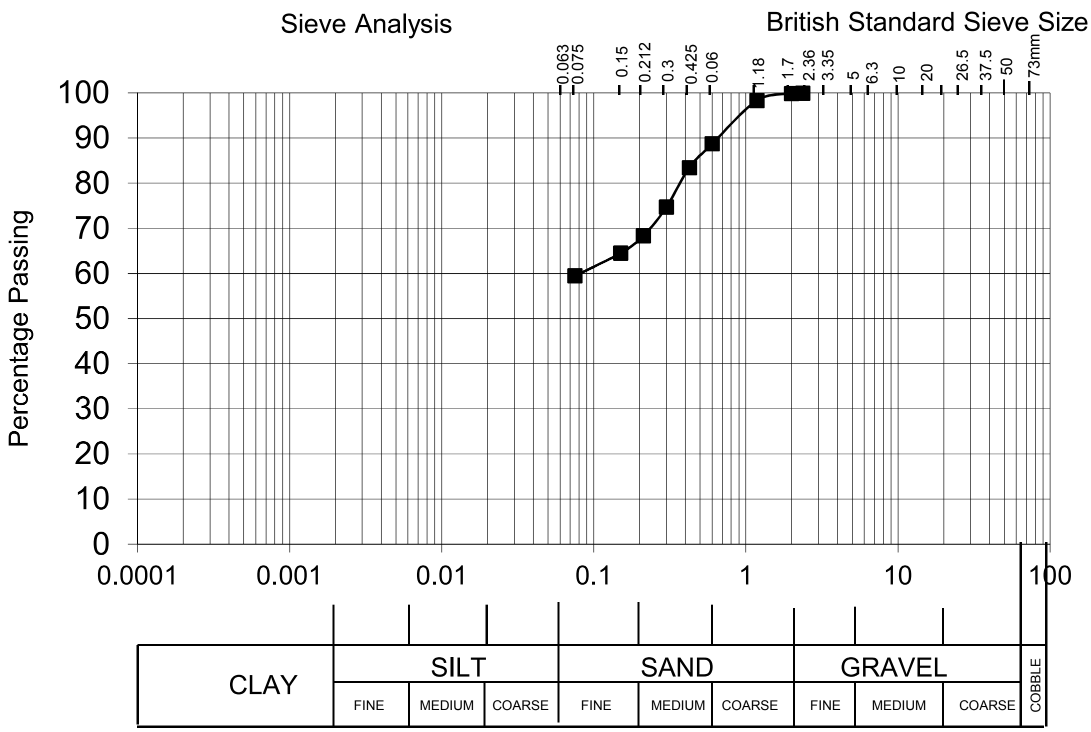
UNIBEN GEOTECH RESEARCH
GRAIN SIZE ANALYSIS BY WET-SIEVING

SITE: … **OKOMU** **JOB:............**

LOCATION: .....WEIGH BRIDGE , BH7. DATE**: 08-06--2018**………

DEPTH: **……. 13.0m……** TESTED BY:……**WET SIEVE**………

SIEVE NO.				
APPROX IMPERIAL EQUIV (Seive No.)	BRITISH STANDARD SIEVE SIZES (mm)	RETAINED IN gm	PASSING IN gm	PASSING IN (%)
3	75			
2 ½				
2	50			
1 ½	37.5			
1	26.5			
¾	20			
½	14			
⅜	10			
¼	6.3			
3/16	5			
⅛	3.35		100	100
7	2.36	0.1	99.9	99.9
10	2	0.05	99.85	99.85
14	1.18	1.56	98.29	98.29
25	0.6	9.59	88.7	88.7
36	0.425	5.26	83.44	83.44
52	0.3	8.76	74.68	74.68
72	0.212	6.34	68.34	68.34
100	0.15	3.86	64.48	64.48
200	0.075	5.03	59.45	59.45



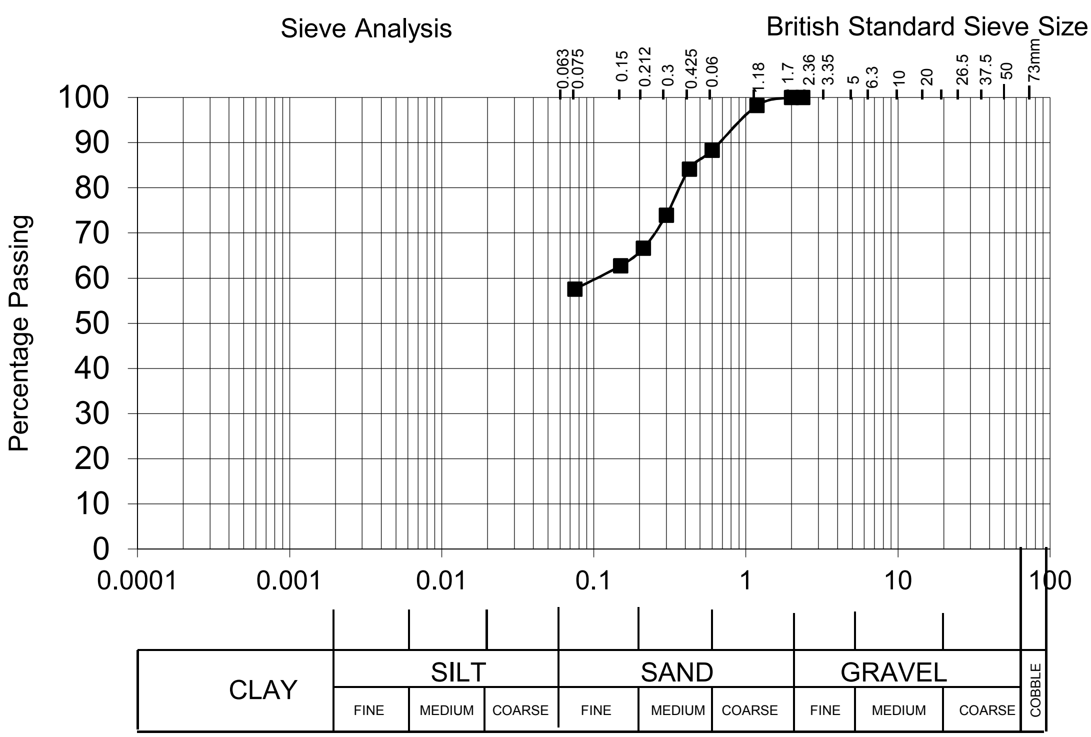
UNIBEN GEOTECH RESEARCH
GRAIN SIZE ANALYSIS BY WET-SIEVING

SITE: … **OKOMU** **JOB:………….**

LOCATION: …..WEIGH BRIDGE , BH7. DATE**: 08-06--2018**………

DEPTH: **……. 15.0m……** TESTED BY:……**WET SIEVE**………

SIEVE NO.				
APPROX IMPERIAL EQUIV (Seive No.)	BRITISH STANDARD SIEVE SIZES (mm)	RETAINED IN gm	PASSING IN gm	PASSING IN (%)
3	75			
2 ½				
2	50			
1 ½	37.5			
1	26.5			
¾	20			
½	14			
⅜	10			
¼	6.3			
3/16	5			
⅛	3.35		100	100
7	2.36		100	100
10	2		100	100
14	1.18	1.8	98.2	98.2
25	0.6	9.9	88.3	88.3
36	0.425	4.18	84.12	84.12
52	0.3	10.16	73.96	73.96
72	0.212	7.35	66.61	66.61
100	0.15	3.86	62.75	62.75
200	0.075	5.2	57.55	57.55



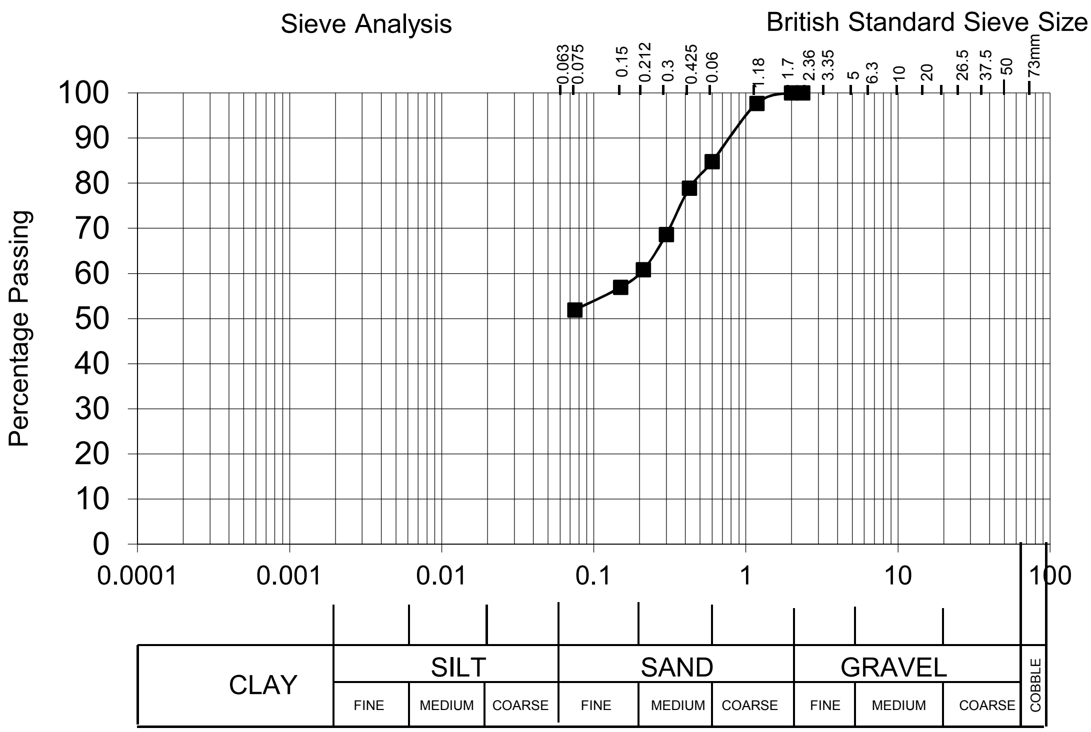
UNIBEN GEOTECH RESEARCH
GRAIN SIZE ANALYSIS BY WET-SIEVING

SITE: ... **OKOMU** **JOB:............**

LOCATION: .....WATER TANK , BH8. DATE**: 08-06--2018**………

DEPTH: **……. 3.0m……** TESTED BY:……**WET SIEVE**………

SIEVE NO.				
APPROX IMPERIAL EQUIV (Seive No.)	BRITISH STANDARD SIEVE SIZES (mm)	RETAINED IN gm	PASSING IN gm	PASSING IN (%)
3	75			
2 ½				
2	50			
1 ½	37.5			
1	26.5			
¾	20			
½	14			
⅜	10			
¼	6.3			
3/16	5			
⅛	3.35		100	100
7	2.36		100	100
10	2		100	100
14	1.18	2.32	97.68	97.68
25	0.6	12.88	84.8	84.8
36	0.425	5.9	78.90	78.90
52	0.3	10.27	68.63	68.63
72	0.212	7.79	60.84	60.84
100	0.15	3.9	56.94	56.94
200	0.075	5.02	51.92	51.92



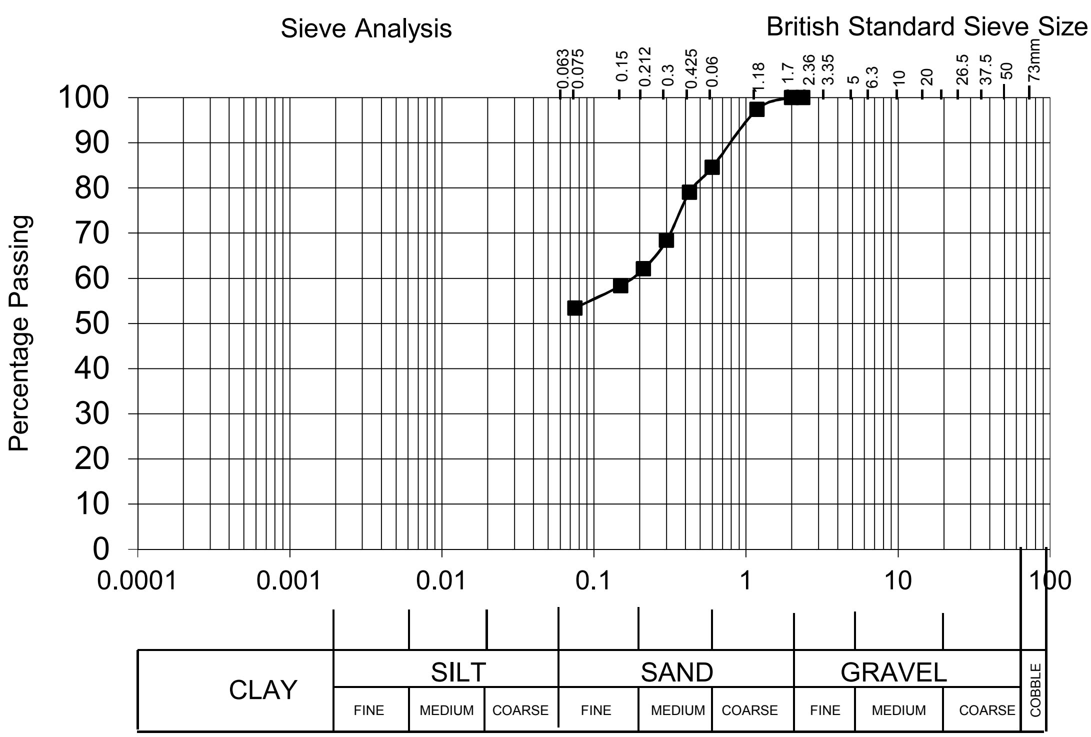
UNIBEN GEOTECH RESEARCH
GRAIN SIZE ANALYSIS BY WET-SIEVING

SITE: ... **OKOMU** **JOB:............**

LOCATION: .....WATER TANK , BH8. DATE**: 08-06--2018**.........

DEPTH: **....... 6.0m......** TESTED BY:......**WET SIEVE**.........

SIEVE NO.				
APPROX IMPERIAL EQUIV (Seive No.)	BRITISH STANDARD SIEVE SIZES (mm)	RETAINED IN gm	PASSING IN gm	PASSING IN (%)
3	75			
2 ½				
2	50			
1 ½	37.5			
1	26.5			
¾	20			
½	14			
⅜	10			
¼	6.3			
3/16	5			
⅛	3.35		100	100
7	2.36		100	100
10	2		100	100
14	1.18	2.65	97.35	97.35
25	0.6	12.79	84.56	84.56
36	0.425	5.5	79.06	79.06
52	0.3	10.69	68.37	68.37
72	0.212	6.27	62.1	62.1
100	0.15	3.74	58.36	58.36
200	0.075	4.97	53.39	53.39



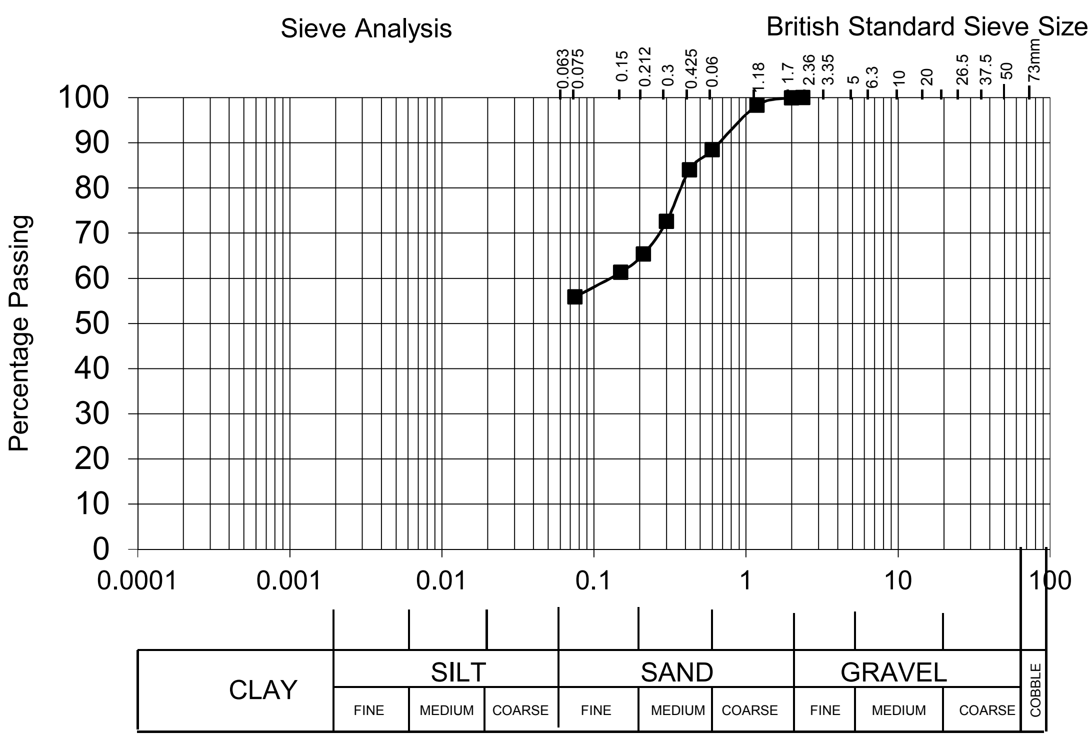
UNIBEN GEOTECH RESEARCH
GRAIN SIZE ANALYSIS BY WET-SIEVING

SITE: ... **OKOMU** **JOB:............**

LOCATION: .....WATER TANK , BH8. DATE**: 08-06--2018**.........

DEPTH: **....... 9.0m......** TESTED BY:......**WET SIEVE**.........

SIEVE NO.				
APPROX IMPERIAL EQUIV (Seive No.)	BRITISH STANDARD SIEVE SIZES (mm)	RETAINED IN gm	PASSING IN gm	PASSING IN (%)
3	75			
2 ½				
2	50			
1 ½	37.5			
1	26.5			
¾	20			
½	14			
⅜	10			
¼	6.3			
3/16	5			
⅛	3.35		100	100
7	2.36		100	100
10	2	0.06	99.94	99.94
14	1.18	1.67	98.27	98.27
25	0.6	9.84	88.43	88.43
36	0.425	4.44	83.99	83.99
52	0.3	11.42	72.57	72.57
72	0.212	7.23	65.34	65.34
100	0.15	4.01	61.33	61.33
200	0.075	5.5	55.83	55.83



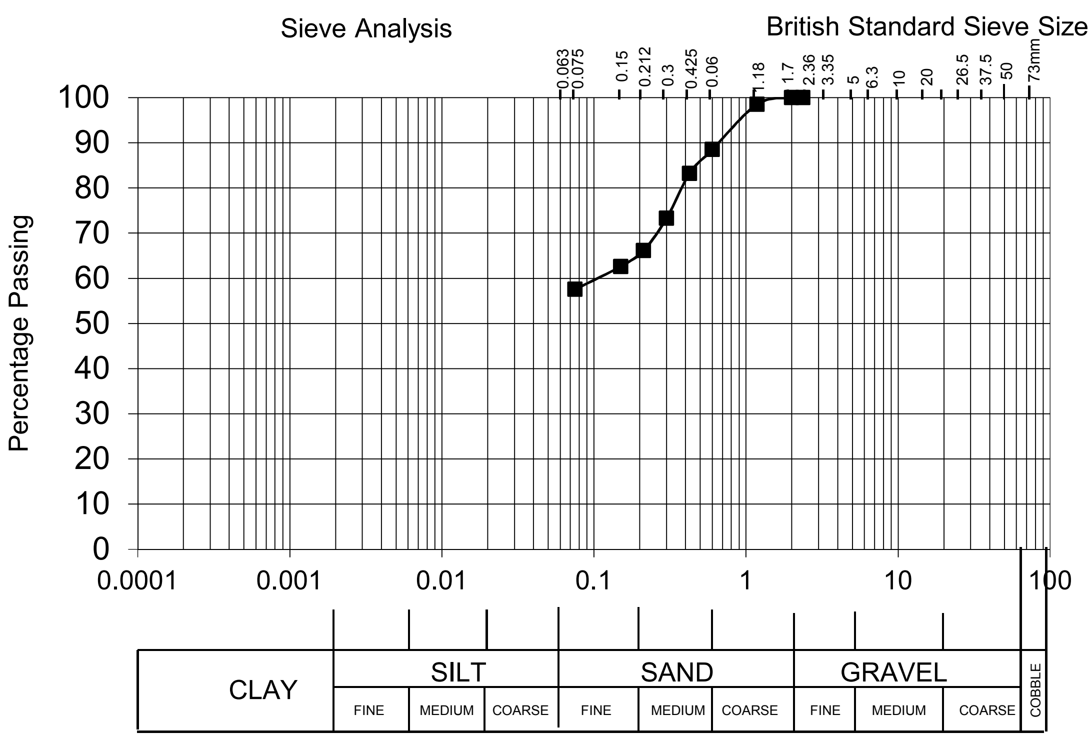
UNIBEN GEOTECH RESEARCH
GRAIN SIZE ANALYSIS BY WET-SIEVING

SITE: ... **OKOMU** **JOB:............**

LOCATION: .....WATER TANK , BH8. DATE**: 08-06--2018**.........

DEPTH: **....... 12.0m......** TESTED BY:......**WET SIEVE**.........

SIEVE NO.				
APPROX IMPERIAL EQUIV (Seive No.)	BRITISH STANDARD SIEVE SIZES (mm)	RETAINED IN gm	PASSING IN gm	PASSING IN (%)
3	75			
2 ½				
2	50			
1 ½	37.5			
1	26.5			
¾	20			
½	14			
⅜	10			
¼	6.3			
3/16	5			
⅛	3.35		100	100
7	2.36		100	100
10	2		100	100
14	1.18	1.49	98.51	98.51
25	0.6	10.01	88.5	88.5
36	0.425	5.32	83.18	83.18
52	0.3	9.9	73.28	73.28
72	0.212	7.12	66.16	66.16
100	0.15	3.54	62.62	62.62
200	0.075	5.09	57.53	57.53



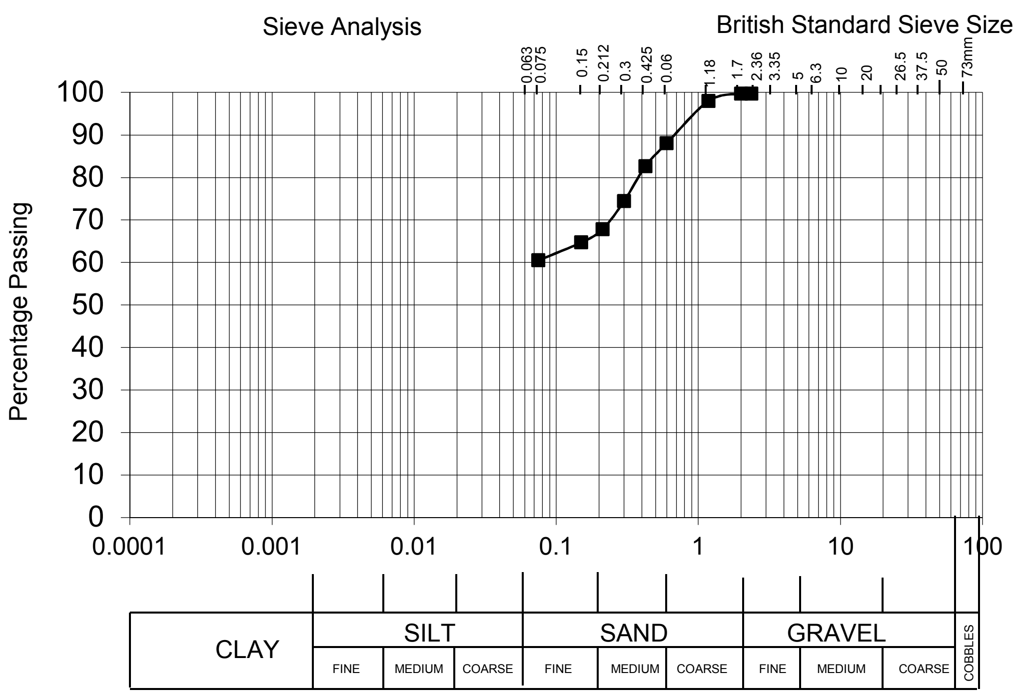
UNIBEN GEOTECH RESEARCH
GRAIN SIZE ANALYSIS BY WET-SIEVING

SITE: **… OKOMU** **JOB:.............**

LOCATION: .....WATER TANK , BH8. DATE**: 08-06--2018**………

DEPTH: **……. 15.0m……** TESTED BY:……**WET SIEVE**………

SIEVE NO.				
APPROX IMPERIAL EQUIV (inches)	BRITISH STANDARD SIEVE SIZES (mm)	RETAINED IN gm	PASSING IN gm	PASSING IN (%)
3	75			
2 ½				
2	50			
1 ½	37.5			
1	26.5			
¾	20			
½	14			
⅜	10			
¼	6.3			
3/16	5			
⅛	3.35		100	100
7	2.36	0.29	99.71	99.71
10	2		99.71	99.71
14	1.18	1.74	97.97	97.97
25	0.6	9.91	88.06	88.06
36	0.425	5.42	82.64	82.64
52	0.3	8.22	74.42	74.42
72	0.212	6.6	67.82	67.82
100	0.15	3.14	64.68	64.68
200	0.075	4.17	60.51	60.51



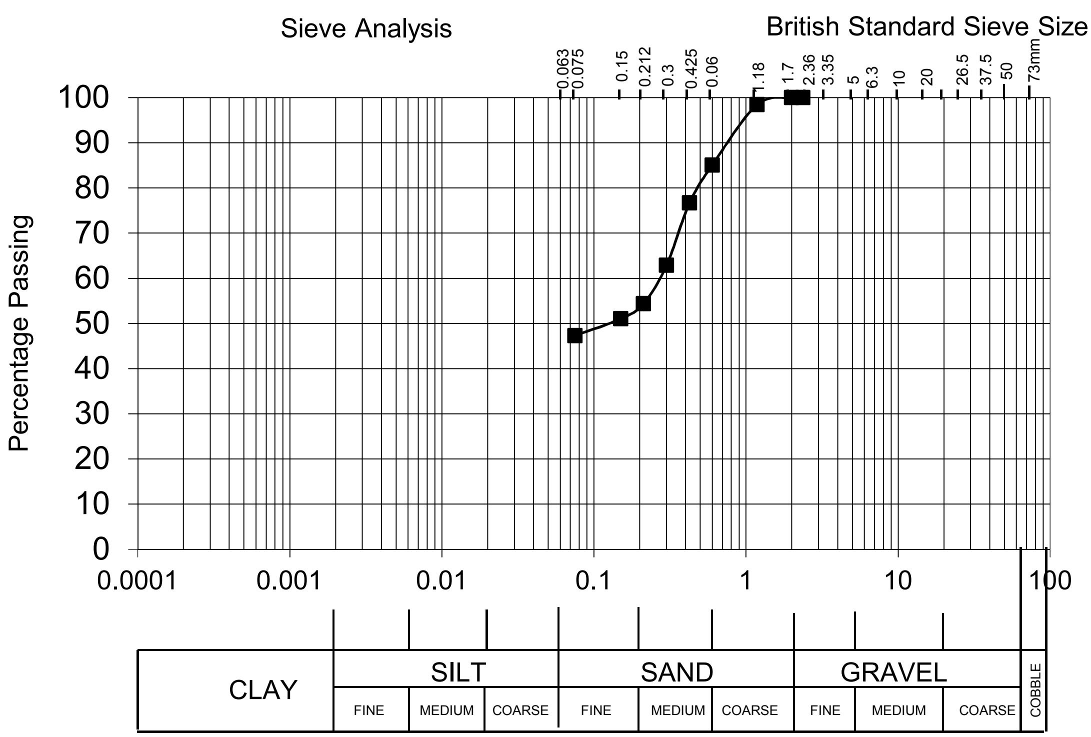
UNIBEN GEOTECH RESEARCH
GRAIN SIZE ANALYSIS BY WET-SIEVING

SITE: … **OKOMU** **JOB:............**

LOCATION: ...RAMP1 , BH9. DATE**: 08-06--2018**………

DEPTH: **……. 2.0m……** TESTED BY:……**WET SIEVE**………

SIEVE NO.				
APPROX IMPERIAL EQUIV (Seive No.)	BRITISH STANDARD SIEVE SIZES (mm)	RETAINED IN gm	PASSING IN gm	PASSING IN (%)
3	75			
2 ½				
2	50			
1 ½	37.5			
1	26.5			
¾	20			
½	14			
⅜	10			
¼	6.3			
3/16	5			
⅛	3.35		100	100
7	2.36		100	100
10	2		100	100
14	1.18	1.57	98.43	98.43
25	0.6	13.37	85.06	85.06
36	0.425	8.4	76.66	76.66
52	0.3	13.82	62.84	62.84
72	0.212	8.44	54.4	54.4
100	0.15	3.38	51.02	51.02
200	0.075	3.7	47.32	47.32



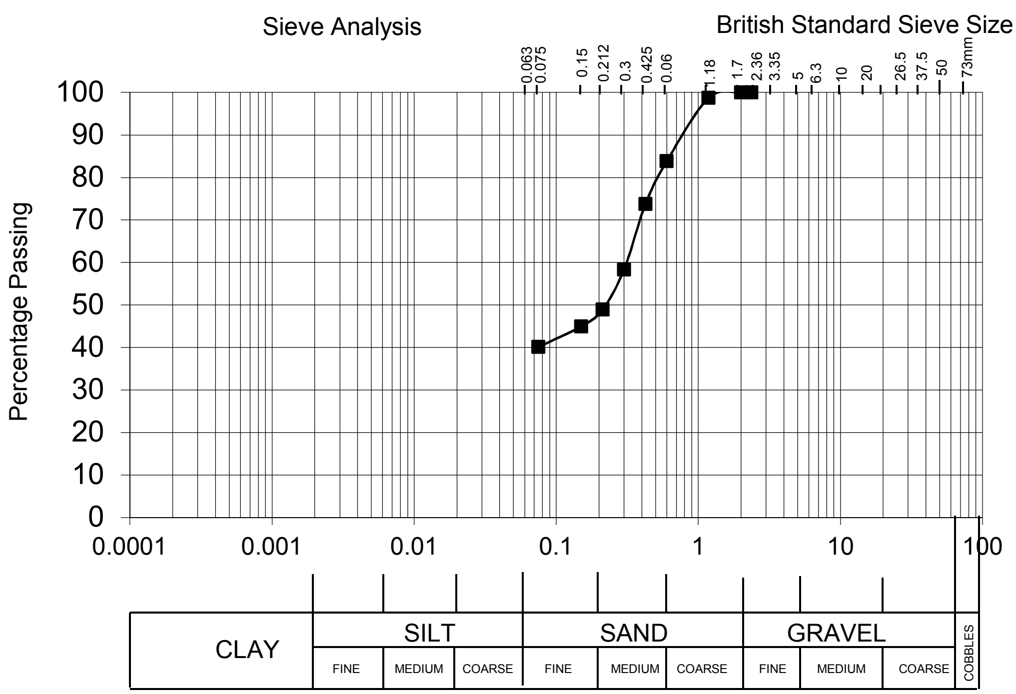
UNIBEN GEOTECH RESEARCH
GRAIN SIZE ANALYSIS BY WET-SIEVING

SITE: **… OKOMU** **JOB:.............**

LOCATION: ...RAMP1 , BH9. DATE**: 08-06--2018**………

DEPTH: **……. 5.0m……** TESTED BY:……**WET SIEVE**………

SIEVE NO.				
APPROX IMPERIAL EQUIV (Seive No.)	BRITISH STANDARD SIEVE SIZES (mm)	RETAINED IN gm	PASSING IN gm	PASSING IN (%)
3	75			
2 ½				
2	50			
1 ½	37.5			
1	26.5			
¾	20			
½	14			
⅜	10			
¼	6.3			
3/16	5			
⅛	3.35		100	100
7	2.36		100	100
10	2		100	100
14	1.18	1.31	98.69	98.69
25	0.6	14.87	83.82	83.82
36	0.425	10.05	73.77	73.77
52	0.3	15.44	58.33	58.33
72	0.212	9.4	48.93	48.93
100	0.15	3.97	44.96	44.96
200	0.075	4.85	40.11	40.11



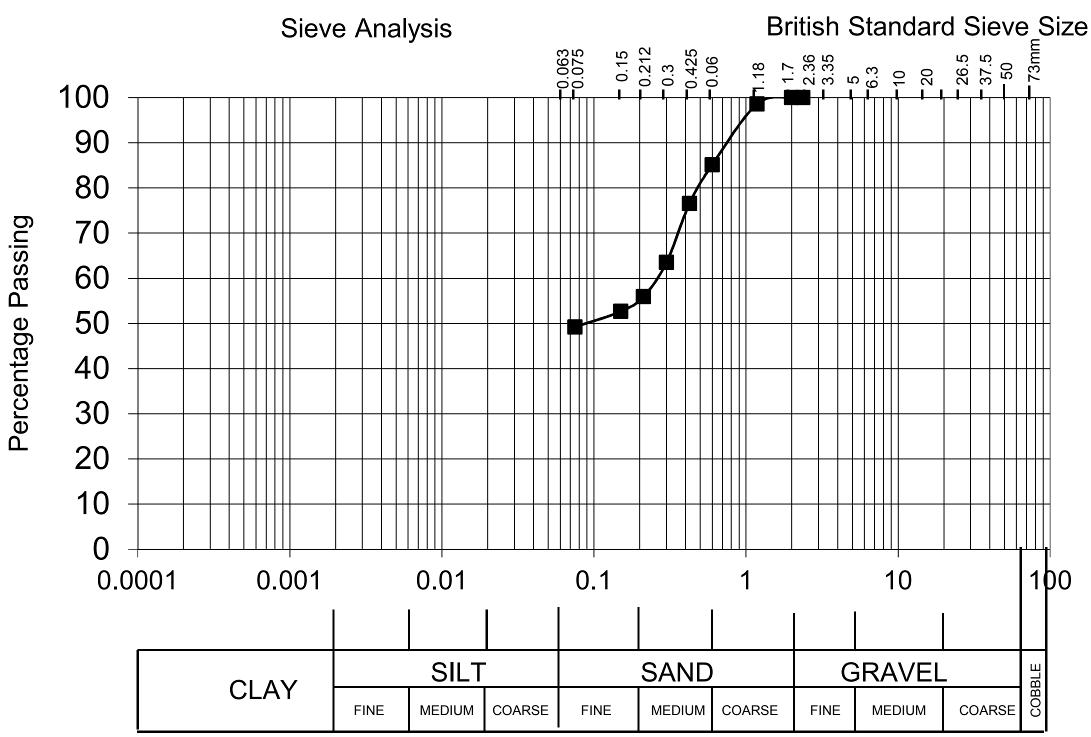
UNIBEN GEOTECH RESEARCH
GRAIN SIZE ANALYSIS BY WET-SIEVING

SITE: … **OKOMU** **JOB:………….**

LOCATION: ...RAMP1 , BH9. DATE**: 08-06--2018**………

DEPTH: **……. 8.0m……** TESTED BY:……**WET SIEVE**………

SIEVE NO.				
APPROX IMPERIAL EQUIV (Seive No.)	BRITISH STANDARD SIEVE SIZES (mm)	RETAINED IN gm	PASSING IN gm	PASSING IN (%)
3	75			
2 ½				
2	50			
1 ½	37.5			
1	26.5			
¾	20			
½	14			
⅜	10			
¼	6.3			
3/16	5			
⅛	3.35		100	100
7	2.36		100	100
10	2		100	100
14	1.18	1.4	98.6	98.6
25	0.6	13.45	85.15	85.15
36	0.425	8.6	76.55	76.55
52	0.3	13.02	63.53	63.53
72	0.212	7.59	55.94	55.94
100	0.15	3.27	52.67	52.67
200	0.075	3.48	49.19	49.19



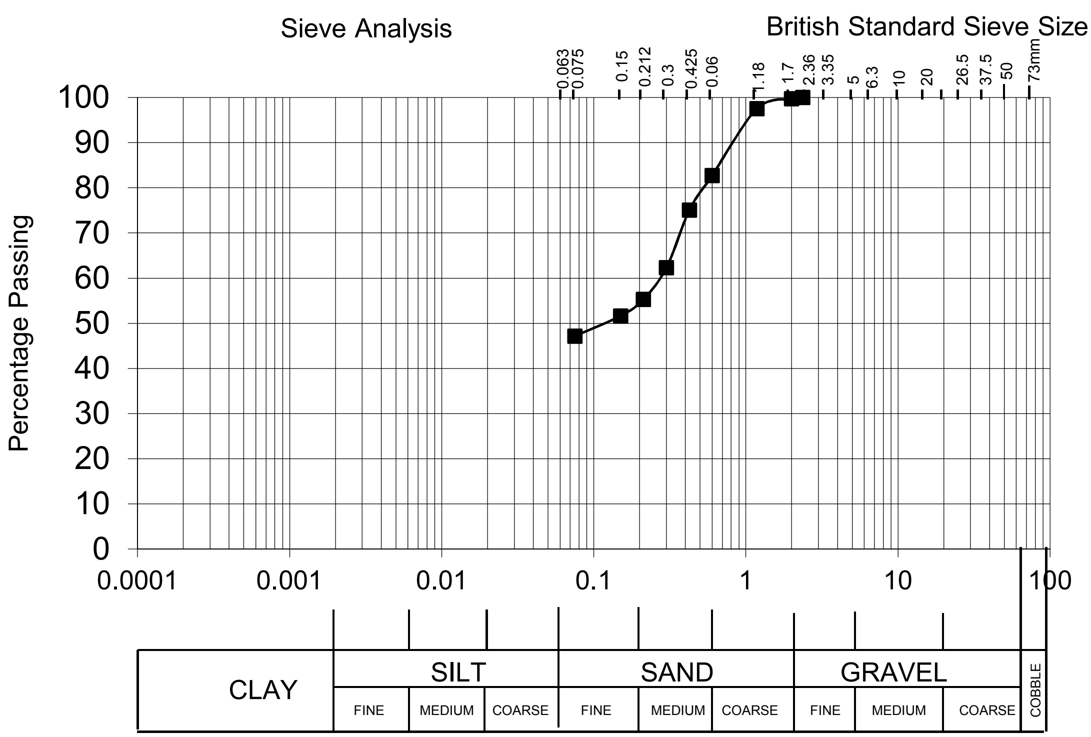
UNIBEN GEOTECH RESEARCH
GRAIN SIZE ANALYSIS BY WET-SIEVING

SITE: ... **OKOMU** **JOB:............**

LOCATION: ...RAMP1 , BH9. DATE: **08-06--2018**.........

DEPTH: **....... 11.0m......** TESTED BY:......**WET SIEVE**.........

SIEVE NO.				
APPROX IMPERIAL EQUIV (Seive No.)	BRITISH STANDARD SIEVE SIZES (mm)	RETAINED IN gm	PASSING IN gm	PASSING IN (%)
3	75			
2 ½				
2	50			
1 ½	37.5			
1	26.5			
¾	20			
½	14			
⅜	10			
¼	6.3			
3/16	5			
⅛	3.35		100	100
7	2.36		100	100
10	2	0.27	99.73	99.73
14	1.18	2.24	97.49	97.49
25	0.6	14.76	82.73	82.73
36	0.425	7.68	75.05	75.05
52	0.3	12.74	62.31	62.31
72	0.212	6.99	55.32	55.32
100	0.15	3.68	51.64	51.64
200	0.075	4.47	47.17	47.17



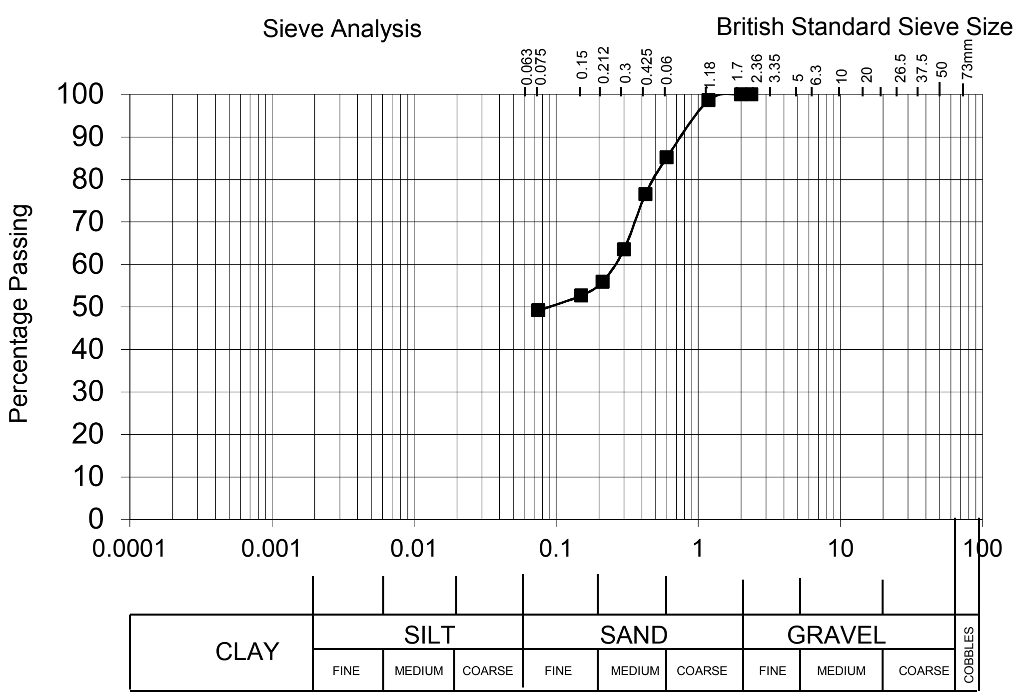
UNIBEN GEOTECH RESEARCH
GRAIN SIZE ANALYSIS BY WET-SIEVING

SITE: **… OKOMU** **JOB:………….**

LOCATION: ...RAMP1 , BH9. DATE**: 08-06--2018**………

DEPTH: **……. 8.0m……** TESTED BY:……**WET SIEVE**………

SIEVE NO.				
APPROX IMPERIAL EQUIV (Seive No.)	BRITISH STANDARD SIEVE SIZES (mm)	RETAINED IN gm	PASSING IN gm	PASSING IN (%)
3	75			
2 ½				
2	50			
1 ½	37.5			
1	26.5			
¾	20			
½	14			
⅜	10			
¼	6.3			
3/16	5			
⅛	3.35		100	100
7	2.36		100	100
10	2		100	100
14	1.18	1.4	98.6	98.6
25	0.6	13.45	85.15	85.15
36	0.425	8.6	76.55	76.55
52	0.3	13.02	63.53	63.53
72	0.212	7.59	55.94	55.94
100	0.15	3.27	52.67	52.67
200	0.075	3.48	49.19	49.19



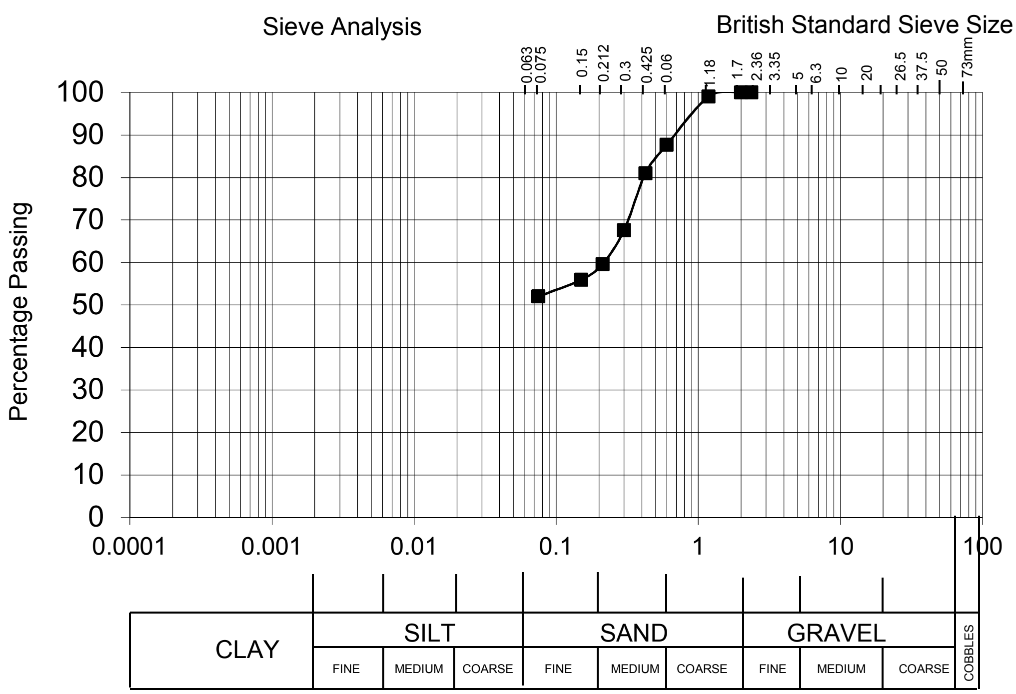
UNIBEN GEOTECH RESEARCH
GRAIN SIZE ANALYSIS BY WET-SIEVING

SITE: … **OKOMU** **JOB:………….**

LOCATION: ...RAMPII , BH10. DATE: **08-06--2018**………

DEPTH: **……. 1.5m……** TESTED BY:……**WET SIEVE**………

SIEVE NO.				
APPROX IMPERIAL EQUIV (Seive No.)	BRITISH STANDARD SIEVE SIZES (mm)	RETAINED IN gm	PASSING IN gm	PASSING IN (%)
3	75			
2 ½				
2	50			
1 ½	37.5			
1	26.5			
¾	20			
½	14			
⅜	10			
¼	6.3			
3/16	5			
⅛	3.35		100	100
7	2.36		100	100
10	2		100	100
14	1.18	1.03	98.97	98.97
25	0.6	11.32	87.65	87.65
36	0.425	6.69	80.96	80.96
52	0.3	13.4	67.56	67.56
72	0.212	7.93	59.63	59.63
100	0.15	3.69	55.94	55.94
200	0.075	3.96	51.98	51.98



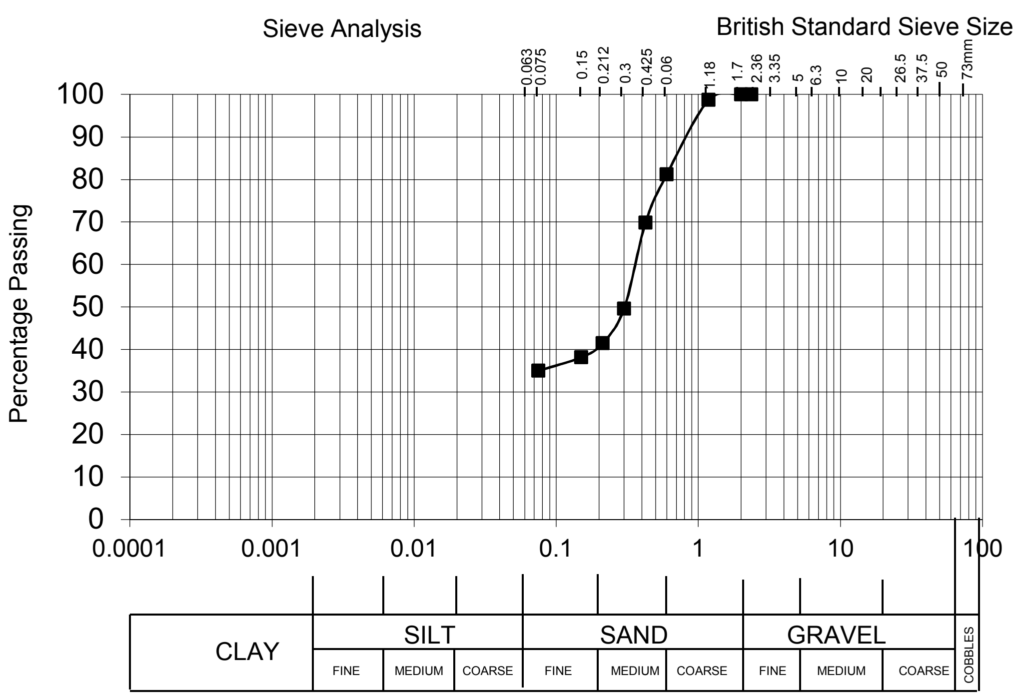
UNIBEN GEOTECH RESEARCH
GRAIN SIZE ANALYSIS BY WET-SIEVING

SITE: **… OKOMU** **JOB:.............**

LOCATION: ...RAMPII , BH10. DATE**: 08-06--2018**………

DEPTH: **……. 4.5m……** TESTED BY:……**WET SIEVE**………

SIEVE NO.				
APPROX IMPERIAL EQUIV (Seive No.)	BRITISH STANDARD SIEVE SIZES (mm)	RETAINED IN gm	PASSING IN gm	PASSING IN (%)
3	75			
2 ½				
2	50			
1 ½	37.5			
1	26.5			
¾	20			
½	14			
⅜	10			
¼	6.3			
3/16	5			
⅛	3.35		100	100
7	2.36		100	100
10	2		100	100
14	1.18	1.33	98.67	98.67
25	0.6	17.5	81.17	81.17
36	0.425	11.35	69.82	69.82
52	0.3	20.26	49.56	49.56
72	0.212	8.1	41.46	41.46
100	0.15	3.32	38.14	38.14
200	0.075	3.13	35.01	35.01



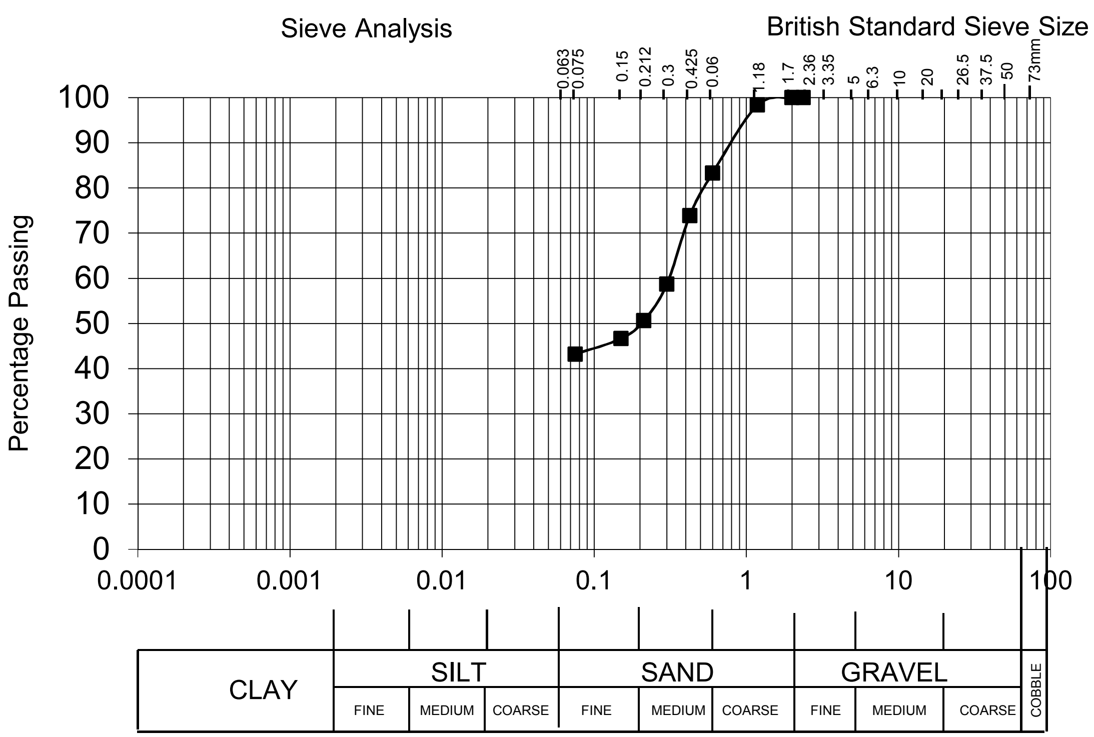
UNIBEN GEOTECH RESEARCH
GRAIN SIZE ANALYSIS BY WET-SIEVING

SITE: ... **OKOMU** **JOB:............**

LOCATION: ...RAMPII , BH10. DATE**: 08-06--2018**.........

DEPTH: **....... 7.5m......** TESTED BY:......**WET SIEVE**.........

SIEVE NO.				
APPROX IMPERIAL EQUIV (Seive No.)	BRITISH STANDARD SIEVE SIZES (mm)	RETAINED IN gm	PASSING IN gm	PASSING IN (%)
3	75			
2 ½				
2	50			
1 ½	37.5			
1	26.5			
¾	20			
½	14			
⅜	10			
¼	6.3			
3/16	5			
⅛	3.35		100	100
7	2.36		100	100
10	2		100	100
14	1.18	1.66	98.34	98.34
25	0.6	15.05	83.29	83.29
36	0.425	9.4	73.89	73.89
52	0.3	15.22	58.67	58.67
72	0.212	8.08	50.59	50.59
100	0.15	3.96	46.63	46.63
200	0.075	3.45	43.18	43.18



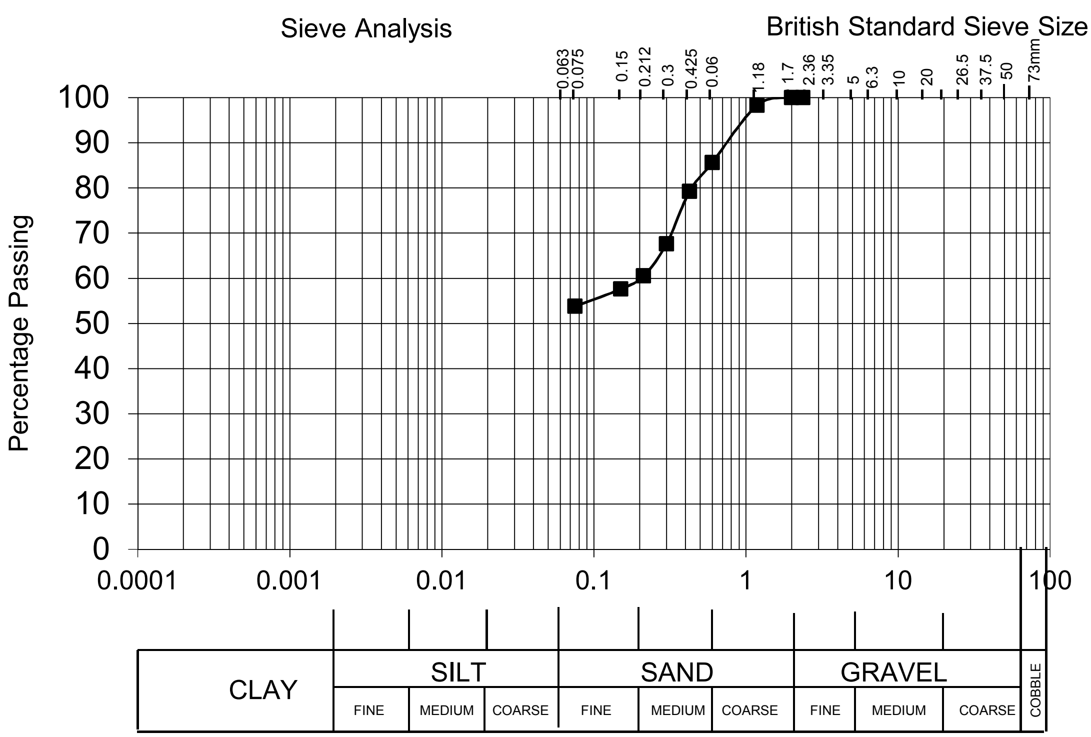
UNIBEN GEOTECH RESEARCH
GRAIN SIZE ANALYSIS BY WET-SIEVING

SITE: ... **OKOMU** **JOB:............**

LOCATION: ...RAMPII , BH10. DATE**: 08-06--2018**.........

DEPTH: **....... 10.0m......** TESTED BY:......**WET SIEVE**.........

SIEVE NO.				
APPROX IMPERIAL EQUIV (Seive No.)	BRITISH STANDARD SIEVE SIZES (mm)	RETAINED IN gm	PASSING IN gm	PASSING IN (%)
3	75			
2 ½				
2	50			
1 ½	37.5			
1	26.5			
¾	20			
½	14			
⅜	10			
¼	6.3			
3/16	5			
⅛	3.35		100	100
7	2.36		100	100
10	2		100	100
14	1.18	1.72	98.28	98.28
25	0.6	12.66	85.62	85.62
36	0.425	6.4	79.22	79.22
52	0.3	11.58	67.64	67.64
72	0.212	7.13	60.51	60.51
100	0.15	2.91	57.6	57.6
200	0.075	3.83	53.77	53.77



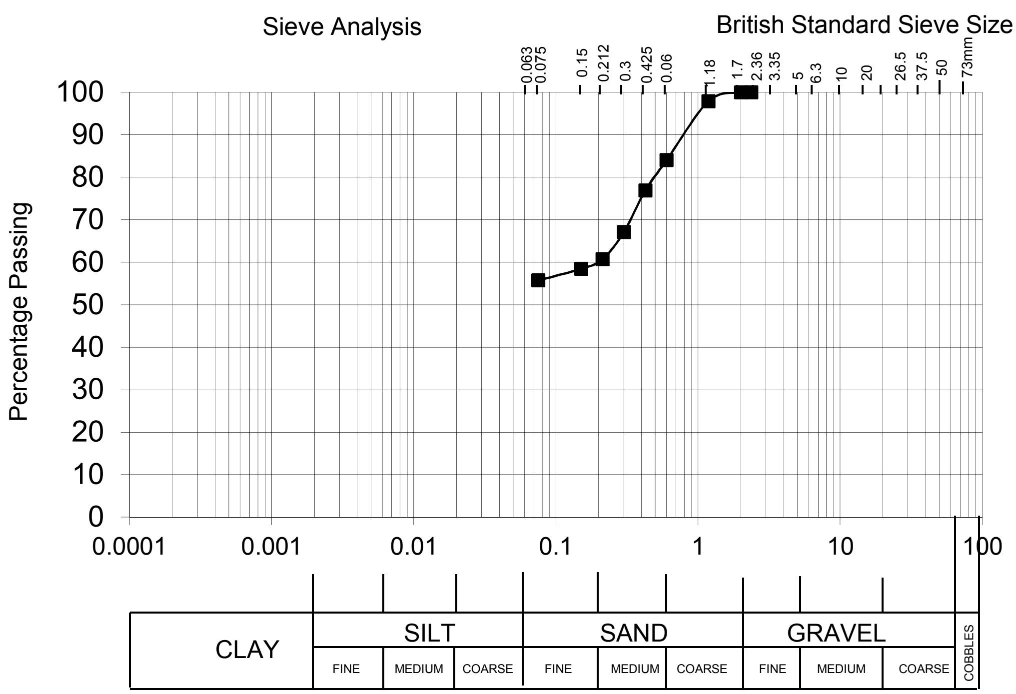
UNIBEN GEOTECH RESEARCH
GRAIN SIZE ANALYSIS BY WET-SIEVING

SITE: **… OKOMU** **JOB:.............**

LOCATION: ...RAMPII , BH10. DATE: **08-06--2018**………

DEPTH: **……. 10.5m……** TESTED BY:……**WET SIEVE**………

SIEVE NO.				
APPROX IMPERIAL EQUIV (inches)	BRITISH STANDARD SIEVE SIZES (mm)	RETAINED IN gm	PASSING IN gm	PASSING IN (%)
3	75			
2 ½				
2	50			
1 ½	37.5			
1	26.5			
¾	20			
½	14			
⅜	10			
¼	6.3			
3/16	5			
⅛	3.35		100	100
7	2.36		100	100
10	2		100	100
14	1.18	2.12	97.88	97.88
25	0.6	13.87	84.01	84.01
36	0.425	7.08	76.93	76.93
52	0.3	9.8	67.13	67.13
72	0.212	6.43	60.7	60.7
100	0.15	2.24	58.46	58.46
200	0.075	2.73	55.73	55.73



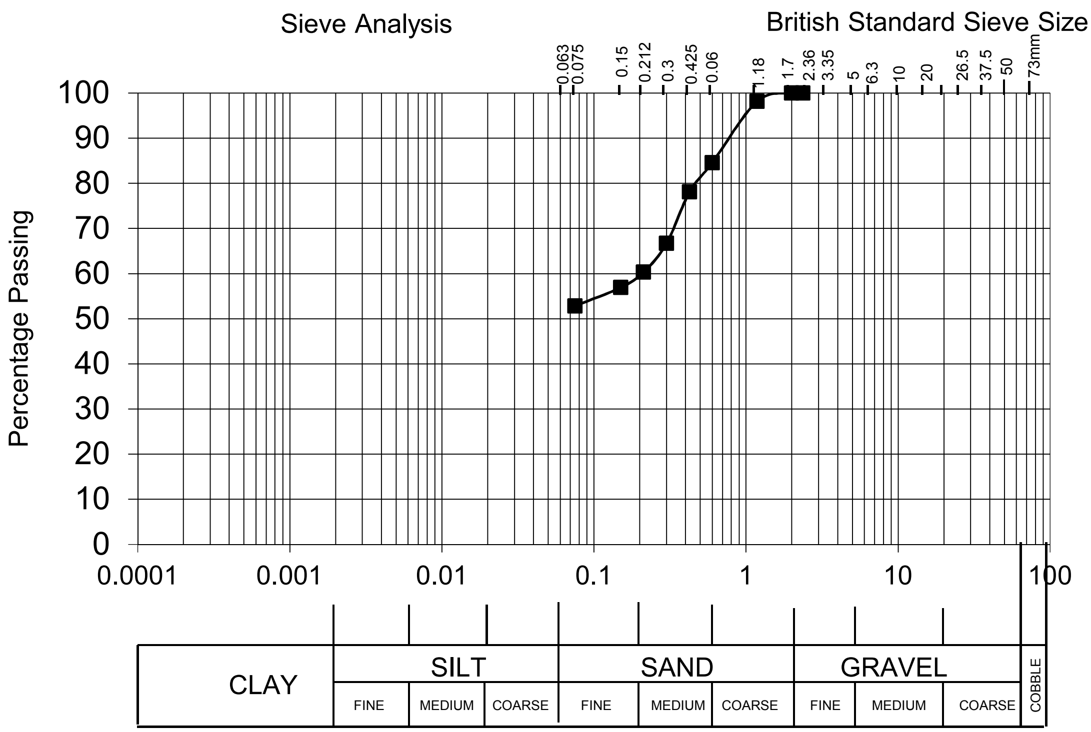
UNIBEN GEOTECH RESEARCH
GRAIN SIZE ANALYSIS BY WET-SIEVING

SITE: ... **OKOMU** **JOB:............**

LOCATION: ...RAMPII , BH10. DATE**: 08-06--2018**………

DEPTH: **……. 13.5m……** TESTED BY:……**WET SIEVE**………

SIEVE NO.				
APPROX IMPERIAL EQUIV (Seive No.)	BRITISH STANDARD SIEVE SIZES (mm)	RETAINED IN gm	PASSING IN gm	PASSING IN (%)
3	75			
2 ½				
2	50			
1 ½	37.5			
1	26.5			
¾	20			
½	14			
⅜	10			
¼	6.3			
3/16	5			
⅛	3.35		100	100
7	2.36		100	100
10	2		100	100
14	1.18	1.83	98.17	98.17
25	0.6	13.59	84.58	84.58
36	0.425	6.5	78.08	78.08
52	0.3	11.38	66.7	66.7
72	0.212	6.37	60.33	60.33
100	0.15	3.43	56.9	56.9
200	0.075	4.07	52.83	52.83



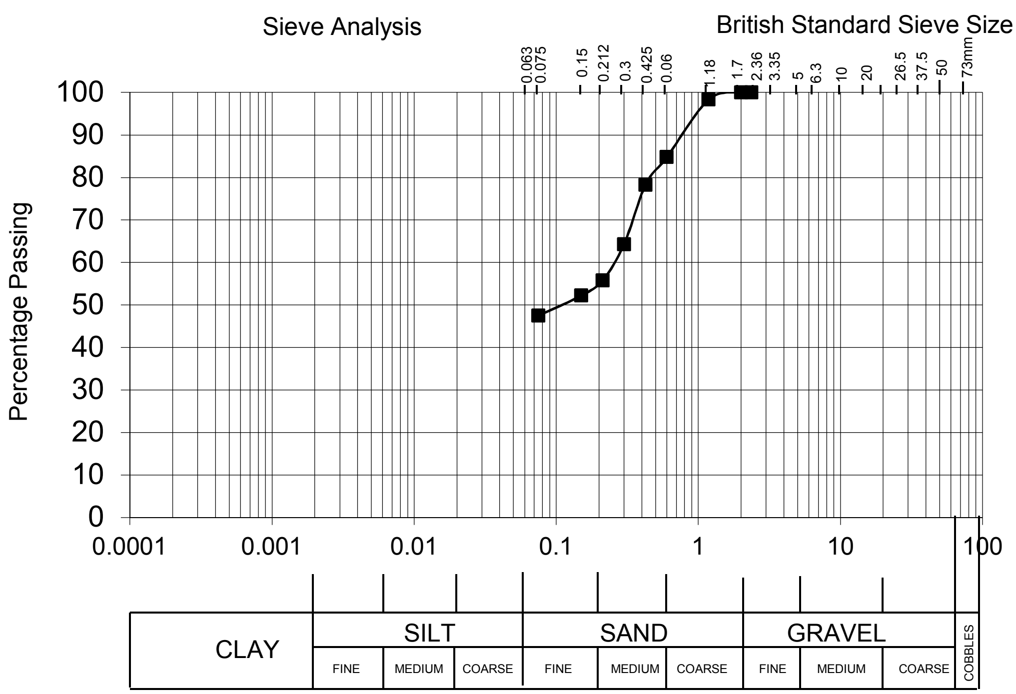
UNIBEN GEOTECH RESEARCH
GRAIN SIZE ANALYSIS BY WET-SIEVING

SITE: **… OKOMU** **JOB:.............**

LOCATION: ...RAMPII , BH10. DATE**: 08-06--2018**………

DEPTH: **……. 15.0m……** TESTED BY:……**WET SIEVE**………

SIEVE NO.				
APPROX IMPERIAL EQUIV (Seive No.)	BRITISH STANDARD SIEVE SIZES (mm)	RETAINED IN gm	PASSING IN gm	PASSING IN (%)
3	75			
2 ½				
2	50			
1 ½	37.5			
1	26.5			
¾	20			
½	14			
⅜	10			
¼	6.3			
3/16	5			
⅛	3.35		100	100
7	2.36		100	100
10	2		100	100
14	1.18	1.71	98.29	98.29
25	0.6	13.52	84.77	84.77
36	0.425	6.5	78.27	78.27
52	0.3	14.01	64.26	64.26
72	0.212	8.48	55.78	55.78
100	0.15	3.57	52.21	52.21
200	0.075	4.72	47.49	47.49



APPENDIX III

LIQUID AND PLASTIC LIMITS,LINEAR SHRINKAGE

Sample No. **POINT 2, 1.5m...** Liquid Limit **: 56.85** Plastic Limit**: 28.61**

Date**: 25/06/2018……….** Plastic Index**: 28.25...** Linear Shrinkage

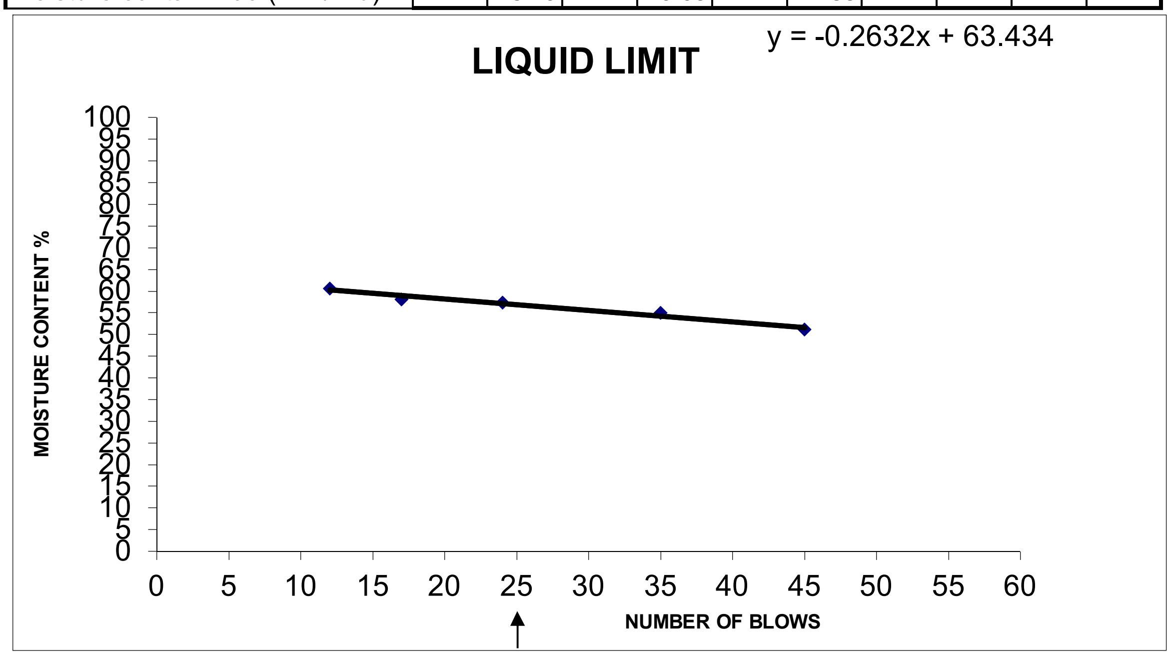
Job**….** Description of Soil…

Site**: OKOMU……**

L.L. Machine No..................... Operator.....................................

Proportion of sample retained on No. 36 B.S. Steve = Per cent
No. of blows refers to liquid limit determination.
Shrinkage % refers to linear Shrinkage.
Liquid limit marked L.L. plastic limit marked P.L. Linear shrinkage marked L.S.

Type of Test	**LL**		**LL**		**LL**		**LL**		**LL**	
No. of Blows/shrinkage %	45.00		35.00		24.00		17.00		12.00	
Container No.	O6		BA		OK		OK		NN	
Wt of wet soil & container (g)	59.00		56.19		58.50		56.99		55.18	
Wt of dried soil & container (g)	44.12		41.89		44.15		41.89		40.35	
Wt of container (g)	15.00		15.90		19.10		15.90		15.90	
Wt of dry soil (Wd) (g)	29.12		25.99		25.05		25.99		24.45	
Wt of moisture (Wm) (g)	14.88		14.30		14.35		15.10		14.83	
Moisture contain 100 (Wm/Wd)	51.10		55.02		57.29		58.10		60.65	
Type of Test		**PL**		**PL**		**PL**		**PL**		**PL**
No. of Blows/shrinkage %										
Container No.		HF		OK		Z4				
Wt of wet soil & container (g)		30.12		26.75		30.00				
Wt of dried soil & container (g)		27.58		24.20		27.58				
Wt of container (g)		18.60		15.60		18.90				
Wt of dry soil (Wd) (g)		8.98		8.60		8.68				
Wt of moisture (Wm) (g)		2.54		2.55		2.42				
Moisture contain 100 (Wm/Wd)		28.29		29.65		27.88				



LIQUID AND PLASTIC LIMITS,LINEAR SHRINKAGE

Sample No. **POINT 3, 1.5m...** Liquid Limit **: 52.88** Plastic Limit**: 27.77**

Date**: 25/06/2018……….** Plastic Index**: 25.12...** Linear Shrinkage

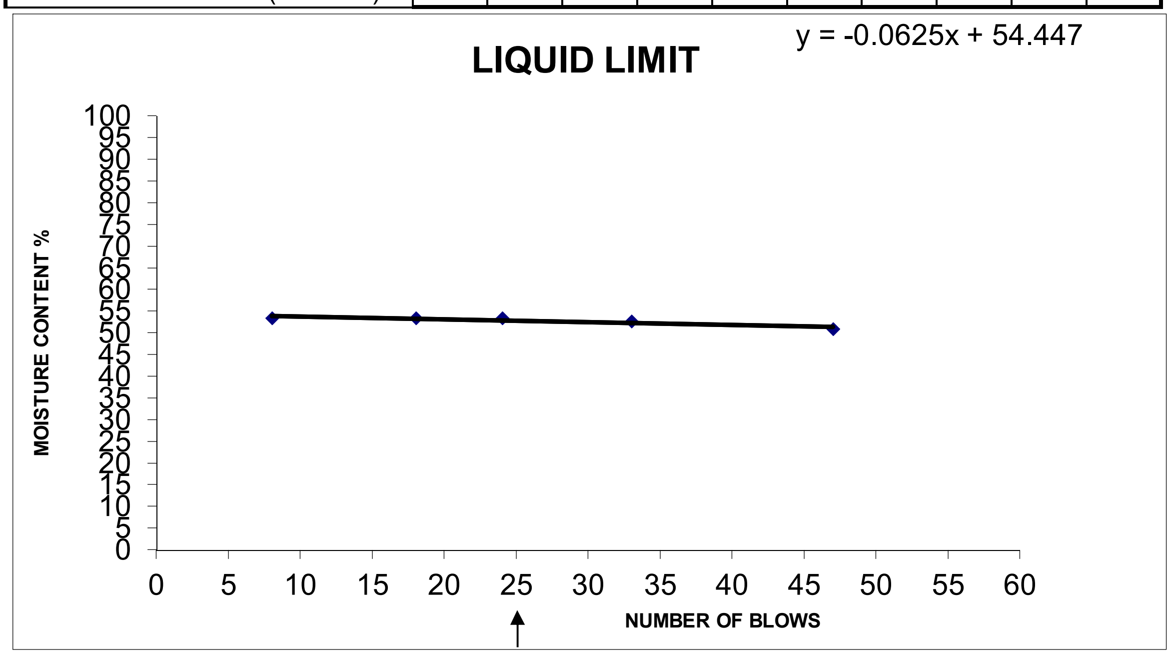
Job**….** Description of Soil…

Site**: OKOMU……**

L.L. Machine No.................... Operator.....................................

Proportion of sample retained on No. 36 B.S. Steve = Per cent
No. of blows refers to liquid limit determination.
Shrinkage % refers to linear Shrinkage.
Liquid limit marked L.L. plastic limit marked P.L. Linear shrinkage marked L.S.

Type of Test	**LL**		**LL**		**LL**		**LL**		**LL**	
No. of Blows/shrinkage %	47.00		33.00		24.00		18.00		8.00	
Container No.	O6		BA		OK		OK		NN	
Wt of wet soil & container (g)	58.50		57.90		56.10		56.10		53.70	
Wt of dried soil & container (g)	43.80		44.50		42.10		42.10		40.50	
Wt of container (g)	15.00		19.10		15.90		15.90		15.80	
Wt of dry soil (Wd) (g)	28.80		25.40		26.20		26.20		24.70	
Wt of moisture (Wm) (g)	14.70		13.40		14.00		14.00		13.20	
Moisture contain 100 (Wm/Wd)	51.04		52.76		53.44		53.44		53.44	
Type of Test		**PL**		**PL**		**PL**		**PL**		**PL**
No. of Blows/shrinkage %										
Container No.		HF		OK		Z4				
Wt of wet soil & container (g)		30.10		25.30		29.50				
Wt of dried soil & container (g)		27.60		23.10		27.30				
Wt of container (g)		18.60		15.60		18.90				
Wt of dry soil (Wd) (g)		9.00		7.50		8.40				
Wt of moisture (Wm) (g)		2.50		2.20		2.20				
Moisture contain 100 (Wm/Wd)		27.78		29.33		26.19				



LIQUID AND PLASTIC LIMITS,LINEAR SHRINKAGE

Sample No**. OKOMU ROAD, POINT 1, 1.5m...** Liquid Limit **: 38.46** Plastic Limit**: 22.03**

Date**: 25/06/2018……….** Plastic Index**: 16.43...** Linear Shrinkage

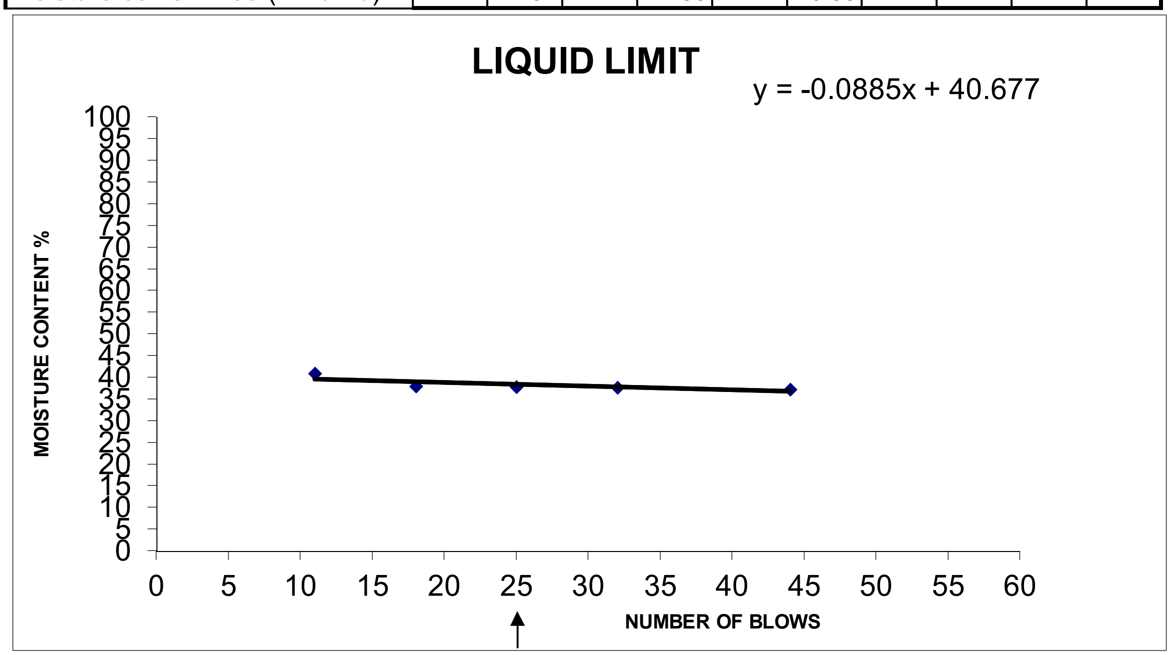
Job**….** Description of Soil…

Site**: OKOMU……**

L.L. Machine No.................... Operator....................................

Proportion of sample retained on No. 36 B.S. Steve = Per cent
No. of blows refers to liquid limit determination.
Shrinkage % refers to linear Shrinkage.
Liquid limit marked L.L. plastic limit marked P.L. Linear shrinkage marked L.S.

Type of Test	**LL**		**LL**		**LL**		**LL**		**LL**	
No. of Blows/shrinkage %	44.00		32.00		25.00		18.00		11.00	
Container No.	W		ST		OH		QO		SI	
Wt of wet soil & container (g)	48.00		52.50		51.80		57.20		54.60	
Wt of dried soil & container (g)	39.30		42.40		43.00		46.60		44.00	
Wt of container (g)	16.00		15.60		19.80		18.70		18.10	
Wt of dry soil (Wd) (g)	23.30		26.80		23.20		27.90		25.90	
Wt of moisture (Wm) (g)	8.70		10.10		8.80		10.60		10.60	
Moisture contain 100 (Wm/Wd)	37.34		37.69		37.93		37.99		40.93	
Type of Test		**PL**		**PL**		**PL**		**PL**		**PL**
No. of Blows/shrinkage %										
Container No.		IE		N		OB				
Wt of wet soil & container (g)		27.60		25.70		25.50				
Wt of dried soil & container (g)		25.90		24.30		24.00				
Wt of container (g)		18.50		18.10		16.70				
Wt of dry soil (Wd) (g)		7.40		6.20		7.30				
Wt of moisture (Wm) (g)		1.70		1.40		1.50				
Moisture contain 100 (Wm/Wd)		22.97		22.58		20.55				



LIQUID AND PLASTIC LIMITS,LINEAR SHRINKAGE

Sample No. **BOILER, BH1, 9.0m...** Liquid Limit **: 54.48** Plastic Limit**: 28.48**

Date**: 25/06/2018……….** Plastic Index**: 25.66...** Linear Shrinkage

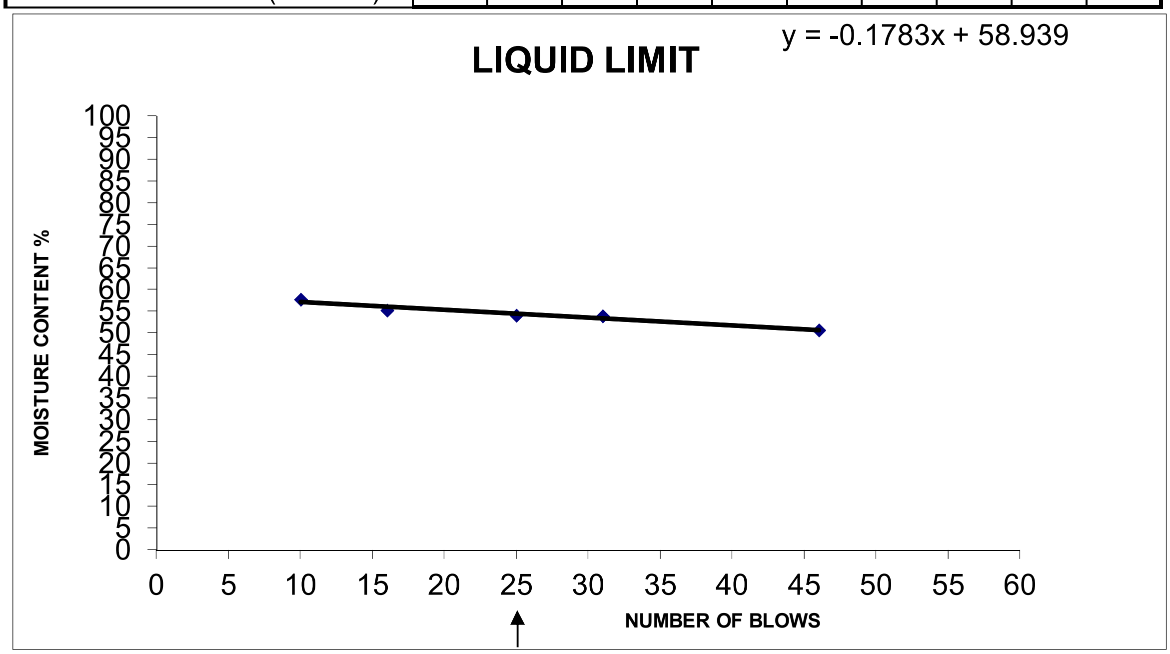
Job**….** Description of Soil…

Site**: OKOMU……**

L.L. Machine No.................... Operator....................................

Proportion of sample retained on No. 36 B.S. Steve = Per cent
No. of blows refers to liquid limit determination.
Shrinkage % refers to linear Shrinkage.
Liquid limit marked L.L. plastic limit marked P.L. Linear shrinkage marked L.S.

Type of Test	**LL**		**LL**		**LL**		**LL**		**LL**	
No. of Blows/shrinkage %	46.00		31.00		25.00		16.00		10.00	
Container No.	LA		AL		KK		TH		BP	
Wt of wet soil & container (g)	51.00		52.70		56.00		59.10		55.40	
Wt of dried soil & container (g)	40.20		40.40		41.60		43.40		41.70	
Wt of container (g)	18.90		17.60		15.00		15.00		18.00	
Wt of dry soil (Wd) (g)	21.30		22.80		26.60		28.40		23.70	
Wt of moisture (Wm) (g)	10.80		12.30		14.40		15.70		13.70	
Moisture contain 100 (Wm/Wd)	50.70		53.95		54.14		55.28		57.81	
Type of Test		**PL**		**PL**		**PL**		**PL**		**PL**
No. of Blows/shrinkage %										
Container No.		BH		II		AI				
Wt of wet soil & container (g)		26.90		24.90		25.90				
Wt of dried soil & container (g)		25.20		23.20		23.90				
Wt of container (g)		19.60		17.20		16.70				
Wt of dry soil (Wd) (g)		5.60		6.00		7.20				
Wt of moisture (Wm) (g)		1.70		1.70		2.00				
Moisture contain 100 (Wm/Wd)		30.36		28.33		27.78				



LIQUID AND PLASTIC LIMITS,LINEAR SHRINKAGE

Sample No. **BOILER, BH1, 12.0m...** Liquid Limit **: 52.48** Plastic Limit**: 29.94**

Date**: 25/06/2018……….** Plastic Index**: 22.54...** Linear Shrinkage

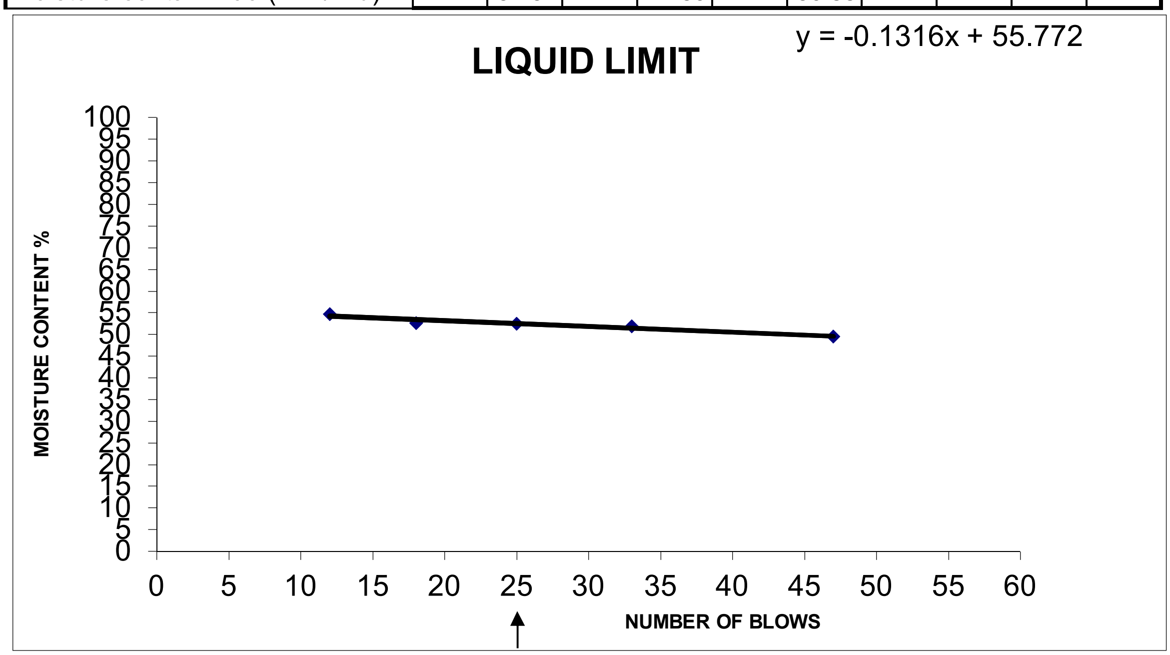
Job**….** Description of Soil…

Site**: OKOMU……**

L.L. Machine No.................... Operator....................................

Proportion of sample retained on No. 36 B.S. Steve = Per cent
No. of blows refers to liquid limit determination.
Shrinkage % refers to linear Shrinkage.
Liquid limit marked L.L. plastic limit marked P.L. Linear shrinkage marked L.S.

Type of Test	**LL**		**LL**		**LL**		**LL**		**LL**	
No. of Blows/shrinkage %	47.00		33.00		25.00		18.00		12.00	
Container No.	FN		OH		ZO		TA		DT	
Wt of wet soil & container (g)	58.40		58.20		53.40		59.10		58.20	
Wt of dried soil & container (g)	44.40		44.50		41.40		45.00		43.10	
Wt of container (g)	16.10		18.10		18.50		18.20		15.50	
Wt of dry soil (Wd) (g)	28.30		26.40		22.90		26.80		27.60	
Wt of moisture (Wm) (g)	14.00		13.70		12.00		14.10		15.10	
Moisture contain 100 (Wm/Wd)	49.47		51.89		52.40		52.61		54.71	
Type of Test		**PL**		**PL**		**PL**		**PL**		**PL**
No. of Blows/shrinkage %										
Container No.		TH		WW		FH				
Wt of wet soil & container (g)		26.90		22.50		26.50				
Wt of dried soil & container (g)		24.80		20.90		24.40				
Wt of container (g)		18.10		15.10		17.60				
Wt of dry soil (Wd) (g)		6.70		5.80		6.80				
Wt of moisture (Wm) (g)		2.10		1.60		2.10				
Moisture contain 100 (Wm/Wd)		31.34		27.59		30.88				



LIQUID AND PLASTIC LIMITS,LINEAR SHRINKAGE

Sample No. **BOILER, BH1, 15.0m...** Liquid Limit **: 54.19** Plastic Limit**: 25.86**

Date**: 25/06/2018……….** Plastic Index**: 28.33...** Linear Shrinkage

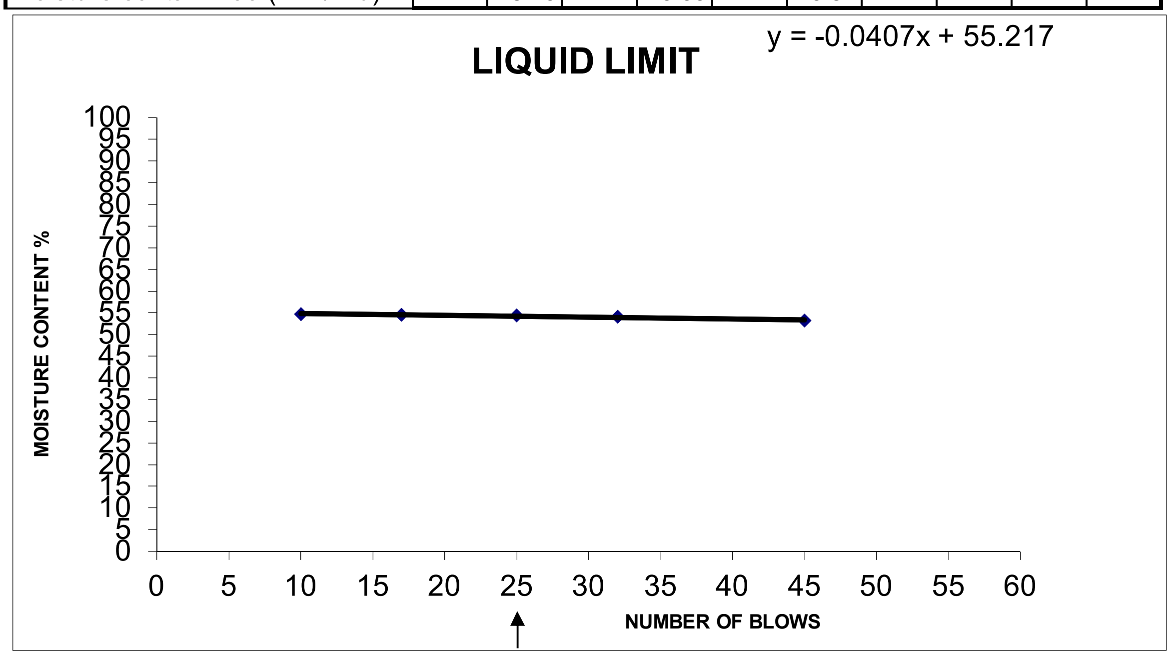
Job**….** Description of Soil…

Site**: OKOMU……**

L.L. Machine No.................... Operator....................................

Proportion of sample retained on No. 36 B.S. Steve = Per cent
No. of blows refers to liquid limit determination.
Shrinkage % refers to linear Shrinkage.
Liquid limit marked L.L. plastic limit marked P.L. Linear shrinkage marked L.S.

Type of Test	**LL**		**LL**		**LL**		**LL**		**LL**	
No. of Blows/shrinkage %	45.00		32.00		25.00		17.00		10.00	
Container No.	GL		UW		IA		CC		SA	
Wt of wet soil & container (g)	56.30	56.30	58.30		57.10		56.10		54.60	
Wt of dried soil & container (g)	43.80	43.80	44.40		43.50		41.70		41.00	
Wt of container (g)	20.30	20.30	18.70		18.50		15.30		16.10	
Wt of dry soil (Wd) (g)	23.50		25.70		25.00		26.40		24.90	
Wt of moisture (Wm) (g)	12.50		13.90		13.60		14.40		13.60	
Moisture contain 100 (Wm/Wd)	53.19		54.09		54.40		54.55		54.62	
Type of Test		**PL**		**PL**		**PL**		**PL**		**PL**
No. of Blows/shrinkage %										
Container No.		OR		NK		KC				
Wt of wet soil & container (g)		22.50		24.00		23.90				
Wt of dried soil & container (g)		20.85		22.20		22.40				
Wt of container (g)		14.30		15.30		16.70				
Wt of dry soil (Wd) (g)		6.55		6.90		5.70				
Wt of moisture (Wm) (g)		1.65		1.80		1.50				
Moisture contain 100 (Wm/Wd)		25.19		26.09		26.32				



LIQUID AND PLASTIC LIMITS,LINEAR SHRINKAGE

Sample No. **CLARIFICATION STATION, BH3, 5.5m...** Liquid Limit **: 53.87** Plastic Limit**: 27.02**

Date**: 25/06/2018……….** Plastic Index**: 26.85...** Linear Shrinkage

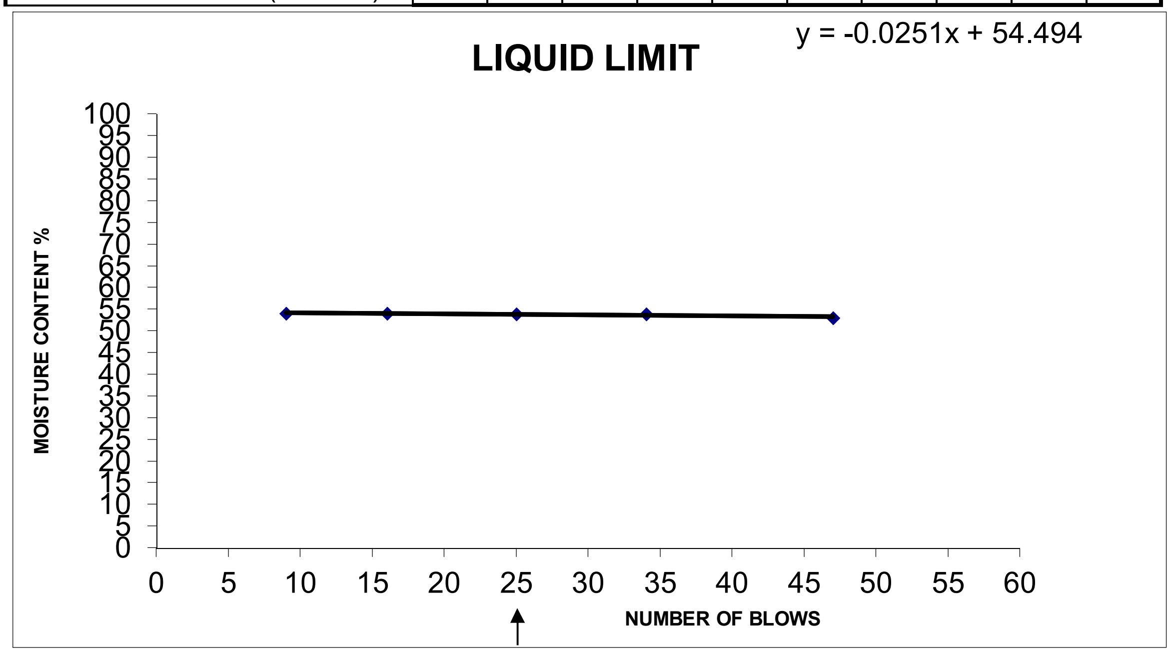
Job**….** Description of Soil…

Site**: OKOMU……**

L.L. Machine No.................... Operator....................................

Proportion of sample retained on No. 36 B.S. Steve = Per cent
No. of blows refers to liquid limit determination.
Shrinkage % refers to linear Shrinkage.
Liquid limit marked L.L. plastic limit marked P.L. Linear shrinkage marked L.S.

Type of Test	**LL**		**LL**		**LL**		**LL**		**LL**	
No. of Blows/shrinkage %	47.00		34.00		25.00		16.00		9.00	
Container No.	UK		ZB		TH		WN		KL	
Wt of wet soil & container (g)	51.70		57.90		55.20		53.10		56.00	
Wt of dried soil & container (g)	39.40		43.10		42.40		40.40		42.80	
Wt of container (g)	16.20		15.70		18.70		16.90		18.40	
Wt of dry soil (Wd) (g)	23.20		27.40		23.70		23.50		24.40	
Wt of moisture (Wm) (g)	12.30		14.80		12.80		12.70		13.20	
Moisture contain 100 (Wm/Wd)	53.02		54.01		54.01		54.04		54.10	
Type of Test		**PL**		**PL**		**PL**		**PL**		**PL**
No. of Blows/shrinkage %										
Container No.		AL		MO		KI				
Wt of wet soil & container (g)		24.00		25.10		27.20				
Wt of dried soil & container (g)		22.00		23.40		25.00				
Wt of container (g)		14.90		16.30		17.40				
Wt of dry soil (Wd) (g)		7.10		7.10		7.60				
Wt of moisture (Wm) (g)		2.00		1.70		2.20				
Moisture contain 100 (Wm/Wd)		28.17		23.94		28.95				



LIQUID AND PLASTIC LIMITS,LINEAR SHRINKAGE

Sample No**. CLARIFICATION STATION, BH3, 8.5m...** Liquid Limit **: 51.06** Plastic Limit**: 27.24**

Date**: 25/06/2018……….** Plastic Index**: 23.82...** Linear Shrinkage

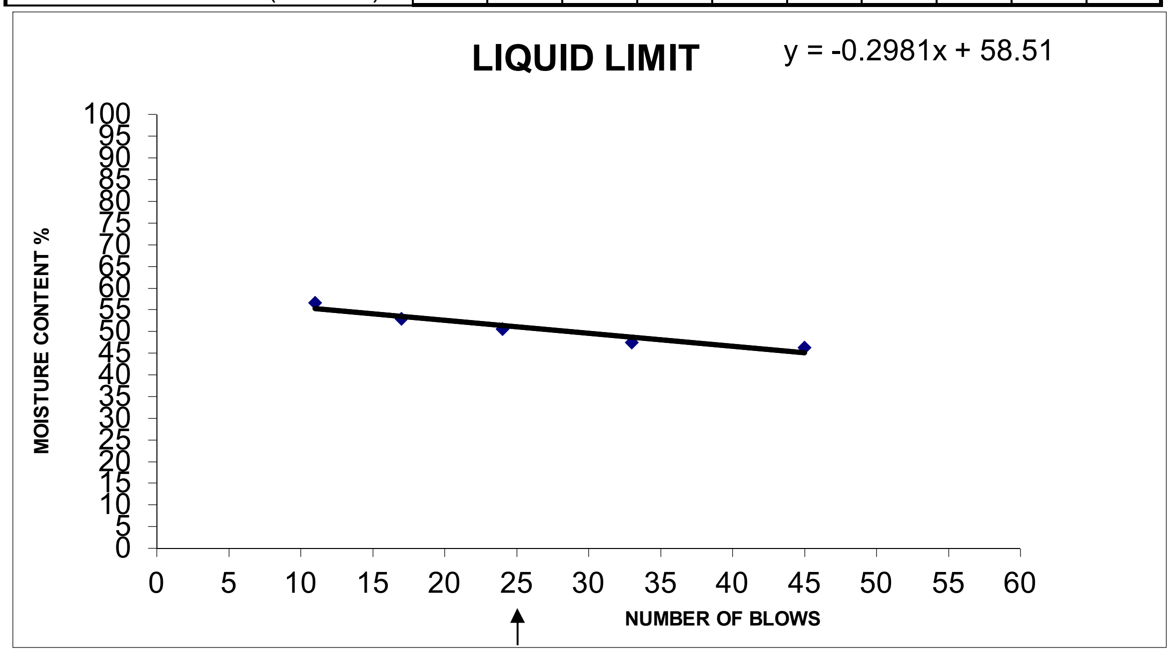
Job**….** Description of Soil…

Site**: OKOMU……**

L.L. Machine No.................... Operator....................................

Proportion of sample retained on No. 36 B.S. Steve = Per cent
No. of blows refers to liquid limit determination.
Shrinkage % refers to linear Shrinkage.
Liquid limit marked L.L. plastic limit marked P.L. Linear shrinkage marked L.S.

Type of Test	LL		LL		LL		LL		LL	
No. of Blows/shrinkage %	45.00		33.00		24.00		17.00		11.00	
Container No.	XE		W		TH		ST		OS	
Wt of wet soil & container (g)	48.30		50.90		47.80		50.50		48.20	
Wt of dried soil & container (g)	37.60		40.70		37.90		38.50		36.30	
Wt of container (g)	14.50		19.20		18.30		15.80		15.30	
Wt of dry soil (Wd) (g)	23.10		21.50		19.60		22.70		21.00	
Wt of moisture (Wm) (g)	10.70		10.20		9.90		12.00		11.90	
Moisture contain 100 (Wm/Wd)	46.32		47.44		50.51		52.86		56.67	
Type of Test		PL		PL		PL		PL		PL
No. of Blows/shrinkage %										
Container No.		WO		OG		RO				
Wt of wet soil & container (g)		25.90		23.50		21.80				
Wt of dried soil & container (g)		24.00		22.40		20.40				
Wt of container (g)		17.10		18.20		15.40				
Wt of dry soil (Wd) (g)		6.90		4.20		5.00				
Wt of moisture (Wm) (g)		1.90		1.10		1.40				
Moisture contain 100 (Wm/Wd)		27.54		26.19		28.00				



LIQUID AND PLASTIC LIMITS,LINEAR SHRINKAGE

Sample No**. CLARIFICATION STATION, BH3, 11.5m...** Liquid Limit **: 51.85** Plastic Limit**: 27.22**

Date**: 25/06/2018……….** Plastic Index**: 24.64...** Linear Shrinkage

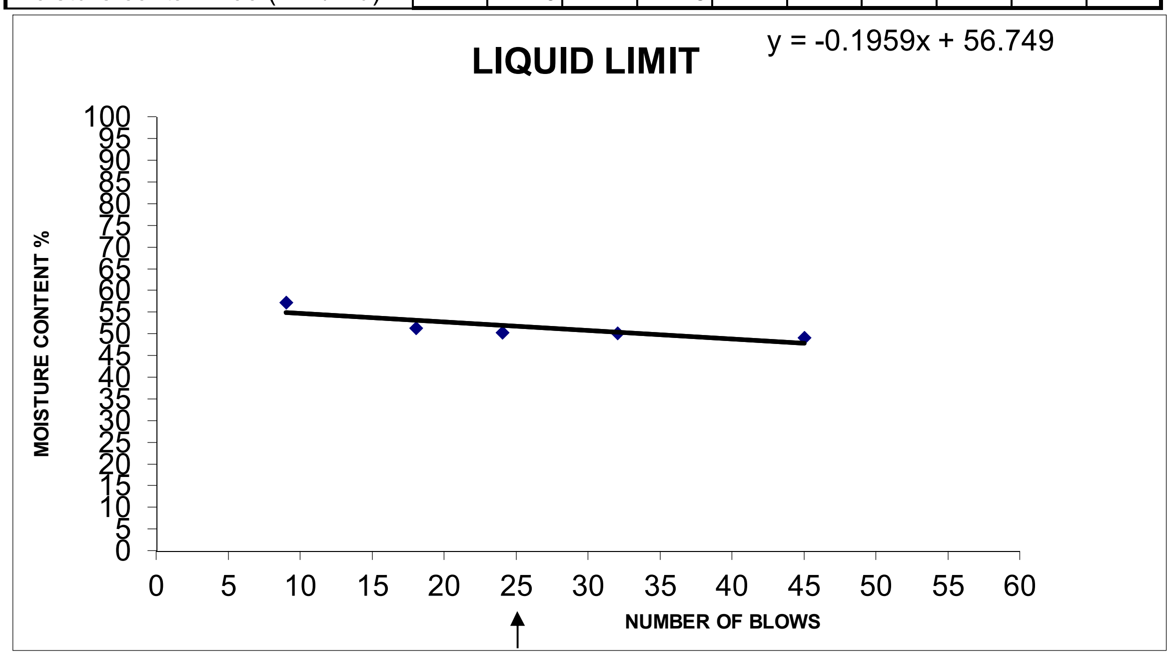
Job**….** Description of Soil…

Site**: OKOMU……**

L.L. Machine No.................... Operator....................................

Proportion of sample retained on No. 36 B.S. Steve = Per cent
No. of blows refers to liquid limit determination.
Shrinkage % refers to linear Shrinkage.
Liquid limit marked L.L. plastic limit marked P.L. Linear shrinkage marked L.S.

Type of Test	**LL**		**LL**		**LL**		**LL**		**LL**	
No. of Blows/shrinkage %	45.00		32.00		24.00		18.00		9.00	
Container No.	NZ		IB		SG		ST		CP	
Wt of wet soil & container (g)	56.00		49.60		56.00		51.20		51.20	
Wt of dried soil & container (g)	42.90		38.60		42.10		40.40		38.80	
Wt of container (g)	16.30		16.70		14.50		19.40		17.20	
Wt of dry soil (Wd) (g)	26.60		21.90		27.60		21.00		21.60	
Wt of moisture (Wm) (g)	13.10		11.00		13.90		10.80		12.40	
Moisture contain 100 (Wm/Wd)	49.25		50.23		50.36		51.43		57.41	
Type of Test		**PL**		**PL**		**PL**		**PL**		**PL**
No. of Blows/shrinkage %										
Container No.		IK		TH		OK				
Wt of wet soil & container (g)		24.20		26.50		23.30				
Wt of dried soil & container (g)		22.20		24.75		21.70				
Wt of container (g)		14.90		18.30		15.80				
Wt of dry soil (Wd) (g)		7.30		6.45		5.90				
Wt of moisture (Wm) (g)		2.00		1.75		1.60				
Moisture contain 100 (Wm/Wd)		27.40		27.13		27.12				



LIQUID AND PLASTIC LIMITS,LINEAR SHRINKAGE

Sample No. **POWER HOUSE, BH2, 5.0m...** Liquid Limit **: 48.97** Plastic Limit**: 27.80**

Date**: 25/06/2018……….** Plastic Index**: 21.17...** Linear Shrinkage

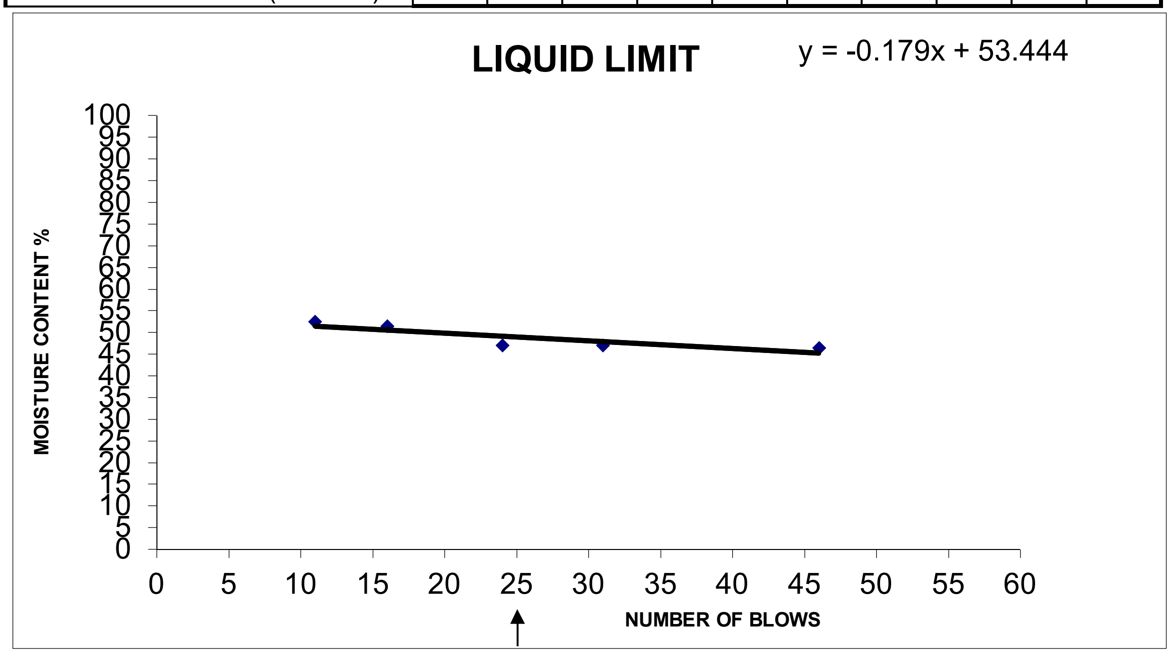
Job**….** Description of Soil…

Site**: OKOMU……**

L.L. Machine No.................... Operator....................................

Proportion of sample retained on No. 36 B.S. Steve = Per cent
No. of blows refers to liquid limit determination.
Shrinkage % refers to linear Shrinkage.
Liquid limit marked L.L. plastic limit marked P.L. Linear shrinkage marked L.S.

Type of Test	**LL**		**LL**		**LL**		**LL**		**LL**	
No. of Blows/shrinkage %	46.00		31.00		24.00		16.00		11.00	
Container No.	OH		RO		PA		CA		IE	
Wt of wet soil & container (g)	52.40		55.10		47.60		50.80		51.80	
Wt of dried soil & container (g)	41.40		43.50		37.30		39.70		40.30	
Wt of container (g)	17.70		18.80		15.40		18.10		18.40	
Wt of dry soil (Wd) (g)	23.70		24.70		21.90		21.60		21.90	
Wt of moisture (Wm) (g)	11.00		11.60		10.30		11.10		11.50	
Moisture contain 100 (Wm/Wd)	46.41		46.96		47.03		51.39		52.51	
Type of Test		**PL**		**PL**		**PL**		**PL**		**PL**
No. of Blows/shrinkage %										
Container No.		OX		UL		CA				
Wt of wet soil & container (g)		24.40		23.90		27.10				
Wt of dried soil & container (g)		22.90		22.60		25.10				
Wt of container (g)		17.20		17.90		18.30				
Wt of dry soil (Wd) (g)		5.70		4.70		6.80				
Wt of moisture (Wm) (g)		1.50		1.30		2.00				
Moisture contain 100 (Wm/Wd)		26.32		27.66		29.41				



LIQUID AND PLASTIC LIMITS,LINEAR SHRINKAGE

Sample No. **POWER HOUSE, BH2, 8.0m...** Liquid Limit **: 53.43** Plastic Limit**: 28.16**

Date**: 25/06/2018……….** Plastic Index**: 25.27...** Linear Shrinkage

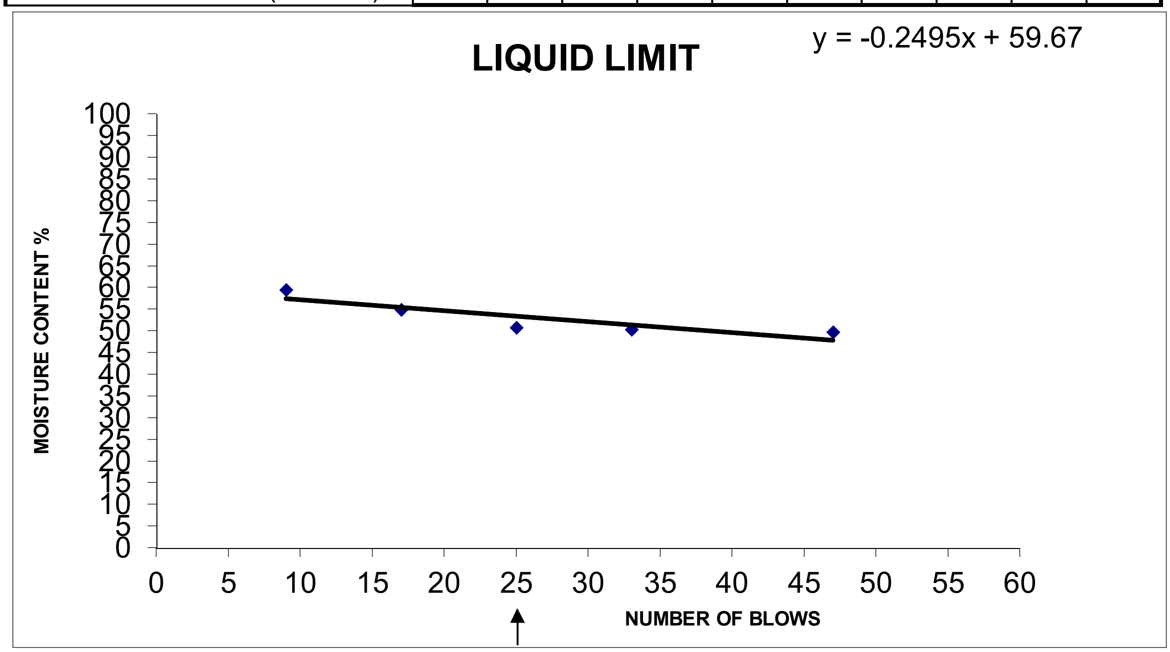
Job**….** Description of Soil…

Site**: OKOMU……**

L.L. Machine No.................... Operator....................................

Proportion of sample retained on No. 36 B.S. Steve = Per cent
No. of blows refers to liquid limit determination.
Shrinkage % refers to linear Shrinkage.
Liquid limit marked L.L. plastic limit marked P.L. Linear shrinkage marked L.S.

Type of Test	**LL**		**LL**		**LL**		**LL**		**LL**	
No. of Blows/shrinkage %	47.00		33.00		25.00		17.00		9.00	
Container No.	MA		ET		BZ		TH		CV	
Wt of wet soil & container (g)	49.50		52.20		53.00		48.20		45.30	
Wt of dried soil & container (g)	38.00		39.60		40.30		37.30		34.40	
Wt of container (g)	14.90		14.60		15.30		17.50		16.12	
Wt of dry soil (Wd) (g)	23.10		25.00		25.00		19.80		18.28	
Wt of moisture (Wm) (g)	11.50		12.60		12.70		10.90		10.90	
Moisture contain 100 (Wm/Wd)	49.78		50.40		50.80		55.05		59.63	
Type of Test		**PL**		**PL**		**PL**		**PL**		**PL**
No. of Blows/shrinkage %										
Container No.		CA		UB		TO				
Wt of wet soil & container (g)		25.50		23.40		24.00				
Wt of dried soil & container (g)		23.90		21.60		22.30				
Wt of container (g)		18.10		15.30		16.30				
Wt of dry soil (Wd) (g)		5.80		6.30		6.00				
Wt of moisture (Wm) (g)		1.60		1.80		1.70				
Moisture contain 100 (Wm/Wd)		27.59		28.57		28.33				



LIQUID AND PLASTIC LIMITS,LINEAR SHRINKAGE

Sample No**. STORAGE TANK, BH6, 10.0m...** Liquid Limit **: 54.09** Plastic Limit**: 25.74**

Date**: 25/06/2018……….** Plastic Index**: 28.35...** Linear Shrinkage

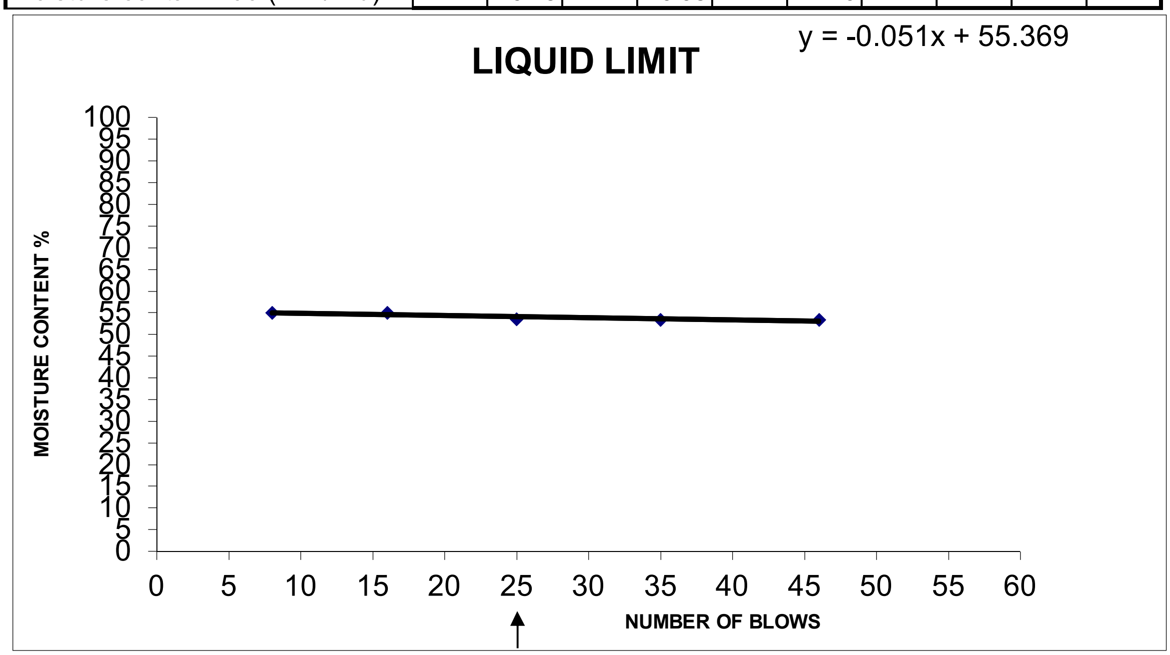
Job**….** Description of Soil…

Site**: OKOMU……**

L.L. Machine No.................... Operator.....................................

Proportion of sample retained on No. 36 B.S. Steve = Per cent
No. of blows refers to liquid limit determination.
Shrinkage % refers to linear Shrinkage.
Liquid limit marked L.L. plastic limit marked P.L. Linear shrinkage marked L.S.

Type of Test	**LL**		**LL**		**LL**		**LL**		**LL**	
No. of Blows/shrinkage %	46.00		35.00		25.00		16.00		8.00	
Container No.	IA		ZU		YZ		CV		HI	
Wt of wet soil & container (g)	55.20		59.00		58.50		57.80		59.20	
Wt of dried soil & container (g)	41.50		44.10		44.20		42.80		44.90	
Wt of container (g)	15.80		16.20		17.50		15.50		18.90	
Wt of dry soil (Wd) (g)	25.70		27.90		26.70		27.30		26.00	
Wt of moisture (Wm) (g)	13.70		14.90		14.30		15.00		14.30	
Moisture contain 100 (Wm/Wd)	53.31		53.41		53.56		54.95		55.00	
Type of Test		**PL**		**PL**		**PL**		**PL**		**PL**
No. of Blows/shrinkage %										
Container No.		EM		OH		ZA				
Wt of wet soil & container (g)		26.20		26.80		27.80				
Wt of dried soil & container (g)		24.50		25.10		25.80				
Wt of container (g)		18.00		18.80		17.50				
Wt of dry soil (Wd) (g)		6.50		6.30		8.30				
Wt of moisture (Wm) (g)		1.70		1.70		2.00				
Moisture contain 100 (Wm/Wd)		26.15		26.98		24.10				



LIQUID AND PLASTIC LIMITS,LINEAR SHRINKAGE

Sample No. **BOILER, BH1, 1.0m...** Liquid Limit **: 50.15** Plastic Limit**: 27.44**

Date**: 25/06/2018……….** Plastic Index**: 22.71...** Linear Shrinkage

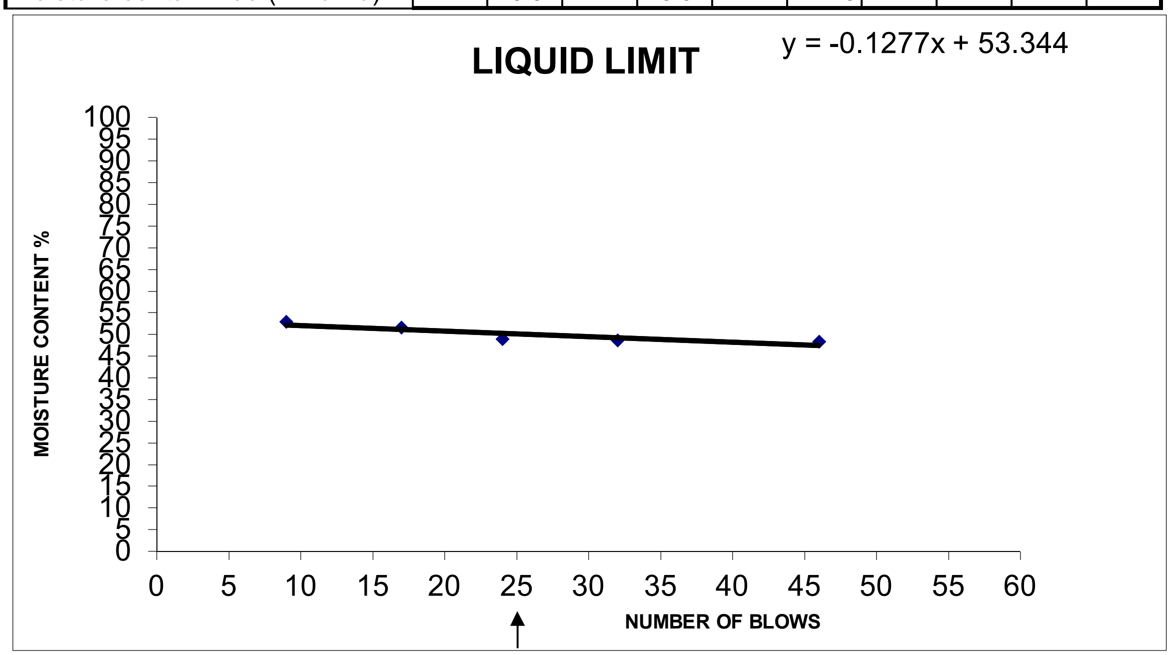
Job**….** Description of Soil…

Site**: OKOMU……**

L.L. Machine No.................... Operator.....................................

Proportion of sample retained on No. 36 B.S. Steve = Per cent
No. of blows refers to liquid limit determination.
Shrinkage % refers to linear Shrinkage.
Liquid limit marked L.L. plastic limit marked P.L. Linear shrinkage marked L.S.

Type of Test	**LL**		**LL**		**LL**		**LL**		**LL**	
No. of Blows/shrinkage %	46.00		32.00		24.00		17.00		9.00	
Container No.	CO		ZU		RB		7Z		8Z	
Wt of wet soil & container (g)	56.70		55.10		55.10		56.20		59.20	
Wt of dried soil & container (g)	43.90		42.20		42.00		43.40		43.70	
Wt of container (g)	17.40		15.70		15.20		18.60		14.40	
Wt of dry soil (Wd) (g)	26.50		26.50		26.80		24.80		29.30	
Wt of moisture (Wm) (g)	12.80		12.90		13.10		12.80		15.50	
Moisture contain 100 (Wm/Wd)	48.30		48.68		48.88		51.61		52.90	
Type of Test		**PL**		**PL**		**PL**		**PL**		**PL**
No. of Blows/shrinkage %										
Container No.		PP		RI		PX				
Wt of wet soil & container (g)		26.10		25.80		25.40				
Wt of dried soil & container (g)		23.90		23.80		23.40				
Wt of container (g)		16.20		16.10		16.20				
Wt of dry soil (Wd) (g)		7.70		7.70		7.20				
Wt of moisture (Wm) (g)		2.20		2.00		2.00				
Moisture contain 100 (Wm/Wd)		28.57		25.97		27.78				



LIQUID AND PLASTIC LIMITS,LINEAR SHRINKAGE

Sample No. **BOILER, BH1, 3.0m...** Liquid Limit **: 52.13** Plastic Limit**: 27.79**

Date**: 25/06/2018……….** Plastic Index**: 24.33...** Linear Shrinkage

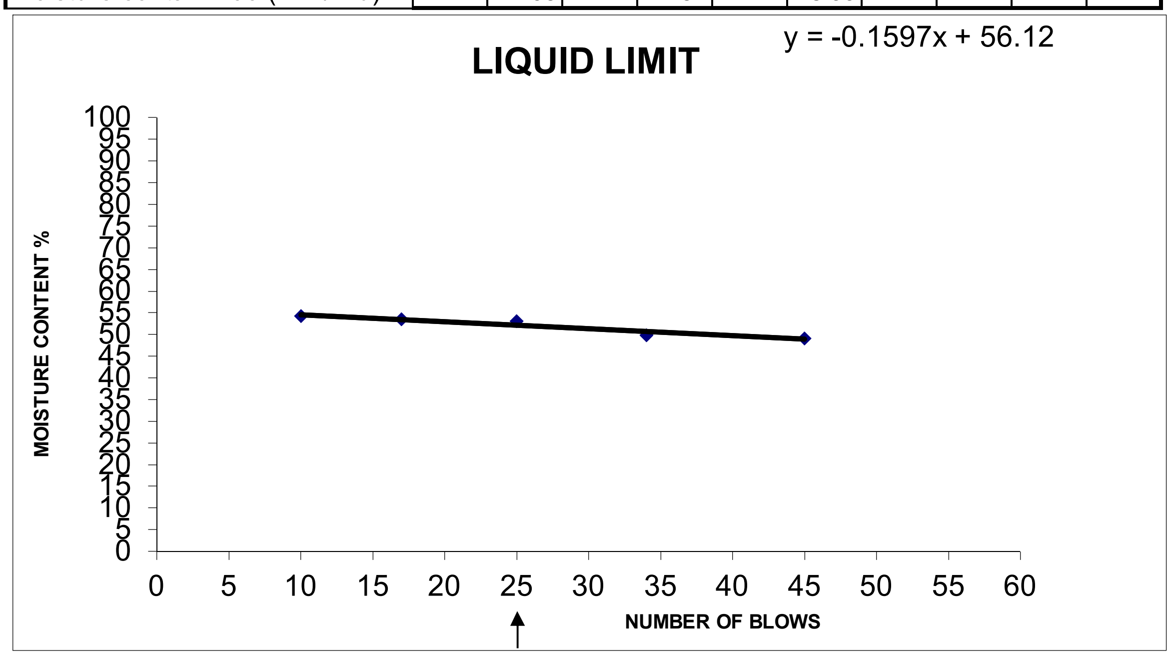
Job**….** Description of Soil…

Site**: OKOMU……**

L.L. Machine No.................... Operator.....................................

Proportion of sample retained on No. 36 B.S. Steve = Per cent
No. of blows refers to liquid limit determination.
Shrinkage % refers to linear Shrinkage.
Liquid limit marked L.L. plastic limit marked P.L. Linear shrinkage marked L.S.

Type of Test	**LL**		**LL**		**LL**		**LL**		**LL**	
No. of Blows/shrinkage %	45.00		34.00		25.00		17.00		10.00	
Container No.	ON		P5		MP		QP		VC	
Wt of wet soil & container (g)	58.00		58.10		55.70		52.60		58.80	
Wt of dried soil & container (g)	43.70		44.20		42.50		40.20		43.50	
Wt of container (g)	14.60		16.30		17.60		17.00		15.30	
Wt of dry soil (Wd) (g)	29.10		27.90		24.90		23.20		28.20	
Wt of moisture (Wm) (g)	14.30		13.90		13.20		12.40		15.30	
Moisture contain 100 (Wm/Wd)	49.14		49.82		53.01		53.45		54.26	
Type of Test		**PL**		**PL**		**PL**		**PL**		**PL**
No. of Blows/shrinkage %										
Container No.		EE		TT		MA				
Wt of wet soil & container (g)		26.30		27.40		24.00				
Wt of dried soil & container (g)		24.30		24.80		22.00				
Wt of container (g)		16.90		15.30		15.10				
Wt of dry soil (Wd) (g)		7.40		9.50		6.90				
Wt of moisture (Wm) (g)		2.00		2.60		2.00				
Moisture contain 100 (Wm/Wd)		27.03		27.37		28.99				



LIQUID AND PLASTIC LIMITS,LINEAR SHRINKAGE

Sample No. **BOILER, BH1, 6.0m...** Liquid Limit **: 49.32** Plastic Limit**: 25.47**

Date**: 25/06/2018……….** Plastic Index**: 23..85...** Linear Shrinkage

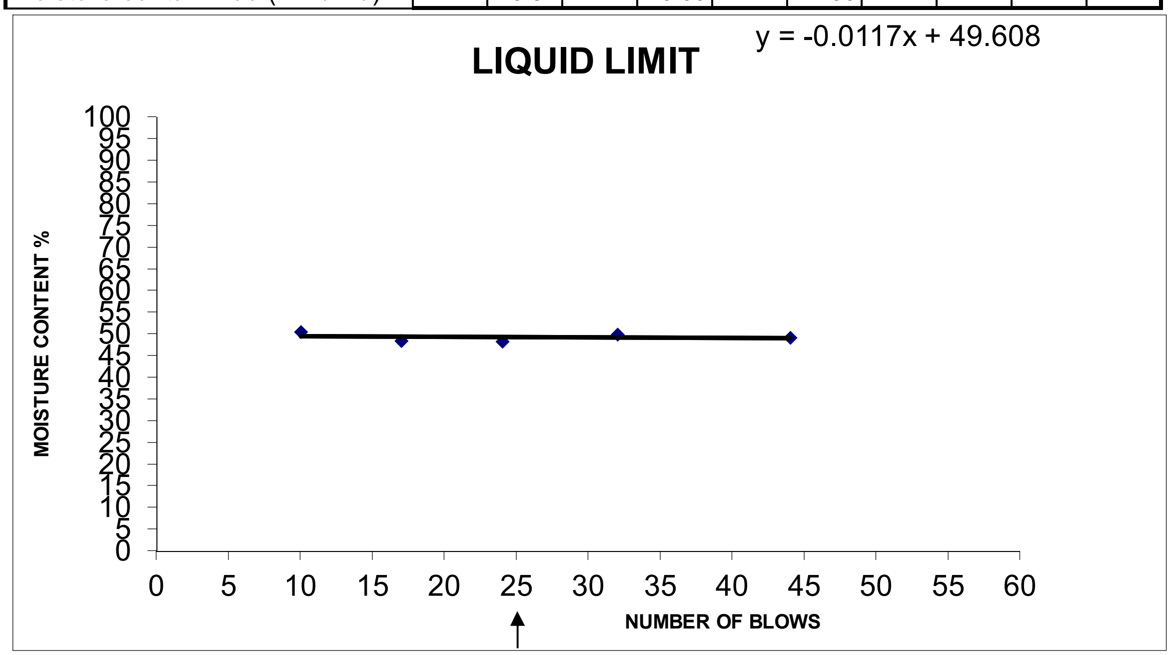
Job**….** Description of Soil…

Site**: OKOMU……**

L.L. Machine No.................... Operator....................................

Proportion of sample retained on No. 36 B.S. Steve = Per cent
No. of blows refers to liquid limit determination.
Shrinkage % refers to linear Shrinkage.
Liquid limit marked L.L. plastic limit marked P.L. Linear shrinkage marked L.S.

Type of Test	**LL**		**LL**		**LL**		**LL**		**LL**	
No. of Blows/shrinkage %	44.00		32.00		24.00		17.00		10.00	
Container No.	TM		NM		OY		WR		TT	
Wt of wet soil & container (g)	54.80		49.00		45.30		51.40		57.00	
Wt of dried soil & container (g)	42.40		37.80		35.40		40.00		43.00	
Wt of container (g)	17.20		15.40		14.90		16.50		15.30	
Wt of dry soil (Wd) (g)	25.20		22.40		20.50		23.50		27.70	
Wt of moisture (Wm) (g)	12.40		11.20		9.90		11.40		14.00	
Moisture contain 100 (Wm/Wd)	49.21		50.00		48.29		48.51		50.54	
Type of Test		**PL**		**PL**		**PL**		**PL**		**PL**
No. of Blows/shrinkage %										
Container No.		FY		UM		SG				
Wt of wet soil & container (g)		25.30		23.30		25.80				
Wt of dried soil & container (g)		23.80		21.50		24.60				
Wt of container (g)		18.10		14.60		19.60				
Wt of dry soil (Wd) (g)		5.70		6.90		5.00				
Wt of moisture (Wm) (g)		1.50		1.80		1.20				
Moisture contain 100 (Wm/Wd)		26.32		26.09		24.00				



LIQUID AND PLASTIC LIMITS,LINEAR SHRINKAGE

Sample No**. CLARIFICATION STATION, BH3, 2.5m...** Liquid Limit **: 47.28** Plastic Limit**: 27.97**

Date**: 25/06/2018……….** Plastic Index**: 20.31...** Linear Shrinkage

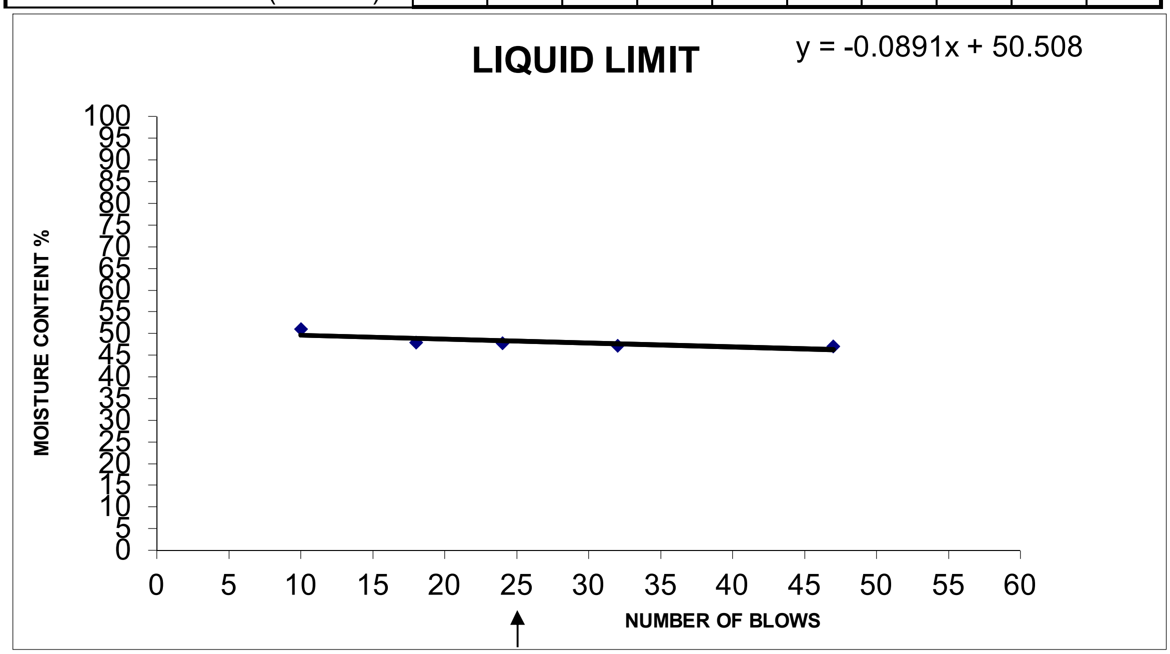
Job**….** Description of Soil…

Site**: OKOMU……**

L.L. Machine No.................... Operator.....................................

Proportion of sample retained on No. 36 B.S. Steve = Per cent
No. of blows refers to liquid limit determination.
Shrinkage % refers to linear Shrinkage.
Liquid limit marked L.L. plastic limit marked P.L. Linear shrinkage marked L.S.

Type of Test	**LL**		**LL**		**LL**		**LL**		**LL**	
No. of Blows/shrinkage %	47.00		32.00		24.00		18.00		10.00	
Container No.	PO		CN		Z6		OG		7Z	
Wt of wet soil & container (g)	55.90		56.80		58.40		55.10		58.50	
Wt of dried soil & container (g)	43.00		43.60		45.60		42.80		43.50	
Wt of container (g)	15.60		15.60		18.80		17.10		14.10	
Wt of dry soil (Wd) (g)	27.40		28.00		26.80		25.70		29.40	
Wt of moisture (Wm) (g)	12.90		13.20		12.80		12.30		15.00	
Moisture contain 100 (Wm/Wd)	47.08		47.14		47.76		47.86		51.02	
Type of Test		**PL**		**PL**		**PL**		**PL**		**PL**
No. of Blows/shrinkage %										
Container No.		TA		AL		X				
Wt of wet soil & container (g)		28.10		24.90		25.20				
Wt of dried soil & container (g)		26.30		22.80		23.60				
Wt of container (g)		20.00		15.10		17.90				
Wt of dry soil (Wd) (g)		6.30		7.70		5.70				
Wt of moisture (Wm) (g)		1.80		2.10		1.60				
Moisture contain 100 (Wm/Wd)		28.57		27.27		28.07				



LIQUID AND PLASTIC LIMITS,LINEAR SHRINKAGE

Sample No. **CLARIFICATION STATION, BH3, 14.5m...** Liquid Limit **: 52.51** Plastic Limit**: 30.23**

Date**: 25/06/2018……….** Plastic Index**: 22.27...** Linear Shrinkage

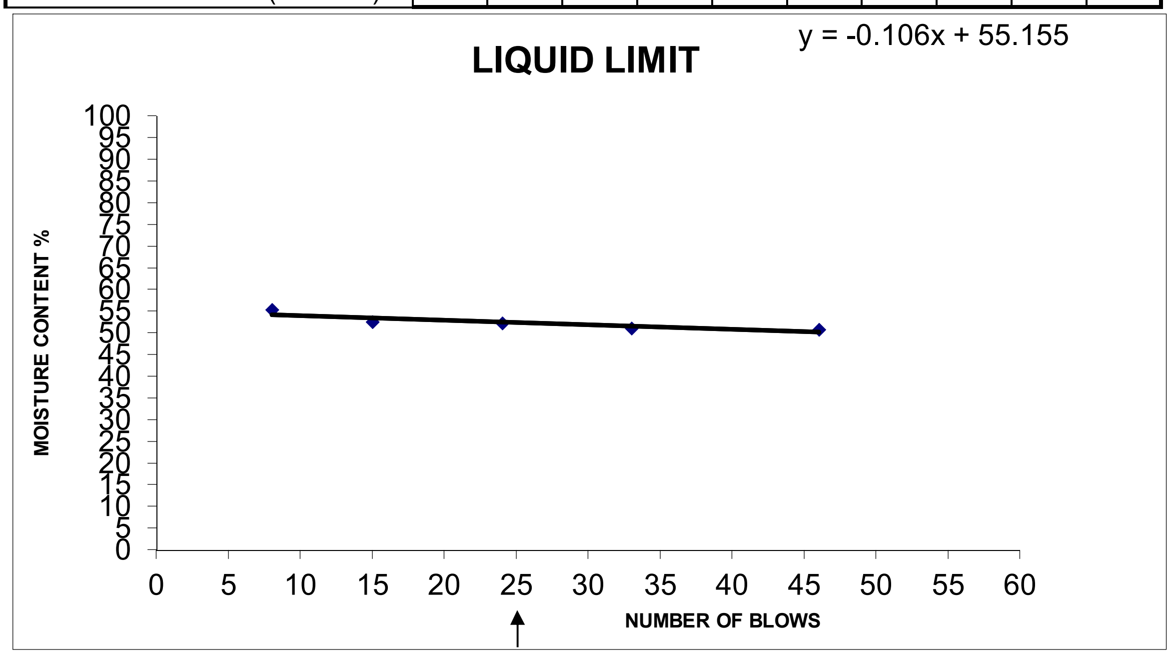
Job**….** Description of Soil…

Site**: OKOMU……**

L.L. Machine No.................... Operator....................................

Proportion of sample retained on No. 36 B.S. Steve = Per cent
No. of blows refers to liquid limit determination.
Shrinkage % refers to linear Shrinkage.
Liquid limit marked L.L. plastic limit marked P.L. Linear shrinkage marked L.S.

Type of Test	**LL**		**LL**		**LL**		**LL**		**LL**	
No. of Blows/shrinkage %	46.00		33.00		24.00		15.00		8.00	
Container No.	NN		RZ		IP		PI		KK	
Wt of wet soil & container (g)	57.30		60.50		59.30		56.90		55.80	
Wt of dried soil & container (g)	43.30		46.90		44.70		43.20		42.90	
Wt of container (g)	15.80		20.30		16.80		17.20		19.60	
Wt of dry soil (Wd) (g)	27.50		26.60		27.90		26.00		23.30	
Wt of moisture (Wm) (g)	14.00		13.60		14.60		13.70		12.90	
Moisture contain 100 (Wm/Wd)	50.91		51.13		52.33		52.69		55.36	
Type of Test		**PL**		**PL**		**PL**		**PL**		**PL**
No. of Blows/shrinkage %										
Container No.		IA		A		8Z				
Wt of wet soil & container (g)		25.40		26.70		26.60				
Wt of dried soil & container (g)		23.00		24.10		24.00				
Wt of container (g)		15.30		15.70		14.90				
Wt of dry soil (Wd) (g)		7.70		8.40		9.10				
Wt of moisture (Wm) (g)		2.40		2.60		2.60				
Moisture contain 100 (Wm/Wd)		31.17		30.95		28.57				



LIQUID AND PLASTIC LIMITS,LINEAR SHRINKAGE

Sample No**. POWER HOUSE, BH2, 2.0m....** Liquid Limit **: 49.29** Plastic Limit**: 23.37**

Date**: 25/06/2018……….** Plastic Index**: 25.92...** Linear Shrinkage

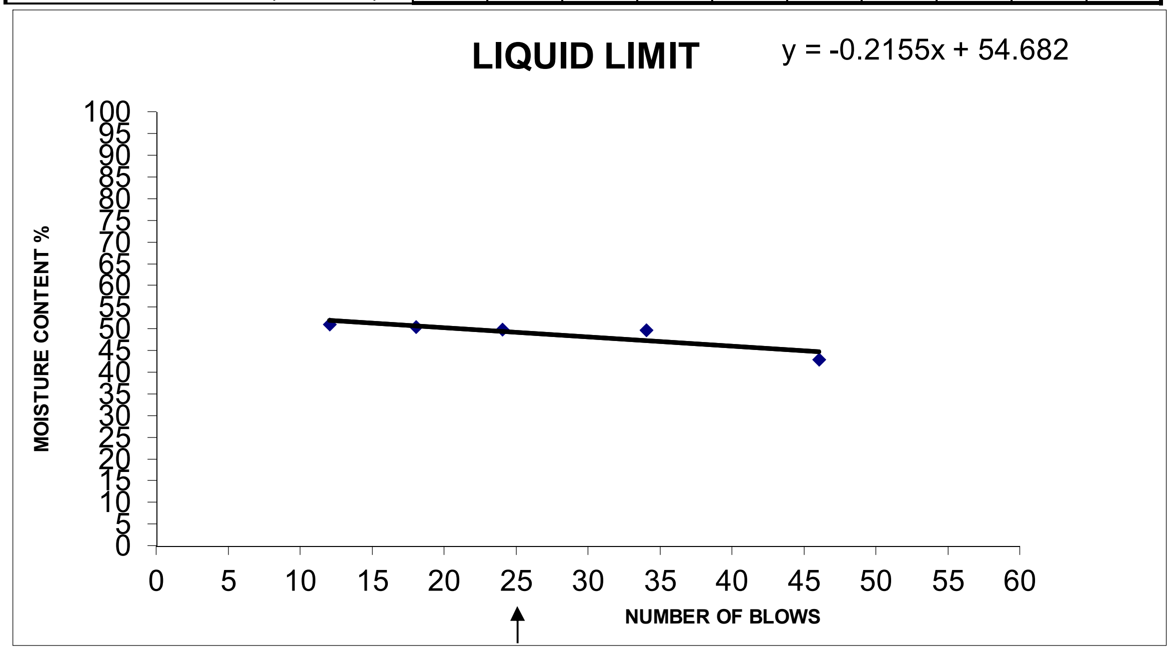
Job**….** Description of Soil…

Site**: OKOMU……**

L.L. Machine No.................... Operator....................................

Proportion of sample retained on No. 36 B.S. Steve = Per cent
No. of blows refers to liquid limit determination.
Shrinkage % refers to linear Shrinkage.
Liquid limit marked L.L. plastic limit marked P.L. Linear shrinkage marked L.S.

Type of Test	**LL**		**LL**		**LL**		**LL**		**LL**	
No. of Blows/shrinkage %	46.00		34.00		24.00		18.00		12.00	
Container No.	AL		9O		OR		IZ		IB	
Wt of wet soil & container (g)	55.70		52.40		58.10		54.60		57.20	
Wt of dried soil & container (g)	43.60		40.30		43.60		41.30		43.40	
Wt of container (g)	15.50		16.00		14.60		15.00		16.40	
Wt of dry soil (Wd) (g)	28.10		24.30		29.00		26.30		27.00	
Wt of moisture (Wm) (g)	12.10		12.10		14.50		13.30		13.80	
Moisture contain 100 (Wm/Wd)	43.06		49.79		50.00		50.57		51.11	
Type of Test		**PL**		**PL**		**PL**		**PL**		**PL**
No. of Blows/shrinkage %										
Container No.		OB		CP		EX				
Wt of wet soil & container (g)		24.80		24.40		25.60				
Wt of dried soil & container (g)		23.60		23.00		24.30				
Wt of container (g)		18.40		17.40		18.40				
Wt of dry soil (Wd) (g)		5.20		5.60		5.90				
Wt of moisture (Wm) (g)		1.20		1.40		1.30				
Moisture contain 100 (Wm/Wd)		23.08		25.00		22.03				



LIQUID AND PLASTIC LIMITS,LINEAR SHRINKAGE

Sample No. **POWER HOUSE, BH2, 11.0m....** Liquid Limit **: 50.65** Plastic Limit**: 27.78**

Date**: 25/06/2018……….** Plastic Index**: 22.86...** Linear Shrinkage

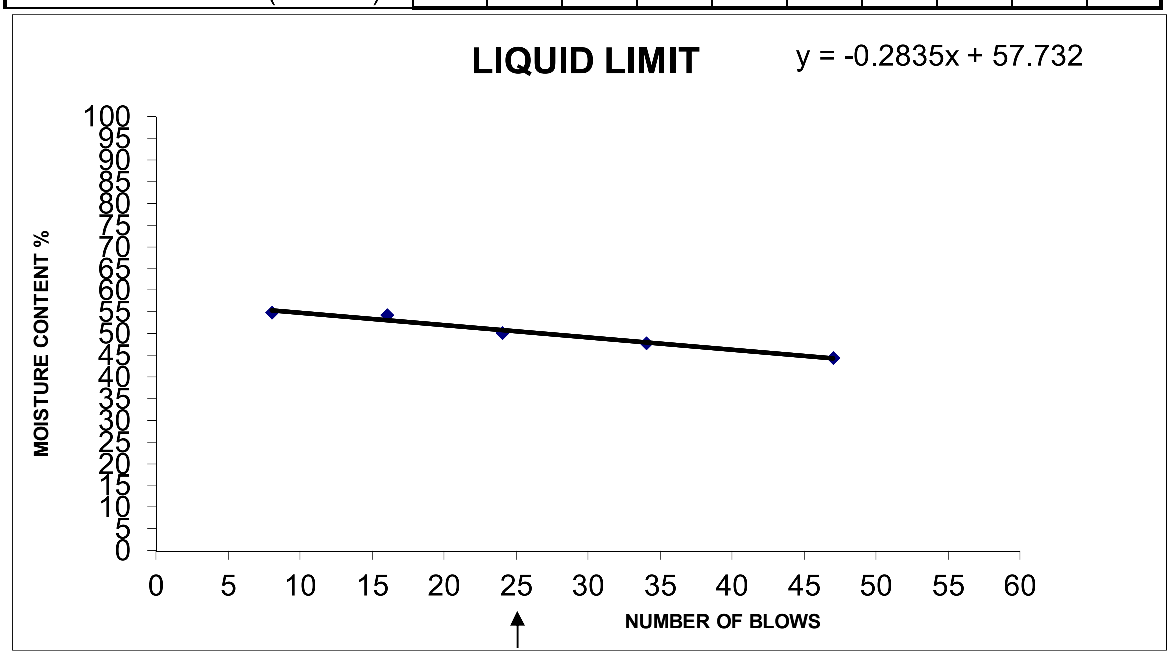
Job**….** Description of Soil…

Site**: OKOMU……**

L.L. Machine No.................... Operator....................................

Proportion of sample retained on No. 36 B.S. Steve = Per cent
No. of blows refers to liquid limit determination.
Shrinkage % refers to linear Shrinkage.
Liquid limit marked L.L. plastic limit marked P.L. Linear shrinkage marked L.S.

Type of Test	**LL**		**LL**		**LL**		**LL**		**LL**	
No. of Blows/shrinkage %	47.00		34.00		24.00		16.00		8.00	
Container No.	IA		GG		VO		CA		AL	
Wt of wet soil & container (g)	51.60		46.50		51.10		58.00		52.70	
Wt of dried soil & container (g)	40.50		36.30		40.00		43.90		39.40	
Wt of container (g)	15.60		15.00		17.90		18.00		15.20	
Wt of dry soil (Wd) (g)	24.90		21.30		22.10		25.90		24.20	
Wt of moisture (Wm) (g)	11.10		10.20		11.10		14.10		13.30	
Moisture contain 100 (Wm/Wd)	44.58		47.89		50.23		54.44		54.96	
Type of Test		**PL**		**PL**		**PL**		**PL**		**PL**
No. of Blows/shrinkage %										
Container No.		LI		JO		PK				
Wt of wet soil & container (g)		26.10		24.10		24.90				
Wt of dried soil & container (g)		24.70		22.00		22.90				
Wt of container (g)		19.60		14.90		15.30				
Wt of dry soil (Wd) (g)		5.10		7.10		7.60				
Wt of moisture (Wm) (g)		1.40		2.10		2.00				
Moisture contain 100 (Wm/Wd)		27.45		29.58		26.32				



LIQUID AND PLASTIC LIMITS,LINEAR SHRINKAGE

Sample No**. POWER HOUSE, BH2, 15.0m....** Liquid Limit **: 45.23** Plastic Limit**: 25.69**

Date**: 25/06/2018……….** Plastic Index**: 22.54...** Linear Shrinkage

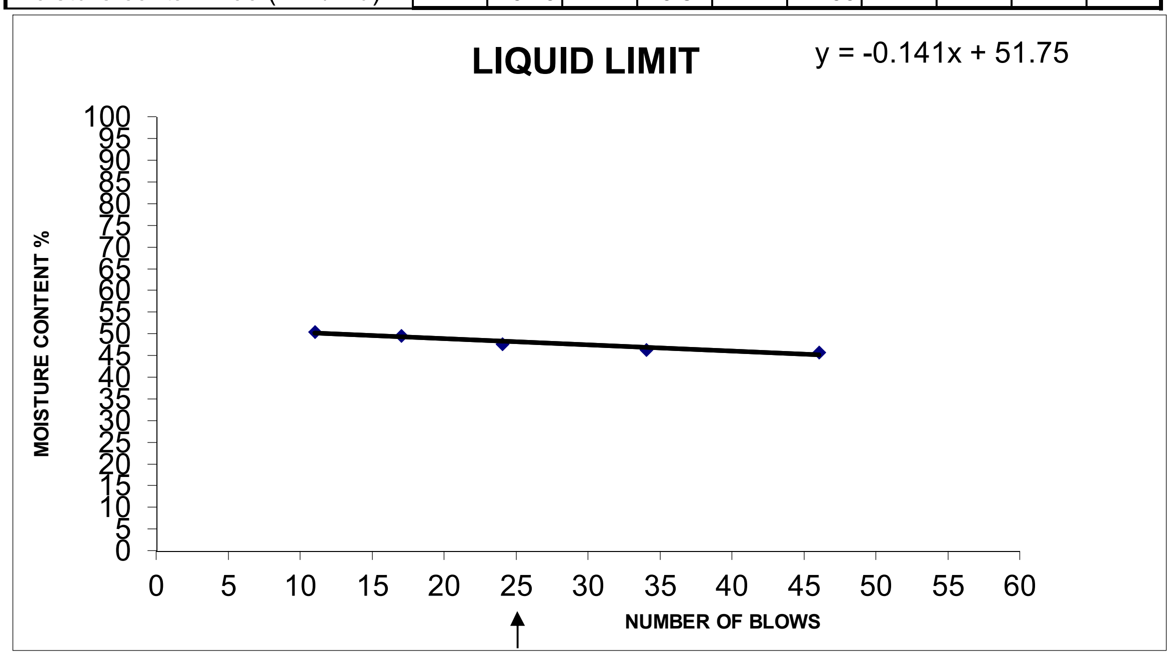
Job**….** Description of Soil…

Site**: OKOMU……**

L.L. Machine No.................... Operator.....................................

Proportion of sample retained on No. 36 B.S. Steve = Per cent
No. of blows refers to liquid limit determination.
Shrinkage % refers to linear Shrinkage.
Liquid limit marked L.L. plastic limit marked P.L. Linear shrinkage marked L.S.

Type of Test	**LL**		**LL**		**LL**		**LL**		**LL**	
No. of Blows/shrinkage %	46.00		34.00		24.00		17.00		11.00	
Container No.	PP		EM		TA		IZ		OF	
Wt of wet soil & container (g)	47.40		51.10		48.90		54.60		59.20	
Wt of dried soil & container (g)	37.10		39.90		39.50		41.60		45.50	
Wt of container (g)	14.60		15.80		19.80		15.40		18.40	
Wt of dry soil (Wd) (g)	22.50		24.10		19.70		26.20		27.10	
Wt of moisture (Wm) (g)	10.30		11.20		9.40		13.00		13.70	
Moisture contain 100 (Wm/Wd)	45.78		46.47		47.72		49.62		50.55	
Type of Test		**PL**		**PL**		**PL**		**PL**		**PL**
No. of Blows/shrinkage %										
Container No.		PA		KK		I9				
Wt of wet soil & container (g)		28.50		26.40		28.60				
Wt of dried soil & container (g)		26.30		24.60		26.80				
Wt of container (g)		17.90		17.90		19.30				
Wt of dry soil (Wd) (g)		8.40		6.70		7.50				
Wt of moisture (Wm) (g)		2.20		1.80		1.80				
Moisture contain 100 (Wm/Wd)		26.19		26.87		24.00				



LIQUID AND PLASTIC LIMITS,LINEAR SHRINKAGE

Sample No. **PRESSING STATION, BH5, 7.5m...** Liquid Limit **: 53.32** Plastic Limit**: 26.85**

Date**: 25/06/2018……….** Plastic Index**: 26.46...** Linear Shrinkage

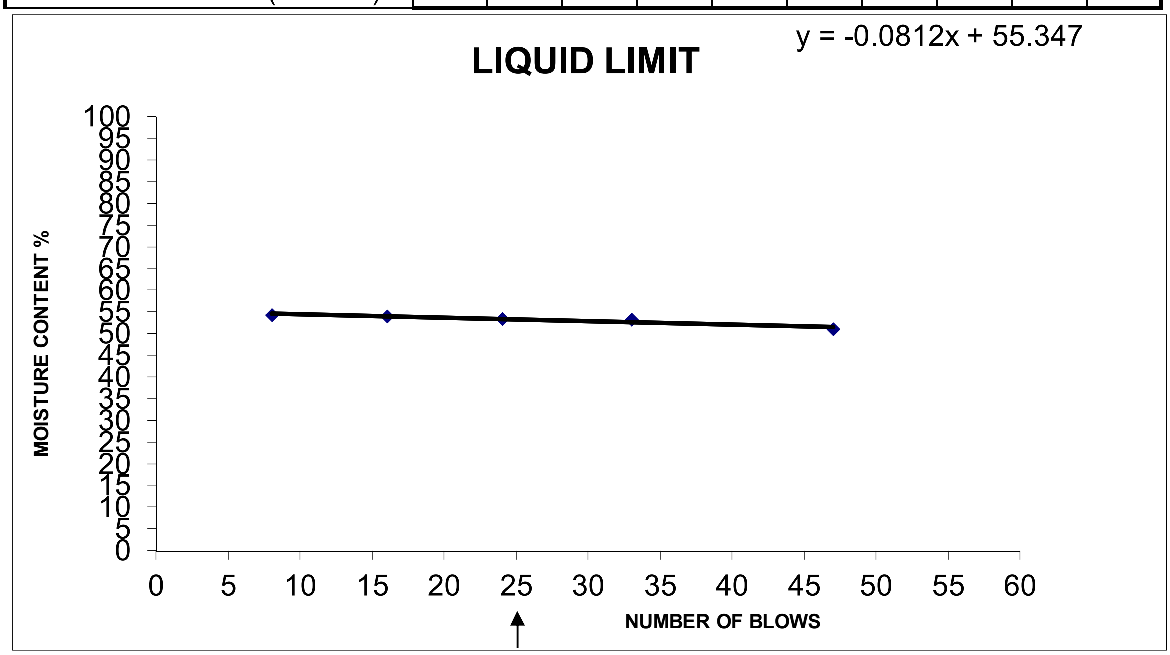
Job**….** Description of Soil…

Site**: OKOMU……**

L.L. Machine No.................... Operator....................................

Proportion of sample retained on No. 36 B.S. Steve = Per cent
No. of blows refers to liquid limit determination.
Shrinkage % refers to linear Shrinkage.
Liquid limit marked L.L. plastic limit marked P.L. Linear shrinkage marked L.S.

Type of Test	**LL**		**LL**		**LL**		**LL**		**LL**	
No. of Blows/shrinkage %	47.00		33.00		24.00		16.00		8.00	
Container No.	A9		LO		PB		UZ		ZA	
Wt of wet soil & container (g)	56.60		54.90		54.60		57.30		53.70	
Wt of dried soil & container (g)	42.40		42.00		41.40		44.30		41.20	
Wt of container (g)	14.60		17.80		16.70		20.30		18.20	
Wt of dry soil (Wd) (g)	27.80		24.20		24.70		24.00		23.00	
Wt of moisture (Wm) (g)	14.20		12.90		13.20		13.00		12.50	
Moisture contain 100 (Wm/Wd)	51.08		53.31		53.44		54.17		54.35	
Type of Test		**PL**		**PL**		**PL**		**PL**		**PL**
No. of Blows/shrinkage %										
Container No.		CA		OS		ON				
Wt of wet soil & container (g)		27.30		24.80		26.60				
Wt of dried soil & container (g)		25.20		23.00		24.60				
Wt of container (g)		17.80		16.30		16.70				
Wt of dry soil (Wd) (g)		7.40		6.70		7.90				
Wt of moisture (Wm) (g)		2.10		1.80		2.00				
Moisture contain 100 (Wm/Wd)		28.38		26.87		25.32				



LIQUID AND PLASTIC LIMITS,LINEAR SHRINKAGE

Sample No. **PRESSING STATION, BH5, 14.5m...** Liquid Limit **: 51.30** Plastic Limit**: 28.67**

Date**: 25/06/2018……….** Plastic Index**: 22.63...** Linear Shrinkage

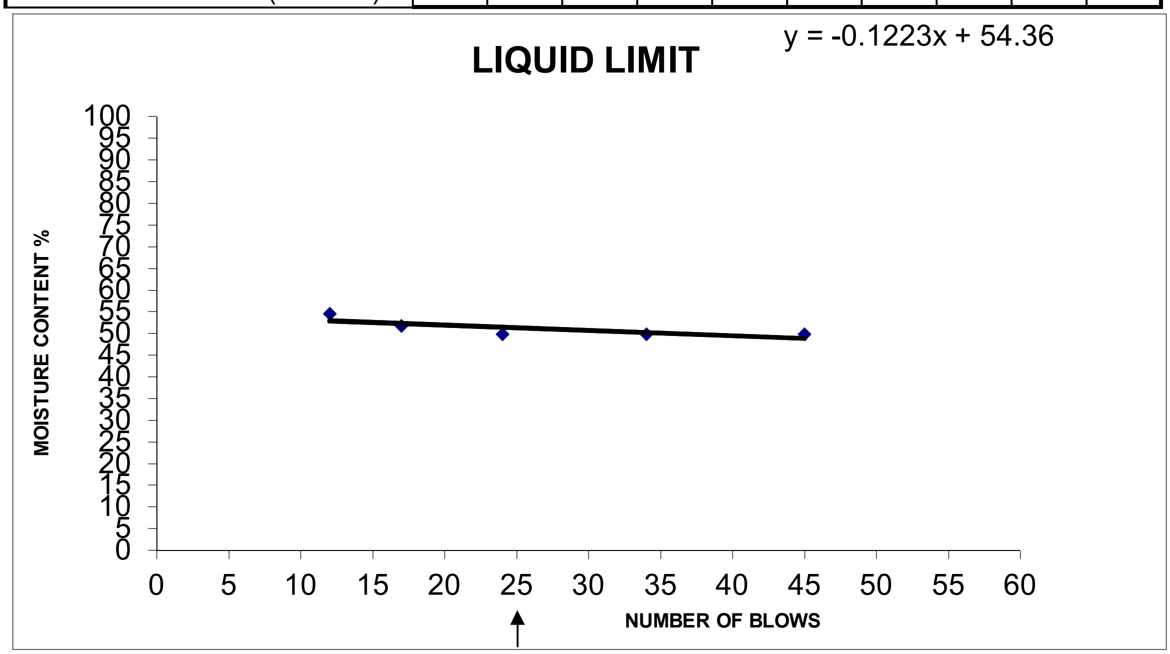
Job**….** Description of Soil…

Site**: OKOMU……**

L.L. Machine No.................... Operator....................................

Proportion of sample retained on No. 36 B.S. Steve = Per cent
No. of blows refers to liquid limit determination.
Shrinkage % refers to linear Shrinkage.
Liquid limit marked L.L. plastic limit marked P.L. Linear shrinkage marked L.S.

Type of Test	**LL**		**LL**		**LL**		**LL**		**LL**	
No. of Blows/shrinkage %	45.00		34.00		24.00		17.00		12.00	
Container No.	EM		7Z		BO		FR		4TH	
Wt of wet soil & container (g)	54.30		56.00		56.60		53.20		57.10	
Wt of dried soil & container (g)	42.90		42.90		43.50		40.10		42.50	
Wt of container (g)	20.00		16.60		17.20		14.80		15.70	
Wt of dry soil (Wd) (g)	22.90		26.30		26.30		25.30		26.80	
Wt of moisture (Wm) (g)	11.40		13.10		13.10		13.10		14.60	
Moisture contain 100 (Wm/Wd)	49.78		49.81		49.81		51.78		54.48	
Type of Test		**PL**		**PL**		**PL**		**PL**		**PL**
No. of Blows/shrinkage %										
Container No.		MA		JA		MO				
Wt of wet soil & container (g)		25.20		27.80		25.00				
Wt of dried soil & container (g)		23.00		25.60		23.10				
Wt of container (g)		15.00		18.20		16.50				
Wt of dry soil (Wd) (g)		8.00		7.40		6.60				
Wt of moisture (Wm) (g)		2.20		2.20		1.90				
Moisture contain 100 (Wm/Wd)		27.50		29.73		28.79				



LIQUID AND PLASTIC LIMITS,LINEAR SHRINKAGE

Sample No. **RAMP 1, BH9, 2.0m...** Liquid Limit **: 54.63** Plastic Limit**: 27.44**

Date**: 25/06/2018……….** Plastic Index**: 27.19...** Linear Shrinkage

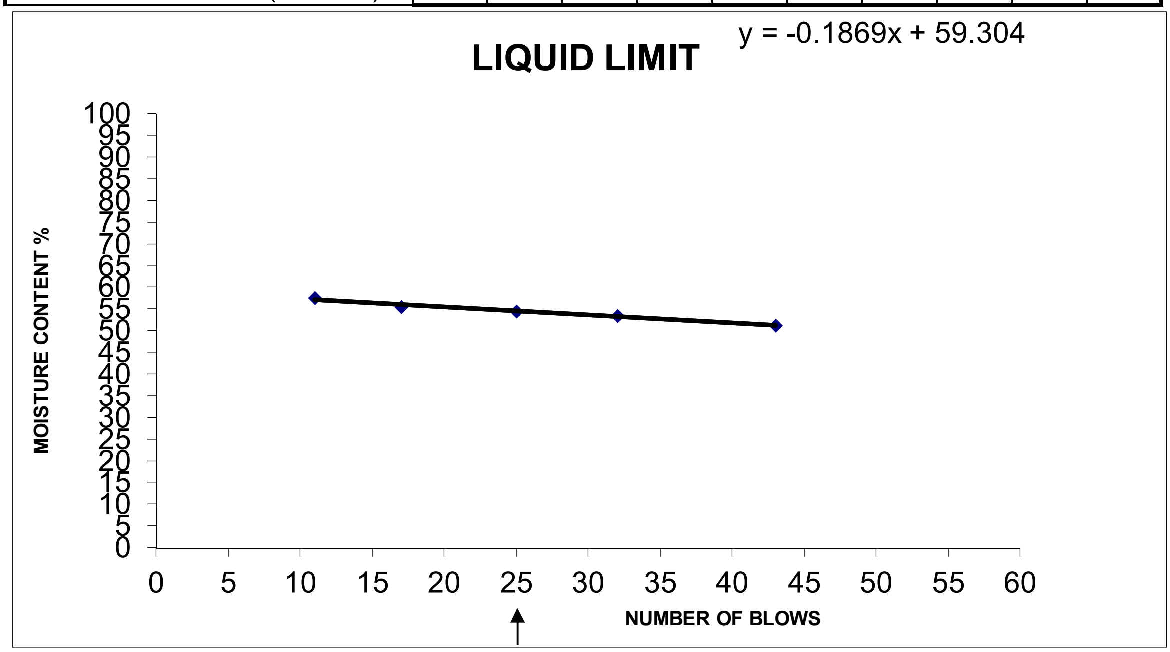
Job**….** Description of Soil…

Site**: OKOMU……**

L.L. Machine No.................... Operator.....................................

Proportion of sample retained on No. 36 B.S. Steve = Per cent
No. of blows refers to liquid limit determination.
Shrinkage % refers to linear Shrinkage.
Liquid limit marked L.L. plastic limit marked P.L. Linear shrinkage marked L.S.

Type of Test	**LL**		**LL**		**LL**		**LL**		**LL**	
No. of Blows/shrinkage %	43.00		32.00		25.00		17.00		11.00	
Container No.	II		EX		KI		IK		B4	
Wt of wet soil & container (g)	53.30		50.90		58.00		48.30		50.00	
Wt of dried soil & container (g)	40.90		39.60		43.70		36.40		38.85	
Wt of container (g)	16.70		18.50		17.50		15.00		19.50	
Wt of dry soil (Wd) (g)	24.20		21.10		26.20		21.40		19.35	
Wt of moisture (Wm) (g)	12.40		11.30		14.30		11.90		11.15	
Moisture contain 100 (Wm/Wd)	51.24		53.55		54.58		55.61		57.62	
Type of Test		**PL**		**PL**		**PL**		**PL**		**PL**
No. of Blows/shrinkage %										
Container No.		Z		OB		UB				
Wt of wet soil & container (g)		24.30		26.60		23.90				
Wt of dried soil & container (g)		22.30		24.80		22.10				
Wt of container (g)		15.20		18.30		15.30				
Wt of dry soil (Wd) (g)		7.10		6.50		6.80				
Wt of moisture (Wm) (g)		2.00		1.80		1.80				
Moisture contain 100 (Wm/Wd)		28.17		27.69		26.47				



LIQUID AND PLASTIC LIMITS,LINEAR SHRINKAGE

Sample No. **RAMP 1, BH9, 5.0m...** Liquid Limit **: 56.70** Plastic Limit**: 31.28**

Date**: 25/06/2018……….** Plastic Index**: 25.43...** Linear Shrinkage

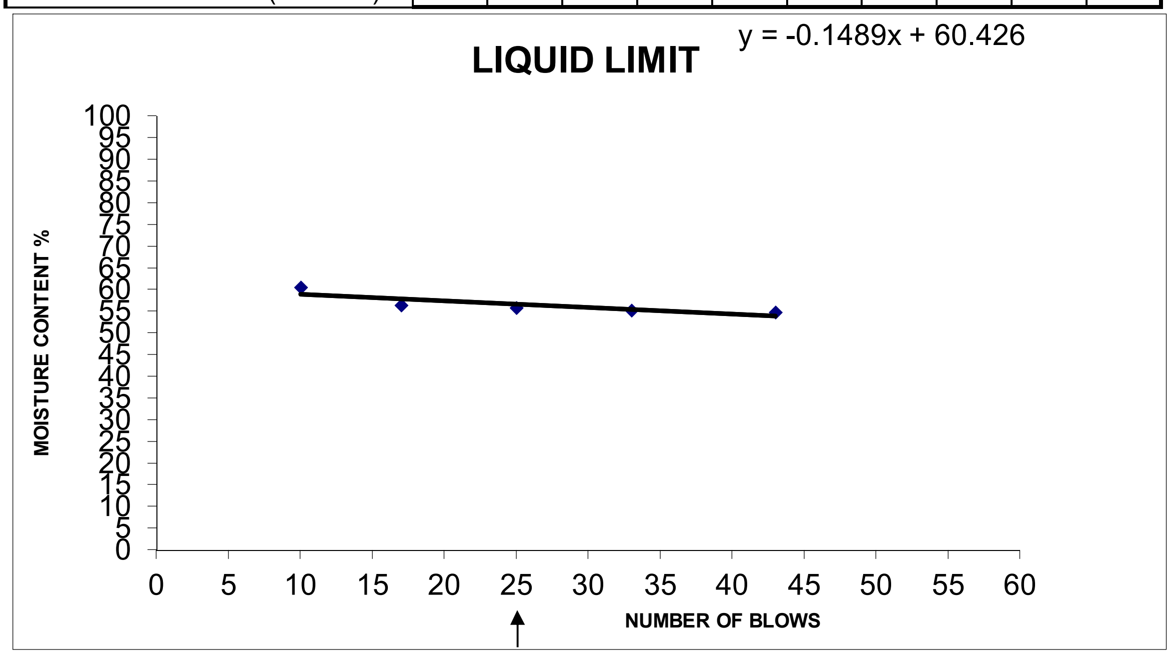
Job**….** Description of Soil…

Site**: OKOMU……**

L.L. Machine No.................... Operator.....................................

Proportion of sample retained on No. 36 B.S. Steve = Per cent
No. of blows refers to liquid limit determination.
Shrinkage % refers to linear Shrinkage.
Liquid limit marked L.L. plastic limit marked P.L. Linear shrinkage marked L.S.

Type of Test	**LL**		**LL**		**LL**		**LL**		**LL**	
No. of Blows/shrinkage %	43.00		33.00		25.00		17.00		10.00	
Container No.	KC		OB		HF		N		8I	
Wt of wet soil & container (g)	48.60		57.50		52.70		53.30		52.40	
Wt of dried soil & container (g)	37.20		43.00		40.40		40.60		39.50	
Wt of container (g)	16.40		16.80		18.40		18.10		18.20	
Wt of dry soil (Wd) (g)	20.80		26.20		22.00		22.50		21.30	
Wt of moisture (Wm) (g)	11.40		14.50		12.30		12.70		12.90	
Moisture contain 100 (Wm/Wd)	54.81		55.34		55.91		56.44		60.56	
Type of Test		**PL**		**PL**		**PL**		**PL**		**PL**
No. of Blows/shrinkage %										
Container No.		LI		PK		MO				
Wt of wet soil & container (g)		27.60		25.20		24.50				
Wt of dried soil & container (g)		25.80		22.90		22.40				
Wt of container (g)		19.50		15.30		16.40				
Wt of dry soil (Wd) (g)		6.30		7.60		6.00				
Wt of moisture (Wm) (g)		1.80		2.30		2.10				
Moisture contain 100 (Wm/Wd)		28.57		30.26		35.00				



LIQUID AND PLASTIC LIMITS,LINEAR SHRINKAGE

Sample No. **RAMP 1, BH9, 8.0m...** Liquid Limit **: 56.17** Plastic Limit**: 28.50**

Date**: 25/06/2018……….** Plastic Index**: 27.67...** Linear Shrinkage

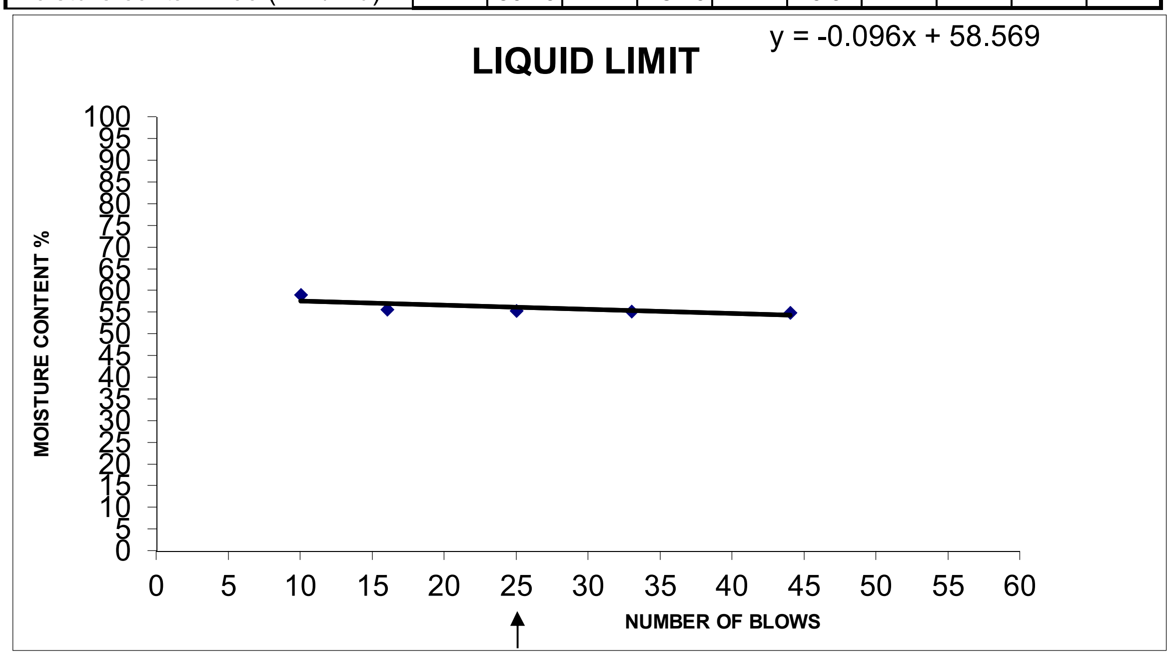
Job**….** Description of Soil…

Site**: OKOMU……**

L.L. Machine No.................... Operator....................................

Proportion of sample retained on No. 36 B.S. Steve = Per cent
No. of blows refers to liquid limit determination.
Shrinkage % refers to linear Shrinkage.
Liquid limit marked L.L. plastic limit marked P.L. Linear shrinkage marked L.S.

Type of Test	**LL**		**LL**		**LL**		**LL**		**LL**	
No. of Blows/shrinkage %	44.00		33.00		25.00		16.00		10.00	
Container No.	HI		VO		F7		AI		8Z	
Wt of wet soil & container (g)	55.80		49.70		53.80		49.20		53.80	
Wt of dried soil & container (g)	42.00		38.20		41.00		37.60		40.50	
Wt of container (g)	16.90		17.40		17.90		16.80		18.00	
Wt of dry soil (Wd) (g)	25.10		20.80		23.10		20.80		22.50	
Wt of moisture (Wm) (g)	13.80		11.50		12.80		11.60		13.30	
Moisture contain 100 (Wm/Wd)	54.98		55.29		55.41		55.77		59.11	
Type of Test		**PL**		**PL**		**PL**		**PL**		**PL**
No. of Blows/shrinkage %										
Container No.		OK		NK		EM				
Wt of wet soil & container (g)		22.40		25.80		27.90				
Wt of dried soil & container (g)		20.80		23.50		25.80				
Wt of container (g)		15.50		15.40		18.00				
Wt of dry soil (Wd) (g)		5.30		8.10		7.80				
Wt of moisture (Wm) (g)		1.60		2.30		2.10				
Moisture contain 100 (Wm/Wd)		30.19		28.40		26.92				



LIQUID AND PLASTIC LIMITS,LINEAR SHRINKAGE

Sample No**. RAMP 1, BH9, 11.0m...** Liquid Limit **: 48.41** Plastic Limit**: 27.23**

Date**: 25/06/2018……….** Plastic Index**: 21.18...** Linear Shrinkage

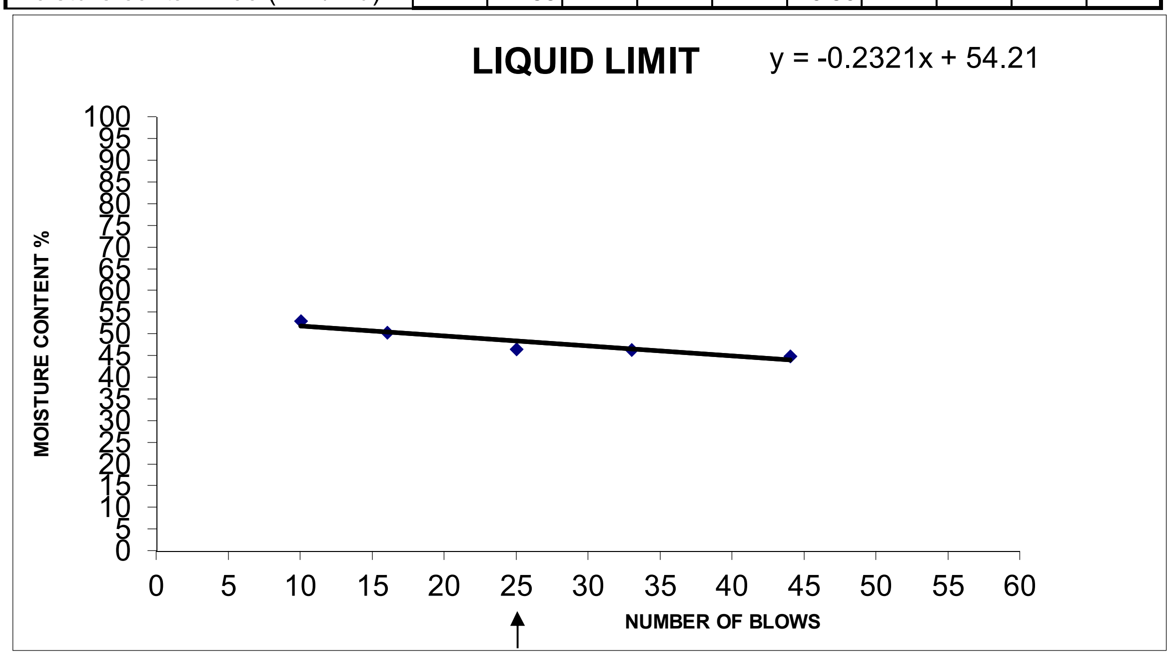
Job**….** Description of Soil…

Site**: OKOMU……**

L.L. Machine No.................... Operator....................................

Proportion of sample retained on No. 36 B.S. Steve = Per cent
No. of blows refers to liquid limit determination.
Shrinkage % refers to linear Shrinkage.
Liquid limit marked L.L. plastic limit marked P.L. Linear shrinkage marked L.S.

Type of Test	**LL**		**LL**		**LL**		**LL**		**LL**	
No. of Blows/shrinkage %	44.00		33.00		25.00		16.00		10.00	
Container No.	PO		P4		TA		BO		PR	
Wt of wet soil & container (g)	53.30		59.50		57.60		58.70		50.80	
Wt of dried soil & container (g)	42.30		45.30		45.10		45.30		39.40	
Wt of container (g)	17.80		14.70		18.30		18.70		17.90	
Wt of dry soil (Wd) (g)	24.50		30.60		26.80		26.60		21.50	
Wt of moisture (Wm) (g)	11.00		14.20		12.50		13.40		11.40	
Moisture contain 100 (Wm/Wd)	44.90		46.41		46.64		50.38		53.02	
Type of Test		**PL**		**PL**				**PL**		**PL**
No. of Blows/shrinkage %										
Container No.		WN		AN		O6				
Wt of wet soil & container (g)		25.50		25.80		23.70				
Wt of dried soil & container (g)		23.30		23.40		22.00				
Wt of container (g)		15.40		14.60		15.60				
Wt of dry soil (Wd) (g)		7.90		8.80		6.40				
Wt of moisture (Wm) (g)		2.20		2.40		1.70				
Moisture contain 100 (Wm/Wd)		27.85		27.27		26.56				



LIQUID AND PLASTIC LIMITS,LINEAR SHRINKAGE

Sample No. **RAMP 11, BH10, 1.5m...** Liquid Limit **: 48.14** Plastic Limit**: 28.19**

Date**: 25/06/2018……….** Plastic Index**: 19.95...** Linear Shrinkage

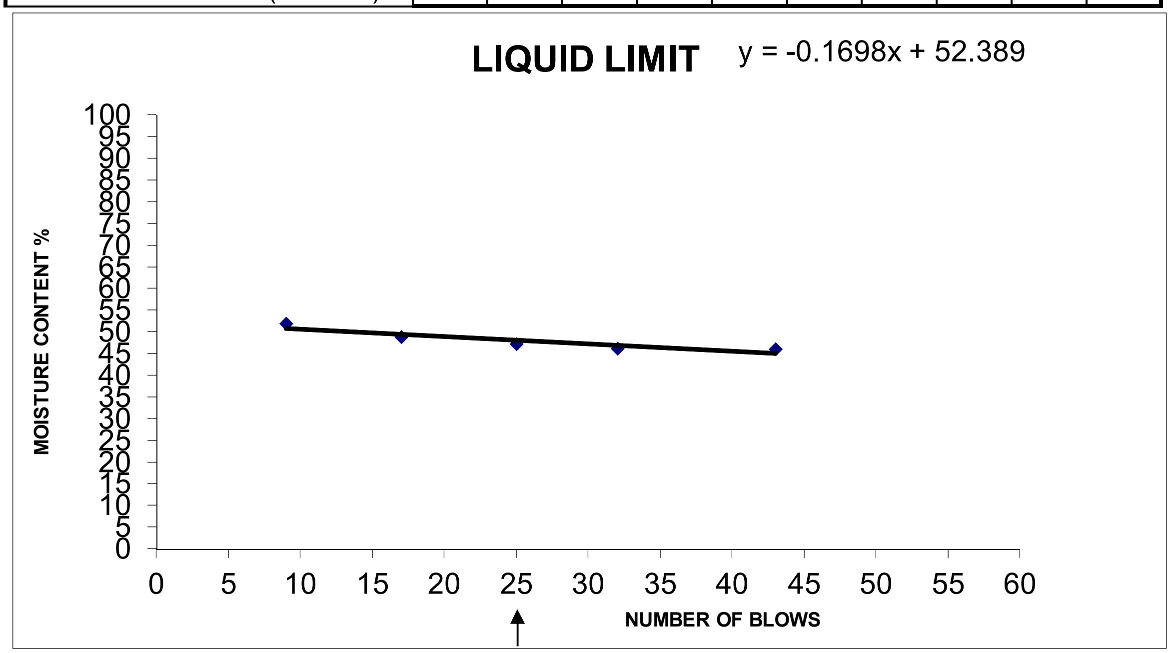
Job**….** Description of Soil…

Site**: OKOMU……**

L.L. Machine No.................... Operator.....................................

Proportion of sample retained on No. 36 B.S. Steve = Per cent
No. of blows refers to liquid limit determination.
Shrinkage % refers to linear Shrinkage.
Liquid limit marked L.L. plastic limit marked P.L. Linear shrinkage marked L.S.

Type of Test	**LL**		**LL**		**LL**		**LL**		**LL**	
No. of Blows/shrinkage %	43.00		32.00		25.00		17.00		9.00	
Container No.	TI		JO		OZ		PI		H	
Wt of wet soil & container (g)	53.10		55.60		58.70		56.90		56.20	
Wt of dried soil & container (g)	40.60		43.40		45.50		43.80		43.30	
Wt of container (g)	13.50		17.00		17.60		17.00		18.50	
Wt of dry soil (Wd) (g)	27.10		26.40		27.90		26.80		24.80	
Wt of moisture (Wm) (g)	12.50		12.20		13.20		13.10		12.90	
Moisture contain 100 (Wm/Wd)	46.13		46.21		47.31		48.88		52.02	
Type of Test		**PL**		**PL**		**PL**		**PL**		**PL**
No. of Blows/shrinkage %										
Container No.		WR		MO		RE				
Wt of wet soil & container (g)		29.30		23.60		26.50				
Wt of dried soil & container (g)		26.60		21.60		24.70				
Wt of container (g)		16.60		15.00		18.10				
Wt of dry soil (Wd) (g)		10.00		6.60		6.60				
Wt of moisture (Wm) (g)		2.70		2.00		1.80				
Moisture contain 100 (Wm/Wd)		27.00		30.30		27.27				



LIQUID AND PLASTIC LIMITS,LINEAR SHRINKAGE

Sample No. **RAMP 11, BH10, 7.5m...** Liquid Limit **: 49.50** Plastic Limit**: 28.46**

Date**: 25/06/2018……….** Plastic Index**: 21.04...** Linear Shrinkage

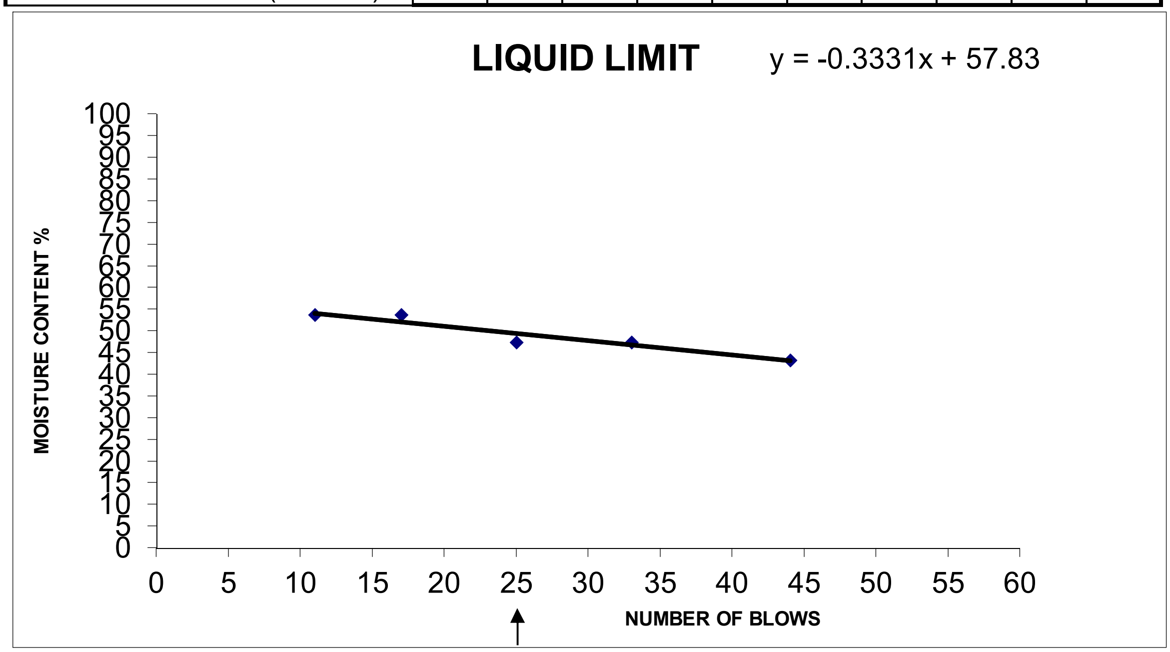
Job**….** Description of Soil…

Site**: OKOMU……**

L.L. Machine No.................... Operator....................................

Proportion of sample retained on No. 36 B.S. Steve = Per cent
No. of blows refers to liquid limit determination.
Shrinkage % refers to linear Shrinkage.
Liquid limit marked L.L. plastic limit marked P.L. Linear shrinkage marked L.S.

Type of Test	**LL**		**LL**		**LL**		**LL**		**LL**	
No. of Blows/shrinkage %	44.00		33.00		25.00		17.00		11.00	
Container No.	4TH		N		UZ		KK		FA	
Wt of wet soil & container (g)	53.20		52.10		55.50		52.70		50.90	
Wt of dried soil & container (g)	42.50		40.00		44.00		39.80		39.60	
Wt of container (g)	17.80		14.50		19.80		15.80		18.60	
Wt of dry soil (Wd) (g)	24.70		25.50		24.20		24.00		21.00	
Wt of moisture (Wm) (g)	10.70		12.10		11.50		12.90		11.30	
Moisture contain 100 (Wm/Wd)	43.32		47.45		47.52		53.75		53.81	
Type of Test		**PL**		**PL**		**PL**		**PL**		**PL**
No. of Blows/shrinkage %										
Container No.		EM		OF		CA				
Wt of wet soil & container (g)		23.60		28.90		26.60				
Wt of dried soil & container (g)		21.80		26.70		24.60				
Wt of container (g)		15.60		18.40		17.90				
Wt of dry soil (Wd) (g)		6.20		8.30		6.70				
Wt of moisture (Wm) (g)		1.80		2.20		2.00				
Moisture contain 100 (Wm/Wd)		29.03		26.51		29.85				



LIQUID AND PLASTIC LIMITS,LINEAR SHRINKAGE

Sample No. **RAMP 11, BH10, 10.5m...** Liquid Limit **: 48.85** Plastic Limit**: 27.23**

Date**: 25/06/2018……….** Plastic Index**: 21.63...** Linear Shrinkage

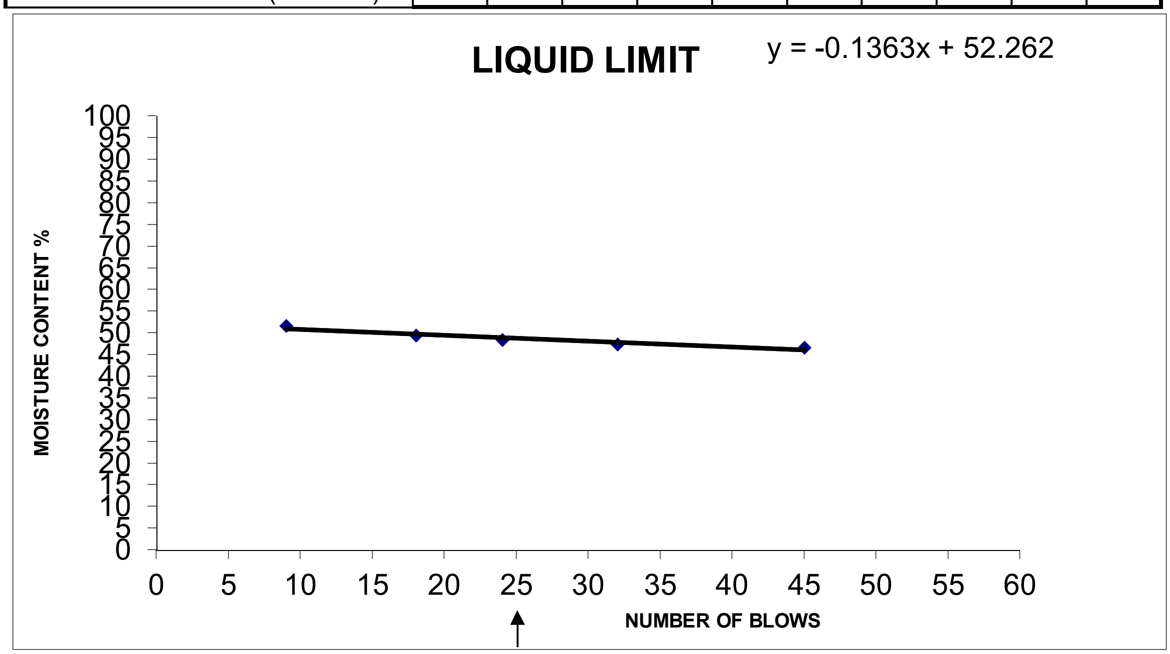
Job**….** Description of Soil…

Site**: OKOMU……**

L.L. Machine No.................... Operator....................................

Proportion of sample retained on No. 36 B.S. Steve = Per cent
No. of blows refers to liquid limit determination.
Shrinkage % refers to linear Shrinkage.
Liquid limit marked L.L. plastic limit marked P.L. Linear shrinkage marked L.S.

Type of Test	**LL**		**LL**		**LL**		**LL**		**LL**	
No. of Blows/shrinkage %	45.00		32.00		24.00		18.00		9.00	
Container No.	IE		EM		VI		BA		AR	
Wt of wet soil & container (g)	51.30		57.10		53.60		50.30		48.70	
Wt of dried soil & container (g)	40.70		45.20		42.00		39.40		37.90	
Wt of container (g)	18.00		20.10		18.10		17.40		17.00	
Wt of dry soil (Wd) (g)	22.70		25.10		23.90		22.00		20.90	
Wt of moisture (Wm) (g)	10.60		11.90		11.60		10.90		10.80	
Moisture contain 100 (Wm/Wd)	46.70		47.41		48.54		49.55		51.67	
Type of Test		**PL**		**PL**		**PL**		**PL**		**PL**
No. of Blows/shrinkage %										
Container No.		ZZ		ET		IZ				
Wt of wet soil & container (g)		25.80		27.40		25.10				
Wt of dried soil & container (g)		23.40		25.40		22.99				
Wt of container (g)		14.80		17.70		15.40				
Wt of dry soil (Wd) (g)		8.60		7.70		7.59				
Wt of moisture (Wm) (g)		2.40		2.00		2.11				
Moisture contain 100 (Wm/Wd)		27.91		25.97		27.80				



LIQUID AND PLASTIC LIMITS,LINEAR SHRINKAGE

Sample No. **RAMP 11, BH10, 13.5m...** Liquid Limit **: 55.34** Plastic Limit**: 25.62**

Date**: 25/06/2018……….** Plastic Index**: 29.73...** Linear Shrinkage

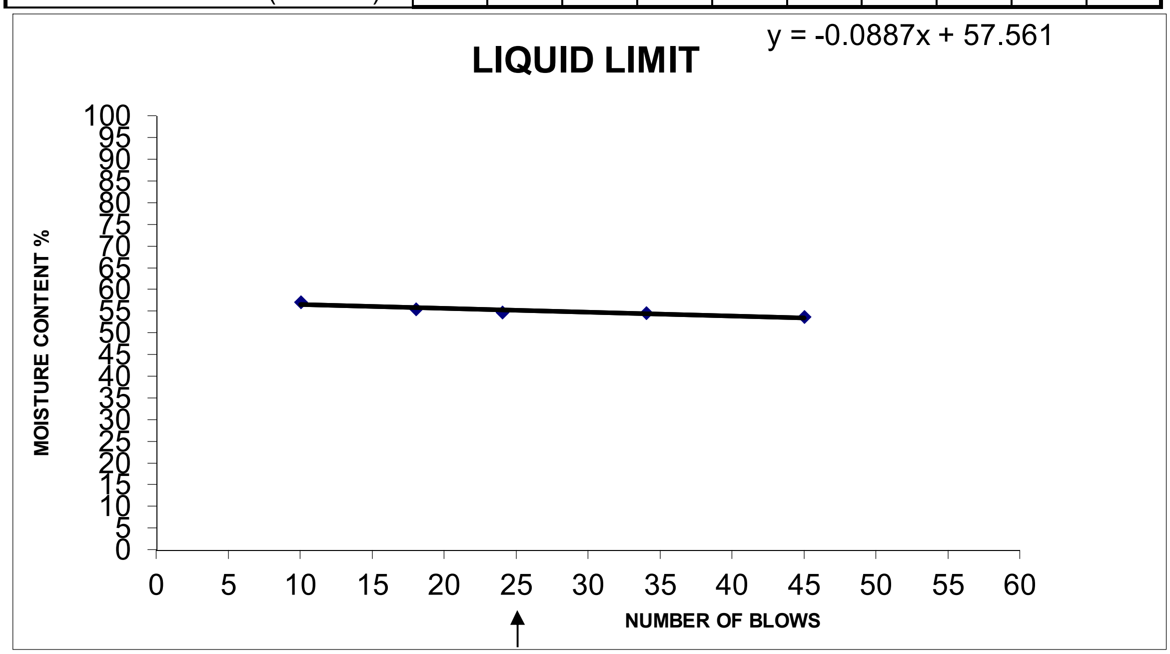
Job**….** Description of Soil…

Site**: OKOMU……**

L.L. Machine No.................... Operator....................................

Proportion of sample retained on No. 36 B.S. Steve = Per cent
No. of blows refers to liquid limit determination.
Shrinkage % refers to linear Shrinkage.
Liquid limit marked L.L. plastic limit marked P.L. Linear shrinkage marked L.S.

Type of Test	**LL**		**LL**		**LL**		**LL**		**LL**	
No. of Blows/shrinkage %	45.00		34.00		24.00		18.00		10.00	
Container No.	RA		ZA		UL		OR		TO	
Wt of wet soil & container (g)	50.30		48.30		50.00		51.80		51.90	
Wt of dried soil & container (g)	38.90		37.30		38.60		38.40		38.90	
Wt of container (g)	17.70		17.20		17.80		14.30		16.20	
Wt of dry soil (Wd) (g)	21.20		20.10		20.80		24.10		22.70	
Wt of moisture (Wm) (g)	11.40		11.00		11.40		13.40		13.00	
Moisture contain 100 (Wm/Wd)	53.77		54.73		54.81		55.60		57.27	
Type of Test		**PL**		**PL**		**PL**		**PL**		**PL**
No. of Blows/shrinkage %										
Container No.		WW		OX		WO				
Wt of wet soil & container (g)		23.50		25.70		26.40				
Wt of dried soil & container (g)		21.40		23.80		24.20				
Wt of container (g)		13.00		17.00		15.00				
Wt of dry soil (Wd) (g)		8.40		6.80		9.20				
Wt of moisture (Wm) (g)		2.10		1.90		2.20				
Moisture contain 100 (Wm/Wd)		25.00		27.94		23.91				



LIQUID AND PLASTIC LIMITS,LINEAR SHRINKAGE

Sample No. **RAMP 11, BH10, 13.5m...** Liquid Limit **: 55.34** Plastic Limit**: 25.62**

Date**: 25/06/2018……….** Plastic Index**: 29.73...** Linear Shrinkage

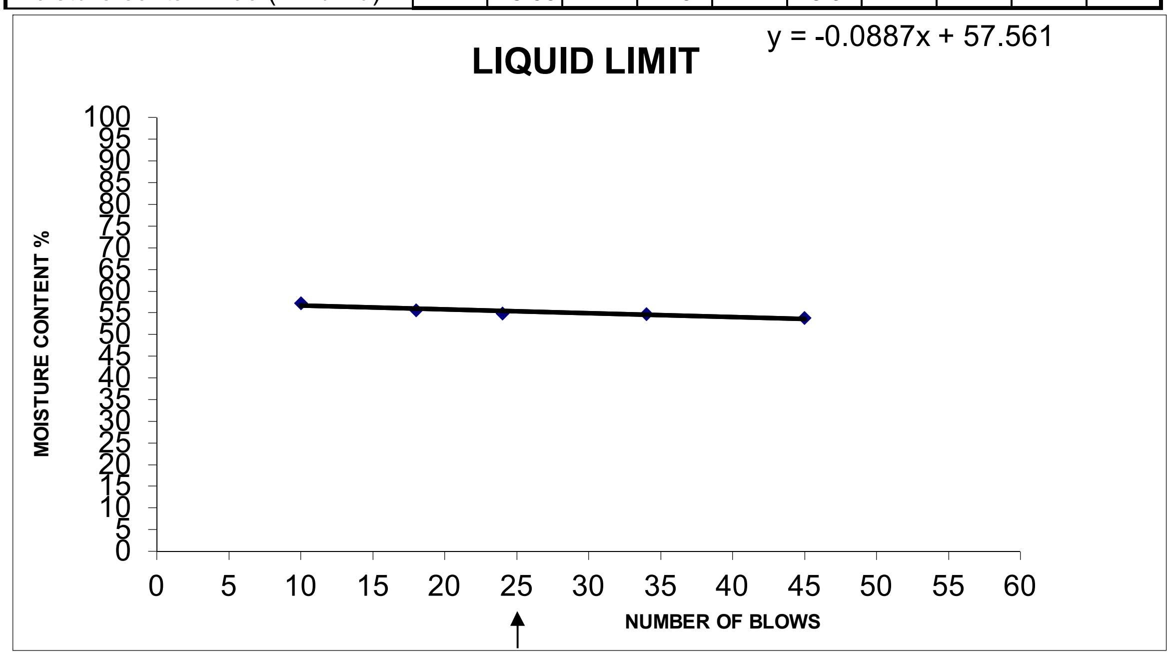
Job**….** Description of Soil…

Site**: OKOMU……**

L.L. Machine No.................... Operator....................................

Proportion of sample retained on No. 36 B.S. Steve = Per cent
No. of blows refers to liquid limit determination.
Shrinkage % refers to linear Shrinkage.
Liquid limit marked L.L. plastic limit marked P.L. Linear shrinkage marked L.S.

Type of Test	**LL**		**LL**		**LL**		**LL**		**LL**	
No. of Blows/shrinkage %	45.00		34.00		24.00		18.00		10.00	
Container No.	RA		ZA		UL		OR		TO	
Wt of wet soil & container (g)	50.30		48.30		50.00		51.80		51.90	
Wt of dried soil & container (g)	38.90		37.30		38.60		38.40		38.90	
Wt of container (g)	17.70		17.20		17.80		14.30		16.20	
Wt of dry soil (Wd) (g)	21.20		20.10		20.80		24.10		22.70	
Wt of moisture (Wm) (g)	11.40		11.00		11.40		13.40		13.00	
Moisture contain 100 (Wm/Wd)	53.77		54.73		54.81		55.60		57.27	
Type of Test		**PL**		**PL**		**PL**		**PL**		**PL**
No. of Blows/shrinkage %										
Container No.		WW		OX		WO				
Wt of wet soil & container (g)		23.50		25.70		26.40				
Wt of dried soil & container (g)		21.40		23.80		24.20				
Wt of container (g)		13.00		17.00		15.00				
Wt of dry soil (Wd) (g)		8.40		6.80		9.20				
Wt of moisture (Wm) (g)		2.10		1.90		2.20				
Moisture contain 100 (Wm/Wd)		25.00		27.94		23.91				



LIQUID AND PLASTIC LIMITS,LINEAR SHRINKAGE

Sample No. **STERBILIZER, BH4, 0.5m....** Liquid Limit **: 45.34** Plastic Limit**: 24.55**

Date**: 25/06/2018……….** Plastic Index**: 20.80...** Linear Shrinkage

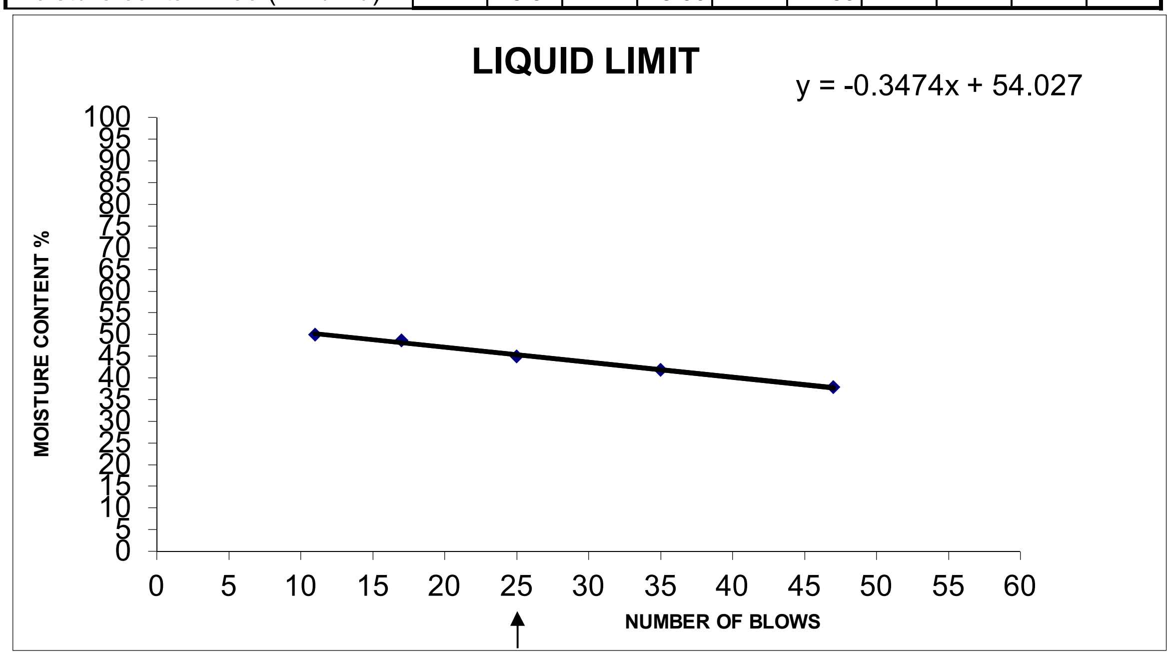
Job**….** Description of Soil…

Site**: OKOMU……**

L.L. Machine No.................... Operator.....................................

Proportion of sample retained on No. 36 B.S. Steve = Per cent
No. of blows refers to liquid limit determination.
Shrinkage % refers to linear Shrinkage.
Liquid limit marked L.L. plastic limit marked P.L. Linear shrinkage marked L.S.

Type of Test	**LL**		**LL**		**LL**		**LL**		**LL**	
No. of Blows/shrinkage %	47.00		35.00		25.00		17.00		11.00	
Container No.	TW		VC		VI		HO		BT	
Wt of wet soil & container (g)	57.70		56.50		52.30		51.50		50.50	
Wt of dried soil & container (g)	46.40		44.20		41.70		40.30		38.70	
Wt of container (g)	16.50		14.80		18.10		17.30		15.10	
Wt of dry soil (Wd) (g)	29.90		29.40		23.60		23.00		23.60	
Wt of moisture (Wm) (g)	11.30		12.30		10.60		11.20		11.80	
Moisture contain 100 (Wm/Wd)	37.79		41.84		44.92		48.70		50.00	
Type of Test		**PL**		**PL**		**PL**		**PL**		**PL**
No. of Blows/shrinkage %										
Container No.		CP		NI		VO				
Wt of wet soil & container (g)		26.00		21.40		27.50				
Wt of dried soil & container (g)		24.30		19.90		25.50				
Wt of container (g)		17.20		13.90		17.40				
Wt of dry soil (Wd) (g)		7.10		6.00		8.10				
Wt of moisture (Wm) (g)		1.70		1.50		2.00				
Moisture contain 100 (Wm/Wd)		23.94		25.00		24.69				



LIQUID AND PLASTIC LIMITS,LINEAR SHRINKAGE

Sample No. **STERBILIZER, BH4, 3.5m....** Liquid Limit **: 29.50** Plastic Limit**: 27.03**

Date**: 25/06/2018……….** Plastic Index**: 2.47...** Linear Shrinkage

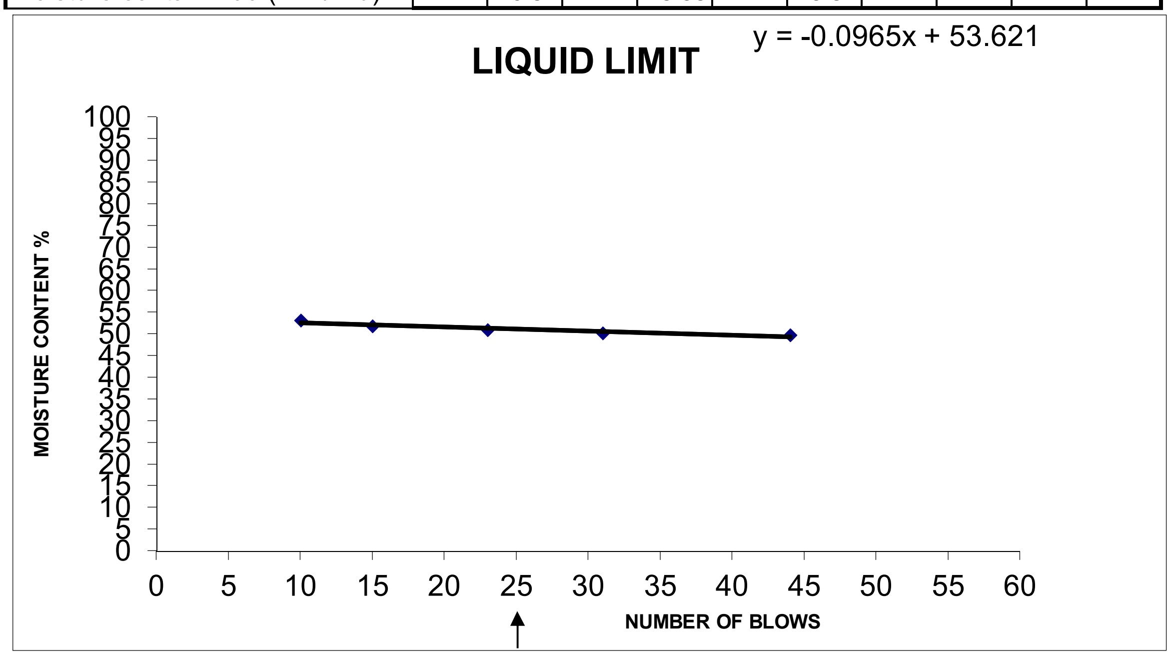
Job**….** Description of Soil…

Site**: OKOMU……**

L.L. Machine No.................... Operator....................................

Proportion of sample retained on No. 36 B.S. Steve = Per cent
No. of blows refers to liquid limit determination.
Shrinkage % refers to linear Shrinkage.
Liquid limit marked L.L. plastic limit marked P.L. Linear shrinkage marked L.S.

Type of Test	**LL**		**LL**		**LL**		**LL**		**LL**	
No. of Blows/shrinkage %	44.00		31.00		23.00		15.00		10.00	
Container No.	PX		7Z		9TH		BA		QZ	
Wt of wet soil & container (g)	56.70		51.30		47.70		49.00		54.80	
Wt of dried soil & container (g)	43.60		40.40		37.70		38.10		42.60	
Wt of container (g)	17.30		18.70		18.10		17.10		19.70	
Wt of dry soil (Wd) (g)	26.30		21.70		19.60		21.00		22.90	
Wt of moisture (Wm) (g)	13.10		10.90		10.00		10.90		12.20	
Moisture contain 100 (Wm/Wd)	49.81		50.23		51.02		51.90		53.28	
Type of Test		**PL**		**PL**		**PL**		**PL**		**PL**
No. of Blows/shrinkage %										
Container No.		ZI		RI		TA				
Wt of wet soil & container (g)		22.80		28.40		29.10				
Wt of dried soil & container (g)		21.00		26.30		26.80				
Wt of container (g)		14.30		18.90		17.90				
Wt of dry soil (Wd) (g)		6.70		7.40		8.90				
Wt of moisture (Wm) (g)		1.80		2.10		2.30				
Moisture contain 100 (Wm/Wd)		26.87		28.38		25.84				



LIQUID AND PLASTIC LIMITS,LINEAR SHRINKAGE

Sample No. **STERBILIZER, BH4, 9.5m...** Liquid Limit **: 53.35** Plastic Limit**: 27.22**

Date**: 25/06/2018……….** Plastic Index**: 26.13...** Linear Shrinkage

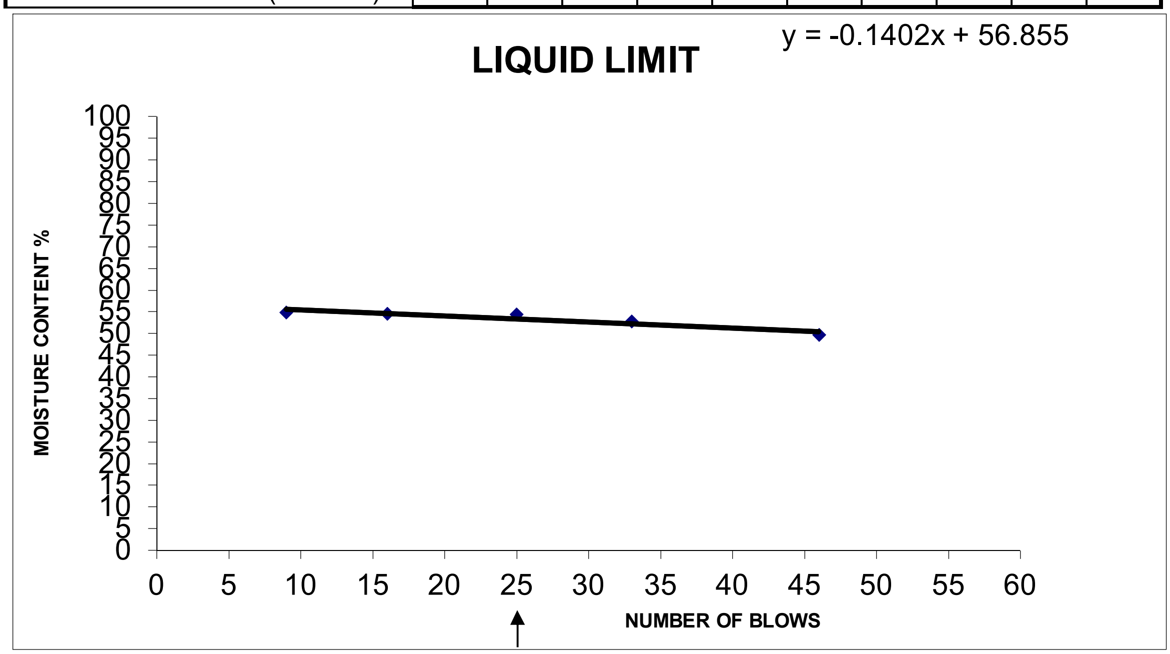
Job**….** Description of Soil…

Site**: OKOMU……**

L.L. Machine No.................... Operator....................................

Proportion of sample retained on No. 36 B.S. Steve = Per cent
No. of blows refers to liquid limit determination.
Shrinkage % refers to linear Shrinkage.
Liquid limit marked L.L. plastic limit marked P.L. Linear shrinkage marked L.S.

Type of Test	**LL**		**LL**		**LL**		**LL**		**LL**	
No. of Blows/shrinkage %	46.00		33.00		25.00		16.00		9.00	
Container No.	MP		OZ		FA		F7		6Z	
Wt of wet soil & container (g)	56.80		56.90		56.90		55.30		51.00	
Wt of dried soil & container (g)	43.80		43.40		43.40		42.10		38.00	
Wt of container (g)	17.60		17.80		18.60		17.90		14.30	
Wt of dry soil (Wd) (g)	26.20		25.60		24.80		24.20		23.70	
Wt of moisture (Wm) (g)	13.00		13.50		13.50		13.20		13.00	
Moisture contain 100 (Wm/Wd)	49.62		52.73		54.44		54.55		54.85	
Type of Test		**PL**		**PL**		**PL**		**PL**		**PL**
No. of Blows/shrinkage %										
Container No.		OO		OH		UK				
Wt of wet soil & container (g)		28.70		29.10		27.10				
Wt of dried soil & container (g)		26.00		26.90		24.80				
Wt of container (g)		16.70		18.60		16.00				
Wt of dry soil (Wd) (g)		9.30		8.30		8.80				
Wt of moisture (Wm) (g)		2.70		2.20		2.30				
Moisture contain 100 (Wm/Wd)		29.03		26.51		26.14				



LIQUID AND PLASTIC LIMITS,LINEAR SHRINKAGE

Sample No. **STERILIZER, BH4, 12.5m....** Liquid Limit **: 45.34** Plastic Limit**: 24.55**

Date**: 25/06/2018……….** Plastic Index**: 20.80...** Linear Shrinkage

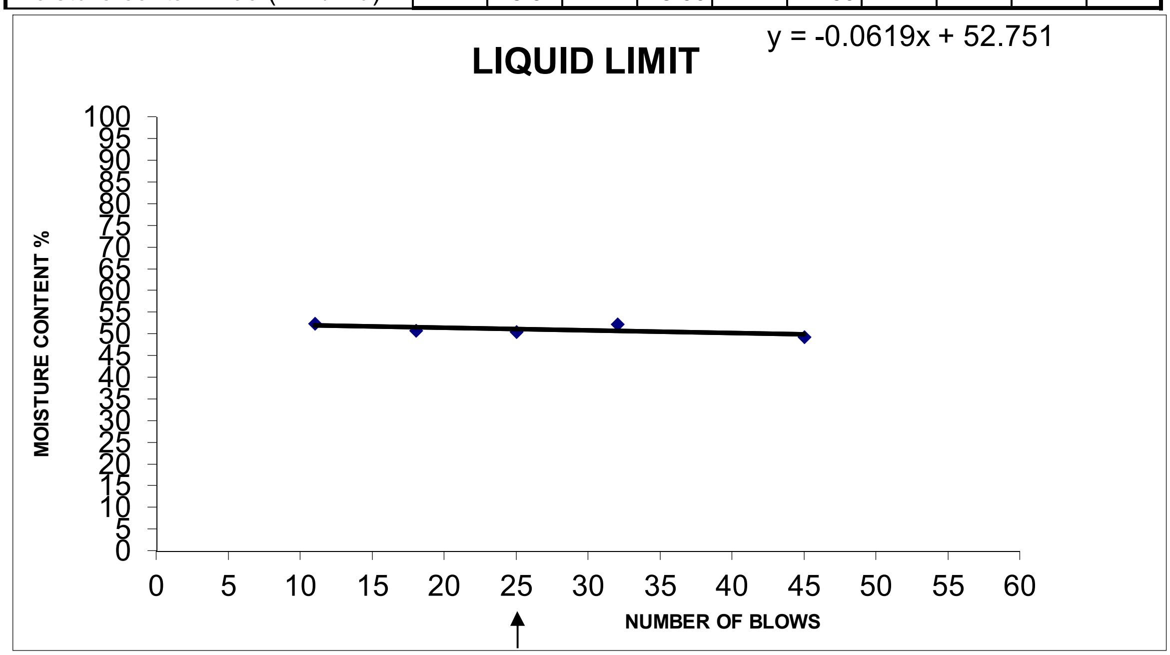
Job**….** Description of Soil…

Site**: OKOMU……**

L.L. Machine No.................... Operator....................................

Proportion of sample retained on No. 36 B.S. Steve = Per cent
No. of blows refers to liquid limit determination.
Shrinkage % refers to linear Shrinkage.
Liquid limit marked L.L. plastic limit marked P.L. Linear shrinkage marked L.S.

Type of Test	**LL**		**LL**		**LL**		**LL**		**LL**	
No. of Blows/shrinkage %	45.00		32.00		25.00		18.00		11.00	
Container No.	HI		PO		CO		ST		CN	
Wt of wet soil & container (g)	54.40		51.00		56.10		54.00		56.00	
Wt of dried soil & container (g)	42.10		38.80		43.30		41.90		42.10	
Wt of container (g)	17.20		15.50		18.00		18.10		15.60	
Wt of dry soil (Wd) (g)	24.90		23.30		25.30		23.80		26.50	
Wt of moisture (Wm) (g)	12.30		12.20		12.80		12.10		13.90	
Moisture contain 100 (Wm/Wd)	49.40		52.36		50.59		50.84		52.45	
Type of Test		**PL**		**PL**		**PL**		**PL**		**PL**
No. of Blows/shrinkage %										
Container No.		CP		NI		VO				
Wt of wet soil & container (g)		26.00		21.40		27.50				
Wt of dried soil & container (g)		24.30		19.90		25.50				
Wt of container (g)		17.20		13.90		17.40				
Wt of dry soil (Wd) (g)		7.10		6.00		8.10				
Wt of moisture (Wm) (g)		1.70		1.50		2.00				
Moisture contain 100 (Wm/Wd)		23.94		25.00		24.69				



LIQUID AND PLASTIC LIMITS,LINEAR SHRINKAGE

Sample No. **STORAGE TANK, BH6, 10.0m...** Liquid Limit **: 54.13** Plastic Limit**: 25.74**

Date**: 25/06/2018……….** Plastic Index**: 28.39...** Linear Shrinkage

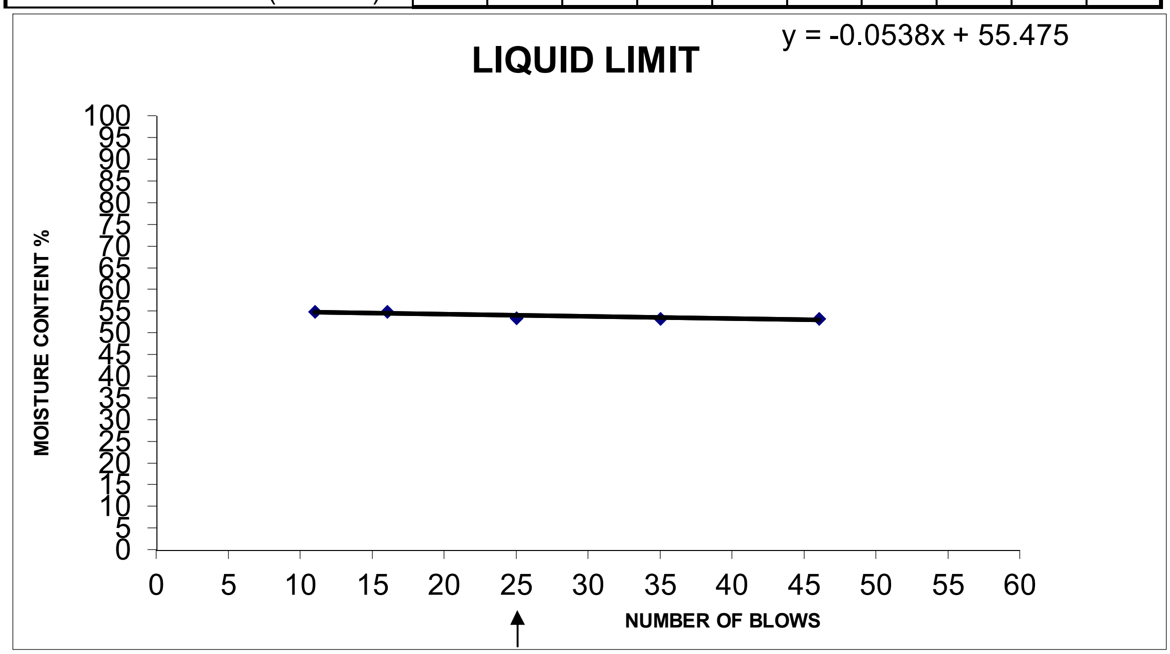
Job**….** Description of Soil…

Site**: OKOMU……**

L.L. Machine No.................... Operator.....................................

Proportion of sample retained on No. 36 B.S. Steve = Per cent
No. of blows refers to liquid limit determination.
Shrinkage % refers to linear Shrinkage.
Liquid limit marked L.L. plastic limit marked P.L. Linear shrinkage marked L.S.

Type of Test	**LL**		**LL**		**LL**		**LL**		**LL**	
No. of Blows/shrinkage %	46.00		35.00		25.00		16.00		11.00	
Container No.	IA		CV		ZU		HI		YZ	
Wt of wet soil & container (g)	55.20		59.00		58.50		57.80		59.20	
Wt of dried soil & container (g)	41.50		44.10		44.20		42.80		44.90	
Wt of container (g)	15.80		16.20		17.50		15.50		18.90	
Wt of dry soil (Wd) (g)	25.70		27.90		26.70		27.30		26.00	
Wt of moisture (Wm) (g)	13.70		14.90		14.30		15.00		14.30	
Moisture contain 100 (Wm/Wd)	53.31		53.41		53.56		54.95		55.00	
Type of Test		**PL**		**PL**		**PL**		**PL**		**PL**
No. of Blows/shrinkage %										
Container No.		EM		O4		ZA				
Wt of wet soil & container (g)		26.20		26.80		27.80				
Wt of dried soil & container (g)		24.50		25.10		25.80				
Wt of container (g)		18.00		18.80		17.50				
Wt of dry soil (Wd) (g)		6.50		6.30		8.30				
Wt of moisture (Wm) (g)		1.70		1.70		2.00				
Moisture contain 100 (Wm/Wd)		26.15		26.98		24.10				



LIQUID AND PLASTIC LIMITS,LINEAR SHRINKAGE

Sample No. **WATER TANK, BH8, 6.0m...** Liquid Limit **: 50.87** Plastic Limit**: 30.87**

Date**: 25/06/2018……….** Plastic Index**: 20.28...** Linear Shrinkage

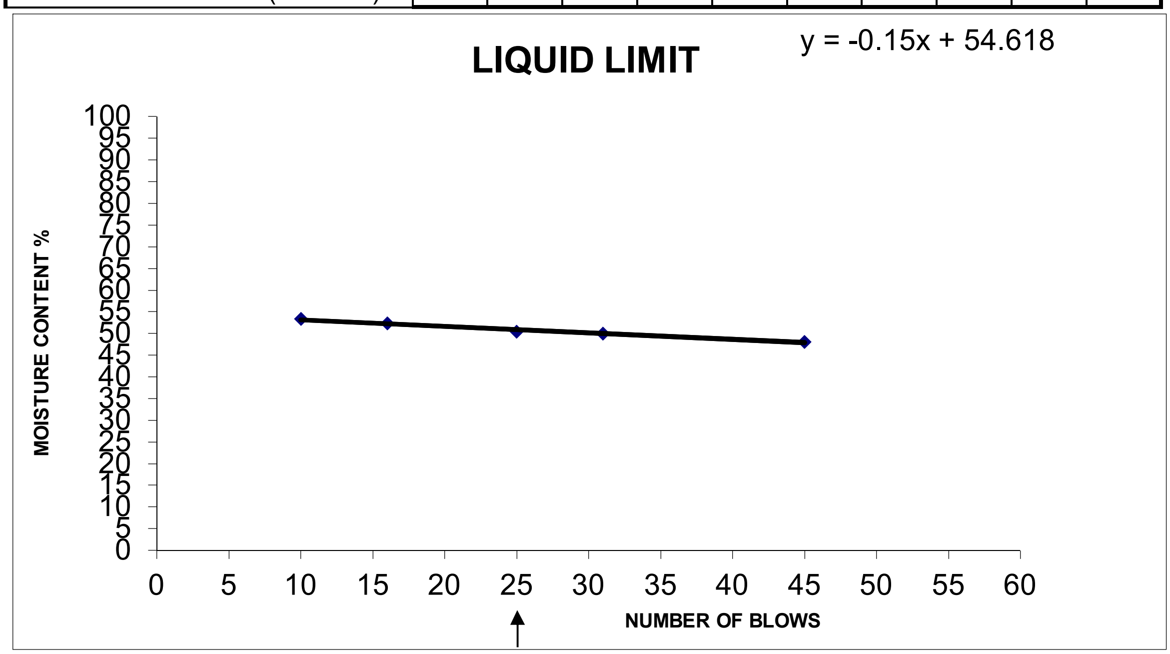
Job**….** Description of Soil…

Site**: OKOMU……**

L.L. Machine No.................... Operator....................................

Proportion of sample retained on No. 36 B.S. Steve = Per cent
No. of blows refers to liquid limit determination.
Shrinkage % refers to linear Shrinkage.
Liquid limit marked L.L. plastic limit marked P.L. Linear shrinkage marked L.S.

Type of Test	**LL**		**LL**		**LL**		**LL**		**LL**	
No. of Blows/shrinkage %	45.00		31.00		25.00		16.00		10.00	
Container No.	JO		JJ		IA		GO		JO	
Wt of wet soil & container (g)	46.40		50.40		53.70		57.40		52.50	
Wt of dried soil & container (g)	36.60		39.30		40.80		43.80		40.40	
Wt of container (g)	16.20		17.10		15.20		17.80		17.70	
Wt of dry soil (Wd) (g)	20.40		22.20		25.60		26.00		22.70	
Wt of moisture (Wm) (g)	9.80		11.10		12.90		13.60		12.10	
Moisture contain 100 (Wm/Wd)	48.04		50.00		50.39		52.31		53.30	
Type of Test		**PL**		**PL**		**PL**		**PL**		**PL**
No. of Blows/shrinkage %										
Container No.		VO		IJ		TM				
Wt of wet soil & container (g)		26.90		25.20		25.70				
Wt of dried soil & container (g)		24.70		23.40		23.70				
Wt of container (g)		18.10		17.00		17.10				
Wt of dry soil (Wd) (g)		6.60		6.40		6.60				
Wt of moisture (Wm) (g)		2.20		1.80		2.00				
Moisture contain 100 (Wm/Wd)		33.33		28.13		30.30				



LIQUID AND PLASTIC LIMITS,LINEAR SHRINKAGE

Sample No. **WATER TANK, BH8, 9.0m...** Liquid Limit **: 49.79** Plastic Limit**: 26.38**

Date**: 25/06/2018……….** Plastic Index**: 23.41...** Linear Shrinkage

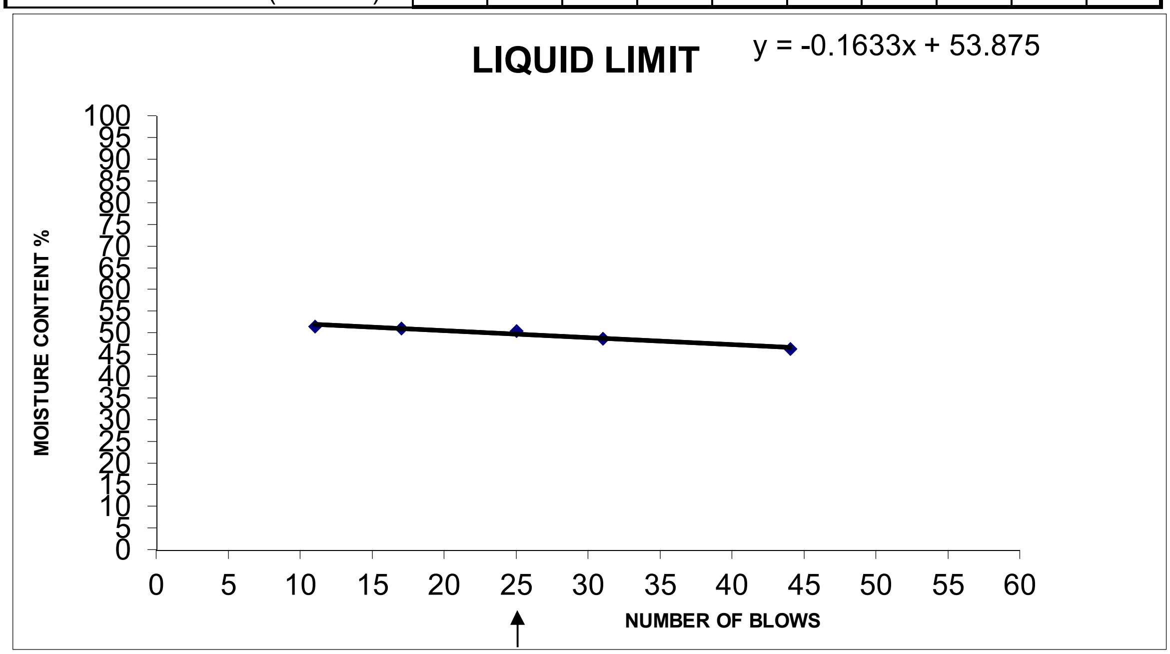
Job**….** Description of Soil…

Site**: OKOMU……**

L.L. Machine No.................... Operator.....................................

Proportion of sample retained on No. 36 B.S. Steve = Per cent
No. of blows refers to liquid limit determination.
Shrinkage % refers to linear Shrinkage.
Liquid limit marked L.L. plastic limit marked P.L. Linear shrinkage marked L.S.

Type of Test	**LL**		**LL**		**LL**		**LL**		**LL**	
No. of Blows/shrinkage %	44.00		31.00		25.00		17.00		11.00	
Container No.	8I		KO		FO		OZ		7O	
Wt of wet soil & container (g)	56.40		58.40		55.60		56.40		56.20	
Wt of dried soil & container (g)	44.20		44.60		42.10		42.90		43.50	
Wt of container (g)	17.90		16.30		15.40		16.50		18.90	
Wt of dry soil (Wd) (g)	26.30		28.30		26.70		26.40		24.60	
Wt of moisture (Wm) (g)	12.20		13.80		13.50		13.50		12.70	
Moisture contain 100 (Wm/Wd)	46.39		48.76		50.56		51.14		51.63	
Type of Test		**PL**		**PL**		**PL**		**PL**		**PL**
No. of Blows/shrinkage %										
Container No.		CV		JO		GO				
Wt of wet soil & container (g)		23.70		28.50		28.70				
Wt of dried soil & container (g)		22.20		26.30		26.30				
Wt of container (g)		16.20		17.70		17.90				
Wt of dry soil (Wd) (g)		6.00		8.60		8.40				
Wt of moisture (Wm) (g)		1.50		2.20		2.40				
Moisture contain 100 (Wm/Wd)		25.00		25.58		28.57				



LIQUID AND PLASTIC LIMITS,LINEAR SHRINKAGE

Sample No. **WATER TANK, BH8, 12.0m...** Liquid Limit **: 51.21** Plastic Limit**: 27.97**

Date**: 25/06/2018……….** Plastic Index**: 23.24...** Linear Shrinkage

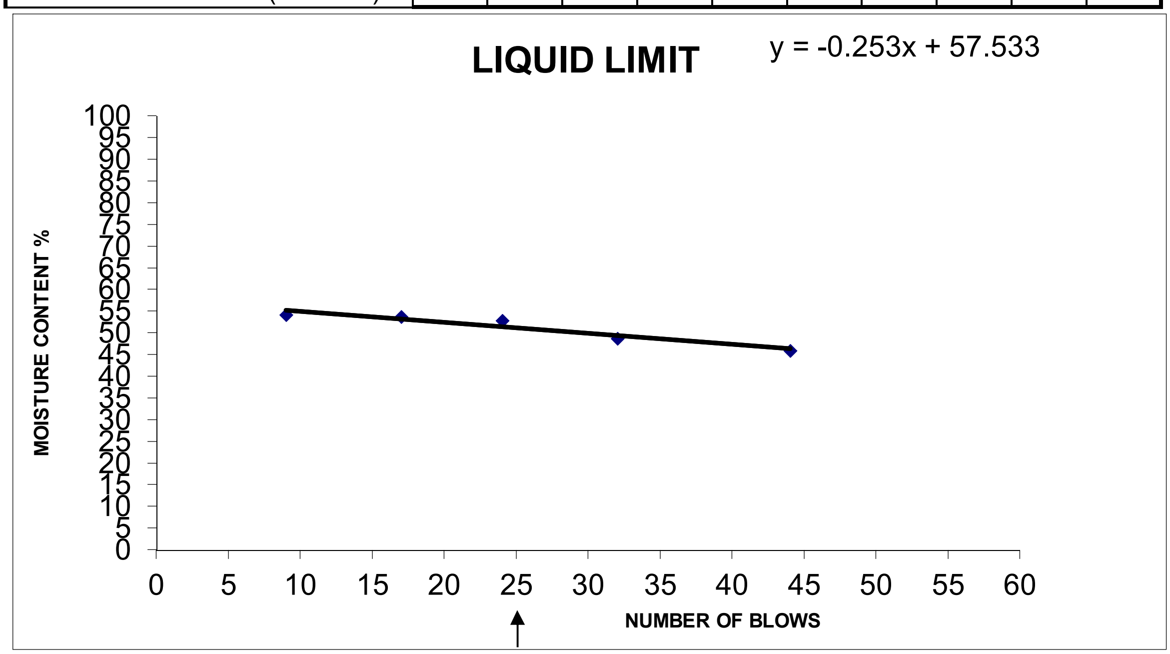
Job**….** Description of Soil…

Site**: OKOMU……**

L.L. Machine No.................... Operator....................................

Proportion of sample retained on No. 36 B.S. Steve = Per cent
No. of blows refers to liquid limit determination.
Shrinkage % refers to linear Shrinkage.
Liquid limit marked L.L. plastic limit marked P.L. Linear shrinkage marked L.S.

Type of Test	**LL**		**LL**		**LL**		**LL**		**LL**	
No. of Blows/shrinkage %	44.00		32.00		24.00		17.00		9.00	
Container No.	KI		JO		4M		CA		F3	
Wt of wet soil & container (g)	47.50		55.50		56.90		56.90		58.20	
Wt of dried soil & container (g)	37.00		42.15		42.50		43.40		44.00	
Wt of container (g)	14.20		14.80		15.30		18.30		17.80	
Wt of dry soil (Wd) (g)	22.80		27.35		27.20		25.10		26.20	
Wt of moisture (Wm) (g)	10.50		13.35		14.40		13.50		14.20	
Moisture contain 100 (Wm/Wd)	46.05		48.81		52.94		53.78		54.20	
Type of Test		**PL**		**PL**		**PL**		**PL**		**PL**
No. of Blows/shrinkage %										
Container No.		TA		AL		X				
Wt of wet soil & container (g)		28.10		24.90		25.20				
Wt of dried soil & container (g)		26.30		22.80		23.60				
Wt of container (g)		20.00		15.10		17.90				
Wt of dry soil (Wd) (g)		6.30		7.70		5.70				
Wt of moisture (Wm) (g)		1.80		2.10		1.60				
Moisture contain 100 (Wm/Wd)		28.57		27.27		28.07				



LIQUID AND PLASTIC LIMITS,LINEAR SHRINKAGE

Sample No. **WATER TANK, BH8, 15.0m...** Liquid Limit **: 51.41** Plastic Limit**: 26.16**

Date**: 25/06/2018……….** Plastic Index**: 25.26...** Linear Shrinkage

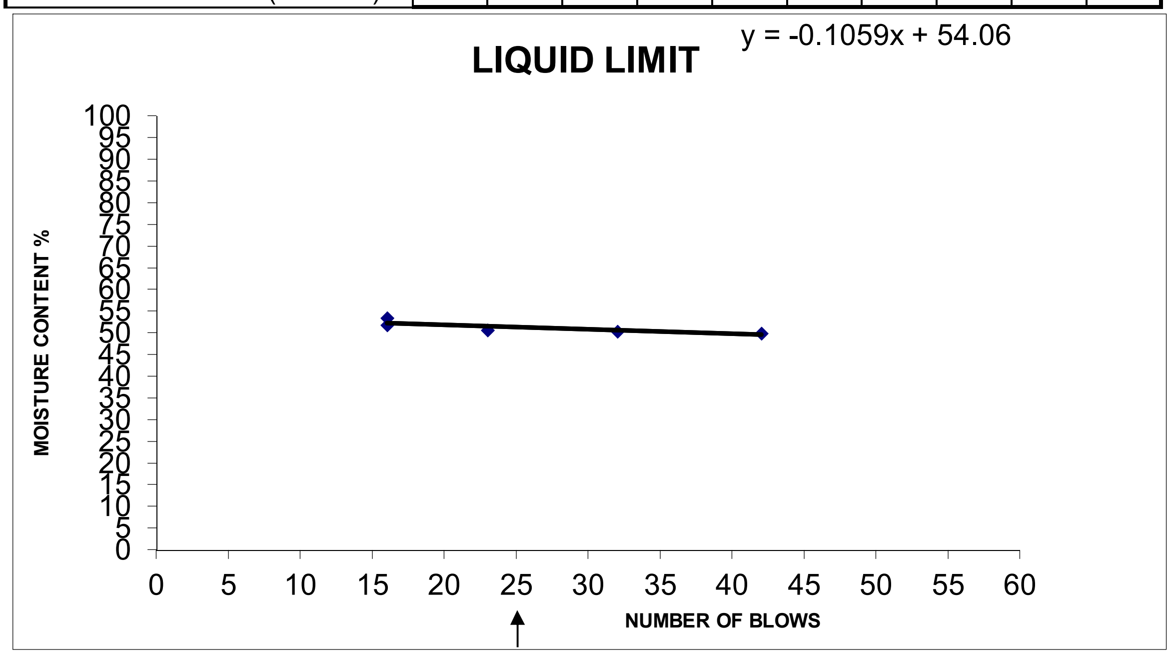
Job**….** Description of Soil…

Site**: OKOMU……**

L.L. Machine No.................... Operator....................................

Proportion of sample retained on No. 36 B.S. Steve = Per cent
No. of blows refers to liquid limit determination.
Shrinkage % refers to linear Shrinkage.
Liquid limit marked L.L. plastic limit marked P.L. Linear shrinkage marked L.S.

Type of Test	**LL**		**LL**		**LL**		**LL**		**LL**	
No. of Blows/shrinkage %	42.00		32.00		23.00		16.00		16.00	
Container No.	LO		ZA		K		6TH		AA	
Wt of wet soil & container (g)	59.50		53.60		54.90		58.50		54.70	
Wt of dried soil & container (g)	45.00		41.70		41.20		44.80		40.99	
Wt of container (g)	16.00		18.10		14.20		18.40		15.40	
Wt of dry soil (Wd) (g)	29.00		23.60		27.00		26.40		25.59	
Wt of moisture (Wm) (g)	14.50		11.90		13.70		13.70		13.71	
Moisture contain 100 (Wm/Wd)	50.00		50.42		50.74		51.89		53.58	
Type of Test		**PL**		**PL**		**PL**		**PL**		**PL**
No. of Blows/shrinkage %										
Container No.		GG		IN		PX				
Wt of wet soil & container (g)		26.10		25.80		25.40				
Wt of dried soil & container (g)		23.90		23.80		23.40				
Wt of container (g)		15.00		16.10		16.20				
Wt of dry soil (Wd) (g)		8.90		7.70		7.20				
Wt of moisture (Wm) (g)		2.20		2.00		2.00				
Moisture contain 100 (Wm/Wd)		24.72		25.97		27.78				



LIQUID AND PLASTIC LIMITS,LINEAR SHRINKAGE

Sample No. **WEIGH BRIGDE, BH7, 7.0m...** Liquid Limit **: 52.37** Plastic Limit**: 28.07**

Date**: 25/06/2018……….** Plastic Index**: 24.30...** Linear Shrinkage

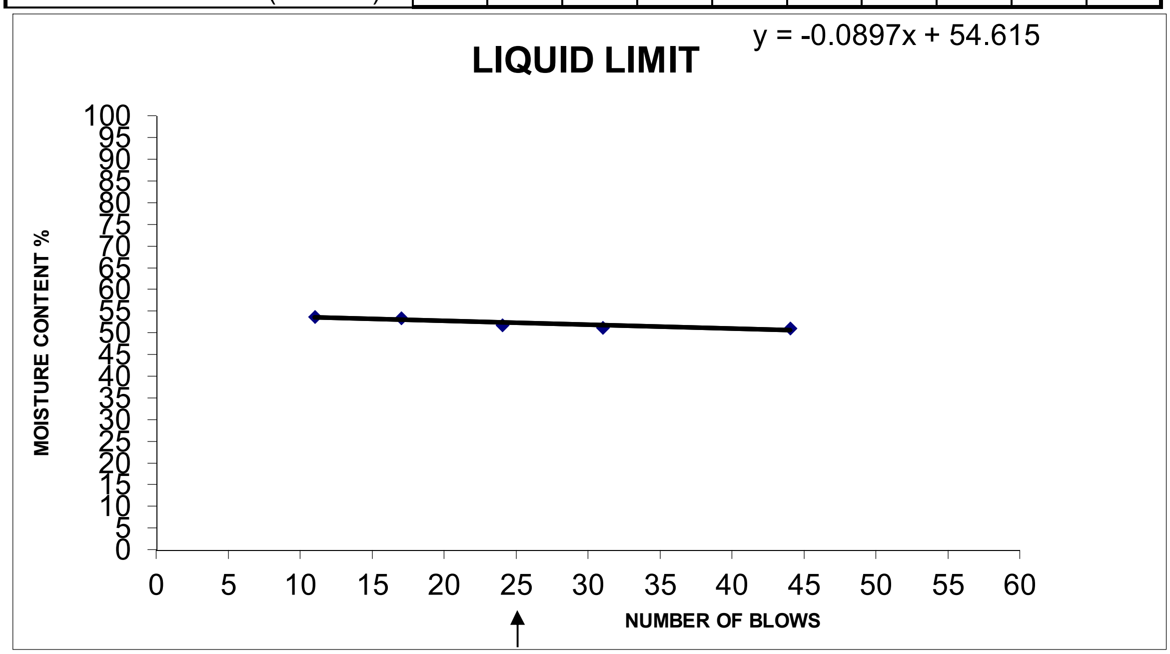
Job**….** Description of Soil…

Site**: OKOMU……**

L.L. Machine No.................... Operator....................................

Proportion of sample retained on No. 36 B.S. Steve = Per cent
No. of blows refers to liquid limit determination.
Shrinkage % refers to linear Shrinkage.
Liquid limit marked L.L. plastic limit marked P.L. Linear shrinkage marked L.S.

Type of Test	**LL**		**LL**		**LL**		**LL**		**LL**	
No. of Blows/shrinkage %	44.00		31.00		24.00		17.00		11.00	
Container No.	P5		CL		IJ		8Z		D	
Wt of wet soil & container (g)	58.20		51.20		57.50		52.30		53.50	
Wt of dried soil & container (g)	44.70		39.40		43.80		39.30		40.90	
Wt of container (g)	18.30		16.40		17.40		15.00		17.50	
Wt of dry soil (Wd) (g)	26.40		23.00		26.40		24.30		23.40	
Wt of moisture (Wm) (g)	13.50		11.80		13.70		13.00		12.60	
Moisture contain 100 (Wm/Wd)	51.14		51.30		51.89		53.50		53.85	
Type of Test		**PL**		**PL**		**PL**		**PL**		**PL**
No. of Blows/shrinkage %										
Container No.		LB		PA		NZ				
Wt of wet soil & container (g)		23.10		25.60		25.90				
Wt of dried soil & container (g)		21.60		23.90		23.80				
Wt of container (g)		16.00		17.70		16.80				
Wt of dry soil (Wd) (g)		5.60		6.20		7.00				
Wt of moisture (Wm) (g)		1.50		1.70		2.10				
Moisture contain 100 (Wm/Wd)		26.79		27.42		30.00				



LIQUID AND PLASTIC LIMITS,LINEAR SHRINKAGE

Sample No. **WEIGH BRIGDE, BH7, 4.0m...** Liquid Limit **: 54.79** Plastic Limit**: 29.11**

Date**: 25/06/2018……….** Plastic Index**: 25.69...** Linear Shrinkage

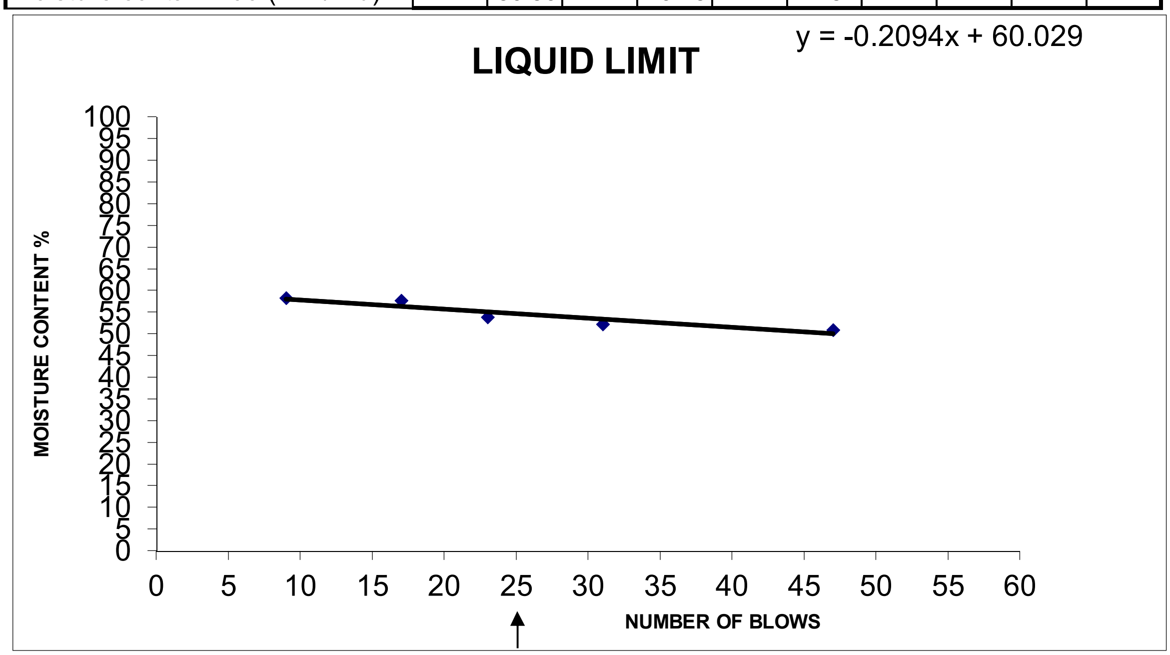
Job**….** Description of Soil…

Site**: OKOMU……**

L.L. Machine No.................... Operator....................................

Proportion of sample retained on No. 36 B.S. Steve = Per cent
No. of blows refers to liquid limit determination.
Shrinkage % refers to linear Shrinkage.
Liquid limit marked L.L. plastic limit marked P.L. Linear shrinkage marked L.S.

Type of Test	**LL**		**LL**		**LL**		**LL**		**LL**	
No. of Blows/shrinkage %	47.00		31.00		23.00		17.00		9.00	
Container No.	OS		OB		ED		JI		NA	
Wt of wet soil & container (g)	52.40		49.00		52.60		51.50		52.30	
Wt of dried soil & container (g)	40.40		39.10		40.20		39.20		38.80	
Wt of container (g)	16.90		20.20		17.20		17.90		15.70	
Wt of dry soil (Wd) (g)	23.50		18.90		23.00		21.30		23.10	
Wt of moisture (Wm) (g)	12.00		9.90		12.40		12.30		13.50	
Moisture contain 100 (Wm/Wd)	51.06		52.38		53.91		57.75		58.44	
Type of Test		**PL**		**PL**		**PL**		**PL**		**PL**
No. of Blows/shrinkage %										
Container No.		FO		OK		OS				
Wt of wet soil & container (g)		27.50		25.40		23.60				
Wt of dried soil & container (g)		25.30		23.50		21.70				
Wt of container (g)		18.10		17.00		14.80				
Wt of dry soil (Wd) (g)		7.20		6.50		6.90				
Wt of moisture (Wm) (g)		2.20		1.90		1.90				
Moisture contain 100 (Wm/Wd)		30.56		29.23		27.54				



APPENDIX III

DETERMINATION OF THE MOISTURE/DENSITY RELATION OF SOIL
USING STANDARD/HEAVY COMPACTION

Job... **OKOMU** Sample No:....**ROAD POINT 1...** Operator…………

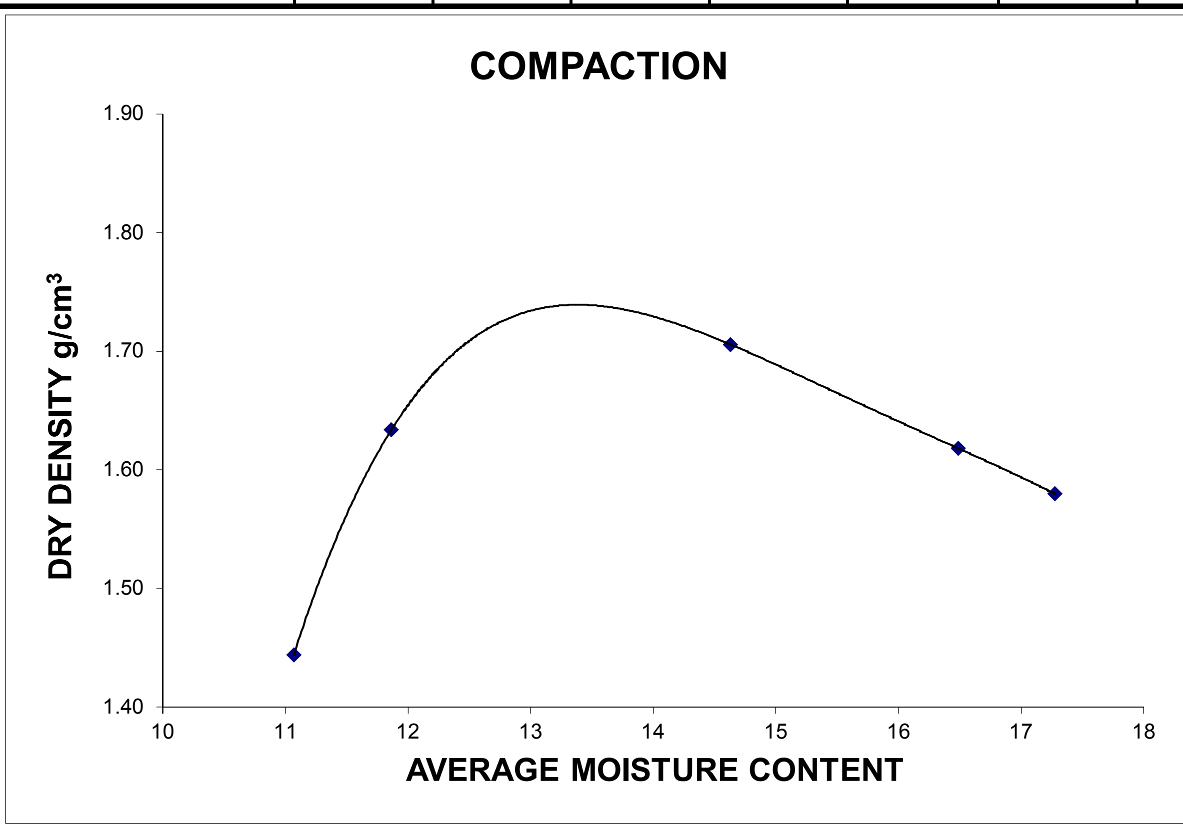
Site….... Dept... **1.5m……** Date:...**25/05/2018…** MDD:**1.74g/cm³**

Amount retained on 20mm B.S. Sieve……… Total weight of Sample…… OPT.MC:**13.4%**

B.S. / C.B.R. Mould……**4723g…**……………...............................

Wt. of mould & wet Soil (W2) g	6320.00	6543.00	6670.00	6600.00	6568.00		
Wt. of mould (W1) g	4723.00	4723.00	4723.00	4723.00	4723.00	+	
Wt. of wet soil (W2-W1) g	1597.00	1820.00	1947.00	1877.00	1845.00		
Bulk Density (Pb) (W2-W1)/x g/cm³	1.60	1.83	1.96	1.88	1.85		
MOISTURE CONTENT DETERMINATIONS for B.S. Mould, X = 1000cm³							

Container No.	AC	LH	AZ	SU	II	PK	MO	UB	AB	AI				
Wt. of wet soil & container (g)	37.70	44.10	45.30	40.90	47.60	51.10	46.90	46.60	41.50	47.30				
Wt. of Dry soil & container (g)	35.50	41.50	42.30	38.10	43.60	46.60	42.80	42.20	37.90	42.80				
Wt. of Container (g)	15.00	18.70	16.80	14.70	16.80	15.20	18.30	15.10	17.10	16.70				
Wt. of dry soil (Wd) g	20.50	22.80	25.50	23.40	26.80	31.40	24.50	27.10	20.80	26.10				
Wt. of Moisture (Wm) g	2.20	2.60	3.00	2.80	4.00	4.50	4.10	4.40	3.60	4.50				
Moistur Content 100(Wm/Wd) %	10.73	11.40	11.76	11.97	14.93	14.33	16.73	16.24	17.31	17.24				
Average Moisture Content (m) %	11.07		11.87		14.63		16.49		17.27					
Dry Density = Pb/1+ (m/100) (g/cm³)	1.44		1.63		1.71		1.62		1.58					
C.B.R. (mseen of top & bottom) %														



DETERMINATION OF THE MOISTURE/DENSITY RELATION OF SOIL
USING STANDARD/HEAVY COMPACTION

Job… **OKOMU** Sample No:**….ROAD POINT 2…** Operator…………

Site…**...** Dept…**1.50m……** Date:**…25/05/2018…** MDD:**1.51g/cm³**

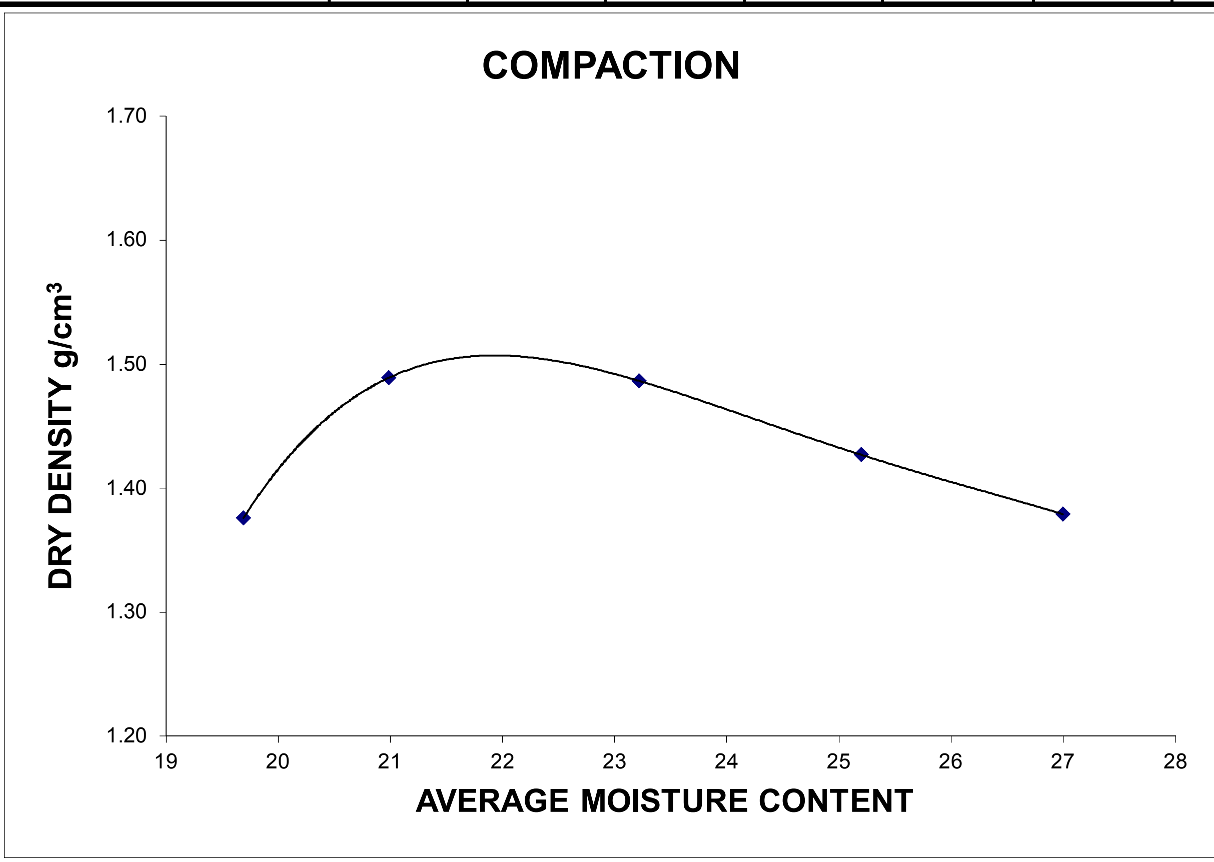
Amount retained on 20mm B.S. Sieve……… Total weight of Sample…… OPT.MC:**21.9%**

B.S. / C.B.R. Mould……**3252g…**…………...............................

Wt. of mould & wet Soil (W2) g	4890.00	5044.00	5074.00	5029.00	4994.00		
Wt. of mould (W1) g	3250.00	3250.00	3250.00	3250.00	3250.00		
Wt. of wet soil (W2-W1) g	1640.00	1794.00	1824.00	1779.00	1744.00		
Bulk Density (Pb) (W2-W1)/x g/cm ^{3}	1.65	1.80	1.83	1.79	1.75		

MOISTURE CONTENT DETERMINATIONS for B.S. Mould, X = 1000cm ^{3}

Container No.	III	RO	JK	BE	Z3	Z4	ZA	NZ	IN	RO				
Wt. of wet soil & container (g)	52.00	52.68	52.71	52.02	51.80	55.50	51.30	54.63	55.68	53.17				
Wt. of Dry soil & container (g)	46.20	47.00	46.50	46.10	45.50	48.20	44.60	47.00	47.10	44.80				
Wt. of Container (g)	16.90	18.00	17.20	17.61	17.71	17.49	18.02	16.71	15.16	13.95				
Wt. of dry soil (Wd) g	29.30	29.00	29.30	28.49	27.79	30.71	26.58	30.29	31.94	30.85				
Wt. of Moisture (Wm) g	5.80	5.68	6.21	5.92	6.30	7.30	6.70	7.63	8.58	8.37				
Moistur Content 100(Wm/Wd) %	19.80	19.59	21.19	20.78	22.67	23.77	25.21	25.19	26.86	27.13				
Average Moisture Content (m) %	19.69		20.99		23.22		25.20		27.00					
Dry Density = Pb/1+ (m/100) (g/cm ^{3})	1.38		1.49		1.49		1.43		1.38					
C.B.R. (mseen of top & bottom) %														



DETERMINATION OF THE MOISTURE/DENSITY RELATION OF SOIL
USING STANDARD/HEAVY COMPACTION

Job... **OKOMU** Sample No:**....ROAD POINT 3...** Operator…………

Site…..... Dept**...1.50m……** Date:**…25/05/2018…** MDD:**1.47g/cm³**

Amount retained on 20mm B.S. Sieve……… Total weight of Sample…… OPT.MC:**25.3%**

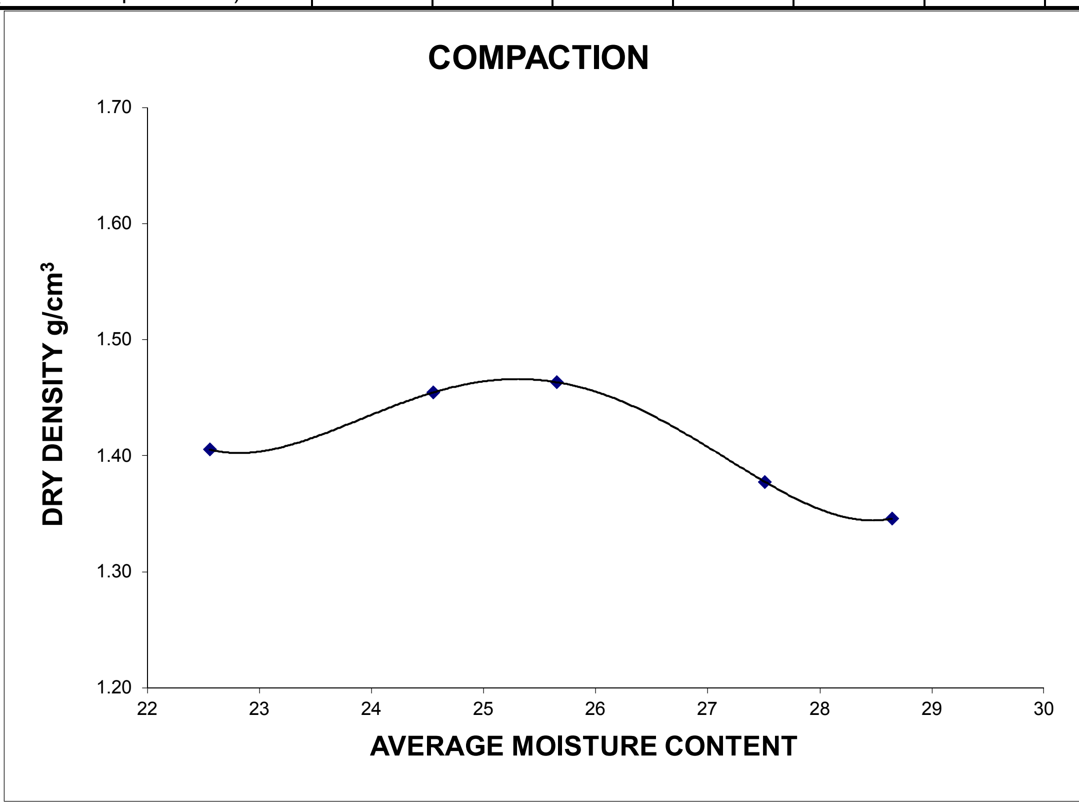
B.S. / C.B.R. Mould……**3252g…**……………..............................

Wt. of mould & wet Soil (W2) g	4965.00	5054.00	5081.00	4999.00	4974.00		
Wt. of mould (W1) g	3250.00	3250.00	3250.00	3250.00	3250.00		
Wt. of wet soil (W2-W1) g	1715.00	1804.00	1831.00	1749.00	1724.00		
Bulk Density (Pb) (W2-W1)/x g/cm^3	1.72	1.81	1.84	1.76	1.73		

MOISTURE CONTENT DETERMINATIONS for B.S. Mould, X = 1000cm^3

Container No.	CP	OB	B4	OH	MN	EI	NI	Z8	PB	AZ				
Wt. of wet soil & container (g)	57.21	59.53	55.32	49.96	54.60	53.05	49.94	55.55	52.12	50.55				
Wt. of Dry soil & container (g)	49.91	51.55	47.81	43.37	46.70	45.86	42.23	47.78	44.28	42.99				
Wt. of Container (g)	17.41	16.31	16.91	16.79	16.03	17.71	14.07	19.67	16.75	16.75				
Wt. of dry soil (Wd) g	32.50	35.24	30.90	26.58	30.67	28.15	28.16	28.11	27.53	26.24				
Wt. of Moisture (Wm) g	7.30	7.98	7.51	6.59	7.90	7.19	7.71	7.77	7.84	7.56				
Moistur Content 100(Wm/Wd) %	22.46	22.64	24.30	24.79	25.76	25.54	27.38	27.64	28.48	28.81				

Average Moisture Content (m) %	22.55	24.55	25.65	27.51	28.64		
Dry Density = Pb/1+ (m/100) (g/cm^3)	1.41	1.45	1.46	1.38	1.35		
C.B.R. (mseen of top & bottom) %							



DETERMINATION OF THE MOISTURE/DENSITY RELATION OF SOIL
USING STANDARD/HEAVY COMPACTION

Job... **OKOMU** Sample No:**....BOILER, BH1...** Operator…………

Site…... Dept**...1.0m……** Date:**…25/05/2018…** MDD:**1.51g/cm³**

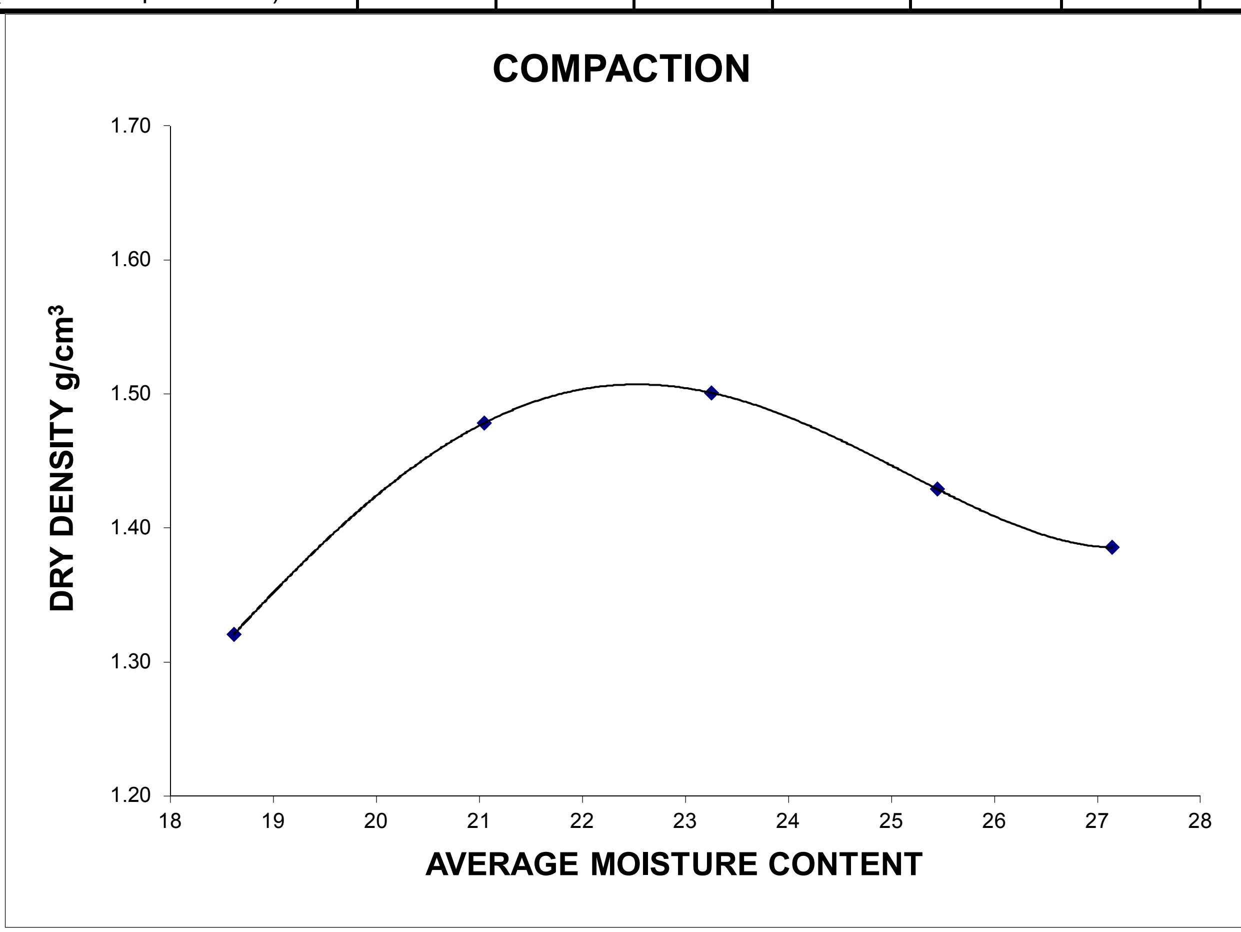
Amount retained on 20mm B.S. Sieve……… Total weight of Sample…… OPT.MC:**22.5%**

B.S. / C.B.R. Mould……**3252g…**…………..............................

Wt. of mould & wet Soil (W2) g	4810.00	5032.00	5092.00	5035.00	5004.00		
Wt. of mould (W1) g	3250.00	3250.00	3250.00	3250.00	3250.00		
Wt. of wet soil (W2-W1) g	1560.00	1782.00	1842.00	1785.00	1754.00		
Bulk Density (Pb) (W2-W1)/x g/cm ^{3}	1.57	1.79	1.85	1.79	1.76		

MOISTURE CONTENT DETERMINATIONS for B.S. Mould, X = 1000cm ^{3}

Container No.	BA	64M	OX	UN	7S	PT	T	PO	SO	ST				
Wt. of wet soil & container (g)	44.51	41.62	54.62	54.85	53.97	54.13	52.55	53.01	53.91	54.84				
Wt. of Dry soil & container (g)	40.35	37.54	48.10	48.32	46.82	46.68	45.60	45.50	46.34	46.40				
Wt. of Container (g)	18.13	15.50	17.21	17.21	15.51	15.21	17.95	16.35	18.40	15.36				
Wt. of dry soil (Wd) g	22.22	22.04	30.89	31.11	31.31	31.47	27.65	29.15	27.94	31.04				
Wt. of Moisture (Wm) g	4.16	4.08	6.52	6.53	7.15	7.45	6.95	7.51	7.57	8.44				
Moistur Content 100(Wm/Wd) %	18.72	18.51	21.11	20.99	22.84	23.67	25.14	25.76	27.09	27.19				
Average Moisture Content (m) %	18.62		21.05		23.25		25.45		27.14					
Dry Density = Pb/1+ (m/100) (g/cm ^{3})	1.32		1.48		1.50		1.43		1.39					
C.B.R. (mseen of top & bottom) %														



DETERMINATION OF THE MOISTURE/DENSITY RELATION OF SOIL
USING STANDARD/HEAVY COMPACTION

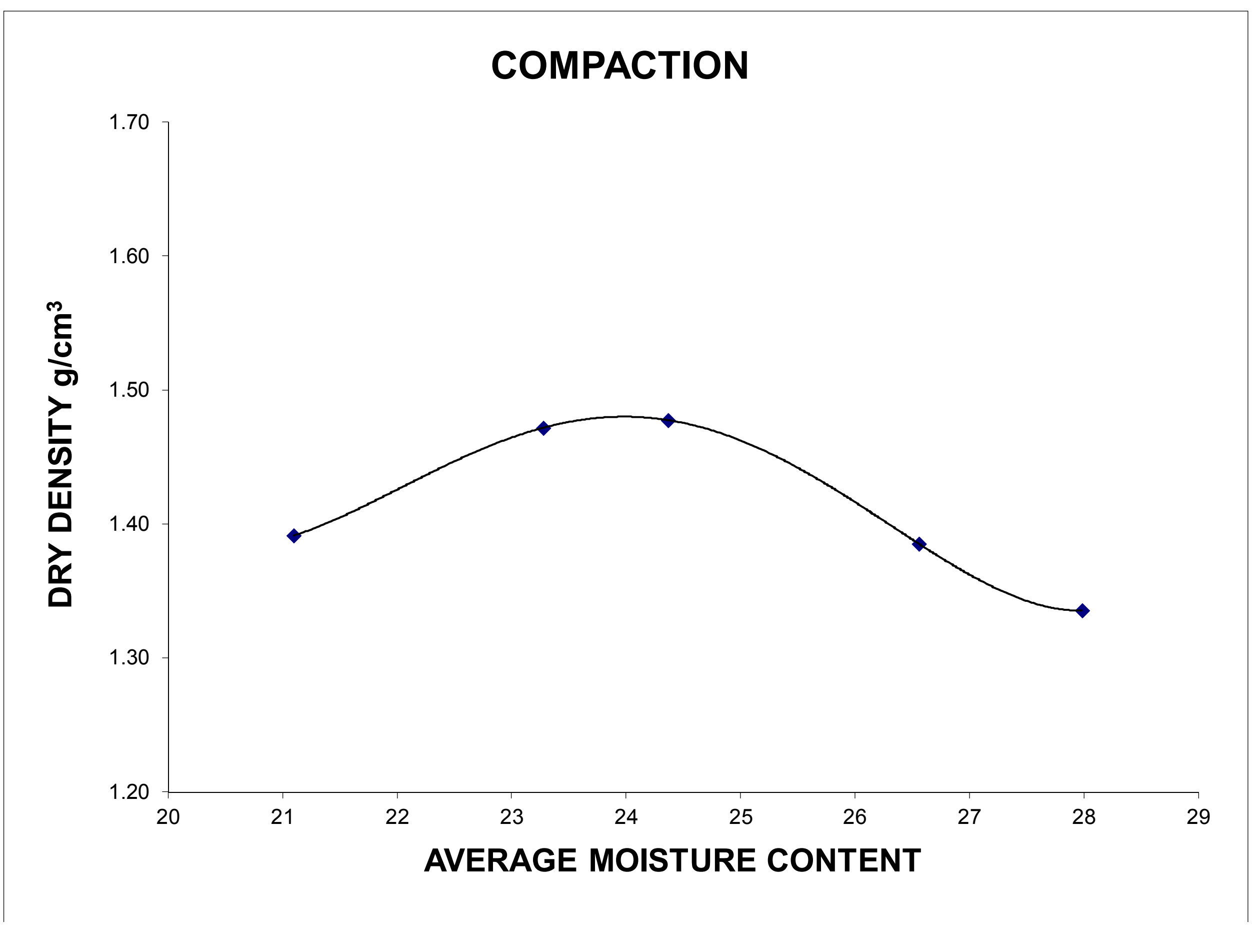
Job… **OKOMU** Sample No:**....BOILER, BH1...** Operator…………

Site…**....** Dept**…3.0m……** Date:**…25/05/2018…** MDD:**1.48g/cm³**

Amount retained on 20mm B.S. Sieve……… Total weight of Sample…… OPT.MC**:24.0%**

B.S. / C.B.R. Mould……**3252g…**…………..............................

Wt. of mould & wet Soil (W2) g	4928.00		5057.00		5080.00		4996.00		4952.00					
Wt. of mould (W1) g	3250.00		3250.00		3250.00		3250.00		3250.00					
Wt. of wet soil (W2-W1) g	1678.00		1807.00		1830.00		1746.00		1702.00					
Bulk Density (Pb) (W2-W1)/x g/cm ^{3}	1.69		1.81		1.84		1.75		1.71					
MOISTURE CONTENT DETERMINATIONS for B.S. Mould, X = 1000cm ^{3}														
Container No.	OY	LB	LK	RO	UC	LO	IP	NI	XX	GZ				
Wt. of wet soil & container (g)	51.55	53.95	56.54	51.49	48.28	50.50	56.22	51.52	51.39	57.20				
Wt. of Dry soil & container (g)	45.32	47.23	49.52	45.54	41.62	43.73	47.64	44.72	44.23	48.91				
Wt. of Container (g)	15.43	15.75	19.62	19.75	14.60	15.62	16.49	18.12	18.09	19.90				
Wt. of dry soil (Wd) g	29.89	31.48	29.90	25.79	27.02	28.11	31.15	26.60	26.14	29.01				
Wt. of Moisture (Wm) g	6.23	6.72	7.02	5.95	6.66	6.77	8.58	6.80	7.16	8.29				
Moistur Content 100(Wm/Wd) %	20.84	21.35	23.48	23.07	24.65	24.08	27.54	25.56	27.39	28.58				
Average Moisture Content (m) %	21.09		23.27		24.37		26.55		27.98					
Dry Density = Pb/1+ (m/100) (g/cm ^{3})	1.39		1.47		1.48		1.39		1.34					
C.B.R. (mseen of top & bottom) %														



DETERMINATION OF THE MOISTURE/DENSITY RELATION OF SOIL
USING STANDARD/HEAVY COMPACTION

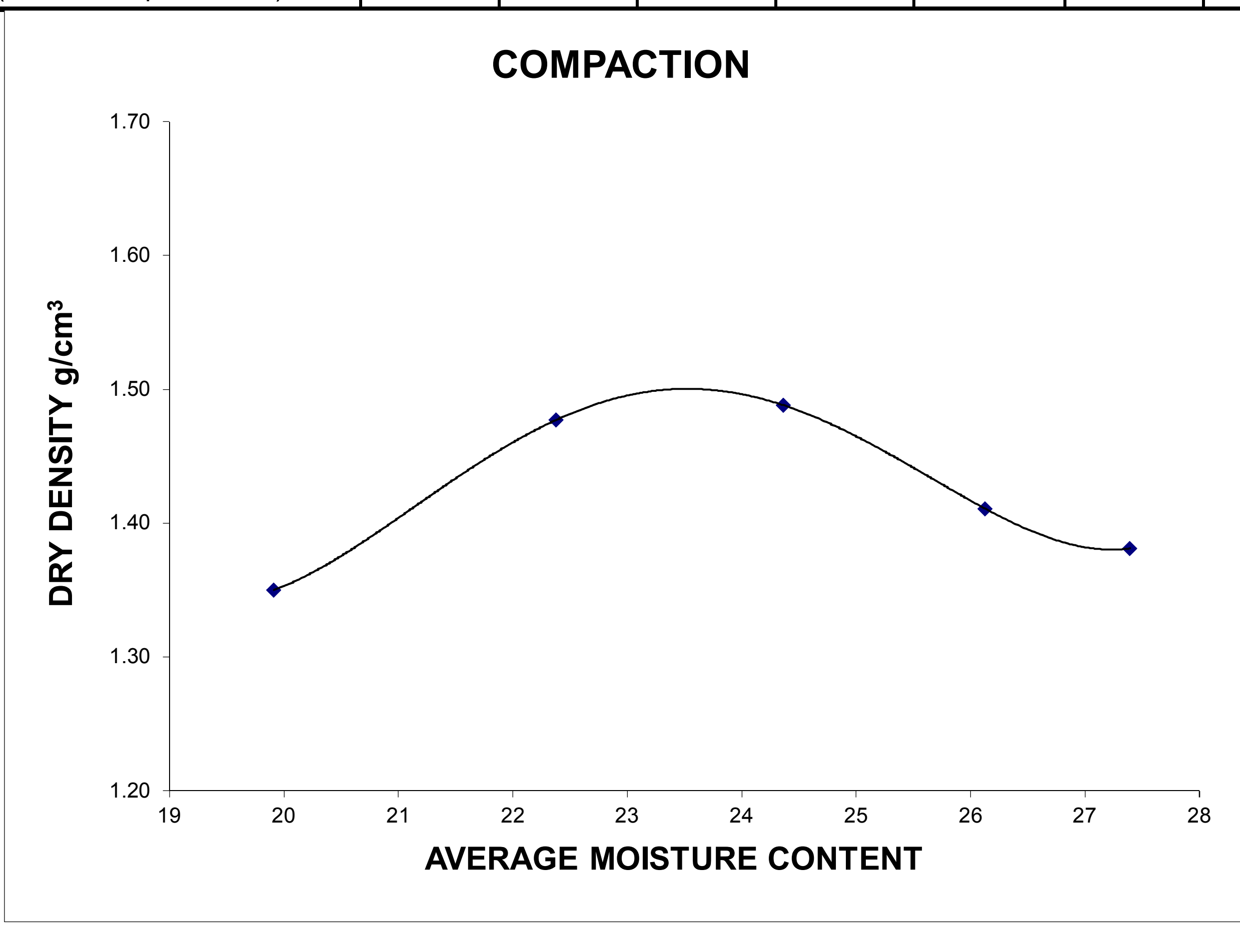
Job... **OKOMU** Sample No:**....BOILER, BH1...** Operator…………

Site….... Dept**...6.0m……** Date:**...25/05/2018...** MDD:**1.50g/cm³**

Amount retained on 20mm B.S. Sieve……… Total weight of Sample…… OPT.MC:**23.4%**

B.S. / C.B.R. Mould……**3252g...**…………..............................

Wt. of mould & wet Soil (W2) g	4862.00		5050.00		5093.00		5022.00		5002.00					
Wt. of mould (W1) g	3250.00		3250.00		3250.00		3250.00		3250.00					
Wt. of wet soil (W2-W1) g	1612.00		1800.00		1843.00		1772.00		1752.00					
Bulk Density (Pb) (W2-W1)/x g/cm ^{3}	1.62		1.81		1.85		1.78		1.76					
MOISTURE CONTENT DETERMINATIONS					for B.S. Mould, X = 1000cm ^{3}									
Container No.	PA	JO	JN	LA	IE	VO	OG	MP	OY	F7				
Wt. of wet soil & container (g)	57.92	53.56	50.44	50.65	52.22	52.72	54.26	55.35	52.88	57.09				
Wt. of Dry soil & container (g)	51.28	47.10	44.46	44.17	45.68	45.74	46.78	47.55	44.99	48.73				
Wt. of Container (g)	17.81	14.78	17.84	15.10	18.47	17.47	18.23	17.61	16.41	17.97				
Wt. of dry soil (Wd) g	33.47	32.32	26.62	29.07	27.21	28.27	28.55	29.94	28.58	30.76				
Wt. of Moisture (Wm) g	6.64	6.46	5.98	6.48	6.54	6.98	7.48	7.80	7.89	8.36				
Moistur Content 100(Wm/Wd) %	19.84	19.99	22.46	22.29	24.04	24.69	26.20	26.05	27.61	27.18				
Average Moisture Content (m) %	19.91		22.38		24.36		26.13		27.39					
Dry Density = Pb/1+ (m/100) (g/cm ^{3})	1.35		1.48		1.49		1.41		1.38					
C.B.R. (mseen of top & bottom) %														



DETERMINATION OF THE MOISTURE/DENSITY RELATION OF SOIL
USING STANDARD/HEAVY COMPACTION

Job... **OKOMU** Sample No:**....BOILER, BH1...** Operator…………

Site…..... Dept**...12.0m……** Date**:...25/05/2018…** MDD:**1.44g/cm^3**

Amount retained on 20mm B.S. Sieve……… Total weight of Sample…… OPT.MC**:24.7%**

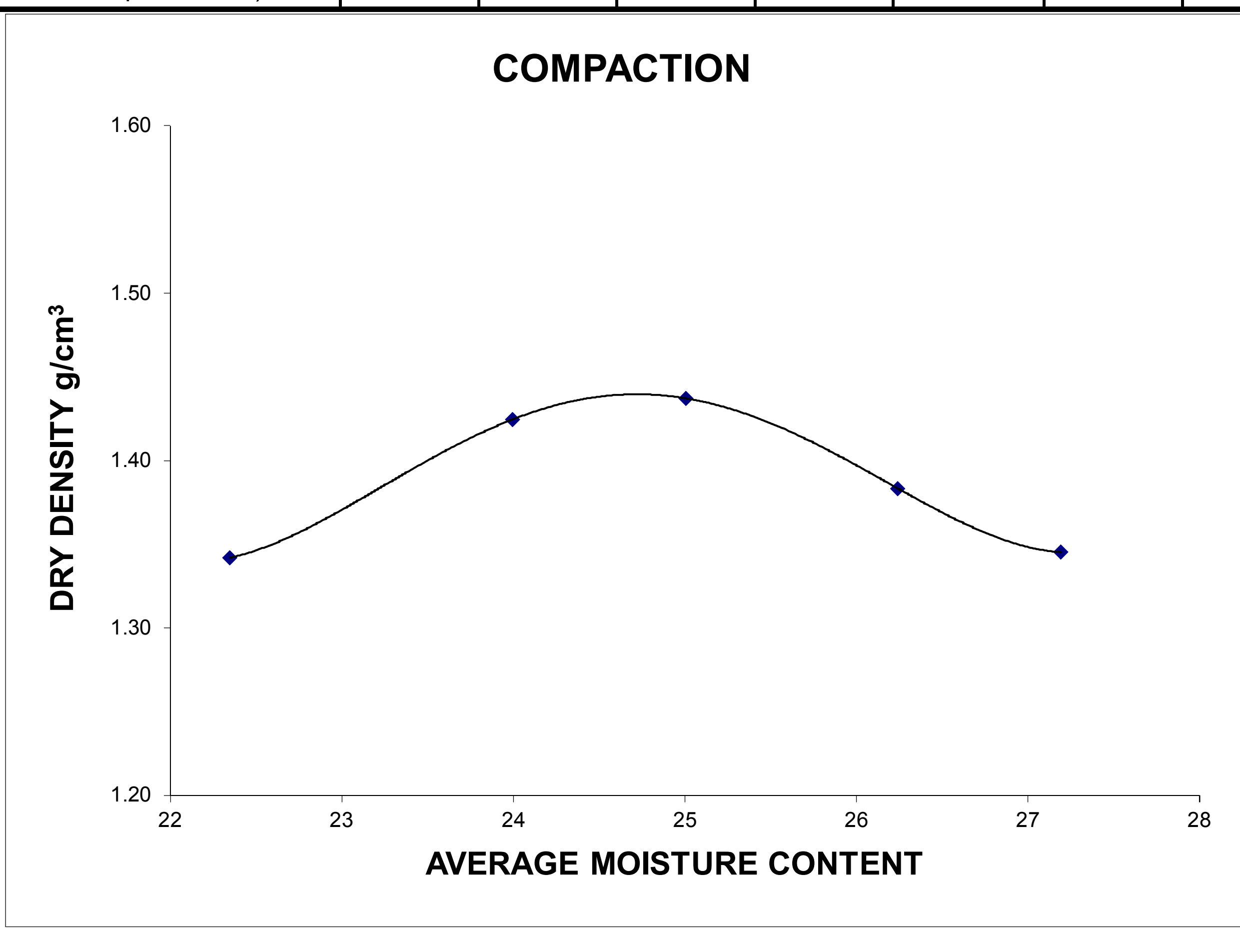
B.S. / C.B.R. Mould……**4726g…**……………..............................

Wt. of mould & wet Soil (W2) g	6361.00	6485.00	6515.00	6465.00	6430.00		
Wt. of mould (W1) g	4726.00	4726.00	4726.00	4726.00	4726.00		
Wt. of wet soil (W2-W1) g	1635.00	1759.00	1789.00	1739.00	1704.00		
Bulk Density (Pb) (W2-W1)/x g/cm^3	1.64	1.77	1.80	1.75	1.71		

MOISTURE CONTENT DETERMINATIONS for B.S. Mould, X = 1000cm^3

Container No.	AG	MI	EV	ZU	QO	FO	CO	AF	IP	AD				
Wt. of wet soil & container (g)	42.63	53.77	48.75	39.47	46.23	35.80	43.93	40.04	43.88	44.31				
Wt. of Dry soil & container (g)	38.10	47.31	42.52	34.94	40.83	31.62	38.54	35.05	38.41	38.60				
Wt. of Container (g)	18.05	18.08	16.84	15.85	18.67	15.32	17.75	16.26	18.50	17.38				
Wt. of dry soil (Wd) g	20.05	29.23	25.68	19.09	22.16	16.30	20.79	18.79	19.91	21.22				
Wt. of Moisture (Wm) g	4.53	6.46	6.23	4.53	5.40	4.18	5.39	4.99	5.47	5.71				
Moistur Content 100(Wm/Wd) %	22.59	22.10	24.26	23.73	24.37	25.64	25.93	26.56	27.47	26.91				

Average Moisture Content (m) %	22.35	23.99	25.01	26.24	27.19		
Dry Density = Pb/1+ (m/100) (g/cm^3)	1.34	1.42	1.44	1.38	1.35		
C.B.R. (mseen of top & bottom) %							



DETERMINATION OF THE MOISTURE/DENSITY RELATION OF SOIL
USING STANDARD/HEAVY COMPACTION

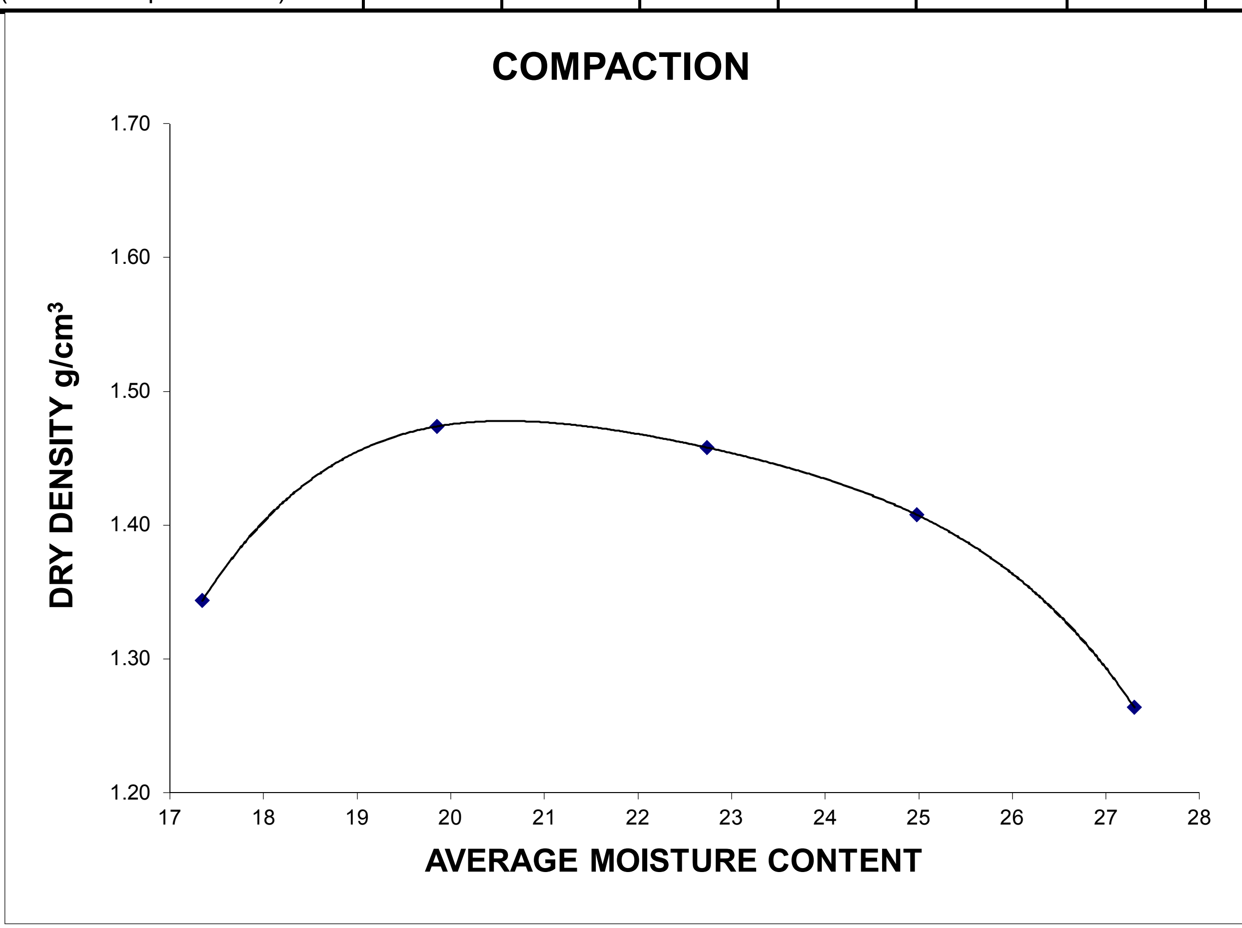
Job... **OKOMU** Sample No:**....BOILER, BH1...** Operator……

Site…..... Dept....**9.0m……** Date:**…25/05/2018…** MDD:**1.48g/cm³**

Amount retained on 20mm B.S. Sieve……… Total weight of Sample…… OPT.MC:**20.6%**

B.S. / C.B.R. Mould……**4718g…**………….............................

Wt. of mould & wet Soil (W2) g	6288.00		6477.00		6500.00		6470.00		6320.00					
Wt. of mould (W1) g	4718.00		4718.00		4718.00		4718.00		4718.00					
Wt. of wet soil (W2-W1) g	1570.00		1759.00		1782.00		1752.00		1602.00					
Bulk Density (Pb) (W2-W1)/x g/cm ^{3}	1.58		1.77		1.79		1.76		1.61					
MOISTURE CONTENT DETERMINATIONS for B.S. Mould, X = 1000cm ^{3}														
Container No.	OB	AZ	OH	UM	CP	ST	OB	BO	EB	E6				
Wt. of wet soil & container (g)	39.65	45.90	47.12	51.65	53.97	45.35	54.18	56.74	49.97	47.62				
Wt. of Dry soil & container (g)	36.21	41.59	42.14	45.48	47.17	39.80	46.74	49.03	43.02	41.16				
Wt. of Container (g)	16.40	16.72	16.83	14.68	17.35	15.32	16.87	18.25	17.34	17.71				
Wt. of dry soil (Wd) g	19.81	24.87	25.31	30.80	29.82	24.48	29.87	30.78	25.68	23.45				
Wt. of Moisture (Wm) g	3.44	4.31	4.98	6.17	6.80	5.55	7.44	7.71	6.95	6.46				
Moistur Content 100(Wm/Wd) %	17.36	17.33	19.68	20.03	22.80	22.67	24.91	25.05	27.06	27.55				
Average Moisture Content (m) %	17.35		19.85		22.74		24.98		27.31					
Dry Density = Pb/1+ (m/100) (g/cm ^{3})	1.34		1.47		1.46		1.41		1.26					
C.B.R. (mseen of top & bottom) %														



DETERMINATION OF THE MOISTURE/DENSITY RELATION OF SOIL
USING STANDARD/HEAVY COMPACTION

Job... **OKOMU** Sample No:....**BOILER...** Operator............

Site…..... Dept...**BH1, 15.0m……** Date:...**25/05/2018...** MDD:**1.48g/cm^3**

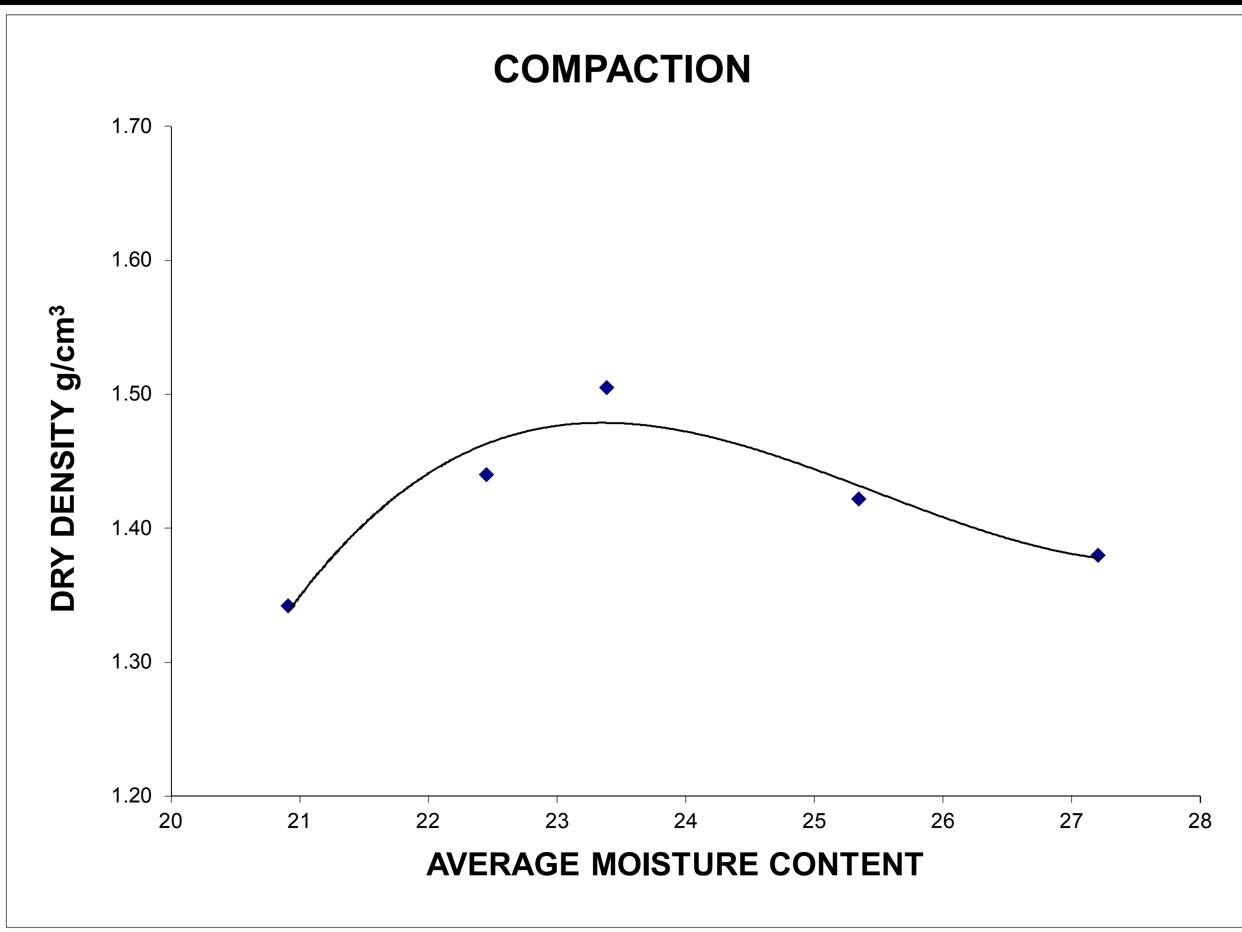
Amount retained on 20mm B.S. Sieve……… Total weight of Sample…… OPT.MC:**23.4%**

B.S. / C.B.R. Mould……**3252g...**……………................................

Wt. of mould & wet Soil (W2) g	4866.00	5006.00	5099.00	5025.00	4998.00		
Wt. of mould (W1) g	3250.00	3250.00	3250.00	3250.00	3250.00		
Wt. of wet soil (W2-W1) g	1616.00	1756.00	1849.00	1775.00	1748.00		
Bulk Density (Pb) (W2-W1)/x g/cm ^{3}	1.62	1.76	1.86	1.78	1.76		

MOISTURE CONTENT DETERMINATIONS for B.S. Mould, X = 1000cm ^{3}

Container No.	P3	CO	PV	BA	PO	84O	KI	ZO	TO	OZ				
Wt. of wet soil & container (g)	49.41	59.27	53.28	54.17	49.27	50.14	56.49	56.52	56.18	52.12				
Wt. of Dry soil & container (g)	43.90	52.10	46.80	47.10	43.70	43.90	47.90	48.90	48.00	44.50				
Wt. of Container (g)	17.04	18.45	17.32	16.25	19.88	17.22	14.17	18.69	17.96	16.46				
Wt. of dry soil (Wd) g	26.86	33.65	29.48	30.85	23.82	26.68	33.73	30.21	30.04	28.04				
Wt. of Moisture (Wm) g	5.51	7.17	6.48	7.07	5.57	6.24	8.59	7.62	8.18	7.62				
Moistur Content 100(Wm/Wd) %	20.51	21.31	21.98	22.92	23.38	23.39	25.47	25.22	27.23	27.18				
Average Moisture Content (m) %	20.91		22.45		23.39		25.35		27.20					
Dry Density = Pb/1+ (m/100) (g/cm ^{3})	1.34		1.44		1.50		1.42		1.38					
C.B.R. (mseen of top & bottom) %														



DETERMINATION OF THE MOISTURE/DENSITY RELATION OF SOIL
USING STANDARD/HEAVY COMPACTION

Job... **OKOMU** Sample No:....**CLARIFICATION STATION, BH3...** Operator…………

Site…..... Dept...**2.50m**…… Date:...**25/05/2018**... MDD:**1.51g/cm^3**

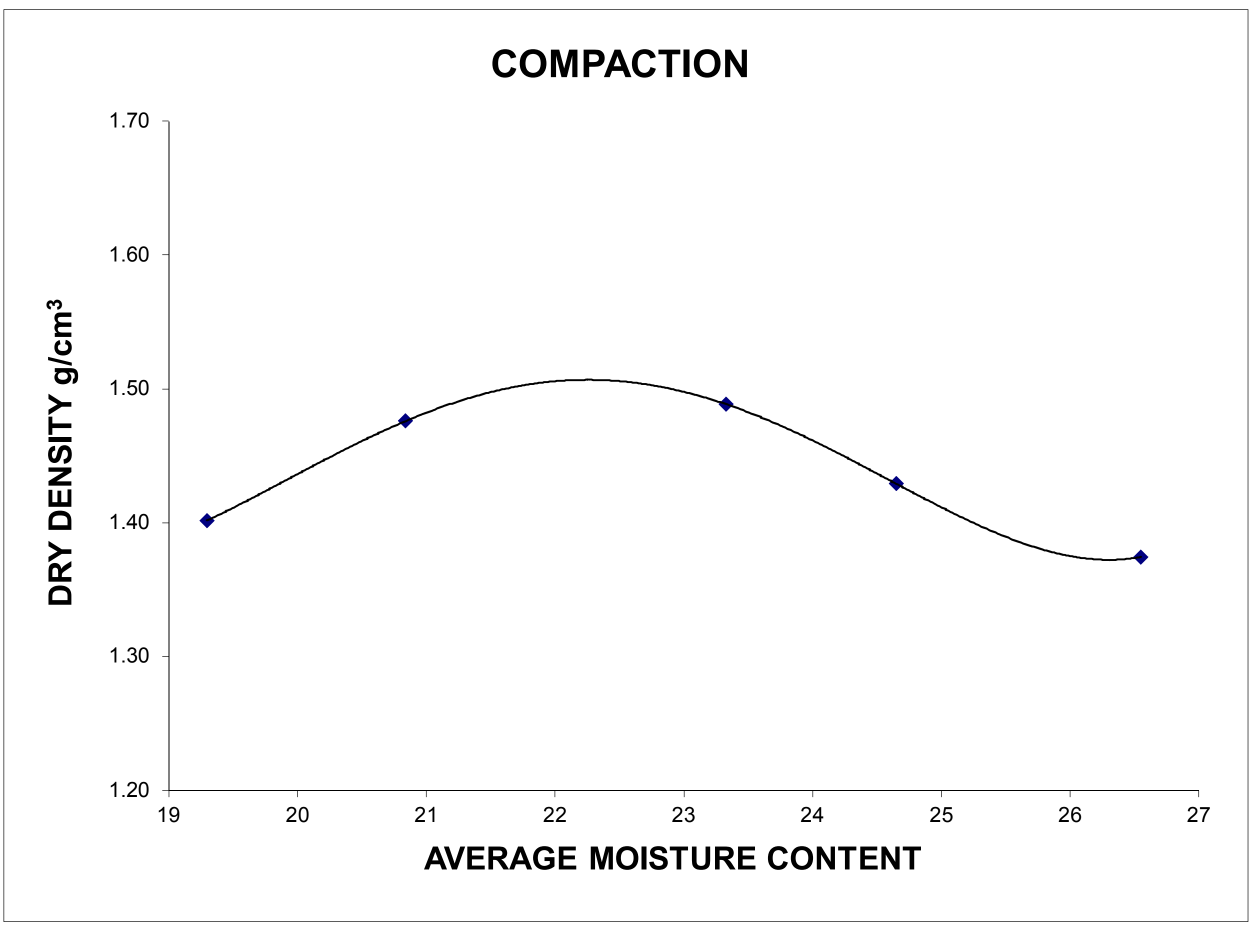
Amount retained on 20mm B.S. Sieve……… Total weight of Sample…… OPT.MC:**22.3%**

B.S. / C.B.R. Mould……**3252g**…………................................

Wt. of mould & wet Soil (W2) g	4915.00	5026.00	5078.00	5024.00	4982.00		
Wt. of mould (W1) g	3250.00	3250.00	3250.00	3250.00	3250.00		
Wt. of wet soil (W2-W1) g	1665.00	1776.00	1828.00	1774.00	1732.00		
Bulk Density (Pb) (W2-W1)/x g/cm^3	1.67	1.78	1.84	1.78	1.74		

MOISTURE CONTENT DETERMINATIONS for B.S. Mould, X = 1000cm^3

Container No.	III	P3	8I	BE	Z3	PO	PV	IN	TO	KI				
Wt. of wet soil & container (g)	51.76	50.99	53.40	57.93	54.60	50.79	55.34	56.42	57.60	51.02				
Wt. of Dry soil & container (g)	46.20	45.45	47.29	50.83	47.64	44.92	47.75	48.33	49.29	43.29				
Wt. of Container (g)	16.97	17.14	17.19	17.62	17.72	19.83	17.30	15.13	17.97	14.19				
Wt. of dry soil (Wd) g	29.23	28.31	30.10	33.21	29.92	25.09	30.45	33.20	31.32	29.10				
Wt. of Moisture (Wm) g	5.56	5.54	6.11	7.10	6.96	5.87	7.59	8.09	8.31	7.73				
Moistur Content 100(Wm/Wd) %	19.02	19.57	20.30	21.38	23.26	23.40	24.93	24.37	26.53	26.56				
Average Moisture Content (m) %	19.30		20.84		23.33		24.65		26.55					
Dry Density = Pb/1+ (m/100) (g/cm^3)	1.40		1.48		1.49		1.43		1.37					
C.B.R. (mseen of top & bottom) %														



DETERMINATION OF THE MOISTURE/DENSITY RELATION OF SOIL
USING STANDARD/HEAVY COMPACTION

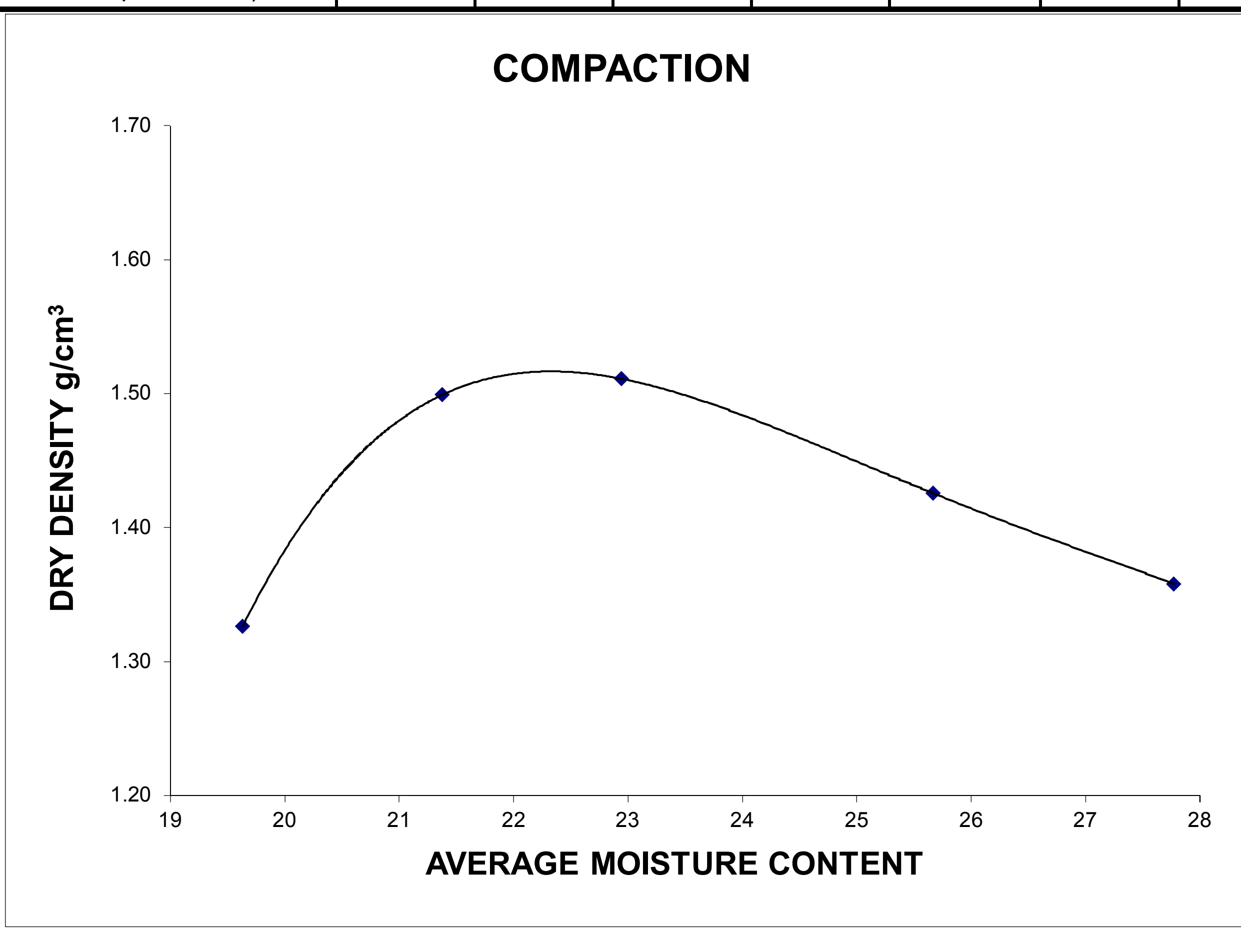
Job... **OKOMU** Sample No:....**CLARIFICATION STATION, BH3...** Operator…………

Site…..... Dept...**5.50m**…… Date:...**25/05/2018**… MDD:**1.52g/cm³**

Amount retained on 20mm B.S. Sieve……… Total weight of Sample…… OPT.MC:**22.3%**

B.S. / C.B.R. Mould……**3252g**…………...............................

Wt. of mould & wet Soil (W2) g	4830.00		5062.00		5100.00		5034.00		4978.00					
Wt. of mould (W1) g	3250.00		3250.00		3250.00		3250.00		3250.00					
Wt. of wet soil (W2-W1) g	1580.00		1812.00		1850.00		1784.00		1728.00					
Bulk Density (Pb) (W2-W1)/x g/cm^3	1.59		1.82		1.86		1.79		1.74					
MOISTURE CONTENT DETERMINATIONS for B.S. Mould, X = $1000cm^3$														
Container No.	CO	QA	ZA	JK	RO	ZO	ZA	NZ	RO	BA				
Wt. of wet soil & container (g)	50.87	54.76	53.94	53.33	52.83	56.43	54.81	52.20	56.80	53.07				
Wt. of Dry soil & container (g)	45.60	48.21	47.59	46.91	45.63	49.38	47.34	44.91	48.50	44.98				
Wt. of Container (g)	18.50	15.16	17.47	17.29	14.12	18.77	18.02	16.72	18.04	16.39				
Wt. of dry soil (Wd) g	27.10	33.05	30.12	29.62	31.51	30.61	29.32	28.19	30.46	28.59				
Wt. of Moisture (Wm) g	5.27	6.55	6.35	6.42	7.20	7.05	7.47	7.29	8.30	8.09				
Moistur Content 100(Wm/Wd) %	19.45	19.82	21.08	21.67	22.85	23.03	25.48	25.86	27.25	28.30				
Average Moisture Content (m) %	19.63		21.38		22.94		25.67		27.77					
Dry Density = Pb/1+ (m/100) (g/cm^3)	1.33		1.50		1.51		1.43		1.36					
C.B.R. (mseen of top & bottom) %														



DETERMINATION OF THE MOISTURE/DENSITY RELATION OF SOIL
USING STANDARD/HEAVY COMPACTION

Job... **OKOMU** Sample No:**....CLARIFICATION STATION, BH3...** Operator…………

Site…**...** Dept**…11.5m……** Date:**…25/05/2018…** MDD:**1.49g/cm³**

Amount retained on 20mm B.S. Sieve……… Total weight of Sample…… OPT.MC**:21.9%**

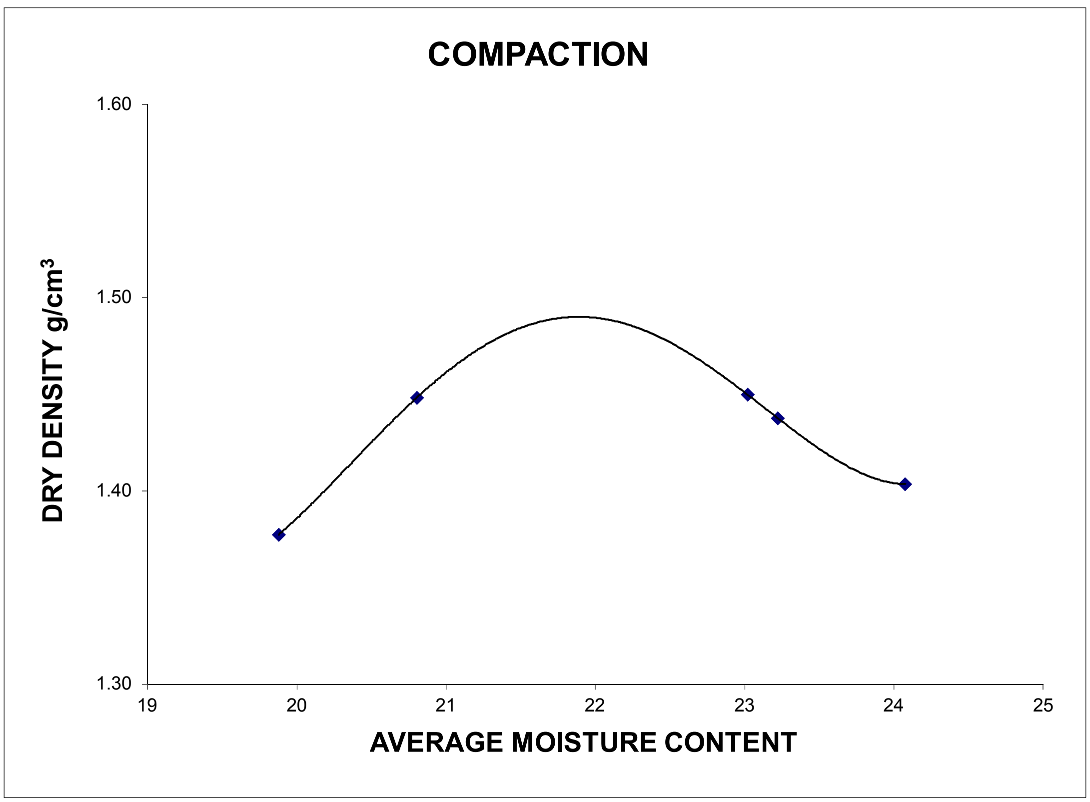
B.S. / C.B.R. Mould……**4726g…**………….................................

Wt. of mould & wet Soil (W2) g	6370.00	6468.00	6502.00	6490.00	6460.00		
Wt. of mould (W1) g	4726.00	4726.00	4726.00	4726.00	4726.00		
Wt. of wet soil (W2-W1) g	1644.00	1742.00	1776.00	1764.00	1734.00		
Bulk Density (Pb) (W2-W1)/x g/cm^3	1.65	1.75	1.78	1.77	1.74		

MOISTURE CONTENT DETERMINATIONS for B.S. Mould, X = 1000cm^3

Container No.	GL	UN	AI	ID	8TH	AA	E5	PX	DO	Z3				
Wt. of wet soil & container (g)	50.25	49.74	44.27	61.67	53.54	55.93	54.87	53.79	42.45	45.81				
Wt. of Dry soil & container (g)	44.52	44.73	37.98	54.20	46.91	48.32	48.21	46.91	37.78	40.10				
Wt. of Container (g)	14.69	20.35	7.57	18.50	18.01	15.37	18.57	18.21	18.37	16.40				
Wt. of dry soil (Wd) g	29.83	24.38	30.41	35.70	28.90	32.95	29.64	28.70	19.41	23.70				
Wt. of Moisture (Wm) g	5.73	5.01	6.29	7.47	6.63	7.61	6.66	6.88	4.67	5.71				
Moistur Content 100(Wm/Wd) %	19.21	20.55	20.68	20.92	22.94	23.10	22.47	23.97	24.06	24.09				

Average Moisture Content (m) %	19.88	20.80	23.02	23.22	24.08		
Dry Density = Pb/1+ (m/100) (g/cm^3)	1.38	1.45	1.45	1.44	1.40		
C.B.R. (mseen of top & bottom) %							



DETERMINATION OF THE MOISTURE/DENSITY RELATION OF SOIL
USING STANDARD/HEAVY COMPACTION

Job... **OKOMU** Sample No:**....CLARIFICATION, BH3...** Operator…………

Site…..... Dept**...14.5m……** Date:**…25/05/2018…** MDD:**1.51g/cm^3**

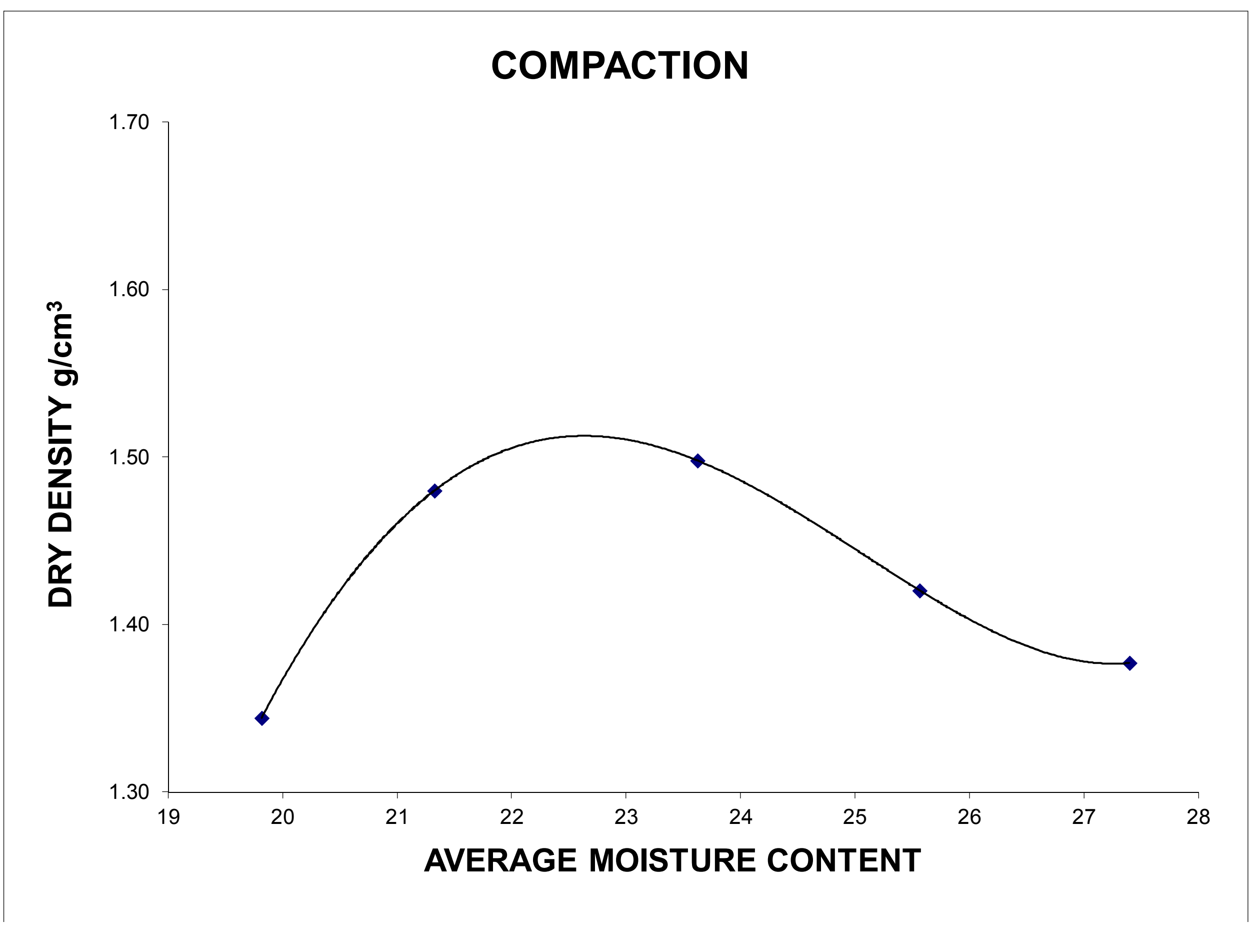
Amount retained on 20mm B.S. Sieve……… Total weight of Sample…… OPT.MC:**22.6%**

B.S. / C.B.R. Mould……**3252g…**………….............................

Wt. of mould & wet Soil (W2) g	4856.00	5040.00	5096.00	5028.00	4999.00		
Wt. of mould (W1) g	3252.00	3252.00	3252.00	3252.00	3252.00		
Wt. of wet soil (W2-W1) g	1604.00	1788.00	1844.00	1776.00	1747.00		
Bulk Density (Pb) (W2-W1)/x g/cm^3	1.61	1.80	1.85	1.78	1.75		

MOISTURE CONTENT DETERMINATIONS for B.S. Mould, X = 1000cm^3

Container No.	ED	BO	OA	IO	EI	EV	TK	WO	EB	UN				
Wt. of wet soil & container (g)	54.92	56.02	56.57	61.20	57.79	46.66	45.50	56.70	53.14	55.80				
Wt. of Dry soil & container (g)	48.57	49.87	49.80	53.50	50.14	40.61	39.28	48.62	45.51	46.90				
Wt. of Container (g)	17.03	18.32	17.75	17.72	17.86	14.92	14.92	17.05	17.37	14.74				
Wt. of dry soil (Wd) g	31.54	31.55	32.05	35.78	32.28	25.69	24.36	31.57	28.14	32.16				
Wt. of Moisture (Wm) g	6.35	6.15	6.77	7.70	7.65	6.05	6.22	8.08	7.63	8.90				
Moistur Content 100(Wm/Wd) %	20.13	19.49	21.12	21.52	23.70	23.55	25.53	25.59	27.11	27.67				
Average Moisture Content (m) %	19.81		21.32		23.62		25.56		27.39					
Dry Density = Pb/1+ (m/100) (g/cm^3)	1.34		1.48		1.50		1.42		1.38					
C.B.R. (mseen of top & bottom) %														



DETERMINATION OF THE MOISTURE/DENSITY RELATION OF SOIL
USING STANDARD/HEAVY COMPACTION

Job... **OKOMU** Sample No:**....CLARIFICATION STATION, BH3...** Operator……

Site…**...** Dept....**8.5m……** Date:**…25/05/2018…** MDD:**1.58g/cm³**

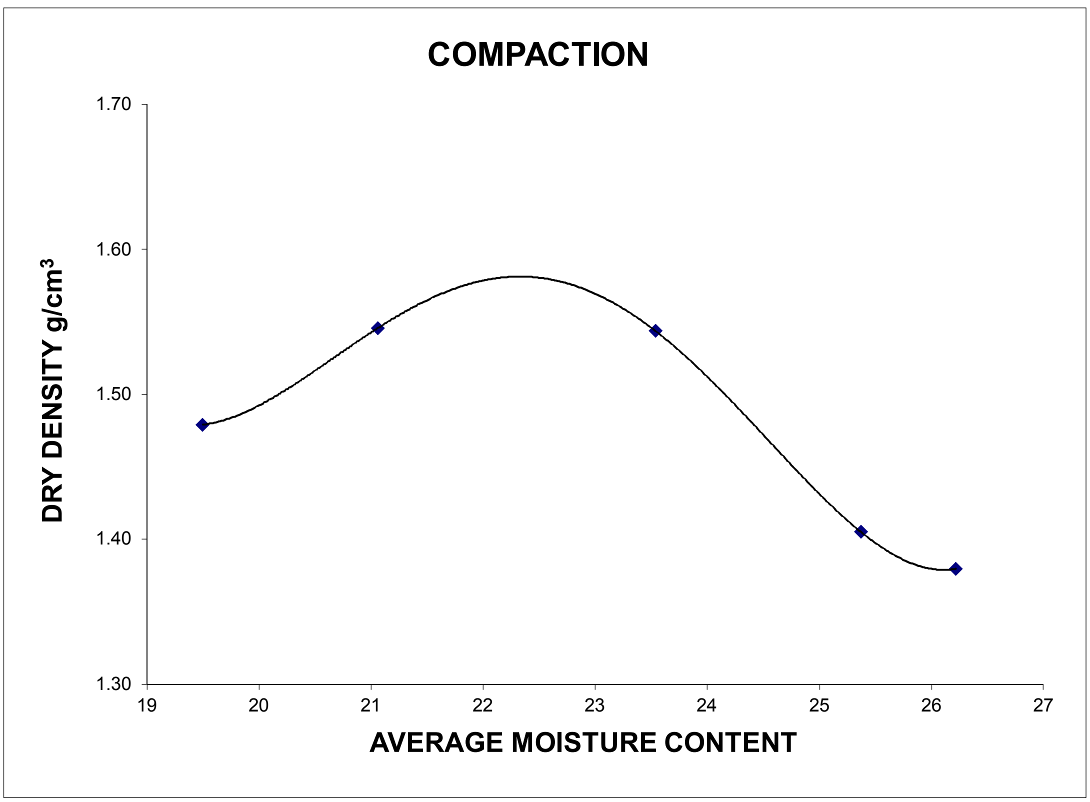
Amount retained on 20mm B.S. Sieve……… Total weight of Sample…… OPT.MC**:22.3%**

B.S. / C.B.R. Mould……**3252g…**……………...............................

Wt. of mould & wet Soil (W2) g	5012.00	5115.00	5151.00	5006.00	4986.00		
Wt. of mould (W1) g	3252.00	3252.00	3252.00	3252.00	3252.00		
Wt. of wet soil (W2-W1) g	1760.00	1863.00	1899.00	1754.00	1734.00		
Bulk Density (Pb) (W2-W1)/x g/cm^3	1.77	1.87	1.91	1.76	1.74		

MOISTURE CONTENT DETERMINATIONS for B.S. Mould, X = 1000cm^3

Container No.	PO	JO	Z5	ZA	UN	SO	PT	UI	BO	MO		
Wt. of wet soil & container (g)	51.25	50.29	53.14	51.87	51.68	58.85	48.36	47.33	56.17	54.59		
Wt. of Dry soil & container (g)	45.51	44.91	47.26	45.94	45.05	51.18	41.64	40.60	47.99	46.47		
Wt. of Container (g)	16.26	17.13	19.38	17.73	17.16	18.26	14.86	14.36	17.02	15.27		
Wt. of dry soil (Wd) g	29.25	27.78	27.88	28.21	27.89	32.92	26.78	26.24	30.97	31.20		
Wt. of Moisture (Wm) g	5.74	5.38	5.88	5.93	6.63	7.67	6.72	6.73	8.18	8.12		
Moistur Content 100(Wm/Wd) %	19.62	19.37	21.09	21.02	23.77	23.30	25.09	25.65	26.41	26.03		
Average Moisture Content (m) %	19.50		21.06		23.54		25.37		26.22			
Dry Density = Pb/1+ (m/100) (g/cm^3)	1.48		1.55		1.54		1.40		1.38			
C.B.R. (mseen of top & bottom) %												



DETERMINATION OF THE MOISTURE/DENSITY RELATION OF SOIL
USING STANDARD/HEAVY COMPACTION

Job... **OKOMU** Sample No:**....POWER HOUSE, BH2...** Operator…………

Site…**....** Dept**…11.0m……** Date:**…25/05/2018…** MDD:**1.53g/cm³**

Amount retained on 20mm B.S. Sieve……… Total weight of Sample…… OPT.MC**:24.3%**

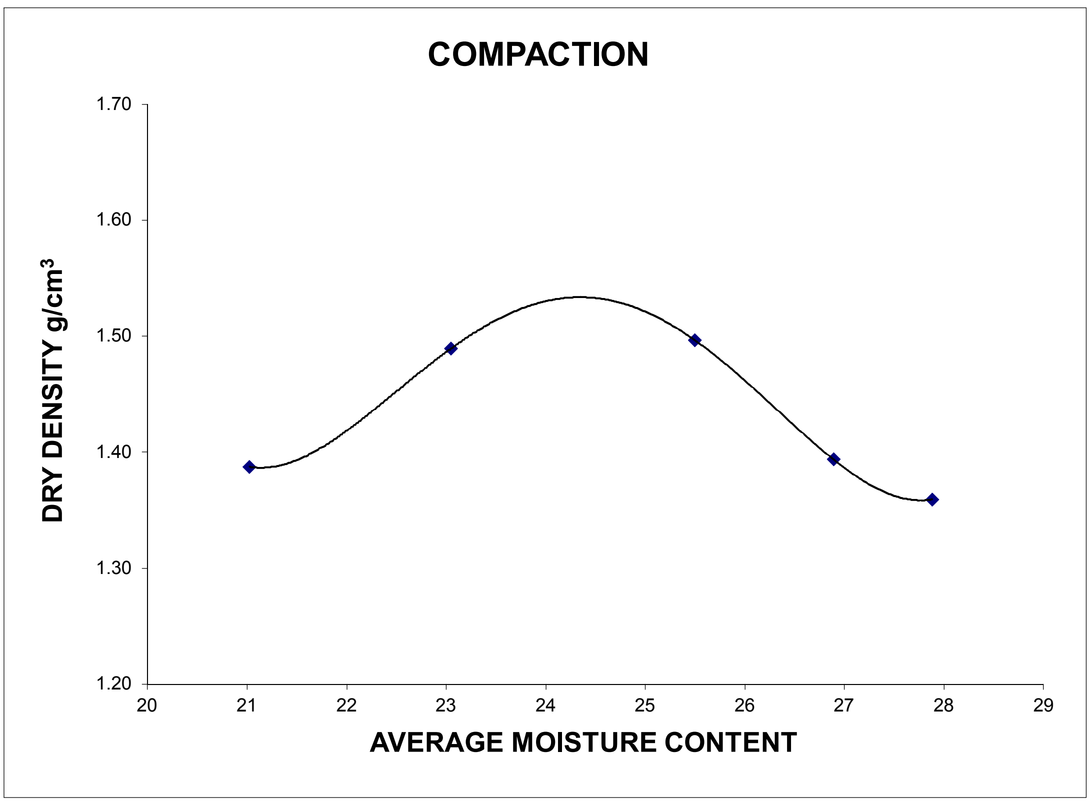
B.S. / C.B.R. Mould……**3252g…**………….................................

Wt. of mould & wet Soil (W2) g	4922.00	5075.00	5120.00	5011.00	4981.00		
Wt. of mould (W1) g	3250.00	3250.00	3250.00	3250.00	3250.00		
Wt. of wet soil (W2-W1) g	1672.00	1825.00	1870.00	1761.00	1731.00		
Bulk Density (Pb) (W2-W1)/x g/cm^3	1.68	1.83	1.88	1.77	1.74		

MOISTURE CONTENT DETERMINATIONS for B.S. Mould, X = 1000cm^3

Container No.	OF	3A	UI	ZS	SG	JO	ZE	MT	ZA	JI				
Wt. of wet soil & container (g)	51.73	56.76	52.25	64.61	61.35	52.97	53.70	54.25	54.87	53.66				
Wt. of Dry soil & container (g)	45.77	49.90	45.24	56.04	53.04	45.52	45.73	46.01	47.15	45.45				
Wt. of Container (g)	17.55	17.12	14.41	19.36	19.45	17.15	16.21	15.24	19.40	16.07				
Wt. of dry soil (Wd) g	28.22	32.78	30.83	36.68	33.59	28.37	29.52	30.77	27.75	29.38				
Wt. of Moisture (Wm) g	5.96	6.86	7.01	8.57	8.31	7.45	7.97	8.24	7.72	8.21				
Moistur Content 100(Wm/Wd) %	21.12	20.93	22.74	23.36	24.74	26.26	27.00	26.78	27.82	27.94				

Average Moisture Content (m) %	21.02	23.05	25.50	26.89	27.88		
Dry Density = Pb/1+ (m/100) (g/cm^3)	1.39	1.49	1.50	1.39	1.36		
C.B.R. (mseen of top & bottom) %							



DETERMINATION OF THE MOISTURE/DENSITY RELATION OF SOIL
USING STANDARD/HEAVY COMPACTION

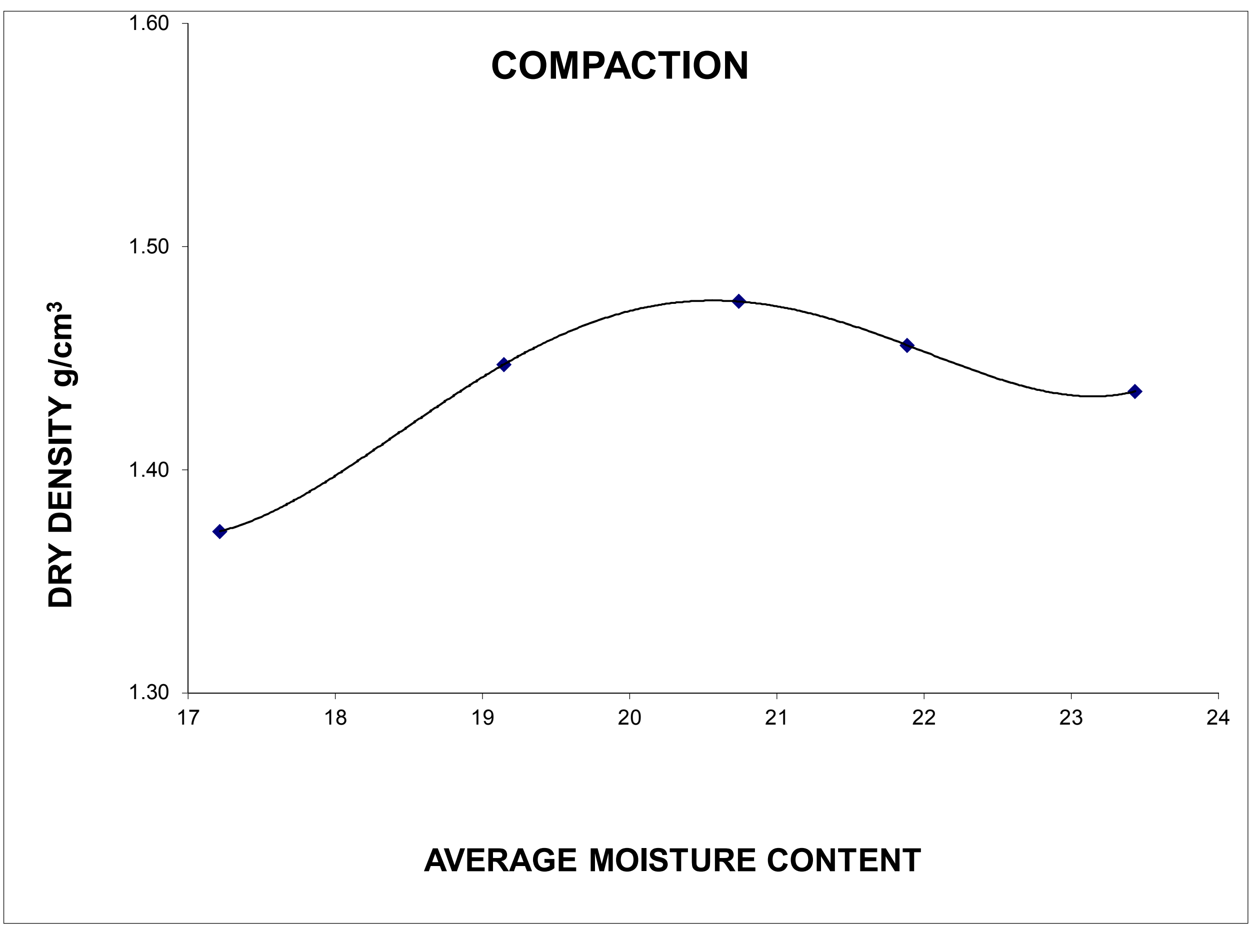
Job... **OKOMU** Sample No:....**POWER HOUSE...** Operator...........

Site…..... Dept... **BH2, 2.0m……** Date:...**25/05/2018…** MDD:**1.47g/cm³**

Amount retained on 20mm B.S. Sieve……… Total weight of Sample…… OPT.MC:**20.6%**

B.S. / C.B.R. Mould……**4723g**...…………...............................

Wt. of mould & wet Soil (W2) g	6325.00		6440.00		6497.00		6490.00		6487.00					
Wt. of mould (W1) g	4723.00		4723.00		4723.00		4723.00		4723.00					
Wt. of wet soil (W2-W1) g	1602.00		1717.00		1774.00		1767.00		1764.00					
Bulk Density (Pb) (W2-W1)/x g/cm^3	1.61		1.72		1.78		1.77		1.77					
MOISTURE CONTENT DETERMINATIONS for B.S. Mould, X = 1000cm^3														
Container No.	UK	PK	O4	IK	KC	XE	B4	EM	LE	OR				
Wt. of wet soil & container (g)	48.10	52.80	57.70	59.10	52.60	50.40	57.70	53.30	58.10	49.80				
Wt. of Dry soil & container (g)	43.20	47.58	51.40	52.00	46.40	44.30	51.10	46.70	50.80	43.00				
Wt. of Container (g)	14.60	17.40	18.50	14.90	16.50	14.90	19.80	17.60	19.30	14.30				
Wt. of dry soil (Wd) g	28.60	30.18	32.90	37.10	29.90	29.40	31.30	29.10	31.50	28.70				
Wt. of Moisture (Wm) g	4.90	5.22	6.30	7.10	6.20	6.10	6.60	6.60	7.30	6.80				
Moistur Content 100(Wm/Wd) %	17.13	17.30	19.15	19.14	20.74	20.75	21.09	22.68	23.17	23.69				
Average Moisture Content (m) %	17.21		19.14		20.74		21.88		23.43					
Dry Density = Pb/1+ (m/100) (g/cm^3)	1.37		1.45		1.48		1.46		1.44					
C.B.R. (mseen of top & bottom) %														



DETERMINATION OF THE MOISTURE/DENSITY RELATION OF SOIL
USING STANDARD/HEAVY COMPACTION

Job... **OKOMU** Sample No:**....POWER HOUSE...** Operator…………

Site…..... Dept... **BH2, 5.0m……** Date:**…25/05/2018…** MDD:**1.49g/cm³**

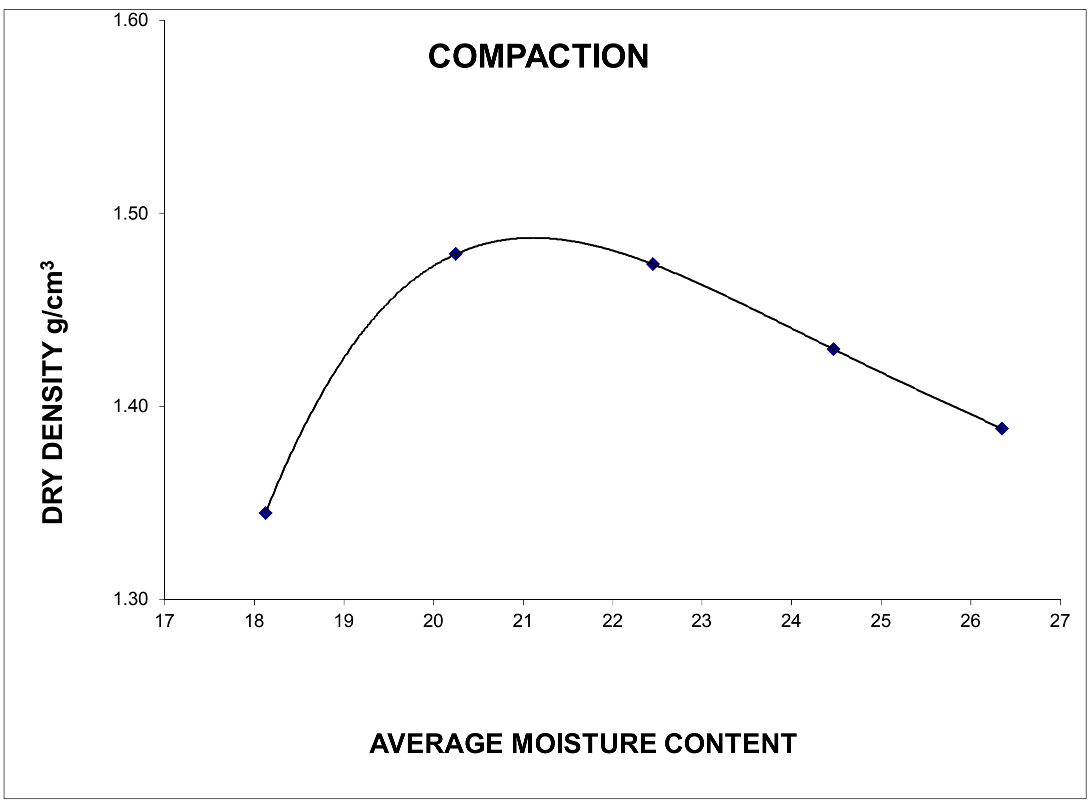
Amount retained on 20mm B.S. Sieve……… Total weight of Sample…… OPT.MC:**20.1%**

B.S. / C.B.R. Mould……**4723g…**………….................................

Wt. of mould & wet Soil (W2) g	6305.00	6494.00	6520.00	6495.00	6470.00		
Wt. of mould (W1) g	4723.00	4723.00	4723.00	4723.00	4723.00		
Wt. of wet soil (W2-W1) g	1582.00	1771.00	1797.00	1772.00	1747.00		
Bulk Density (Pb) (W2-W1)/x g/cm^3	1.59	1.78	1.80	1.78	1.75		

MOISTURE CONTENT DETERMINATIONS for B.S. Mould, X = 1000cm^3

Container No.	I8	AB	KB	S3	EZ	P5	JK	PZ	E9	II				
Wt. of wet soil & container (g)	41.20	48.00	46.70	42.80	45.30	47.80	48.30	46.70	48.00	44.20				
Wt. of Dry soil & container (g)	37.20	43.50	41.80	38.00	39.70	42.40	42.60	41.20	41.70	38.90				
Wt. of Container (g)	15.20	18.60	17.50	14.40	14.80	18.30	19.00	19.00	18.00	18.60				
Wt. of dry soil (Wd) g	22.00	24.90	24.30	23.60	24.90	24.10	23.60	22.20	23.70	20.30				
Wt. of Moisture (Wm) g	4.00	4.50	4.90	4.80	5.60	5.40	5.70	5.50	6.30	5.30				
Moistur Content 100(Wm/Wd) %	18.18	18.07	20.16	20.34	22.49	22.41	24.15	24.77	26.58	26.11				
Average Moisture Content (m) %	18.13		20.25		22.45		24.46		26.35					
Dry Density = Pb/1+ (m/100) (g/cm^3)	1.34		1.48		1.47		1.43		1.39					
C.B.R. (mseen of top & bottom) %														



DETERMINATION OF THE MOISTURE/DENSITY RELATION OF SOIL
USING STANDARD/HEAVY COMPACTION

Job… **OKOMU** Sample No:**....POWER HOUSE...** Operator…………

Site…..... Dept… **BH2, 8.0m……** Date:**…25/05/2018…** MDD:**1.49g/cm³**

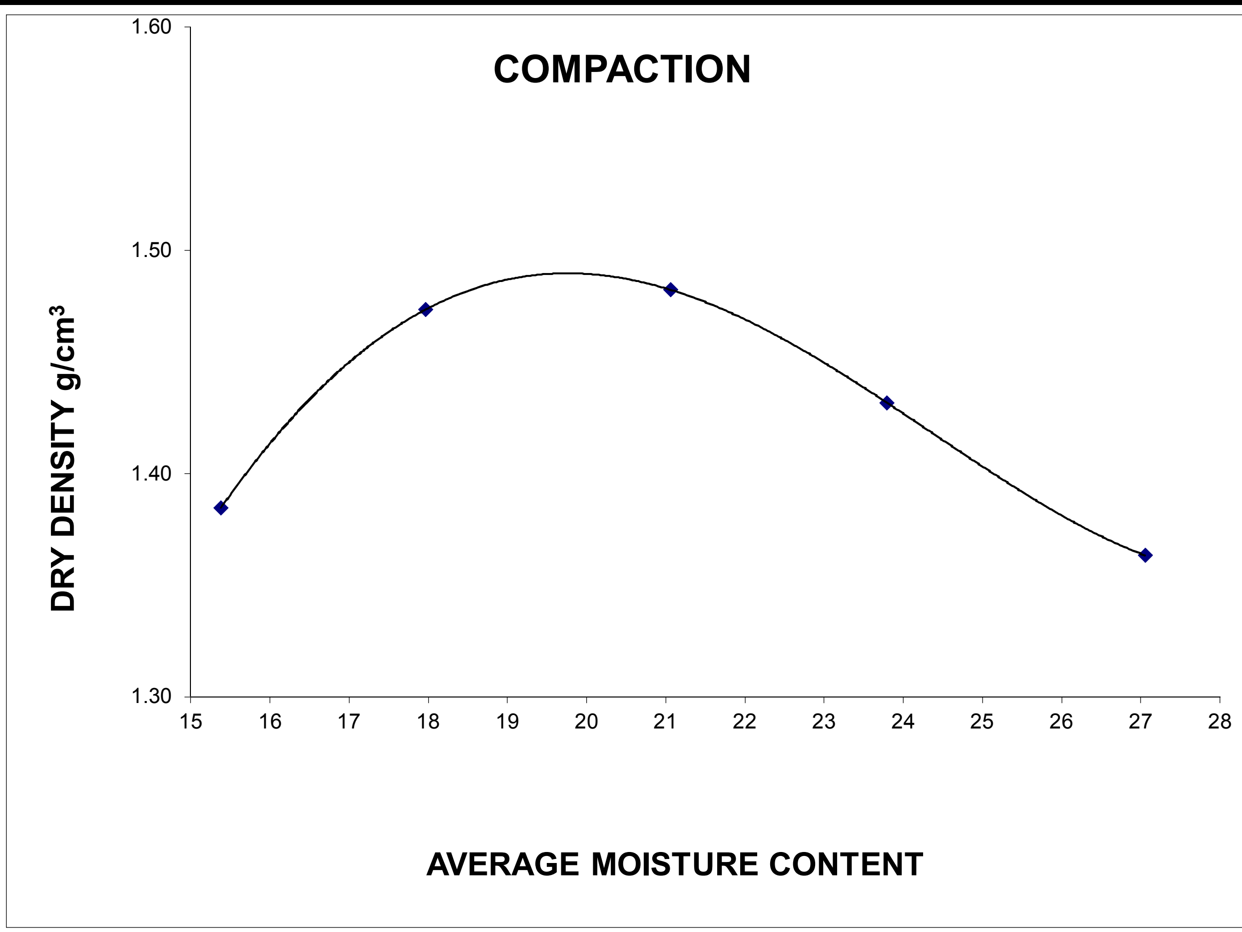
Amount retained on 20mm B.S. Sieve……… Total weight of Sample…… OPT.MC**:19.4%**

B.S. / C.B.R. Mould……**4723g…**………….............................

Wt. of mould & wet Soil (W2) g	6314.00	6454.00	6510.00	6488.00	6448.00		
Wt. of mould (W1) g	4723.00	4723.00	4723.00	4723.00	4723.00		
Wt. of wet soil (W2-W1) g	1591.00	1731.00	1787.00	1765.00	1725.00		
Bulk Density (Pb) (W2-W1)/x g/cm ^{3}	1.60	1.74	1.79	1.77	1.73		

MOISTURE CONTENT DETERMINATIONS for B.S. Mould, X = 1000cm ^{3}

Container No.	GB	OX	OE	QZ	8I	UK	8Z	OQ	FU	LE				
Wt. of wet soil & container (g)	47.42	50.60	48.24	46.62	47.19	43.54	47.82	41.64	40.90	54.71				
Wt. of Dry soil & container (g)	43.10	46.20	43.10	42.30	42.10	38.90	42.00	36.60	35.40	47.10				
Wt. of Container (g)	14.90	17.71	13.92	18.72	18.04	16.77	18.10	14.91	15.50	18.35				
Wt. of dry soil (Wd) g	28.20	28.49	29.18	23.58	24.06	22.13	23.90	21.69	19.90	28.75				
Wt. of Moisture (Wm) g	4.32	4.40	5.14	4.32	5.09	4.64	5.82	5.04	5.50	7.61				
Moistur Content 100(Wm/Wd) %	15.32	15.44	17.61	18.32	21.16	20.97	24.35	23.24	27.64	26.47				
Average Moisture Content (m) %	15.38		17.97		21.06		23.79		27.05					
Dry Density = Pb/1+ (m/100) (g/cm ^{3})	1.38		1.47		1.48		1.43		1.36					
C.B.R. (mseen of top & bottom) %														



DETERMINATION OF THE MOISTURE/DENSITY RELATION OF SOIL
USING STANDARD/HEAVY COMPACTION

Job… **OKOMU** Sample No:**....POWER HOUSE...** Operator…………

Site…..... Dept… **BH2, 15.0m……** Date:**…25/05/2018…** MDD:**1.44g/cm^3**

Amount retained on 20mm B.S. Sieve……… Total weight of Sample…… OPT.MC:**24.8%**

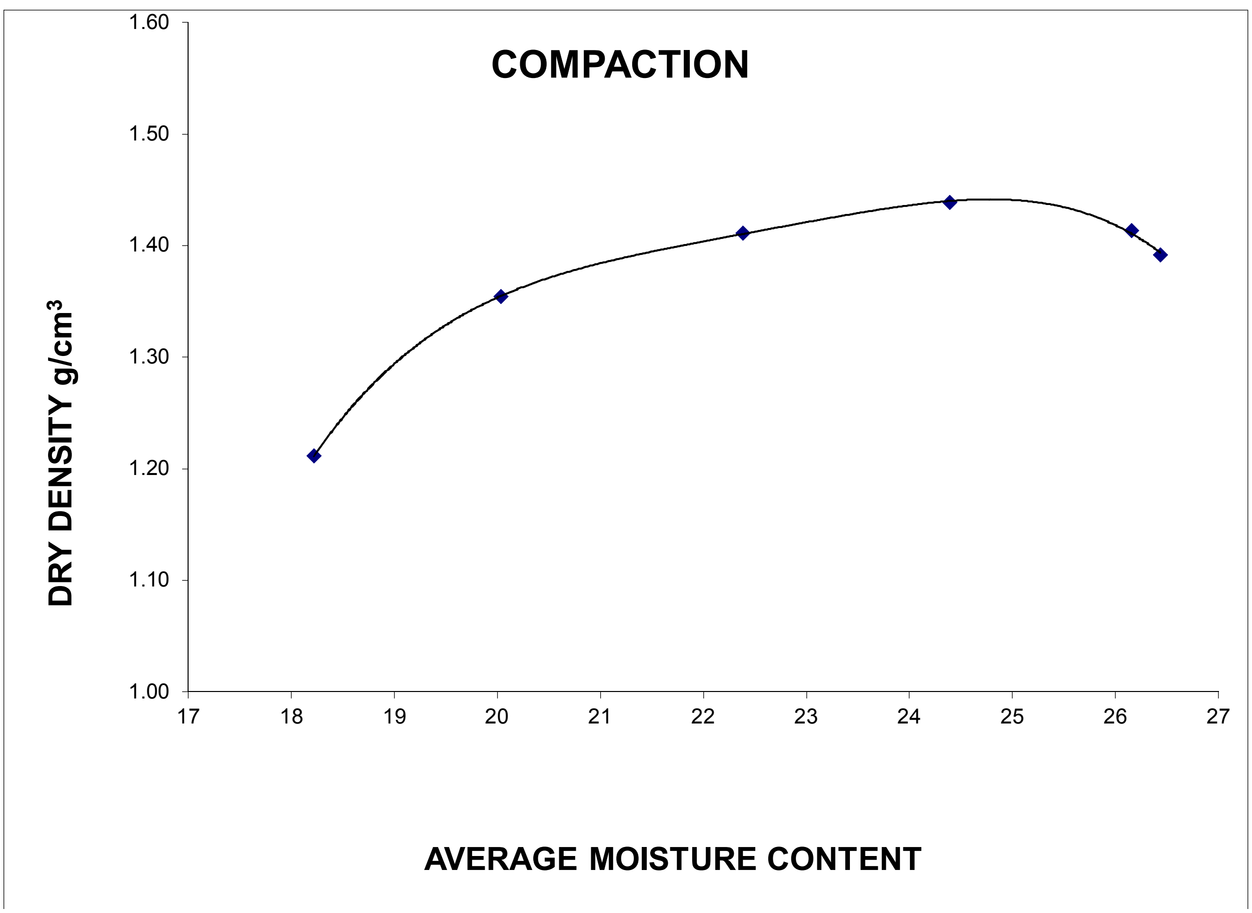
B.S. / C.B.R. Mould……**3252g…**………….............................

Wt. of mould & wet Soil (W2) g	4678.00	4871.00	4972.00	5034.00	5028.00	5004.00	
Wt. of mould (W1) g	3252.00	3252.00	3252.00	3252.00	3252.00	3252.00	
Wt. of wet soil (W2-W1) g	1426.00	1619.00	1720.00	1782.00	1776.00	1752.00	
Bulk Density (Pb) (W2-W1)/x g/cm^3	1.43	1.63	1.73	1.79	1.78	1.76	

MOISTURE CONTENT DETERMINATIONS for B.S. Mould, X = 1000cm^3

Container No.	IL	NN	AF	NA	EH	OV	ZO	MI	BC	K7	OK	ST		
Wt. of wet soil & container (g)	47.60	48.30	52.00	53.20	55.50	48.10	53.20	47.20	54.90	53.60	50.10	47.60		
Wt. of Dry soil & container (g)	42.80	43.30	46.00	46.90	48.00	42.70	46.40	41.10	46.99	45.69	42.90	41.40		
Wt. of Container (g)	16.60	15.70	16.10	15.40	15.00	18.20	18.40	16.20	16.70	15.50	15.60	18.00		
Wt. of dry soil (Wd) g	26.20	27.60	29.90	31.50	33.00	24.50	28.00	24.90	30.29	30.19	27.30	23.40		
Wt. of Moisture (Wm) g	4.80	5.00	6.00	6.30	7.50	5.40	6.80	6.10	7.91	7.91	7.20	6.20		
Moistur Content 100(Wm/Wd) %	18.32	18.12	20.07	20.00	22.73	22.04	24.29	24.50	26.11	26.20	26.37	26.50		

Average Moisture Content (m) %	18.22	20.03	22.38	24.39	26.16	26.43	
Dry Density = Pb/1+ (m/100) (g/cm^3)	1.21	1.35	1.41	1.44	1.41	1.39	
C.B.R. (mseen of top & bottom) %							



DETERMINATION OF THE MOISTURE/DENSITY RELATION OF SOIL
USING STANDARD/HEAVY COMPACTION

Job... **OKOMU** Sample No:**....PRESSING STATION, BH5...** Operator…………

Site……. Dept**…7.5m……** Date:**…25/05/2018…** MDD:**1.55g/cm³**

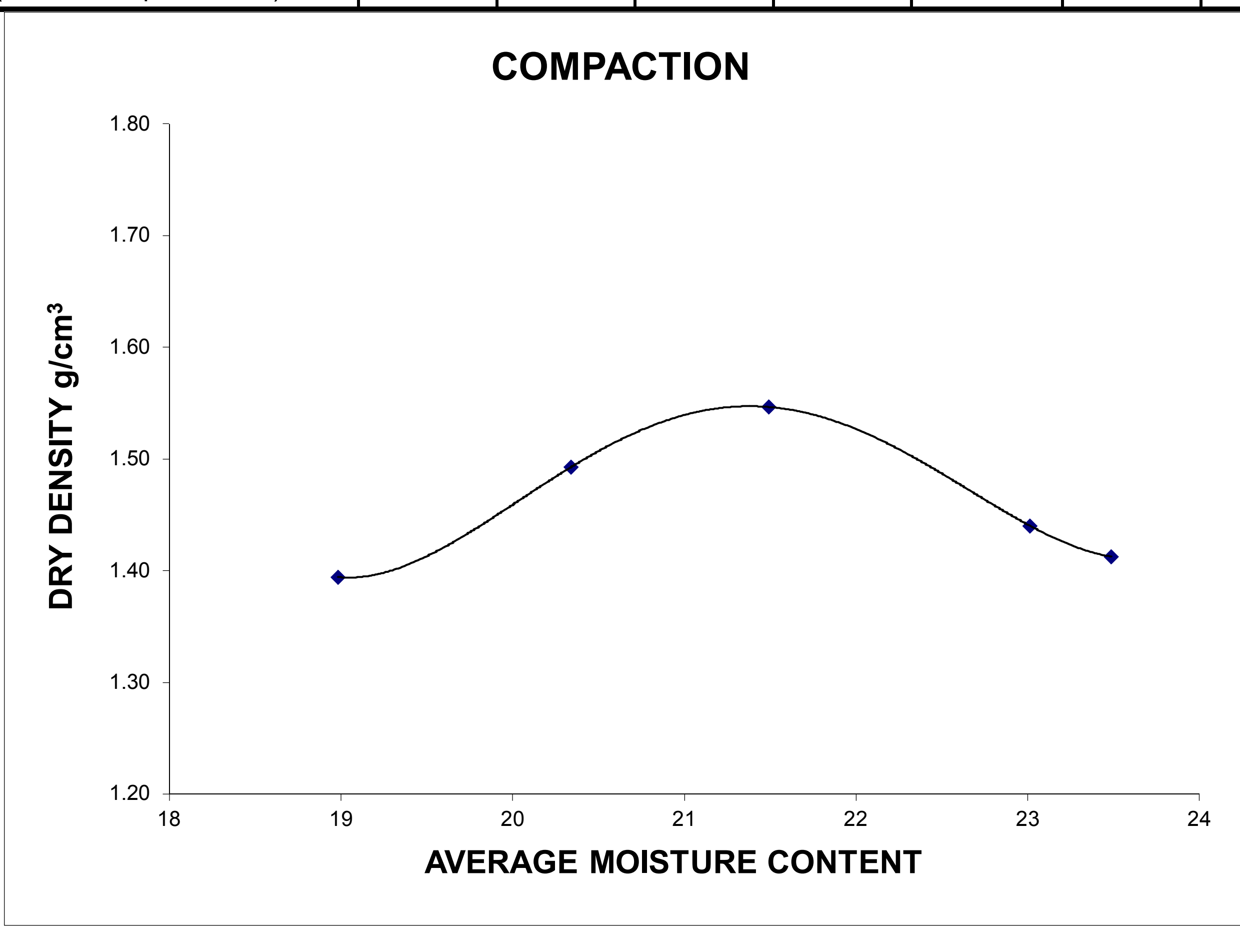
Amount retained on 20mm B.S. Sieve……… Total weight of Sample…… OPT.MC:**21.4%**

B.S. / C.B.R. Mould……**3248g…**…………..............................

Wt. of mould & wet Soil (W2) g	4900.00	5037.00	5119.00	5012.00	4985.00		
Wt. of mould (W1) g	3248.00	3248.00	3248.00	3248.00	3248.00		
Wt. of wet soil (W2-W1) g	1652.00	1789.00	1871.00	1764.00	1737.00		
Bulk Density (Pb) (W2-W1)/x g/cm ^{3}	1.66	1.80	1.88	1.77	1.74		

MOISTURE CONTENT DETERMINATIONS for B.S. Mould, X = 1000cm ^{3}

Container No.	SE	F5	AA	SO	E6	WD	8YH	JA	AH	BA				
Wt. of wet soil & container (g)	49.65	54.42	49.74	49.52	60.04	53.16	54.85	49.17	52.94	52.07				
Wt. of Dry soil & container (g)	44.17	48.64	44.17	43.64	52.74	46.47	48.15	42.48	46.49	44.84				
Wt. of Container (g)	15.67	17.79	16.48	15.05	17.70	16.27	17.95	14.42	17.32	15.76				
Wt. of dry soil (Wd) g	28.50	30.85	27.69	28.59	35.04	30.20	30.20	28.06	29.17	29.08				
Wt. of Moisture (Wm) g	5.48	5.78	5.57	5.88	7.30	6.69	6.70	6.69	6.45	7.23				
Moistur Content 100(Wm/Wd) %	19.23	18.74	20.12	20.57	20.83	22.15	22.19	23.84	22.11	24.86				
Average Moisture Content (m) %	18.98		20.34		21.49		23.01		23.49					
Dry Density = Pb/1+ (m/100) (g/cm ^{3})	1.39		1.49		1.55		1.44		1.41					
C.B.R. (mseen of top & bottom) %														



DETERMINATION OF THE MOISTURE/DENSITY RELATION OF SOIL
USING STANDARD/HEAVY COMPACTION

Job... **OKOMU** Sample No:**....PRESSING STATION, BH5...** Operator…………

Site…..... Dept**...4.5m……** Date:**…25/05/2018…** MDD:**1.47g/cm³**

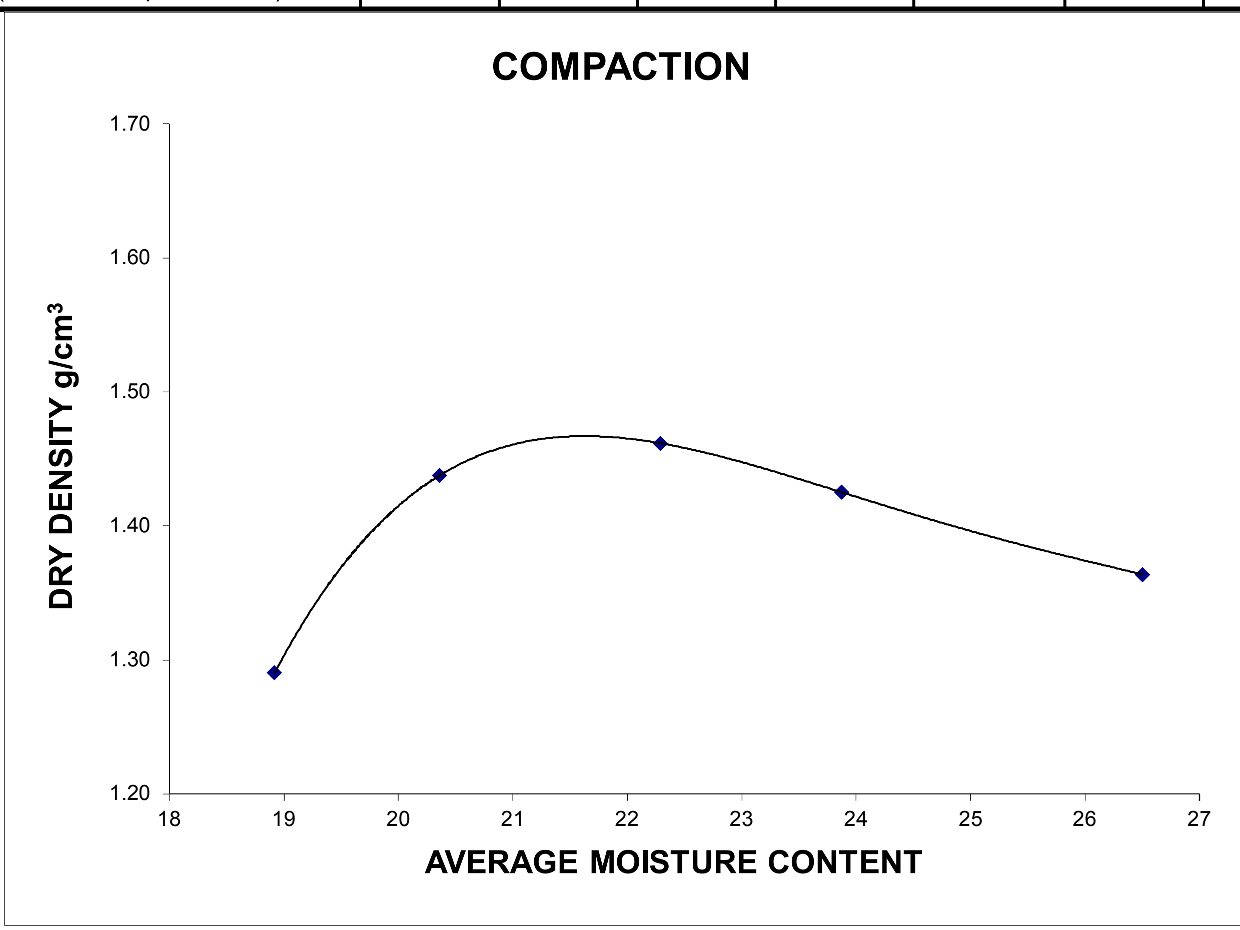
Amount retained on 20mm B.S. Sieve……… Total weight of Sample…… OPT.MC:**21.6%**

B.S. / C.B.R. Mould……**4722g…**……….............................

Wt. of mould & wet Soil (W2) g	6250.00	6445.00	6502.00	6480.00	6440.00		
Wt. of mould (W1) g	4722.00	4722.00	4722.00	4722.00	4722.00		
Wt. of wet soil (W2-W1) g	1528.00	1723.00	1780.00	1758.00	1718.00		
Bulk Density (Pb) (W2-W1)/x g/cm ^{3}	1.53	1.73	1.79	1.77	1.73		

MOISTURE CONTENT DETERMINATIONS for B.S. Mould, X = 1000cm ^{3}

Container No.	OX	JI	BZ	Z5	PZ	JO	TU	P5	CA	ME				
Wt. of wet soil & container (g)	45.56	51.99	49.15	45.39	42.00	41.99	44.65	47.11	46.33	54.11				
Wt. of Dry soil & container (g)	40.85	46.55	44.00	40.70	37.40	37.34	38.84	41.23	40.35	46.66				
Wt. of Container (g)	15.88	17.88	18.53	17.82	16.70	16.54	14.55	16.55	17.93	18.37				
Wt. of dry soil (Wd) g	24.97	28.67	25.47	22.88	20.70	20.80	24.29	24.68	22.42	28.29				
Wt. of Moisture (Wm) g	4.71	5.44	5.15	4.69	4.60	4.65	5.81	5.88	5.98	7.45				
Moistur Content 100(Wm/Wd) %	18.86	18.97	20.22	20.50	22.22	22.36	23.92	23.82	26.67	26.33				
Average Moisture Content (m) %	18.92		20.36		22.29		23.87		26.50					
Dry Density = Pb/1+ (m/100) (g/cm ^{3})	1.29		1.44		1.46		1.43		1.36					
C.B.R. (mseen of top & bottom) %														



DETERMINATION OF THE MOISTURE/DENSITY RELATION OF SOIL
USING STANDARD/HEAVY COMPACTION

Job... **OKOMU** Sample No:**....PRESSING STATION, BH5..** Operator…………

Site….... Dept**...14.5.0m……** Date:**...25/05/2018…** MDD:**1.58g/cm^3**

Amount retained on 20mm B.S. Sieve……… Total weight of Sample…… OPT.MC**:22.0%**

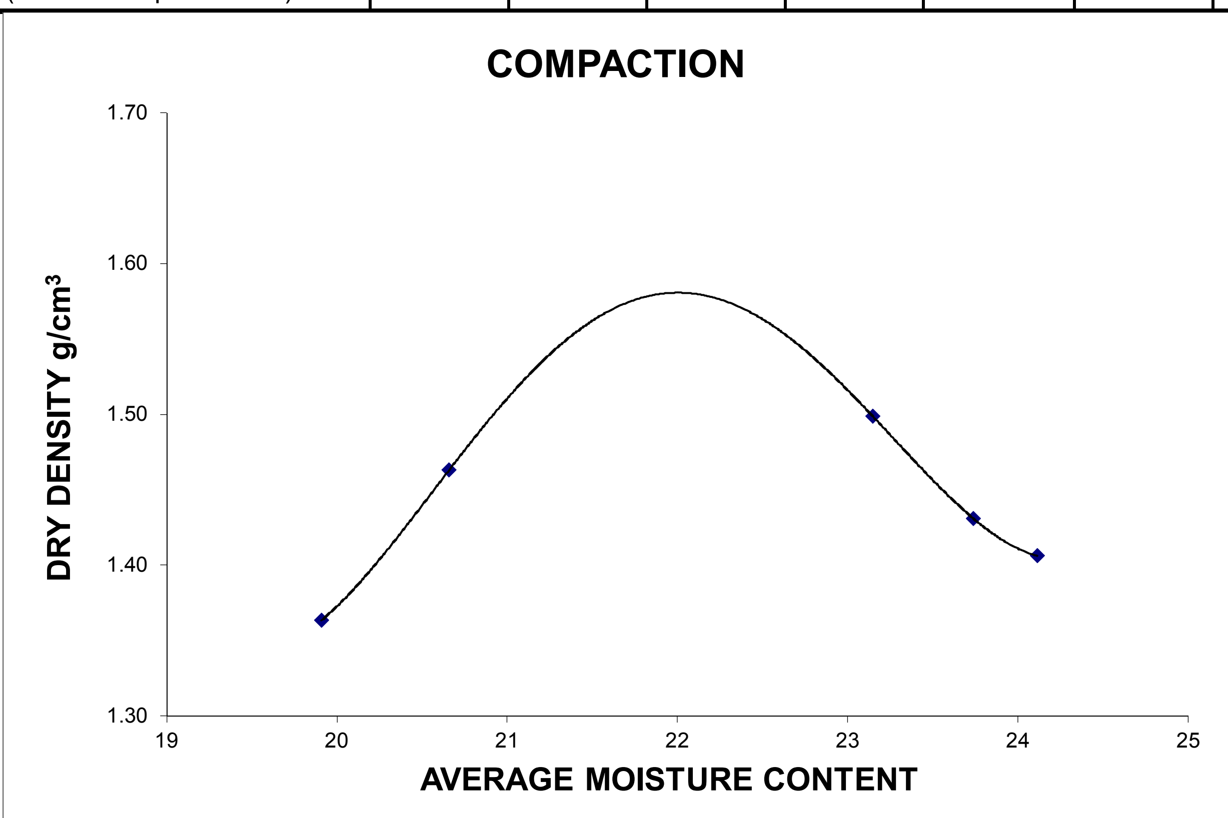
B.S. / C.B.R. Mould……**4722g…**………….............................

Wt. of mould & wet Soil (W2) g	6350.00	6480.00	6560.00	6485.00	6460.00		
Wt. of mould (W1) g	4722.00	4722.00	4722.00	4722.00	4722.00		
Wt. of wet soil (W2-W1) g	1628.00	1758.00	1838.00	1763.00	1738.00		
Bulk Density (Pb) (W2-W1)/x g/cm ^{3}	1.63	1.77	1.85	1.77	1.75		

MOISTURE CONTENT DETERMINATIONS for B.S. Mould, X = 1000cm^3

Container No.	3R	OO	JE	OX	OR	OB	NB	QR	JA	BA				
Wt. of wet soil & container (g)	49.79	50.19	50.11	58.38	48.19	47.55	44.40	45.38	42.67	43.48				
Wt. of Dry soil & container (g)	44.39	44.91	44.42	51.73	42.51	41.70	38.90	40.18	37.37	38.63				
Wt. of Container (g)	18.01	17.62	17.50	18.78	18.12	16.27	18.08	15.49	16.16	17.76				
Wt. of dry soil (Wd) g	26.38	27.29	26.92	32.95	24.39	25.43	20.82	24.69	21.21	20.87				
Wt. of Moisture (Wm) g	5.40	5.28	5.69	6.65	5.68	5.85	5.50	5.20	5.30	4.85				
Moistur Content 100(Wm/Wd) %	20.47	19.35	21.14	20.18	23.29	23.00	26.42	21.06	24.99	23.24				

Average Moisture Content (m) %	19.91	20.66	23.15	23.74	24.11		
Dry Density = Pb/1+ (m/100) (g/cm ^{3})	1.36	1.46	1.50	1.43	1.41		
C.B.R. (mseen of top & bottom) %							



DETERMINATION OF THE MOISTURE/DENSITY RELATION OF SOIL
USING STANDARD/HEAVY COMPACTION

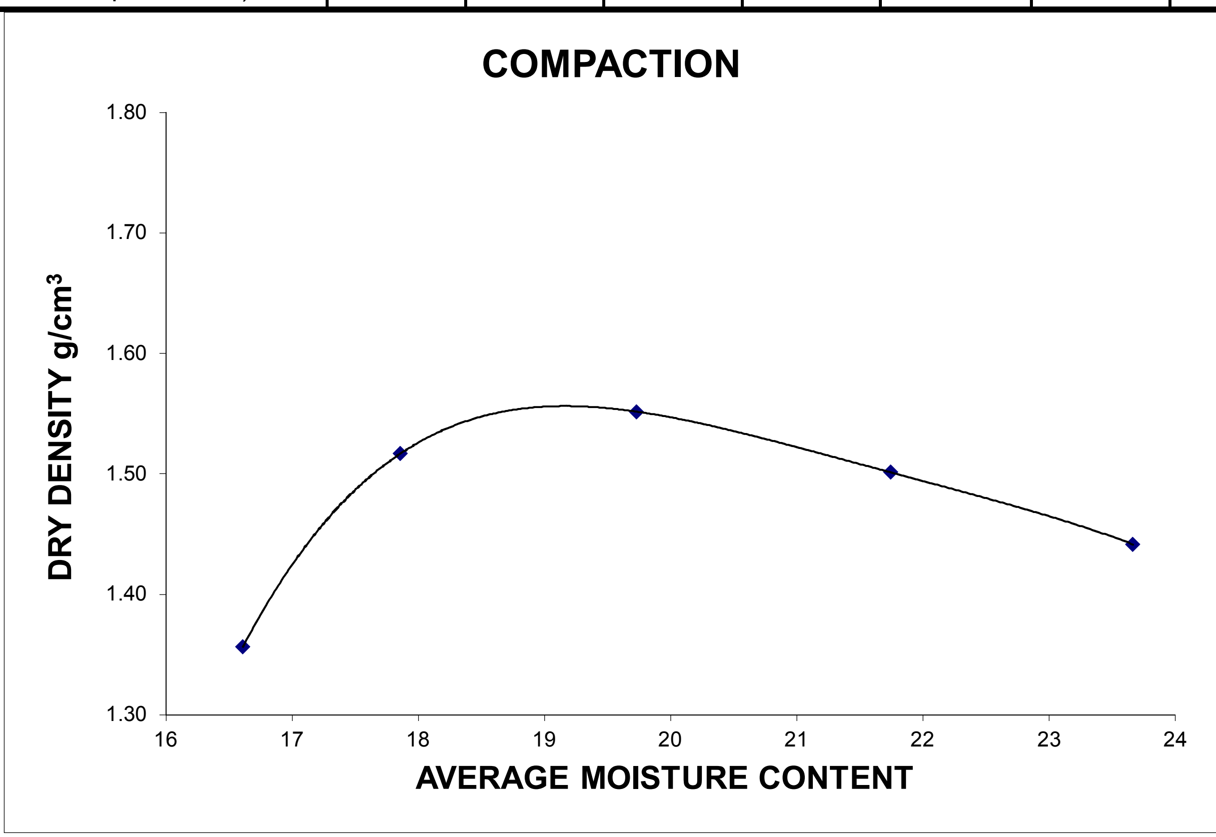
Job... **OKOMU**   Sample No:....**PRESSING STATION, BH5..**   Operator…………

Site…... Dept...**1.5m**……   Date:...**25/05/2018**…   MDD:**1.56g/cm^3**

Amount retained on 20mm B.S. Sieve……… Total weight of Sample…… OPT.MC:**19.2%**

B.S. / C.B.R. Mould……**4720g**…………...............................

Wt. of mould & wet Soil (W2) g	6295.00		6500.00		6570.00		6540.00		6495.00					
Wt. of mould (W1) g	4720.00		4720.00		4720.00		4720.00		4720.00					
Wt. of wet soil (W2-W1) g	1575.00		1780.00		1850.00		1820.00		1775.00					
Bulk Density (Pb) (W2-W1)/x g/cm^3	1.58		1.79		1.86		1.83		1.78					
MOISTURE CONTENT DETERMINATIONS	for B.S. Mould, X = 1000cm^3													
Container No.	ZO	CC	ID	SA	NI	OE	UW	CL	AC	OZ				
Wt. of wet soil & container (g)	60.60	55.90	54.50	57.60	48.00	49.60	48.90	48.90	50.50	50.10				
Wt. of Dry soil & container (g)	54.48	50.67	49.05	51.99	42.43	44.28	43.50	43.14	44.29	44.14				
Wt. of Container (g)	18.40	18.50	18.60	20.50	14.00	17.50	18.80	16.50	18.00	19.00				
Wt. of dry soil (Wd) g	36.08	32.17	30.45	31.49	28.43	26.78	24.70	26.64	26.29	25.14				
Wt. of Moisture (Wm) g	6.12	5.23	5.45	5.61	5.57	5.32	5.40	5.76	6.21	5.96				
Moistur Content 100(Wm/Wd) %	16.96	16.26	17.90	17.82	19.59	19.87	21.86	21.62	23.62	23.71				
Average Moisture Content (m) %	16.61		17.86		19.73		21.74		23.66					
Dry Density = Pb/1+ (m/100) (g/cm^3)	1.36		1.52		1.55		1.50		1.44					
C.B.R. (mseen of top & bottom) %														



DETERMINATION OF THE MOISTURE/DENSITY RELATION OF SOIL
USING STANDARD/HEAVY COMPACTION

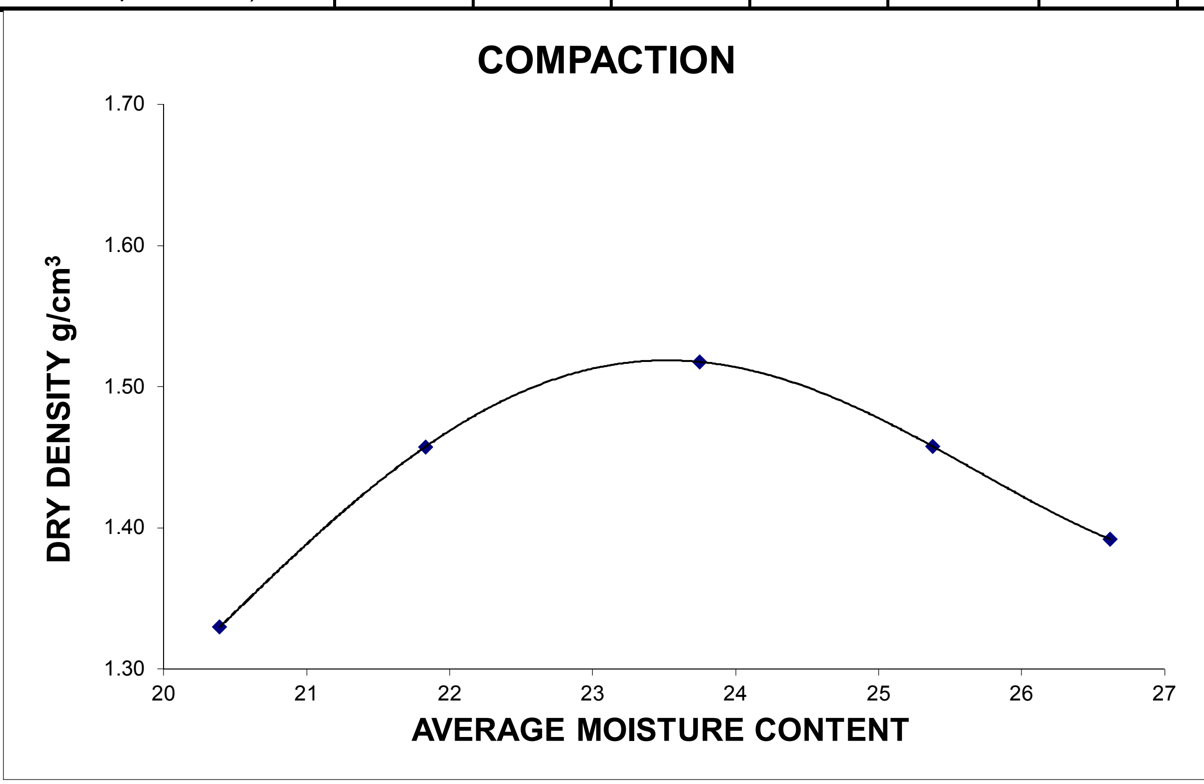
Job... **OKOMU** Sample No:....**PRESSING STATION, BH5..** Operator…………

Site…..... Dept...**10.5m……** Date:...**25/05/2018…** MDD:**1.52g/cm³**

Amount retained on 20mm B.S. Sieve……… Total weight of Sample…… OPT.MC:**23.5%**

B.S. / C.B.R. Mould……**4720g**…………..............................

Wt. of mould & wet Soil (W2) g	6314.00		6488.00		6590.00		6540.00		6475.00			
Wt. of mould (W1) g	4720.00		4720.00		4720.00		4720.00		4720.00			
Wt. of wet soil (W2-W1) g	1594.00		1768.00		1870.00		1820.00		1755.00			
Bulk Density (Pb) (W2-W1)/x g/cm ^{3}	1.60		1.78		1.88		1.83		1.76			
MOISTURE CONTENT DETERMINATIONS for B.S. Mould, X = 1000cm ^{3}												
Container No.	BA	UK	YZ	OZ	LO	OO	OE	P5	PK	HI		
Wt. of wet soil & container (g)	56.20	51.00	53.00	57.60	47.50	52.20	49.80	48.60	50.30	51.80		
Wt. of Dry soil & container (g)	49.91	45.31	46.90	50.67	41.60	45.72	42.83	42.53	43.46	44.13		
Wt. of Container (g)	19.50	17.00	18.80	19.10	16.60	18.60	15.60	18.40	17.60	15.50		
Wt. of dry soil (Wd) g	30.41	28.31	28.10	31.57	25.00	27.12	27.23	24.13	25.86	28.63		
Wt. of Moisture (Wm) g	6.29	5.69	6.10	6.93	5.90	6.48	6.97	6.07	6.84	7.67		
Moistur Content 100(Wm/Wd) %	20.68	20.10	21.71	21.95	23.60	23.89	25.60	25.16	26.45	26.79		
Average Moisture Content (m) %	20.39		21.83		23.75		25.38		26.62			
Dry Density = Pb/1+ (m/100) (g/cm ^{3})	1.33		1.46		1.52		1.46		1.39			
C.B.R. (mseen of top & bottom) %												



DETERMINATION OF THE MOISTURE/DENSITY RELATION OF SOIL
USING STANDARD/HEAVY COMPACTION

Job... **OKOMU** Sample No:**....PRESSING STATION, BH5...** Operator……

Site…**...** Dept....**14.5m……** Date:**…25/05/2018…** MDD:**1.51g/cm^3**

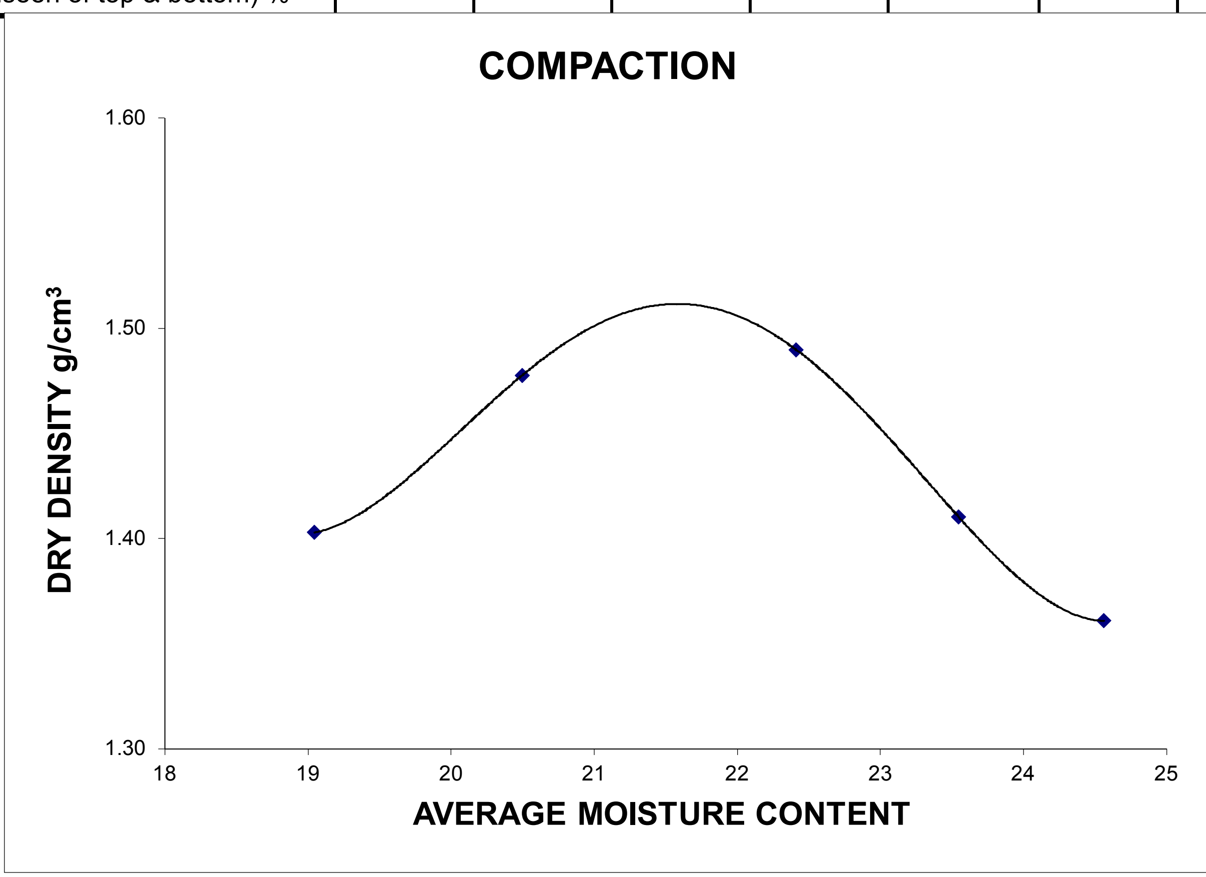
Amount retained on 20mm B.S. Sieve……… Total weight of Sample…… OPT.MC:**21.6%**

B.S. / C.B.R. Mould……**4722g…**………….............................

Wt. of mould & wet Soil (W2) g	6385.00	6495.00	6538.00	6457.00	6410.00		
Wt. of mould (W1) g	4722.00	4722.00	4722.00	4722.00	4722.00		
Wt. of wet soil (W2-W1) g	1663.00	1773.00	1816.00	1735.00	1688.00		
Bulk Density (Pb) (W2-W1)/x g/cm^3	1.67	1.78	1.82	1.74	1.70		

MOISTURE CONTENT DETERMINATIONS for B.S. Mould, X = 1000cm^3

Container No.	TJ	JA	SL	F5	EI	VI	PI	JO	FZ	BF				
Wt. of wet soil & container (g)	47.94	47.84	48.96	55.14	50.51	50.07	50.22	50.95	56.55	51.42				
Wt. of Dry soil & container (g)	43.07	43.09	43.09	48.96	44.38	44.27	44.10	44.51	48.82	44.99				
Wt. of Container (g)	17.53	18.12	14.21	19.06	17.24	18.19	17.83	17.45	17.35	18.81				
Wt. of dry soil (Wd) g	25.54	24.97	28.88	29.90	27.14	26.08	26.27	27.06	31.47	26.18				
Wt. of Moisture (Wm) g	4.87	4.75	5.87	6.18	6.13	5.80	6.12	6.44	7.73	6.43				
Moistur Content 100(Wm/Wd) %	19.07	19.02	20.33	20.67	22.59	22.24	23.30	23.80	24.56	24.56				
Average Moisture Content (m) %	19.05		20.50		22.41		23.55		24.56					
Dry Density = Pb/1+ (m/100) (g/cm^3)	1.40		1.48		1.49		1.41		1.36					
C.B.R. (mseen of top & bottom) %														



DETERMINATION OF THE MOISTURE/DENSITY RELATION OF SOIL
USING STANDARD/HEAVY COMPACTION

Job... **OKOMU** Sample No:....**RAMP I, BH9..** Operator…………

Site…..... Dept...**2.0m**…… Date:...**25/05/2018**… MDD:**1.57g/cm³**

Amount retained on 20mm B.S. Sieve……… Total weight of Sample…… OPT.MC:**19.2%**

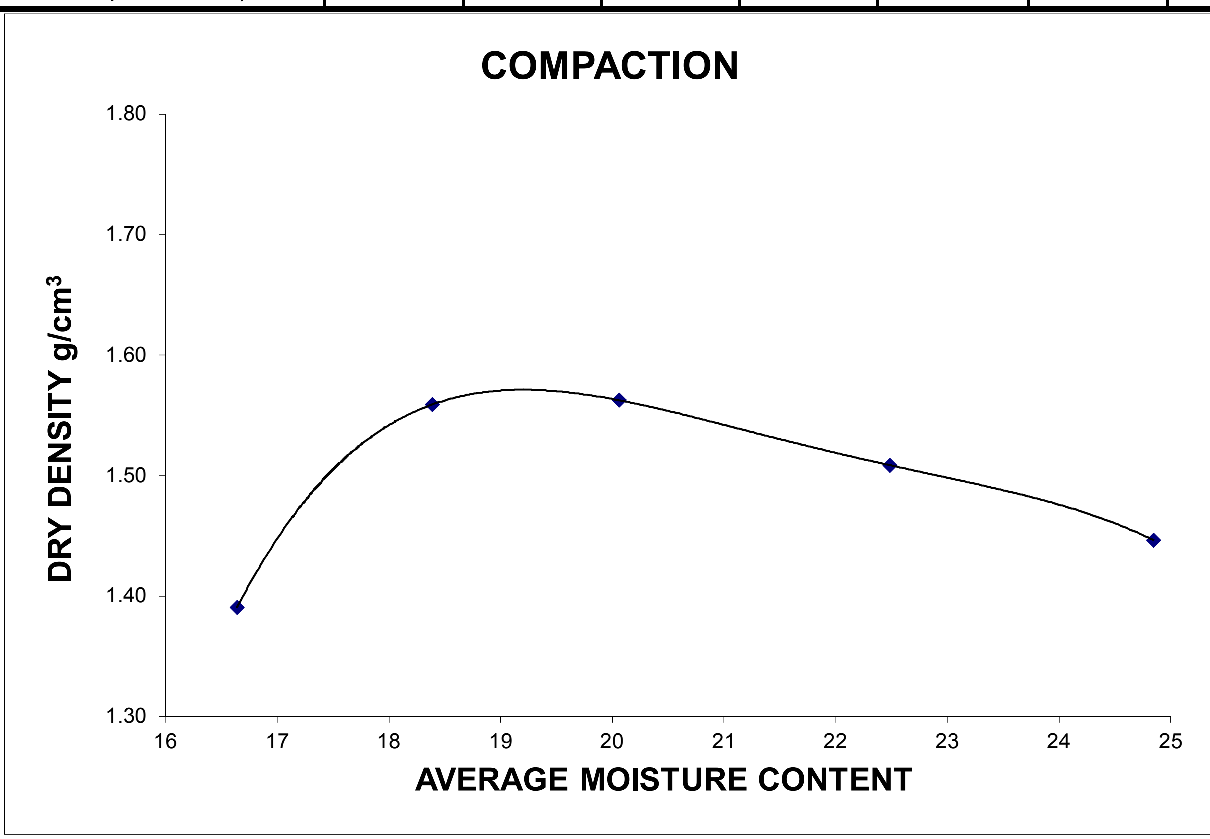
B.S. / C.B.R. Mould……**4722g**…………….............................

Wt. of mould & wet Soil (W2) g	6337.00	6560.00	6590.00	6562.00	6520.00		
Wt. of mould (W1) g	4722.00	4722.00	4722.00	4722.00	4722.00		
Wt. of wet soil (W2-W1) g	1615.00	1838.00	1868.00	1840.00	1798.00		
Bulk Density (Pb) (W2-W1)/x g/cm ^{3}	1.62	1.85	1.88	1.85	1.81		

MOISTURE CONTENT DETERMINATIONS for B.S. Mould, X = 1000cm ^{3}

Container No.	IG	PZ	S4	GA	BZ	CE	NI	JO	TI	MT				
Wt. of wet soil & container (g)	53.16	39.70	46.21	57.78	49.87	44.52	42.00	52.02	46.09	47.86				
Wt. of Dry soil & container (g)	47.75	36.44	41.26	51.55	44.59	40.12	36.80	45.52	40.45	41.40				
Wt. of Container (g)	15.35	16.78	14.30	17.73	18.58	17.93	13.68	16.60	17.87	15.26				
Wt. of dry soil (Wd) g	32.40	19.66	26.96	33.82	26.01	22.19	23.12	28.92	22.58	26.14				
Wt. of Moisture (Wm) g	5.41	3.26	4.95	6.23	5.28	4.40	5.20	6.50	5.64	6.46				
Moistur Content 100(Wm/Wd) %	16.70	16.58	18.36	18.42	20.30	19.83	22.49	22.48	24.98	24.71				

Average Moisture Content (m) %	16.64	18.39	20.06	22.48	24.85		
Dry Density = Pb/1+ (m/100) (g/cm ^{3})	1.39	1.56	1.56	1.51	1.45		
C.B.R. (mseen of top & bottom) %							



DETERMINATION OF THE MOISTURE/DENSITY RELATION OF SOIL
USING STANDARD/HEAVY COMPACTION

Job... **OKOMU** Sample No:....**RAMP I, BH9...** Operator...........

Site…..... Dept...**5.0m**...... Date:...**25/05/2018**... MDD:**1.68g/cm³**

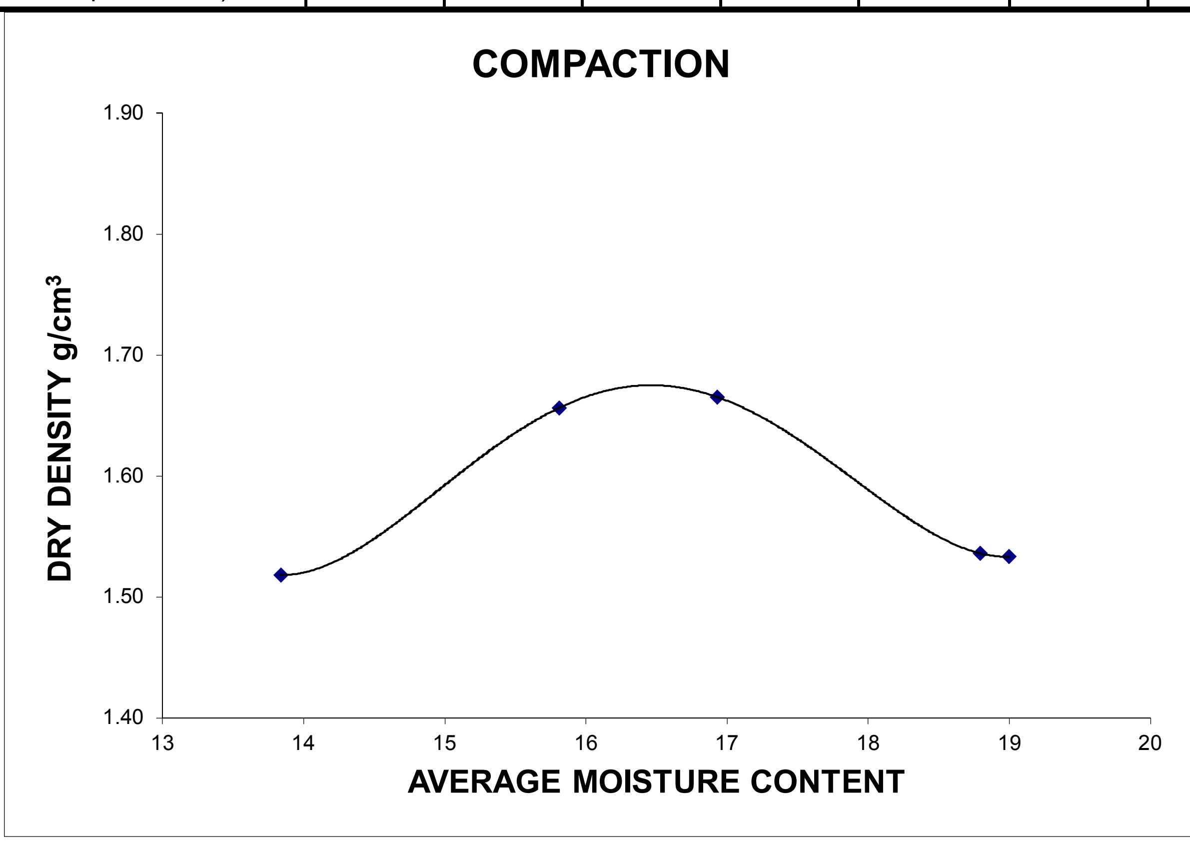
Amount retained on 20mm B.S. Sieve……… Total weight of Sample…… OPT.MC:**16.5%**

B.S. / C.B.R. Mould……**3250g**…………….............................

Wt. of mould & wet Soil (W2) g	4971.00	5160.00	5189.00	5067.00	5067.00		
Wt. of mould (W1) g	3250.00	3250.00	3250.00	3250.00	3250.00		
Wt. of wet soil (W2-W1) g	1721.00	1910.00	1939.00	1817.00	1817.00		
Bulk Density (Pb) (W2-W1)/x g/cm ^{3}	1.73	1.92	1.95	1.82	1.82		

MOISTURE CONTENT DETERMINATIONS for B.S. Mould, X = 1000cm ^{3}

Container No.	II	TO	IL	TH	IX	6Z	ME	PZ	RO	AB				
Wt. of wet soil & container (g)	47.22	50.58	51.02	44.77	41.44	41.48	50.67	56.47	49.07	49.97				
Wt. of Dry soil & container (g)	43.65	46.70	46.50	41.00	38.00	37.60	46.00	50.30	44.10	44.99				
Wt. of Container (g)	18.53	17.88	16.66	18.11	16.71	15.68	19.88	19.00	18.05	18.67				
Wt. of dry soil (Wd) g	25.12	28.82	29.84	22.89	21.29	21.92	26.12	31.30	26.05	26.32				
Wt. of Moisture (Wm) g	3.57	3.88	4.52	3.77	3.44	3.88	4.67	6.17	4.97	4.98				
Moistur Content 100(Wm/Wd) %	14.21	13.46	15.15	16.47	16.16	17.70	17.88	19.71	19.08	18.92				
Average Moisture Content (m) %	13.84		15.81		16.93		18.80		19.00					
Dry Density = Pb/1+ (m/100) (g/cm ^{3})	1.52		1.66		1.67		1.54		1.53					
C.B.R. (mseen of top & bottom) %														



DETERMINATION OF THE MOISTURE/DENSITY RELATION OF SOIL
USING STANDARD/HEAVY COMPACTION

Job... **OKOMU** Sample No:**....RAMP I, BH9..** Operator…………

Site…**....** Dept**…8.0m……** Date:**…25/05/2018…** MDD:**1.52g/cm^3**

Amount retained on 20mm B.S. Sieve……… Total weight of Sample…… OPT.MC**:19.9%**

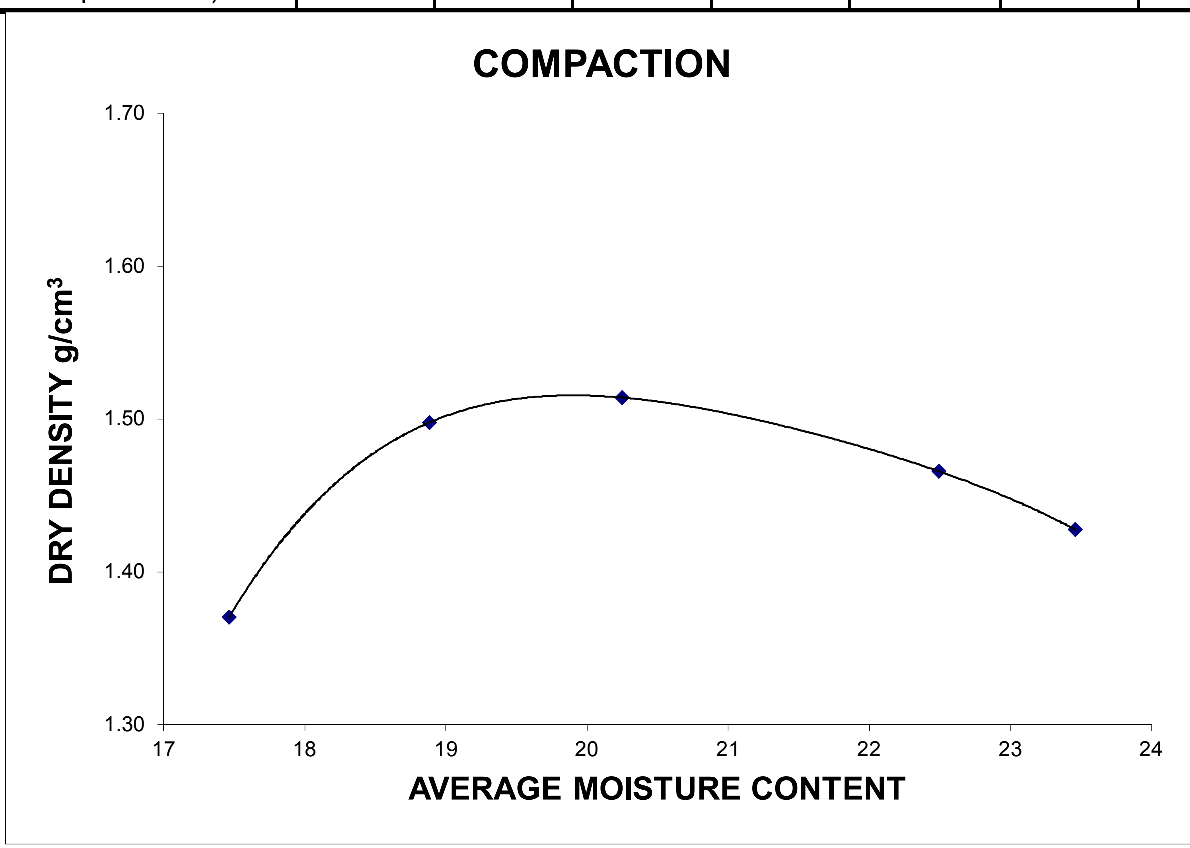
B.S. / C.B.R. Mould……**4722g…**……….............................

Wt. of mould & wet Soil (W2) g	6325.00	6495.00	6535.00	6510.00	6477.00		
Wt. of mould (W1) g	4722.00	4722.00	4722.00	4722.00	4722.00		
Wt. of wet soil (W2-W1) g	1603.00	1773.00	1813.00	1788.00	1755.00		
Bulk Density (Pb) (W2-W1)/x g/cm^3	1.61	1.78	1.82	1.80	1.76		

MOISTURE CONTENT DETERMINATIONS for B.S. Mould, X = 1000cm^3

Container No.	XX	AZ	PZ	TT	JA	CH	F6	OE	CH	SU				
Wt. of wet soil & container (g)	53.77	54.47	56.01	52.43	47.17	54.89	54.06	59.10	51.91	55.05				
Wt. of Dry soil & container (g)	48.41	48.87	49.91	46.83	41.78	48.34	47.37	51.70	44.78	47.88				
Wt. of Container (g)	17.80	16.72	17.56	17.21	15.44	15.64	17.85	18.55	14.64	17.06				
Wt. of dry soil (Wd) g	30.61	32.15	32.35	29.62	26.34	32.70	29.52	33.15	30.14	30.82				
Wt. of Moisture (Wm) g	5.36	5.60	6.10	5.60	5.39	6.55	6.69	7.40	7.13	7.17				
Moistur Content 100(Wm/Wd) %	17.51	17.42	18.86	18.91	20.46	20.03	22.66	22.32	23.66	23.26				

Average Moisture Content (m) %	17.46	18.88	20.25	22.49	23.46		
Dry Density = Pb/1+ (m/100) (g/cm^3)	1.37	1.50	1.51	1.47	1.43		
C.B.R. (mseen of top & bottom) %							



DETERMINATION OF THE MOISTURE/DENSITY RELATION OF SOIL
USING STANDARD/HEAVY COMPACTION

Job... **OKOMU** Sample No:**....RAMP I, BH9..** Operator…………

Site…**....** Dept**...11.0m……** Date**:...25/05/2018…** MDD:**1.54g/cm^3**

Amount retained on 20mm B.S. Sieve……… Total weight of Sample…… OPT.MC**:17.8%**

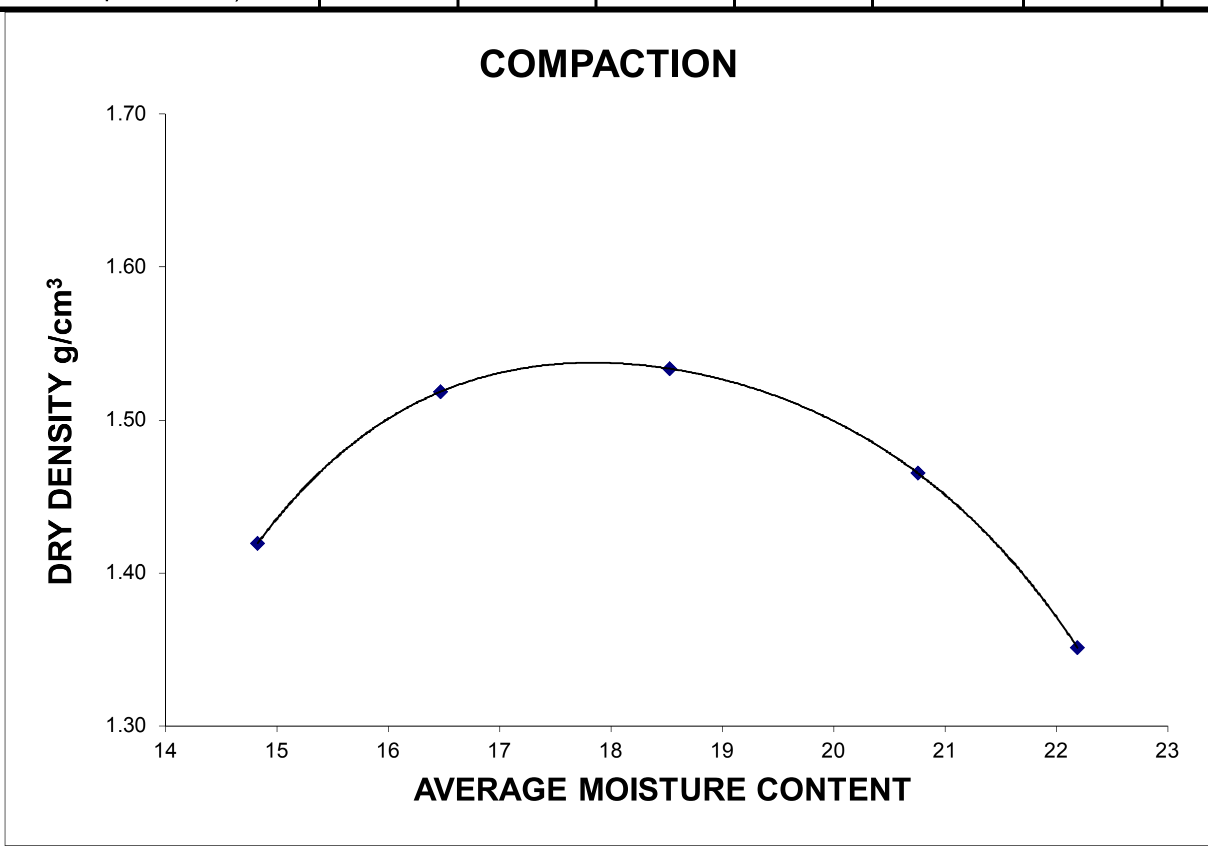
B.S. / C.B.R. Mould……**4722g…**………….............................

Wt. of mould & wet Soil (W2) g	6345.00	6483.00	6532.00	6484.00	6366.00		
Wt. of mould (W1) g	4722.00	4722.00	4722.00	4722.00	4722.00		
Wt. of wet soil (W2-W1) g	1623.00	1761.00	1810.00	1762.00	1644.00		
Bulk Density (Pb) (W2-W1)/x g/cm^3	1.63	1.77	1.82	1.77	1.65		

MOISTURE CONTENT DETERMINATIONS for B.S. Mould, X = 1000cm^3

Container No.	CU	CR	PO	MO	SI	I8	AI	TO	AA	PM				
Wt. of wet soil & container (g)	45.79	48.43	46.52	56.19	51.61	48.68	51.61	51.40	65.12	59.23				
Wt. of Dry soil & container (g)	42.09	44.14	42.85	50.76	46.44	43.40	45.64	45.73	56.40	51.70				
Wt. of Container (g)	17.33	14.98	20.82	17.40	17.95	15.48	16.93	18.36	16.54	18.24				
Wt. of dry soil (Wd) g	24.76	29.16	22.03	33.36	28.49	27.92	28.71	27.37	39.86	33.46				
Wt. of Moisture (Wm) g	3.70	4.29	3.67	5.43	5.17	5.28	5.97	5.67	8.72	7.53				
Moistur Content 100(Wm/Wd) %	14.94	14.71	16.66	16.28	18.15	18.91	20.79	20.72	21.88	22.50				

Average Moisture Content (m) %	14.83	16.47	18.53	20.76	22.19		
Dry Density = Pb/1+ (m/100) (g/cm^3)	1.42	1.52	1.53	1.47	1.35		
C.B.R. (mseen of top & bottom) %							



DETERMINATION OF THE MOISTURE/DENSITY RELATION OF SOIL
USING STANDARD/HEAVY COMPACTION

Job... **OKOMU** Sample No:**....OKOMU RAMP I, BH9...** Operator……

Site…**....** Dept....**14.0m……** Date:**…25/05/2018…** MDD:**1.51g/cm^3**

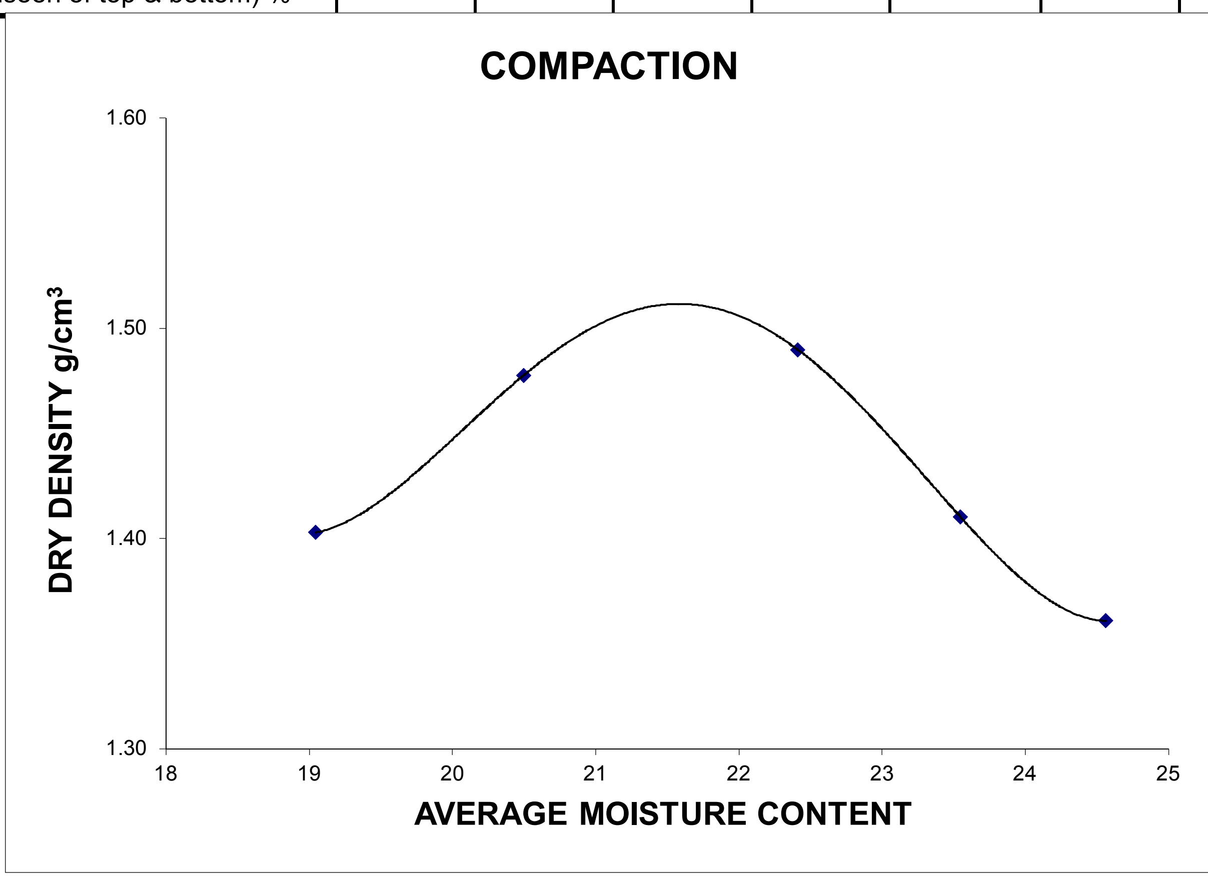
Amount retained on 20mm B.S. Sieve……… Total weight of Sample…… OPT.MC**:21.6%**

B.S. / C.B.R. Mould……**4722g…**………...............................

Wt. of mould & wet Soil (W2) g	6385.00	6495.00	6538.00	6457.00	6410.00		
Wt. of mould (W1) g	4722.00	4722.00	4722.00	4722.00	4722.00		
Wt. of wet soil (W2-W1) g	1663.00	1773.00	1816.00	1735.00	1688.00		
Bulk Density (Pb) (W2-W1)/x g/cm^3	1.67	1.78	1.82	1.74	1.70		

MOISTURE CONTENT DETERMINATIONS for B.S. Mould, X = 1000cm^3

Container No.	TJ	JA	SL	F5	EI	VI	PI	JO	FZ	BF				
Wt. of wet soil & container (g)	47.94	47.84	48.96	55.14	50.51	50.07	50.22	50.95	56.55	51.42				
Wt. of Dry soil & container (g)	43.07	43.09	43.09	48.96	44.38	44.27	44.10	44.51	48.82	44.99				
Wt. of Container (g)	17.53	18.12	14.21	19.06	17.24	18.19	17.83	17.45	17.35	18.81				
Wt. of dry soil (Wd) g	25.54	24.97	28.88	29.90	27.14	26.08	26.27	27.06	31.47	26.18				
Wt. of Moisture (Wm) g	4.87	4.75	5.87	6.18	6.13	5.80	6.12	6.44	7.73	6.43				
Moistur Content 100(Wm/Wd) %	19.07	19.02	20.33	20.67	22.59	22.24	23.30	23.80	24.56	24.56				
Average Moisture Content (m) %	19.05		20.50		22.41		23.55		24.56					
Dry Density = Pb/1+ (m/100) (g/cm^3)	1.40		1.48		1.49		1.41		1.36					
C.B.R. (mseen of top & bottom) %														



DETERMINATION OF THE MOISTURE/DENSITY RELATION OF SOIL
USING STANDARD/HEAVY COMPACTION

Job... **OKOMU** Sample No:....**RAMP II, BH10...** Operator…………

Site…..... Dept...**1.5m……** Date:...**25/05/2018…** MDD:**1.58g/cm³**

Amount retained on 20mm B.S. Sieve……… Total weight of Sample…… OPT.MC:**18.7%**

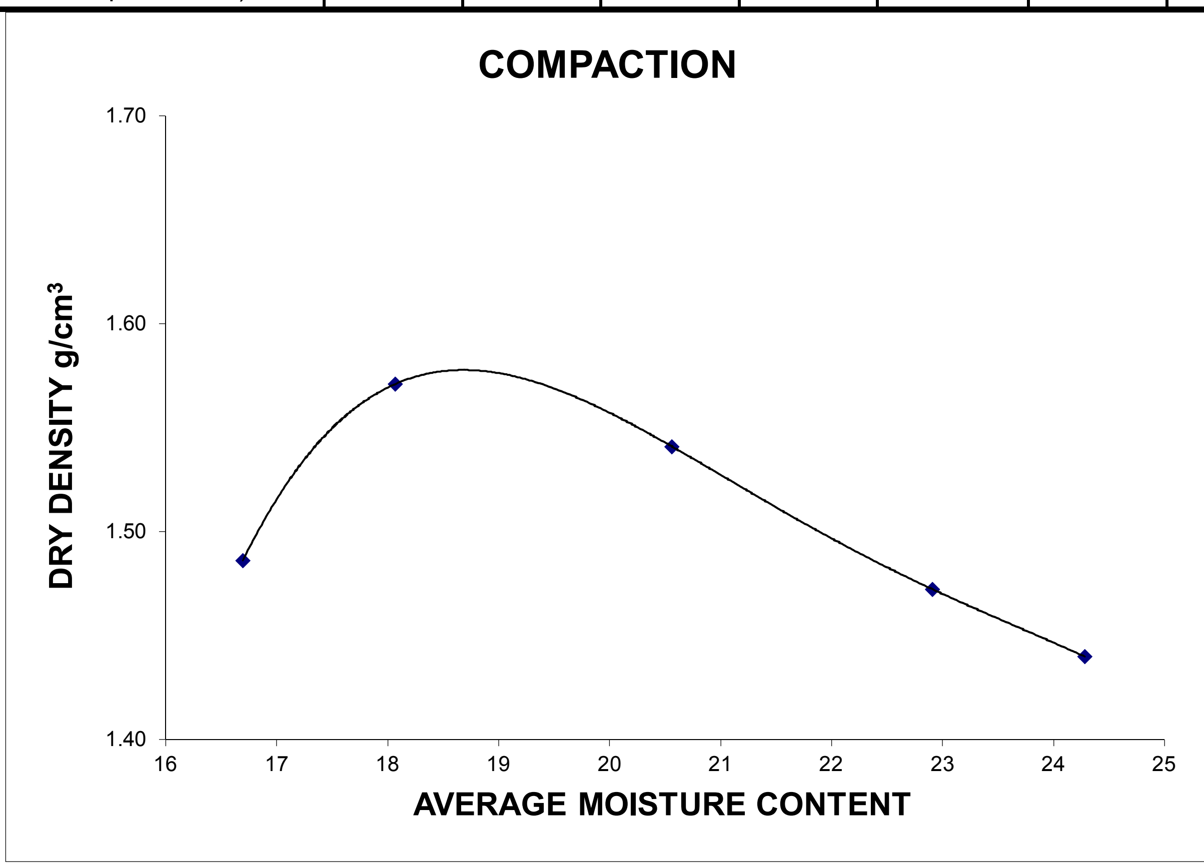
B.S. / C.B.R. Mould……**3250g…**………….............................

Wt. of mould & wet Soil (W2) g	4977.00	5097.00	5100.00	5052.00	5032.00		
Wt. of mould (W1) g	3250.00	3250.00	3250.00	3250.00	3250.00		
Wt. of wet soil (W2-W1) g	1727.00	1847.00	1850.00	1802.00	1782.00		
Bulk Density (Pb) (W2-W1)/x g/cm ^{3}	1.73	1.85	1.86	1.81	1.79		

MOISTURE CONTENT DETERMINATIONS for B.S. Mould, X = 1000cm ^{3}

Container No.	AB	MA	H8	P5	OE	MQ	JN	IN	DI	S3				
Wt. of wet soil & container (g)	50.57	48.92	44.29	45.39	38.09	42.30	47.34	39.12	42.44	47.40				
Wt. of Dry soil & container (g)	45.80	44.20	40.40	41.00	34.00	38.20	41.70	35.30	37.70	40.80				
Wt. of Container (g)	17.31	15.85	17.02	18.48	14.27	18.10	17.81	18.10	17.51	14.49				
Wt. of dry soil (Wd) g	28.49	28.35	23.38	22.52	19.73	20.10	23.89	17.20	20.19	26.31				
Wt. of Moisture (Wm) g	4.77	4.72	3.89	4.39	4.09	4.10	5.64	3.82	4.74	6.60				
Moistur Content 100(Wm/Wd) %	16.74	16.65	16.64	19.49	20.73	20.40	23.61	22.21	23.48	25.09				

Average Moisture Content (m) %	16.70	18.07	20.56	22.91	24.28		
Dry Density = Pb/1+ (m/100) (g/cm ^{3})	1.49	1.57	1.54	1.47	1.44		
C.B.R. (mseen of top & bottom) %							



DETERMINATION OF THE MOISTURE/DENSITY RELATION OF SOIL
USING STANDARD/HEAVY COMPACTION

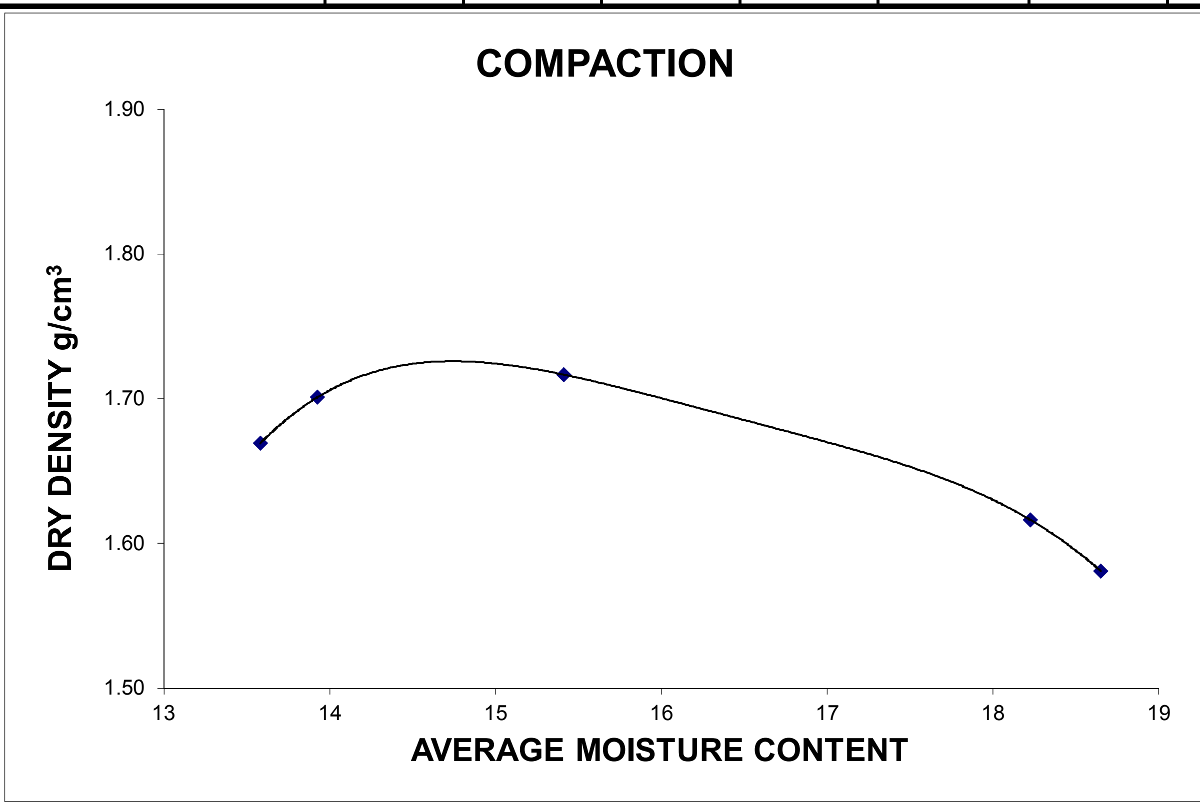
Job... **OKOMU** Sample No:**....RAMP II, BH10..** Operator…………

Site…..... Dept**…4.5m……** Date:**…25/05/2018…** MDD:**1.73g/cm^3**

Amount retained on 20mm B.S. Sieve……… Total weight of Sample…… OPT.MC**:15.0%**

B.S. / C.B.R. Mould……**4722g…**…………..............................

Wt. of mould & wet Soil (W2) g	6610.00		6652.00		6695.00		6625.00		6590.00					
Wt. of mould (W1) g	4722.00		4722.00		4722.00		4722.00		4722.00					
Wt. of wet soil (W2-W1) g	1888.00		1930.00		1973.00		1903.00		1868.00					
Bulk Density (Pb) (W2-W1)/x g/cm ^{3}	1.90		1.94		1.98		1.91		1.88					
MOISTURE CONTENT DETERMINATIONS	for B.S. Mould, X = 1000cm ^{3}													
Container No.	JI	RO	ZE	DO	EX	E3	IO	OT	4O	EI				
Wt. of wet soil & container (g)	45.62	48.14	54.40	49.99	57.34	59.19	45.34	50.92	50.75	54.74				
Wt. of Dry soil & container (g)	42.11	44.38	50.15	45.99	51.70	53.75	41.32	45.38	45.67	48.93				
Wt. of Container (g)	16.49	16.45	19.09	17.76	15.87	17.67	17.66	16.91	18.41	17.80				
Wt. of dry soil (Wd) g	25.62	27.93	31.06	28.23	35.83	36.08	23.66	28.47	27.26	31.13				
Wt. of Moisture (Wm) g	3.51	3.76	4.25	4.00	5.64	5.44	4.02	5.54	5.08	5.81				
Moistur Content 100(Wm/Wd) %	13.70	13.46	13.68	14.17	15.74	15.08	16.99	19.46	18.64	18.66				
Average Moisture Content (m) %	13.58		13.93		15.41		18.22		18.65					
Dry Density = Pb/1+ (m/100) (g/cm ^{3})	1.67		1.70		1.72		1.62		1.58					
C.B.R. (mseen of top & bottom) %														



DETERMINATION OF THE MOISTURE/DENSITY RELATION OF SOIL
USING STANDARD/HEAVY COMPACTION

Job… **OKOMU** Sample No:**....RAMP II, BH10..** Operator…………

Site…..... Dept…**7.5m……** Date:…**25/05/2018…** MDD:**1.65g/cm³**

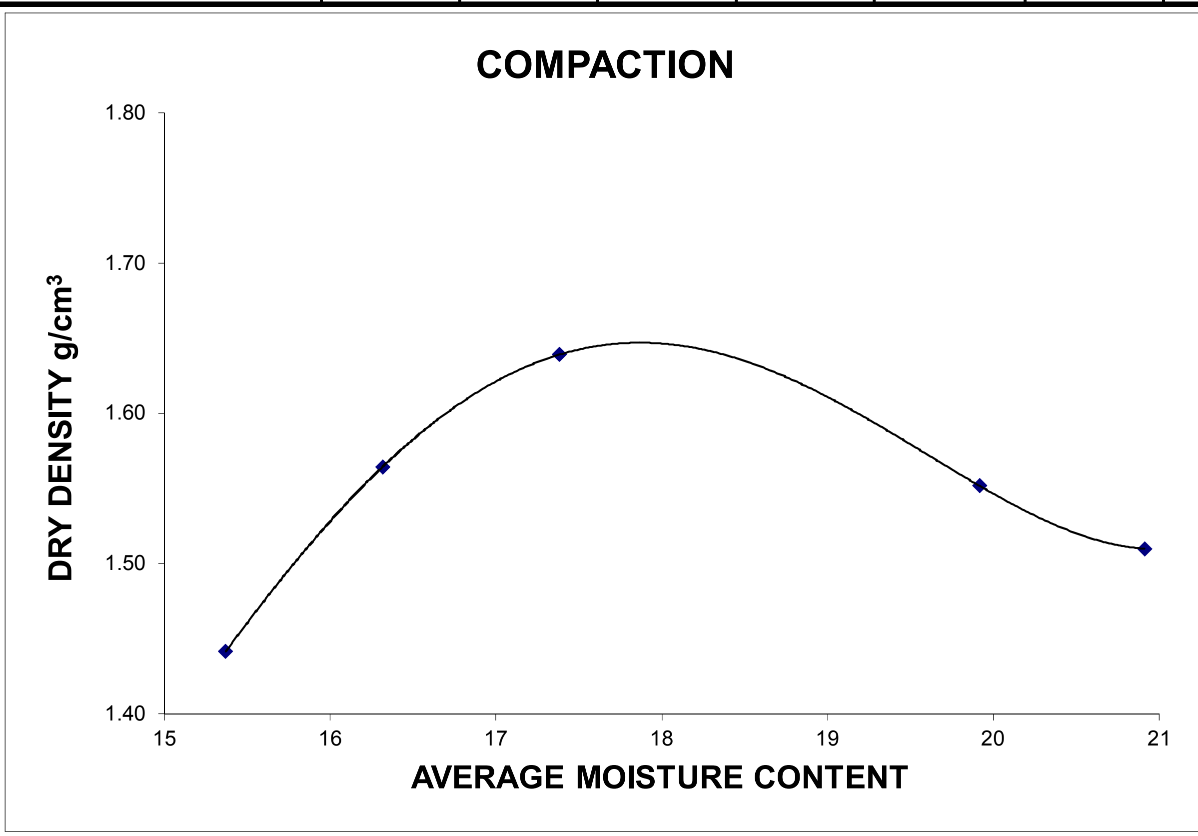
Amount retained on 20mm B.S. Sieve……… Total weight of Sample…… OPT.MC:**17.9%**

B.S. / C.B.R. Mould……**4722g…**………….............................

Wt. of mould & wet Soil (W2) g	6378.00	6534.00	6638.00	6575.00	6540.00		
Wt. of mould (W1) g	4722.00	4722.00	4722.00	4722.00	4722.00		
Wt. of wet soil (W2-W1) g	1656.00	1812.00	1916.00	1853.00	1818.00		
Bulk Density (Pb) (W2-W1)/x g/cm ^{3}	1.66	1.82	1.92	1.86	1.83		

MOISTURE CONTENT DETERMINATIONS for B.S. Mould, X = 1000cm ^{3}

Container No.	JO	F5	EI	SO	AN	VO	OY	AH	SE	LO				
Wt. of wet soil & container (g)	58.76	53.88	48.46	50.95	54.13	47.36	44.40	46.39	52.07	47.89				
Wt. of Dry soil & container (g)	53.18	49.05	44.32	45.94	49.08	42.91	39.67	41.65	45.77	42.78				
Wt. of Container (g)	16.89	17.61	19.07	15.08	19.90	17.42	16.41	17.34	15.72	18.28				
Wt. of dry soil (Wd) g	36.29	31.44	25.25	30.86	29.18	25.49	23.26	24.31	30.05	24.50				
Wt. of Moisture (Wm) g	5.58	4.83	4.14	5.01	5.05	4.45	4.73	4.74	6.30	5.11				
Moistur Content 100(Wm/Wd) %	15.38	15.36	16.40	16.23	17.31	17.46	20.34	19.50	20.97	20.86				
Average Moisture Content (m) %	15.37		16.32		17.38		19.92		20.91					
Dry Density = Pb/1+ (m/100) (g/cm ^{3})	1.44		1.56		1.64		1.55		1.51					
C.B.R. (mseen of top & bottom) %														



DETERMINATION OF THE MOISTURE/DENSITY RELATION OF SOIL
USING STANDARD/HEAVY COMPACTION

Job… **OKOMU** Sample No:**....RAMP II, BH10.** Operator…………

Site…**....** Dept**…10.5m……** Date**:…25/05/2018…** MDD:**1.54g/cm³**

Amount retained on 20mm B.S. Sieve……… Total weight of Sample…… OPT.MC**:18.9%**

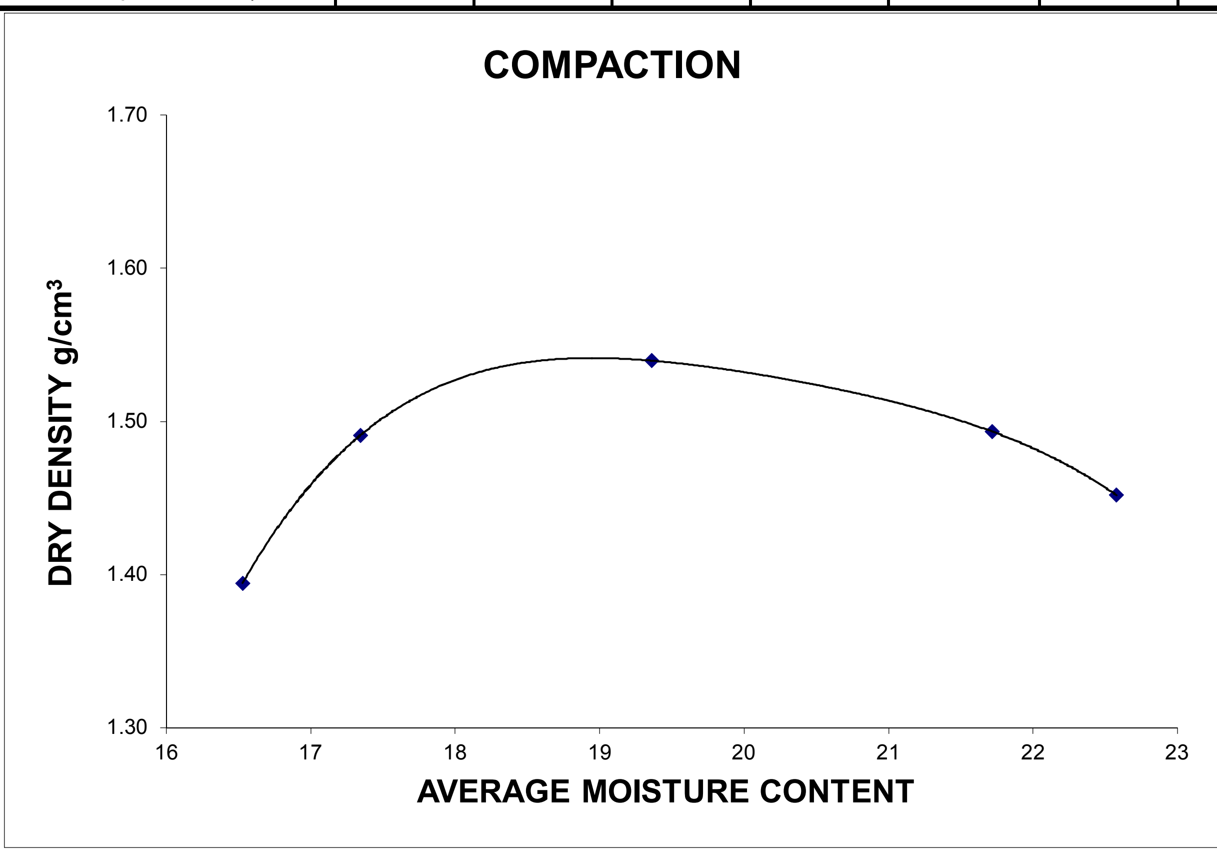
B.S. / C.B.R. Mould……**3250g…**………….............................

Wt. of mould & wet Soil (W2) g	4868.00	4992.00	5080.00	5060.00	5022.00		
Wt. of mould (W1) g	3250.00	3250.00	3250.00	3250.00	3250.00		
Wt. of wet soil (W2-W1) g	1618.00	1742.00	1830.00	1810.00	1772.00		
Bulk Density (Pb) (W2-W1)/x g/cm ^{3}	1.62	1.75	1.84	1.82	1.78		

MOISTURE CONTENT DETERMINATIONS for B.S. Mould, X = 1000cm ^{3}

Container No.	Z3	GT	JK	SO	OV	EZ	Z9	DO	IN	AC				
Wt. of wet soil & container (g)	50.26	50.24	53.42	44.18	50.90	48.07	44.86	52.03	47.98	42.88				
Wt. of Dry soil & container (g)	45.60	45.50	48.30	40.10	45.40	42.65	40.32	46.00	42.00	38.00				
Wt. of Container (g)	17.74	16.47	19.29	16.15	16.66	14.98	19.38	18.28	15.50	16.40				
Wt. of dry soil (Wd) g	27.86	29.03	29.01	23.95	28.74	27.67	20.94	27.72	26.50	21.60				
Wt. of Moisture (Wm) g	4.66	4.74	5.12	4.08	5.50	5.42	4.54	6.03	5.98	4.88				
Moistur Content 100(Wm/Wd) %	16.73	16.33	17.65	17.04	19.14	19.59	21.68	21.75	22.57	22.59				

Average Moisture Content (m) %	16.53	17.34	19.36	21.72	22.58		
Dry Density = Pb/1+ (m/100) (g/cm ^{3})	1.39	1.49	1.54	1.49	1.45		
C.B.R. (mseen of top & bottom) %							



DETERMINATION OF THE MOISTURE/DENSITY RELATION OF SOIL
USING STANDARD/HEAVY COMPACTION

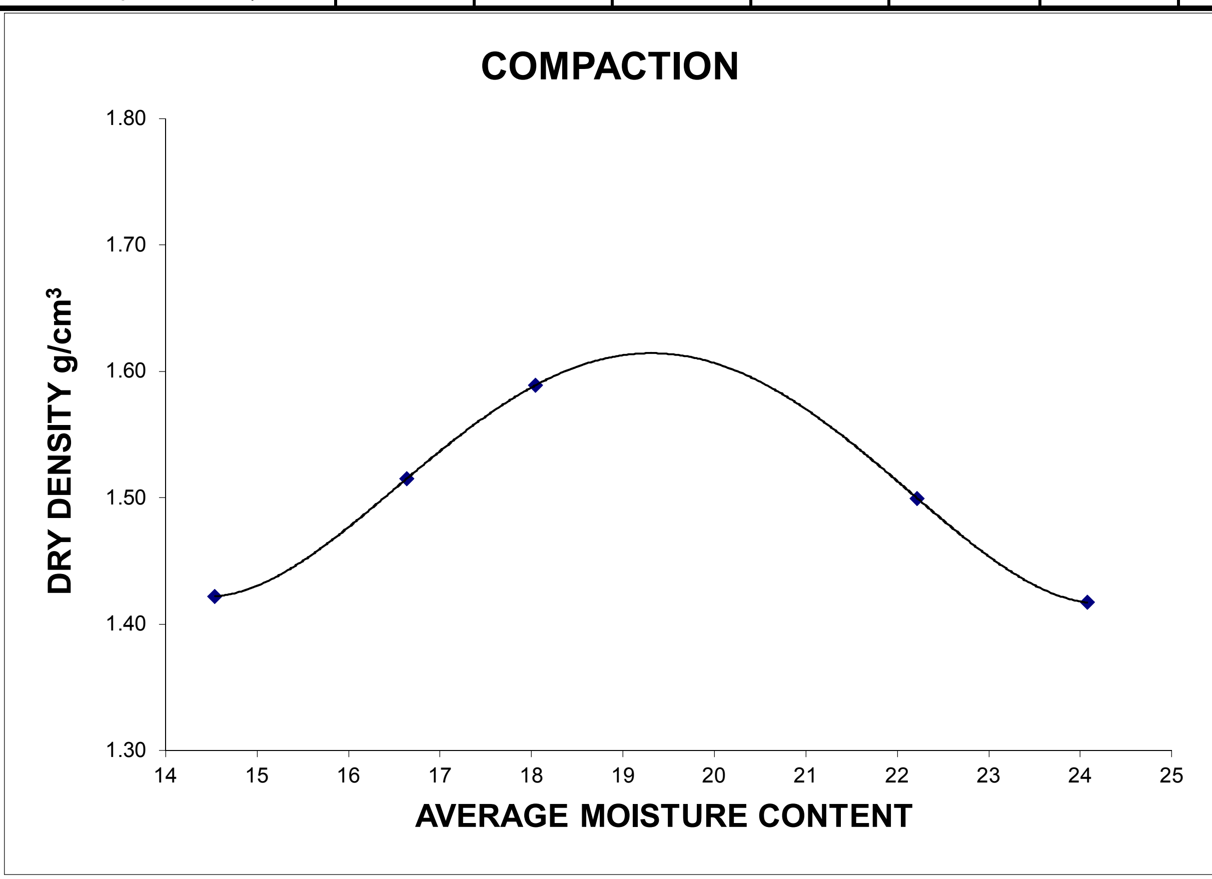
Job… **OKOMU** Sample No:**....RAMP II, BH10..** Operator…………

Site…..... Dept…**13.5m**…… Date:**…25/05/2018…** MDD:**1.62g/cm³**

Amount retained on 20mm B.S. Sieve……… Total weight of Sample…… OPT.MC:**19.3%**

B.S. / C.B.R. Mould……**3250g**……………...............................

Wt. of mould & wet Soil (W2) g	4872.00		5010.00		5118.00		5075.00		5001.00			
Wt. of mould (W1) g	3250.00		3250.00		3250.00		3250.00		3250.00			
Wt. of wet soil (W2-W1) g	1622.00		1760.00		1868.00		1825.00		1751.00			
Bulk Density (Pb) (W2-W1)/x g/cm³	1.63		1.77		1.88		1.83		1.76			
MOISTURE CONTENT DETERMINATIONS for B.S. Mould, X = 1000cm³												
Container No.	ST	PE	BA	EB	TK	OO	IB	IP	JA	MA		
Wt. of wet soil & container (g)	45.39	40.43	38.88	38.96	44.96	40.92	50.19	48.39	42.68	47.03		
Wt. of Dry soil & container (g)	41.87	37.54	35.55	35.90	41.10	37.22	44.90	42.93	37.20	40.90		
Wt. of Container (g)	18.10	17.29	15.74	17.32	19.76	16.67	20.97	18.48	14.40	15.48		
Wt. of dry soil (Wd) g	23.77	20.25	19.81	18.58	21.34	20.55	23.93	24.45	22.80	25.42		
Wt. of Moisture (Wm) g	3.52	2.89	3.33	3.06	3.86	3.70	5.29	5.46	5.48	6.13		
Moistur Content 100(Wm/Wd) %	14.81	14.27	16.81	16.47	18.09	18.00	22.11	22.33	24.04	24.11		
Average Moisture Content (m) %	14.54		16.64		18.05		22.22		24.07			
Dry Density = Pb/1+ (m/100) (g/cm³)	1.42		1.52		1.59		1.50		1.42			
C.B.R. (mseen of top & bottom) %												



DETERMINATION OF THE MOISTURE/DENSITY RELATION OF SOIL
USING STANDARD/HEAVY COMPACTION

Job... **OKOMU** Sample No:....**RAMP II, BH10...** Operator…………

Site…..... Dept...**15.0m……** Date:...**25/05/2018…** MDD:**1.56g/cm^3**

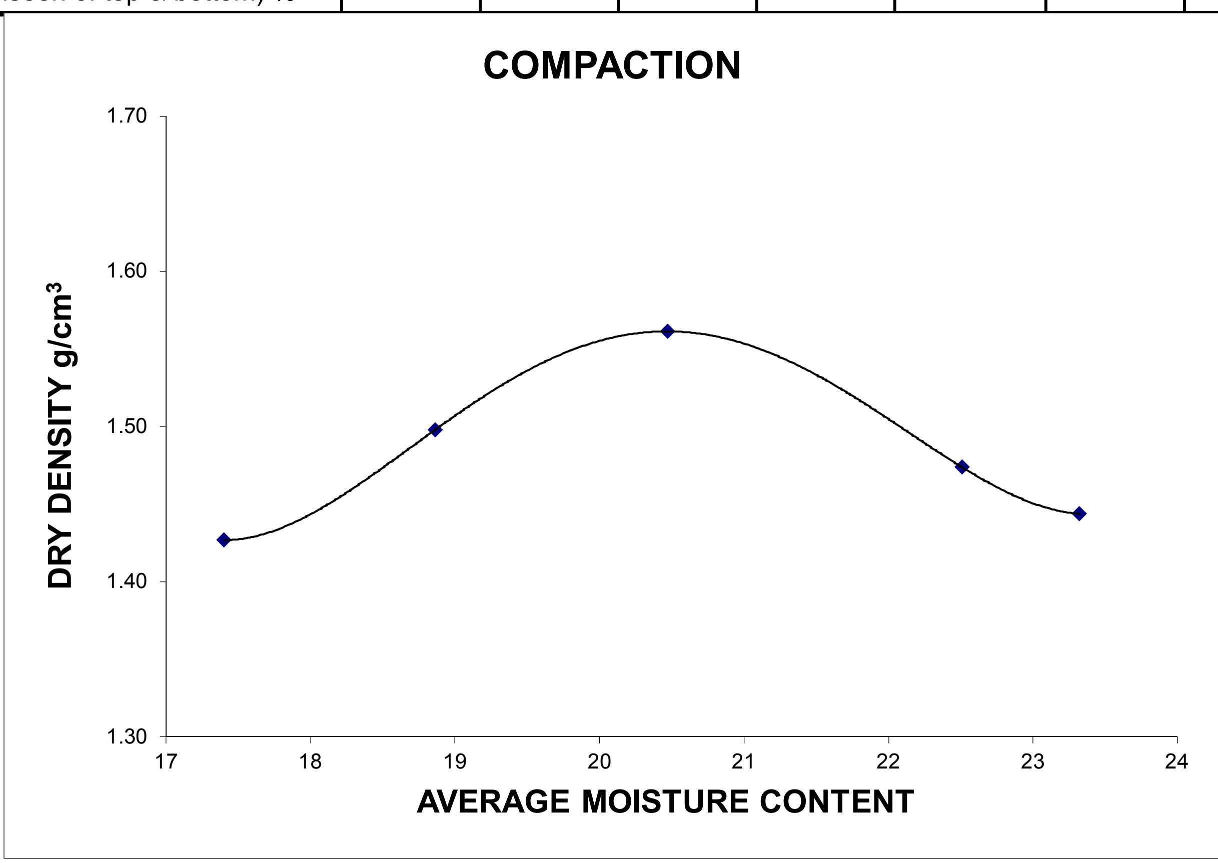
Amount retained on 20mm B.S. Sieve……… Total weight of Sample…… OPT.MC:**20.5%**

B.S. / C.B.R. Mould……**4722g…**……………...............................

Wt. of mould & wet Soil (W2) g	6390.00	6495.00	6595.00	6520.00	6495.00		
Wt. of mould (W1) g	4722.00	4722.00	4722.00	4722.00	4722.00		
Wt. of wet soil (W2-W1) g	1668.00	1773.00	1873.00	1798.00	1773.00		
Bulk Density (Pb) (W2-W1)/x g/cm^3	1.68	1.78	1.88	1.81	1.78		

MOISTURE CONTENT DETERMINATIONS for B.S. Mould, X = 1000cm^3

Container No.	3A	NA	PB	FA	OG	NO	FU	N8	BA	CO				
Wt. of wet soil & container (g)	47.66	46.02	50.41	54.67	62.67	46.11	55.97	58.60	58.44	47.69				
Wt. of Dry soil & container (g)	43.10	41.59	45.04	48.83	55.03	40.75	48.93	51.06	50.73	41.99				
Wt. of Container (g)	17.27	15.76	16.70	17.73	18.04	14.33	17.89	17.30	17.80	17.45				
Wt. of dry soil (Wd) g	25.83	25.83	28.34	31.10	36.99	26.42	31.04	33.76	32.93	24.54				
Wt. of Moisture (Wm) g	4.56	4.43	5.37	5.84	7.64	5.36	7.04	7.54	7.71	5.70				
Moistur Content 100(Wm/Wd) %	17.65	17.15	18.95	18.78	20.65	20.29	22.68	22.33	23.41	23.23				
Average Moisture Content (m) %	17.40		18.86		20.47		22.51		23.32					
Dry Density = Pb/1+ (m/100) (g/cm^3)	1.43		1.50		1.56		1.47		1.44					
C.B.R. (mseen of top & bottom) %														



DETERMINATION OF THE MOISTURE/DENSITY RELATION OF SOIL
USING STANDARD/HEAVY COMPACTION

Job… **OKOMU** Sample No:**....STERILIZER, BH4...** Operator…………

Site…**....** Dept**…12.5m……** Date:**…25/05/2018…** MDD:**1.55g/cm³**

Amount retained on 20mm B.S. Sieve……… Total weight of Sample…… OPT.MC**:21.4%**

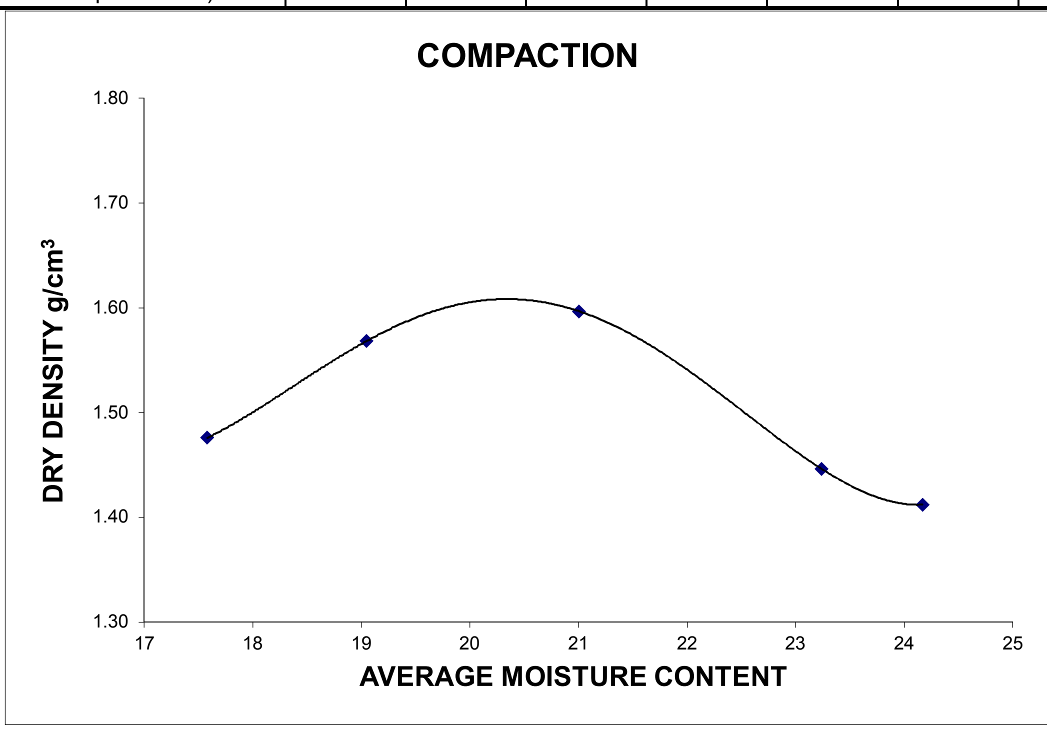
B.S. / C.B.R. Mould……**3248g…**……………..................................

Wt. of mould & wet Soil (W2) g	4976.00	5107.00	5172.00	5023.00	4994.00		
Wt. of mould (W1) g	3248.00	3248.00	3248.00	3248.00	3248.00		
Wt. of wet soil (W2-W1) g	1728.00	1859.00	1924.00	1775.00	1746.00		
Bulk Density (Pb) (W2-W1)/x g/cm^3	1.74	1.87	1.93	1.78	1.75		

MOISTURE CONTENT DETERMINATIONS for B.S. Mould, X = 1000cm^3

Container No.	AI	ME	Z8	ZO	MO	7O	EI	NM	TU	SU				
Wt. of wet soil & container (g)	49.28	52.85	65.24	56.83	54.16	56.04	54.73	47.88	50.93	47.96				
Wt. of Dry soil & container (g)	44.42	47.72	58.23	50.29	47.70	49.65	47.96	41.81	43.99	41.99				
Wt. of Container (g)	16.96	18.34	19.67	17.45	17.39	18.77	19.08	15.45	14.53	17.90				
Wt. of dry soil (Wd) g	27.46	29.38	38.56	32.84	30.31	30.88	28.88	26.36	29.46	24.09				
Wt. of Moisture (Wm) g	4.86	5.13	7.01	6.54	6.46	6.39	6.77	6.07	6.94	5.97				
Moistur Content 100(Wm/Wd) %	17.70	17.46	18.18	19.91	21.31	20.69	23.44	23.03	23.56	24.78				

Average Moisture Content (m) %	17.58	19.05	21.00	23.23	24.17		
Dry Density = Pb/1+ (m/100) (g/cm^3)	1.48	1.57	1.60	1.45	1.41		
C.B.R. (mseen of top & bottom) %							



DETERMINATION OF THE MOISTURE/DENSITY RELATION OF SOIL
USING STANDARD/HEAVY COMPACTION

Job... **OKOMU** Sample No:**....STERILIZER, BH4...** Operator…………

Site…..... Dept...**0.5m……** Date:**…25/05/2018…** MDD:**1.58g/cm^3**

Amount retained on 20mm B.S. Sieve……… Total weight of Sample…… OPT.MC:**18.9%**

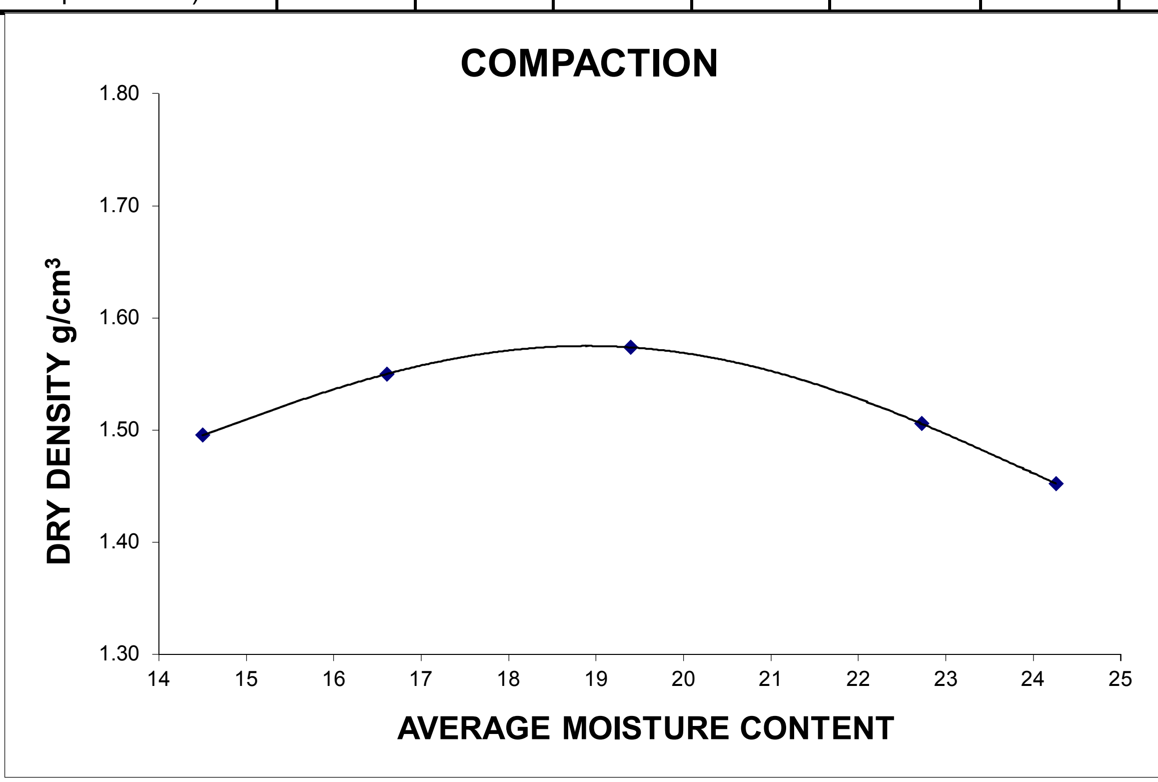
B.S. / C.B.R. Mould……**4720g…**………….............................

Wt. of mould & wet Soil (W2) g	6425.00	6520.00	6591.00	6560.00	6517.00		
Wt. of mould (W1) g	4720.00	4720.00	4720.00	4720.00	4720.00		
Wt. of wet soil (W2-W1) g	1705.00	1800.00	1871.00	1840.00	1797.00		
Bulk Density (Pb) (W2-W1)/x g/cm^3	1.71	1.81	1.88	1.85	1.80		

MOISTURE CONTENT DETERMINATIONS for B.S. Mould, X = 1000cm^3

Container No.	CL	P3	BE	AF	Z3	KL	CE	GL	CL	PX				
Wt. of wet soil & container (g)	51.00	53.40	45.50	45.30	49.50	51.60	53.60	50.00	49.50	48.60				
Wt. of Dry soil & container (g)	46.85	48.69	41.53	41.18	44.10	46.23	47.33	43.68	42.70	42.60				
Wt. of Container (g)	17.40	17.10	17.80	16.20	16.30	18.50	19.50	16.10	14.40	18.10				
Wt. of dry soil (Wd) g	29.45	31.59	23.73	24.98	27.80	27.73	27.83	27.58	28.30	24.50				
Wt. of Moisture (Wm) g	4.15	4.71	3.97	4.12	5.40	5.37	6.27	6.32	6.80	6.00				
Moistur Content 100(Wm/Wd) %	14.09	14.91	16.73	16.49	19.42	19.37	22.53	22.92	24.03	24.49				

Average Moisture Content (m) %	14.50	16.61	19.39	22.72	24.26		
Dry Density = Pb/1+ (m/100) (g/cm^3)	1.50	1.55	1.57	1.51	1.45		
C.B.R. (mseen of top & bottom) %							



DETERMINATION OF THE MOISTURE/DENSITY RELATION OF SOIL
USING STANDARD/HEAVY COMPACTION

Job... **OKOMU** Sample No:**....STERILIZER, BH4...** Operator…………

Site…**....** Dept**…3.5m……** Date**:…25/05/2018…** MDD:**1.48g/cm^3**

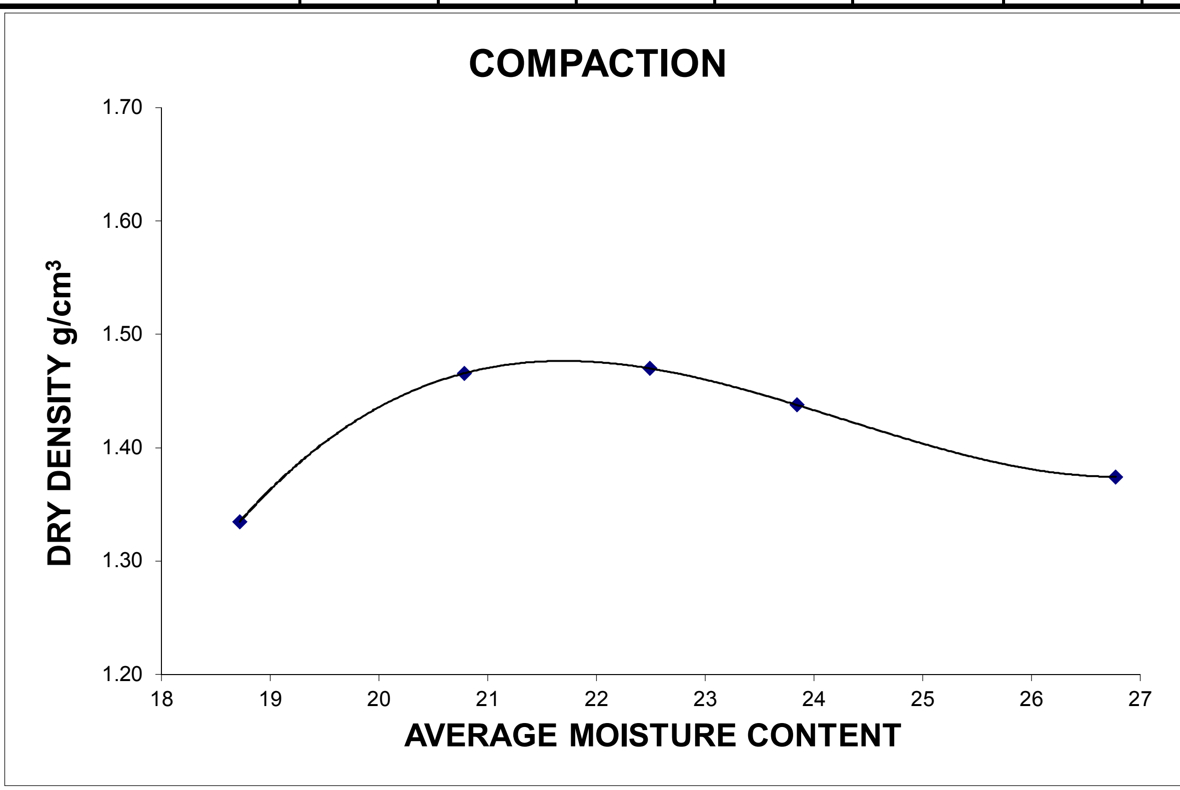
Amount retained on 20mm B.S. Sieve……… Total weight of Sample…… OPT.MC**:21.7%**

B.S. / C.B.R. Mould……**4722g…**…………..............................

Wt. of mould & wet Soil (W2) g	6300.00	6485.00	6515.00	6495.00	6457.00		
Wt. of mould (W1) g	4722.00	4722.00	4722.00	4722.00	4722.00		
Wt. of wet soil (W2-W1) g	1578.00	1763.00	1793.00	1773.00	1735.00		
Bulk Density (Pb) (W2-W1)/x g/cm ^{3}	1.58	1.77	1.80	1.78	1.74		

MOISTURE CONTENT DETERMINATIONS for B.S. Mould, X = 1000cm^3

Container No.	PD	S9	3R	X	T	FY	EX	TK	UF	SO				
Wt. of wet soil & container (g)	53.18	48.20	60.22	69.33	53.44	58.31	54.85	51.32	59.10	54.43				
Wt. of Dry soil & container (g)	47.20	42.88	53.08	60.35	47.11	50.45	47.72	44.35	49.68	46.76				
Wt. of Container (g)	15.14	14.56	18.38	17.58	19.21	15.19	17.80	15.13	14.36	18.22				
Wt. of dry soil (Wd) g	32.06	28.32	34.70	42.77	27.90	35.26	29.92	29.22	35.32	28.54				
Wt. of Moisture (Wm) g	5.98	5.32	7.14	8.98	6.33	7.86	7.13	6.97	9.42	7.67				
Moistur Content 100(Wm/Wd) %	18.65	18.79	20.58	21.00	22.69	22.29	23.83	23.85	26.67	26.87				
Average Moisture Content (m) %	18.72		20.79		22.49		23.84		26.77					
Dry Density = Pb/1+ (m/100) (g/cm ^{3})	1.33		1.47		1.47		1.44		1.37					
C.B.R. (mseen of top & bottom) %														



DETERMINATION OF THE MOISTURE/DENSITY RELATION OF SOIL
USING STANDARD/HEAVY COMPACTION

Job... **OKOMU** Sample No:**....STERILIZER, BH4...** Operator…………

Site…... Dept**…6.5m……** Date:**…25/05/2018…** MDD:**1.61g/cm³**

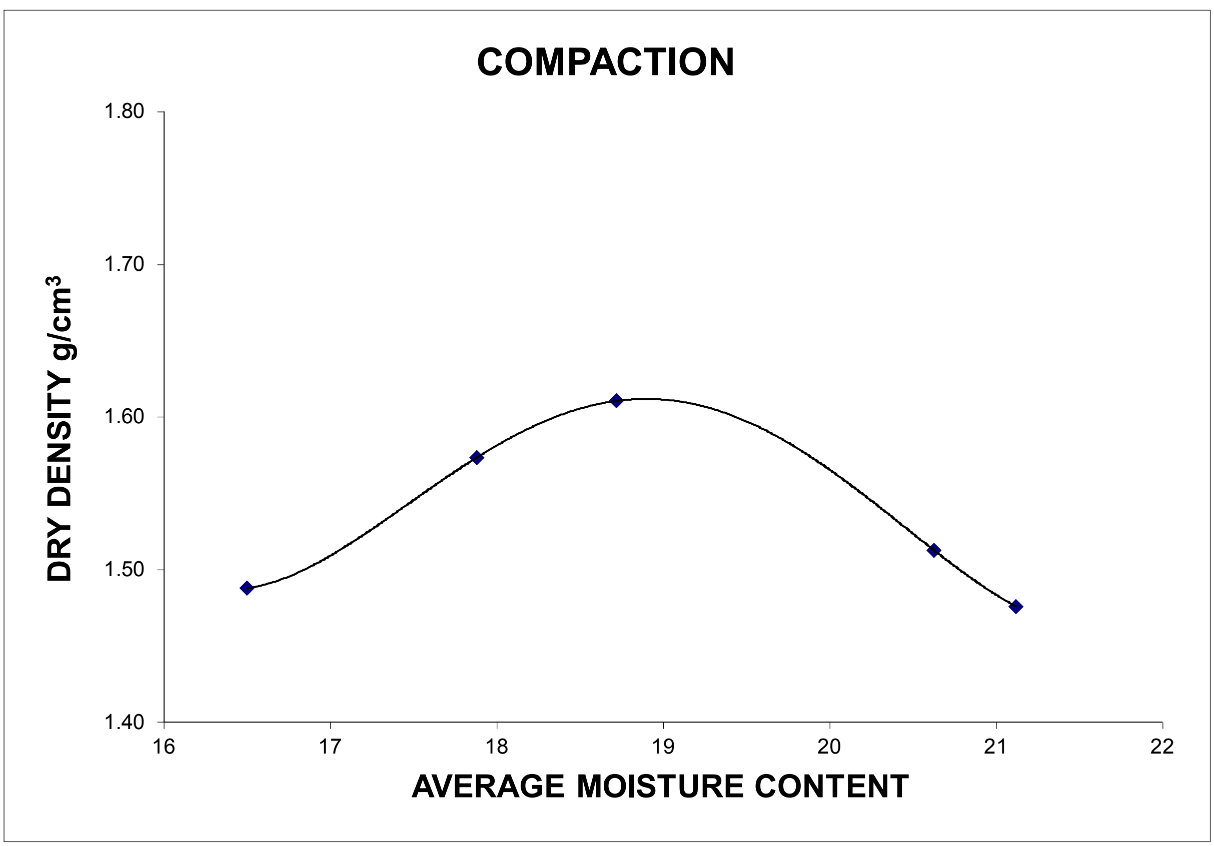
Amount retained on 20mm B.S. Sieve……… Total weight of Sample…… OPT.MC**:18.9%**

B.S. / C.B.R. Mould……**3248g…**………….............................

Wt. of mould & wet Soil (W2) g	4974.00	5095.00	5152.00	5065.00	5028.00		
Wt. of mould (W1) g	3248.00	3248.00	3248.00	3248.00	3248.00		
Wt. of wet soil (W2-W1) g	1726.00	1847.00	1904.00	1817.00	1780.00		
Bulk Density (Pb) (W2-W1)/x g/cm ^{3}	1.73	1.85	1.91	1.82	1.79		

MOISTURE CONTENT DETERMINATIONS for B.S. Mould, X = 1000cm ^{3}

Container No.	KO	EN	AN	LO	BO	I6	SK	OO	8Z	PO				
Wt. of wet soil & container (g)	49.52	52.92	53.53	56.81	53.61	59.14	56.86	56.07	55.16	51.77				
Wt. of Dry soil & container (g)	44.90	47.80	48.40	51.00	47.63	52.76	50.32	49.26	48.69	45.78				
Wt. of Container (g)	16.28	17.42	19.91	18.27	16.16	18.15	18.17	16.69	17.58	17.84				
Wt. of dry soil (Wd) g	28.62	30.38	28.49	32.73	31.47	34.61	32.15	32.57	31.11	27.94				
Wt. of Moisture (Wm) g	4.62	5.12	5.13	5.81	5.98	6.38	6.54	6.81	6.47	5.99				
Moistur Content 100(Wm/Wd) %	16.14	16.85	18.01	17.75	19.00	18.43	20.34	20.91	20.80	21.44				
Average Moisture Content (m) %	16.50		17.88		18.72		20.63		21.12					
Dry Density = Pb/1+ (m/100) (g/cm ^{3})	1.49		1.57		1.61		1.51		1.48					
C.B.R. (mseen of top & bottom) %														



DETERMINATION OF THE MOISTURE/DENSITY RELATION OF SOIL
USING STANDARD/HEAVY COMPACTION

Job... **OKOMU** Sample No:**....STERILIZER, BH4..** Operator...........

Site…..... Dept**...9.5.0m……** Date:**...25/05/2018…** MDD:**1.50g/cm^3**

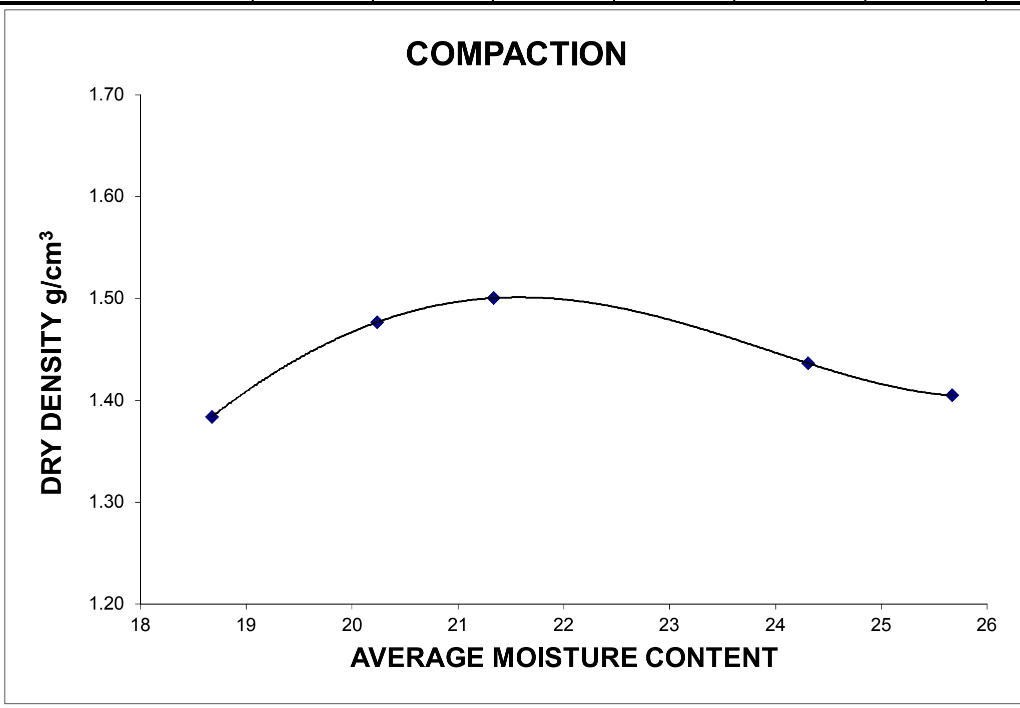
Amount retained on 20mm B.S. Sieve……… Total weight of Sample…… OPT.MC:**21.6%**

B.S. / C.B.R. Mould……**4722g…**………….................................

Wt. of mould & wet Soil (W2) g	6357.00	6490.00	6535.00	6500.00	6480.00		
Wt. of mould (W1) g	4722.00	4722.00	4722.00	4722.00	4722.00		
Wt. of wet soil (W2-W1) g	1635.00	1768.00	1813.00	1778.00	1758.00		
Bulk Density (Pb) (W2-W1)/x g/cm^3	1.64	1.78	1.82	1.79	1.77		

MOISTURE CONTENT DETERMINATIONS for B.S. Mould, X = 1000cm^3

Container No.	OK	OR	GS	ZO	OF	AB	AI	PO	DA	E				
Wt. of wet soil & container (g)	48.66	52.08	52.22	51.36	46.42	51.36	44.35	59.14	60.00	52.18				
Wt. of Dry soil & container (g)	43.46	46.49	46.49	45.40	41.26	45.67	38.52	50.85	51.69	44.91				
Wt. of Container (g)	15.60	16.57	17.98	16.14	17.57	18.44	13.94	17.56	19.20	16.69				
Wt. of dry soil (Wd) g	27.86	29.92	28.51	29.26	23.69	27.23	24.58	33.29	32.49	28.22				
Wt. of Moisture (Wm) g	5.20	5.59	5.73	5.96	5.16	5.69	5.83	8.29	8.31	7.27				
Moistur Content 100(Wm/Wd) %	18.66	18.68	20.10	20.37	21.78	20.90	23.72	24.90	25.58	25.76				
Average Moisture Content (m) %	18.67		20.23		21.34		24.31		25.67					
Dry Density = Pb/1+ (m/100) (g/cm^3)	1.38		1.48		1.50		1.44		1.40					
C.B.R. (mseen of top & bottom) %														



DETERMINATION OF THE MOISTURE/DENSITY RELATION OF SOIL
USING STANDARD/HEAVY COMPACTION

Job... **OKOMU** Sample No:....**STERILIZER, BH4...** Operator…………

Site…..... Dept...**15.0m**…… Date:...**25/05/2018**… MDD:**1.51g/cm^3**

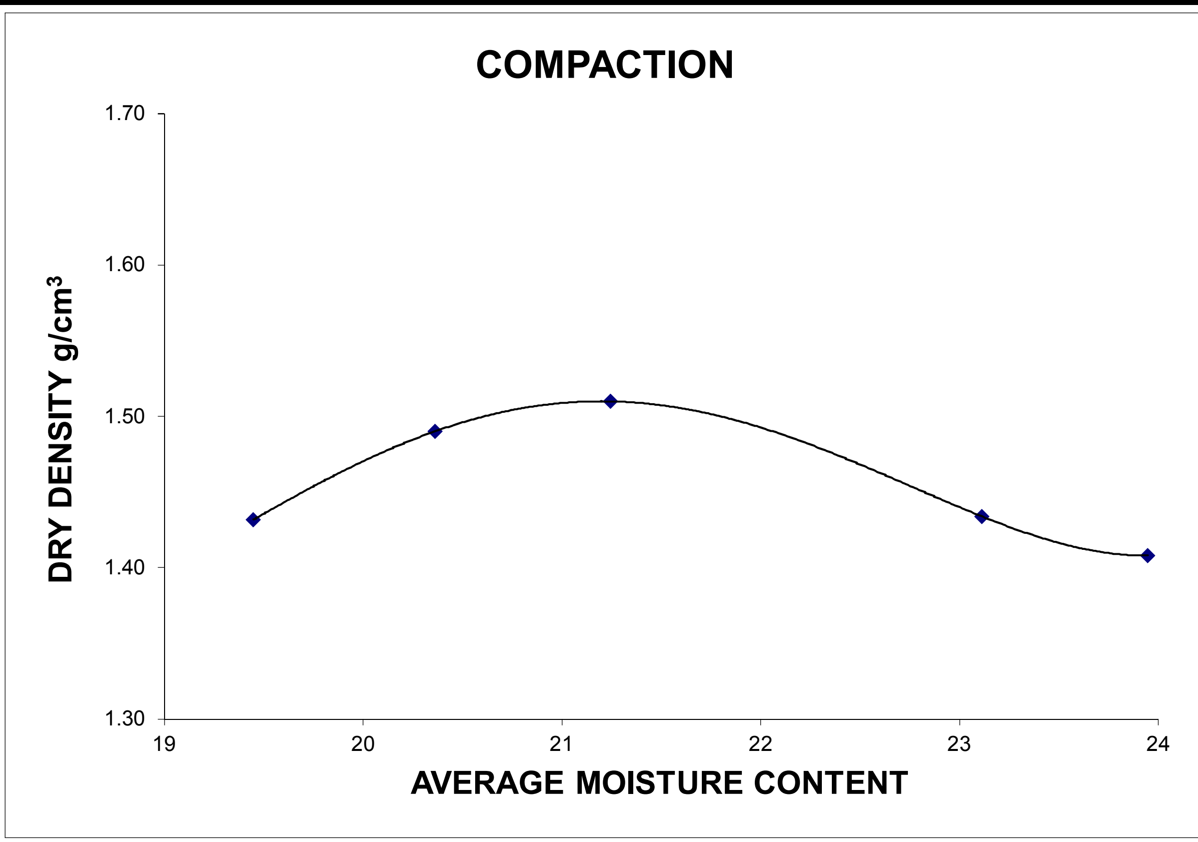
Amount retained on 20mm B.S. Sieve……… Total weight of Sample…… OPT.MC:**21.2%**

B.S. / C.B.R. Mould……**4722g**…………..............................

Wt. of mould & wet Soil (W2) g	6425.00	6508.00	6545.00	6480.00	6460.00		
Wt. of mould (W1) g	4722.00	4722.00	4722.00	4722.00	4722.00		
Wt. of wet soil (W2-W1) g	1703.00	1786.00	1823.00	1758.00	1738.00		
Bulk Density (Pb) (W2-W1)/x g/cm^3	1.71	1.79	1.83	1.77	1.75		

MOISTURE CONTENT DETERMINATIONS for B.S. Mould, X = 1000cm^3

Container No.	PI	I6	AI	IG	NM	FS	EI	VI	KO	TJ				
Wt. of wet soil & container (g)	47.33	50.75	50.57	50.77	56.90	53.45	57.73	51.96	44.00	45.09				
Wt. of Dry soil & container (g)	42.52	45.39	44.82	44.82	49.65	47.20	50.50	45.58	38.65	39.75				
Wt. of Container (g)	17.52	18.12	16.90	15.26	15.46	17.83	19.06	18.11	16.32	17.44				
Wt. of dry soil (Wd) g	25.00	27.27	27.92	29.56	34.19	29.37	31.44	27.47	22.33	22.31				
Wt. of Moisture (Wm) g	4.81	5.36	5.75	5.95	7.25	6.25	7.23	6.38	5.35	5.34				
Moistur Content 100(Wm/Wd) %	19.24	19.66	20.59	20.13	21.21	21.28	23.00	23.23	23.96	23.94				
Average Moisture Content (m) %	19.45		20.36		21.24		23.11		23.95					
Dry Density = Pb/1+ (m/100) (g/cm^3)	1.43		1.49		1.51		1.43		1.41					
C.B.R. (mseen of top & bottom) %														



DETERMINATION OF THE MOISTURE/DENSITY RELATION OF SOIL
USING STANDARD/HEAVY COMPACTION

Job... **OKOMU** Sample No:**....STORAGE TANK, BH6...** Operator…………

Site…**...** Dept**...10.0m……** Date**:...25/05/2018…** MDD:**1.51g/cm^3**

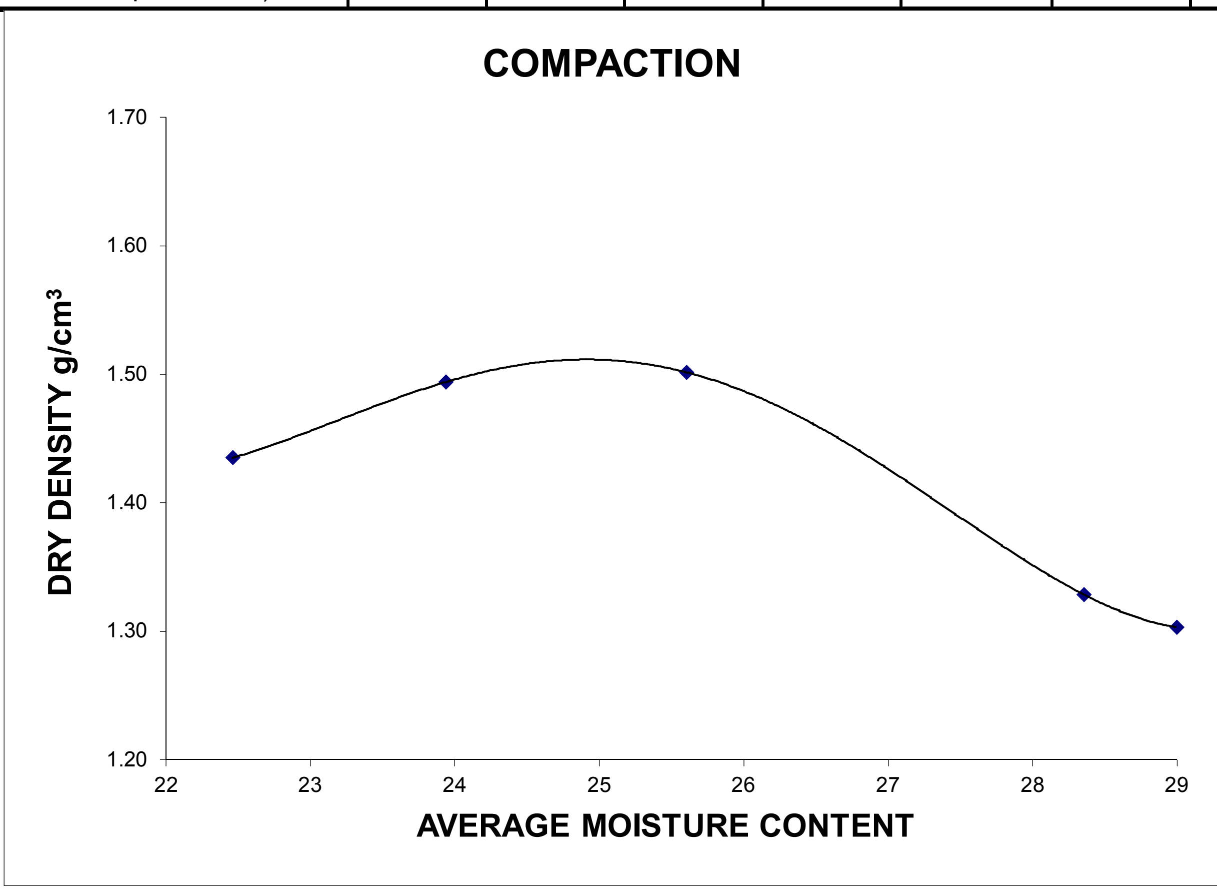
Amount retained on 20mm B.S. Sieve……… Total weight of Sample…… OPT.MC**:24.9%**

B.S. / C.B.R. Mould……**3252g…**…………...............................

Wt. of mould & wet Soil (W2) g	5002.00	5096.00	5130.00	4950.00	4926.00		
Wt. of mould (W1) g	3252.00	3252.00	3252.00	3252.00	3252.00		
Wt. of wet soil (W2-W1) g	1750.00	1844.00	1878.00	1698.00	1674.00		
Bulk Density (Pb) (W2-W1)/x g/cm^3	1.76	1.85	1.89	1.71	1.68		

MOISTURE CONTENT DETERMINATIONS for B.S. Mould, X = 1000cm^3

Container No.	3R	OR	OE	NB	TP	CH	QR	XX	JR	CH				
Wt. of wet soil & container (g)	49.80	49.60	53.70	58.20	57.00	52.10	48.90	53.80	54.60	50.70				
Wt. of Dry soil & container (g)	43.90	44.00	47.00	50.30	48.80	44.70	41.50	45.80	46.20	42.60				
Wt. of Container (g)	18.30	18.40	18.30	18.10	17.10	15.50	15.30	17.70	17.40	14.50				
Wt. of dry soil (Wd) g	25.60	25.60	28.70	32.20	31.70	29.20	26.20	28.10	28.80	28.10				
Wt. of Moisture (Wm) g	5.90	5.60	6.70	7.90	8.20	7.40	7.40	8.00	8.40	8.10				
Moistur Content 100(Wm/Wd) %	23.05	21.88	23.34	24.53	25.87	25.34	28.24	28.47	29.17	28.83				
Average Moisture Content (m) %	22.46		23.94		25.60		28.36		29.00					
Dry Density = Pb/1+ (m/100) (g/cm^3)	1.44		1.49		1.50		1.33		1.30					
C.B.R. (mseen of top & bottom) %														



DETERMINATION OF THE MOISTURE/DENSITY RELATION OF SOIL
USING STANDARD/HEAVY COMPACTION

Job... **OKOMU** Sample No:**....STORAGE TANK, BH6...** Operator…………

Site…... Dept**1.0m……** Date:**…25/05/2018…** MDD:**1.47g/cm³**

Amount retained on 20mm B.S. Sieve……… Total weight of Sample…… OPT.MC**:19.6%**

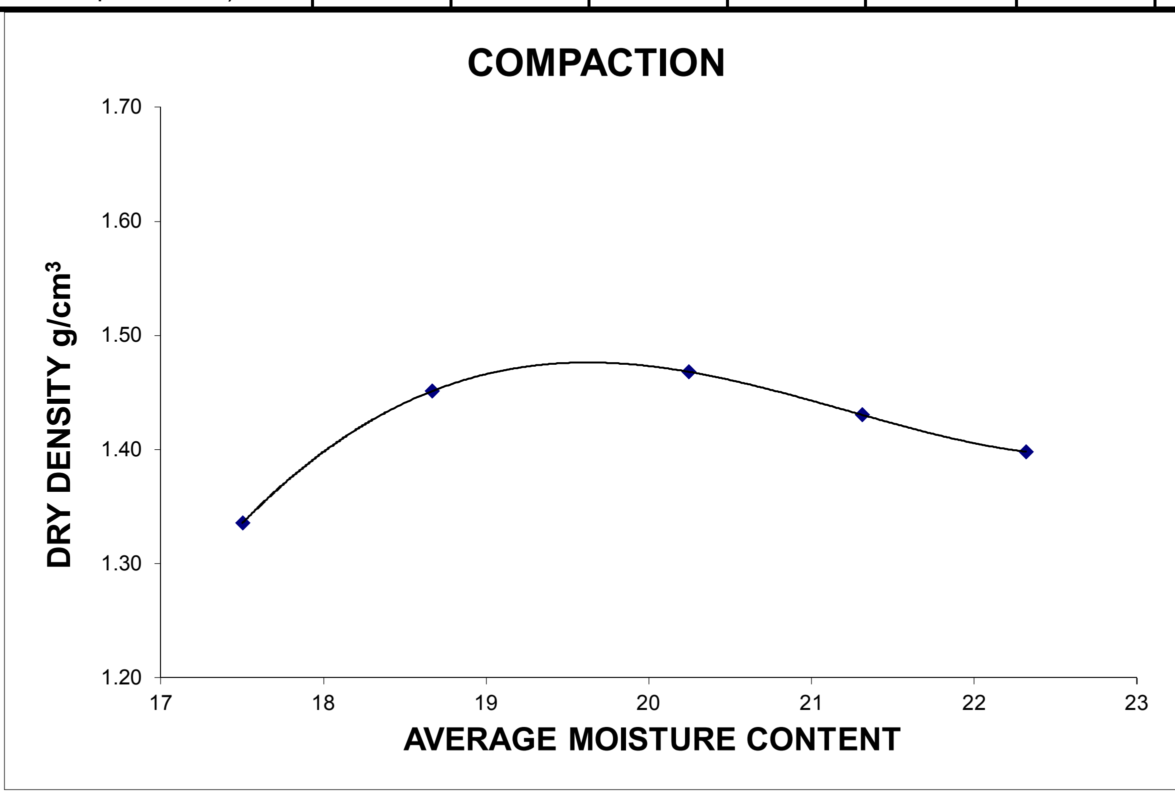
B.S. / C.B.R. Mould……**4722g…**………….............................

Wt. of mould & wet Soil (W2) g	6285.00	6437.00	6480.00	6450.00	6425.00		
Wt. of mould (W1) g	4722.00	4722.00	4722.00	4722.00	4722.00		
Wt. of wet soil (W2-W1) g	1563.00	1715.00	1758.00	1728.00	1703.00		
Bulk Density (Pb) (W2-W1)/x g/cm ^{3}	1.57	1.72	1.77	1.74	1.71		

MOISTURE CONTENT DETERMINATIONS for B.S. Mould, X = 1000cm ^{3}

Container No.	PM	TW	PD	OS	GA	PO	SO	N	ZI	NI				
Wt. of wet soil & container (g)	41.83	53.30	55.09	48.54	45.31	53.42	54.57	53.65	53.69	51.35				
Wt. of Dry soil & container (g)	38.25	47.81	48.82	43.57	40.64	47.44	47.67	46.70	47.27	44.29				
Wt. of Container (g)	17.81	16.42	15.00	17.13	17.67	17.78	14.80	14.57	17.48	13.71				
Wt. of dry soil (Wd) g	20.44	31.39	33.82	26.44	22.97	29.66	32.87	32.13	29.79	30.58				
Wt. of Moisture (Wm) g	3.58	5.49	6.27	4.97	4.67	5.98	6.90	6.95	6.42	7.06				
Moistur Content 100(Wm/Wd) %	17.51	17.49	18.54	18.80	20.33	20.16	20.99	21.63	21.55	23.09				

Average Moisture Content (m) %	17.50	18.67	20.25	21.31	22.32		
Dry Density = Pb/1+ (m/100) (g/cm ^{3})	1.34	1.45	1.47	1.43	1.40		
C.B.R. (mseen of top & bottom) %							



DETERMINATION OF THE MOISTURE/DENSITY RELATION OF SOIL
USING STANDARD/HEAVY COMPACTION

Job… **OKOMU** Sample No:….**STORAGE TANK, BH6…** Operator…………

Site…... Dept…**4.0m**…… Date:…**25/05/2018**… MDD:**1.48g/cm^3**

Amount retained on 20mm B.S. Sieve……… Total weight of Sample…… OPT.MC:**20.8%**

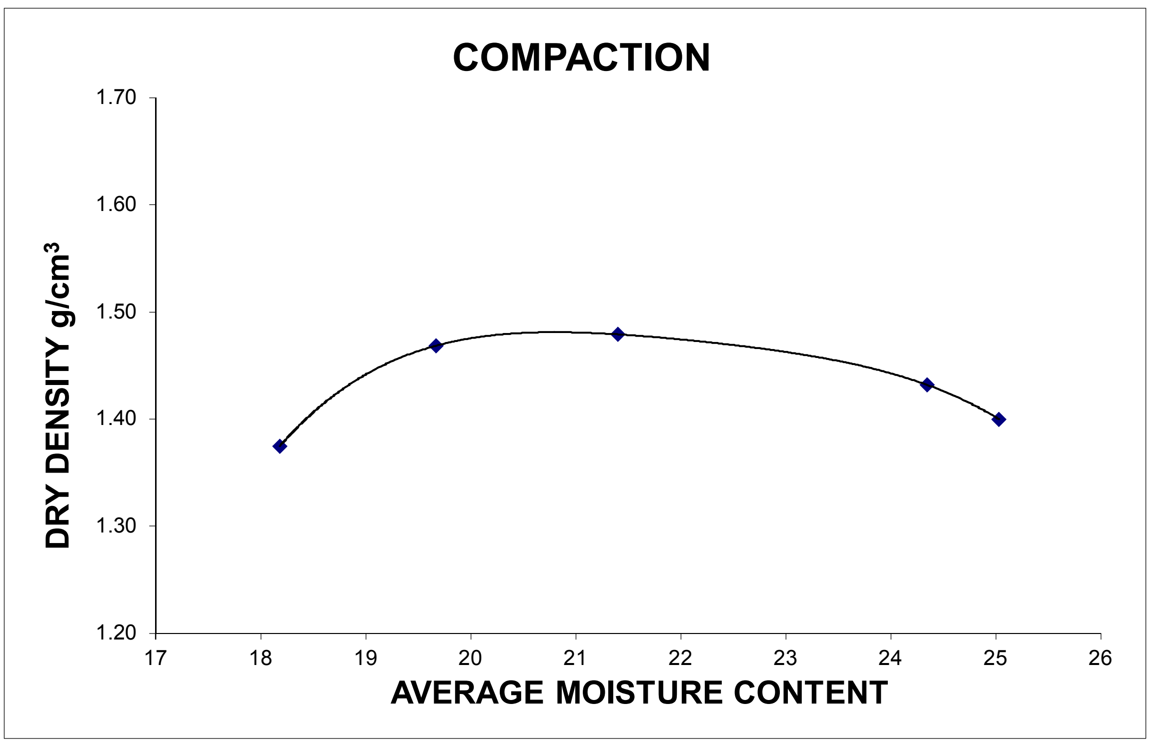
B.S. / C.B.R. Mould……**4722g**……………...............................

Wt. of mould & wet Soil (W2) g	6340.00	6472.00	6510.00	6495.00	6465.00		
Wt. of mould (W1) g	4722.00	4722.00	4722.00	4722.00	4722.00		
Wt. of wet soil (W2-W1) g	1618.00	1750.00	1788.00	1773.00	1743.00		
Bulk Density (Pb) (W2-W1)/x g/cm ^{3}	1.62	1.76	1.80	1.78	1.75		

MOISTURE CONTENT DETERMINATIONS for B.S. Mould, X = 1000cm^3

Container No.	X	PO	S9	FY	QP	4O	OS	JJ	3RD	CE				
Wt. of wet soil & container (g)	47.41	39.81	36.54	41.82	45.27	42.90	47.25	45.01	39.72	46.65				
Wt. of Dry soil & container (g)	42.88	36.02	32.94	37.42	40.32	38.21	41.34	39.32	35.46	40.91				
Wt. of Container (g)	17.63	15.45	14.56	15.15	17.02	16.45	16.88	16.12	18.41	18.02				
Wt. of dry soil (Wd) g	25.25	20.57	18.38	22.27	23.30	21.76	24.46	23.20	17.05	22.89				
Wt. of Moisture (Wm) g	4.53	3.79	3.60	4.40	4.95	4.69	5.91	5.69	4.26	5.74				
Moistur Content 100(Wm/Wd) %	17.94	18.42	19.59	19.76	21.24	21.55	24.16	24.53	24.99	25.08				

Average Moisture Content (m) %	18.18	19.67	21.40	24.34	25.03		
Dry Density = Pb/1+ (m/100) (g/cm ^{3})	1.37	1.47	1.48	1.43	1.40		
C.B.R. (mseen of top & bottom) %							



DETERMINATION OF THE MOISTURE/DENSITY RELATION OF SOIL
USING STANDARD/HEAVY COMPACTION

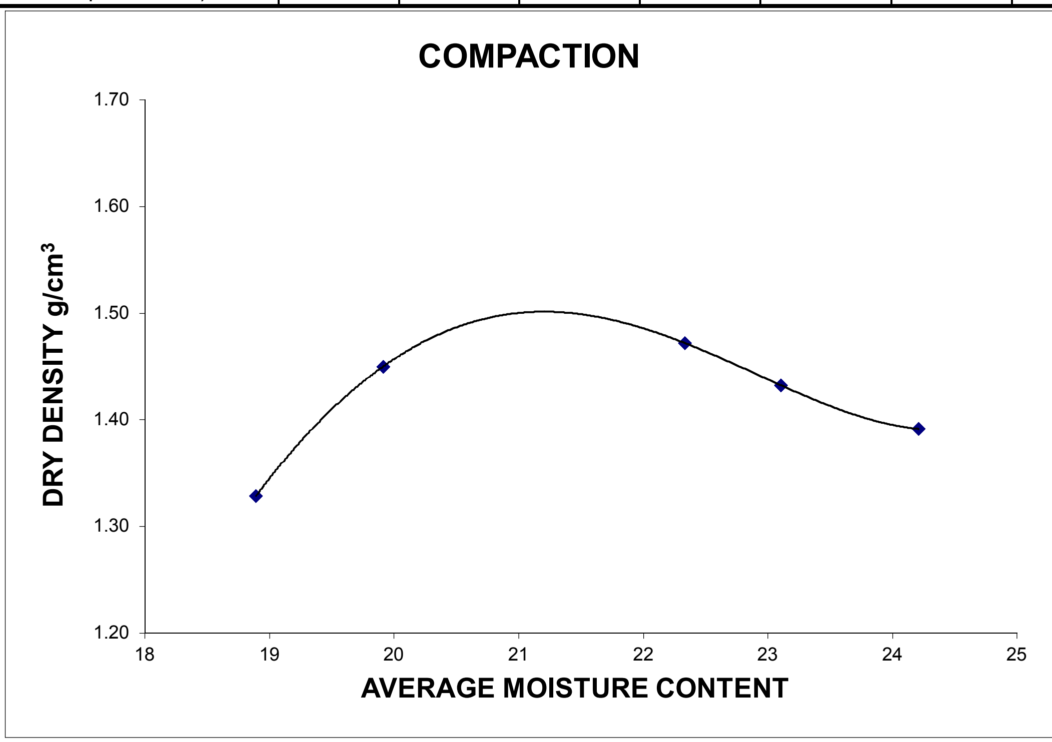
Job… **OKOMU** Sample No:**....STORAGE TANK, BH6...** Operator…………

Site…**....** Dept**7.0m……** Date:**…25/05/2018…** MDD:**1.50g/cm³**

Amount retained on 20mm B.S. Sieve……… Total weight of Sample…… OPT.MC**:21.2%**

B.S. / C.B.R. Mould……**4722g…**………….................................

Wt. of mould & wet Soil (W2) g	6295.00		6453.00		6515.00		6478.00		6443.00					
Wt. of mould (W1) g	4722.00		4722.00		4722.00		4722.00		4722.00					
Wt. of wet soil (W2-W1) g	1573.00		1731.00		1793.00		1756.00		1721.00					
Bulk Density (Pb) (W2-W1)/x g/cm³	1.58		1.74		1.80		1.76		1.73					
MOISTURE CONTENT DETERMINATIONS for B.S. Mould, X = 1000cm³														
Container No.	RO	JA	BA	FZ	UO	NO	SL	JI	FU	7Z				
Wt. of wet soil & container (g)	45.70	46.45	47.81	49.48	50.79	46.26	44.38	54.92	49.92	47.70				
Wt. of Dry soil & container (g)	41.07	41.93	42.43	44.20	44.60	40.53	38.97	47.39	43.68	41.99				
Wt. of Container (g)	16.45	18.11	15.73	17.36	17.41	14.37	14.16	16.53	17.89	18.42				
Wt. of dry soil (Wd) g	24.62	23.82	26.70	26.84	27.19	26.16	24.81	30.86	25.79	23.57				
Wt. of Moisture (Wm) g	4.63	4.52	5.38	5.28	6.19	5.73	5.41	7.53	6.24	5.71				
Moistur Content 100(Wm/Wd) %	18.81	18.98	20.15	19.67	22.77	21.90	21.81	24.40	24.20	24.23				
Average Moisture Content (m) %	18.89		19.91		22.33		23.10		24.21					
Dry Density = Pb/1+ (m/100) (g/cm³)	1.33		1.45		1.47		1.43		1.39					
C.B.R. (mseen of top & bottom) %														



DETERMINATION OF THE MOISTURE/DENSITY RELATION OF SOIL
USING STANDARD/HEAVY COMPACTION

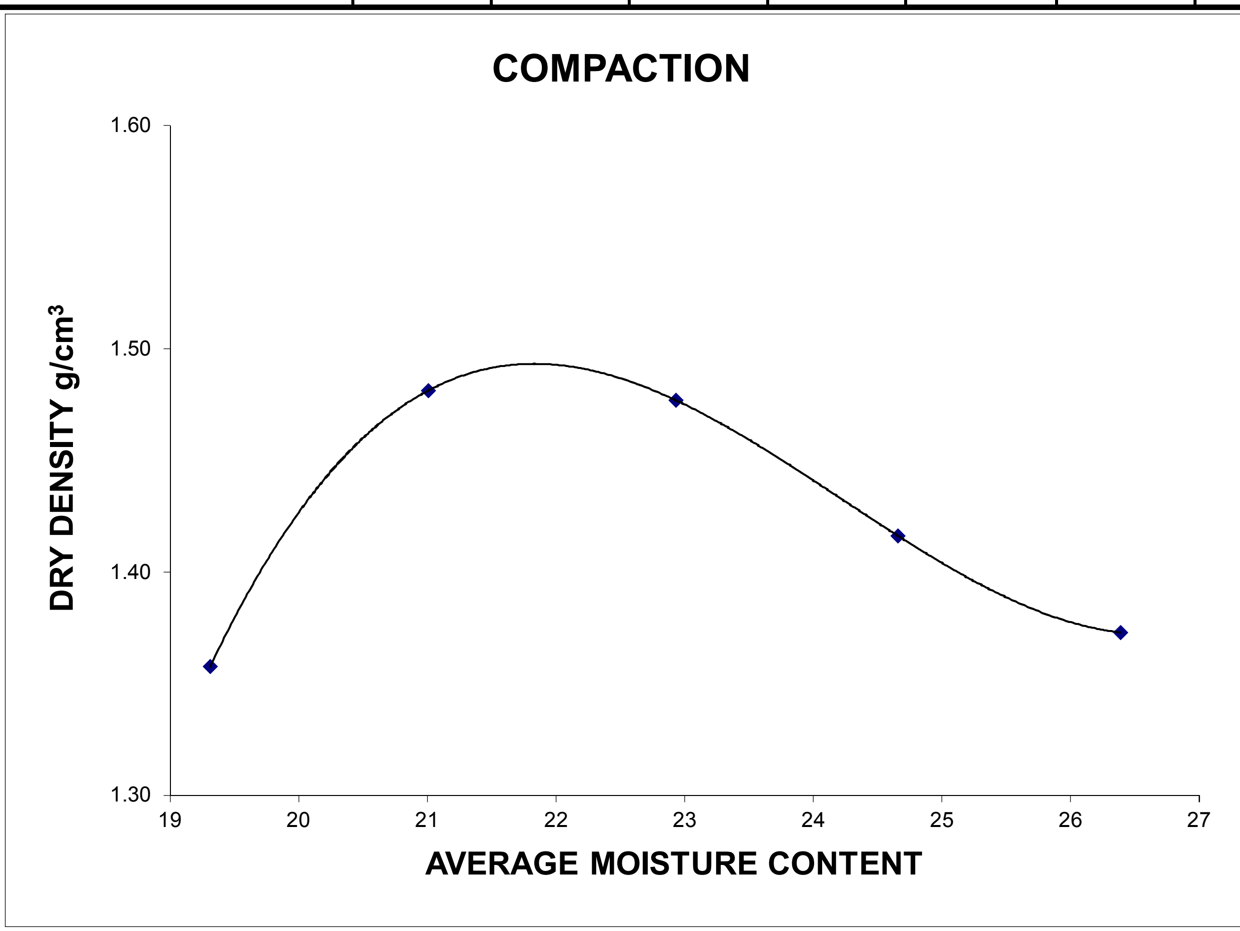
Job... **OKOMU** Sample No:**....STORAGE TANK, BH6...** Operator……

Site…**....** Dept....**13.0m……** Date:**…25/05/2018…** MDD:**1.49g/cm³**

Amount retained on 20mm B.S. Sieve……… Total weight of Sample…… OPT.MC:**21.9%**

B.S. / C.B.R. Mould……**4722g…**………….............................

Wt. of mould & wet Soil (W2) g	6335.00		6507.00		6530.00		6480.00		6450.00					
Wt. of mould (W1) g	4722.00		4722.00		4722.00		4722.00		4722.00					
Wt. of wet soil (W2-W1) g	1613.00		1785.00		1808.00		1758.00		1728.00					
Bulk Density (Pb) (W2-W1)/x g/cm ^{3}	1.62		1.79		1.82		1.77		1.74					
MOISTURE CONTENT DETERMINATIONS for B.S. Mould, X = 1000cm ^{3}														
Container No.	LO	F3	BA	4O	Z	S4	EX	JA	OB	SI				
Wt. of wet soil & container (g)	51.97	53.70	49.02	55.12	51.44	58.28	58.14	57.48	53.66	50.83				
Wt. of Dry soil & container (g)	46.05	48.02	43.64	48.56	44.65	50.12	50.27	49.20	46.20	44.05				
Wt. of Container (g)	15.97	18.03	17.93	17.45	15.24	14.30	18.47	15.50	18.33	17.98				
Wt. of dry soil (Wd) g	30.08	29.99	25.71	31.11	29.41	35.82	31.80	33.70	27.87	26.07				
Wt. of Moisture (Wm) g	5.92	5.68	5.38	6.56	6.79	8.16	7.87	8.28	7.46	6.78				
Moistur Content 100(Wm/Wd) %	19.68	18.94	20.93	21.09	23.09	22.78	24.75	24.57	26.77	26.01				
Average Moisture Content (m) %	19.31		21.01		22.93		24.66		26.39					
Dry Density = Pb/1+ (m/100) (g/cm ^{3})	1.36		1.48		1.48		1.42		1.37					
C.B.R. (mseen of top & bottom) %														



DETERMINATION OF THE MOISTURE/DENSITY RELATION OF SOIL
USING STANDARD/HEAVY COMPACTION

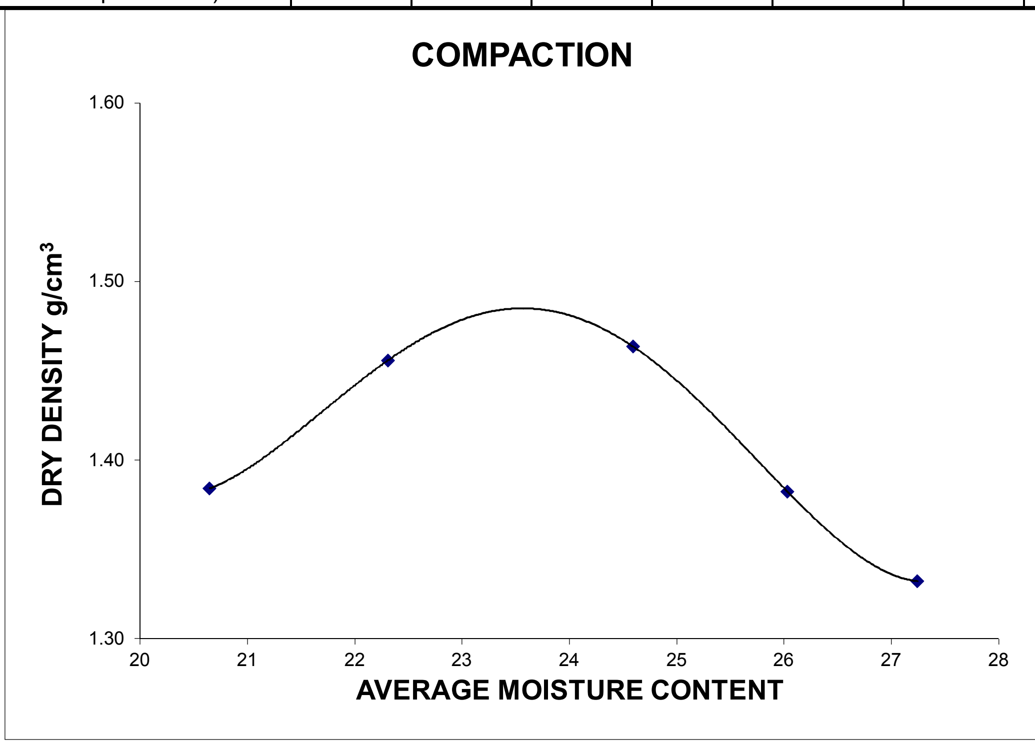
Job... **OKOMU** Sample No:**....STORAGE TANK, BH6...** Operator……

Site….... Dept....**15.0m……** Date:**…25/05/2018…** MDD:**1.49g/cm³**

Amount retained on 20mm B.S. Sieve……… Total weight of Sample…… OPT.MC:**23.5%**

B.S. / C.B.R. Mould……**4722g…**………….................................

Wt. of mould & wet Soil (W2) g	6385.00		6495.00		6538.00		6457.00		6410.00					
Wt. of mould (W1) g	4722.00		4722.00		4722.00		4722.00		4722.00					
Wt. of wet soil (W2-W1) g	1663.00		1773.00		1816.00		1735.00		1688.00					
Bulk Density (Pb) (W2-W1)/x g/cm³	1.67		1.78		1.82		1.74		1.70					
MOISTURE CONTENT DETERMINATIONS for B.S. Mould, X = 1000cm³														
Container No.	BF	BA	OG	JO	DO	LO	VI	MO	OT	T				
Wt. of wet soil & container (g)	53.90	49.40	51.10	52.93	46.77	42.75	58.62	54.91	52.58	60.06				
Wt. of Dry soil & container (g)	47.84	44.04	45.03	46.50	41.06	37.91	50.27	47.16	44.86	51.40				
Wt. of Container (g)	18.80	17.80	18.02	17.46	17.78	18.28	18.18	17.40	16.90	19.18				
Wt. of dry soil (Wd) g	29.04	26.24	27.01	29.04	23.28	19.63	32.09	29.76	27.96	32.22				
Wt. of Moisture (Wm) g	6.06	5.36	6.07	6.43	5.71	4.84	8.35	7.75	7.72	8.66				
Moistur Content 100(Wm/Wd) %	20.87	20.43	22.47	22.14	24.53	24.66	26.02	26.04	27.61	26.88				
Average Moisture Content (m) %	20.65		22.31		24.59		26.03		27.24					
Dry Density = Pb/1+ (m/100) (g/cm³)	1.38		1.46		1.46		1.38		1.33					
C.B.R. (mseen of top & bottom) %														



DETERMINATION OF THE MOISTURE/DENSITY RELATION OF SOIL
USING STANDARD/HEAVY COMPACTION

Job... **OKOMU** Sample No:**....WATER TANK, BH8..** Operator…………

Site…..... Dept...**9.0m……** Date:**…25/05/2018…** MDD:**1.49g/cm³**

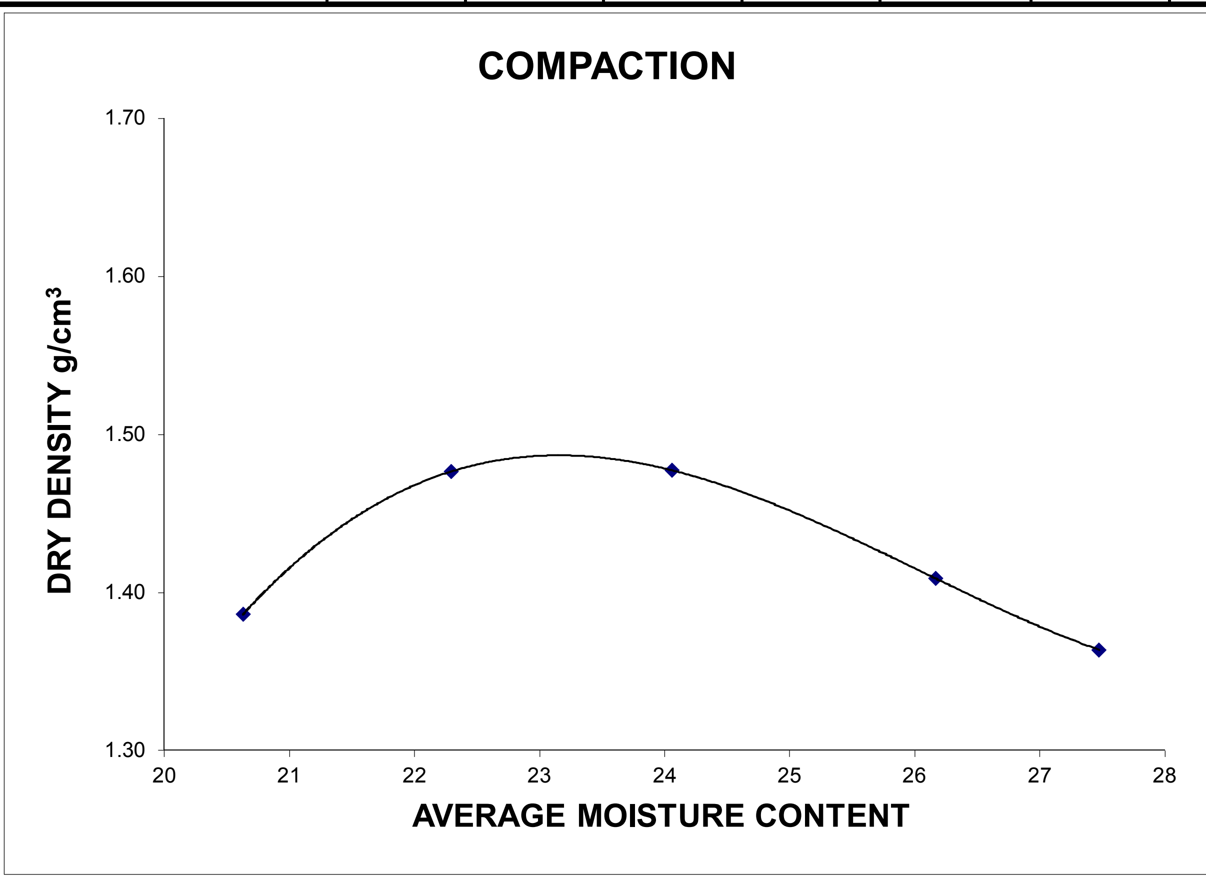
Amount retained on 20mm B.S. Sieve……… Total weight of Sample…… OPT.MC:**23.2%**

B.S. / C.B.R. Mould……**4720g…**………….............................

Wt. of mould & wet Soil (W2) g	6385.00	6518.00	6545.00	6490.00	6451.00		
Wt. of mould (W1) g	4720.00	4720.00	4720.00	4720.00	4720.00		
Wt. of wet soil (W2-W1) g	1665.00	1798.00	1825.00	1770.00	1731.00		
Bulk Density (Pb) (W2-W1)/x g/cm ^{3}	1.67	1.81	1.83	1.78	1.74		

MOISTURE CONTENT DETERMINATIONS for B.S. Mould, X = 1000cm ^{3}

Container No.	6T	OO	MQ	TF	WI	H4	OK	D	X	AI				
Wt. of wet soil & container (g)	52.10	55.30	46.20	48.70	49.90	55.70	54.30	49.40	53.90	40.10				
Wt. of Dry soil & container (g)	45.93	48.92	40.76	42.40	43.06	48.70	46.47	42.80	46.09	33.14				
Wt. of Container (g)	16.20	17.80	16.30	14.20	16.50	17.40	16.40	17.70	18.00	7.50				
Wt. of dry soil (Wd) g	29.73	31.12	24.46	28.20	26.56	31.30	30.07	25.10	28.09	25.64				
Wt. of Moisture (Wm) g	6.17	6.38	5.44	6.30	6.84	7.00	7.83	6.60	7.81	6.96				
Moistur Content 100(Wm/Wd) %	20.75	20.50	22.24	22.34	25.75	22.36	26.04	26.29	27.80	27.15				
Average Moisture Content (m) %	20.63		22.29		24.06		26.17		27.47					
Dry Density = Pb/1+ (m/100) (g/cm ^{3})	1.39		1.48		1.48		1.41		1.36					
C.B.R. (mseen of top & bottom) %														



DETERMINATION OF THE MOISTURE/DENSITY RELATION OF SOIL
USING STANDARD/HEAVY COMPACTION

Job... **OKOMU** Sample No:**....WATER TANK, BH8..** Operator............

Site…..... Dept**...15.0m......** Date**:...25/05/2018...** MDD:**1.58g/cm^3**

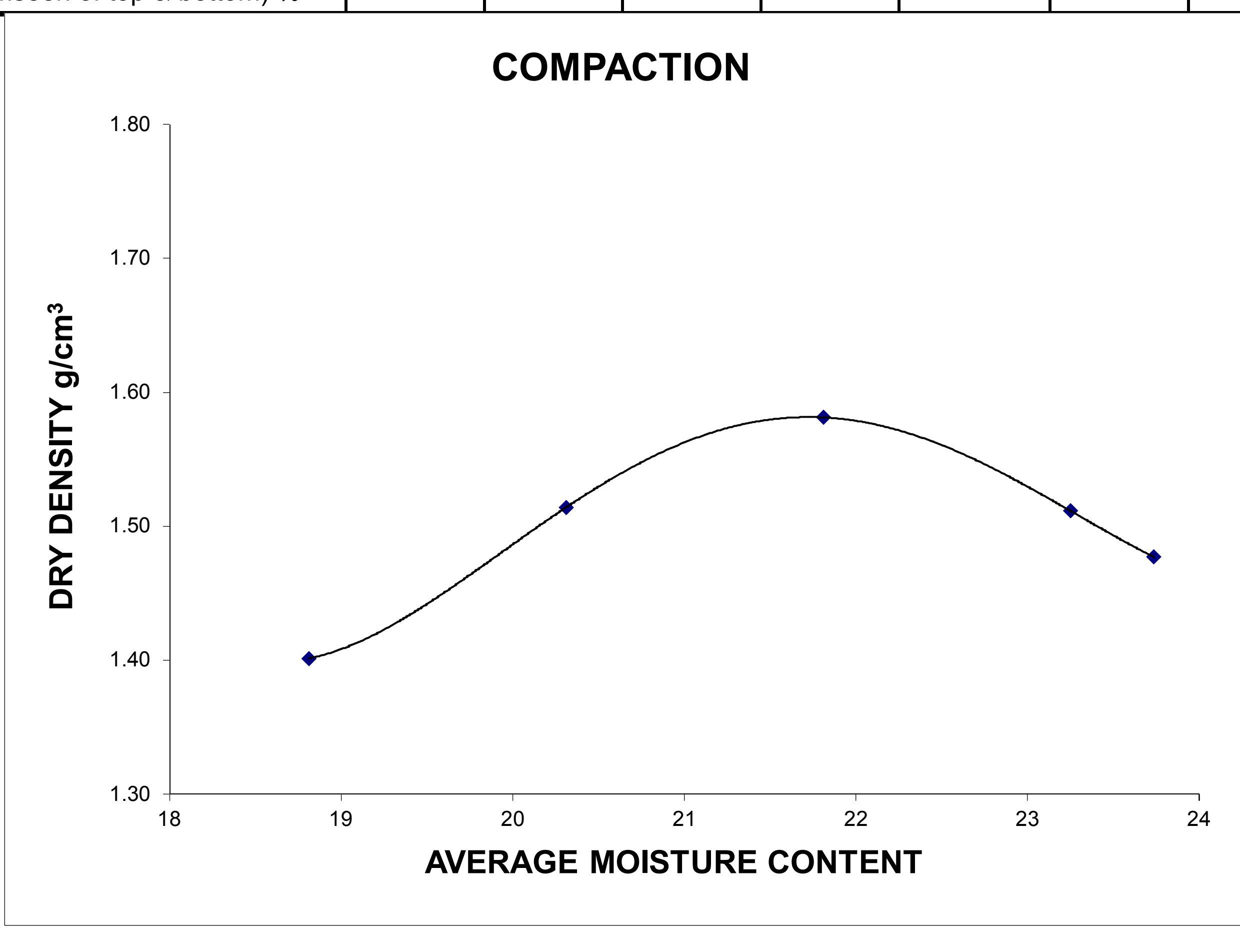
Amount retained on 20mm B.S. Sieve……… Total weight of Sample…… OPT.MC**:21.8%**

B.S. / C.B.R. Mould……**4720g…**………….............................

Wt. of mould & wet Soil (W2) g	6378.00	6534.00	6638.00	6575.00	6540.00		
Wt. of mould (W1) g	4720.00	4720.00	4720.00	4720.00	4720.00		
Wt. of wet soil (W2-W1) g	1658.00	1814.00	1918.00	1855.00	1820.00		
Bulk Density (Pb) (W2-W1)/x g/cm^3	1.67	1.82	1.93	1.86	1.83		

MOISTURE CONTENT DETERMINATIONS for B.S. Mould, X = 1000cm^3

Container No.	AH	AI	EX	BA	FA	I9	AA	IK	BO	NA				
Wt. of wet soil & container (g)	50.72	42.51	47.72	50.34	46.97	54.00	53.36	57.92	49.51	46.63				
Wt. of Dry soil & container (g)	45.54	37.90	42.39	44.62	41.80	47.77	46.87	50.63	42.99	40.81				
Wt. of Container (g)	17.31	13.98	15.89	16.73	17.87	19.47	19.30	18.88	16.04	15.81				
Wt. of dry soil (Wd) g	28.23	23.92	26.50	27.89	23.93	28.30	27.57	31.75	26.95	25.00				
Wt. of Moisture (Wm) g	5.18	4.61	5.33	5.72	5.17	6.23	6.49	7.29	6.52	5.82				
Moistur Content 100(Wm/Wd) %	18.35	19.27	20.11	20.51	21.60	22.01	23.54	22.96	24.19	23.28				
Average Moisture Content (m) %	18.81		20.31		21.81		23.25		23.74					
Dry Density = Pb/1+ (m/100) (g/cm^3)	1.40		1.51		1.58		1.51		1.48					
C.B.R. (mseen of top & bottom) %														



DETERMINATION OF THE MOISTURE/DENSITY RELATION OF SOIL
USING STANDARD/HEAVY COMPACTION

Job... **OKOMU** Sample No:**....WATER TANK, BH8...** Operator…………

Site…..... Dept**...3.0m……** Date:**…25/05/2018…** MDD:**1.48g/cm^3**

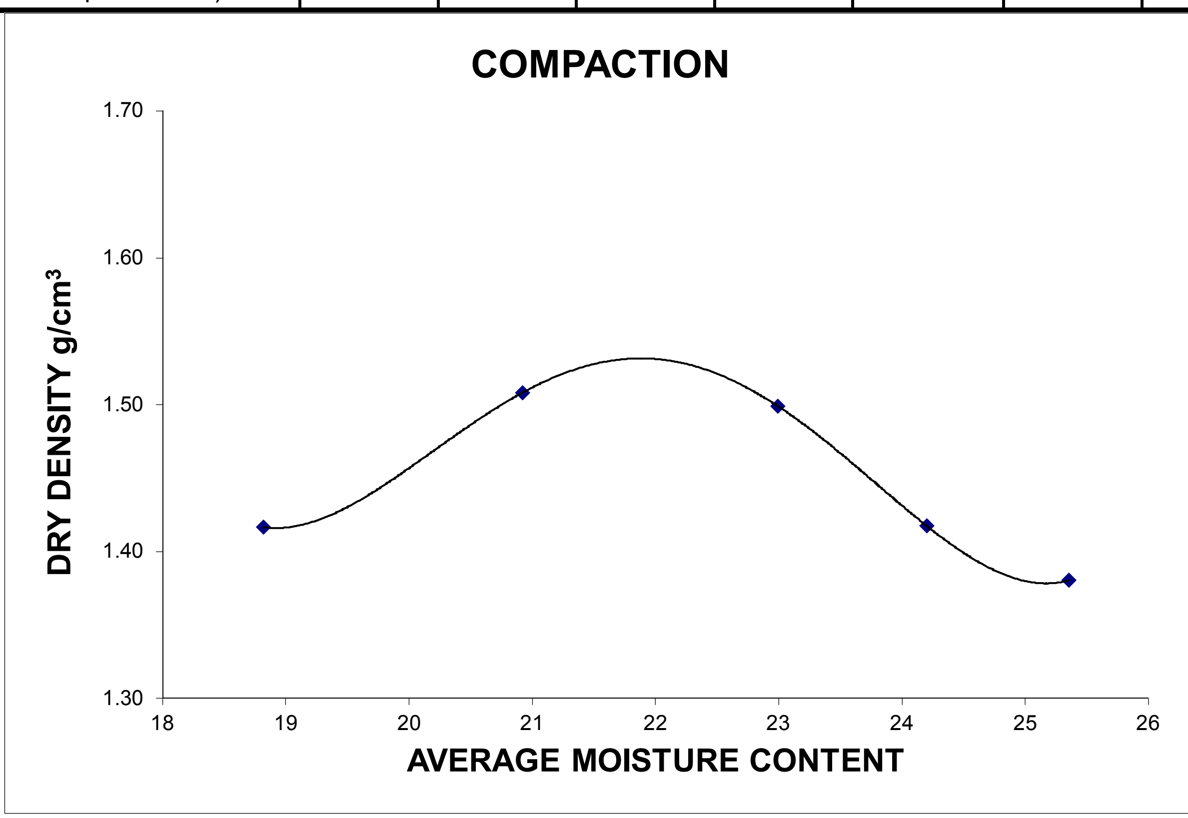
Amount retained on 20mm B.S. Sieve……… Total weight of Sample…… OPT.MC:**26.4%**

B.S. / C.B.R. Mould……**4722g…**………….............................

Wt. of mould & wet Soil (W2) g	6398.00	6538.00	6558.00	6475.00	6445.00		
Wt. of mould (W1) g	4722.00	4722.00	4722.00	4722.00	4722.00		
Wt. of wet soil (W2-W1) g	1676.00	1816.00	1836.00	1753.00	1723.00		
Bulk Density (Pb) (W2-W1)/x g/cm^3	1.68	1.82	1.84	1.76	1.73		

MOISTURE CONTENT DETERMINATIONS for B.S. Mould, X = 1000cm^3

Container No.	AZ	OR	ZO	CA	PO	SU	E3	O5	AB	JO				
Wt. of wet soil & container (g)	47.70	45.80	43.60	49.90	56.00	48.60	57.40	54.40	46.66	46.18				
Wt. of Dry soil & container (g)	42.48	41.23	38.86	44.42	48.82	42.87	50.21	46.37	40.89	40.36				
Wt. of Container (g)	15.11	16.61	16.12	18.32	17.51	18.01	20.03	13.70	18.41	17.12				
Wt. of dry soil (Wd) g	27.37	24.62	22.74	26.10	31.31	24.86	30.18	32.67	22.48	23.24				
Wt. of Moisture (Wm) g	5.22	4.57	4.74	5.48	7.18	5.73	7.19	8.03	5.77	5.82				
Moistur Content 100(Wm/Wd) %	19.07	18.56	20.84	21.00	22.93	23.05	23.82	24.58	25.67	25.04				
Average Moisture Content (m) %	18.82		20.92		22.99		24.20		25.36					
Dry Density = Pb/1+ (m/100) (g/cm^3)	1.42		1.51		1.50		1.42		1.38					
C.B.R. (mseen of top & bottom) %														



DETERMINATION OF THE MOISTURE/DENSITY RELATION OF SOIL
USING STANDARD/HEAVY COMPACTION

Job... **OKOMU** Sample No:**....WATER TANK, BH8...** Operator...........

Site…... Dept…**6.0m**…… Date:**…25/05/2018…** MDD:**1.48g/cm^3**

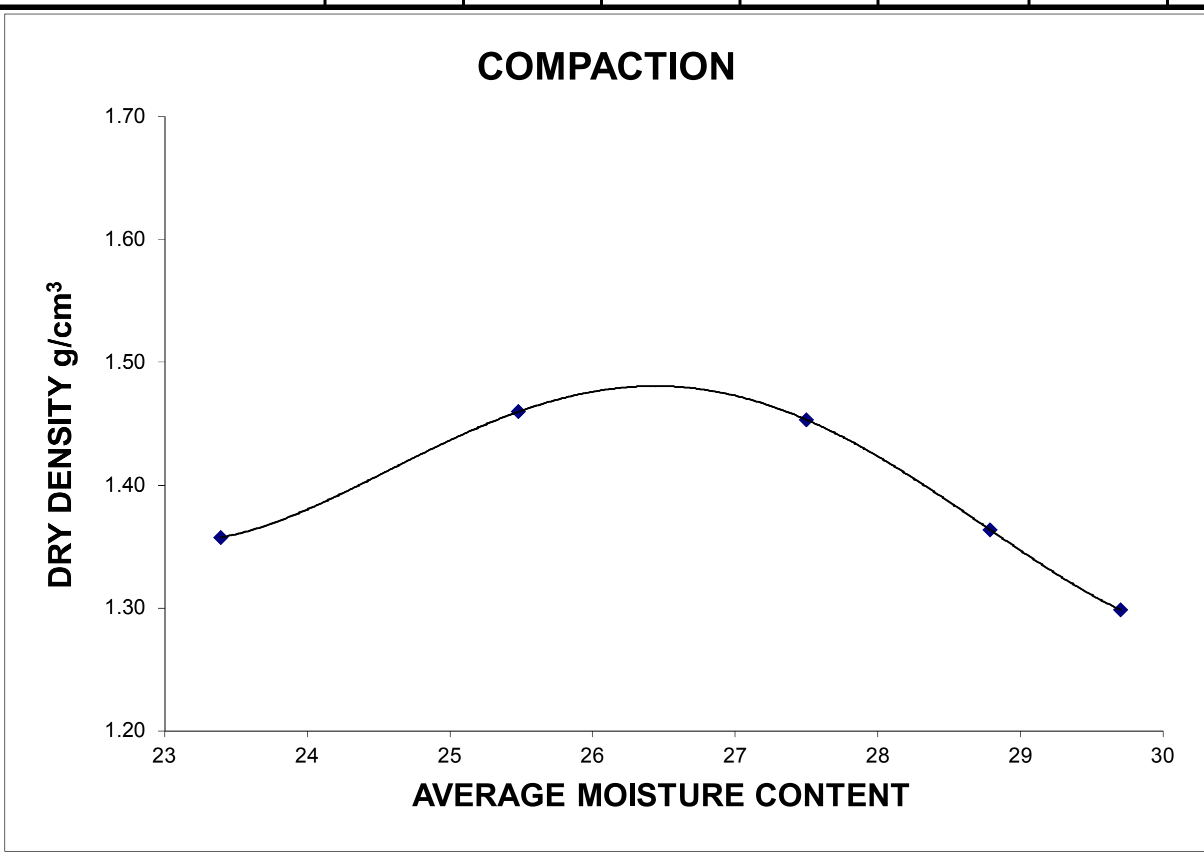
Amount retained on 20mm B.S. Sieve……… Total weight of Sample…… OPT.MC:**26.4%**

B.S. / C.B.R. Mould……**3252g**…………..............................

Wt. of mould & wet Soil (W2) g	4920.00	5076.00	5097.00	5001.00	4929.00		
Wt. of mould (W1) g	3252.00	3252.00	3252.00	3252.00	3252.00		
Wt. of wet soil (W2-W1) g	1668.00	1824.00	1845.00	1749.00	1677.00		
Bulk Density (Pb) (W2-W1)/x g/cm^3	1.68	1.83	1.85	1.76	1.68		

MOISTURE CONTENT DETERMINATIONS for B.S. Mould, X = 1000cm^3

Container No.	ZO	JA	E3	EI	PZ	OO	JA	OX	OG	SU				
Wt. of wet soil & container (g)	52.10	57.30	55.20	52.70	54.20	48.30	47.60	52.30	53.10	49.00				
Wt. of Dry soil & container (g)	45.45	49.80	47.45	45.60	46.40	41.60	40.55	44.80	45.10	41.70				
Wt. of Container (g)	17.40	17.30	17.60	17.20	17.60	17.60	16.10	18.70	18.30	17.00				
Wt. of dry soil (Wd) g	28.05	32.50	29.85	28.40	28.80	24.00	24.45	26.10	26.80	24.70				
Wt. of Moisture (Wm) g	6.65	7.50	7.75	7.10	7.80	6.70	7.05	7.50	8.00	7.30				
Moistur Content 100(Wm/Wd) %	23.71	23.08	25.96	25.00	27.08	27.92	28.83	28.74	29.85	29.55				
Average Moisture Content (m) %	23.39		25.48		27.50		28.78		29.70					
Dry Density = Pb/1+ (m/100) (g/cm^3)	1.36		1.46		1.45		1.36		1.30					
C.B.R. (mseen of top & bottom) %														



DETERMINATION OF THE MOISTURE/DENSITY RELATION OF SOIL
USING STANDARD/HEAVY COMPACTION

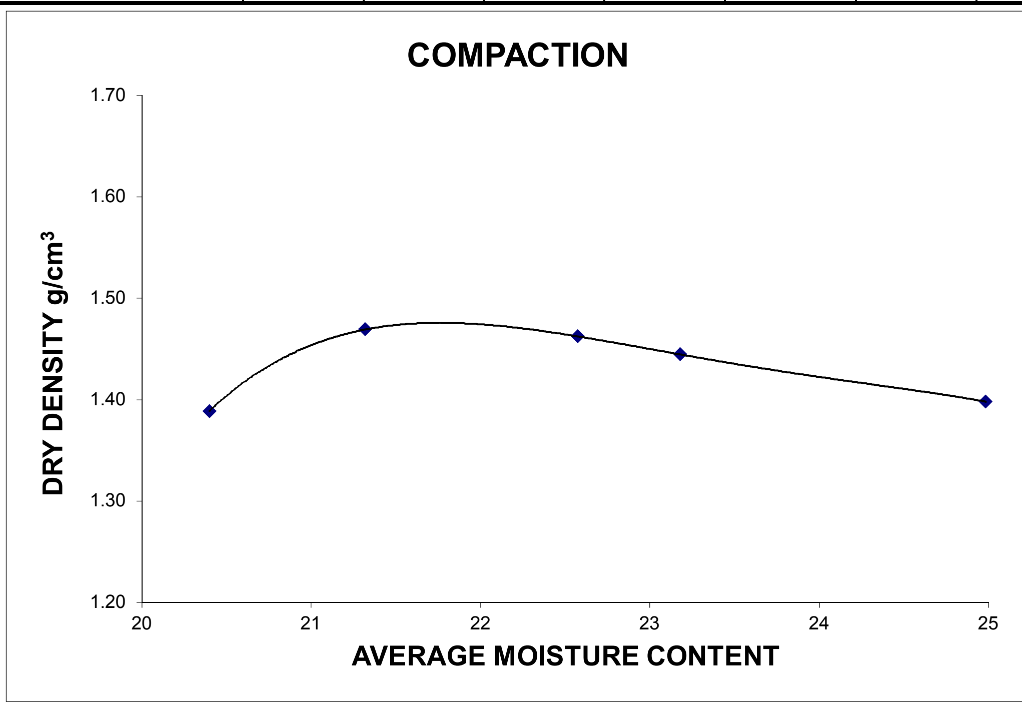
Job... **OKOMU** Sample No:**....WATER TANK, BH8...** Operator...........

Site…..... Dept**...12.0m......** Date:**...25/05/2018...** MDD:**1.48g/cm³**

Amount retained on 20mm B.S. Sieve......... Total weight of Sample...... OPT.MC**:21.7%**

B.S. / C.B.R. Mould......**4720g...**...

Wt. of mould & wet Soil (W2) g	6385.00		6495.00		6505.00		6492.00		6460.00					
Wt. of mould (W1) g	4720.00		4720.00		4720.00		4720.00		4720.00					
Wt. of wet soil (W2-W1) g	1665.00		1775.00		1785.00		1772.00		1740.00					
Bulk Density (Pb) (W2-W1)/x g/cm^3	1.67		1.78		1.79		1.78		1.75					
MOISTURE CONTENT DETERMINATIONS for B.S. Mould, X = 1000cm^3														
Container No.	TI	SO	7O	M	JA	ZE	OO	SK	TK	I4				
Wt. of wet soil & container (g)	45.66	49.42	43.66	54.58	42.82	53.39	45.87	56.74	43.74	55.08				
Wt. of Dry soil & container (g)	40.83	43.84	39.29	48.24	37.54	47.13	40.36	49.50	37.96	48.01				
Wt. of Container (g)	17.85	15.63	18.97	18.24	14.37	19.13	16.70	18.12	15.19	19.25				
Wt. of dry soil (Wd) g	22.98	28.21	20.32	30.00	23.17	28.00	23.66	31.38	22.77	28.76				
Wt. of Moisture (Wm) g	4.83	5.58	4.37	6.34	5.28	6.26	5.51	7.24	5.78	7.07				
Moistur Content 100(Wm/Wd) %	21.02	19.78	21.51	21.13	22.79	22.36	23.29	23.07	25.38	24.58				
Average Moisture Content (m) %	20.40		21.32		22.57		23.18		24.98					
Dry Density = Pb/1+ (m/100) (g/cm^3)	1.39		1.47		1.46		1.44		1.40					
C.B.R. (mseen of top & bottom) %														



DETERMINATION OF THE MOISTURE/DENSITY RELATION OF SOIL
USING STANDARD/HEAVY COMPACTION

Job... **OKOMU** Sample No:....**WEIGH BRIDGE, BH7...** Operator…………

Site…... Dept...**15.0m……** Date:...**25/05/2018…** MDD:**1.55g/cm^3**

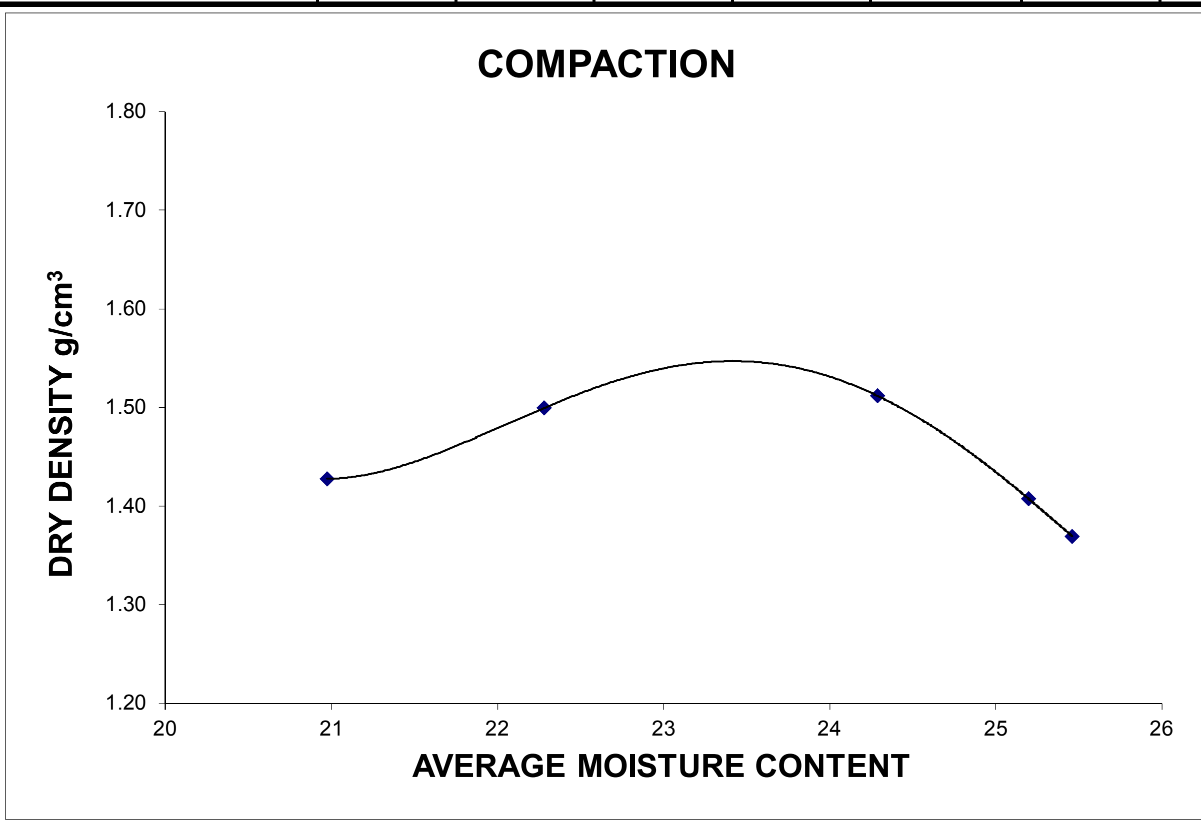
Amount retained on 20mm B.S. Sieve……… Total weight of Sample…… OPT.MC:**23.4%**

B.S. / C.B.R. Mould……**3248g…**…………..............................

Wt. of mould & wet Soil (W2) g	4968.00	5074.00	5119.00	5003.00	4959.00		
Wt. of mould (W1) g	3248.00	3248.00	3248.00	3248.00	3248.00		
Wt. of wet soil (W2-W1) g	1720.00	1826.00	1871.00	1755.00	1711.00		
Bulk Density (Pb) (W2-W1)/x g/cm^3	1.73	1.83	1.88	1.76	1.72		

MOISTURE CONTENT DETERMINATIONS for B.S. Mould, X = 1000cm^3

Container No.	PE	JO	SI	BO	LO	BA	OG	EB	CU	HO				
Wt. of wet soil & container (g)	53.56	51.38	49.64	51.08	53.04	50.90	52.92	54.61	45.95	48.62				
Wt. of Dry soil & container (g)	47.32	45.37	43.82	45.15	45.88	44.37	46.09	46.94	39.88	42.60				
Wt. of Container (g)	17.32	16.95	17.99	18.23	15.98	17.86	18.19	17.34	17.36	17.48				
Wt. of dry soil (Wd) g	30.00	28.42	25.83	26.92	29.90	26.51	27.90	29.60	22.52	25.12				
Wt. of Moisture (Wm) g	6.24	6.01	5.82	5.93	7.16	6.53	6.83	7.67	6.07	6.02				
Moistur Content 100(Wm/Wd) %	20.80	21.15	22.53	22.03	23.95	24.63	24.48	25.91	26.95	23.96				
Average Moisture Content (m) %	20.97		22.28		24.29		25.20		25.46					
Dry Density = Pb/1+ (m/100) (g/cm^3)	1.43		1.50		1.51		1.41		1.37					
C.B.R. (mseen of top & bottom) %														



DETERMINATION OF THE MOISTURE/DENSITY RELATION OF SOIL
USING STANDARD/HEAVY COMPACTION

Job... **OKOMU** Sample No:**....WEIGH BRIDGE, BH7...** Operator…………

Site…**....** Dept**...4.0m……** Date:**…25/05/2018…** MDD:**1.52g/cm^3**

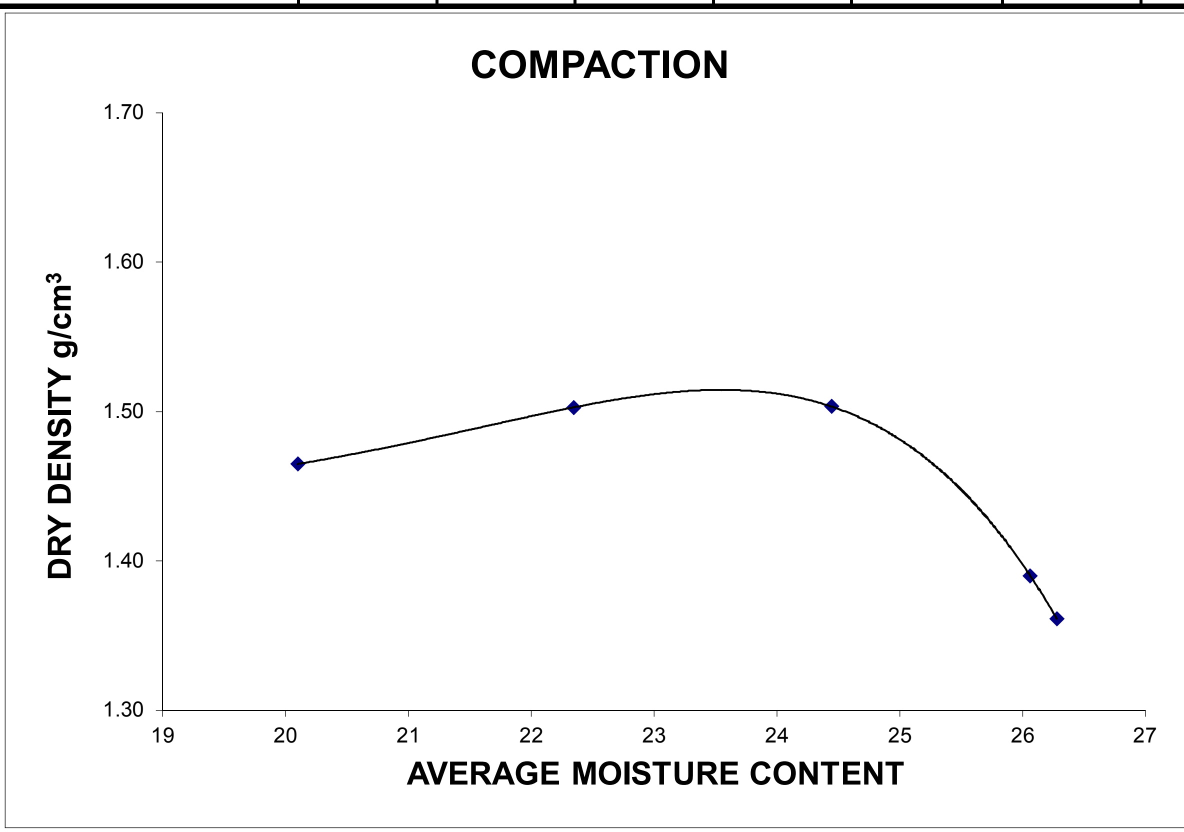
Amount retained on 20mm B.S. Sieve……… Total weight of Sample…… OPT.MC**:23.5%**

B.S. / C.B.R. Mould……**3252g…**………….............................

Wt. of mould & wet Soil (W2) g	5004.00	5083.00	5115.00	4997.00	4964.00		
Wt. of mould (W1) g	3252.00	3252.00	3252.00	3252.00	3252.00		
Wt. of wet soil (W2-W1) g	1752.00	1831.00	1863.00	1745.00	1712.00		
Bulk Density (Pb) (W2-W1)/x g/cm^3	1.76	1.84	1.87	1.75	1.72		

MOISTURE CONTENT DETERMINATIONS for B.S. Mould, X = 1000cm^3

Container No.	EI	Z8	PB	SG	WO	IO	OX	4M	3A	OF				
Wt. of wet soil & container (g)	51.87	53.72	50.36	53.84	48.30	49.83	48.87	48.85	51.68	46.89				
Wt. of Dry soil & container (g)	46.18	48.01	44.20	47.58	42.16	43.51	42.30	41.96	44.51	40.78				
Wt. of Container (g)	17.82	19.65	16.71	19.49	17.03	17.67	17.17	15.44	17.21	17.54				
Wt. of dry soil (Wd) g	28.36	28.36	27.49	28.09	25.13	25.84	25.13	26.52	27.30	23.24				
Wt. of Moisture (Wm) g	5.69	5.71	6.16	6.26	6.14	6.32	6.57	6.89	7.17	6.11				
Moistur Content 100(Wm/Wd) %	20.06	20.13	22.41	22.29	24.43	24.46	26.14	25.98	26.26	26.29				
Average Moisture Content (m) %	20.10		22.35		24.45		26.06		26.28					
Dry Density = Pb/1+ (m/100) (g/cm^3)	1.46		1.50		1.50		1.39		1.36					
C.B.R. (mseen of top & bottom) %														



DETERMINATION OF THE MOISTURE/DENSITY RELATION OF SOIL
USING STANDARD/HEAVY COMPACTION

Job... **OKOMU** Sample No:....**WEIGH BRIDGE, BH9..** Operator...........

Site…..... Dept...**10.0m......** Date:...**25/05/2018...** MDD:**1.46g/cm^3**

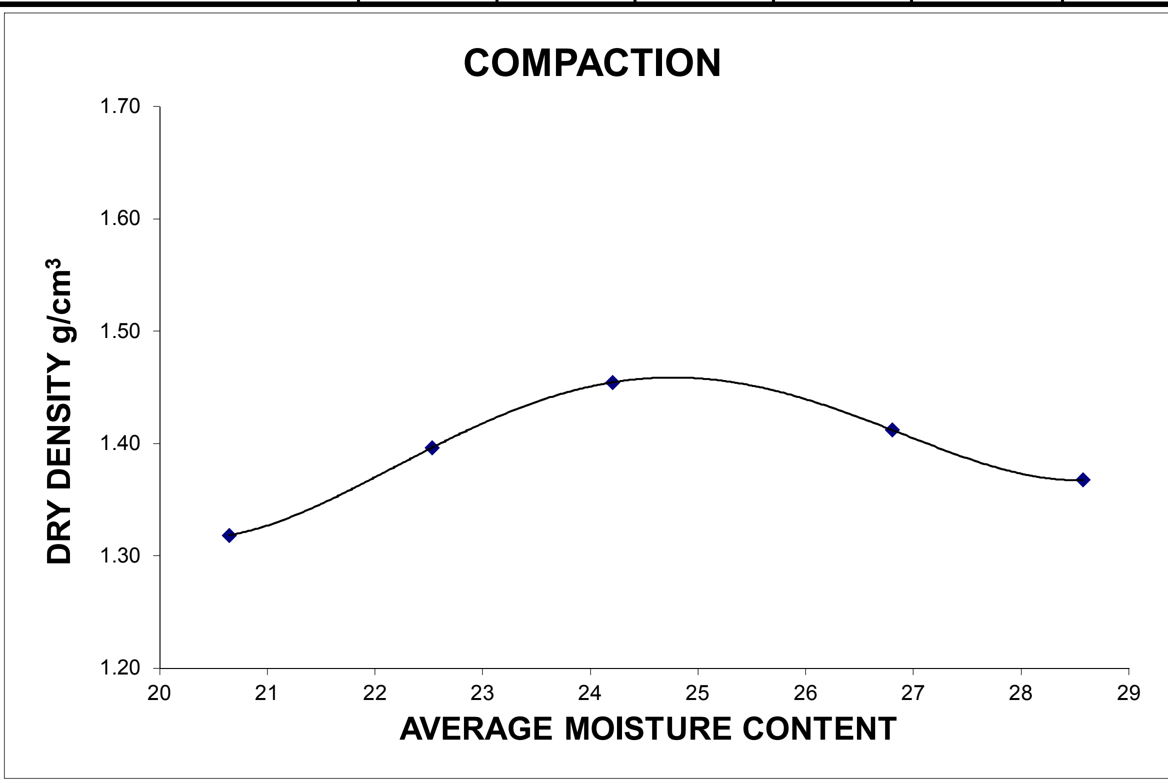
Amount retained on 20mm B.S. Sieve......... Total weight of Sample...... OPT.MC:**24.7%**

B.S. / C.B.R. Mould......**4722g...**..

Wt. of mould & wet Soil (W2) g	6306.00	6426.00	6521.00	6505.00	6473.00		
Wt. of mould (W1) g	4722.00	4722.00	4722.00	4722.00	4722.00		
Wt. of wet soil (W2-W1) g	1584.00	1704.00	1799.00	1783.00	1751.00		
Bulk Density (Pb) (W2-W1)/x g/cm^3	1.59	1.71	1.81	1.79	1.76		

MOISTURE CONTENT DETERMINATIONS for B.S. Mould, X = 1000cm^3

Container No.	4TH	OQ	LH	LA	GB	AZ	F4	SU	SO	TA				
Wt. of wet soil & container (g)	49.93	35.97	57.74	63.75	52.58	52.88	51.03	43.88	50.47	62.58				
Wt. of Dry soil & container (g)	44.65	32.44	50.38	55.30	45.45	45.90	43.51	37.73	42.77	52.49				
Wt. of Container (g)	19.33	15.17	18.18	17.25	15.85	17.20	15.46	14.78	15.69	17.35				
Wt. of dry soil (Wd) g	25.32	17.27	32.20	38.05	29.60	28.70	28.05	22.95	27.08	35.14				
Wt. of Moisture (Wm) g	5.28	3.53	7.36	8.45	7.13	6.98	7.52	6.15	7.70	10.09				
Moistur Content 100(Wm/Wd) %	20.85	20.44	22.86	22.21	24.09	24.32	26.81	26.80	28.43	28.71				
Average Moisture Content (m) %	20.65		22.53		24.20		26.80		28.57					
Dry Density = Pb/1+ (m/100) (g/cm^3)	1.32		1.40		1.45		1.41		1.37					
C.B.R. (mseen of top & bottom) %														



DETERMINATION OF THE MOISTURE/DENSITY RELATION OF SOIL
USING STANDARD/HEAVY COMPACTION

Job... **OKOMU** Sample No:**....WEIGH BRIGDE, BH7..** Operator...........

Site…..... Dept...**1.0m**...... Date:**...25/05/2018...** MDD:**1.50g/cm³**

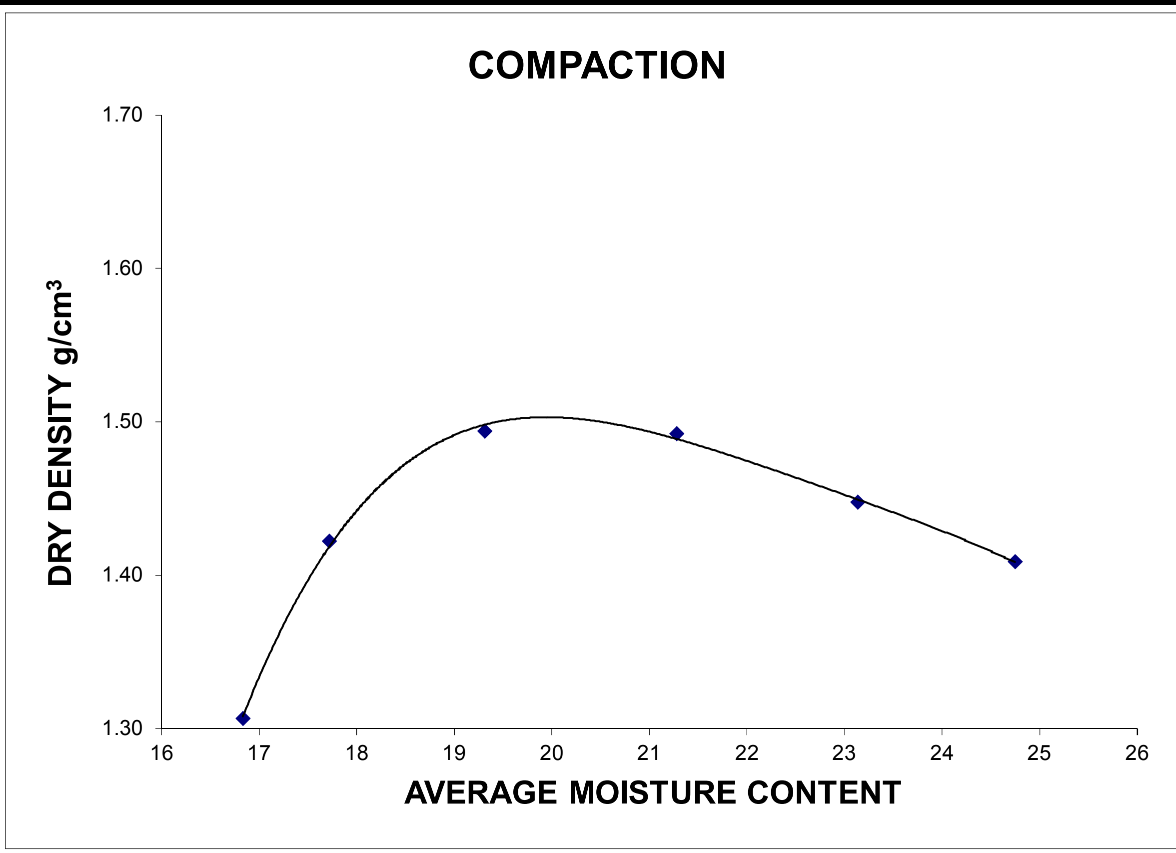
Amount retained on 20mm B.S. Sieve......... Total weight of Sample...... OPT.MC:**20.0%**

B.S. / C.B.R. Mould......**4720g...**...

Wt. of mould & wet Soil (W2) g	6240.00	6387.00	6495.00	6522.00	6495.00	6470.00	
Wt. of mould (W1) g	4720.00	4720.00	4720.00	4720.00	4720.00	4720.00	
Wt. of wet soil (W2-W1) g	1520.00	1667.00	1775.00	1802.00	1775.00	1750.00	
Bulk Density (Pb) (W2-W1)/x g/cm ^{3}	1.53	1.67	1.78	1.81	1.78	1.76	

MOISTURE CONTENT DETERMINATIONS for B.S. Mould, X = 1000cm ^{3}

Container No.	CU	AN	F5	CO	PM	OK	HO	PO	GS	SE	Z	UL		
Wt. of wet soil & container (g)	40.92	52.24	52.97	64.36	53.48	56.87	55.64	53.84	49.95	45.90	49.80	49.89		
Wt. of Dry soil & container (g)	37.53	47.59	47.87	57.30	47.81	50.16	49.12	47.09	43.97	40.21	43.53	43.54		
Wt. of Container (g)	17.42	19.92	19.08	17.46	18.25	15.64	18.41	15.44	18.01	15.72	18.17	17.90		
Wt. of dry soil (Wd) g	20.11	27.67	28.79	39.84	29.56	34.52	30.71	31.65	25.96	24.49	25.36	25.64		
Wt. of Moisture (Wm) g	3.39	4.65	5.10	7.06	5.67	6.71	6.52	6.75	5.98	5.69	6.27	6.35		
Moistur Content 100(Wm/Wd) %	16.86	16.81	17.71	17.72	19.18	19.44	21.23	21.33	23.04	23.23	24.72	24.77		
Average Moisture Content (m) %	16.83		17.72		19.31		21.28		23.13		24.74			
Dry Density = Pb/1+ (m/100) (g/cm ^{3})	1.31		1.42		1.49		1.49		1.45		1.41			
C.B.R. (mseen of top & bottom) %														



DETERMINATION OF THE MOISTURE/DENSITY RELATION OF SOIL
USING STANDARD/HEAVY COMPACTION

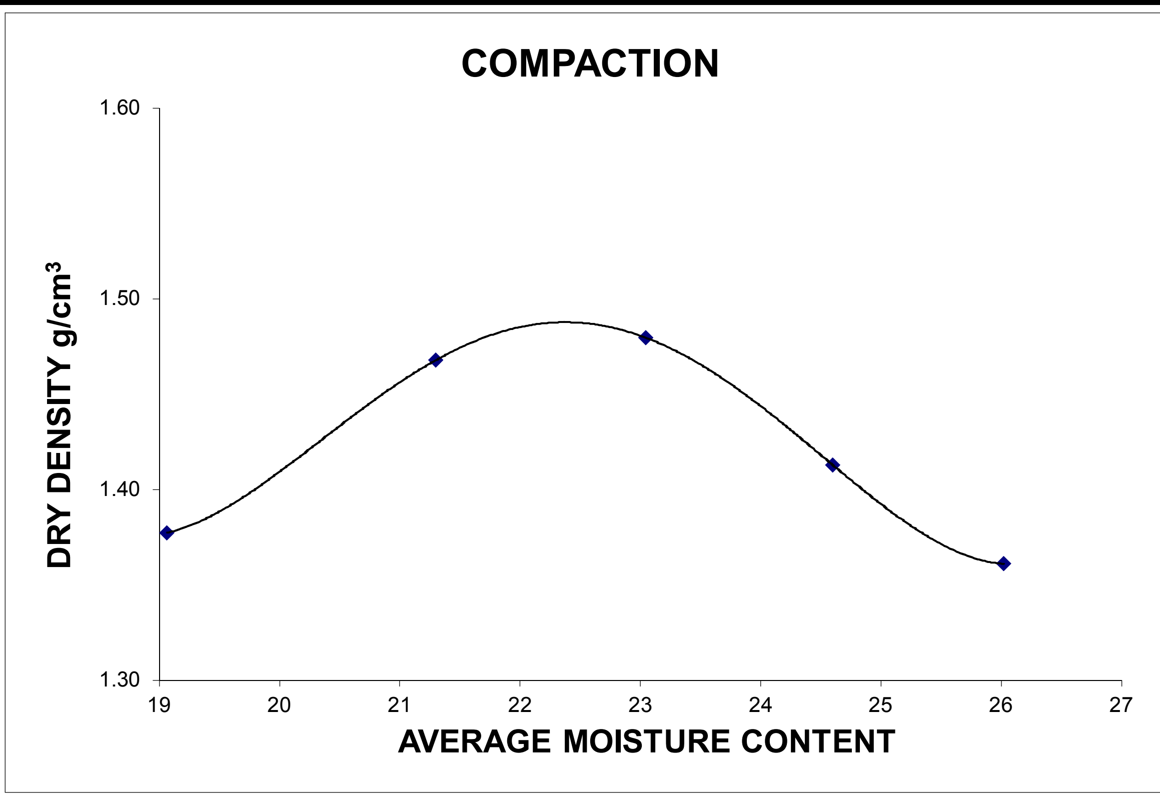
Job... **OKOMU** Sample No:**....WEIGH BRIDGE, BH7...** Operator……

Site…**....** Dept....**7.0m……** Date:**…25/05/2018…** MDD:**1.49g/cm^3**

Amount retained on 20mm B.S. Sieve……… Total weight of Sample…… OPT.MC:**22.3%**

B.S. / C.B.R. Mould……**4722g…**……………...............................

Wt. of mould & wet Soil (W2) g	6355.00		6495.00		6535.00		6475.00		6430.00					
Wt. of mould (W1) g	4722.00		4722.00		4722.00		4722.00		4722.00					
Wt. of wet soil (W2-W1) g	1633.00		1773.00		1813.00		1753.00		1708.00					
Bulk Density (Pb) (W2-W1)/x g/cm^3	1.64		1.78		1.82		1.76		1.72					
MOISTURE CONTENT DETERMINATIONS for B.S. Mould, X = 1000cm^3														
Container No.	WD	KK	8Z	N8	F6	EX	PE	AA	BA	F4				
Wt. of wet soil & container (g)	47.31	49.00	45.79	46.77	55.71	52.36	55.89	50.70	52.02	48.30				
Wt. of Dry soil & container (g)	42.34	44.00	40.86	41.58	48.56	45.92	48.00	44.16	44.94	41.99				
Wt. of Container (g)	16.21	17.83	17.61	17.32	17.82	17.71	17.22	16.41	17.73	17.74				
Wt. of dry soil (Wd) g	26.13	26.17	23.25	24.26	30.74	28.21	30.78	27.75	27.21	24.25				
Wt. of Moisture (Wm) g	4.97	5.00	4.93	5.19	7.15	6.44	7.89	6.54	7.08	6.31				
Moistur Content 100(Wm/Wd) %	19.02	19.11	21.20	21.39	23.26	22.83	25.63	23.57	26.02	26.02				
Average Moisture Content (m) %	19.06		21.30		23.04		24.60		26.02					
Dry Density = Pb/1+ (m/100) (g/cm^3)	1.38		1.47		1.48		1.41		1.36					
C.B.R. (mseen of top & bottom) %														



DETERMINATION OF THE MOISTURE/DENSITY RELATION OF SOIL
USING STANDARD/HEAVY COMPACTION

Job... **OKOMU** Sample No:....**WEIGH BRIDGE, BH7...** Operator……

Site…..... Dept....**13.0m……** Date:…**25/05/2018…** MDD:**1.46g/cm^3**

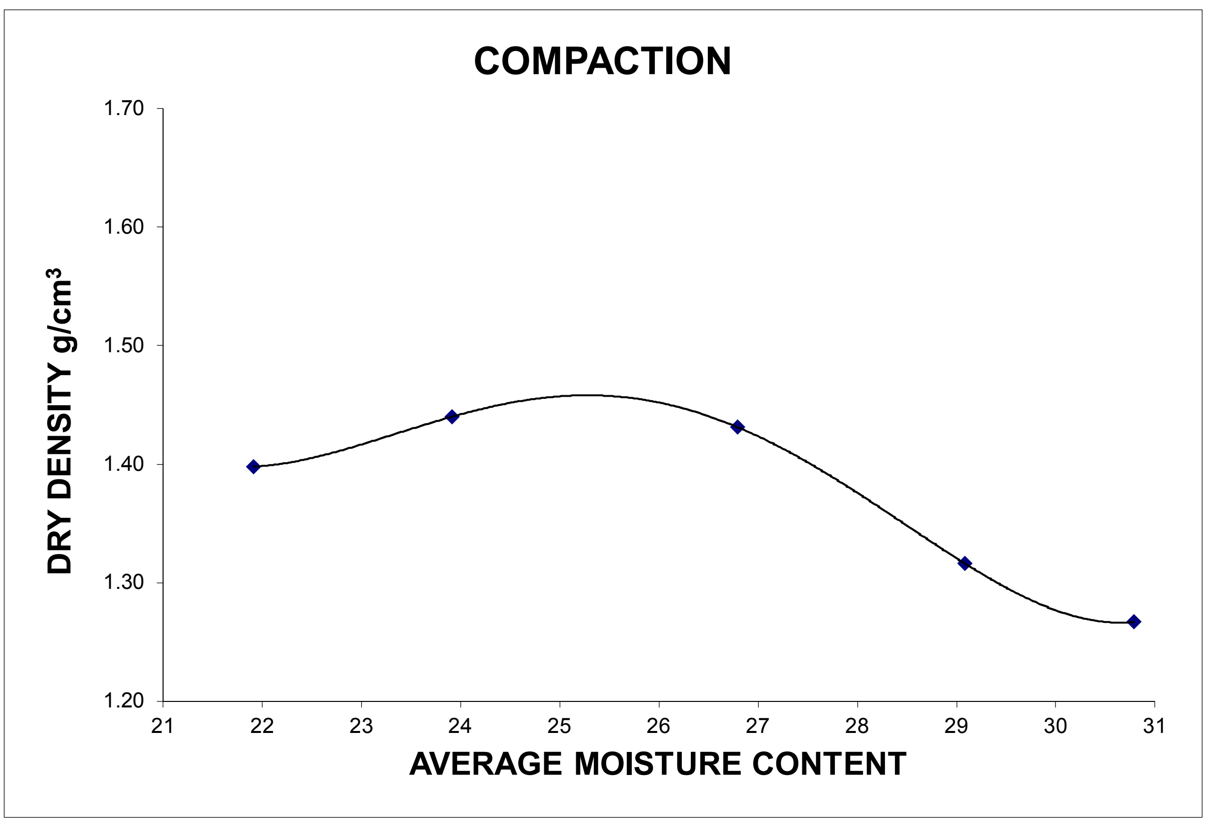
Amount retained on 20mm B.S. Sieve……… Total weight of Sample…… OPT.MC:**25.3%**

B.S. / C.B.R. Mould……**4718g…**…………..............................

Wt. of mould & wet Soil (W2) g	6415.00	6495.00	6525.00	6410.00	6368.00		
Wt. of mould (W1) g	4718.00	4718.00	4718.00	4718.00	4718.00		
Wt. of wet soil (W2-W1) g	1697.00	1777.00	1807.00	1692.00	1650.00		
Bulk Density (Pb) (W2-W1)/x g/cm^3	1.70	1.78	1.81	1.70	1.66		

MOISTURE CONTENT DETERMINATIONS for B.S. Mould, X = 1000cm^3

Container No.	LA	VO	IE	MP	F7	OY	OG	JN	JO	PA				
Wt. of wet soil & container (g)	46.23	43.23	57.08	55.72	50.32	47.19	52.21	53.24	42.54	48.38				
Wt. of Dry soil & container (g)	40.54	38.67	49.64	48.34	43.52	40.64	44.56	45.25	35.98	41.14				
Wt. of Container (g)	15.07	17.44	18.43	17.58	17.93	16.39	18.22	17.81	14.76	17.53				
Wt. of dry soil (Wd) g	25.47	21.23	31.21	30.76	25.59	24.25	26.34	27.44	21.22	23.61				
Wt. of Moisture (Wm) g	5.69	4.56	7.44	7.38	6.80	6.55	7.65	7.99	6.56	7.24				
Moistur Content 100(Wm/Wd) %	22.34	21.48	23.84	23.99	26.57	27.01	29.04	29.12	30.91	30.66				
Average Moisture Content (m) %	21.91		23.92		26.79		29.08		30.79					
Dry Density = Pb/1+ (m/100) (g/cm^3)	1.40		1.44		1.43		1.32		1.27					
C.B.R. (mseen of top & bottom) %														



APPENDIX V

GEOTECHNICAL ENGINEERING LABORATORY TEST

TRIAXIAL COMPRESSION TEST

JOB**.... OKOMU BOILER** DATE**...24/06/2018………**

SAMPLE NO**… BH1, 15.0m ……** LENGTH…… DIAMETER…… CELL PRESSURE: **100, 205, 310KN/m²**

FRICTION ANGLE:. ....**5.88º**..... COHESION**:...38.0kN/m²**..... WET WEIGHT:..**142g,148g,152g....** DRY WEIGHT**g,g....** MOISTURE CONTENT:..........

Strain Dial	Stress Dial	SD2	SD3	Stress Dial Diff	SDD2	SDD3	Area Sq m	Compressive Stress	CS2	CS3	Strain %
0	0	0	0	0.00	0.00	0.00	0.00114	0.00	0.00	0.00	0.00
15	4.7	3	6	0.02	0.01	0.03	0.00115	17.44	11.13	22.26	0.50
30	5.8	10	7.5	0.02	0.04	0.03	0.00115	21.52	37.11	27.83	1.00
45	6.5	11.9	8	0.03	0.05	0.03	0.00116	23.91	43.78	29.43	1.50
60	7.5	13.5	15.3	0.03	0.06	0.07	0.00116	27.59	49.66	56.28	2.00
75	8.3	14.9	17	0.04	0.06	0.07	0.00117	30.27	54.34	62.00	2.50
90	9	16	18.9	0.04	0.07	0.08	0.00118	32.55	57.86	68.35	3.00
105	9.8	17.3	20.5	0.04	0.07	0.09	0.00118	35.44	62.56	74.14	3.50
120	10.3	18.5	22	0.04	0.08	0.09	0.00119	36.94	66.34	78.89	4.00
135	11	20	23.3	0.05	0.09	0.10	0.00119	39.45	71.72	83.55	4.50
150	11.8	21.3	24.8	0.05	0.09	0.11	0.00120	41.96	75.75	88.19	5.00
165	12.5	22.5	26	0.05	0.10	0.11	0.00121	44.08	79.35	91.70	5.50
180	13	23.9	27.5	0.06	0.10	0.12	0.00121	45.85	84.29	96.99	6.00
210	14	26	29.8	0.06	0.11	0.13	0.00122	48.97	90.94	104.24	7.00
240	15	28.3	30.5	0.13	0.12	0.13	0.00124	103.24	97.39	104.96	8.00
270	30	30.5	33.8	0.07	0.13	0.14	0.00125	56.33	104.12	115.39	9.00
300	16.5	32	36	0.07	0.14	0.15	0.00127	58.80	107.52	120.96	10.00
330	17.5	33.5	37.5	0.08	0.14	0.16	0.00128	61.68	111.68	125.02	11.00
360	18.5	34.8	39.3	0.08	0.15	0.17	0.00130	62.37	114.23	129.01	12.00
390	19	36	41	0.08	0.15	0.17	0.00131	62.87	117.27	133.56	12.00
420	19.3	37	42	0.08	0.16	0.18	0.00131	62.87	120.53	136.82	13.00
450	19.3	38	43.1	0.08	0.16	0.18	0.00133	61.92	121.92	138.29	14.00
480	19.3	39	44	0.08	0.17	0.19	0.00134	61.46	124.20	140.12	15.00
510	19.3	40	44.5	0.08	0.17	0.19	0.00136	60.56	125.51	139.63	16.00
540	19.3	40.8	45	0.08	0.17	0.19	0.00137	60.12	127.09	140.17	17.00
570	19.3	41	45	0.08	0.17	0.19	0.00139	59.25	125.87	138.15	18.00
600	19.3	41.8	45	0.08	0.18	0.19	0.00139	59.25	128.33	138.15	19.00
630	19.3	42	45	0.08	0.18	0.19	0.00143	57.59	125.33	134.29	20.00
660	19.3	42.8	45	0.08	0.18	0.19	0.00144	57.19	126.84	133.35	21.00
690	19.3	43	45	0.08	0.18	0.19	0.00146	56.41	125.68	131.53	22.00
720	19.3	43.9	45	0.08	0.19	0.19	0.00150	54.91	124.89	128.02	24.00
750	19.3	44.8	45	0.08	0.19	0.19	0.00152	54.18	125.77	126.34	25.00

	∂3	**∂2**	**∂1**	**Radius**	**Centre**								
1	100.00	103.24	203.24	51.6212	151.621								
	0.00	28.55	38.46	44.70	48.68	50.90	**51.62**	50.90	48.68	44.70	38.46	28.55	**0.00**
	100.00	108.62	117.19	125.81	134.43	143.00	**151.62**	160.24	168.81	177.43	186.05	194.62	**203.24**
2	205.00	128.33	333.33	64.1638	269.164								
	0.00	35.48	47.80	55.57	60.51	63.27	**64.16**	63.27	60.51	55.57	47.80	35.48	**0.00**
	205.00	215.72	226.37	237.08	247.80	258.45	**269.16**	279.88	290.53	301.25	311.96	322.61	**333.33**
3	310.00	140.17	450.17	70.0842	380.084								
	0.00	38.76	52.21	60.69	66.09	69.10	**70.08**	69.10	66.09	60.69	52.21	38.76	**0.00**
	310.00	321.70	333.34	345.04	356.75	368.38	**380.08**	391.79	403.42	415.13	426.83	438.46	**450.17**

DESCRIPTION OF SAMPLE

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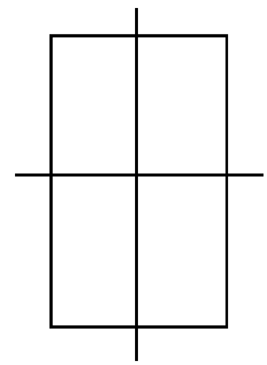
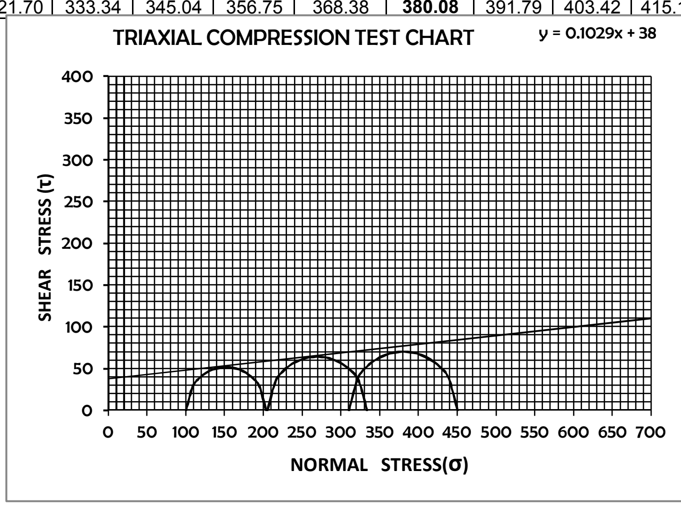
……………………………………………………………



SKETCH OF SAMPLE AFTER SHEAR

Compressive Sress

Corresponding Strain



GEOTECHNICAL ENGINEERING LABORATORY TEST

TRIAXIAL COMPRESSION TEST

JOB.... **OKOMU BOILER** DATE...**24/06/2018**.........

SAMPLE NO... **BH1, 3.0m** ...... LENGTH...... DIAMETER...... CELL PRESSURE: **100, 205, 310KN/m²**

FRICTION ANGLE:. ....**4.00º**..... COHESION:...**11.0kN/m²**..... WET WEIGHT:..**135g,157g,156g**.... DRY WEIGHT**g,g**.... MOISTURE CONTENT:..........

Strain Dial	Stress Dial	SD2	SD3	Stress Dial Diff	SDD2	SDD3	Area Sq m	Compressive Stress	CS2	CS3	Strain %
0	0	0	0	0.00	0.00	0.00	0.00114	0.00	0.00	0.00	0.00
15	1.5	1.2	2	0.01	0.01	0.01	0.00115	5.57	4.45	7.42	0.50
30	2	2	6	0.01	0.01	0.03	0.00115	7.42	7.42	22.26	1.00
45	2.5	3	8.5	0.01	0.01	0.04	0.00116	9.20	11.04	31.27	1.50
60	3	3.5	9	0.01	0.01	0.04	0.00116	11.04	12.88	33.11	2.00
75	3.5	4	10	0.01	0.02	0.04	0.00117	12.77	14.59	36.47	2.50
90	4	4.5	11	0.02	0.02	0.05	0.00118	14.47	16.27	39.78	3.00
105	4.8	5	11.5	0.02	0.02	0.05	0.00118	17.36	18.08	41.59	3.50
120	5.5	5.5	12	0.02	0.02	0.05	0.00119	19.72	19.72	43.03	4.00
135	6	6	12.5	0.03	0.03	0.05	0.00119	21.52	21.52	44.83	4.50
150	6.5	6.5	13.2	0.03	0.03	0.06	0.00120	23.11	23.11	46.94	5.00
165	7	7	14	0.03	0.03	0.06	0.00121	24.69	24.69	49.37	5.50
180	7.5	8	14.5	0.03	0.03	0.06	0.00121	26.45	28.21	51.14	6.00
210	8.5	9	15.8	0.04	0.04	0.07	0.00122	29.73	31.48	55.27	7.00
240	9.2	10	17	0.04	0.04	0.07	0.00124	34.41	34.41	58.50	8.00
270	10	10.5	18	0.05	0.04	0.08	0.00125	36.87	35.85	61.45	9.00
300	10.8	11	18.8	0.05	0.05	0.08	0.00127	36.96	36.96	63.17	10.00
330	11	11.5	19.5	0.05	0.05	0.08	0.00128	37.34	38.34	65.01	11.00
360	11.2	11.8	20	0.05	0.05	0.09	0.00130	37.75	38.73	65.65	12.00
390	11.5	12	20.5	0.05	0.05	0.09	0.00131	38.44	39.09	66.78	12.00
420	11.8	12	21	0.05	0.05	0.09	0.00131	38.44	39.09	68.41	13.00
450	11.8	12	21.5	0.05	0.05	0.09	0.00133	37.86	38.50	68.98	14.00
480	11.8	12	22	0.05	0.05	0.09	0.00134	37.58	38.22	70.06	15.00
510	11.8	12	22.2	0.05	0.05	0.09	0.00136	37.03	37.65	69.66	16.00
540	11.8	12	22.5	0.05	0.05	0.10	0.00137	36.76	37.38	70.08	17.00
570	11.8	12	22.5	0.05	0.05	0.10	0.00139	36.23	36.84	69.08	18.00
600	11.8	12	22.5	0.05	0.05	0.10	0.00139	36.23	36.84	69.08	19.00
630	11.8	12	22.5	0.05	0.05	0.10	0.00143	35.21	35.81	67.14	20.00
660	11.8	12	22.5	0.05	0.05	0.10	0.00144	34.97	35.56	66.68	21.00
690	11.8	12	22.5	0.05	0.05	0.10	0.00146	34.49	35.07	65.76	22.00
720	11.8	12	22.5	0.05	0.05	0.10	0.00150	33.57	34.14	64.01	24.00
750	11.8	12	22.5	0.05	0.05	0.10	0.00152	33.13	33.69	63.17	25.00

DESCRIPTION OF SAMPLE

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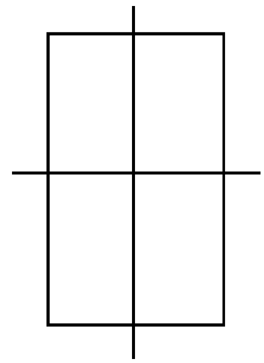
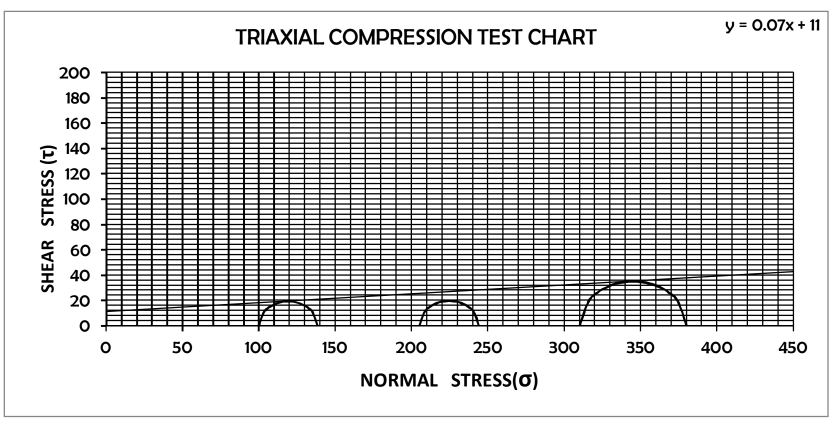


SKETCH OF SAMPLE AFTER SHEAR

Compressive Sress

Corresponding Strain

	∂3	∂2	∂1	Radius	Centre							
1	100.00	38.44	138.44	19.2194	119.219							
	0.00	10.63	14.32	16.64	18.12	18.95	**19.22**	18.95	18.12	16.64	14.32	10.63	**0.00**
	100.00	103.21	106.40	109.61	112.82	116.01	**119.22**	122.43	125.62	128.83	132.04	135.23	**138.44**
2	205.00	39.09	244.09	19.5451	224.545								
	0.00	10.81	14.56	16.93	18.43	19.27	**19.55**	19.27	18.43	16.93	14.56	10.81	**0.00**
	205.00	208.26	211.51	214.77	218.04	221.28	**224.55**	227.81	231.05	234.32	237.58	240.83	**244.09**
3	310.00	70.08	380.08	35.0421	345.042								
	0.00	19.38	26.11	30.35	33.04	34.55	**35.04**	34.55	33.04	30.35	26.11	19.38	**0.00**
	310.00	315.85	321.67	327.52	333.37	339.19	**345.04**	350.89	356.71	362.56	368.42	374.23	**380.08**



GEOTECHNICAL ENGINEERING LABORATORY TEST

TRIAXIAL COMPRESSION TEST

JOB**.... OKOMU BOILER** DATE**...24/06/2018.........**

SAMPLE NO**... BH1, 9.0m ......** LENGTH...... DIAMETER...... CELL PRESSURE: **100, 205, 310KN/m²**

FRICTION ANGLE:. ....**6.73º**..... COHESION:**...29.0kN/m²**..... WET WEIGHT:..**157g,160g,157g**.... DRY WEIGHT**g,g....** MOISTURE CONTENT:..........

Strain Dial	Stress Dial	SD2	SD3	Stress Dial Diff	SDD2	SDD3	Area Sq m	Compressive Stress	CS2	CS3	Strain %
0	0	0	0	0.00	0.00	0.00	0.00114	0.00	0.00	0.00	0.00
15	1	3	4	0.00	0.01	0.02	0.00115	3.71	11.13	14.84	0.50
30	1.5	4.5	7	0.01	0.02	0.03	0.00115	5.57	16.70	25.98	1.00
45	1.7	7	10	0.01	0.03	0.04	0.00116	6.25	25.75	36.79	1.50
60	2	9	12	0.01	0.04	0.05	0.00116	7.36	33.11	44.15	2.00
75	2.3	12	14	0.01	0.05	0.06	0.00117	8.39	43.77	51.06	2.50
90	2.8	14	16	0.01	0.06	0.07	0.00118	10.13	50.63	57.86	3.00
105	3	16	17.5	0.01	0.07	0.07	0.00118	10.85	57.86	63.29	3.50
120	4	18	19	0.02	0.08	0.08	0.00119	14.34	64.55	68.13	4.00
135	4.5	19.5	20	0.02	0.08	0.09	0.00119	16.14	69.93	71.72	4.50
150	5	21	21.5	0.02	0.09	0.09	0.00120	17.78	74.68	76.46	5.00
165	5.5	22	23	0.02	0.09	0.10	0.00121	19.40	77.59	81.11	5.50
180	6	23.5	24	0.03	0.10	0.10	0.00121	21.16	82.88	84.64	6.00
210	6.5	25.5	26	0.03	0.11	0.11	0.00122	22.74	89.19	90.94	7.00
240	7	27.5	28	0.03	0.12	0.12	0.00124	27.53	94.64	96.36	8.00
270	8	29	30	0.03	0.12	0.13	0.00125	27.99	99.00	102.42	9.00
300	8.2	30.2	32	0.04	0.13	0.14	0.00127	30.24	101.48	107.52	10.00
330	9	31.2	33.5	0.04	0.13	0.14	0.00128	30.67	104.02	111.68	11.00
360	9.2	32.5	35	0.04	0.14	0.15	0.00130	32.83	106.68	114.89	12.00
390	10	33.5	37	0.04	0.14	0.16	0.00131	33.23	109.13	120.53	12.00
420	10.2	34.5	38.5	0.05	0.15	0.16	0.00131	35.83	112.38	125.41	13.00
450	11	35	40	0.05	0.15	0.17	0.00133	36.90	112.30	128.34	14.00
480	11.5	36	42	0.05	0.15	0.18	0.00134	38.22	114.65	133.75	15.00
510	12	37	44	0.05	0.16	0.19	0.00136	39.22	116.10	138.06	16.00
540	12.5	38	45	0.06	0.16	0.19	0.00137	40.49	118.36	140.17	17.00
570	13	38.5	46	0.06	0.16	0.20	0.00139	41.45	118.20	141.22	18.00
600	13.5	39	47.5	0.06	0.17	0.20	0.00139	42.98	119.73	145.83	19.00
630	14	40	48.5	0.06	0.17	0.21	0.00143	43.27	119.37	144.73	20.00
660	14.5	40.8	49	0.07	0.17	0.21	0.00144	45.93	120.91	145.21	21.00
690	15.5	41.5	50.5	0.07	0.18	0.22	0.00146	46.77	121.30	147.60	22.00
720	16	42.5	51.5	0.07	0.18	0.22	0.00150	46.94	120.91	146.51	24.00
750	16.5	43	52.5	0.07	0.18	0.22	0.00152	46.32	120.72	147.39	25.00

	∂3	∂2	∂1	Radius	Centre								
1	100.00	46.94	146.94	23.4704	123.47								
	0.00	12.98	17.49	20.33	22.13	23.14	**23.47**	23.14	22.13	20.33	17.49	12.98	**0.00**
	100.00	103.92	107.82	111.74	115.65	119.55	**123.47**	127.39	131.29	135.21	139.13	143.02	**146.94**
2	205.00	121.30	326.30	60.649	265.649								
	0.00	33.54	45.18	52.52	57.19	59.80	**60.65**	59.80	57.19	52.52	45.18	33.54	**0.00**
	205.00	215.13	225.20	235.32	245.45	255.52	**265.65**	275.78	285.85	295.97	306.10	316.17	**326.30**
3	310.00	147.60	457.60	73.8018	383.802								
	0.00	40.81	54.98	63.91	69.60	72.77	**73.80**	72.77	69.60	63.91	54.98	40.81	**0.00**
	310.00	322.32	334.58	346.90	359.23	371.48	**383.80**	396.13	408.38	420.70	433.03	445.28	**457.60**

DESCRIPTION OF SAMPLE

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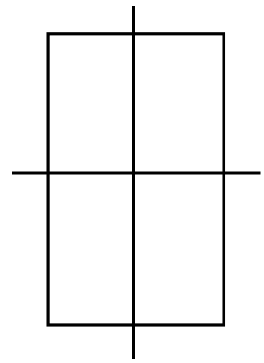
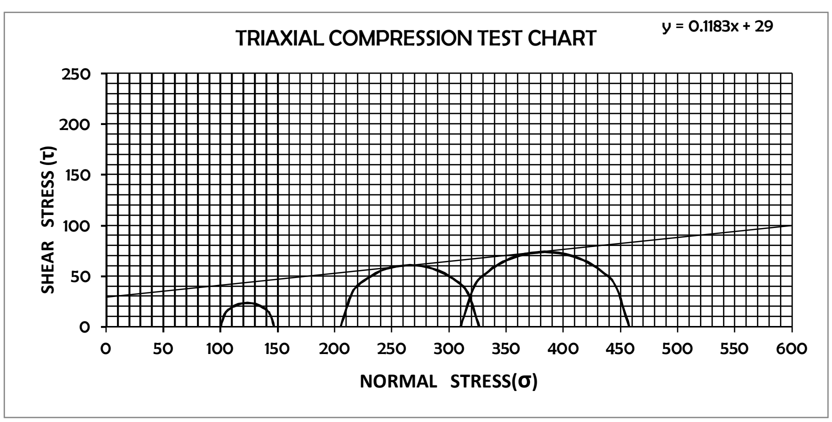


SKETCH OF SAMPLE AFTER SHEAR

Compressive Sress

Corresponding Strain



GEOTECHNICAL ENGINEERING LABORATORY TEST

TRIAXIAL COMPRESSION TEST

JOB**.... OKOMU BOILER** DATE**...24/06/2018………**

SAMPLE NO**... BH1, 15.0m ……** LENGTH…… DIAMETER…… CELL PRESSURE: **100, 205, 310KN/m²**

FRICTION ANGLE:. ....**5.88º**..... COHESION:**...38.0kN/m²**..... WET WEIGHT:**..142g,148g,152g....** DRY WEIGHT**g,g....** MOISTURE CONTENT:..........

Strain Dial	Stress Dial	SD2	SD3	Stress Dial Diff	SDD2	SDD3	Area Sq m	Compressive Stress	CS2	CS3	Strain %
0	0	0	0	0.00	0.00	0.00	0.00114	0.00	0.00	0.00	0.00
15	4.7	3	6	0.02	0.01	0.03	0.00115	17.44	11.13	22.26	0.50
30	5.8	10	7.5	0.02	0.04	0.03	0.00115	21.52	37.11	27.83	1.00
45	6.5	11.9	8	0.03	0.05	0.03	0.00116	23.91	43.78	29.43	1.50
60	7.5	13.5	15.3	0.03	0.06	0.07	0.00116	27.59	49.66	56.28	2.00
75	8.3	14.9	17	0.04	0.06	0.07	0.00117	30.27	54.34	62.00	2.50
90	9	16	18.9	0.04	0.07	0.08	0.00118	32.55	57.86	68.35	3.00
105	9.8	17.3	20.5	0.04	0.07	0.09	0.00118	35.44	62.56	74.14	3.50
120	10.3	18.5	22	0.04	0.08	0.09	0.00119	36.94	66.34	78.89	4.00
135	11	20	23.3	0.05	0.09	0.10	0.00119	39.45	71.72	83.55	4.50
150	11.8	21.3	24.8	0.05	0.09	0.11	0.00120	41.96	75.75	88.19	5.00
165	12.5	22.5	26	0.05	0.10	0.11	0.00121	44.08	79.35	91.70	5.50
180	13	23.9	27.5	0.06	0.10	0.12	0.00121	45.85	84.29	96.99	6.00
210	14	26	29.8	0.06	0.11	0.13	0.00122	48.97	90.94	104.24	7.00
240	15	28.3	30.5	0.13	0.12	0.13	0.00124	103.24	97.39	104.96	8.00
270	30	30.5	33.8	0.07	0.13	0.14	0.00125	56.33	104.12	115.39	9.00
300	16.5	32	36	0.07	0.14	0.15	0.00127	58.80	107.52	120.96	10.00
330	17.5	33.5	37.5	0.08	0.14	0.16	0.00128	61.68	111.68	125.02	11.00
360	18.5	34.8	39.3	0.08	0.15	0.17	0.00130	62.37	114.23	129.01	12.00
390	19	36	41	0.08	0.15	0.17	0.00131	62.87	117.27	133.56	12.00
420	19.3	37	42	0.08	0.16	0.18	0.00131	62.87	120.53	136.82	13.00
450	19.3	38	43.1	0.08	0.16	0.18	0.00133	61.92	121.92	138.29	14.00
480	19.3	39	44	0.08	0.17	0.19	0.00134	61.46	124.20	140.12	15.00
510	19.3	40	44.5	0.08	0.17	0.19	0.00136	60.56	125.51	139.63	16.00
540	19.3	40.8	45	0.08	0.17	0.19	0.00137	60.12	127.09	140.17	17.00
570	19.3	41	45	0.08	0.17	0.19	0.00139	59.25	125.87	138.15	18.00
600	19.3	41.8	45	0.08	0.18	0.19	0.00139	59.25	128.33	138.15	19.00
630	19.3	42	45	0.08	0.18	0.19	0.00143	57.59	125.33	134.29	20.00
660	19.3	42.8	45	0.08	0.18	0.19	0.00144	57.19	126.84	133.35	21.00
690	19.3	43	45	0.08	0.18	0.19	0.00146	56.41	125.68	131.53	22.00
720	19.3	43.9	45	0.08	0.19	0.19	0.00150	54.91	124.89	128.02	24.00
750	19.3	44.8	45	0.08	0.19	0.19	0.00152	54.18	125.77	126.34	25.00

	∂3	**∂2**	**∂1**	**Radius**	**Centre**								
1	100.00	103.24	203.24	51.6212	151.621								
	0.00	28.55	38.46	44.70	48.68	50.90	**51.62**	50.90	48.68	44.70	38.46	28.55	**0.00**
	100.00	108.62	117.19	125.81	134.43	143.00	**151.62**	160.24	168.81	177.43	186.05	194.62	**203.24**
2	205.00	128.33	333.33	64.1638	269.164								
	0.00	35.48	47.80	55.57	60.51	63.27	**64.16**	63.27	60.51	55.57	47.80	35.48	**0.00**
	205.00	215.72	226.37	237.08	247.80	258.45	**269.16**	279.88	290.53	301.25	311.96	322.61	**333.33**
3	310.00	140.17	450.17	70.0842	380.084								
	0.00	38.76	52.21	60.69	66.09	69.10	**70.08**	69.10	66.09	60.69	52.21	38.76	**0.00**
	310.00	321.70	333.34	345.04	356.75	368.38	**380.08**	391.79	403.42	415.13	426.83	438.46	**450.17**

DESCRIPTION OF SAMPLE

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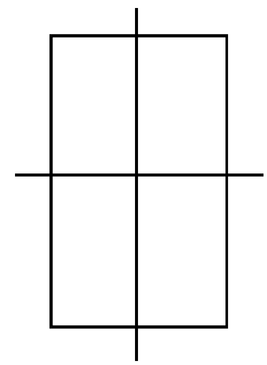
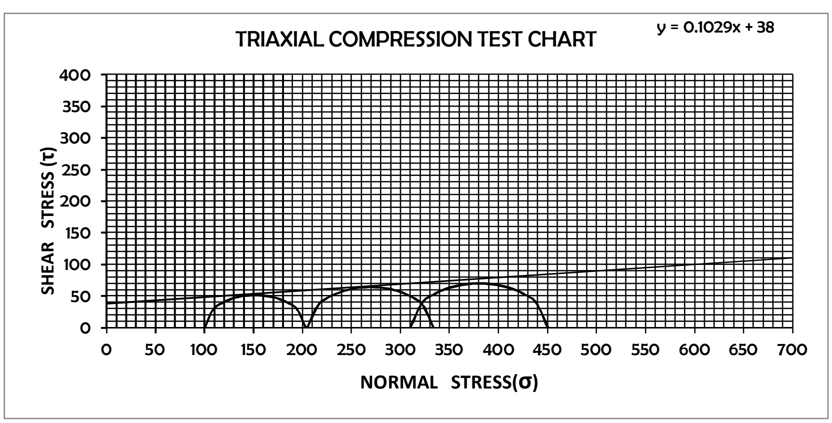


SKETCH OF SAMPLE AFTER SHEAR

Compressive Sress

Corresponding Strain



GEOTECHNICAL ENGINEERING LABORATORY TEST

TRIAXIAL COMPRESSION TEST

JOB.... **OKOMU POWER HOUSE** DATE...**24/06/2018.........**

SAMPLE NO... **BH2, 2.0m ......** LENGTH...... DIAMETER...... CELL PRESSURE: **100, 205, 310KN/m²**

FRICTION ANGLE:. ....**12.68º**..... COHESION:...**12.0kN/m²**..... WET WEIGHT:..**154g,156g,162g....** DRY WEIGHT**g,g....** MOISTURE CONTENT:..........

Strain Dial	Stress Dial	SD2	SD3	Stress Dial Diff	SDD2	SDD3	Area Sq m	Compressive Stress	CS2	CS3	Strain %
0	0	0	0	0.00	0.00	0.00	0.00114	0.00	0.00	0.00	0.00
15	7	5	6.5	0.03	0.02	0.03	0.00115	25.98	18.55	24.12	0.50
30	8	9	9.5	0.03	0.04	0.04	0.00115	29.69	33.40	35.25	1.00
45	10.3	14.9	21	0.04	0.06	0.09	0.00116	37.89	54.81	77.25	1.50
60	12.8	18	25	0.05	0.08	0.11	0.00116	47.09	66.22	91.97	2.00
75	14.5	20	27.5	0.06	0.09	0.12	0.00117	52.89	72.95	100.30	2.50
90	16.1	21.9	29	0.07	0.09	0.12	0.00118	58.22	79.20	104.88	3.00
105	18	23	30.5	0.08	0.10	0.13	0.00118	65.10	83.18	110.30	3.50
120	19.5	24	31.9	0.08	0.10	0.14	0.00119	69.93	86.06	114.39	4.00
135	21	25	33	0.09	0.11	0.14	0.00119	75.31	89.65	118.34	4.50
150	22.7	26	34.8	0.10	0.11	0.15	0.00120	80.72	92.46	123.75	5.00
165	24	27	36	0.10	0.12	0.15	0.00121	84.64	95.22	126.96	5.50
180	25.9	28.3	37.3	0.11	0.12	0.16	0.00121	91.34	99.81	131.55	6.00
210	28.2	30	40	0.12	0.13	0.17	0.00122	98.64	104.93	139.91	7.00
240	29.5	32	42.5	0.13	0.14	0.18	0.00124	103.24	110.13	146.26	8.00
270	30	33.9	45	0.13	0.14	0.19	0.00125	105.83	115.73	153.62	9.00
300	31	35	47.8	0.14	0.15	0.20	0.00127	107.52	117.60	160.61	10.00
330	32	36.5	50	0.14	0.16	0.21	0.00128	111.02	121.69	166.69	11.00
360	33.3	38	52.3	0.15	0.16	0.22	0.00130	111.61	124.74	171.68	12.00
390	34	39.3	54.8	0.15	0.17	0.23	0.00131	115.64	128.02	178.51	12.00
420	35.5	40.5	56.5	0.16	0.17	0.24	0.00131	118.90	131.93	184.05	13.00
450	36.5	41.3	58.5	0.16	0.18	0.25	0.00133	120.32	132.51	187.70	14.00
480	37.5	42.5	60	0.16	0.18	0.26	0.00134	121.97	135.35	191.08	15.00
510	38.3	43.9	61.9	0.17	0.19	0.26	0.00136	122.37	137.75	194.23	16.00
540	39	44.8	63.5	0.17	0.19	0.27	0.00137	123.04	139.55	197.79	17.00
570	39.5	45.3	65	0.17	0.19	0.28	0.00139	122.80	139.07	199.55	18.00
600	40	46	66.5	0.17	0.20	0.28	0.00139	125.87	141.22	204.16	19.00
630	41	46.8	67.5	0.18	0.20	0.29	0.00143	126.83	139.66	201.43	20.00
660	42.5	47.1	69	0.19	0.20	0.29	0.00144	130.09	139.58	204.48	21.00
690	43.9	47.9	69.9	0.19	0.20	0.30	0.00146	131.24	140.00	204.31	22.00
720	44.9	48.5	71	0.19	0.21	0.30	0.00150	129.73	137.98	201.99	24.00
750	45.6	49.5	72.5	0.19	0.21	0.31	0.00152	128.02	138.97	203.54	25.00

	∂3	∂2	∂1	Radius	Centre							
1	100.00	131.24	231.24	65.6178	165.618							
	0.00	36.29	48.89	56.83	61.88	64.70	**65.62**	64.70	61.88	56.83	48.89	36.29	**0.00**
	100.00	110.96	121.85	132.81	143.77	154.66	**165.62**	176.58	187.47	198.43	209.38	220.28	**231.24**
2	205.00	141.22	346.22	70.6108	275.611							
	0.00	39.05	52.61	61.15	66.59	69.62	**70.61**	69.62	66.59	61.15	52.61	39.05	**0.00**
	205.00	216.79	228.51	240.31	252.10	263.82	**275.61**	287.40	299.12	310.92	322.71	334.43	**346.22**
3	310.00	204.48	514.48	102.239	412.239							
	0.00	56.54	76.17	88.54	96.41	100.81	**102.24**	100.81	96.41	88.54	76.17	56.54	**0.00**
	310.00	327.07	344.05	361.12	378.19	395.16	**412.24**	429.31	446.28	463.36	480.43	497.40	**514.48**

DESCRIPTION OF SAMPLE

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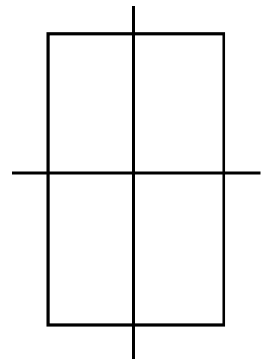
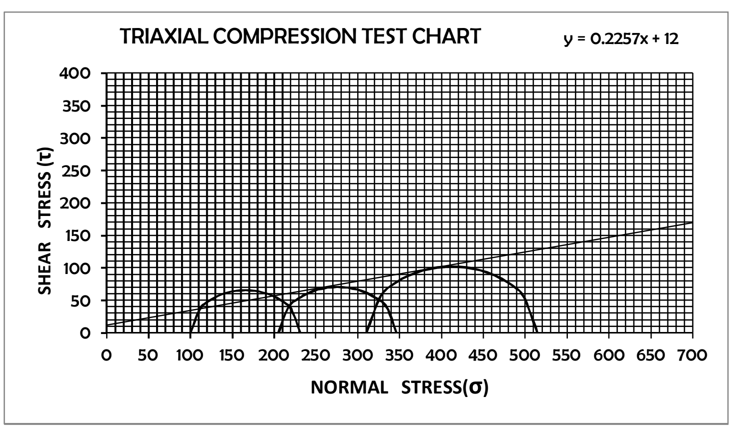


SKETCH OF SAMPLE AFTER SHEAR

Compressive Sress

Corresponding Strain



GEOTECHNICAL ENGINEERING LABORATORY TEST

TRIAXIAL COMPRESSION TEST

JOB.... **OKOMU POWER HOUSE** DATE...**24/06/2018**.........

SAMPLE NO... **BH2, 5.0m** ...... LENGTH...... DIAMETER...... CELL PRESSURE: **100, 205, 310KN/m²**

FRICTION ANGLE:. ....**6.66º**..... COHESION:... **58.0kN/m²**..... WET WEIGHT:..**160g,169g,166g**.... DRY WEIGHT**g,g**.... MOISTURE CONTENT:..........

Strain Dial	Stress Dial	SD2	SD3	Stress Dial Diff	SDD2	SDD3	Area Sq m	Compressive Stress	CS2	CS3	Strain %
0	0	0	0	0.00	0.00	0.00	0.00114	0.00	0.00	0.00	0.00
15	32	7	4.8	0.14	0.03	0.02	0.00115	118.74	25.98	17.81	0.50
30	34	11	8.5	0.15	0.05	0.04	0.00115	126.17	40.82	31.54	1.00
45	38	21.5	30	0.16	0.09	0.13	0.00116	139.79	79.09	110.36	1.50
60	39.5	27	31	0.17	0.12	0.13	0.00116	145.31	99.33	114.04	2.00
75	40	31	31	0.17	0.13	0.13	0.00117	145.89	113.07	113.07	2.50
90	41	33	31	0.17	0.14	0.13	0.00118	148.27	119.34	112.11	3.00
105	42	34	33	0.18	0.15	0.14	0.00118	151.89	122.96	119.34	3.50
120	42.5	35.5	33.5	0.18	0.15	0.14	0.00119	152.41	127.30	120.13	4.00
135	43	37	34	0.18	0.16	0.15	0.00119	154.20	132.68	121.92	4.50
150	43	38	36	0.18	0.16	0.15	0.00120	152.91	135.13	128.02	5.00
165	43	39	37	0.18	0.17	0.16	0.00121	151.65	137.54	130.49	5.50
180	43	40	37.5	0.18	0.17	0.16	0.00121	151.65	141.07	132.25	6.00
210	43	42	38	0.18	0.18	0.16	0.00122	150.41	146.91	132.92	7.00
240	43	43.5	38.5	0.18	0.19	0.16	0.00124	147.98	149.70	132.49	8.00
270	43	45	39	0.18	0.19	0.17	0.00125	146.80	153.62	133.14	9.00
300	43	47	39.5	0.18	0.20	0.17	0.00127	144.49	157.93	132.72	10.00
330	43	49	41	0.18	0.21	0.17	0.00128	143.36	163.36	136.69	11.00
360	43	50	43	0.18	0.21	0.18	0.00130	141.15	164.13	141.15	12.00
390	43	51.5	45	0.18	0.22	0.19	0.00131	140.07	167.76	146.59	12.00
420	43	53	47	0.18	0.23	0.20	0.00131	140.07	172.65	153.10	13.00
450	43	54	49	0.18	0.23	0.21	0.00133	137.97	173.26	157.22	14.00
480	43	55	50	0.18	0.23	0.21	0.00134	136.94	175.15	159.23	15.00
510	43	56	52	0.18	0.24	0.22	0.00136	134.92	175.71	163.16	16.00
540	43	57	53.5	0.18	0.24	0.23	0.00137	133.94	177.55	166.64	17.00
570	43	58	55	0.18	0.25	0.23	0.00139	132.01	178.06	168.85	18.00
600	43	58.8	57	0.18	0.25	0.24	0.00139	132.01	180.52	174.99	19.00
630	43	59.8	59	0.18	0.26	0.25	0.00143	128.32	178.45	176.07	20.00
660	43	60.8	61	0.18	0.26	0.26	0.00144	127.43	180.18	180.77	21.00
690	43	62	62	0.18	0.26	0.26	0.00146	125.68	181.22	181.22	22.00
720	43	62.5	64	0.18	0.27	0.27	0.00150	122.33	177.81	182.07	24.00
750	43	62.5	65	0.18	0.27	0.28	0.00152	120.72	175.47	182.49	25.00

		∂3	**∂2**	**∂1**	**Radius**	**Centre**								
	1	100.00	154.20	254.20	77.0992	177.099								
		0.00	42.64	57.44	66.77	72.70	76.02	**77.10**	76.02	72.70	66.77	57.44	42.64	**0.00**
		100.00	112.88	125.67	138.55	151.43	164.22	**177.10**	189.97	202.77	215.65	228.52	241.32	**254.20**
	2	205.00	181.22	386.22	90.6081	295.608								
		0.00	50.11	67.50	78.47	85.44	89.34	**90.61**	89.34	85.44	78.47	67.50	50.11	**0.00**
		205.00	220.13	235.17	250.30	265.44	280.48	**295.61**	310.74	325.78	340.91	356.04	371.08	**386.22**
	3	310.00	182.49	492.49	91.2427	401.243								
		0.00	50.46	67.98	79.02	86.04	89.97	**91.24**	89.97	86.04	79.02	67.98	50.46	**0.00**
		310.00	325.24	340.38	355.62	370.86	386.01	**401.24**	416.48	431.63	446.86	462.10	477.25	**492.49**

DESCRIPTION OF SAMPLE

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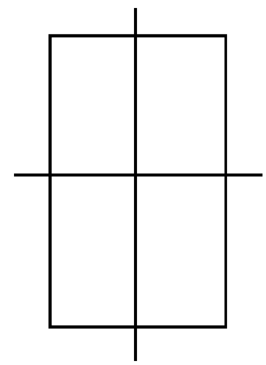
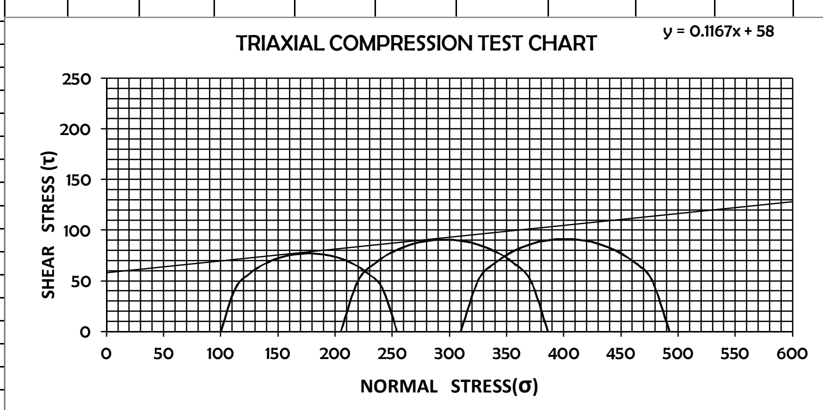


SKETCH OF SAMPLE AFTER SHEAR

Compressive Sress

Corresponding Strain



GEOTECHNICAL ENGINEERING LABORATORY TEST

TRIAXIAL COMPRESSION TEST

JOB**.... OKOMU POWER HOUSE** DATE**...24/06/2018………**

SAMPLE NO**... BH2, 15.0m……** LENGTH…… DIAMETER…… CELL PRESSURE: **100, 205, 310KN/m²**

FRICTION ANGLE:. ....**9.93º**..... COHESION**:... 17.0kN/m²**..... WET WEIGHT:..**150g,156g,158g**.... DRY WEIGHT**g,g....** MOISTURE CONTENT:..........

Strain Dial	Stress Dial	SD2	SD3	Stress Dial Diff	SDD2	SDD3	Area Sq m	Compressive Stress	CS2	CS3	Strain %
0	0	0	0	0.00	0.00	0.00	0.00114	0.00	0.00	0.00	0.00
15	8.2	6	15.8	0.03	0.03	0.07	0.00115	30.43	22.26	58.63	0.50
30	11	10	19	0.05	0.04	0.08	0.00115	40.82	37.11	70.50	1.00
45	13	17	21.2	0.06	0.07	0.09	0.00116	47.82	62.54	77.99	1.50
60	15.3	21	23	0.07	0.09	0.10	0.00116	56.28	77.25	84.61	2.00
75	17.5	24	24	0.07	0.10	0.10	0.00117	63.83	87.54	87.54	2.50
90	18.9	26.5	24.3	0.08	0.11	0.10	0.00118	68.35	95.83	87.88	3.00
105	20	28	24.6	0.09	0.12	0.10	0.00118	72.33	101.26	88.96	3.50
120	20.5	29	24.9	0.09	0.12	0.11	0.00119	73.51	103.99	89.29	4.00
135	20.6	30	25	0.09	0.13	0.11	0.00119	73.87	107.58	89.65	4.50
150	20.8	30.8	26	0.09	0.13	0.11	0.00120	73.97	109.53	92.46	5.00
165	20.9	31.5	27	0.09	0.13	0.12	0.00121	73.71	111.09	95.22	5.50
180	21.2	32	27.8	0.09	0.14	0.12	0.00121	74.77	112.86	98.04	6.00
210	21.5	33.5	29.2	0.09	0.14	0.12	0.00122	75.20	117.18	102.14	7.00
240	22	34.5	30.5	0.10	0.15	0.13	0.00124	77.43	118.73	104.96	8.00
270	22.5	35	32	0.10	0.15	0.14	0.00125	78.52	119.49	109.24	9.00
300	23	36.5	33.5	0.10	0.16	0.14	0.00127	79.97	122.64	112.56	10.00
330	23.8	37	35	0.10	0.16	0.15	0.00128	80.01	123.35	116.69	11.00
360	24	37.5	36.2	0.10	0.16	0.15	0.00130	79.77	123.10	118.83	12.00
390	24.3	38	37.5	0.11	0.16	0.16	0.00131	80.79	123.79	122.16	12.00
420	24.8	38.2	38.5	0.11	0.16	0.16	0.00131	81.44	124.44	125.41	13.00
450	25	38.5	39.5	0.11	0.16	0.17	0.00133	80.21	123.53	126.74	14.00
480	25	39	40.5	0.11	0.17	0.17	0.00134	80.57	124.20	128.98	15.00
510	25.3	39.3	41.5	0.11	0.17	0.18	0.00136	80.01	123.31	130.22	16.00
540	25.5	39.8	42.3	0.11	0.17	0.18	0.00137	80.36	123.97	131.76	17.00
570	25.8	40	43	0.11	0.17	0.18	0.00139	79.82	122.80	132.01	18.00
600	26	40	43.9	0.11	0.17	0.19	0.00139	79.82	122.80	134.77	19.00
630	26	40	44.3	0.11	0.17	0.19	0.00143	77.59	119.37	132.20	20.00
660	26	40	44.9	0.11	0.17	0.19	0.00144	77.05	118.54	133.06	21.00
690	26	40	45.3	0.11	0.17	0.19	0.00146	75.99	116.91	132.40	22.00
720	26	40	46	0.11	0.17	0.20	0.00150	73.97	113.80	130.87	24.00
750	26	40	46.9	0.11	0.17	0.20	0.00152	72.99	112.30	131.67	25.00

	∂3	∂2	∂1	Radius	Centre								
1	100.00	81.44	181.44	40.719	140.719								
	0.00	22.52	30.34	35.26	38.40	40.15	**40.72**	40.15	38.40	35.26	30.34	22.52	**0.00**
	100.00	106.80	113.56	120.36	127.16	133.92	**140.72**	147.52	154.28	161.08	167.88	174.64	**181.44**
2	205.00	124.44	329.44	62.2186	267.219								
	0.00	34.41	46.35	53.88	58.67	61.35	**62.22**	61.35	58.67	53.88	46.35	34.41	**0.00**
	205.00	215.39	225.72	236.11	246.50	256.83	**267.22**	277.61	287.94	298.33	308.72	319.05	**329.44**
3	310.00	134.77	444.77	67.3873	377.387								
	0.00	37.27	50.20	58.36	63.55	66.44	**67.39**	66.44	63.55	58.36	50.20	37.27	**0.00**
	310.00	321.25	332.44	343.69	354.95	366.13	**377.39**	388.64	399.83	411.08	422.33	433.52	**444.77**

DESCRIPTION OF SAMPLE

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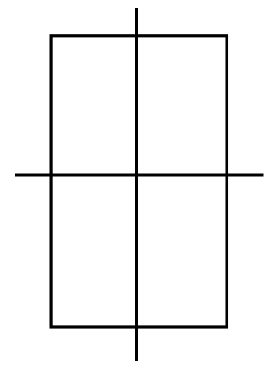
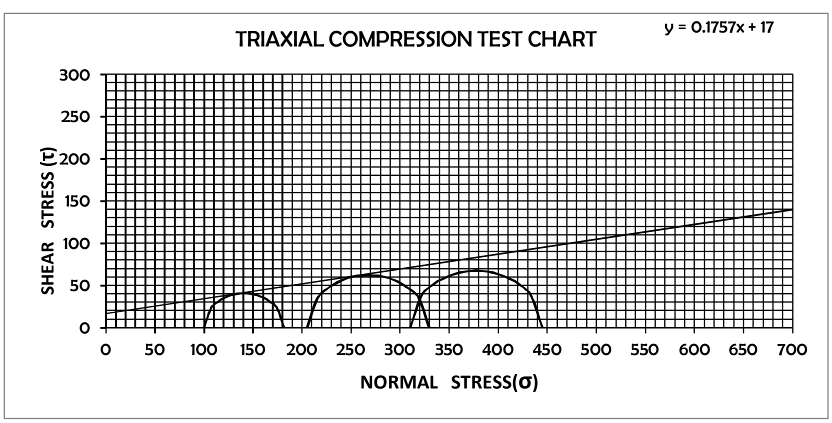


SKETCH OF SAMPLE AFTER SHEAR

Compressive Sress

Corresponding Strain



GEOTECHNICAL ENGINEERING LABORATORY TEST

TRIAXIAL COMPRESSION TEST

JOB**.... OKOMU CLARIFICATION STATION** DATE**...24/06/2018………**

SAMPLE NO**... BH3, 14.5m……** LENGTH…… DIAMETER…… CELL PRESSURE: **100, 205, 310KN/m²**

FRICTION ANGLE:. ....**10.36º**..... COHESION:**... 37.0kN/m²**..... WET WEIGHT:..**159g,161g,162g....** DRY WEIGHT**g,g....** MOISTURE CONTENT:..........

Strain Dial	Stress Dial	SD2	SD3	Stress Dial Diff	SDD2	SDD3	Area Sq m	Compressive Stress	CS2	CS3	Strain %
0	0	0	0	0.00	0.00	0.00	0.00114	0.00	0.00	0.00	0.00
15	7	8	6.3	0.03	0.03	0.03	0.00115	25.98	29.69	23.38	0.50
30	9.8	11.5	8.3	0.04	0.05	0.04	0.00115	36.37	42.67	30.80	1.00
45	11.6	15	15.5	0.05	0.06	0.07	0.00116	42.67	55.18	57.02	1.50
60	13.5	16.8	16.5	0.06	0.07	0.07	0.00116	49.66	61.80	60.70	2.00
75	15	18.5	20	0.06	0.08	0.09	0.00117	54.71	67.48	72.95	2.50
90	16.5	19.8	22	0.07	0.08	0.09	0.00118	59.67	71.60	79.56	3.00
105	18.2	21	23.5	0.08	0.09	0.10	0.00118	65.82	75.94	84.99	3.50
120	20	22.5	24.5	0.09	0.10	0.10	0.00119	71.72	80.69	87.86	4.00
135	22	24	26	0.09	0.10	0.11	0.00119	78.89	86.06	93.24	4.50
150	23.5	25.7	27	0.10	0.11	0.12	0.00120	83.57	91.39	96.02	5.00
165	25.5	27.3	28.5	0.11	0.12	0.12	0.00121	89.93	96.28	100.51	5.50
180	27	29	30	0.12	0.12	0.13	0.00121	95.22	102.28	105.80	6.00
210	30	32.5	33	0.13	0.14	0.14	0.00122	104.93	113.68	115.43	7.00
240	32.5	35.8	36	0.15	0.15	0.15	0.00124	122.17	123.20	123.89	8.00
270	35.5	38.5	39	0.16	0.16	0.17	0.00125	129.73	131.43	133.14	9.00
300	38	41.3	41.5	0.16	0.18	0.18	0.00127	127.68	138.77	139.44	10.00
330	38	44	44.9	0.16	0.19	0.19	0.00128	126.69	146.69	149.69	11.00
360	38	46.5	47.9	0.16	0.20	0.20	0.00130	124.74	152.64	157.24	12.00
390	38	48.5	50.3	0.16	0.21	0.21	0.00131	123.79	157.99	163.85	12.00
420	38	50.8	52.5	0.16	0.22	0.22	0.00131	123.79	165.48	171.02	13.00
450	38	52.9	54.9	0.16	0.23	0.23	0.00133	121.92	169.73	176.15	14.00
480	38	55	57	0.16	0.23	0.24	0.00134	121.01	175.15	181.52	15.00
510	38	55	58.5	0.16	0.23	0.25	0.00136	119.23	172.58	183.56	16.00
540	38	55	60.8	0.16	0.23	0.26	0.00137	118.36	171.32	189.38	17.00
570	38	55	62.5	0.16	0.23	0.27	0.00139	116.66	168.85	191.88	18.00
600	38	55	64	0.16	0.23	0.27	0.00139	116.66	168.85	196.48	19.00
630	38	55	65	0.16	0.23	0.28	0.00143	113.40	164.13	193.97	20.00
660	38	55	65.9	0.16	0.23	0.28	0.00144	112.61	162.99	195.29	21.00
690	38	55	65.9	0.16	0.23	0.28	0.00146	111.07	160.76	192.62	22.00
720	38	55	66.2	0.16	0.23	0.28	0.00150	108.11	156.47	188.33	24.00
750	38	55	66.9	0.16	0.23	0.29	0.00152	106.68	154.41	187.82	25.00

	∂3	∂2	∂1	Radius	Centre							
1	100.00	129.73	229.73	64.8637	164.864							
	0.00	35.87	48.32	56.17	61.17	63.96	**64.86**	63.96	61.17	56.17	48.32	35.87	**0.00**
	100.00	110.83	121.60	132.43	143.26	154.03	**164.86**	175.70	186.46	197.30	208.13	218.90	**229.73**
2	205.00	175.15	380.15	87.5762	292.576							
	0.00	48.43	65.24	75.84	82.58	86.35	**87.58**	86.35	82.58	75.84	65.24	48.43	**0.00**
	205.00	219.63	234.16	248.79	263.41	277.95	**292.58**	307.20	321.74	336.36	350.99	365.53	**380.15**
3	310.00	196.48	506.48	98.2412	408.241							
	0.00	54.33	73.19	85.08	92.64	96.87	**98.24**	96.87	92.64	85.08	73.19	54.33	**0.00**
	310.00	326.41	342.71	359.12	375.53	391.83	**408.24**	424.65	440.96	457.36	473.77	490.08	**506.48**

DESCRIPTION OF SAMPLE

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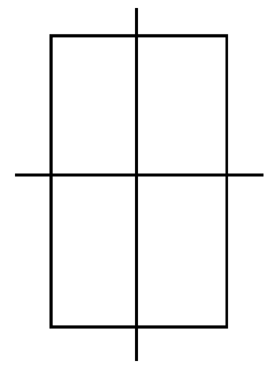
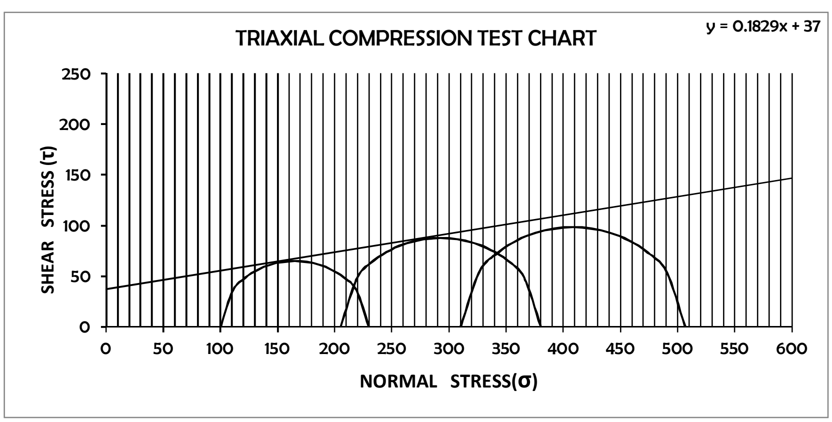


SKETCH OF SAMPLE AFTER SHEAR

Compressive Sress

Corresponding Strain



GEOTECHNICAL ENGINEERING LABORATORY TEST

TRIAXIAL COMPRESSION TEST

JOB.... **OKOMU WATER TANK** DATE...**24/06/2018**.........

SAMPLE NO... **BH3, 2.5m**...... LENGTH...... DIAMETER...... CELL PRESSURE: **100, 205, 310KN/m²**

FRICTION ANGLE:. ....**12.48º**..... COHESION:... **46.0kN/m²**..... WET WEIGHT:..**156g,160g,160g**.... DRY WEIGHT**g,g**.... MOISTURE CONTENT:..........

Strain Dial	Stress Dial	SD2	SD3	Stress Dial Diff	SDD2	SDD3	Area Sq m	Compressive Stress	CS2	CS3	Strain %
0	0	0	0	0.00	0.00	0.00	0.00114	0.00	0.00	0.00	0.00
15	10.5	6	17	0.04	0.03	0.07	0.00115	38.96	22.26	63.08	0.50
30	13	20.5	25.5	0.06	0.09	0.11	0.00115	48.24	76.07	94.62	1.00
45	14.5	22.5	30.6	0.06	0.10	0.13	0.00116	53.34	82.77	112.57	1.50
60	16	24.5	33.5	0.07	0.10	0.14	0.00116	58.86	90.13	123.24	2.00
75	18	26.5	35.7	0.08	0.11	0.15	0.00117	65.65	96.65	130.21	2.50
90	19	28.5	37.5	0.08	0.12	0.16	0.00118	68.71	103.07	135.61	3.00
105	21	30	39.5	0.09	0.13	0.17	0.00118	75.94	108.49	142.85	3.50
120	23	31.5	41.2	0.10	0.13	0.18	0.00119	82.48	112.96	147.74	4.00
135	25	32.8	43	0.11	0.14	0.18	0.00119	89.65	117.62	154.20	4.50
150	26.5	34	45	0.11	0.15	0.19	0.00120	94.24	120.91	160.03	5.00
165	28.5	35	46.9	0.12	0.15	0.20	0.00121	100.51	123.44	165.40	5.50
180	30	36.7	48.5	0.13	0.16	0.21	0.00121	105.80	129.43	171.05	6.00
210	33.5	39.5	52.5	0.14	0.17	0.22	0.00122	117.18	138.16	183.64	7.00
240	36.3	42.2	55.3	0.17	0.18	0.24	0.00124	134.22	145.23	190.31	8.00
270	39	45	59	0.17	0.19	0.25	0.00125	139.97	153.62	201.42	9.00
300	41	46.5	61.5	0.18	0.20	0.26	0.00127	144.49	156.25	206.65	10.00
330	43	48.3	64	0.19	0.21	0.27	0.00128	148.36	161.03	213.37	11.00
360	44.5	49.5	66.5	0.20	0.21	0.28	0.00130	151.00	162.49	218.29	12.00
390	46	50.9	68.9	0.20	0.22	0.29	0.00131	153.10	165.81	224.44	12.00
420	47	52	70.5	0.21	0.22	0.30	0.00131	156.69	169.39	229.66	13.00
450	48.1	53.3	73	0.21	0.23	0.31	0.00133	157.22	171.01	234.22	14.00
480	49	54.3	76.5	0.21	0.23	0.33	0.00134	160.18	172.92	243.62	15.00
510	50.3	55.5	80.3	0.22	0.24	0.34	0.00136	160.65	174.15	251.96	16.00
540	51.2	56.9	83	0.22	0.24	0.35	0.00137	161.97	177.24	258.53	17.00
570	52	58	86	0.23	0.25	0.37	0.00139	162.71	178.06	264.02	18.00
600	53	60	88.5	0.23	0.26	0.38	0.00139	166.09	184.20	271.70	19.00
630	54.1	61.9	91	0.23	0.26	0.39	0.00143	164.13	184.72	271.56	20.00
660	55	63.5	93.5	0.24	0.27	0.40	0.00144	165.06	188.18	277.08	21.00
690	55.7	64.5	96	0.24	0.28	0.41	0.00146	166.31	188.52	280.59	22.00
720	56.9	65.5	98.5	0.25	0.28	0.42	0.00150	165.00	186.34	280.22	24.00
750	58	67	100.5	0.25	0.29	0.43	0.00152	162.83	188.10	282.15	25.00

	∂3	**∂2**	**∂1**	**Radius**	**Centre**								
1	100.00	166.31	266.31	83.1549	183.155								
	0.00	45.98	61.95	72.01	78.42	81.99	**83.15**	81.99	78.42	72.01	61.95	45.98	**0.00**
	100.00	113.89	127.69	141.58	155.46	169.27	**183.15**	197.04	210.85	224.73	238.62	252.42	**266.31**
2	205.00	188.52	393.52	94.2617	299.262								
	0.00	52.13	70.22	81.63	88.89	92.94	**94.26**	92.94	88.89	81.63	70.22	52.13	**0.00**
	205.00	220.74	236.39	252.13	267.87	283.52	**299.26**	315.00	330.65	346.39	362.13	377.78	**393.52**
3	310.00	282.15	592.15	141.075	451.075								
	0.00	78.01	105.10	122.17	133.03	139.10	**141.08**	139.10	133.03	122.17	105.10	78.01	**0.00**
	310.00	333.56	356.98	380.54	404.10	427.52	**451.08**	474.63	498.05	521.61	545.17	568.59	**592.15**

DESCRIPTION OF SAMPLE

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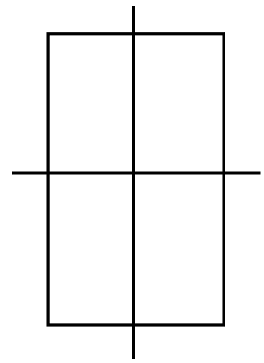
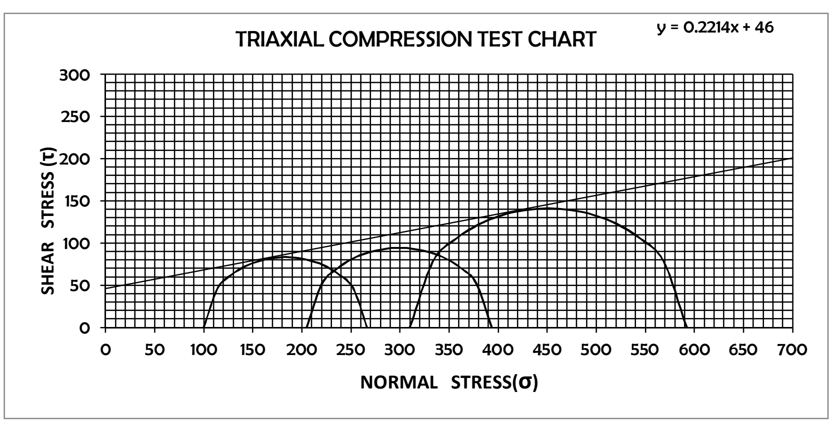


SKETCH OF SAMPLE AFTER SHEAR

Compressive Sress

Corresponding Strain



GEOTECHNICAL ENGINEERING LABORATORY TEST

TRIAXIAL COMPRESSION TEST

JOB**…. OKOMU CLARIFICATION STATION** DATE**…24/06/2018………**

SAMPLE NO**… BH3, 8.5m ……** LENGTH…… DIAMETER…… CELL PRESSURE: **100, 205, 310KN/m²**

FRICTION ANGLE:. ….**11.49º**….. COHESION**:…38.0kN/m²**….. WET WEIGHT:..**158g,156g,163g…**. DRY WEIGHT**g,g….** MOISTURE CONTENT:……….

Strain Dial	Stress Dial	SD2	SD3	Stress Dial Diff	SDD2	SDD3	Area Sq m	Compressive Stress	CS2	CS3	Strain %
0	0	0	0	0.00	0.00	0.00	0.00114	0.00	0.00	0.00	0.00
15	4	3	5	0.02	0.01	0.02	0.00115	14.84	11.13	18.55	0.50
30	6	5	15	0.03	0.02	0.06	0.00115	22.26	18.55	55.66	1.00
45	7.5	9	21	0.03	0.04	0.09	0.00116	27.59	33.11	77.25	1.50
60	9	13.5	25	0.04	0.06	0.11	0.00116	33.11	49.66	91.97	2.00
75	11	17	29	0.05	0.07	0.12	0.00117	40.12	62.00	105.77	2.50
90	13	20	31	0.06	0.09	0.13	0.00118	47.01	72.33	112.11	3.00
105	15	23	34	0.06	0.10	0.15	0.00118	54.25	83.18	122.96	3.50
120	16.5	25	36	0.07	0.11	0.15	0.00119	59.17	89.65	129.10	4.00
135	18	28	38	0.08	0.12	0.16	0.00119	64.55	100.41	136.27	4.50
150	20	31	40	0.09	0.13	0.17	0.00120	71.12	110.24	142.25	5.00
165	22	33	42	0.09	0.14	0.18	0.00121	77.59	116.38	148.12	5.50
180	23	34.5	44	0.10	0.15	0.19	0.00121	81.11	121.67	155.18	6.00
210	26	38.5	48	0.11	0.16	0.20	0.00122	90.94	134.67	167.90	7.00
240	29	41.5	51	0.13	0.18	0.22	0.00124	106.68	142.82	175.51	8.00
270	31	44	54	0.14	0.19	0.23	0.00125	112.66	150.21	184.35	9.00
300	33	46	57	0.15	0.20	0.24	0.00127	115.92	154.57	191.53	10.00
330	34.5	48	58	0.15	0.20	0.25	0.00128	120.02	160.03	193.36	11.00
360	36	49.5	62	0.16	0.21	0.26	0.00130	124.74	162.49	203.52	12.00
390	38	50.5	64.5	0.17	0.22	0.28	0.00131	128.67	164.50	210.11	12.00
420	39.5	51	68	0.17	0.22	0.29	0.00131	131.93	166.13	221.51	13.00
450	40.5	52	70	0.18	0.22	0.30	0.00133	132.19	166.84	224.60	14.00
480	41.2	52.2	72	0.18	0.22	0.31	0.00134	133.75	166.24	229.29	15.00
510	42	52.5	74	0.18	0.22	0.32	0.00136	133.35	164.73	232.19	16.00
540	42.5	53	76	0.18	0.23	0.32	0.00137	133.94	165.09	236.73	17.00
570	43	53	78	0.19	0.23	0.33	0.00139	135.08	162.71	239.46	18.00
600	44	53	79	0.19	0.23	0.34	0.00139	138.15	162.71	242.53	19.00
630	45	53	80	0.20	0.23	0.34	0.00143	137.27	158.16	238.73	20.00
660	46	53	81	0.20	0.23	0.35	0.00144	137.80	157.06	240.04	21.00
690	46.5	53	82	0.20	0.23	0.35	0.00146	137.37	154.91	239.67	22.00
720	47	53	82	0.20	0.23	0.35	0.00150	136.56	150.78	233.28	24.00
750	48	53	82	0.20	0.23	0.35	0.00152	134.76	148.80	230.21	25.00

	∂3	∂2	∂1	Radius	Centre								
1	100.00	138.15	238.15	69.0758	169.076								
	0.00	38.20	51.46	59.82	65.14	68.11	**69.08**	68.11	65.14	59.82	51.46	38.20	**0.00**
	100.00	111.54	123.00	134.54	146.07	157.54	**169.08**	180.61	192.08	203.61	215.15	226.62	**238.15**
2	205.00	166.84	371.84	83.4219	288.422								
	0.00	46.13	62.15	72.24	78.67	82.25	**83.42**	82.25	78.67	72.24	62.15	46.13	**0.00**
	205.00	218.93	232.78	246.71	260.64	274.49	**288.42**	302.35	316.20	330.13	344.06	357.91	**371.84**
3	310.00	242.53	552.53	121.266	431.266								
	0.00	67.06	90.34	105.02	114.35	119.57	**121.27**	119.57	114.35	105.02	90.34	67.06	**0.00**
	310.00	330.25	350.38	370.63	390.88	411.01	**431.27**	451.52	471.65	491.90	512.15	532.28	**552.53**

DESCRIPTION OF SAMPLE

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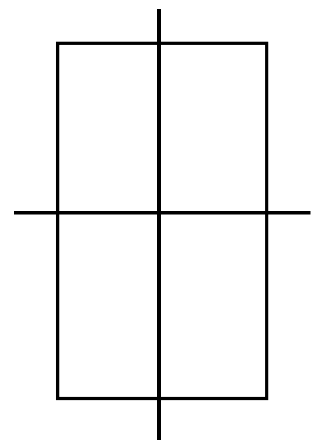
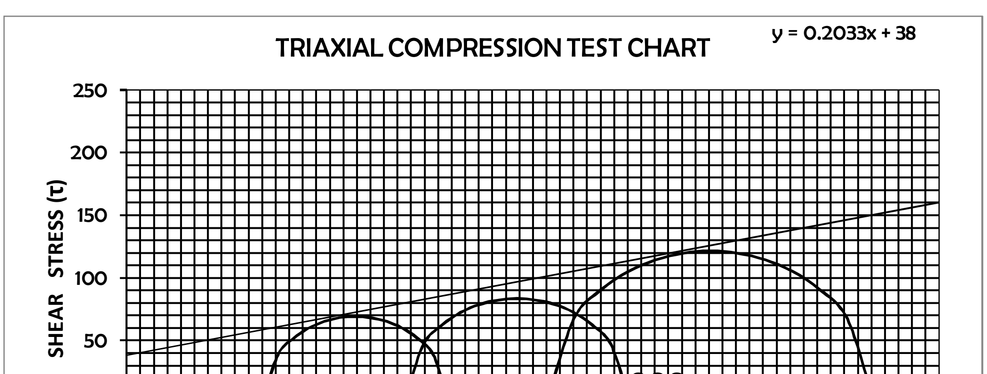


SKETCH OF SAMPLE AFTER SHEAR

Compressive Sress

Corresponding Strain



GEOTECHNICAL ENGINEERING LABORATORY TEST

TRIAXIAL COMPRESSION TEST

JOB**.... OKOMU STERILIZER** DATE**...24/06/2018.........**

SAMPLE NO**... BH4, 0.5m ......** LENGTH...... DIAMETER...... CELL PRESSURE: **100, 205, 310KN/m²**

FRICTION ANGLE:. ....**6.46º**..... COHESION**:...18.0kN/m²**..... WET WEIGHT:..**151g,160g,151g...**. DRY WEIGHT**g,g....** MOISTURE CONTENT:..........

Strain Dial	Stress Dial	SD2	SD3	Stress Dial Diff	SDD2	SDD3	Area Sq m	Compressive Stress	CS2	CS3	Strain %
0	0	0	0	0.00	0.00	0.00	0.00114	0.00	0.00	0.00	0.00
15	1	1.5	3.5	0.00	0.01	0.01	0.00115	3.71	5.57	12.99	0.50
30	1.8	2	6.5	0.01	0.01	0.03	0.00115	6.68	7.42	24.12	1.00
45	2.5	3	9	0.01	0.01	0.04	0.00116	9.20	11.04	33.11	1.50
60	3	4	10.5	0.01	0.02	0.04	0.00116	11.04	14.72	38.63	2.00
75	4	4.5	12	0.02	0.02	0.05	0.00117	14.59	16.41	43.77	2.50
90	4.5	5.2	14	0.02	0.02	0.06	0.00118	16.27	18.81	50.63	3.00
105	5.2	6	16	0.02	0.03	0.07	0.00118	18.81	21.70	57.86	3.50
120	6	7	18	0.03	0.03	0.08	0.00119	21.52	25.10	64.55	4.00
135	6.5	8	20	0.03	0.03	0.09	0.00119	23.31	28.69	71.72	4.50
150	7	8.5	22	0.03	0.04	0.09	0.00120	24.89	30.23	78.23	5.00
165	8	9	23	0.03	0.04	0.10	0.00121	28.21	31.74	81.11	5.50
180	8.5	10	25	0.04	0.04	0.11	0.00121	29.98	35.27	88.17	6.00
210	9.5	11.5	27	0.04	0.05	0.12	0.00122	33.23	40.23	94.44	7.00
240	11	13.5	29	0.05	0.06	0.12	0.00124	41.30	46.46	99.80	8.00
270	12	15	31	0.05	0.06	0.13	0.00125	42.67	51.21	105.83	9.00
300	12.5	16	31.5	0.06	0.07	0.13	0.00127	45.36	53.76	105.84	10.00
330	13.5	18	33	0.06	0.08	0.14	0.00128	48.34	60.01	110.02	11.00
360	14.5	19	33.5	0.07	0.08	0.14	0.00130	50.88	62.37	109.97	12.00
390	15.5	20.5	34	0.07	0.09	0.15	0.00131	52.12	66.78	110.76	12.00
420	16	21.5	35	0.07	0.09	0.15	0.00131	55.38	70.04	114.01	13.00
450	17	22.5	36	0.07	0.10	0.15	0.00133	55.19	72.19	115.51	14.00
480	17.2	24	36.5	0.08	0.10	0.16	0.00134	57.32	76.43	116.24	15.00
510	18	25	36.8	0.08	0.11	0.16	0.00136	59.62	78.44	115.47	16.00
540	19	26	37	0.08	0.11	0.16	0.00137	61.67	80.99	115.25	17.00
570	19.8	27	37.2	0.09	0.12	0.16	0.00139	62.01	82.89	114.21	18.00
600	20.2	27.5	37.5	0.09	0.12	0.16	0.00139	64.47	84.43	115.13	19.00
630	21	28	37.5	0.09	0.12	0.16	0.00143	65.65	83.56	111.91	20.00
660	22	29	37.5	0.10	0.12	0.16	0.00144	68.16	85.94	111.13	21.00
690	23	30	37.5	0.10	0.13	0.16	0.00146	68.69	87.69	109.61	22.00
720	23.5	31	37.5	0.10	0.13	0.16	0.00150	68.28	88.19	106.68	24.00
750	24	32	37.5	0.10	0.14	0.16	0.00152	67.38	89.84	105.28	25.00

	∂3	∂2	∂1	Radius	Centre							
1	100.00	68.69	168.69	34.3434	134.343							
	0.00	18.99	25.59	29.74	32.39	33.86	**34.34**	33.86	32.39	29.74	25.59	18.99	**0.00**
	100.00	105.74	111.44	117.17	122.91	128.61	**134.34**	140.08	145.78	151.52	157.25	162.95	**168.69**
2	205.00	89.84	294.84	44.9195	249.919							
	0.00	24.84	33.47	38.90	42.36	44.29	**44.92**	44.29	42.36	38.90	33.47	24.84	**0.00**
	205.00	212.50	219.96	227.46	234.96	242.42	**249.92**	257.42	264.88	272.38	279.88	287.34	**294.84**
3	310.00	116.24	426.24	58.1188	368.119							
	0.00	32.14	43.30	50.33	54.81	57.31	**58.12**	57.31	54.81	50.33	43.30	32.14	**0.00**
	310.00	319.71	329.35	339.06	348.77	358.41	**368.12**	377.82	387.47	397.18	406.88	416.53	**426.24**

DESCRIPTION OF SAMPLE

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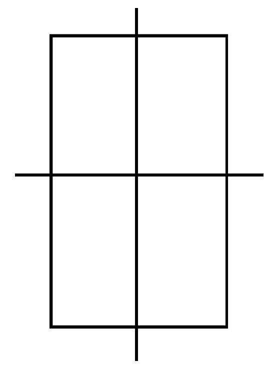
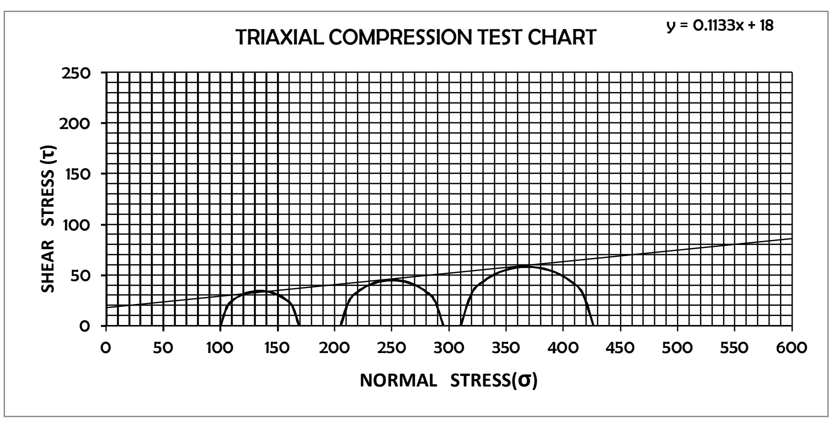


SKETCH OF SAMPLE AFTER SHEAR

Compressive Sress

Corresponding Strain



GEOTECHNICAL ENGINEERING LABORATORY TEST

TRIAXIAL COMPRESSION TEST

JOB**.... OKOMU STERILIZER** DATE**...24/06/2018.........**

SAMPLE NO**... BH4, 6.5m......** LENGTH...... DIAMETER...... CELL PRESSURE: **100, 205, 310KN/m²**

FRICTION ANGLE:. **....7.57º.....** COHESION:**... 15.0kN/m².....** WET WEIGHT:**..139g,130g,150g....** DRY WEIGHT**g,g....** MOISTURE CONTENT:..........

Strain Dial	Stress Dial	SD2	SD3	Stress Dial Diff	SDD2	SDD3	Area Sq m	Compressive Stress	CS2	CS3	Strain %
0	0	0	0	0.00	0.00	0.00	0.00114	0.00	0.00	0.00	0.00
15	10.5	5.8	3	0.04	0.02	0.01	0.00115	38.96	21.52	11.13	0.50
30	13.8	6.5	6	0.06	0.03	0.03	0.00115	51.21	24.12	22.26	1.00
45	16	8.2	8.5	0.07	0.03	0.04	0.00116	58.86	30.17	31.27	1.50
60	17	8.8	11	0.07	0.04	0.05	0.00116	62.54	32.37	40.47	2.00
75	17	9	12.5	0.07	0.04	0.05	0.00117	62.00	32.83	45.59	2.50
90	17	9.3	14.2	0.07	0.04	0.06	0.00118	61.48	33.63	51.35	3.00
105	17	9.8	16	0.07	0.04	0.07	0.00118	61.48	35.44	57.86	3.50
120	17	10	17.8	0.07	0.04	0.08	0.00119	60.96	35.86	63.83	4.00
135	17	10.2	19.5	0.07	0.04	0.08	0.00119	60.96	36.58	69.93	4.50
150	17	10.5	21.2	0.07	0.04	0.09	0.00120	60.45	37.34	75.39	5.00
165	17	10.8	22.5	0.07	0.05	0.10	0.00121	59.95	38.09	79.35	5.50
180	17	11.1	23.8	0.07	0.05	0.10	0.00121	59.95	39.15	83.94	6.00
210	17	12	26	0.07	0.05	0.11	0.00122	59.46	41.97	90.94	7.00
240	17	12.9	27.5	0.07	0.06	0.12	0.00124	58.50	44.39	94.64	8.00
270	17	13.8	29	0.07	0.06	0.12	0.00125	58.04	47.11	99.00	9.00
300	17	15	31.8	0.07	0.06	0.14	0.00127	57.12	50.40	106.85	10.00
330	17	15.7	32	0.07	0.07	0.14	0.00128	56.68	52.34	106.68	11.00
360	17	16	33	0.07	0.07	0.14	0.00130	55.80	52.52	108.33	12.00
390	17	17.8	34.5	0.07	0.08	0.15	0.00131	55.38	57.98	112.38	12.00
420	17	18.8	35.8	0.07	0.08	0.15	0.00131	55.38	61.24	116.62	13.00
450	17	19.7	37	0.07	0.08	0.16	0.00133	54.55	63.21	118.72	14.00
480	17	20.3	38	0.07	0.09	0.16	0.00134	54.14	64.65	121.01	15.00
510	17	21	39	0.07	0.09	0.17	0.00136	53.34	65.89	122.37	16.00
540	17	21.8	39.8	0.07	0.09	0.17	0.00137	52.95	67.90	123.97	17.00
570	17	22	40.3	0.07	0.09	0.17	0.00139	52.19	67.54	123.72	18.00
600	17	22.2	41	0.07	0.09	0.17	0.00139	52.19	68.15	125.87	19.00
630	17	23	41.5	0.07	0.10	0.18	0.00143	50.73	68.64	123.84	20.00
660	17	24	42	0.07	0.10	0.18	0.00144	50.38	71.12	124.46	21.00
690	17	24.8	42.5	0.07	0.11	0.18	0.00146	49.69	72.49	124.22	22.00
720	17	25	43	0.07	0.11	0.18	0.00150	48.36	71.12	122.33	24.00
750	17	25.7	43.8	0.07	0.11	0.19	0.00152	47.73	72.15	122.97	25.00

	∂3	**∂2**	**∂1**	**Radius**	**Centre**							
1	100.00	62.54	162.54	31.2694	131.269							
	0.00	17.29	23.30	27.08	29.49	30.83	**31.27**	30.83	29.49	27.08	23.30	17.29	**0.00**
	100.00	105.22	110.41	115.63	120.86	126.05	**131.27**	136.49	141.68	146.90	152.13	157.32	**162.54**
2	205.00	72.49	277.49	36.2432	241.243							
	0.00	20.04	27.00	31.39	34.18	35.74	**36.24**	35.74	34.18	31.39	27.00	20.04	**0.00**
	205.00	211.05	217.07	223.12	229.17	235.19	**241.24**	247.30	253.31	259.36	265.42	271.43	**277.49**
3	310.00	125.87	435.87	62.9357	372.936							
	0.00	34.80	46.89	54.50	59.35	62.05	**62.94**	62.05	59.35	54.50	46.89	34.80	**0.00**
	310.00	320.51	330.96	341.47	351.98	362.43	**372.94**	383.45	393.89	404.40	414.91	425.36	**435.87**

DESCRIPTION OF SAMPLE

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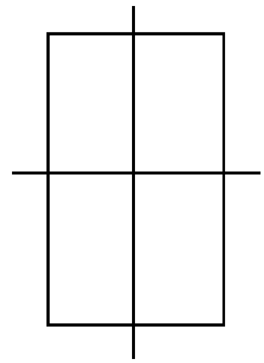
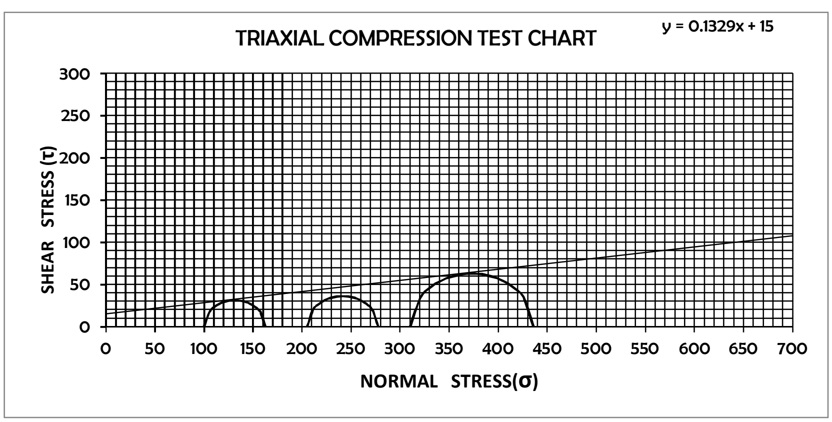


SKETCH OF SAMPLE AFTER SHEAR

Compressive Sress

Corresponding Strain



GEOTECHNICAL ENGINEERING LABORATORY TEST

TRIAXIAL COMPRESSION TEST

JOB.... **OKOMU STERILIZER** DATE...**24/06/2018**.........

SAMPLE NO... **BH4, 12.5m** ...... LENGTH...... DIAMETER...... CELL PRESSURE: **100, 205, 310KN/m²**

FRICTION ANGLE:. ....**6.16º**..... COHESION:...**5.0kN/m²**..... WET WEIGHT:..**145g,133g,155g**.... DRY WEIGHT**g,g**.... MOISTURE CONTENT:..........

Strain Dial	Stress Dial	SD2	SD3	Stress Dial Diff	SDD2	SDD3	Area Sq m	Compressive Stress	CS2	CS3	Strain %
0	0	0	0	0.00	0.00	0.00	0.00114	0.00	0.00	0.00	0.00
15	3	2	2	0.01	0.01	0.01	0.00115	11.13	7.42	7.42	0.50
30	3.5	2.5	3	0.01	0.01	0.01	0.00115	12.99	9.28	11.13	1.00
45	4	3	3.5	0.02	0.01	0.01	0.00116	14.72	11.04	12.88	1.50
60	5	3.8	4	0.02	0.02	0.02	0.00116	18.39	13.98	14.72	2.00
75	5.5	4	5	0.02	0.02	0.02	0.00117	20.06	14.59	18.24	2.50
90	6	5	5.5	0.03	0.02	0.02	0.00118	21.70	18.08	19.89	3.00
105	6.5	6	6	0.03	0.03	0.03	0.00118	23.51	21.70	21.70	3.50
120	7	7	7	0.03	0.03	0.03	0.00119	25.10	25.10	25.10	4.00
135	7.5	7.5	7.5	0.03	0.03	0.03	0.00119	26.90	26.90	26.90	4.50
150	8	8	8	0.03	0.03	0.03	0.00120	28.45	28.45	28.45	5.00
165	8.2	8.5	8.5	0.03	0.04	0.04	0.00121	28.92	29.98	29.98	5.50
180	8.5	9	9.5	0.04	0.04	0.04	0.00121	29.98	31.74	33.50	6.00
210	9	10	11	0.04	0.04	0.05	0.00122	31.48	34.98	38.48	7.00
240	9.8	11	12	0.04	0.05	0.05	0.00124	34.41	37.86	41.30	8.00
270	10	12	13	0.04	0.05	0.06	0.00125	34.14	40.97	44.38	9.00
300	10	12.8	14	0.04	0.05	0.06	0.00127	33.60	43.01	47.04	10.00
330	10	13	15	0.04	0.06	0.06	0.00128	33.34	43.34	50.01	11.00
360	10	13.5	16	0.04	0.06	0.07	0.00130	32.83	44.31	52.52	12.00
390	10	14	16.5	0.04	0.06	0.07	0.00131	32.58	45.61	53.75	12.00
420	10	15	17	0.04	0.06	0.07	0.00131	32.58	48.86	55.38	13.00
450	10	15.5	18	0.04	0.07	0.08	0.00133	32.09	49.73	57.75	14.00
480	10	16	18.5	0.04	0.07	0.08	0.00134	31.85	50.95	58.91	15.00
510	10	16.5	19.5	0.04	0.07	0.08	0.00136	31.38	51.77	61.19	16.00
540	10	17	20.2	0.04	0.07	0.09	0.00137	31.15	52.95	62.92	17.00
570	10	18	20.5	0.04	0.08	0.09	0.00139	30.70	55.26	62.94	18.00
600	10	18.5	21	0.04	0.08	0.09	0.00139	30.70	56.80	64.47	19.00
630	10	19	21.5	0.04	0.08	0.09	0.00143	29.84	56.70	64.16	20.00
660	10	19.5	22.5	0.04	0.08	0.10	0.00144	29.63	57.79	66.68	21.00
690	10	20	23	0.04	0.09	0.10	0.00146	29.23	58.46	67.23	22.00
720	10	20.5	24	0.04	0.09	0.10	0.00150	28.45	58.32	68.28	24.00
750	10	21	25	0.04	0.09	0.11	0.00152	28.07	58.96	70.19	25.00

DESCRIPTION OF SAMPLE

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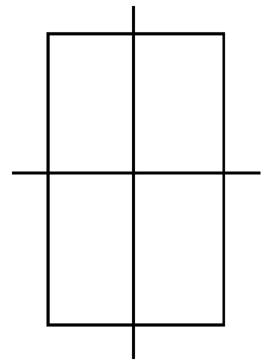
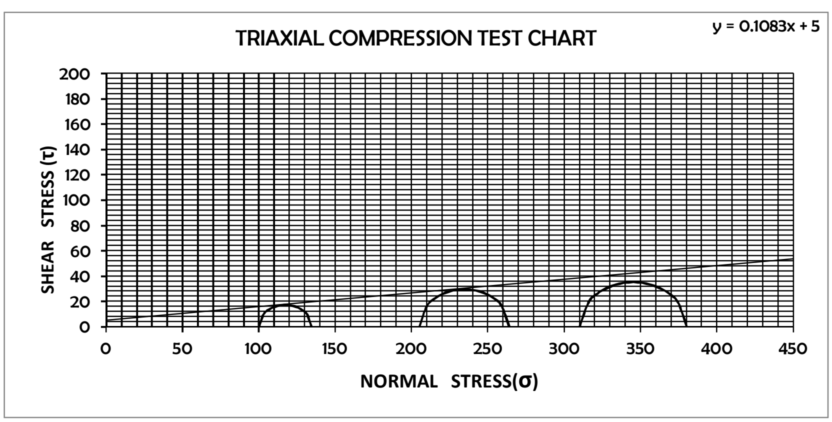


SKETCH OF SAMPLE AFTER SHEAR

Compressive Sress

Corresponding Strain

	∂3	∂2	∂1	Radius	Centre								
1	100.00	34.41	134.41	17.2071	117.207								
	0.00	9.52	12.82	14.90	16.23	16.97	**17.21**	16.97	16.23	14.90	12.82	9.52	**0.00**
	100.00	102.87	105.73	108.60	111.48	114.33	**117.21**	120.08	122.94	125.81	128.68	131.54	**134.41**
2	205.00	58.96	263.96	29.4784	234.478								
	0.00	16.30	21.96	25.53	27.80	29.07	**29.48**	29.07	27.80	25.53	21.96	16.30	**0.00**
	205.00	209.92	214.82	219.74	224.66	229.56	**234.48**	239.40	244.29	249.22	254.14	259.03	**263.96**
3	310.00	70.19	380.19	35.0933	345.093								
	0.00	19.41	26.14	30.39	33.09	34.60	**35.09**	34.60	33.09	30.39	26.14	19.41	**0.00**
	310.00	315.86	321.69	327.55	333.41	339.23	**345.09**	350.95	356.78	362.64	368.50	374.33	**380.19**



GEOTECHNICAL ENGINEERING LABORATORY TEST

TRIAXIAL COMPRESSION TEST

JOB**…. OKOMU PRESSING STATION** DATE**…24/06/2018………**

SAMPLE NO**… BH5, 7.5m ……** LENGTH…… DIAMETER…… CELL PRESSURE: **100, 205, 310KN/m²**

FRICTION ANGLE:. ….**15.64º**….. COHESION:**…9.0kN/m²**….. WET WEIGHT:**..160g,155g,155g**…. DRY WEIGHT**g,g….** MOISTURE CONTENT:……….

Strain Dial	Stress Dial	SD2	SD3	Stress Dial Diff	SDD2	SDD3	Area Sq m	Compressive Stress	CS2	CS3	Strain %
0	0	0	0	0.00	0.00	0.00	0.00114	0.00	0.00	0.00	0.00
15	6.5	4.5	9	0.03	0.02	0.04	0.00115	24.12	16.70	33.40	0.50
30	8.5	5	20	0.04	0.02	0.09	0.00115	31.54	18.55	74.21	1.00
45	10.5	7	26	0.04	0.03	0.11	0.00116	38.63	25.75	95.65	1.50
60	12.5	8.5	29	0.05	0.04	0.12	0.00116	45.98	31.27	106.68	2.00
75	14	10	32	0.06	0.04	0.14	0.00117	51.06	36.47	116.71	2.50
90	16	12	34	0.07	0.05	0.15	0.00118	57.86	43.40	122.96	3.00
105	17.5	14	36	0.07	0.06	0.15	0.00118	63.29	50.63	130.19	3.50
120	18.5	16	38	0.08	0.07	0.16	0.00119	66.34	57.38	136.27	4.00
135	20	18	40	0.09	0.08	0.17	0.00119	71.72	64.55	143.44	4.50
150	21.5	20	42	0.09	0.09	0.18	0.00120	76.46	71.12	149.36	5.00
165	22.5	22	44	0.10	0.09	0.19	0.00121	79.35	77.59	155.18	5.50
180	23	23.5	46	0.10	0.10	0.20	0.00121	81.11	82.88	162.23	6.00
210	24	27	50.5	0.10	0.12	0.22	0.00122	83.95	94.44	176.64	7.00
240	24.5	31	55	0.11	0.13	0.23	0.00124	89.48	106.68	189.28	8.00
270	26	33	58	0.12	0.14	0.25	0.00125	92.17	112.66	198.01	9.00
300	27	36	62	0.12	0.15	0.26	0.00127	94.08	120.96	208.33	10.00
330	28	38	65.5	0.12	0.16	0.28	0.00128	93.35	126.69	218.37	11.00
360	28	40	68	0.12	0.17	0.29	0.00130	91.91	131.30	223.22	12.00
390	28	42.5	72.5	0.12	0.18	0.31	0.00131	91.21	138.44	236.17	12.00
420	28	44.5	75.5	0.12	0.19	0.32	0.00131	91.21	144.96	245.94	13.00
450	28	46	78	0.12	0.20	0.33	0.00133	89.84	147.59	250.27	14.00
480	28	48	80	0.12	0.20	0.34	0.00134	89.17	152.86	254.77	15.00
510	28	50	82	0.12	0.21	0.35	0.00136	87.86	156.89	257.30	16.00
540	28	51	84	0.12	0.22	0.36	0.00137	87.22	158.86	261.65	17.00
570	28	52	85.5	0.12	0.22	0.36	0.00139	85.96	159.64	262.49	18.00
600	28	54	88	0.12	0.23	0.38	0.00139	85.96	165.78	270.16	19.00
630	28	55	89	0.12	0.23	0.38	0.00143	83.56	164.13	265.59	20.00
660	28	57	90.5	0.12	0.24	0.39	0.00144	82.98	168.92	268.19	21.00
690	28	58	92.5	0.12	0.25	0.39	0.00146	81.84	169.52	270.36	22.00
720	28	59.5	94.5	0.12	0.25	0.40	0.00150	79.66	169.27	268.84	24.00
750	28	61	96	0.12	0.26	0.41	0.00152	78.61	171.26	269.52	25.00

	∂3	∂2	∂1	Radius	Centre								
1	100.00	94.08	194.08	47.0417	147.042								
	0.00	26.01	35.05	40.74	44.36	46.38	**47.04**	46.38	44.36	40.74	35.05	26.01	**0.00**
	100.00	107.86	115.66	123.52	131.38	139.19	**147.04**	154.90	162.71	170.56	178.42	186.23	**194.08**
2	205.00	171.26	376.26	85.6277	290.628								
	0.00	47.35	63.79	74.15	80.75	84.43	**85.63**	84.43	80.75	74.15	63.79	47.35	**0.00**
	205.00	219.30	233.51	247.81	262.11	276.33	**290.63**	304.93	319.14	333.44	347.74	361.96	**376.26**
3	310.00	270.36	580.36	135.181	445.181								
	0.00	74.76	100.71	117.07	127.48	133.29	**135.18**	133.29	127.48	117.07	100.71	74.76	**0.00**
	310.00	332.58	355.02	377.59	400.17	422.61	**445.18**	467.76	490.20	512.77	535.35	557.79	**580.36**

DESCRIPTION OF SAMPLE

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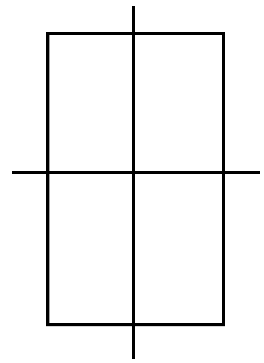
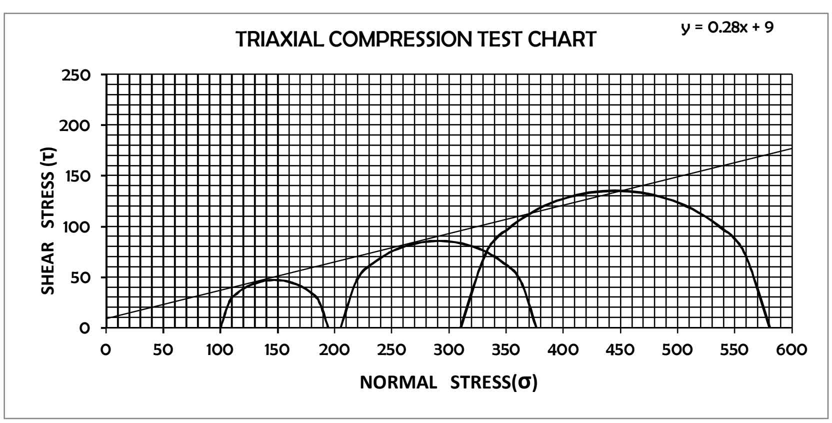


SKETCH OF SAMPLE AFTER SHEAR

Compressive Sress

Corresponding Strain



GEOTECHNICAL ENGINEERING LABORATORY TEST

TRIAXIAL COMPRESSION TEST

JOB**.... OKOMU PRESSING STATION** DATE**...24/06/2018.........**

SAMPLE NO**... BH5, 10.5m......** LENGTH...... DIAMETER...... CELL PRESSURE: **100, 205, 310KN/m²**

FRICTION ANGLE:. ....**11.62º**..... COHESION:**... 18.0kN/m²**..... WET WEIGHT:..**155g,135g,160g....** DRY WEIGHT**g,g....** MOISTURE CONTENT:..........

Strain Dial	Stress Dial	SD2	SD3	Stress Dial Diff	SDD2	SDD3	Area Sq m	Compressive Stress	CS2	CS3	Strain %
0	0	0	0	0.00	0.00	0.00	0.00114	0.00	0.00	0.00	0.00
15	7	7.7	11	0.03	0.03	0.05	0.00115	25.98	28.57	40.82	0.50
30	9.3	9	15	0.04	0.04	0.06	0.00115	34.51	33.40	55.66	1.00
45	10.5	10	17	0.04	0.04	0.07	0.00116	38.63	36.79	62.54	1.50
60	12	11	19.5	0.05	0.05	0.08	0.00116	44.15	40.47	71.74	2.00
75	13	11.8	24	0.06	0.05	0.10	0.00117	47.42	43.04	87.54	2.50
90	14	12.5	26	0.06	0.05	0.11	0.00118	50.63	45.20	94.03	3.00
105	15.1	14	28	0.06	0.06	0.12	0.00118	54.61	50.63	101.26	3.50
120	16.2	15	30	0.07	0.06	0.13	0.00119	58.09	53.79	107.58	4.00
135	17.5	16	31.5	0.07	0.07	0.13	0.00119	62.76	57.38	112.96	4.50
150	19	17	33.3	0.08	0.07	0.14	0.00120	67.57	60.45	118.42	5.00
165	20.8	17.8	35.2	0.09	0.08	0.15	0.00121	73.36	62.78	124.14	5.50
180	22	19.3	37.2	0.09	0.08	0.16	0.00121	77.59	68.07	131.19	6.00
210	24.2	21.5	40.8	0.10	0.09	0.17	0.00122	84.65	75.20	142.71	7.00
240	26.5	23.8	43.9	0.12	0.10	0.19	0.00124	98.77	81.91	151.08	8.00
270	28.7	25.8	46.5	0.13	0.11	0.20	0.00125	104.12	88.08	158.75	9.00
300	30.5	28.2	49.8	0.14	0.12	0.21	0.00127	109.20	94.76	167.33	10.00
330	32.5	30.3	52.5	0.15	0.13	0.22	0.00128	114.35	101.02	175.03	11.00
360	34.3	32.5	54.8	0.15	0.14	0.23	0.00130	118.17	106.68	179.89	12.00
390	36	34.2	56.6	0.16	0.15	0.24	0.00131	121.18	111.41	184.38	12.00
420	37.2	36.1	58.8	0.16	0.15	0.25	0.00131	123.79	117.60	191.54	13.00
450	38	38	59.2	0.17	0.16	0.25	0.00133	125.77	121.92	189.95	14.00
480	39.2	39.7	61	0.17	0.17	0.26	0.00134	128.02	126.43	194.26	15.00
510	40.2	41	62.5	0.17	0.17	0.27	0.00136	128.65	128.65	196.11	16.00
540	41	42.7	63.5	0.18	0.18	0.27	0.00137	130.82	133.00	197.79	17.00
570	42	44	64.2	0.18	0.19	0.27	0.00139	131.40	135.08	197.10	18.00
600	42.8	45.3	64.5	0.19	0.19	0.28	0.00139	134.47	139.07	198.02	19.00
630	43.8	46.8	65.5	0.19	0.20	0.28	0.00143	133.99	139.66	195.46	20.00
660	44.9	48	66.5	0.19	0.20	0.28	0.00144	134.84	142.25	197.07	21.00
690	45.5	48.9	67.5	0.20	0.21	0.29	0.00146	137.08	142.93	197.29	22.00
720	46.9	50	67.8	0.20	0.21	0.29	0.00150	136.56	142.25	192.88	24.00
750	48	51.2	68.1	0.20	0.22	0.29	0.00152	134.76	143.74	191.19	25.00

	∂3	∂2	∂1	Radius	Centre								
1	100.00	137.08	237.08	68.5407	168.541								
	0.00	37.90	51.06	59.36	64.63	67.58	**68.54**	67.58	64.63	59.36	51.06	37.90	**0.00**
	100.00	111.45	122.82	134.27	145.72	157.09	**168.54**	179.99	191.36	202.81	214.26	225.64	**237.08**
2	205.00	143.74	348.74	71.8712	276.871								
	0.00	39.74	53.54	62.24	67.77	70.86	**71.87**	70.86	67.77	62.24	53.54	39.74	**0.00**
	205.00	217.00	228.93	240.94	252.94	264.87	**276.87**	288.87	300.80	312.81	324.81	336.74	**348.74**
3	310.00	198.02	508.02	99.0087	409.009								
	0.00	54.75	73.76	85.74	93.37	97.62	**99.01**	97.62	93.37	85.74	73.76	54.75	**0.00**
	310.00	326.53	342.97	359.50	376.04	392.47	**409.01**	425.54	441.98	458.51	475.05	491.48	**508.02**

DESCRIPTION OF SAMPLE

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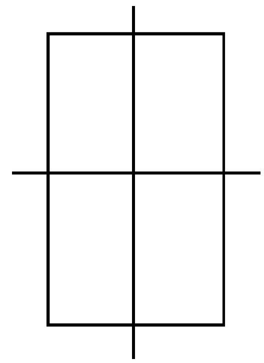
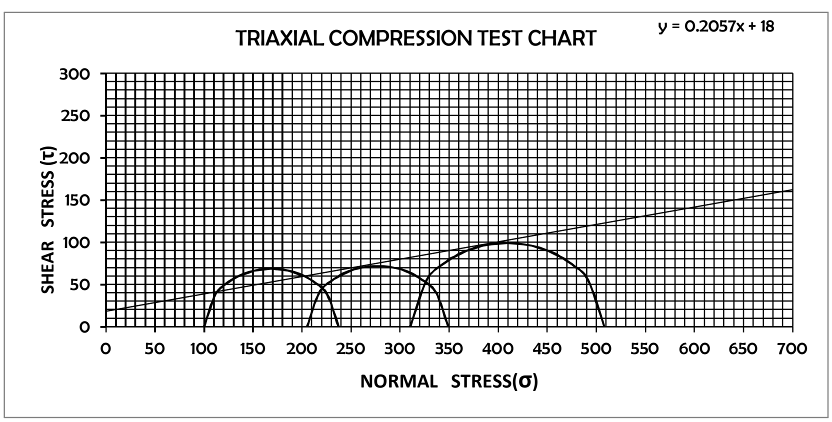


SKETCH OF SAMPLE AFTER SHEAR

Compressive Sress

Corresponding Strain



GEOTECHNICAL ENGINEERING LABORATORY TEST

TRIAXIAL COMPRESSION TEST

JOB**.... OKOMU PRESSING STATION** DATE**...24/06/2018.........**

SAMPLE NO**... BH5, 14.5m......** LENGTH...... DIAMETER...... CELL PRESSURE: **100, 205, 310KN/m²**

FRICTION ANGLE:. ...**10.28º**..... COHESION:**... 5.0kN/m²**..... WET WEIGHT:..**123g,137g,155g....** DRY WEIGHT**g,g....** MOISTURE CONTENT:..........

Strain Dial	Stress Dial	SD2	SD3	Stress Dial Diff	SDD2	SDD3	Area Sq m	Compressive Stress	CS2	CS3	Strain %
0	0	0	0	0.00	0.00	0.00	0.00114	0.00	0.00	0.00	0.00
15	3.2	4	9	0.01	0.02	0.04	0.00115	11.87	14.84	33.40	0.50
30	4	6	12.8	0.02	0.03	0.05	0.00115	14.84	22.26	47.50	1.00
45	5	6.8	15.9	0.02	0.03	0.07	0.00116	18.39	25.02	58.49	1.50
60	5.8	8	17.2	0.02	0.03	0.07	0.00116	21.34	29.43	63.27	2.00
75	6.5	8.9	19	0.03	0.04	0.08	0.00117	23.71	32.46	69.30	2.50
90	7.1	9	20.2	0.03	0.04	0.09	0.00118	25.68	32.55	73.05	3.00
105	8	10	21.5	0.03	0.04	0.09	0.00118	28.93	36.16	77.75	3.50
120	8.8	10.5	22.8	0.04	0.04	0.10	0.00119	31.56	37.65	81.76	4.00
135	9.2	11	23.9	0.04	0.05	0.10	0.00119	32.99	39.45	85.71	4.50
150	9.8	11.9	25	0.04	0.05	0.11	0.00120	34.85	42.32	88.90	5.00
165	10.3	12.5	26.1	0.04	0.05	0.11	0.00121	36.33	44.08	92.05	5.50
180	11	13.2	27.2	0.05	0.06	0.12	0.00121	38.79	46.55	95.93	6.00
210	11.8	14.5	29.5	0.05	0.06	0.13	0.00122	41.27	50.72	103.19	7.00
240	13	15.8	31.2	0.06	0.07	0.13	0.00124	48.18	54.37	107.37	8.00
270	14	17	33	0.06	0.07	0.14	0.00125	50.53	58.04	112.66	9.00
300	14.8	17.8	34.5	0.07	0.08	0.15	0.00127	51.41	59.81	115.92	10.00
330	15.3	19.3	36.2	0.07	0.08	0.15	0.00128	53.34	64.34	120.69	11.00
360	16	20.3	37.8	0.07	0.09	0.16	0.00130	53.51	66.64	124.08	12.00
390	16.3	21.5	39.8	0.07	0.09	0.17	0.00131	53.10	70.04	129.65	12.00
420	16.3	22.5	41.1	0.07	0.10	0.18	0.00131	53.10	73.29	133.88	13.00
450	16.3	23.2	42.5	0.07	0.10	0.18	0.00133	52.30	74.44	136.36	14.00
480	16.3	24.5	43.8	0.07	0.10	0.19	0.00134	51.91	78.02	139.49	15.00
510	16.3	25.2	44.5	0.07	0.11	0.19	0.00136	51.15	79.07	139.63	16.00
540	16.3	26.1	45.5	0.07	0.11	0.19	0.00137	50.77	81.30	141.73	17.00
570	16.3	27	46.1	0.07	0.12	0.20	0.00139	50.04	82.89	141.53	18.00
600	16.3	27.8	47	0.07	0.12	0.20	0.00139	50.04	85.35	144.29	19.00
630	16.3	28	47.8	0.07	0.12	0.20	0.00143	48.64	83.56	142.64	20.00
660	16.3	28.8	48.7	0.07	0.12	0.21	0.00144	48.30	85.35	144.32	21.00
690	16.3	29.2	49.2	0.07	0.12	0.21	0.00146	47.64	85.35	143.80	22.00
720	16.3	30	49.5	0.07	0.13	0.21	0.00150	46.37	85.35	140.82	24.00
750	16.3	30.7	50.1	0.07	0.13	0.21	0.00152	45.76	86.19	140.65	25.00

	∂3	∂2	∂1	Radius	Centre								
1	100.00	53.51	153.51	26.753	126.753								
	0.00	14.79	19.93	23.17	25.23	26.38	**26.75**	26.38	25.23	23.17	19.93	14.79	**0.00**
	100.00	104.47	108.91	113.38	117.84	122.29	**126.75**	131.22	135.66	140.13	144.60	149.04	**153.51**
2	205.00	86.19	291.19	43.0946	248.095								
	0.00	23.83	32.11	37.32	40.64	42.49	**43.09**	42.49	40.64	37.32	32.11	23.83	**0.00**
	205.00	212.20	219.35	226.55	233.74	240.90	**248.09**	255.29	262.45	269.64	276.84	283.99	**291.19**
3	310.00	144.32	454.32	72.1597	382.16								
	0.00	39.90	53.76	62.49	68.05	71.15	**72.16**	71.15	68.05	62.49	53.76	39.90	**0.00**
	310.00	322.05	334.03	346.08	358.13	370.11	**382.16**	394.21	406.19	418.24	430.29	442.27	**454.32**

DESCRIPTION OF SAMPLE

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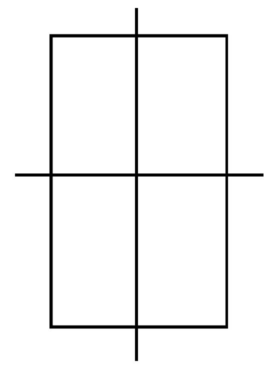
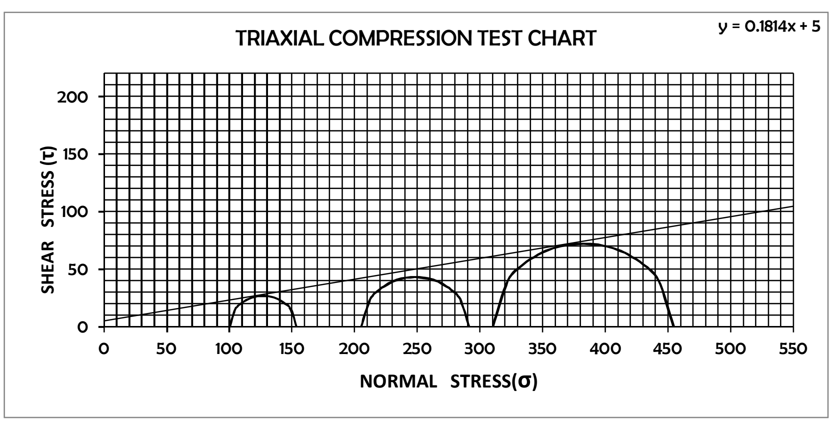


SKETCH OF SAMPLE AFTER SHEAR

Compressive Sress

Corresponding Strain



GEOTECHNICAL ENGINEERING LABORATORY TEST

TRIAXIAL COMPRESSION TEST

JOB.... **OKOMU STORAGE TANK** DATE...**24/06/2018**.........

SAMPLE NO... **BH6, 15.5m** ...... LENGTH...... DIAMETER...... CELL PRESSURE: **100, 205, 310KN/m²**

FRICTION ANGLE: ....**3.43º**..... COHESION:...**46.0kN/m²**..... WET WEIGHT:..**152g,157g,166g**.... DRY WEIGHT**g,g**.... MOISTURE CONTENT:..........

Strain Dial	Stress Dial	SD2	SD3	Stress Dial Diff	SDD2	SDD3	Area Sq m	Compressive Stress	CS2	CS3	Strain %
0	0	0	0	0.00	0.00	0.00	0.00114	0.00	0.00	0.00	0.00
15	2	2	5	0.01	0.01	0.02	0.00115	7.42	7.42	18.55	0.50
30	3	4	9	0.01	0.02	0.04	0.00115	11.13	14.84	33.40	1.00
45	4.1	5.5	10.5	0.02	0.02	0.04	0.00116	15.08	20.23	38.63	1.50
60	4.7	7	12	0.02	0.03	0.05	0.00116	17.29	25.75	44.15	2.00
75	4.7	8	14	0.02	0.03	0.06	0.00117	17.14	29.18	51.06	2.50
90	5	11	15	0.02	0.05	0.06	0.00118	18.08	39.78	54.25	3.00
105	5.2	13	16.5	0.02	0.06	0.07	0.00118	18.81	47.01	59.67	3.50
120	5.5	15	18	0.02	0.06	0.08	0.00119	19.72	53.79	64.55	4.00
135	5.7	16.5	21	0.02	0.07	0.09	0.00119	20.44	59.17	75.31	4.50
150	6	19	21.5	0.03	0.08	0.09	0.00120	21.34	67.57	76.46	5.00
165	6.4	21	22.5	0.03	0.09	0.10	0.00121	22.57	74.06	79.35	5.50
180	7	22	23	0.03	0.09	0.10	0.00121	24.69	77.59	81.11	6.00
210	7.5	24	25	0.03	0.10	0.11	0.00122	26.23	83.95	87.45	7.00
240	8	27	28	0.04	0.12	0.12	0.00124	29.25	92.92	96.36	8.00
270	8.5	30	31	0.04	0.13	0.13	0.00125	30.72	102.42	105.83	9.00
300	9	32	32	0.04	0.14	0.14	0.00127	31.92	107.52	107.52	10.00
330	9.5	33	33	0.04	0.14	0.14	0.00128	32.34	110.02	110.02	11.00
360	9.7	34.5	35	0.04	0.15	0.15	0.00130	32.83	113.25	114.89	12.00
390	10	35	37.5	0.04	0.15	0.16	0.00131	32.58	114.01	122.16	12.00
420	10	36	39	0.04	0.15	0.17	0.00131	32.58	117.27	127.04	13.00
450	10	36.8	41	0.04	0.16	0.17	0.00133	32.09	118.07	131.55	14.00
480	10	37	42	0.04	0.16	0.18	0.00134	31.85	117.83	133.75	15.00
510	10	38.5	43	0.04	0.16	0.18	0.00136	31.38	120.80	134.92	16.00
540	10	39	43	0.04	0.17	0.18	0.00137	31.15	121.48	133.94	17.00
570	10	39.5	43	0.04	0.17	0.18	0.00139	30.70	121.27	132.01	18.00
600	10	40	43	0.04	0.17	0.18	0.00139	30.70	122.80	132.01	19.00
630	10	40	43	0.04	0.17	0.18	0.00143	29.84	119.37	128.32	20.00
660	10	40	43	0.04	0.17	0.18	0.00144	29.63	118.54	127.43	21.00
690	10	40	43	0.04	0.17	0.18	0.00146	29.23	116.91	125.68	22.00
720	10	40	43	0.04	0.17	0.18	0.00150	28.45	113.80	122.33	24.00
750	10	40	43	0.04	0.17	0.18	0.00152	28.07	112.30	120.72	25.00

DESCRIPTION OF SAMPLE

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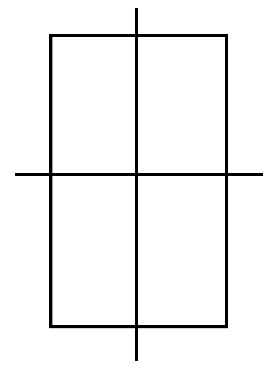
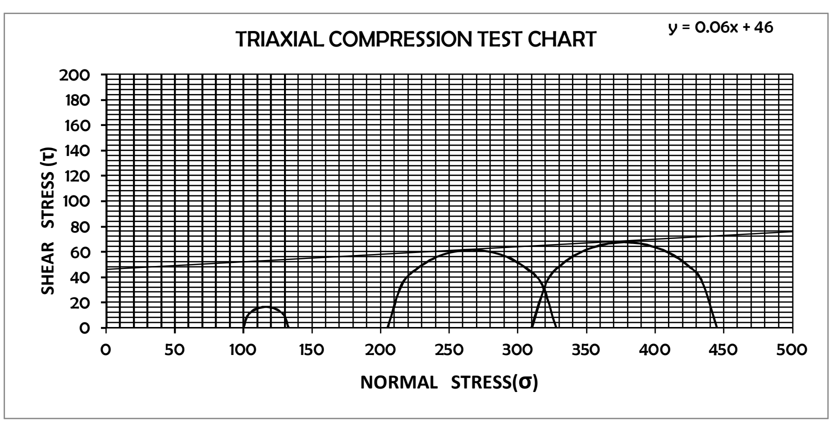


SKETCH OF SAMPLE AFTER SHEAR

Compressive Sress

Corresponding Strain

	∂3	**∂2**	**∂1**	**Radius**	**Centre**								
1	100.00	32.83	132.83	16.4129	116.413								
	0.00	9.08	12.23	14.21	15.48	16.18	**16.41**	16.18	15.48	14.21	12.23	9.08	**0.00**
	100.00	102.74	105.47	108.21	110.95	113.67	**116.41**	119.15	121.88	124.62	127.36	130.08	**132.83**
2	205.00	122.80	327.80	61.4007	266.401								
	0.00	33.95	45.74	53.17	57.90	60.54	**61.40**	60.54	57.90	53.17	45.74	33.95	**0.00**
	205.00	215.25	225.45	235.70	245.95	256.15	**266.40**	276.65	286.85	297.10	307.35	317.55	**327.80**
3	310.00	134.92	444.92	67.4618	377.462								
	0.00	37.31	50.26	58.42	63.62	66.52	**67.46**	66.52	63.62	58.42	50.26	37.31	**0.00**
	310.00	321.27	332.46	343.73	355.00	366.20	**377.46**	388.73	399.93	411.19	422.46	433.66	**444.92**



GEOTECHNICAL ENGINEERING LABORATORY TEST

TRIAXIAL COMPRESSION TEST

JOB**…. STORAGE TANK** DATE**…24/06/2018………**

SAMPLE NO**… BH6, 1.0m ……** LENGTH…… DIAMETER…… CELL PRESSURE: **100, 205, 310KN/m²**

FRICTION ANGLE:. ….**13.71º….** COHESION:**…3.00kN/m²…..** WET WEIGHT:..**135g,156g,158g….** DRY WEIGHT**g,g….** MOISTURE CONTENT:……….

Strain Dial	Stress Dial	SD2	SD3	Stress Dial Diff	SDD2	SDD3	Area Sq m	Compressive Stress	CS2	CS3	Strain %
0	0	0	0	0.00	0.00	0.00	0.00114	0.00	0.00	0.00	0.00
15	2.5	4	4	0.01	0.02	0.02	0.00115	9.28	14.84	14.84	0.50
30	3	8	11.5	0.01	0.03	0.05	0.00115	11.13	29.69	42.67	1.00
45	3.5	9	14	0.01	0.04	0.06	0.00116	12.88	33.11	51.50	1.50
60	4.2	10	16	0.02	0.04	0.07	0.00116	15.45	36.79	58.86	2.00
75	5	18	17.5	0.02	0.08	0.07	0.00117	18.24	65.65	63.83	2.50
90	5.8	21	19	0.02	0.09	0.08	0.00118	20.98	75.94	68.71	3.00
105	6.3	23	20	0.03	0.10	0.09	0.00118	22.78	83.18	72.33	3.50
120	7	24	21	0.03	0.10	0.09	0.00119	25.10	86.06	75.31	4.00
135	8	25.5	22	0.03	0.11	0.09	0.00119	28.69	91.44	78.89	4.50
150	8.5	27	23	0.04	0.12	0.10	0.00120	30.23	96.02	81.79	5.00
165	9.3	29	24.5	0.04	0.12	0.10	0.00121	32.80	102.28	86.41	5.50
180	10	30	25	0.04	0.13	0.11	0.00121	35.27	105.80	88.17	6.00
210	11.5	32	28	0.05	0.14	0.12	0.00122	40.23	111.93	97.94	7.00
240	13.1	34	30	0.06	0.15	0.13	0.00124	51.62	117.01	103.24	8.00
270	15	35.5	32	0.07	0.15	0.14	0.00125	56.33	121.19	109.24	9.00
300	16.5	37	34	0.08	0.16	0.15	0.00127	60.48	124.32	114.24	10.00
330	18	38	36	0.08	0.16	0.15	0.00128	64.34	126.69	120.02	11.00
360	19.3	38.5	37.5	0.09	0.16	0.16	0.00130	65.98	126.38	123.10	12.00
390	20.1	40	39	0.09	0.17	0.17	0.00131	67.76	130.30	127.04	12.00
420	20.8	40.5	40	0.09	0.17	0.17	0.00131	67.76	131.93	130.30	13.00
450	20.8	41	41.5	0.09	0.17	0.18	0.00133	66.74	131.55	133.15	14.00
480	20.8	41.8	42.8	0.09	0.18	0.18	0.00134	66.24	133.12	136.30	15.00
510	20.8	42	43.5	0.09	0.18	0.19	0.00136	65.27	131.79	136.49	16.00
540	20.8	42	44	0.09	0.18	0.19	0.00137	64.79	130.82	137.05	17.00
570	20.8	42.5	45	0.09	0.18	0.19	0.00139	63.86	130.48	138.15	18.00
600	20.8	42.5	45.5	0.09	0.18	0.19	0.00139	63.86	130.48	139.69	19.00
630	20.8	43	46	0.09	0.18	0.20	0.00143	62.07	128.32	137.27	20.00
660	20.8	43.5	47	0.09	0.19	0.20	0.00144	61.64	128.91	139.28	21.00
690	20.8	44	47.2	0.09	0.19	0.20	0.00146	60.80	128.61	137.96	22.00
720	20.8	44.2	48	0.09	0.19	0.20	0.00150	59.17	125.74	136.56	24.00
750	20.8	45	49	0.09	0.19	0.21	0.00152	58.40	126.34	137.57	25.00

DESCRIPTION OF SAMPLE

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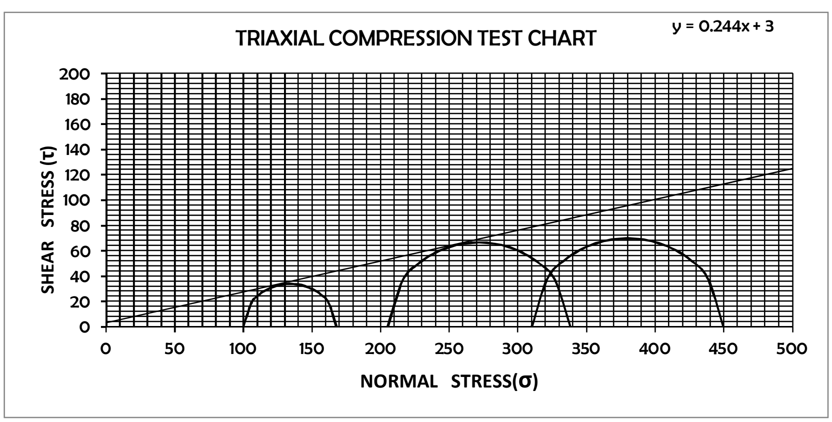
SKETCH OF SAMPLE AFTER SHEAR

Compressive Sress

Corresponding Strain

	∂3	∂2	∂1	Radius	Centre								
1	100.00	67.76	167.76	33.8782	133.878								
	0.00	18.73	25.24	29.34	31.95	33.40	**33.88**	33.40	31.95	29.34	25.24	18.73	**0.00**
	100.00	105.66	111.28	116.94	122.60	128.22	**133.88**	139.54	145.16	150.82	156.47	162.10	**167.76**
2	205.00	133.12	338.12	66.5579	271.558								
	0.00	36.81	49.59	57.64	62.76	65.63	**66.56**	65.63	62.76	57.64	49.59	36.81	**0.00**
	205.00	216.12	227.16	238.28	249.39	260.44	**271.56**	282.67	293.72	304.84	315.95	327.00	**338.12**
3	310.00	139.69	449.69	69.8433	379.843								
	0.00	38.62	52.03	60.48	65.86	68.87	**69.84**	68.87	65.86	60.48	52.03	38.62	**0.00**
	310.00	321.66	333.26	344.92	356.59	368.18	**379.84**	391.51	403.10	414.76	426.43	438.02	**449.69**



GEOTECHNICAL ENGINEERING LABORATORY TEST

TRIAXIAL COMPRESSION TEST

JOB.... **STORAGE TANK** DATE...**24/06/2018**.........

SAMPLE NO... **BH6, 7.0m** ...... LENGTH...... DIAMETER...... CELL PRESSURE: **100, 205, 310KN/m²**

FRICTION ANGLE:. ....**6.22º**..... COHESION:...**22.5kN/m²**..... WET WEIGHT:..**129g,153g,155g**.... DRY WEIGHT**g,g**.... MOISTURE CONTENT:..........

Strain Dial	Stress Dial	SD2	SD3	Stress Dial Diff	SDD2	SDD3	Area Sq m	Compressive Stress	CS2	CS3	Strain %
0	0	0	0	0.00	0.00	0.00	0.00114	0.00	0.00	0.00	0.00
15	3	7.5	7	0.01	0.03	0.03	0.00115	11.13	27.83	25.98	0.50
30	5	8	10	0.02	0.03	0.04	0.00115	18.55	29.69	37.11	1.00
45	6	9.5	11.5	0.03	0.04	0.05	0.00116	22.07	34.95	42.31	1.50
60	7	10.8	12.5	0.03	0.05	0.05	0.00116	25.75	39.73	45.98	2.00
75	7.5	12	13.8	0.03	0.05	0.06	0.00117	27.35	43.77	50.33	2.50
90	8	13	14.5	0.03	0.06	0.06	0.00118	28.93	47.01	52.44	3.00
105	8.5	13.8	16	0.04	0.06	0.07	0.00118	30.74	49.91	57.86	3.50
120	9	14.7	17	0.04	0.06	0.07	0.00119	32.27	52.71	60.96	4.00
135	10	15.5	18	0.04	0.07	0.08	0.00119	35.86	55.58	64.55	4.50
150	11	16.1	19	0.05	0.07	0.08	0.00120	39.12	57.25	67.57	5.00
165	11.2	17	20	0.05	0.07	0.09	0.00121	39.50	59.95	70.53	5.50
180	12	17.8	20.5	0.05	0.08	0.09	0.00121	42.32	62.78	72.30	6.00
210	13.5	19.2	22.5	0.06	0.08	0.10	0.00122	47.22	67.16	78.70	7.00
240	15	20.8	24	0.07	0.09	0.10	0.00124	55.06	71.58	82.59	8.00
270	16	21.8	25.5	0.07	0.09	0.11	0.00125	58.04	74.42	87.05	9.00
300	17	23	27	0.08	0.10	0.12	0.00127	60.48	77.28	90.72	10.00
330	18	24	28.5	0.08	0.10	0.12	0.00128	65.01	80.01	95.02	11.00
360	19.5	25	30	0.09	0.11	0.13	0.00130	68.93	82.06	98.48	12.00
390	21	25.8	31	0.09	0.11	0.13	0.00131	71.67	84.04	100.98	12.00
420	22	26.7	32	0.10	0.11	0.14	0.00131	74.92	86.98	104.24	13.00
450	23	27.5	33.5	0.10	0.12	0.14	0.00133	75.40	88.23	107.49	14.00
480	23.5	28.5	35	0.10	0.12	0.15	0.00134	76.43	90.76	111.46	15.00
510	24	29.3	36	0.10	0.13	0.15	0.00136	76.88	91.94	112.96	16.00
540	24.5	30	37	0.10	0.13	0.16	0.00137	76.31	93.45	115.25	17.00
570	24.5	31	38	0.11	0.13	0.16	0.00139	76.75	95.17	116.66	18.00
600	25	31.5	39	0.11	0.13	0.17	0.00139	78.29	96.71	119.73	19.00
630	25.5	32.7	40.5	0.11	0.14	0.17	0.00143	77.59	97.58	120.86	20.00
660	26	33	41.5	0.11	0.14	0.18	0.00144	79.42	97.79	122.98	21.00
690	26.8	33.5	42	0.12	0.14	0.18	0.00146	80.38	97.92	122.76	22.00
720	27.5	34	43	0.12	0.15	0.18	0.00150	79.66	96.73	122.33	24.00
750	28	34	43.8	0.12	0.15	0.19	0.00152	78.61	95.45	122.97	25.00

	∂3	∂2	∂1	Radius	Centre							
1	100.00	80.38	180.38	40.1891	140.189							
	0.00	22.22	29.94	34.80	37.90	39.63	**40.19**	39.63	37.90	34.80	29.94	22.22	**0.00**
	100.00	106.71	113.38	120.09	126.81	133.48	**140.19**	146.90	153.57	160.28	167.00	173.67	**180.38**
2	205.00	97.92	302.92	48.9576	253.958								
	0.00	27.07	36.47	42.40	46.17	48.27	**48.96**	48.27	46.17	42.40	36.47	27.07	**0.00**
	205.00	213.18	221.30	229.48	237.65	245.78	**253.96**	262.13	270.26	278.44	286.61	294.74	**302.92**
3	310.00	122.98	432.98	61.4913	371.491								
	0.00	34.00	45.81	53.25	57.99	60.63	**61.49**	60.63	57.99	53.25	45.81	34.00	**0.00**
	310.00	320.27	330.48	340.75	351.01	361.22	**371.49**	381.76	391.97	402.24	412.51	422.71	**432.98**

DESCRIPTION OF SAMPLE

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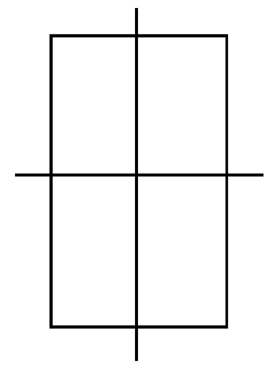
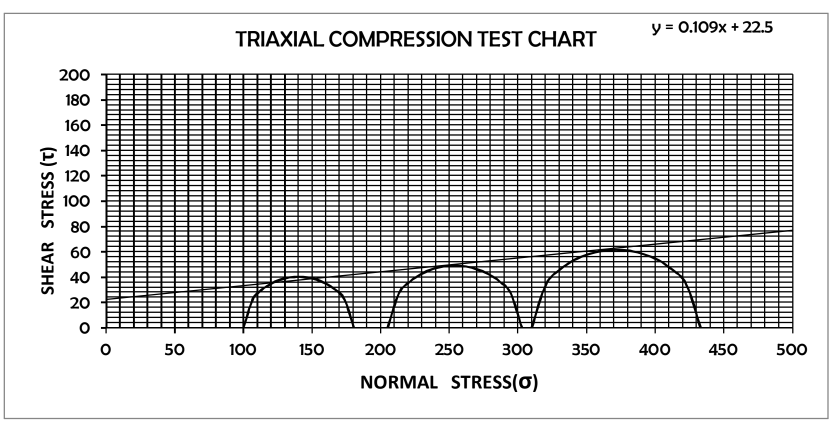


SKETCH OF SAMPLE AFTER SHEAR

Compressive Sress

Corresponding Strain



GEOTECHNICAL ENGINEERING LABORATORY TEST

TRIAXIAL COMPRESSION TEST

JOB**.... OKOMU WEIGH BRIDGE** DATE**...24/06/2018.........**

SAMPLE NO**... BH7, 4.0m......** LENGTH...... DIAMETER...... CELL PRESSURE: **100, 205, 310KN/m²**

FRICTION ANGLE:. ....**7.97º**..... COHESION**:... 15.0kN/m²**..... WET WEIGHT:..**g,g,160g...** DRY WEIGHT**g,g....** MOISTURE CONTENT:..........

Strain Dial	Stress Dial	SD2	SD3	Stress Dial Diff	SDD2	SDD3	Area Sq m	Compressive Stress	CS2	CS3	Strain %
0	0	0	0	0.00	0.00	0.00	0.00114	0.00	0.00	0.00	0.00
15	2	7	2.5	0.01	0.03	0.01	0.00115	7.42	25.98	9.28	0.50
30	2.2	8	4	0.01	0.03	0.02	0.00115	8.16	29.69	14.84	1.00
45	2.8	9	5	0.01	0.04	0.02	0.00116	10.30	33.11	18.39	1.50
60	3.5	10	6	0.01	0.04	0.03	0.00116	12.88	36.79	22.07	2.00
75	4	11	7.5	0.02	0.05	0.03	0.00117	14.59	40.12	27.35	2.50
90	4.8	12	9	0.02	0.05	0.04	0.00118	17.36	43.40	32.55	3.00
105	5.5	13	10	0.02	0.06	0.04	0.00118	19.89	47.01	36.16	3.50
120	6	14.5	11	0.03	0.06	0.05	0.00119	21.52	52.00	39.45	4.00
135	6.5	15.5	12	0.03	0.07	0.05	0.00119	23.31	55.58	43.03	4.50
150	7.5	16.5	13.5	0.03	0.07	0.06	0.00120	26.67	58.68	48.01	5.00
165	8	17.5	14.5	0.03	0.07	0.06	0.00121	28.21	61.72	51.14	5.50
180	8.8	19	16	0.04	0.08	0.07	0.00121	31.04	67.01	56.43	6.00
210	10	20.5	18.5	0.04	0.09	0.08	0.00122	34.98	71.71	64.71	7.00
240	11	21.5	21	0.05	0.09	0.09	0.00124	41.30	73.99	72.27	8.00
270	12	23	23	0.06	0.10	0.10	0.00125	44.38	78.52	78.52	9.00
300	13	24	24.5	0.06	0.10	0.10	0.00127	47.04	80.64	82.32	10.00
330	14	25	26	0.06	0.11	0.11	0.00128	50.01	83.35	86.68	11.00
360	15	26	28	0.07	0.11	0.12	0.00130	52.52	85.35	91.91	12.00
390	16	27	30	0.07	0.12	0.13	0.00131	54.73	87.95	97.73	12.00
420	16.8	28	31.5	0.07	0.12	0.13	0.00131	57.01	91.21	102.61	13.00
450	17.5	29	33	0.08	0.12	0.14	0.00133	59.36	93.05	105.88	14.00
480	18.5	30	34.5	0.08	0.13	0.15	0.00134	60.51	95.54	109.87	15.00
510	19	30.5	35.5	0.09	0.13	0.15	0.00136	62.76	95.70	111.39	16.00
540	20	31	36.5	0.09	0.13	0.16	0.00137	63.85	96.56	113.69	17.00
570	20.5	31.5	37	0.09	0.13	0.16	0.00139	64.47	96.71	113.59	18.00
600	21	32	38	0.09	0.14	0.16	0.00139	66.01	98.24	116.66	19.00
630	21.5	33	38.8	0.09	0.14	0.17	0.00143	65.65	98.48	115.79	20.00
660	22	33.5	39.2	0.09	0.14	0.17	0.00144	65.79	99.28	116.17	21.00
690	22.2	34	40	0.10	0.15	0.17	0.00146	65.76	99.38	116.91	22.00
720	22.5	34.5	41	0.10	0.15	0.17	0.00150	65.43	98.15	116.64	24.00
750	23	35	41	0.10	0.15	0.17	0.00152	64.57	98.26	115.11	25.00

DESCRIPTION OF SAMPLE

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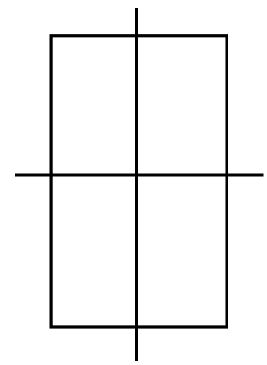
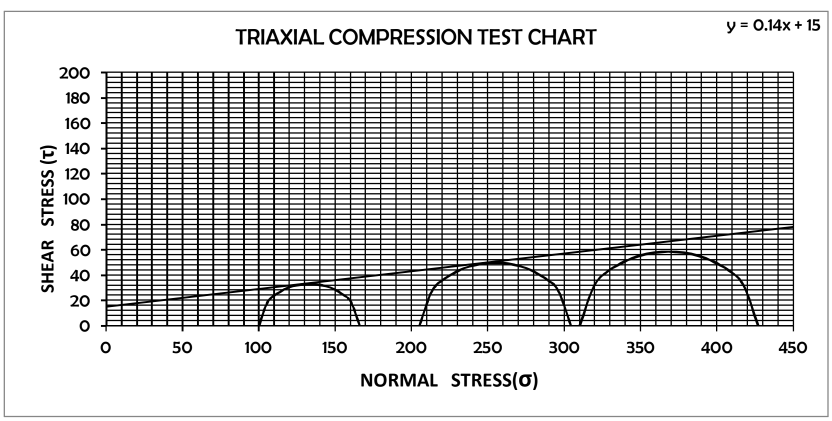


SKETCH OF SAMPLE AFTER SHEAR

Compressive Sress

Corresponding Strain

	∂3	∂2	∂1	Radius	Centre								
1	100.00	66.01	166.01	33.0029	133.003								
	0.00	18.25	24.59	28.58	31.12	32.54	**33.00**	32.54	31.12	28.58	24.59	18.25	**0.00**
	100.00	105.51	110.99	116.50	122.01	127.49	**133.00**	138.51	143.99	149.50	155.02	160.49	**166.01**
2	205.00	99.38	304.38	49.6883	254.688								
	0.00	27.48	37.02	43.03	46.86	48.99	**49.69**	48.99	46.86	43.03	37.02	27.48	**0.00**
	205.00	213.30	221.55	229.84	238.14	246.39	**254.69**	262.99	271.23	279.53	287.83	296.08	**304.38**
3	310.00	116.91	426.91	58.4568	368.457								
	0.00	32.33	43.55	50.62	55.12	57.64	**58.46**	57.64	55.12	50.62	43.55	32.33	**0.00**
	310.00	319.76	329.47	339.23	348.99	358.69	**368.46**	378.22	387.92	397.69	407.45	417.15	**426.91**



GEOTECHNICAL ENGINEERING LABORATORY TEST

TRIAXIAL COMPRESSION TEST

JOB**.... OKOMU WEIGH BRIDGE** DATE**...24/06/2018.........**

SAMPLE NO**... BH7, 15.0m......** LENGTH...... DIAMETER...... CELL PRESSURE: **100, 205, 310KN/m²**

FRICTION ANGLE:. ....**14.49º**..... COHESION:**... 40.0kN/m²**..... WET WEIGHT:..**134g,155g,160g....** DRY WEIGHT**g,g....** MOISTURE CONTENT:..........

Strain Dial	Stress Dial	SD2	SD3	Stress Dial Diff	SDD2	SDD3	Area Sq m	Compressive Stress	CS2	CS3	Strain %
0	0	0	0	0.00	0.00	0.00	0.00114	0.00	0.00	0.00	0.00
15	6	12	11.5	0.03	0.05	0.05	0.00115	22.26	44.53	42.67	0.50
30	9	22	17	0.04	0.09	0.07	0.00115	33.40	81.64	63.08	1.00
45	11.5	28	22.5	0.05	0.12	0.10	0.00116	42.31	103.01	82.77	1.50
60	13	32.5	26	0.06	0.14	0.11	0.00116	47.82	119.56	95.65	2.00
75	14.8	36	29	0.06	0.15	0.12	0.00117	53.98	131.30	105.77	2.50
90	15.9	39.3	32	0.07	0.17	0.14	0.00118	57.50	142.12	115.72	3.00
105	17	42	33.7	0.07	0.18	0.14	0.00118	61.48	151.89	121.87	3.50
120	18.5	45	36.1	0.08	0.19	0.15	0.00119	66.34	161.37	129.45	4.00
135	20	47.5	38.5	0.09	0.20	0.16	0.00119	71.72	170.34	138.06	4.50
150	21.5	50	41	0.09	0.21	0.17	0.00120	76.46	177.81	145.80	5.00
165	23.1	52.5	43	0.10	0.22	0.18	0.00121	81.47	185.15	151.65	5.50
180	25	55	45	0.11	0.23	0.19	0.00121	88.17	193.97	158.70	6.00
210	28.8	59.3	49	0.12	0.25	0.21	0.00122	100.74	207.42	171.39	7.00
240	32	63.5	53.8	0.15	0.27	0.23	0.00124	122.17	218.53	185.15	8.00
270	35.5	68.8	58.1	0.17	0.29	0.25	0.00125	132.46	234.87	198.35	9.00
300	38.8	73.5	63	0.18	0.31	0.27	0.00127	139.44	246.97	211.69	10.00
330	41.5	77.8	69	0.19	0.33	0.29	0.00128	148.36	259.37	230.04	11.00
360	44.5	81.8	73.8	0.20	0.35	0.31	0.00130	153.30	268.51	242.25	12.00
390	46.7	84	78	0.21	0.36	0.33	0.00131	157.99	273.63	254.09	12.00
420	48.5	87.5	80.3	0.21	0.37	0.34	0.00131	162.88	285.03	261.58	13.00
450	50	87.5	84	0.22	0.37	0.36	0.00133	162.99	280.75	269.52	14.00
480	50.8	87.5	87.5	0.22	0.37	0.37	0.00134	162.10	278.65	278.65	15.00
510	50.9	87.5	91	0.22	0.37	0.39	0.00136	159.71	274.55	285.54	16.00
540	50.9	87.5	93.5	0.22	0.37	0.40	0.00137	158.55	272.55	291.24	17.00
570	50.9	87.5	96.2	0.22	0.37	0.41	0.00139	156.26	268.63	295.34	18.00
600	50.9	87.5	97.1	0.22	0.37	0.41	0.00139	156.26	268.63	298.10	19.00
630	50.9	87.5	100	0.22	0.37	0.43	0.00143	151.89	261.11	298.42	20.00
660	50.9	87.5	102	0.22	0.37	0.44	0.00144	150.84	259.30	302.27	21.00
690	50.9	87.5	103.9	0.22	0.37	0.44	0.00146	148.77	255.75	303.68	22.00
720	50.9	87.5	105.2	0.22	0.37	0.45	0.00150	144.81	248.93	299.28	24.00
750	50.9	87.5	107	0.22	0.37	0.46	0.00152	142.90	245.65	300.40	25.00

DESCRIPTION OF SAMPLE

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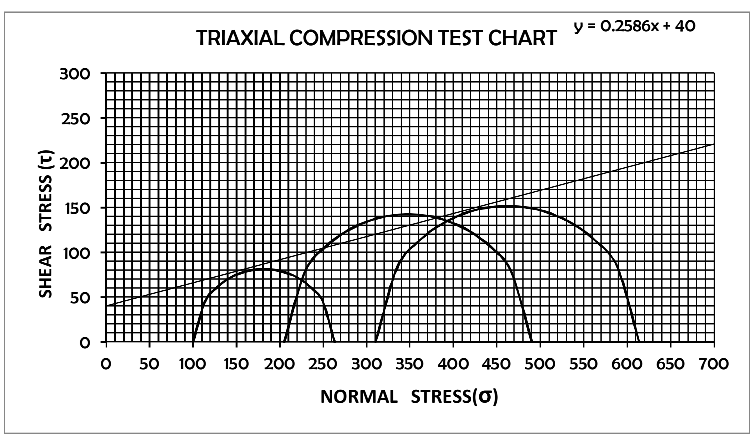
SKETCH OF SAMPLE AFTER SHEAR

Compressive Sress

Corresponding Strain

	∂3	∂2	∂1	Radius	Centre								
1	100.00	162.99	262.99	81.4968	181.497								
	0.00	45.07	60.72	70.58	76.85	80.36	**81.50**	80.36	76.85	70.58	60.72	45.07	**0.00**
	100.00	113.61	127.14	140.75	154.36	167.89	**181.50**	195.11	208.64	222.25	235.86	249.38	**262.99**
2	205.00	285.03	490.03	142.516	347.516								
	0.00	78.81	106.17	123.42	134.39	140.52	**142.52**	140.52	134.39	123.42	106.17	78.81	**0.00**
	205.00	228.80	252.46	276.26	300.06	323.72	**347.52**	371.32	394.97	418.77	442.57	466.23	**490.03**
3	310.00	303.68	613.68	151.842	461.842								
	0.00	83.97	113.12	131.49	143.19	149.72	**151.84**	149.72	143.19	131.49	113.12	83.97	**0.00**
	310.00	335.36	360.56	385.92	411.28	436.48	**461.84**	487.20	512.40	537.76	563.12	588.33	**613.68**



GEOTECHNICAL ENGINEERING LABORATORY TEST

TRIAXIAL COMPRESSION TEST

JOB.... **OKOMU WATER TANK** DATE...**24/06/2018**………

SAMPLE NO... **BH8, 3.0m……** LENGTH…… DIAMETER…… CELL PRESSURE: **100, 205, 310KN/m²**

FRICTION ANGLE:. ....**12.64º**..... COHESION:... **45.0kN/m²**.... WET WEIGHT:..**156g,160g,160g**.... DRY WEIGHT**g,g**.... MOISTURE CONTENT:..........

Strain Dial	Stress Dial	SD2	SD3	Stress Dial Diff	SDD2	SDD3	Area Sq m	Compressive Stress	CS2	CS3	Strain %
0	0	0	0	0.00	0.00	0.00	0.00114	0.00	0.00	0.00	0.00
15	10.5	6	17	0.04	0.03	0.07	0.00115	38.96	22.26	63.08	0.50
30	13	20.5	25.5	0.06	0.09	0.11	0.00115	48.24	76.07	94.62	1.00
45	14.5	22.5	30.6	0.06	0.10	0.13	0.00116	53.34	82.77	112.57	1.50
60	16	24.5	33.5	0.07	0.10	0.14	0.00116	58.86	90.13	123.24	2.00
75	18	26.5	35.7	0.08	0.11	0.15	0.00117	65.65	96.65	130.21	2.50
90	19	28.5	37.5	0.08	0.12	0.16	0.00118	68.71	103.07	135.61	3.00
105	21	30	39.5	0.09	0.13	0.17	0.00118	75.94	108.49	142.85	3.50
120	23	31.5	41.2	0.10	0.13	0.18	0.00119	82.48	112.96	147.74	4.00
135	25	32.8	43	0.11	0.14	0.18	0.00119	89.65	117.62	154.20	4.50
150	26.5	34	45	0.11	0.15	0.19	0.00120	94.24	120.91	160.03	5.00
165	28.5	35	46.9	0.12	0.15	0.20	0.00121	100.51	123.44	165.40	5.50
180	30	36.7	48.5	0.13	0.16	0.21	0.00121	105.80	129.43	171.05	6.00
210	33.5	39.5	52.5	0.14	0.17	0.22	0.00122	117.18	138.16	183.64	7.00
240	36.3	42.2	55.3	0.17	0.18	0.24	0.00124	134.22	145.23	190.31	8.00
270	39	45	59	0.17	0.19	0.25	0.00125	139.97	153.62	201.42	9.00
300	41	46.5	61.5	0.18	0.20	0.26	0.00127	144.49	156.25	206.65	10.00
330	43	48.3	64	0.19	0.21	0.27	0.00128	148.36	161.03	213.37	11.00
360	44.5	49.5	66.5	0.20	0.21	0.28	0.00130	151.00	162.49	218.29	12.00
390	46	50.9	68.9	0.20	0.22	0.29	0.00131	153.10	165.81	224.44	12.00
420	47	52	70.5	0.21	0.22	0.30	0.00131	156.69	169.39	229.66	13.00
450	48.1	53.3	73	0.21	0.23	0.31	0.00133	157.22	171.01	234.22	14.00
480	49	54.3	76.5	0.21	0.23	0.33	0.00134	160.18	172.92	243.62	15.00
510	50.3	55.5	80.3	0.22	0.24	0.34	0.00136	160.65	174.15	251.96	16.00
540	51.2	56.9	83	0.22	0.24	0.35	0.00137	161.97	177.24	258.53	17.00
570	52	58	86	0.23	0.25	0.37	0.00139	162.71	178.06	264.02	18.00
600	53	60	88.5	0.23	0.26	0.38	0.00139	166.09	184.20	271.70	19.00
630	54.1	61.9	91	0.23	0.26	0.39	0.00143	164.13	184.72	271.56	20.00
660	55	63.5	93.5	0.24	0.27	0.40	0.00144	165.06	188.18	277.08	21.00
690	55.7	64.5	96	0.24	0.28	0.41	0.00146	166.31	188.52	280.59	22.00
720	56.9	65.5	98.5	0.25	0.28	0.42	0.00150	165.00	186.34	280.22	24.00
750	58	67	100.5	0.25	0.29	0.43	0.00152	162.83	188.10	282.15	25.00

	∂3	∂2	∂1	Radius	Centre								
1	100.00	166.31	266.31	83.1549	183.155								
	0.00	45.98	61.95	72.01	78.42	81.99	**83.15**	81.99	78.42	72.01	61.95	45.98	**0.00**
	100.00	113.89	127.69	141.58	155.46	169.27	**183.15**	197.04	210.85	224.73	238.62	252.42	**266.31**
2	205.00	188.52	393.52	94.2617	299.262								
	0.00	52.13	70.22	81.63	88.89	92.94	**94.26**	92.94	88.89	81.63	70.22	52.13	**0.00**
	205.00	220.74	236.39	252.13	267.87	283.52	**299.26**	315.00	330.65	346.39	362.13	377.78	**393.52**
3	310.00	282.15	592.15	141.075	451.075								
	0.00	78.01	105.10	122.17	133.03	139.10	**141.08**	139.10	133.03	122.17	105.10	78.01	**0.00**
	310.00	333.56	356.98	380.54	404.10	427.52	**451.08**	474.63	498.05	521.61	545.17	568.59	**592.15**

DESCRIPTION OF SAMPLE

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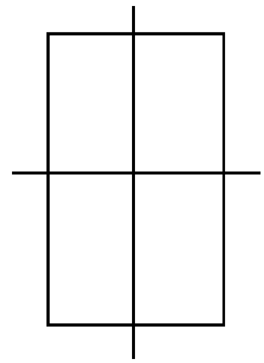
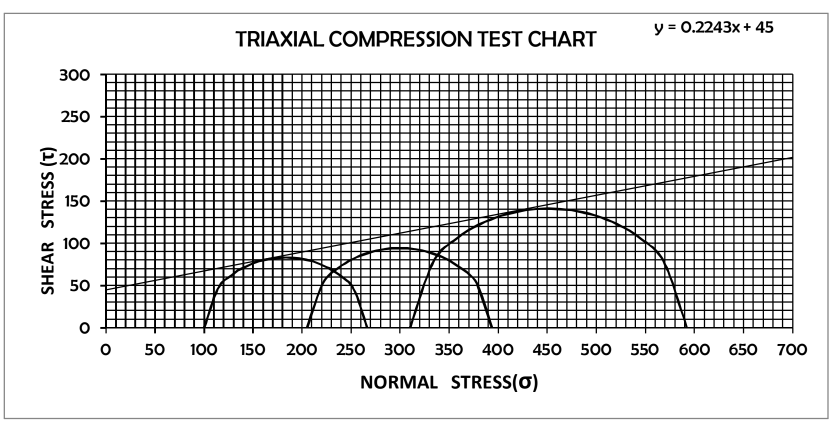


SKETCH OF SAMPLE AFTER SHEAR

Compressive Sress

Corresponding Strain



GEOTECHNICAL ENGINEERING LABORATORY TEST

TRIAXIAL COMPRESSION TEST

JOB.... **OKOMU WATER TANK** DATE...**24/06/2018**.........

SAMPLE NO... **BH8, 9.0m**...... LENGTH...... DIAMETER...... CELL PRESSURE: **100, 205, 310KN/m²**

FRICTION ANGLE: ....**5.94º**..... COHESION:... **45.0kN/m²**..... WET WEIGHT:..**156g,158g,160g**.... DRY WEIGHT**g,g....** MOISTURE CONTENT:..........

Strain Dial	Stress Dial	SD2	SD3	Stress Dial Diff	SDD2	SDD3	Area Sq m	Compressive Stress	CS2	CS3	Strain %
0	0	0	0	0.00	0.00	0.00	0.00114	0.00	0.00	0.00	0.00
15	6	7.5	6.5	0.03	0.03	0.03	0.00115	22.26	27.83	24.12	0.50
30	8	8.9	7.2	0.03	0.04	0.03	0.00115	29.69	33.03	26.72	1.00
45	10	10	8.5	0.04	0.04	0.04	0.00116	36.79	36.79	31.27	1.50
60	12	11	13.8	0.05	0.05	0.06	0.00116	44.15	40.47	50.77	2.00
75	14	12	15.5	0.06	0.05	0.07	0.00117	51.06	43.77	56.53	2.50
90	16	13.5	17	0.07	0.06	0.07	0.00118	57.86	48.82	61.48	3.00
105	18	14.5	18.5	0.08	0.06	0.08	0.00118	65.10	52.44	66.90	3.50
120	20	15	20	0.09	0.06	0.09	0.00119	71.72	53.79	71.72	4.00
135	21.5	16.8	21.9	0.09	0.07	0.09	0.00119	77.10	60.24	78.53	4.50
150	23	18	23.2	0.10	0.08	0.10	0.00120	81.79	64.01	82.50	5.00
165	24	19	25	0.10	0.08	0.11	0.00121	84.64	67.01	88.17	5.50
180	25	20	26.5	0.11	0.09	0.11	0.00121	88.17	70.53	93.46	6.00
210	26.5	23	29	0.11	0.10	0.12	0.00122	92.69	80.45	101.44	7.00
240	28.5	25.5	31.9	0.13	0.11	0.14	0.00124	103.24	87.76	109.78	8.00
270	30	28	34	0.13	0.12	0.15	0.00125	106.85	95.59	116.07	9.00
300	31.3	30	36.5	0.14	0.13	0.16	0.00127	109.20	100.80	122.64	10.00
330	32.5	32	38.5	0.14	0.14	0.16	0.00128	110.02	106.68	128.35	11.00
360	33	34	41	0.15	0.15	0.17	0.00130	111.61	111.61	134.59	12.00
390	34	36	42.5	0.15	0.15	0.18	0.00131	112.38	117.27	138.44	12.00
420	34.5	37.8	44.5	0.15	0.16	0.19	0.00131	115.64	123.13	144.96	13.00
450	35.5	39.2	46	0.15	0.17	0.20	0.00133	115.51	125.77	147.59	14.00
480	36	40.8	47.9	0.16	0.17	0.20	0.00134	117.83	129.93	152.54	15.00
510	37	42.2	49.1	0.16	0.18	0.21	0.00136	118.61	132.41	154.06	16.00
540	37.8	44	50.9	0.16	0.19	0.22	0.00137	119.92	137.05	158.55	17.00
570	38.5	45	52.5	0.17	0.19	0.22	0.00139	120.65	138.15	161.18	18.00
600	39.3	46	53.7	0.17	0.20	0.23	0.00139	122.19	141.22	164.86	19.00
630	39.8	47.3	55	0.17	0.20	0.23	0.00143	120.86	141.15	164.13	20.00
660	40.5	48.8	56	0.17	0.21	0.24	0.00144	121.50	144.62	165.95	21.00
690	41	50	57.2	0.18	0.21	0.24	0.00146	121.30	146.14	167.19	22.00
720	41.5	50.8	58.2	0.18	0.22	0.25	0.00150	119.77	144.52	165.57	24.00
750	42.1	51.9	59.3	0.18	0.22	0.25	0.00152	118.19	145.71	166.48	25.00

DESCRIPTION OF SAMPLE

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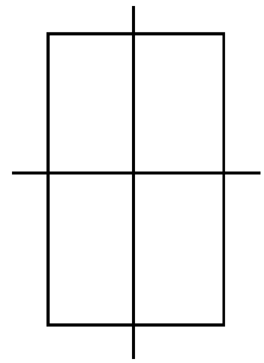
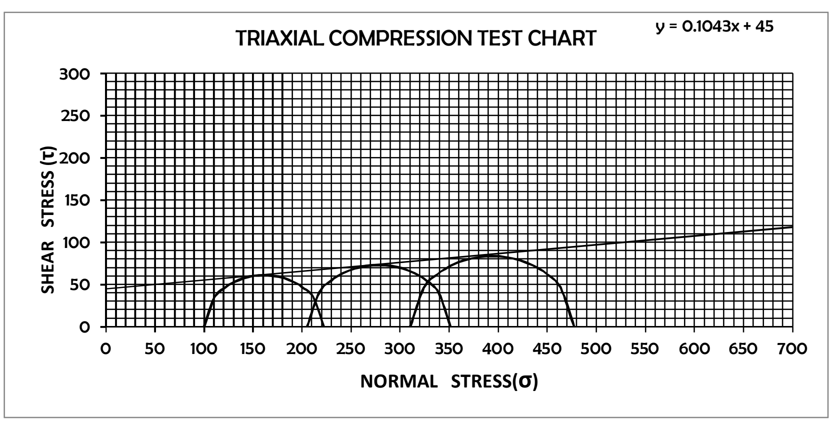


SKETCH OF SAMPLE AFTER SHEAR

Compressive Sress

Corresponding Strain

	∂3	∂2	∂1	Radius	Centre								
1	100.00	122.19	222.19	61.0937	161.094								
	0.00	33.78	45.51	52.91	57.61	60.24	**61.09**	60.24	57.61	52.91	45.51	33.78	**0.00**
	100.00	110.20	120.34	130.55	140.75	150.89	**161.09**	171.30	181.44	191.64	201.84	211.98	**222.19**
2	205.00	146.14	351.14	73.0711	278.071								
	0.00	40.41	54.44	63.28	68.91	72.05	**73.07**	72.05	68.91	63.28	54.44	40.41	**0.00**
	205.00	217.20	229.33	241.54	253.74	265.87	**278.07**	290.27	302.40	314.61	326.81	338.94	**351.14**
3	310.00	167.19	477.19	83.5933	393.593								
	0.00	46.23	62.28	72.39	78.83	82.42	**83.59**	82.42	78.83	72.39	62.28	46.23	**0.00**
	310.00	323.96	337.84	351.80	365.76	379.63	**393.59**	407.55	421.43	435.39	449.35	463.23	**477.19**



GEOTECHNICAL ENGINEERING LABORATORY TEST

TRIAXIAL COMPRESSION TEST

JOB.... **WATER TANK** DATE...**24/06/2018**.........

SAMPLE NO... **BH8, 12.0m** ...... LENGTH...... DIAMETER...... CELL PRESSURE: **100, 205, 310KN/m²**

FRICTION ANGLE:. ....**3.68º**..... COHESION:..**40.0kN/m²**..... WET WEIGHT:..**128g,155g,165g**.... DRY WEIGHT**g,g**.... MOISTURE CONTENT:..........

Strain Dial	Stress Dial	SD2	SD3	Stress Dial Diff	SDD2	SDD3	Area Sq m	Compressive Stress	CS2	CS3	Strain %
0	0	0	0	0.00	0.00	0.00	0.00114	0.00	0.00	0.00	0.00
15	4	5	8	0.02	0.02	0.03	0.00115	14.84	18.55	29.69	0.50
30	4.5	6	10	0.02	0.03	0.04	0.00115	16.70	22.26	37.11	1.00
45	5.2	7.5	13	0.02	0.03	0.06	0.00116	19.13	27.59	47.82	1.50
60	5.3	8.8	14	0.02	0.04	0.06	0.00116	19.50	32.37	51.50	2.00
75	5.5	10	15	0.02	0.04	0.06	0.00117	20.06	36.47	54.71	2.50
90	5.5	11	16	0.02	0.05	0.07	0.00118	19.89	39.78	57.86	3.00
105	6	12	17	0.03	0.05	0.07	0.00118	21.70	43.40	61.48	3.50
120	6.2	13	18	0.03	0.06	0.08	0.00119	22.23	46.62	64.55	4.00
135	6.5	14	19.3	0.03	0.06	0.08	0.00119	23.31	50.20	69.21	4.50
150	7	15	20.5	0.03	0.06	0.09	0.00120	24.89	53.34	72.90	5.00
165	7.5	16	21.3	0.03	0.07	0.09	0.00121	26.45	56.43	75.12	5.50
180	8	17	22	0.03	0.07	0.09	0.00121	28.21	59.95	77.59	6.00
210	8.8	19	23	0.04	0.08	0.10	0.00122	30.78	66.46	80.45	7.00
240	9.5	21	24.5	0.04	0.09	0.10	0.00124	34.41	72.27	84.31	8.00
270	10	23	26	0.05	0.10	0.11	0.00125	37.55	78.52	88.76	9.00
300	11	24	27.2	0.05	0.10	0.12	0.00127	40.32	80.64	91.40	10.00
330	12	26	28.5	0.05	0.11	0.12	0.00128	40.67	86.68	95.02	11.00
360	12.2	27	29.5	0.06	0.12	0.13	0.00130	42.67	88.63	96.84	12.00
390	13	28.5	31	0.06	0.12	0.13	0.00131	43.98	92.84	100.98	12.00
420	13.5	29.2	31.5	0.06	0.12	0.13	0.00131	45.61	95.12	102.61	13.00
450	14	30.5	32.5	0.06	0.13	0.14	0.00133	46.52	97.86	104.28	14.00
480	14.5	31.5	34	0.06	0.13	0.15	0.00134	47.77	100.31	108.28	15.00
510	15	32.2	34.8	0.07	0.14	0.15	0.00136	48.64	101.04	109.19	16.00
540	15.5	33.5	35.8	0.07	0.14	0.15	0.00137	49.84	104.35	111.51	17.00
570	16	34.5	36.8	0.07	0.15	0.16	0.00139	52.19	105.92	112.98	18.00
600	17	35	38	0.08	0.15	0.16	0.00139	55.26	107.45	116.66	19.00
630	18	36.5	38.8	0.08	0.16	0.17	0.00143	55.21	108.92	115.79	20.00
660	18.5	37	40	0.08	0.16	0.17	0.00144	56.31	109.65	118.54	21.00
690	19	38	42	0.09	0.16	0.18	0.00146	58.46	111.07	122.76	22.00
720	20	39	43.5	0.09	0.17	0.19	0.00150	57.47	110.95	123.75	24.00
750	20.2	39	45	0.09	0.17	0.19	0.00152	56.71	109.49	126.34	25.00

DESCRIPTION OF SAMPLE

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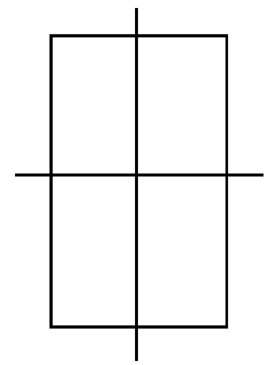
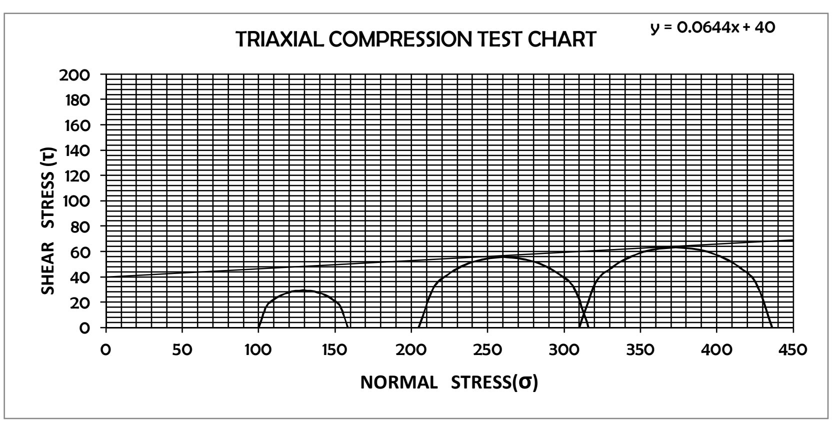


SKETCH OF SAMPLE AFTER SHEAR

Compressive Sress

Corresponding Strain

	∂3	∂2	∂1	Radius	Centre							
1	100.00	58.46	158.46	29.2284	129.228							
	0.00	16.16	21.78	25.31	27.56	28.82	**29.23**	28.82	27.56	25.31	21.78	16.16	**0.00**
	100.00	104.88	109.73	114.61	119.50	124.35	**129.23**	134.11	138.96	143.84	148.72	153.58	**158.46**
2	205.00	111.07	316.07	55.534	260.534							
	0.00	30.71	41.37	48.09	52.37	54.76	**55.53**	54.76	52.37	48.09	41.37	30.71	**0.00**
	205.00	214.27	223.49	232.77	242.04	251.26	**260.53**	269.81	279.03	288.30	297.58	306.79	**316.07**
3	310.00	126.34	436.34	63.168	373.168							
	0.00	34.93	47.06	54.70	59.57	62.28	**63.17**	62.28	59.57	54.70	47.06	34.93	**0.00**
	310.00	320.55	331.03	341.58	352.13	362.62	**373.17**	383.72	394.20	404.75	415.30	425.79	**436.34**



GEOTECHNICAL ENGINEERING LABORATORY TEST

TRIAXIAL COMPRESSION TEST

JOB**.... OKOMU RAMP 1** DATE**...24/06/2018.........**

SAMPLE NO**... BH9, 8.0m ......** LENGTH...... DIAMETER...... CELL PRESSURE: **100, 205, 310KN/m²**

FRICTION ANGLE:. ....**9.15º**..... COHESION**:... 4.0kN/m²**..... WET WEIGHT:..**140g,127g,153g....** DRY WEIGHT**g,g....** MOISTURE CONTENT:..........

Strain Dial	Stress Dial	SD2	SD3	Stress Dial Diff	SDD2	SDD3	Area Sq m	Compressive Stress	CS2	CS3	Strain %
0	0	0	0	0.00	0.00	0.00	0.00114	0.00	0.00	0.00	0.00
15	1	1.2	2	0.00	0.01	0.01	0.00115	3.71	4.45	7.42	0.50
30	1.5	1.8	6	0.01	0.01	0.03	0.00115	5.57	6.68	22.26	1.00
45	2	2	11	0.01	0.01	0.05	0.00116	7.36	7.36	40.47	1.50
60	2.5	2.5	13	0.01	0.01	0.06	0.00116	9.20	9.20	47.82	2.00
75	3	2.8	14.5	0.01	0.01	0.06	0.00117	10.94	10.21	52.89	2.50
90	3.5	3	15	0.01	0.01	0.06	0.00118	12.66	10.85	54.25	3.00
105	4	3.5	16	0.02	0.01	0.07	0.00118	14.47	12.66	57.86	3.50
120	4.5	4	17	0.02	0.02	0.07	0.00119	16.14	14.34	60.96	4.00
135	5	4.5	18	0.02	0.02	0.08	0.00119	17.93	16.14	64.55	4.50
150	5.5	4.8	19	0.02	0.02	0.08	0.00120	19.56	17.07	67.57	5.00
165	6	5	20	0.03	0.02	0.09	0.00121	21.16	17.63	70.53	5.50
180	6.5	5.5	21	0.03	0.02	0.09	0.00121	22.92	19.40	74.06	6.00
210	7.5	6.5	23	0.03	0.03	0.10	0.00122	26.23	22.74	80.45	7.00
240	8.5	7.5	25	0.04	0.03	0.11	0.00124	30.97	25.81	86.04	8.00
270	9	8	26.5	0.04	0.03	0.11	0.00125	34.14	27.31	90.47	9.00
300	10	9	28	0.04	0.04	0.12	0.00127	35.28	30.24	94.08	10.00
330	10.5	10	30	0.05	0.04	0.13	0.00128	36.67	33.34	100.02	11.00
360	11	11	31.5	0.05	0.05	0.13	0.00130	37.75	36.11	103.40	12.00
390	11.5	11.8	32.5	0.05	0.05	0.14	0.00131	39.09	38.44	105.87	12.00
420	12	12.5	34	0.05	0.05	0.15	0.00131	39.74	40.72	110.76	13.00
450	12.2	13	35.2	0.05	0.06	0.15	0.00133	40.11	41.71	112.94	14.00
480	12.5	13.5	36.5	0.06	0.06	0.16	0.00134	41.40	42.99	116.24	15.00
510	13	14	37	0.06	0.06	0.16	0.00136	42.36	43.93	116.10	16.00
540	13.5	14.5	38	0.06	0.06	0.16	0.00137	43.61	45.17	118.36	17.00
570	14	15	39	0.06	0.06	0.17	0.00139	43.59	46.05	119.73	18.00
600	14.2	15.2	40	0.06	0.06	0.17	0.00139	44.52	46.66	122.80	19.00
630	14.5	15.8	40.8	0.06	0.07	0.17	0.00143	44.76	47.15	121.75	20.00
660	15	16	41.2	0.06	0.07	0.18	0.00144	45.04	47.42	122.09	21.00
690	15.2	16.5	43	0.07	0.07	0.18	0.00146	46.77	48.23	125.68	22.00
720	16	16.8	44	0.07	0.07	0.19	0.00150	45.52	47.79	125.18	24.00
750	16	17.5	45	0.07	0.07	0.19	0.00152	44.92	49.13	126.34	25.00

DESCRIPTION OF SAMPLE

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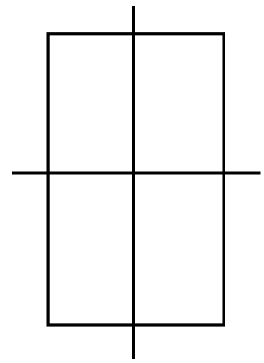
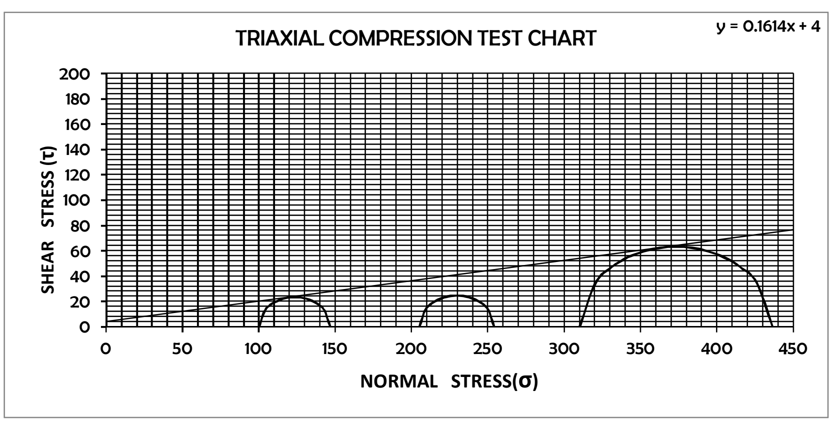


SKETCH OF SAMPLE AFTER SHEAR

Compressive Sress

Corresponding Strain

	∂3	∂2	∂1	Radius	Centre								
1	100.00	46.77	146.77	23.3827	123.383								
	0.00	12.93	17.42	20.25	22.05	23.06	**23.38**	23.06	22.05	20.25	17.42	12.93	**0.00**
	100.00	103.90	107.79	111.69	115.60	119.48	**123.38**	127.29	131.17	135.07	138.98	142.86	**146.77**
2	205.00	49.13	254.13	24.5653	229.565								
	0.00	13.58	18.30	21.27	23.17	24.22	**24.57**	24.22	23.17	21.27	18.30	13.58	**0.00**
	205.00	209.10	213.18	217.28	221.39	225.46	**229.57**	233.67	237.75	241.85	245.95	250.03	**254.13**
3	310.00	126.34	436.34	63.168	373.168								
	0.00	34.93	47.06	54.70	59.57	62.28	**63.17**	62.28	59.57	54.70	47.06	34.93	**0.00**
	310.00	320.55	331.03	341.58	352.13	362.62	**373.17**	383.72	394.20	404.75	415.30	425.79	**436.34**



GEOTECHNICAL ENGINEERING LABORATORY TEST

TRIAXIAL COMPRESSION TEST

JOB**.... OKOMU RAMP 1** DATE**...24/06/2018.........**

SAMPLE NO**... BH9, 11.0m......** LENGTH...... DIAMETER...... CELL PRESSURE: **100, 205, 310KN/m²**

FRICTION ANGLE:. ....**9.29º**..... COHESION:**... 35.0kN/m²**..... WET WEIGHT:..**159g,160g,160g....** DRY WEIGHT**g,g....** MOISTURE CONTENT:..........

Strain Dial	Stress Dial	SD2	SD3	Stress Dial Diff	SDD2	SDD3	Area Sq m	Compressive Stress	CS2	CS3	Strain %
0	0	0	0	0.00	0.00	0.00	0.00114	0.00	0.00	0.00	0.00
15	4	6	5	0.02	0.03	0.02	0.00115	14.84	22.26	18.55	0.50
30	5	7.5	8.5	0.02	0.03	0.04	0.00115	18.55	27.83	31.54	1.00
45	6.1	9.5	13	0.03	0.04	0.06	0.00116	22.44	34.95	47.82	1.50
60	7.2	11.5	15.5	0.03	0.05	0.07	0.00116	26.49	42.31	57.02	2.00
75	8.2	14.7	17	0.03	0.06	0.07	0.00117	29.91	53.62	62.00	2.50
90	9.2	17.2	18.5	0.04	0.07	0.08	0.00118	33.27	62.20	66.90	3.00
105	10.2	19.7	20	0.04	0.08	0.09	0.00118	36.89	71.24	72.33	3.50
120	11.1	22	21.3	0.05	0.09	0.09	0.00119	39.80	78.89	76.38	4.00
135	12.1	24.8	22.7	0.05	0.11	0.10	0.00119	43.39	88.93	81.40	4.50
150	13.2	26.9	24	0.06	0.11	0.10	0.00120	46.94	95.66	85.35	5.00
165	14.2	28.9	25.2	0.06	0.12	0.11	0.00121	50.08	101.92	88.87	5.50
180	15.5	31	26.3	0.07	0.13	0.11	0.00121	54.66	109.33	92.75	6.00
210	17.9	34	28.8	0.08	0.15	0.12	0.00122	62.61	118.93	100.74	7.00
240	19.8	36	31	0.09	0.15	0.13	0.00124	73.99	123.89	106.68	8.00
270	21.5	38	33	0.10	0.16	0.14	0.00125	80.23	129.73	112.66	9.00
300	23.5	40	35	0.11	0.17	0.15	0.00127	85.68	134.40	117.60	10.00
330	25.5	42	36.8	0.12	0.18	0.16	0.00128	90.68	140.02	122.69	11.00
360	27.2	43	38.5	0.12	0.18	0.16	0.00130	93.55	141.15	126.38	12.00
390	28.5	44	40	0.13	0.19	0.17	0.00131	96.10	143.33	130.30	12.00
420	29.5	44.6	41.9	0.13	0.19	0.18	0.00131	99.35	145.29	136.49	13.00
450	30.5	45.3	43.3	0.14	0.19	0.18	0.00133	102.67	145.35	138.93	14.00
480	32	46.1	45	0.14	0.20	0.19	0.00134	103.50	146.81	143.31	15.00
510	32.5	47	46.9	0.15	0.20	0.20	0.00136	109.82	147.47	147.16	16.00
540	35	48.3	48.3	0.15	0.21	0.21	0.00137	113.07	150.45	150.45	17.00
570	36.3	49.7	50	0.16	0.21	0.21	0.00139	115.13	152.58	153.50	18.00
600	37.5	51.1	51	0.17	0.22	0.22	0.00139	118.81	156.88	156.57	19.00
630	38.7	52.5	52.2	0.17	0.22	0.22	0.00143	117.28	156.67	155.77	20.00
660	39.3	53.3	53.5	0.17	0.23	0.23	0.00144	120.02	157.95	158.54	21.00
690	40.5	54.5	54.9	0.18	0.23	0.23	0.00146	120.13	159.29	160.46	22.00
720	41.1	55.9	56.2	0.18	0.24	0.24	0.00150	120.05	159.03	159.88	24.00
750	42.2	56.5	57.5	0.18	0.24	0.25	0.00152	118.48	158.62	161.43	25.00

	∂3	∂2	∂1	Radius	Centre								
1	100.00	120.13	220.13	60.0644	160.064								
	0.00	33.22	44.75	52.02	56.64	59.22	**60.06**	59.22	56.64	52.02	44.75	33.22	**0.00**
	100.00	110.03	120.00	130.03	140.06	150.03	**160.06**	170.10	180.07	190.10	200.13	210.10	**220.13**
2	205.00	159.29	364.29	79.6475	284.647								
	0.00	44.05	59.34	68.97	75.11	78.53	**79.65**	78.53	75.11	68.97	59.34	44.05	**0.00**
	205.00	218.30	231.52	244.82	258.12	271.35	**284.65**	297.95	311.17	324.47	337.77	350.99	**364.29**
3	310.00	161.43	471.43	80.7147	390.715								
	0.00	44.64	60.13	69.90	76.11	79.58	**80.71**	79.58	76.11	69.90	60.13	44.64	**0.00**
	310.00	323.48	336.88	350.36	363.84	377.24	**390.71**	404.19	417.59	431.07	444.55	457.95	**471.43**

DESCRIPTION OF SAMPLE

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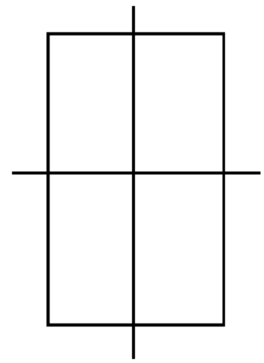
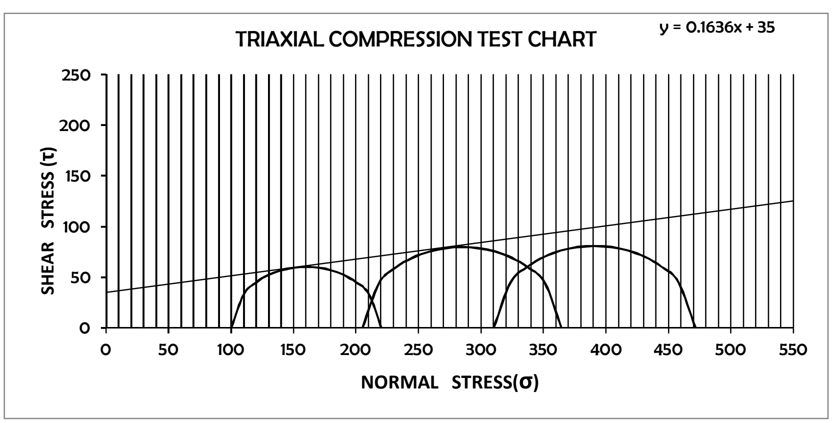


SKETCH OF SAMPLE AFTER SHEAR

Compressive Sress

Corresponding Strain



GEOTECHNICAL ENGINEERING LABORATORY TEST

TRIAXIAL COMPRESSION TEST

JOB.... **RAMP 1** DATE...**24/06/2018………**

SAMPLE NO... **BH9, 2.0m ……** LENGTH…… DIAMETER…… CELL PRESSURE: **100, 205, 310KN/m²**

FRICTION ANGLE:. ....**20.34º**..... COHESION:...**20.0kN/m²**..... WET WEIGHT:..**159g,169g,169g....** DRY WEIGHT**g,g....** MOISTURE CONTENT:..........

Strain Dial	Stress Dial	SD2	SD3	Stress Dial Diff	SDD2	SDD3	Area Sq m	Compressive Stress	CS2	CS3	Strain %
0	0	0	0	0.00	0.00	0.00	0.00114	0.00	0.00	0.00	0.00
15	6	4	4	0.03	0.02	0.02	0.00115	22.26	14.84	14.84	0.50
30	8.8	7.5	6	0.04	0.03	0.03	0.00115	32.65	27.83	22.26	1.00
45	11	16	7	0.05	0.07	0.03	0.00116	40.47	58.86	25.75	1.50
60	12.8	28	10	0.05	0.12	0.04	0.00116	47.09	103.01	36.79	2.00
75	14.5	32	26	0.06	0.14	0.11	0.00117	52.89	116.71	94.83	2.50
90	16	37	35	0.07	0.16	0.15	0.00118	57.86	133.81	126.57	3.00
105	17.8	40	40	0.08	0.17	0.17	0.00118	64.37	144.66	144.66	3.50
120	19.8	43	44	0.08	0.18	0.19	0.00119	71.00	154.20	157.78	4.00
135	21.3	45	46	0.09	0.19	0.20	0.00119	76.38	161.37	164.96	4.50
150	23	47	48.5	0.10	0.20	0.21	0.00120	81.79	167.14	172.47	5.00
165	24.8	49	50	0.11	0.21	0.21	0.00121	87.46	172.81	176.34	5.50
180	26.3	50.5	52	0.11	0.22	0.22	0.00121	92.75	178.10	183.39	6.00
210	29.3	53	56.5	0.13	0.23	0.24	0.00122	102.49	185.38	197.63	7.00
240	31.5	56	60	0.15	0.24	0.26	0.00124	117.01	192.72	206.48	8.00
270	34	58	64	0.15	0.25	0.27	0.00125	123.92	198.01	218.49	9.00
300	36.3	61.5	66.5	0.16	0.26	0.28	0.00127	128.69	206.65	223.45	10.00
330	38.3	64	69.5	0.17	0.27	0.30	0.00128	133.35	213.37	231.70	11.00
360	40	67	72	0.18	0.29	0.31	0.00130	137.87	219.93	236.35	12.00
390	42	69.5	74	0.19	0.30	0.32	0.00131	142.68	226.40	241.06	12.00
420	43.8	72	76	0.19	0.31	0.32	0.00131	147.24	234.54	247.57	13.00
450	45.2	74.5	79	0.20	0.32	0.34	0.00133	153.37	239.04	253.47	14.00
480	47.8	77	81	0.21	0.33	0.35	0.00134	153.18	245.21	257.95	15.00
510	48.1	79	83.5	0.21	0.34	0.36	0.00136	154.38	247.88	262.00	16.00
540	49.2	81.5	85.5	0.21	0.35	0.36	0.00137	156.37	253.86	266.32	17.00
570	50.2	84	87	0.22	0.36	0.37	0.00139	156.57	257.88	267.09	18.00
600	51	86	89	0.22	0.37	0.38	0.00139	159.64	264.02	273.23	19.00
630	52	88	91	0.23	0.38	0.39	0.00143	158.16	262.61	271.56	20.00
660	53	91	93	0.23	0.39	0.40	0.00144	160.03	269.67	275.60	21.00
690	54	93	95	0.23	0.40	0.41	0.00146	160.76	271.82	277.67	22.00
720	55	93	97	0.24	0.40	0.41	0.00150	159.31	264.58	275.96	24.00
750	56	95	98.5	0.24	0.41	0.42	0.00152	157.22	266.71	276.54	25.00

	∂3	∂2	∂1	Radius	Centre								
1	100.00	160.76	260.76	80.3782	180.378								
	0.00	44.45	59.88	69.61	75.80	79.25	**80.38**	79.25	75.80	69.61	59.88	44.45	**0.00**
	100.00	113.42	126.77	140.19	153.61	166.96	**180.38**	193.80	207.14	220.57	233.99	247.33	**260.76**
2	205.00	271.82	476.82	135.912	340.912								
	0.00	75.16	101.25	117.70	128.17	134.01	**135.91**	134.01	128.17	117.70	101.25	75.16	**0.00**
	205.00	227.70	250.26	272.96	295.65	318.21	**340.91**	363.61	386.17	408.87	431.57	454.13	**476.82**
3	310.00	277.67	587.67	138.835	448.835								
	0.00	76.78	103.43	120.23	130.92	136.89	**138.84**	136.89	130.92	120.23	103.43	76.78	**0.00**
	310.00	333.19	356.23	379.42	402.60	425.65	**448.84**	472.02	495.07	518.25	541.44	564.48	**587.67**

DESCRIPTION OF SAMPLE

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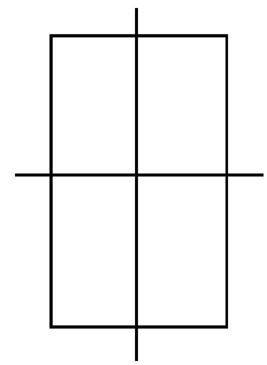
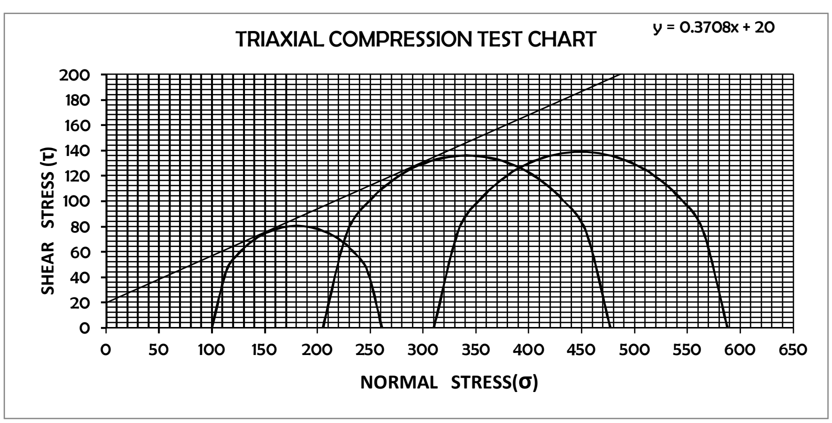


SKETCH OF SAMPLE AFTER SHEAR

Compressive Sress

Corresponding Strain



GEOTECHNICAL ENGINEERING LABORATORY TEST

TRIAXIAL COMPRESSION TEST

JOB**.... OKOMU RAMP II** DATE**...24/06/2018.........**

SAMPLE NO**... BH10, 1.5m ......** LENGTH...... DIAMETER...... CELL PRESSURE: **100, 205, 310KN/m²**

FRICTION ANGLE: ....**7.93º**..... COHESION:**... 15.5kN/m²**..... WET WEIGHT:..**163g,169g,166g....** DRY WEIGHT**g,g....** MOISTURE CONTENT:..........

Strain Dial	Stress Dial	SD2	SD3	Stress Dial Diff	SDD2	SDD3	Area Sq m	Compressive Stress	CS2	CS3	Strain %
0	0	0	0	0.00	0.00	0.00	0.00114	0.00	0.00	0.00	0.00
15	2	7	2.5	0.01	0.03	0.01	0.00115	7.42	25.98	9.28	0.50
30	2.2	8	4	0.01	0.03	0.02	0.00115	8.16	29.69	14.84	1.00
45	2.8	9	5	0.01	0.04	0.02	0.00116	10.30	33.11	18.39	1.50
60	3.5	10	6	0.01	0.04	0.03	0.00116	12.88	36.79	22.07	2.00
75	4	11	7.5	0.02	0.05	0.03	0.00117	14.59	40.12	27.35	2.50
90	4.8	12	9	0.02	0.05	0.04	0.00118	17.36	43.40	32.55	3.00
105	5.5	13	10	0.02	0.06	0.04	0.00118	19.89	47.01	36.16	3.50
120	6	14.5	11	0.03	0.06	0.05	0.00119	21.52	52.00	39.45	4.00
135	6.5	15.5	12	0.03	0.07	0.05	0.00119	23.31	55.58	43.03	4.50
150	7.5	16.5	13.5	0.03	0.07	0.06	0.00120	26.67	58.68	48.01	5.00
165	8	17.5	14.5	0.03	0.07	0.06	0.00121	28.21	61.72	51.14	5.50
180	8.8	19	16	0.04	0.08	0.07	0.00121	31.04	67.01	56.43	6.00
210	10	20.5	18.5	0.04	0.09	0.08	0.00122	34.98	71.71	64.71	7.00
240	11	21.5	21	0.05	0.09	0.09	0.00124	41.30	73.99	72.27	8.00
270	12	23	23	0.06	0.10	0.10	0.00125	44.38	78.52	78.52	9.00
300	13	24	24.5	0.06	0.10	0.10	0.00127	47.04	80.64	82.32	10.00
330	14	25	26	0.06	0.11	0.11	0.00128	50.01	83.35	86.68	11.00
360	15	26	28	0.07	0.11	0.12	0.00130	52.52	85.35	91.91	12.00
390	16	27	30	0.07	0.12	0.13	0.00131	54.73	87.95	97.73	12.00
420	16.8	28	31.5	0.07	0.12	0.13	0.00131	57.01	91.21	102.61	13.00
450	17.5	29	33	0.08	0.12	0.14	0.00133	59.36	93.05	105.88	14.00
480	18.5	30	34.5	0.08	0.13	0.15	0.00134	60.51	95.54	109.87	15.00
510	19	30.5	35.5	0.09	0.13	0.15	0.00136	62.76	95.70	111.39	16.00
540	20	31	36.5	0.09	0.13	0.16	0.00137	63.85	96.56	113.69	17.00
570	20.5	31.5	37	0.09	0.13	0.16	0.00139	64.47	96.71	113.59	18.00
600	21	32	38	0.09	0.14	0.16	0.00139	66.01	98.24	116.66	19.00
630	21.5	33	38.8	0.09	0.14	0.17	0.00143	65.65	98.48	115.79	20.00
660	22	33.5	39.2	0.09	0.14	0.17	0.00144	65.79	99.28	116.17	21.00
690	22.2	34	40	0.10	0.15	0.17	0.00146	65.76	99.38	116.91	22.00
720	22.5	34.5	41	0.10	0.15	0.17	0.00150	65.43	98.15	116.64	24.00
750	23	35	41	0.10	0.15	0.17	0.00152	64.57	98.26	115.11	25.00

	∂3	∂2	∂1	Radius	Centre								
1	100.00	66.01	166.01	33.0029	133.003								
	0.00	18.25	24.59	28.58	31.12	32.54	**33.00**	32.54	31.12	28.58	24.59	18.25	**0.00**
	100.00	105.51	110.99	116.50	122.01	127.49	**133.00**	138.51	143.99	149.50	155.02	160.49	**166.01**
2	205.00	99.38	304.38	49.6883	254.688								
	0.00	27.48	37.02	43.03	46.86	48.99	**49.69**	48.99	46.86	43.03	37.02	27.48	**0.00**
	205.00	213.30	221.55	229.84	238.14	246.39	**254.69**	262.99	271.23	279.53	287.83	296.08	**304.38**
3	310.00	116.91	426.91	58.4568	368.457								
	0.00	32.33	43.55	50.62	55.12	57.64	**58.46**	57.64	55.12	50.62	43.55	32.33	**0.00**
	310.00	319.76	329.47	339.23	348.99	358.69	**368.46**	378.22	387.92	397.69	407.45	417.15	**426.91**

DESCRIPTION OF SAMPLE

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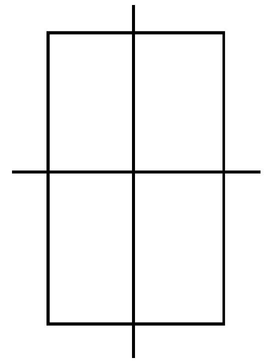
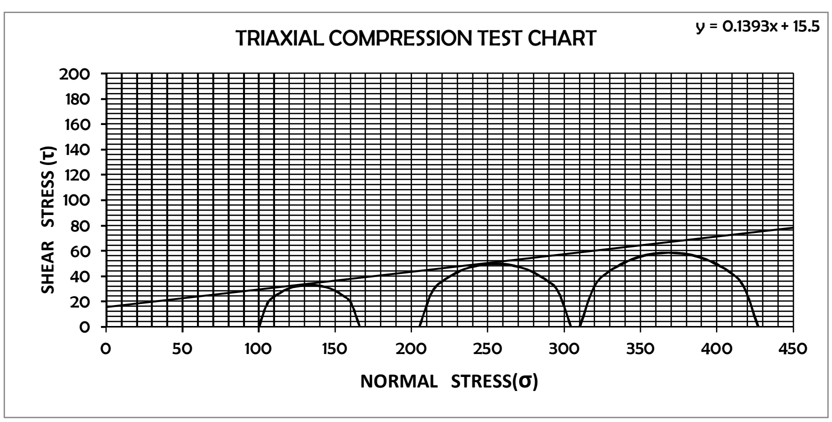


SKETCH OF SAMPLE AFTER SHEAR

Compressive Sress

Corresponding Strain



GEOTECHNICAL ENGINEERING LABORATORY TEST

TRIAXIAL COMPRESSION TEST

JOB**.... OKOMU RAMP II** DATE**...24/06/2018.........**

SAMPLE NO**... BH10, 7.5m ......** LENGTH...... DIAMETER...... CELL PRESSURE: **100, 205, 310KN/m²**

FRICTION ANGLE:. ....**3.61°**..... COHESION:**... 24.0kN/m²**..... WET WEIGHT:..**130g,134g,156g....** DRY WEIGHT**g,g....** MOISTURE CONTENT:..........

Strain Dial	Stress Dial	SD2	SD3	Stress Dial Diff	SDD2	SDD3	Area Sq m	Compressive Stress	CS2	CS3	Strain %			
0	0	0	0	0.00	0.00	0.00	0.00114	0.00	0.00	0.00	0.00			
15	5	4.2	3.5	0.02	0.02	0.01	0.00115	18.55	15.59	12.99	0.50			
30	6	5	7.8	0.03	0.02	0.03	0.00115	22.26	18.55	28.94	1.00			
45	6.3	5.8	10.2	0.03	0.02	0.04	0.00116	23.18	21.34	37.52	1.50			
60	6.9	6	15	0.03	0.03	0.06	0.00116	25.38	22.07	55.18	2.00			
75	7.2	6.8	16	0.03	0.03	0.07	0.00117	26.26	24.80	58.36	2.50			
90	7.5	7.5	18.8	0.03	0.03	0.08	0.00118	27.12	27.12	67.99	3.00			
105	8	8.1	20	0.03	0.03	0.09	0.00118	28.93	29.29	72.33	3.50			
120	8.3	8.8	21.2	0.04	0.04	0.09	0.00119	29.76	31.56	76.02	4.00			
135	8.8	9.2	22.5	0.04	0.04	0.10	0.00119	31.56	32.99	80.69	4.50			
150	9	9.8	23.8	0.04	0.04	0.10	0.00120	32.01	34.85	84.64	5.00			
165	9.6	10.3	25	0.04	0.04	0.11	0.00121	33.86	36.33	88.17	5.50			
180	10	11	26	0.04	0.05	0.11	0.00121	35.27	38.79	91.70	6.00			
210	10.9	13	28.7	0.05	0.06	0.12	0.00122	38.13	45.47	100.39	7.00			
240	11.5	14	31.8	0.05	0.06	0.14	0.00124	41.99	48.18	109.44	8.00			
270	12.2	15.1	32.2	0.06	0.06	0.14	0.00125	44.04	51.55	109.93	9.00			
300	12.9	16.1	34.5	0.06	0.07	0.15	0.00127	43.68	54.10	115.92	10.00			
330	13	17.5	35.3	0.06	0.07	0.15	0.00128	43.34	58.34	117.69	11.00			
360	13	18	38.2	0.06	0.08	0.16	0.00130	45.30	59.09	125.39	12.00			
390	13.8	19.6	40	0.06	0.08	0.17	0.00131	45.61	63.85	130.30	12.00			
420	14	20.5	42	0.06	0.09	0.18	0.00131	47.23	66.78	136.82	13.00			
450	14.5	21.2	43.5	0.06	0.09	0.19	0.00133	48.13	68.02	139.57	14.00			
480	15	21.7	45.2	0.07	0.09	0.19	0.00134	51.59	69.11	143.94	15.00			
510	16.2	22.3	47	0.08	0.10	0.20	0.00136	55.85	69.97	147.47	16.00			
540	17.8	23.1	48.3	0.08	0.10	0.21	0.00137	61.67	71.95	150.45	17.00			
570	19.8	23.1	50.9	0.08	0.10	0.22	0.00139	60.79	70.92	156.26	18.00			
600	19.8	23.1	53.3	0.08	0.10	0.23	0.00139	60.79	70.92	163.63	19.00			
630	19.8	23.1	55.8	0.08	0.10	0.24	0.00143	59.09	68.93	166.52	20.00			
660	19.8	23.1	58.2	0.08	0.10	0.25	0.00144	58.68	68.46	172.47	21.00			
690	19.8	23.1	61.3	0.08	0.10	0.26	0.00146	57.87	67.52	179.17	22.00			
720	19.8	23.1	64.8	0.08	0.10	0.28	0.00150	56.33	65.72	184.35	24.00			
750	19.8	23.1	67.3	0.08	0.10	0.29	0.00152	55.59	64.85	188.94	25.00			
		∂3	**∂2**	**∂1**	**Radius**	**Centre**								
	1	100.00	61.67	161.67	30.8371	130.837								
		0.00	17.05	22.97	26.70	29.08	30.41	**30.84**	30.41	29.08	26.70	22.97	17.05	**0.00**
		100.00	105.15	110.27	115.42	120.57	125.69	**130.84**	135.99	141.11	146.26	151.41	156.52	**161.67**
	2	205.00	71.95	276.95	35.9766	240.977								
		0.00	19.90	26.80	31.16	33.93	35.47	**35.98**	35.47	33.93	31.16	26.80	19.90	**0.00**
		205.00	211.01	216.98	222.99	229.00	234.97	**240.98**	246.98	252.96	258.96	264.97	270.95	**276.95**
	3	310.00	188.94	498.94	94.4713	404.471								
		0.00	52.24	70.38	81.81	89.09	93.15	**94.47**	93.15	89.09	81.81	70.38	52.24	**0.00**
		310.00	325.78	341.46	357.24	373.01	388.69	**404.47**	420.25	435.93	451.71	467.48	483.17	**498.94**

DESCRIPTION OF SAMPLE

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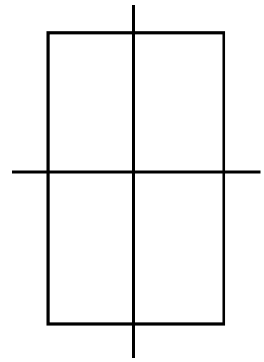
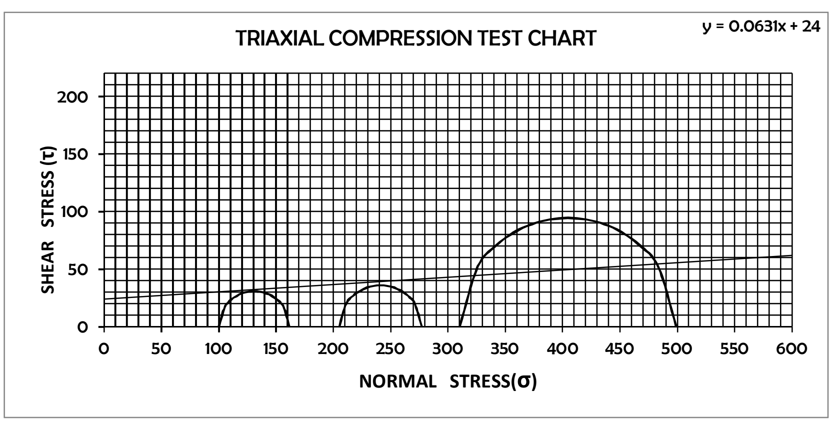


SKETCH OF SAMPLE AFTER SHEAR

Compressive Sress

Corresponding Strain



GEOTECHNICAL ENGINEERING LABORATORY TEST

TRIAXIAL COMPRESSION TEST

JOB**.... OKOMU RAMP II** DATE**...24/06/2018.........**

SAMPLE NO**... BH10, 13.5m ......** LENGTH...... DIAMETER...... CELL PRESSURE: **100, 205, 310KN/m²**

FRICTION ANGLE:. ....**10.20º**..... COHESION**:... 50.0kN/m²**..... WET WEIGHT:..**159g,160g,160g....** DRY WEIGHT**g,g....** MOISTURE CONTENT:..........

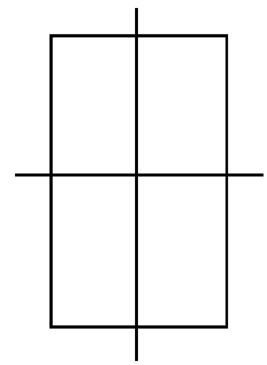
Strain Dial	Stress Dial	SD2	SD3	Stress Dial Diff	SDD2	SDD3	Area Sq m	Compressive Stress	CS2	CS3	Strain %
0	0	0	0	0.00	0.00	0.00	0.00114	0.00	0.00	0.00	0.00
15	6.3	9	5.5	0.03	0.04	0.02	0.00115	23.38	33.40	20.41	0.50
30	8.5	10	10.5	0.04	0.04	0.04	0.00115	31.54	37.11	38.96	1.00
45	10	11.5	19	0.04	0.05	0.08	0.00116	36.79	42.31	69.90	1.50
60	11.9	16.9	25	0.05	0.07	0.11	0.00116	43.78	62.17	91.97	2.00
75	14	18.9	27.5	0.06	0.08	0.12	0.00117	51.06	68.93	100.30	2.50
90	16	20.5	28.2	0.07	0.09	0.12	0.00118	57.86	74.14	101.98	3.00
105	18	22	30.5	0.08	0.09	0.13	0.00118	65.10	79.56	110.30	3.50
120	20	24	32	0.09	0.10	0.14	0.00119	71.72	86.06	114.75	4.00
135	22	25.8	33.5	0.09	0.11	0.14	0.00119	78.89	92.52	120.13	4.50
150	24	27.5	34.8	0.10	0.12	0.15	0.00120	85.35	97.79	123.75	5.00
165	26	29	36.2	0.11	0.12	0.15	0.00121	91.70	102.28	127.67	5.50
180	27.8	30.5	37.5	0.12	0.13	0.16	0.00121	98.04	107.57	132.25	6.00
210	31.5	33.5	41	0.13	0.14	0.17	0.00122	110.18	117.18	143.41	7.00
240	34.8	36.5	44.3	0.16	0.16	0.19	0.00124	128.36	125.61	152.45	8.00
270	37.3	39.3	46.9	0.17	0.17	0.20	0.00125	132.80	134.17	160.11	9.00
300	38.9	42	49.9	0.18	0.18	0.21	0.00127	139.44	141.12	167.67	10.00
330	41.5	44.9	52.9	0.18	0.19	0.23	0.00128	144.02	149.69	176.36	11.00
360	43.2	47.3	55	0.19	0.20	0.23	0.00130	146.73	155.27	180.54	12.00
390	44.7	49.5	58	0.19	0.21	0.25	0.00131	146.59	161.25	188.94	12.00
420	45	52	61	0.20	0.22	0.26	0.00131	150.82	169.39	198.71	13.00
450	46.3	45.2	62.5	0.20	0.19	0.27	0.00133	151.76	145.03	200.53	14.00
480	47.3	56.2	65	0.20	0.24	0.28	0.00134	152.86	178.97	207.00	15.00
510	48	58.3	67.9	0.21	0.25	0.29	0.00136	157.20	182.93	213.05	16.00
540	50.1	60.2	70.5	0.22	0.26	0.30	0.00137	158.23	187.51	219.60	17.00
570	50.8	62	72.8	0.22	0.26	0.31	0.00139	158.11	190.34	223.50	18.00
600	51.5	64	74.5	0.22	0.27	0.32	0.00139	159.33	196.48	228.72	19.00
630	51.9	65.7	78.8	0.22	0.28	0.34	0.00143	155.77	196.06	235.15	20.00
660	52.2	67.3	80	0.23	0.29	0.34	0.00144	157.95	199.44	237.08	21.00
690	53.3	69.8	82.5	0.23	0.30	0.35	0.00146	159.29	204.01	241.13	22.00
720	54.5	71.5	84.5	0.24	0.31	0.36	0.00150	157.04	203.41	240.39	24.00
750	55.2	73	86	0.24	0.31	0.37	0.00152	154.97	204.95	241.44	25.00

	∂3	∂2	∂1	Radius	Centre								
1	100.00	159.33	259.33	79.6674	179.667								
	0.00	44.06	59.35	68.99	75.13	78.55	**79.67**	78.55	75.13	68.99	59.35	44.06	**0.00**
	100.00	113.30	126.53	139.83	153.14	166.36	**179.67**	192.97	206.20	219.50	232.81	246.03	**259.33**
2	205.00	204.95	409.95	102.473	307.473								
	0.00	56.67	76.34	88.74	96.63	101.04	**102.47**	101.04	96.63	88.74	76.34	56.67	**0.00**
	205.00	222.11	239.12	256.24	273.35	290.36	**307.47**	324.59	341.60	358.71	375.82	392.83	**409.95**
3	310.00	241.44	551.44	120.721	430.721								
	0.00	66.76	89.94	104.54	113.84	119.03	**120.72**	119.03	113.84	104.54	89.94	66.76	**0.00**
	310.00	330.16	350.20	370.36	390.52	410.56	**430.72**	450.88	470.92	491.08	511.24	531.28	**551.44**

DESCRIPTION OF SAMPLE

....
....

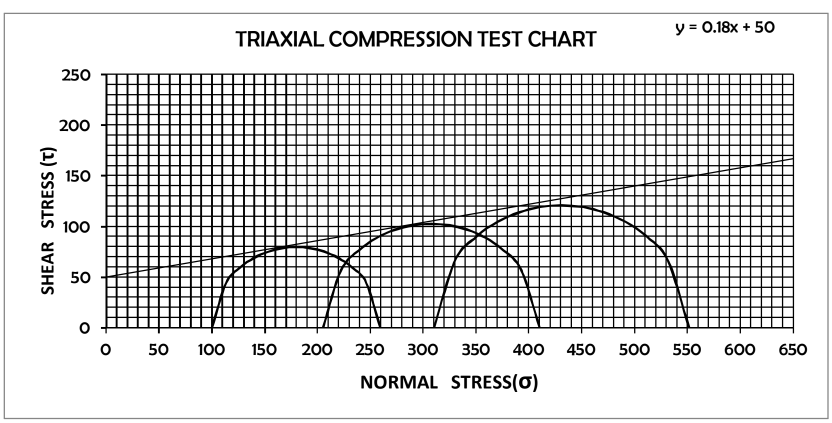
....
....



SKETCH OF SAMPLE AFTER SHEAR

Compressive Sress

Corresponding Strain

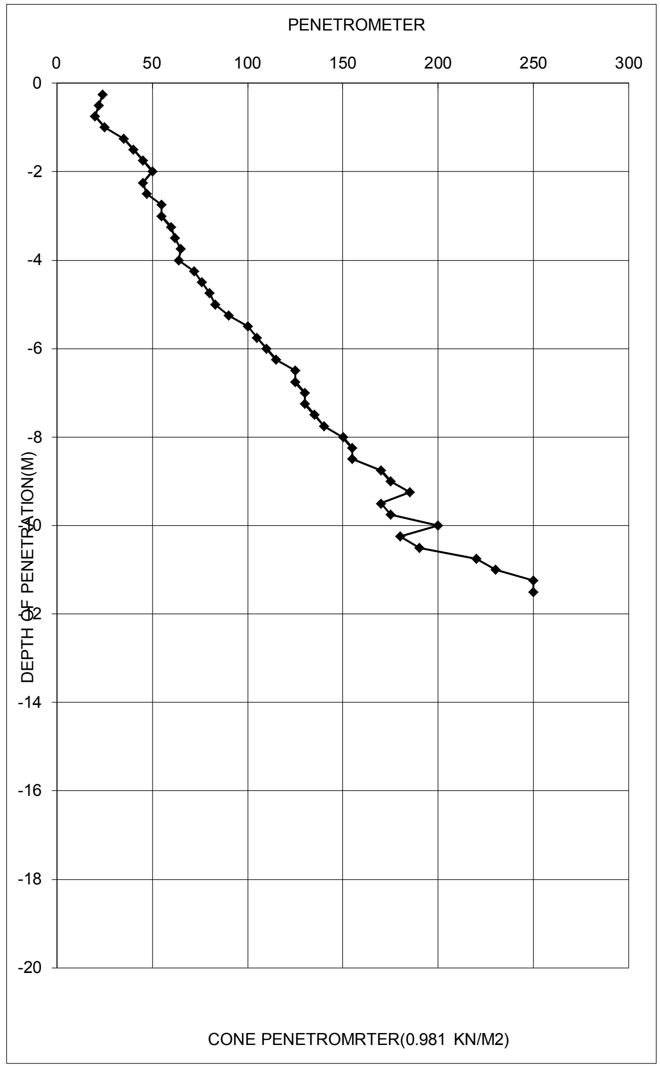


APPENDIX VI

CONE PENETROMETER

JOB: **OKOMU** LOCATION**: ……… BOILER CPT PT1**
DEPTH: **11.5m** BEARING CAPACITY: DATE: **30/05/2018**

Penetration	Depth	Penetration	Depth
24	-0.25		
22	-0.5		
20	-0.75		
25	-1		
35	-1.25		
40	-1.5		
45	-1.75		
50	-2		
45	-2.25		
47	-2.5		
55	-2.75		
55	-3		
60	-3.25		
62	-3.5		
65	-3.75		
64	-4		
72	-4.25		
76	-4.5		
80	-4.75		
83	-5		
90	-5.25		
100	-5.5		
105	-5.75		
110	-6		
115	-6.25		
125	-6.5		
125	-6.75		
130	-7		
130	-7.25		
135	-7.5		
140	-7.75		
150	-8		
155	-8.25		
155	-8.5		
170	-8.75		
175	-9		
185	-9.25		
170	-9.5		
175	-9.75		
200	-10		
180	-10.25		
190	-10.5		
220	-10.75		
230	-11		
250	-11.25		
250	-11.5		

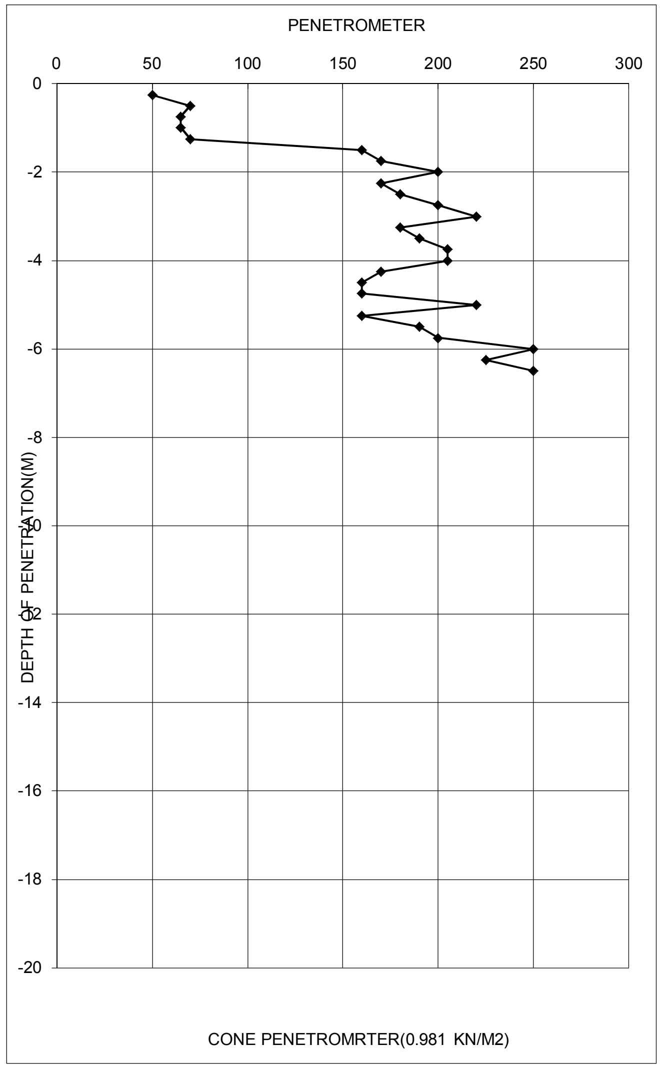


CONE PENETROMETER

JOB: **OKOMU** LOCATION**: ....(RAMP 1) CPT PT2**

DEPTH: **6.5m** BEARING CAPACITY: DATE: **30/05/2018**

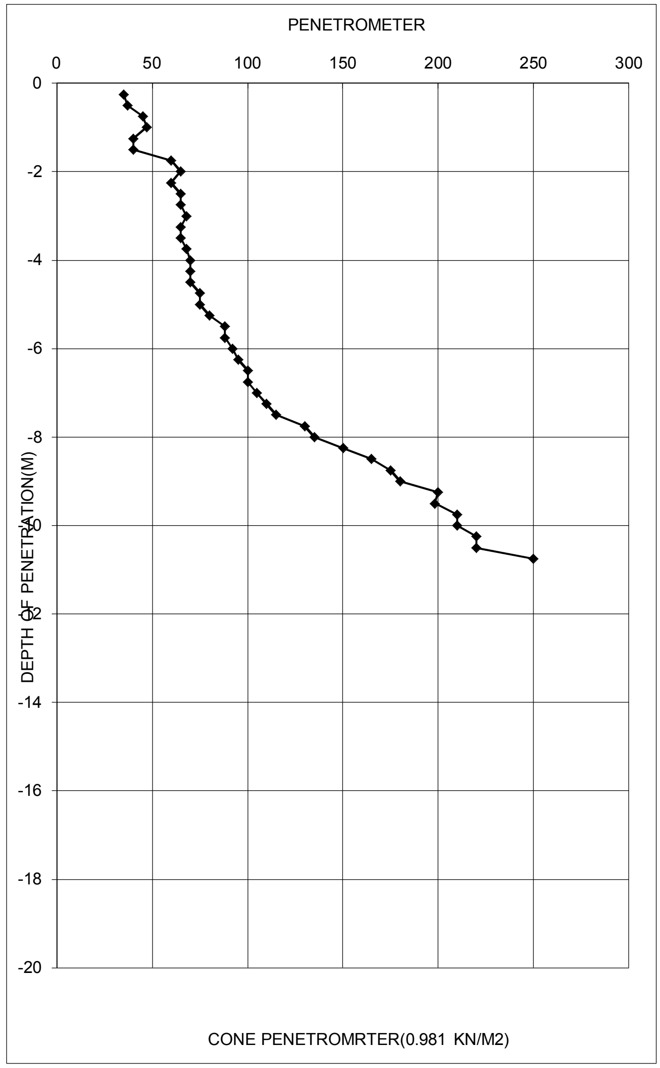
Penetration	Depth	Penetration	Depth
50	-0.25		
70	-0.5		
65	-0.75		
65	-1		
70	-1.25		
160	-1.5		
170	-1.75		
200	-2		
170	-2.25		
180	-2.5		
200	-2.75		
220	-3		
180	-3.25		
190	-3.5		
205	-3.75		
205	-4		
170	-4.25		
160	-4.5		
160	-4.75		
220	-5		
160	-5.25		
190	-5.5		
200	-5.75		
250	-6		
225	-6.25		
250	-6.5		



CONE PENETROMETER

JOB: **OKOMU** LOCATION: **......... (CPO TANK) CPT PT3**
DEPTH: **10.75m** BEARING CAPACITY: DATE: **30/05/2018**

Penetration	Depth	Penetration	Depth
35	-0.25		
37	-0.5		
45	-0.75		
47	-1		
40	-1.25		
40	-1.5		
60	-1.75		
65	-2		
60	-2.25		
65	-2.5		
65	-2.75		
68	-3		
65	-3.25		
65	-3.5		
68	-3.75		
70	-4		
70	-4.25		
70	-4.5		
75	-4.75		
75	-5		
80	-5.25		
88	-5.5		
88	-5.75		
92	-6		
95	-6.25		
100	-6.5		
100	-6.75		
105	-7		
110	-7.25		
115	-7.5		
130	-7.75		
135	-8		
150	-8.25		
165	-8.5		
175	-8.75		
180	-9		
200	-9.25		
198	-9.5		
210	-9.75		
210	-10		
220	-10.25		
220	-10.5		
250	-10.75		



APPENDIX VII

CALIFONIA BEARING RATIO TEST

SAMPLE NO **OKOMU ROAD POINT 1, 1.5m**

DESCRIPTION DATE: 11/**06/2018**

NOTES O SOIL

TEST ON BOTTOM (UNSOAKED) **SURCHARGE**

Penetration (mm)	0.00	0.50	1.00	1.50	2.00	2.50	3.00	4.00	5.00	7.50	10.00	12.50
Load Indicator	0	54.00	69	82	94	105	115	131	147	183	210	218
Ditto corrected												
Load (KN)	0	0.59066	0.75473	0.89693	1.02819	1.14851	1.25789	1.4329	1.60791	2.00168	2.29701	2.38452
C. B. R. %												

TEST ON TOP (UNSOAKED) **SURCHARGE**

Penetration (mm)	0.00	0.50	1.00	1.50	2.00	2.50	3.00	4.00	5.00	7.50	10.00	12.50
Load Indicator	0	38.00	50	60	71	81	90	108	126	167	208	224
Ditto corrected												
Load (KN)	0	0.41565	0.54691	0.65629	0.77661	0.88599	0.98443	1.18132	1.37821	1.82667	2.27514	2.45015
C. B. R. %												

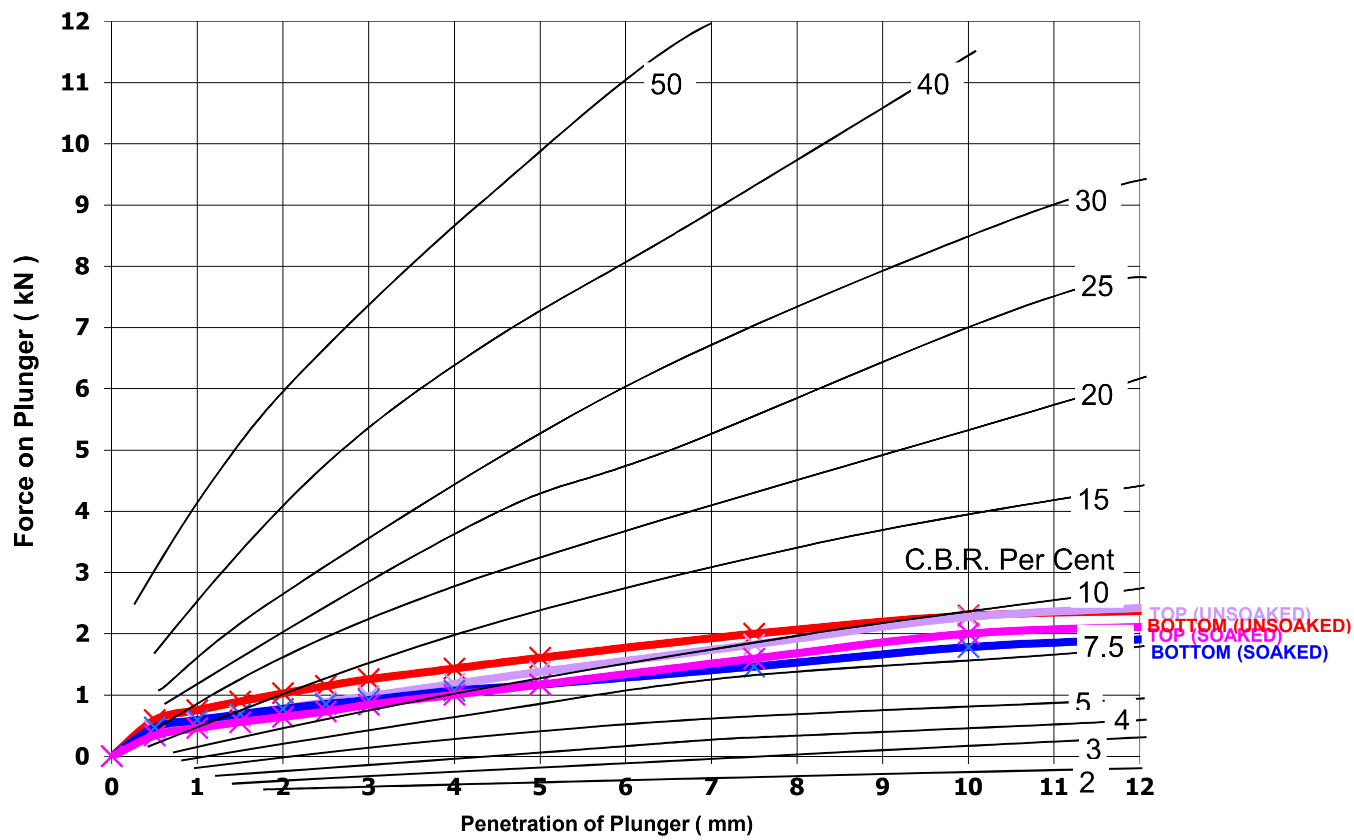
TEST ON BOTTOM (SOAKED) **SURCHARGE**

Penetration (mm)	0.00	0.50	1.00	1.50	2.00	2.50	3.00	4.00	5.00	7.50	10.00	12.50
Load Indicator	0	43	54.00	63	71	78	84	98	107	134	163	177
Ditto corrected												
Load (KN)	0	0.47034	0.59066	0.6891	0.77661	0.85318	0.9188	1.07194	1.17038	1.46571	1.78292	1.93605
C. B. R. %												

TEST ON TOP (SOAKED) **SURCHARGE**

Penetration (mm)	0.00	0.50	1.00	1.50	2.00	2.50	3.00	4.00	5.00	7.50	10.00	12.50
Load Indicator	0	31.00	42	51	59	67	77	92	107	146	183	195
Ditto corrected												
Load (KN)	0	0.33908	0.4594	0.55785	0.64535	0.73286	0.84224	1.00631	1.17038	1.59697	2.00168	2.13294
C. B. R. %												

	UNSOAKED		SOAKED	
	2.5mm	5.0mm	2.5mm	5.0mm
BOTTOM	8.67	8.05562	6.44148	5.86361
TOP	6.68923	6.90482	5.53306	5.86361



CALIFONIA BEARING RATIO TEST

SAMPLE NO — **OKOMU ROAD POINT 2, 1.5m**

DESCRIPTION — DATE: 11/06/2018

NOTES O SOIL

TEST ON BOTTOM (UNSOAKED) — **SURCHARGE**

Penetration (mm)	0.00	0.50	1.00	1.50	2.00	2.50	3.00	4.00	5.00	7.50	10.00	12.50
Load Indicator	0	88	108.00	123	138	149	163	183	200	240	282	301
Ditto corrected												
Load (KN)	0	0.96256	1.18132	1.34539	1.50946	1.62978	1.78292	2.00168	2.18763	2.62516	3.08456	3.29238
C. B. R. %												

TEST ON TOP (UNSOAKED) — **SURCHARGE**

Penetration (mm)	0.00	0.50	1.00	1.50	2.00	2.50	3.00	4.00	5.00	7.50	10.00	12.50
Load Indicator	0	56.00	81	108	127	143	159	182	202	252	297	314
Ditto corrected												
Load (KN)	0	0.61254	0.88599	1.18132	1.38915	1.56416	1.73917	1.99074	2.20951	2.75641	3.24863	3.43458
C. B. R. %												

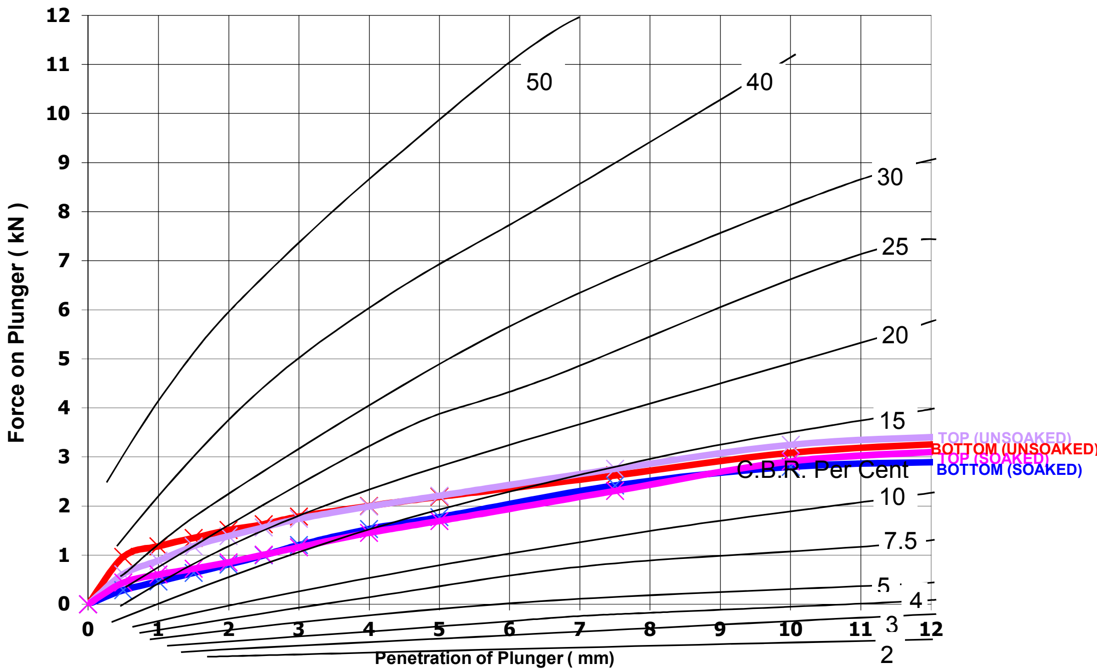
TEST ON BOTTOM (SOAKED) — **SURCHARGE**

Penetration (mm)	0.00	0.50	1.00	1.50	2.00	2.50	3.00	4.00	5.00	7.50	10.00	12.50
Load Indicator	0	26.00	42	58	74	91	110	140	162	221	256	266
Ditto corrected												
Load (KN)	0	0.28439	0.4594	0.63441	0.80942	0.99537	1.2032	1.53134	1.77198	2.41733	2.80017	2.90955
C. B. R. %												

TEST ON TOP (SOAKED) — **SURCHARGE**

Penetration (mm)	0.00	0.50	1.00	1.50	2.00	2.50	3.00	4.00	5.00	7.50	10.00	12.50
Load Indicator	0	40.00	55	66	78	92	106	133	155	211	266	287
Ditto corrected												
Load (KN)	0	0.43753	0.6016	0.72192	0.85318	1.00631	1.15944	1.45477	1.69541	2.30795	2.90955	3.13925
C. B. R. %												

	UNSOAKED		SOAKED	
	2.5mm	5.0mm	2.5mm	5.0mm
BOTTOM	12.30	10.96	7.51506	8.87762
TOP	11.8094	11.0696	7.59764	8.49402



CALIFONIA BEARING RATIO TEST

SAMPLE NO **OKOMU ROAD POINT 3, 1.5m**

DESCRIPTION DATE: 11/06/2018

NOTES O SOIL

TEST ON BOTTOM (UNSOAKED) **SURCHARGE**

Penetration (mm)	0.00	0.50	1.00	1.50	2.00	2.50	3.00	4.00	5.00	7.50	10.00	12.50
Load Indicator	0	60	72.00	84	96	107	130	167	191	208	215	219
Ditto corrected												
Load (KN)	0	0.65629	0.78755	0.9188	1.05006	1.17038	1.42196	1.82667	2.08919	2.27514	2.3517	2.39545
C. B. R. %												

TEST ON TOP (UNSOAKED) **SURCHARGE**

Penetration (mm)	0.00	0.50	1.00	1.50	2.00	2.50	3.00	4.00	5.00	7.50	10.00	12.50
Load Indicator	0	56.00	75	93	112	124	139	171	197	253	307	325
Ditto corrected												
Load (KN)	0	0.61254	0.82036	1.01725	1.22507	1.35633	1.5204	1.87042	2.15482	2.76735	3.35801	3.5549
C. B. R. %												

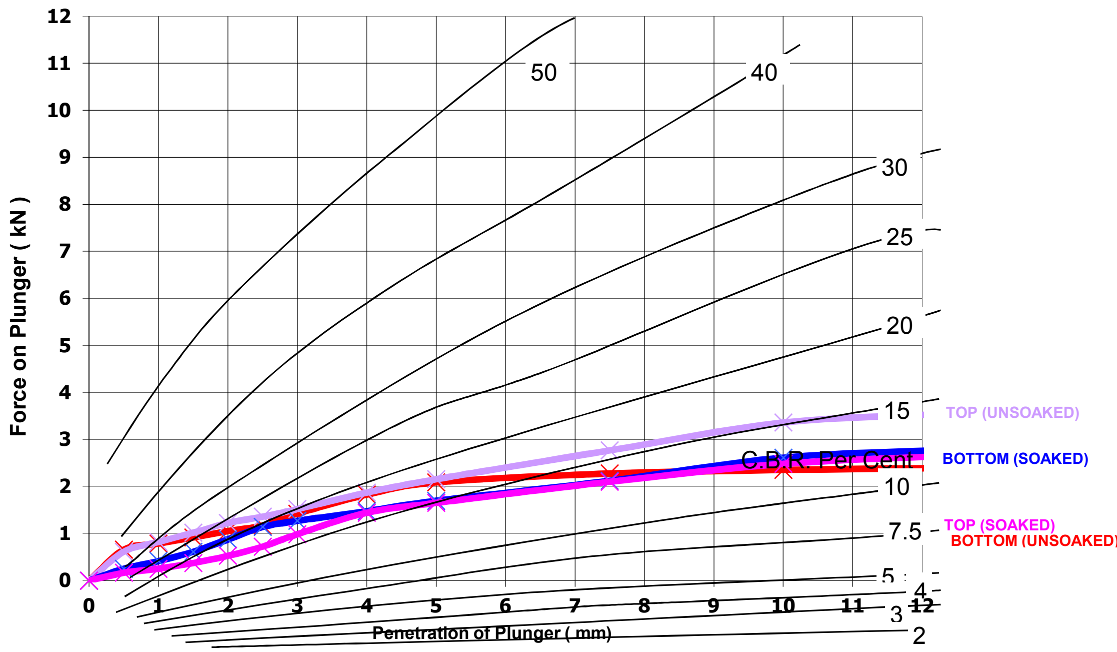
TEST ON BOTTOM (SOAKED) **SURCHARGE**

Penetration (mm)	0.00	0.50	1.00	1.50	2.00	2.50	3.00	4.00	5.00	7.50	10.00	12.50
Load Indicator	0	23.00	38	56	80	104	116	135	155	194	239	255
Ditto corrected												
Load (KN)	0	0.25158	0.41565	0.61254	0.87505	1.13757	1.26883	1.47665	1.69541	2.122	2.61422	2.78923
C. B. R. %												

TEST ON TOP (SOAKED) **SURCHARGE**

Penetration (mm)	0.00	0.50	1.00	1.50	2.00	2.50	3.00	4.00	5.00	7.50	10.00	12.50
Load Indicator	0	15.00	23	34	48	66	90	132	151	192	227	243
Ditto corrected												
Load (KN)	0	0.16407	0.25158	0.3719	0.52503	0.72192	0.98443	1.44384	1.65166	2.10012	2.48296	2.65797
C. B. R. %												

	UNSOAKED		SOAKED	
	2.5mm	5.0mm	2.5mm	5.0mm
BOTTOM	8.84	10.4668	8.58864	8.49402
TOP	10.2403	10.7956	5.45048	8.27482



APPENDIX III

EXTENSION TWO FPIC PROCESS REPORT

THE OKOMU OIL PALM COMPANY PLC

FREE, PRIOR, AND INFORMEND CONSENT (FPIC) OF THE PROPOSED EXTENSION TWO OIL PALM DEVELOPMENT PROJECT AT OVIA-NORTHEAST AND UHUNMWONDE LOCAL GOVERNMENT AREAS, EDO STATE, NIGERIA

FINAL REPORT

October 2016

Free, Prior and Informed Consent (FPIC) of the Proposed Extension Two Oil Palm Development Project at Ovia-North East and Uhunmwonde Local Government Areas, Edo State, Nigeria

Final Report

Prepared by

Foremost Development Services Limited

21 Mercy Eneli Street, Surulere, Lagos. Tel: 01-8981250, 08033314800.

Email:foremost.development@gmail.com, Website: www.foremostdevelopmentservices.com

October 2016

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LIST OF MAPS

LIST OF PLATES

LIST OF ABBREVIATIONS AND ACRONYMS

FFB	-Fresh Fruit Bunch
FPIC	-Free, Prior and Informed Consent
HCV	- High Conservation Value
HSE	-Health Safety and Environment
JIC	- Joint Implementation Committee
NIFOR	- Nigerian Institute for Oil Palm Research
NPP	-New planting procedure
NSE	-Nigerian Stock Exchange
OOPC	-Okomu Oil Palm Company
PAT	-Profit After Tax
RSPO	-Roundtable on Sustainable Palm Oil
TCPC	-Technical Committee on Privatization and Commercialization

OKOMU OIL PALM COMPANY PLC
OUR FPIC PROCESS

Report on the Free, Prior and Informed Consent Process of Extension Two Oil Palm Development Project October 2016

Okomu Oil Palm Company Plc – Company Profile

The Okomu Oil Palm Company was established in 1976 as a Federal Government pilot project aimed at rehabilitating oil palm production in Nigeria. At inception, the pilot project covered a surveyed area of 15,580 hectares out of which 12,500 hectares could be planted with oil palm. It was incorporated on December 3, 1979 as a limited liability company.

As part of efforts to shore up its revenue base, the company acquired and installed a 1.5-tonne fresh Fruit Bunches /hour mill in 1985 to begin to process its FFB. Prior to the installation of the mill, the company derived its revenue from the sale of FFB.

By December 31, 1989, 5,055 hectares of the estate had been planted. The company also began infrastructural developments on the estate at that period. The facilities included office blocks, workshops/stores, staff quarters, a petrol station, a powerhouse and a primary school for children of the company's staff members.

In 1990, the Technical Committee on Privatization and Commercialization (TCPC) privatized The Okomu Oil Palm Company on behalf of the Federal Government of Nigeria. It has since grown to become Nigeria's leading oil palm company with 8,800 ha of mature palm, a young extension of 4,000 ha of rubber, and a palm oil mill of 30 tons per hour capacity.

The privatization of the Okomu Oil Palm Company Plc has been a great success and a huge encouragement for the Nigerian agricultural sector for the future, with profound positive consequences of stable socioeconomic growth for the region where it is implanted. The success of the company was further exemplified by the strong increase of its net income which allowed doubling of its dividend.

This company has consistently posted profits in the last 10 years, a period during which most other agricultural initiatives in the country had either folded –up or were performing sub-optimally.

What is most inspiring is not just the growth and profitability of the company but the fact that The Okomu Oil Palm Company Plc is ranked 10th among listed companies with the largest turnovers quoted on the Nigerian Stock Exchange (NSE). It is the only agribusiness in the NSE‟s top 16 companies with the largest turnovers. According to the June–July issue of the Bottom line magazine, The Okomu Oil Palm Company Plc is the ninth company with the highest profits before tax among companies quoted on the NSE, and the only agro-business on the Exchange's top 16.

Today, what is now known as The Okomu Oil Palm Company Plc has transformed into an economic success, earning presidential commendation and recording over 300 percent rise in profit after - tax (PAT) from the preceding year.

The excellent quality of oil produced by Okomu guarantees good selling price on the local market, which absorbs the whole production.

Just as its expanding in size, its corporate environment is also expanding. Currently, the company employs over 800 permanent staff and several independent sub-contractors. All these have added up to place it on top in the burgeoning oil palm business and to position it as an emerging leader in rubber production.

Okomu benefits from the quality management provided by its main shareholders and technical partner (SOCFINAF). With a 53.32% share in Okomu Oil Palm Plc, SOCFINAF is the biggest single shareholder in the company. SOCFINAF brings into Okomu Oil Palm Plc a little under a century of sound acclaimed technical expertise in the world stage. SOCFINAF (Luxemburg) is a global player in the cultivation of oil palm, rubber, coffee and tropical flower. SOCFIN S. A. founded in 1912 was the first industrial company to plant oil palm in Africa and Indonesia. It has ongoing plantation operations in Cote D'Ivoire, Liberia, Guinea, Cameroon, Kenya and Indonesia.

Executive Summary

As a subsidiary of the Socfin group of companies, OOPC intends to ensure all of its existing oil palm plantations and yet to be established plantations including the palm oil processing facilities conform to the international standards and requirements of the Roundtable on Sustainable Palm Oil (RSPO) including Free, Prior and Informed Consent (FPIC) in order to be able to service the domestic, regional and international markets.

We initiated the FPIC process with initial visits to the communities starting from 2014 and concluded it with the FPIC Agreement signing ceremony on 29 July 2016.

There are no settlements inside the Extension Two project land but there are ten main communities located within 3-10 km from the closest boundaries of the project land. These communities are located within two Local Government Areas of Ovia Northeast and the Uhunmwonde Local Government Areas. There are five communities located within the Ovia Northeast Local Government area namely: Agbanikaka, Owan, Uhiere, Odiguetue and Odighi, while the remaining five communities including Ekpan, Oke, Umuokpe, Irhue and Orhua are located within Uhunmwonde Local Government Area.We thus considered these communities as having customary and/or user right over the project land and therefore need to obtain their free, prior and informed consent.

The FPIC Guide for RSPO members (2015) guided our approach and methodology, which focused on ensuring that consent if free, consent is prior, consent is informed, and consent is given. We started the FPIC process in 2014 with initial visits and consultations with the communities‟ leadership and stakeholders and followed it up with provision of information about the proposed project. The communities seemed satisfied and liked to continue with the project. The communities then appointed their representatives from the different organizations in the communities. Each community later selected those very experienced on land matters to represent them in the participatory mapping that followed. The outcome of the participatory mapping revealed that there are no overlapping boundary issues.

The communities wanted equal treatment and agreed to a neutral and central meeting point. They also agreed to a common legal representation. Iterative meetings were held followed by negotiations. The communities‟ legal representative and the company legal representative drafted the consent based agreements. The consent based agreement was signed by the representatives of each community at a public ceremony on 29 July 2016.The signed agreement has provision for Joint Implementation Committee and Grievance and dispute resolution mechanism.

1.0 Introduction

Free, Prior and Informed Consent (FPIC) is the right of indigenous peoples and other local Communities to give or to withhold their consent to any project affecting their lands, livelihoods and environment.

Indigenous Peoples‟ right to free, prior and informed consent (FPIC) has been recognized by a number of intergovernmental organizations, international bodies, conventions and international human rights law in varying degrees and increasingly in the laws of State.

The right to FPIC is enshrined in international law (in particular, the United Nations Declaration on the Rights of Indigenous Peoples) and jurisprudence and national legal frameworks and constitutions generally support the right of people to be consulted and given a choice in decision-making when it comes to their lands, livelihoods and environment. Even where national laws do not require FPIC in those particular terms, companies that have subscribed to certification standards, such as the RSPO, are expected to go beyond domestic law to uphold the higher international standards by seeking community consent.

International human rights laws and business best practices, recognize that – even where national legal frameworks may provide weak or absent protections of customary rights to land – plantations should not be established on indigenous peoples" lands without recognition of their prior rights to the land and of their right to control what happens on that land.

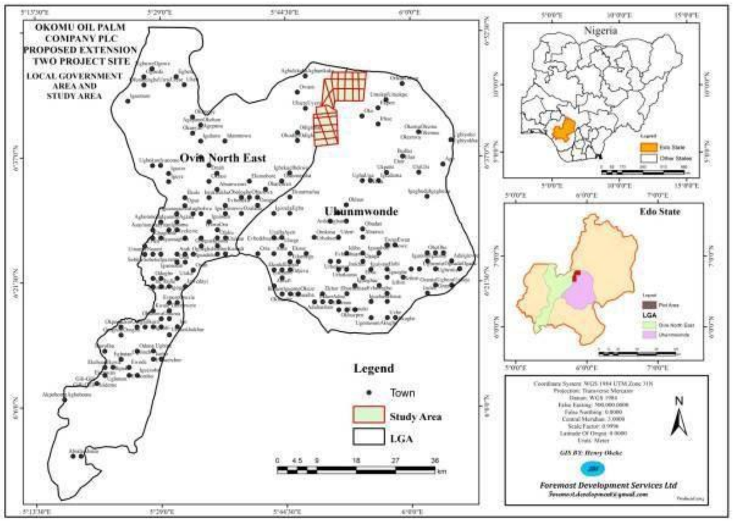
As a subsidiary of the Socfin group of companies, OOPC intends to ensure all of its existing oil palm plantations and yet to be established plantations including the palm oil processing facilities conform to the international standards and requirements of the Roundtable on Sustainable Palm Oil (RSPO) in order to be able to service the domestic, regional and international markets. In this regard therefore, the development of the Extension Two project is designed to follow the new planting procedure (NPP) of RSPO, thus making the obtaining of the Free, Prior and Informed Consent of all the Extension Two communities a condition precedent.

We initiated the FPIC process with initial visits to the communities starting from 2014 and concluded it with the signing of the FPIC Agreement signing ceremony on 29 July 2016.The entire process was undertaken and managed by our FPIC team led by the Managing Director. The other team members included the Agriculture Coordinator, HSE Manager, Community Liaison Officer and Communications Manager. In addition, the RSPO National Interpretation Facilitator in Nigeria provided the necessary guidance and mediatory assistance to the process. The following presentation summarizes our Extension Two FPIC process.

2.0 Proposed Extension Two Project

Extension Two is our latest acquisition in our expansion drive. It was acquired on 28 November 2013from A & Hatman Limited. The total land area of Extension Two is 11,416 ha assigned for a period of 99 years and covered with a Certificate of Occupancy Number EDSR 15666 dated 3rd May 2006 and registered as No 40 at Page 40 in Volume B. 237 in the Land Registry at Benin City, Edo State, Nigeria. Of the 11, 416 ha, about 760 ha was planted with oil palm by the previous owners.

We plan to fully develop the land to oil palm including provisions for infrastructure over a period of four years and install a state of the art palm oil mill of 60 tonnes per hour capacity to process the fresh fruit bunches.



Map 1: Location Map of Extension Two Project

3.1 Extension Two Communities

There are no settlements inside the Extension Two project land but there are ten main communities located within 3-10 km from the closest boundaries of the project land. These communities are located within two Local Government Areas of Ovia Northeast and the Uhunmwonde Local Government Areas. There are five communities located within the Ovia Northeast Local Government area namely: Agbanikaka, Owan, Uhiere, Odiguetue and Odighi, while the remaining five communities including Ekpan, Oke, Umuokpe, Irhue and Orhua are located within Uhunmwonde Local Government Area.

We have thus considered the following communities as being within the area of influence of the proposed Extension Two project and having customary and/or user right over the project land:

3.2 Agbanikaka Community

Agbanikaka, which translates to “The Land of Peace”, is an Uhobe community in Ovia North East Local Government Area in Edo State, Nigeria. The community is in the North-West of the Extension and shares boundaries with Sabogida, Ijagba, Owan, and Sobe in the North, South, East and West respectively.

3.3 Owan Community

Owan, which translates to “The land that protects its children”, is an Uhebe community in Ovia North East Local Government Area in Edo State, Nigeria. The community is in the North-West of Extension Two, and shares boundaries with Sabongida, Ofutabe, Uhiere, and Agbanikaka in the North, South, East and West respectively.

3.4 Uhiere Community

Uhiere, which translates to "The Land of Peace", is an Ishan community in Ovia North East Local Government Area in Edo State, Nigeria. The community is in the West of the project site and shares boundaries with Oke, Ofutabe, Odigwetue and Owan, in the North, South, East and West respectively.

3.5 Odiguetue Community

Odiguetue, which translates to "The Land of dignity", is an Edo community in Ovia North East Local Government Area in Edo State, Nigeria. The community is in the South-West of the project site and shares boundaries with Okokhuo, Oke, Uhiere and Odighi in the North, South, East and West respectively.

3.6 Odighi Community

Odighi, which translates to "The Land of honey", is an Ozoguo community in Ovia North East Local Government Area in Edo State, Nigeria. The community is in the South-West of the project site and shares boundaries with Idunmowo, Oke, Osasimoba, and Uhiere in the North, South, East and West respectively.

3.7 Ihrue Community

Ihrue, which translates to "The Land of evil blood", is a Benin community in Uhunmwonde Local Government Area in Edo State, Nigeria. The community is in the East of the project site and shares boundaries with Oke, Iruekpe, Ekpan and Ikhuo in the North, South, East and West respectively.

3.8 Oke-Irhue Community

Oke, translates to "The Land surrounded by hills", is a Benin community in Uhunmwonde Local Government Area in Edo State, Nigeria. The community is in the East of the project site and is one of the oldest communities based on oral history.

3.9 Ekpan Community

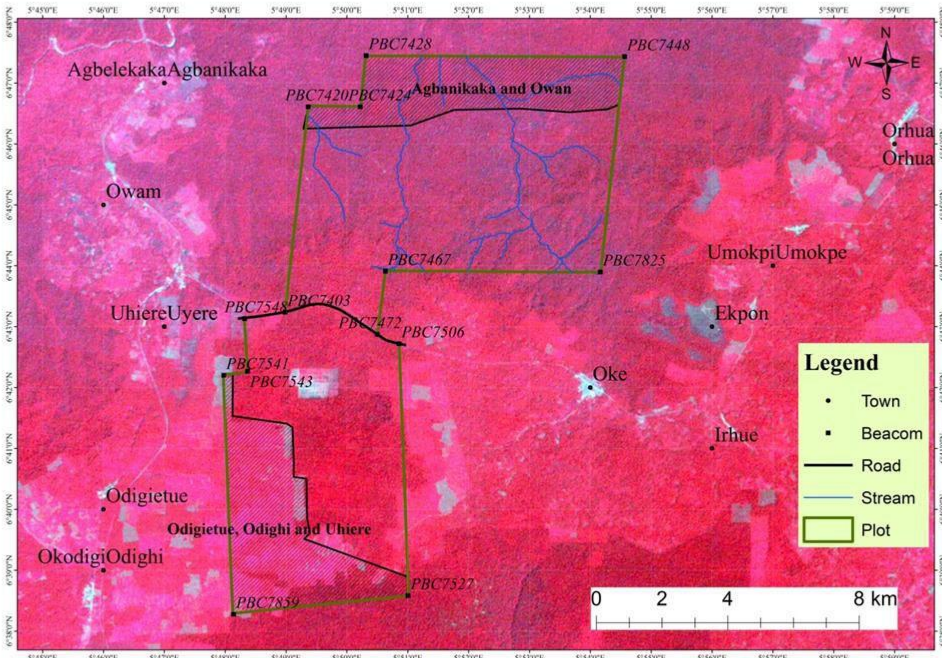
Ekpan, which translates to "The Land of Peace", is a Benin community in Uhunmwonde Local Government Area in Edo State, Nigeria. The community is in the East of the project site. The community which is about 2 square kilometers in size (in-dwelling) is made up of four quarters namely Dumeso, Idueke, Ukpoka and Egohie. It shares boundaries with Isa West, Owan, Irhue and Umukpe-Irhua in the North, South, East and West respectively.

3.10 Umuokpe Community

Umuokpe, which translates to "The Land of Prosperity", is a Benin community in Uhunmwonde Local Government Area in Edo State, Nigeria. The community is in the North-East of Extension Two. It is about 2 square kilometers in size (in-dwelling) and is made up of three quarters and seven compounds. The community shares boundaries with Orhua, Ekpan, Isan West and Owan in the North, South, East and West respectively.

3.11 Orhua Community

Orhua, which translates to "The Land of humility", is a combination of Ishan and Benin community in Uhunmwonde Local Government Area in Edo State, Nigeria. The community is in the North-East of the project site and shares boundaries with Iruekpen, Umuokpe, Isan West and Owan in the North, South, East and West respectively.



Map 2: Location of Extension Two Communities

4.0 Free, Prior and Informed Consent

Free, Prior and Informed Consent (FPIC) is the right of indigenous peoples and other local Communities to give or to withhold their consent to any project affecting their lands, livelihoods and environment.

This consent should be given or withheld freely, meaning without coercion, intimidation or manipulation, and through communities" own freely chosen representatives such as their customary or other institutions. It should be sought prior to the project going ahead, meaning sufficiently in advance of any authorization or commencement of activities and respecting the time requirements of indigenous consultation processes. It should be informed, meaning that communities must have access to and be provided with comprehensive and impartial information on the project, including the nature and purpose of the project, its scale and location, duration, reversibility, and scope; all possible economic, social, cultural and environmental impacts, including potential risks and benefits, resulting from the project and that the costs and benefits of alternative development options can be considered by the community with, or offered by, any other parties who wish to do so, with whom the community is free to engage.

Key to respecting consent are iterative processes of collective consultation, the demonstration of good faith in negotiations, transparent and mutually respectful dialogue, broad and equitable participation, and free decision by the community to give or withhold consent, reached through its self-chosen mode of decision making.

5.0 RSPO and FPIC Requirement

Respect for FPIC has been a central requirement of the RSPO Principles and Criteria since they were first adopted in 2005. It seeks to ensure that RSPO certified sustainable palm oil comes from areas without land conflicts or „land grabs" and that oil palm expansion takes place in ways that do not destroy High Conservation Values (HCVs) or cause social conflict. FPIC is thus a principle of best social practice and of best environmental practice, ensuring just land acquisition and use.

The principle of Free, Prior and Informed Consent is central to the RSPO"s Principles and Criteria and guides the way companies deal with local communities (including indigenous peoples), provide information, carry out impact assessments, acquire land, agree payments and benefits, settle differences and resolve conflicts and pay compensation.

The key RSPO Principles & Criteria relating to FPIC provide that:

Criterion 2.2	**Indicators:**
The right to use the land is demonstrated and is not legitimately contested by local people who can demonstrate that they have legal, customary or user rights.	2.2.1 Documents showing legal ownership or lease, history of land tenure and the actual legal use of the land shall be available. 2.2.2 Legal boundaries shall be clearly demarcated and visibly maintained. 2.2.3 Where there are or have been disputes, additional proof of legal acquisition of title and evidence that fair compensation has been made to previous owners and occupants shall be available, and that these have been accepted with free, prior and informed consent (FPIC). 2.2.4 There shall be an absence of significant land conflict, unless requirements for acceptable conflict resolution processes (see Criteria 6.3 and 6.4) are implemented and accepted by the parties involved. 2.2.5 For any conflict or dispute over the land, the extent of the disputed area shall be mapped out in a participatory way with involvement of affected parties (including neighbouring communities where applicable).

	2.2.6 To avoid escalation of conflict, there shall be no evidence that palm oil operations have instigated violence in maintaining peace and order in their current and planned operations. **Specific Guidance:** For 2.2.2: Plantation operations should cease on land planted beyond the legally determined area and there should be specific plans in place to address such issues for associated smallholders. For 2.2.6: Company policy should prohibit the use of mercenaries and Para-militaries in their operations. Company policy should prohibit extra-judicial intimidation and harassment by contracted security forces (see Criterion 6.13).
Criterion 2.3 Use of the land for oil palm does not diminish the legal, customary or user rights of other users without their free, prior and informed consent.	**Indicators:** 2.3.1 Maps of an appropriate scale showing the extent of recognized legal, customary or user rights(Criteria 2.2, 7.5 and 7.6) shall be developed through participatory mapping involving affected parties (including neighbouring communities where applicable, and relevant authorities). 2.3.2 Copies of negotiated agreements detailing the process of free, prior and informed consent (FPIC) (Criteria 2.2, 7.5 and7.6) shall be available and shall include: a) Evidence that a plan has been developed through consultation and discussion with all affected groups in the communities, and that information has been provided to all affected groups, including information on the steps that shall be taken to involve them in decision making. b) Evidence that the company has respected communities" decisions to give or withhold their consent to the operation at the time that this decision was taken. c) Evidence that the legal, economic, environmental and social implications for permitting operations on their land have been understood and accepted by affected communities, including the implications for the legal status of their land at the expiry of the company's title, concession or lease on the land. 2.3.3 All relevant information shall be available in appropriate forms and languages, including assessments of impacts, proposed benefit sharing, and legal arrangements.

	2.3.4 Evidence shall be available to show that communities are represented through institutions or representatives of their own choosing, including legal counsel. **Specific Guidance:** For 2.3.4: Evidence should be available from the companies, communities or other relevant stakeholders. **Guidance:** All indicators will apply to current operations, but there are exceptions for long-established plantations which may not have records dating back to the time of the decision making, in particular for compliance with Indicators 2.3.1 and 2.3.2. Where there are legal or customary rights over land, the grower should demonstrate that these rights are understood and are not being threatened or reduced. This Criterion should be considered in conjunction with Criteria 6.4, 7.5 and 7.6. Where customary rights areas are unclear these should be established through participatory mapping exercises involving affected parties(including neighbouring communities and local authorities). This Criterion allows for sales and negotiated agreements to compensate other users for lost benefits and/or relinquished rights. Negotiated agreements should be non-coercive and entered into voluntarily, carried out prior to new investments or operations, and based on an open sharing of all relevant information. There presentation of communities should be transparent and in open communication with other community members. Adequate time should be given for customary decision making and iterative negotiations allowed for, where requested. Negotiated agreements should be binding on all parties and enforceable in the courts. Establishing certainty in land negotiations is of long-term benefit for all parties. Companies should be especially careful where they are offered lands acquired from the State by its invoking the national interest (also known as „eminent domain‟). Growers and millers should refer to the RSPO approved FPIC guidance *(‘FPIC and the RSPO: A Guide for Companies’, October 2008)*

	For National Interpretation: Any commonly encountered situations should be identified.
Criterion 7.5 No new plantings are established on local peoples‟ land where it can be demonstrated that there are legal, customary or user rights, without their free, prior and informed consent. This is dealt with through a documented system that enables these and other stakeholders to express their views through their own representative institutions.	**Indicators:** 7.5.1 Evidence shall be available that affected local peoples understand they have the right to say „no‟ to operations planned on their lands before and during initial discussions, during the stage of information gathering and associated consultations, during negotiations, and up until an agreement with the grower/miller is signed and ratified by these local peoples. Refer also to criteria 2.2, 2.3, 6.2, 6.4 and 7.6 for Indicators and Guidance on compliance. **Guidance:** This activity should be integrated with the Social and Environmental Impact Assessment (SEIA) required by Criterion 7.1. Where new plantings are considered to be acceptable, management plans and operations should maintain sacred sites. Agreements with indigenous peoples, local communities and other stakeholders should be made without coercion or other undue influence (see Guidance for Criterion 2.3). Relevant stakeholders include those affected by or concerned with the new plantings. Free, prior and informed consent (FPIC) is a guiding principle and should be applied to all RSPO members throughout the supply chain. Refer to RSPO approved FPIC guidance („*FPIC and the RSPO; A Guide for Companies'*, October 2008). Customary and user rights will be demonstrated through participatory user mapping as part of the FPIC process.
Criterion 7.6 Where it can be demonstrated that local peoples have legal, customary or user rights, they are compensated for any	**Indicators:** 7.6.1 Documented identification and assessment of demonstrable legal, customary and user rights shall be available. 7.6.2 A system for identifying people entitled to compensation shall be in place.

agreed land acquisitions and relinquishment of rights, subject to their free, prior and informed consent and negotiated agreements.	7.6.3 A system for calculating and distributing fair compensation (monetary or otherwise) shall be in place. 7.6.4 Communities that have lost access and rights to land for plantation expansion shall be given opportunities to benefit from plantation development. 7.6.5 The process and outcome of any compensation claims shall be documented and made publicly available. 7.6.6 Evidence shall be available that the affected communities and rights holders have access to information and advice, that is independent of the project proponent, concerning the legal, economic, environmental and social implications of the proposed operations on their lands. **Specific Guidance:** For 7.6.1: This activity shall be integrated with the social and environmental impact assessment (SEIA)required by Criterion 7.1. For 7.6.6: Growers and millers will confirm that the communities (or their representatives) gave consent to the initial planning phases of the operations prior to the new issuance of a concession or land title to the operator. **Guidance:** Refer to Criteria 2.2, 2.3 and 6.4 and associated Guidance. This requirement includes indigenous peoples (see Annex 1). Refer to RSPO approved FPIC guidance („*FPIC and the RSPO; A Guide for Companies'*, October 2008).

6.0 Approach and Methodology

In 2014 when we initiated our FPIC, we were guided by the 2008 RSPO guide for companies. However, in the course of the FPIC process, the RSPO issued the FPIC Guide for RSPO members (2015). The two publications formed the reference documents that guided our approach and methodology. It was focused at ensuring that consent if free, consent is prior, consent is informed, and consent is given. The process and steps are outlined below.

7.1 Our FPIC Steps and Process

7.2 Initial Visits, Consultation and Engagement with Community Stakeholders

We kick-started the FPIC process with initial visits to all the communities to introduce the company and the proposed project. In all, we visited ten communities that were thought to have long time relationship with the project land including customary and user rights. The ten communities included to the east; Ekpan, Oke, Umuokpe, Irhue and Orhua, and to the west; Agbanikaka, Owan, Uhiere, Odiguetue and Odighi.

We followed up on the initial visits with identifying and engaging with community stakeholders especially the community based organizations including the traditional and elders‟ councils, community development associations, women and youth associations. We introduced RSPO to them and the requirement for and their rights under FPIC, especially, the right to say no if they don’t like the proposed oil palm development.

In this particular instance, the communities welcomed the proposed development. They felt that they were better off compared to the former owners and operators that did not accord them such rights and consultations.




Plate 1: Initial visits and consultations with the communities by the Managing Director, Agriculture Coordinator, Community Liaison Officer and other staff of the company.

7.2 Providing information.

We started providing information in earnest for us to comply with the FPIC principle that decision-making and consent should be informed. We provided specific relevant information based on the different stages of the project development including pre-construction, construction, operational and decommissioning phases of the project and ensured that all information met the following guidelines:

- Open and transparent
- In locally appropriate languages and forms
- Delivered in culturally appropriate ways

It was further ensured that all the relevant and mandatory studies such as Environmental Impact Assessment (EIA), Social Impact Assessment (SIA), High Conservation Value (HCV) Assessment were carried out with the full participation of the communities, thus ensuring that the communities further received the following information:

- Balanced treatment of potential positive and negative impacts
- An assessment of costs and benefits, and their distribution
- Alternatives and outcomes of different scenarios
- Information on community’s legal rights and legal implications of the proposed project.
- Benefit sharing

Plate 2: Project Information and Notice Boards at Extension Two Communities

7.3 Representative Organizations

The communities appointed their own representatives from their different community based organization, ensuring that women and youth were included. The community representatives thus came from organizations such as Community development Association, Elders Council, Youth Association, Market Women Association etc. The representatives participated in the iterative meetings and negotiations between the communities and OOPC Plc.

7.4 Power of Attorney

For all the communities, their representatives obtained the power of attorney to represent them duly signed by the respective heads of the communities.

7.5 Participatory Mapping

Each community appointed their members who have good knowledge of the community user rights within the project area and the extent of their lands. The community representatives and company surveyors worked together to delineate the boundaries and identify areas of possible boundary overlaps between the project and community’s land. In all the communities, no issues of boundary overlap were raised during the participatory mapping exercise. However, the outcome of the participatory mapping revealed that two communities namely Umuokpe and Orhua are about 10 kilometers away from the boundary with insignificant claim to user right and also outside of the project’s area of direct and indirect influence. They became disinterested and opted out of the FPIC process, thus leaving us with eight communities to deal with.

Plate 3: Community Representatives involved in Participatory Mapping

7.6 Legal Representation

The remaining eight communities were availed the rights of technical and legal representation. Whereas they felt no need for technical representation, they however chose to appoint one legal representative, who is a member of one of the communities to provide legal advice and guidance for all the communities. The communities thus procured and engaged the services of F. A. Osifo & Co. (Solicitors), as their legal representative. The communities‟ legal representative participated in the iterative meetings and negotiations. He subsequently drafted and finalized the FPIC Agreement in conjunction with the OOPC Plc's legal representative.

7.7 Iterative Meetings

The communities requested that all of them be treated equally and to ensure fairness and equity they agreed that the iterative meetings be held in a central location. Iterative meetings were thus held at the auditorium of the Nigerian Institute for Oil Palm Research. Reasonable time was allowed in between the meetings for the community representatives to feedback and consult with the larger community members. Most of the issues raised, discussed and resolved were cross-cutting issues, while peculiar community issues were left for the negotiation meetings. The iterative meetings were also recorded on video.

Plate 4: Iterative Meetings

7.8 Engaging in Negotiation

We then entered into negotiation phase involving a two-way dialogue between the communities‟ representatives and OOPC Plc's representatives. Negotiations were done under a conducive atmosphere; free from coercion or intimidation and the negotiation process was recorded on video. Each community had their respective cubicles where they sat and engaged the company in negotiation. Negotiation was done with full participation of both the community legal representative and the company's legal representative. The negotiation process provided good support for decision making. The decisions reached at the negotiation table were documented and they formed the cardinal elements of the subsequent FPIC agreement that was drafted.


OWAN


IRHUE

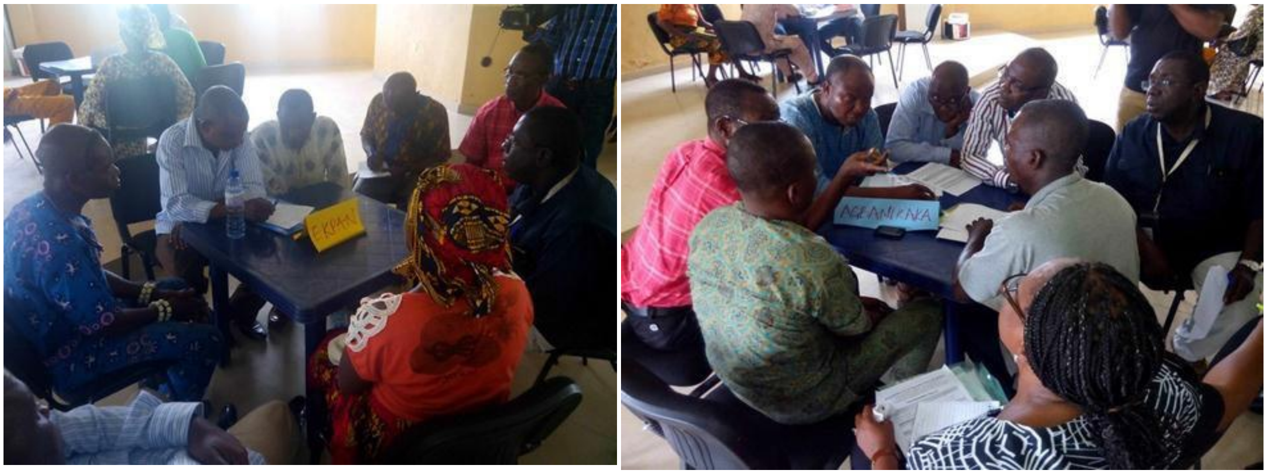


Plate 5: Community Representatives and OOPC Representatives engaged in negotiation

7.9 Compensation

The communities and OOPC Plc resolved the issue of compensation at the iterative meetings and negotiation. Both parties recalled that the former owners; A & Hatman had paid compensation to community members who submitted legitimate claims for loss of crops. An understanding was thus reached during negotiation that OOPC Plc is not liable to pay fresh compensation to individual members of the communities but rather should provide support and assistance that will benefit the entire communities.

7.10 Documenting Consent-Based Agreements

The community specific consent-based agreements were drafted jointly by the legal representatives of the communities and the company. The agreements captured all the decisions and obligations that were mutually agreed by both parties. The two legal representatives submitted the draft agreements to the communities and OOPC Plc for their comments, whereupon the final FPIC Agreements were produced and presented for signing by both parties.

8.0 FPIC Agreement Highlights

The FPIC agreement has provisions for clauses including preamble, the obligations of both parties, Joint Implementation Committee, Force Majeure, Confidentiality and Grievance and Dispute Resolution Mechanisms.

9.0 Signing Consent-Based Agreements

The signing of the FPIC Agreements was done in a public ceremony attended by the leadership of the communities and the management of OOPC Plc on 29 July 2016. The signing ceremony was witnessed by the Executive Director of the Nigerian Institute for Oil Palm Research (NIFOR), while the Honorable Commissioner for Agriculture represented the Edo State government. The event also made the news in both the print and electronic media as the very first of its kind to happen in Edo State, if not Nigeria as a whole.


Plate 6: FPIC Agreement Signing Ceremony

10.0 Presentation of Signed FPIC Agreement

The signed FPIC Agreements were later notarized and delivered to the communities.

Plate 7: Notarized FPIC Agreement Display at Uhiere Community

Plate 8: Notarized FPIC Agreement Display at Owan Community

Plate 9: Notarized FPIC Agreement Display at Agbanikaka Community

Plate 10: Notarized FPIC Agreement Display at Irhue Community

Plate 11: Notarized FPIC Agreement Display at Ekpan Community


Plate 12: Notarized FPIC Agreement Display at Odighi Community

Plate 13: Notarized FPIC Agreement display at Odiguetue Community

11.0 Joint Implementation Committee

The FPIC agreement provides for the formation of Joint Implementation Committee (JIC) with membership to be drawn from the representatives of each community and OOPC Plc. The JIC is vested with the responsibility to plan and monitor the implementation of the FPIC Agreements in their respective communities.

12.0 Grievance and Dispute Resolution

A grievance and dispute resolution mechanism provide a process for resolving differences that may arise in the course of implementing the FPIC agreements. The FPIC Agreement provides for clauses defining how differences will be communicated and resolved.

APPENDIX IV

OOPC STAKEHOLDERS’ ENGAGEMENT PROCEDURE

Action	Name	Function	Date	Signature
Prepared by	Mikle George	HSE Manager		
Verified by	Olise Fidelis Ikponmwosa Osunbor	Communication Officer HRM		
Approved by	Dr. Graham Hefer	Managing Director		

TABLE OF CONTENTS

1. OBJECTIVE

The purpose of this procedure is to define how and why OOPC engages with internal and external stakeholders for all OOPC operation.

2. APPLICATION FIELD

This procedure applies to all stakeholders associated with OOPC.

3. ABBREVIATIONS

REC	Record
MD	Managing Director
HSEM	Health Safety& Environmental Manager
IMS	Integrated Management System
OOPC	Okomu Oil Palm Company
HRM	Human Resources Manager
HRD	Human Resource Department
HOD	Head of Department
CLO	Community Liaison Officer
GDP	Gross Domestic Product
NGO	Non-governmental organization
CO	Communication Officer

4. DEFINITIONS

- **Grievance:** is a concern or complaint raised by an individual, group, or community in relation to activities undertaken by OOPC.
- **Collective Grievance:** is a complaint raised by two or more employees in a unionized workplace.
- **Internal Stakeholders**: Employees, Contractors, Suppliers, and Union.
- **Internal Grievance mechanism**: internal dispute resolution by which an employee may have his or her grievances addressed.
- **External Stakeholders:** includes, *inter alia,* Communities, Government organizations/institutions, NGOs, shareholders and customers that are affected by or have an interest in OOPC activities, products and/or performance.
- **Engagement**: actions taken by OOPC to communicate understand and involve stakeholders in the decision-making processes when appropriate.
- **Stakeholder Engagement Plan (SEP):** system used to identify stakeholders and manage engagement based on the level of interest and influence an individual or group has on company operations.
- **Socioeconomic Indicator:** A tool used to understand an individual or a group's status within their local environment which can include GDP, life expectancy, literacy and levels of employment, in addition to freedom of expression, personal safety and participation in civil society.

- **Partnership:** Agreement between OOPC and a third party to develop projects or engagement activities through shared interests and/or resources.
- **Vulnerable Groups/Individuals:** Vulnerable individuals and groups are potentially more susceptible to negative impacts or have a limited ability to take advantage of positive impacts.
- **Union**: A body under the Nigerian legislation responsible for workers within OOPC.

5. RESPONSIBILITY

HSEM is responsible for ensuring that this procedure is implemented and monitored.

CLOs/CO will communicate with community leaders within OOPC footprint as stated in OOPC stakeholder management plan (OOPC/FORM 1.47, Annex 1&2).

CO/CLOs must provide minutes of meetings and photos, if applicable, to the HSE and MD of all meetings with the communities for documentation purpose.

CO will maintain constant open communication with all stakeholders and ensure that all relevant information pertaining to OOPC is communicated.

MD will ensure constant communication with all stakeholders as stated in OOPC stakeholder management plan (OOPC/FORM 1.47, Annex 1&2).

HOD will communicate with stakeholders as stated in OOPC stakeholder management plan (OOPC/FORM 1.47, Annex 1&2).

HRM will communicate with stakeholders as stated in OOPC stakeholder management plan (OOPC/FORM 1.47, Annex 1&2).

PROJECT will ensure all OOPC approved projects are done according to plan and provide updates to the MD, CO and the HSE department on at least a quarterly basis to keep them abreast of developments with projects, and for documentation purpose.

Company Secretary will provide relevant information to Security and Exchange Commission on a quarterly basis and provide updates to the MD, CO and the HSE department to keep them abreast of developments in respect of OOPC, and for documentation purpose.

6. STAKEHOLDER ENGAGEMENT OVERVIEW

Stakeholders are individuals and groups that are directly or indirectly affected by OOPC activities, in addition to those that may have interests in or influence over OOPC. This interest or influence can affect projects, activities, products or the performance, either positively or negatively, of OOPC. Stakeholders include local communities or individuals living inside OOPC's foot print, their representatives, national or local government authorities, politicians, religious leaders, civil society organizations and groups with special interests.

Stakeholder engagement is a broad term used to describe all activities and interactions between OOPC and its stakeholders.

6.1. Why Stakeholders engage

Stakeholder engagement helps build trusting relationships and opens up lines of communication between OOPC and stakeholders. Communication reduces risks to OOPC by identifying and dealing with issues as they arrive, thus improving the reputation of OOPC in the eyes of all stakeholders.

Stakeholder engagement spans all phases of the project and operation lifecycle, with different stakeholders able to influence each activity.

7. PROCEDURE (Stakeholder Engagement Strategy)

OOPC uses this procedure to engage with stakeholders and it is driven by a commitment to openness and transparency and a respect for the views of stakeholders. This procedure and strategy aims to harmonize stakeholder engagement procedures across all operations, opening communication channels and improving working relationships with all stakeholders.

7.1. Stakeholder Identification

Stakeholder identification is the first stage of the engagement process. This will include those both directly affected, such as communities within OOPC's footprint and those indirectly affected such as national or international NGOs. Stakeholders will be determined through OOPC's stakeholder engagement plan (See OOPC/FORM 1.47, Annex 1&2).

	Description
Internal Stakeholders	• Board of Directors • Senior Management • Shareholders • Unions/employees
Industry Stakeholders	• Suppliers • Customers • Industry associations

	Description
Government Regulators	• Local agencies/officials • Regional/state agencies/officials • National agencies/officials • International organizations
Communities	• Directly affected communities within OOPC foot print • Community leaders
Civic Organizations	• Places of worship • Local trade or labour Unions • Educational or health organizations • Charitable organizations • Organizations supporting vulnerable groups
Non-governmental Organizations	• Local/regional/state groups • National/international groups • Environmental Groups

7.2. Stakeholder prioritization and mapping

Not every stakeholder group will require the same level of engagement in terms of frequency or method of communication. Once a stakeholder identification exercise has been performed, it is therefore important to prioritize and map groups based on who they are and the level of risk they pose to OOPC operation.

7.3. Method of Engagement

Once stakeholder groups have been prioritized in terms of their level of influence and/or operations, a different method of engagement should be developed for each stakeholder if applicable. The reason for this is that individual stakeholders and groups have different requirements in terms of language, communication materials or method necessary to share and receive information.

Engagement can include: *information sharing*, where OOPC informs stakeholders about its performance or any changes; *response (action)*, which is where OOPC responds to stakeholder requests or complaints; or *consultation*, whereby communication with stakeholders is two-way and information gathered can be used to influence changes in operations.

Each stakeholder group may require different forms of engagement such as:

- Local Communities: *consultative engagement* may require written communications in the main local languages, allowing communities to respond in the language they operate in. Some members of the community may also require assistance with submitting or reading written materials. Communities may require engagement with several subgroups separately including leaders and vulnerable groups.
- Government Officials: *Informative engagement* is often required, such as sharing of written materials in the national language. Meetings may also be held where communication is verbal, but minutes should be taken and signed by all parties, where applicable and necessary.
- International NGOs: *Responsive engagement* in the form of written reports and media communications aimed at assisting the building of relationships with international NGOs.

  The examples provided above are simplified for the purpose of this procedure and it is pertinent to note that some stakeholder groups will require a range of engagement methods. Choosing an appropriate method of engagement for each stakeholder group, depending on their need, will ensure that communication is well received and understood, and can be responded to effectively.

7.4. Information Disclosure

Disclosure means making information accessible to stakeholders and communicating in a manner that is understandable. All types of engagement, from consultation to the resolution of grievances, will be more productive if stakeholders, including affected communities, have accurate and timely information about OOPC's activities, impacts, and any other aspects that may have an effect on them. The type and level of information disclosed is dependent on the priority of each stakeholder, though OOPC will strive to be as transparent as possible as per OOPC code of ethics policy. Information disclosure is based on the following key principles:

- Disclosure Timing: If feedback is required, it is important to share information as early as possible to allow stakeholder's adequate time to review and process what is presented and decide appropriately.
- Meaningful Information: the information will need to be culturally appropriate in a format and language that is easily understandable by the stakeholder.
- Accessibility: stakeholders will require information during engagement, but also acknowledge on how they can access further information, if required.
- Information Sensitivity: It is important to share risks and impacts with affected stakeholders, but how this information is presented can influence their reaction to developments. When information is sensitive, it is important to present just the facts and leave out any uncertainties.

7.5. Stakeholder Consultation

Listening and understanding stakeholder concerns and feedback is a valuable source of information, which can help improve OOPC operations, in addition to helping to identify and address potential risks.

Once stakeholders have been identified and prioritized, and the method and frequency of engagement determined, consultation requirements of each stakeholder should be determined. Consultation with stakeholders will build trust with communities within OOPC footprints and raises awareness.

- Gender-inclusive: men and women often have different views and in some cultures it is not acceptable for women to be heard in public. Allowing women the time and space to participate is crucial.
- Free: consultation should not be manipulated or coerced.
- Documented: tracking of consultation is important to ensuring key issues are recorded and addressed
- Report back: those consulted will require information on time frame and when they will receive feedback, further information/consultation.
- Consultation, participation and communication is achieved through one or more of the following documents: minutes of meetings, management reviews, internal office meetings, circulars, memos, letters, emails, newsletter and board meeting.
- Ongoing: consultation is to be undertaken throughout the project lifecycle.

7.6. Vulnerable Groups and Gender Considerations

Vulnerability is determined by the ability of an individual or group to cope or adapt to change and can be affected by the social, economic, technological, institutional and cultural resources available. Vulnerable individuals and groups are potentially more susceptible to negative impacts or have a limited ability to take advantage of positive impacts. Vulnerability is often a pre-existing status that is independent of OOPC and may be reflected in an existing low level of access to key socioeconomic or environmental resources or a low status within certain socioeconomic indicators (low or no education, poor health, low status within the community etc.).
Vulnerability varies from location to location and OOPC will determine who is considered vulnerable within their cultural context and consult with them on an ad hoc basis as per OOPC/Form 1.47 and OOPC/Form 1.47 (Annex 1). Generally there are some groups that are more likely to be vulnerable than others due to their status within society and their ability to access resources. This includes women, elderly, disabled, indigenous groups and the poor.
In many instances vulnerable groups will require special consideration in terms of engagement, as they may not be able to participate in community wide consultation or engagement activities. This will often require separate meetings

for vulnerable groups and consideration of whether they are fully represented by community leaders.

7.7. Establish Partnerships

In many instances, OOPC can benefit from strategic partnerships with communities, companies, government, NGOs or other stakeholders. This can involve joint activities and collaborative efforts based on a common interest. This is based on:

- Common objectives or strategic interests
- The pooling of cash or in-kind resources from all parties
- Sharing information, transparency and joint fact-finding
- Drawing in on core and complementary competencies
- Sharing risks and benefits, both financial and reputational.

8. GRIEVANCE MANAGEMENT

8.1. Internal Grievance

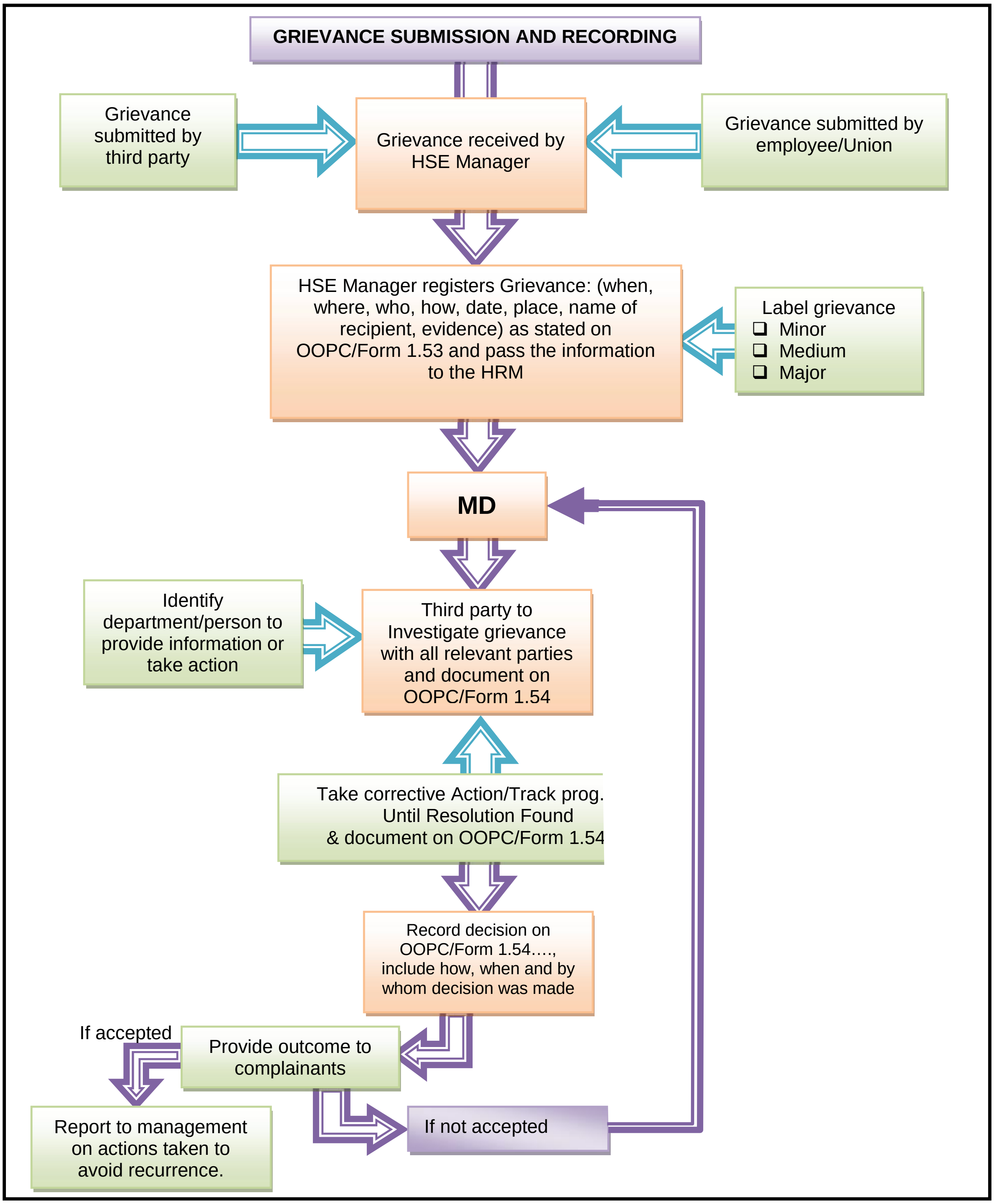
- Where an internal stakeholder feels aggrieved on any decision or action of management, the issue must first be discussed with his/her immediate superior or manager or the HOD or HRD who will try to resolve the issue as quickly as possible within the time constraints of this procedure. If resolution is accepted by the complainant, it should be stated in OOPC/Form 1.54
- If the stakeholder is not satisfied with the outcome of the meeting with his/her superior or manager or the HOD or HRD, the stakeholder must make it known to HRD or HOD in writing that he/she is not satisfied, stating the reason for their dissatisfaction and the HRD shall follow the procedure in clause 5.0.
- If the stakeholder is not satisfied with the decision of the MD, the stakeholder may write formally to the union for intervention.
- Upon the receipt of a formal complaint, the Union shall check if the stakeholder had complied with the above stages.
- If the Union is satisfied that the stakeholder has complied with the above stages, the Union shall request a formal meeting with the MD to discuss the issue.
- If the Union is not satisfied with the meeting with the MD, the union must follow their union constitution.

8.2. Collective Grievance

- Where the union observes, suspects or feels that an aspect of the subsisting collective agreement or company's policy and procedures have been breached, or acts on behalf of a stakeholder or union member, the union will formally write to HRD stating the aspect of the agreement, policies and procedures that have been breached. The union shall fill OOPC/Form 1.53 and send to the HSE Manager

- On receipt of a formal union complaint, the HRD will investigate the claim and thereafter, invite the union representatives to a meeting to resolve the grievance.
- If the grievance is not resolved at the office of the HRD, the grievance will be upgraded to a major grievance and forwarded to the MD.
- If the grievance is not resolved by the MD, the Branch union shall write to the State union executive informing them of the grievance.
- The State union executive will schedule a time to hold a meeting with the MD to find an amicable resolution to the grievance.
- If the grievance is not resolved at the State level, the State union executive will write to the National headquarters informing them of the impasse.
- On receipt of the complaint from the state executive, the National headquarters of the union will strive to resolve the impasse/grievance by having an audience with the MD.
- If the grievance or impasse is not resolved at the level of the National headquarters of the union, the National headquarter will declare a dispute and the Statutory dispute resolution procedure will then be adhered to.
- It will be an offence that will be sanctioned, not to comply with this grievance procedure and all processes of the grievance must be documented on OOPC/Form 1.53, 1.54 and minute, using OOPC Form GF15

8.3. Individual & Collective Grievance Management Process



8.4. RECEIPT OF GRIEVANCE

The HSE Manager receives all grievances and ensures OOPC/Form 1.53 is completed. Grievances can be submitted through the following channels:

- OOPC mail box at various locations within OOPC plantation (including Extension 1 and 2).
- OOPC Website: http://www.okomunigeria.com/
- E mail: hsesec@okomunigeria.com
- In writing: Okomu-Udo Ovia South west LGA P.M.B 1449, Benin City, Edo State Nigeria Attention: HSE Department (Grievance section)
- Lagos office- Coscharis plaza, Adeola Odeku, Victoria Island, Lagos.

8.4.1 Registration of a Grievance

Once a grievance is received by HRD, and OOPC form 1.53 is completed, it will be officially acknowledged by HSEM, and then documented and recorded in the HSE data base and passed to the MD for further investigation (see 8.3.3). After resolution, the HRD will respond to the complainant in written form of the resolution achieved (see 8.3.4).

8.4.2 Investigating unresolved and major Grievances

The MD will assign all investigations to a relevant third party (such as consultants) to resolve these grievances. All investigation should be completed as quickly as possible, but will depend on the nature of the complaint or concern and the required action to be taken. The grievance database should record all actions taken as part of the investigation process, including dates of communications with different departments, responses and expected actions. In some instances, further evidence may be required, which will involve a third party outside of the organization. All grievance investigations must be handled on a strictly confidential manner with no conflicts of interest, personal or professional gain or bias. The HSEM will track all grievances-minor, medium or major.

8.4.3 Recording and Reporting Decisions

All decisions must be recorded on OOPC/Form 1.54 and communicated with all parties involved in writing to ensure that all parties are in agreement. The complainant may not always be satisfied with the resolution on offer, which is why in some instances; several different resolution options may be advisable.

8.5. External grievance

This applies to an external stakeholder who wishes to register a grievance. The grievance should be submitted in writing with the stakeholders contact information on community, government or NGOs letter head. The letter should state the nature and background to the dispute and the proposed solution to resolve the matter.

The submission of the grievance should, at a minimum, include provision of the following:

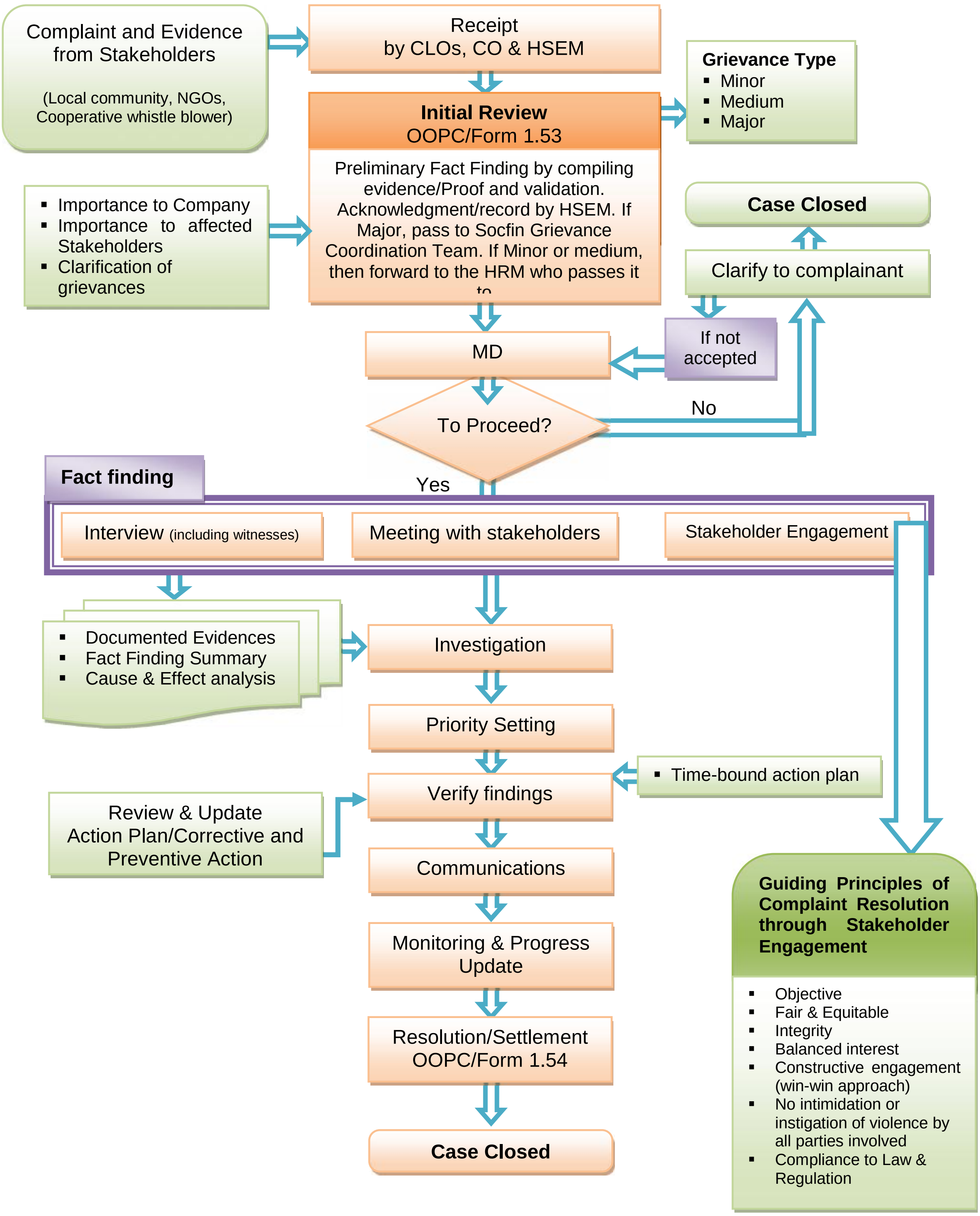
- Full Name
- Name of Organization (as applicable)
- Address
- Phone No./Fax No./Email Address (at least one contact point)
- Description of the grievance in details
- Evidences to support the grievance

External stakeholders can submit their grievances via the under listed channels:

- The Community Liaison Officer
- OOPC Website: http://www.okomunigeria.com/
- E mail: hsesec@okomunigeria.com or transparency@socfin.com
- In writing to:
  - Okomu-Udo Ovia South west LGA P.M.B 1449, Benin City, Edo State Nigeria Attention: HSE Department (Grievance section) or through the Community Liaison Officer or Communication Officer; or
  - Socfin S.A.
    Attn.: Grievance Coordination Team
    4, Avenue Guillaume
    1650 Luxembourg
    Grand-Duché de Luxembourg

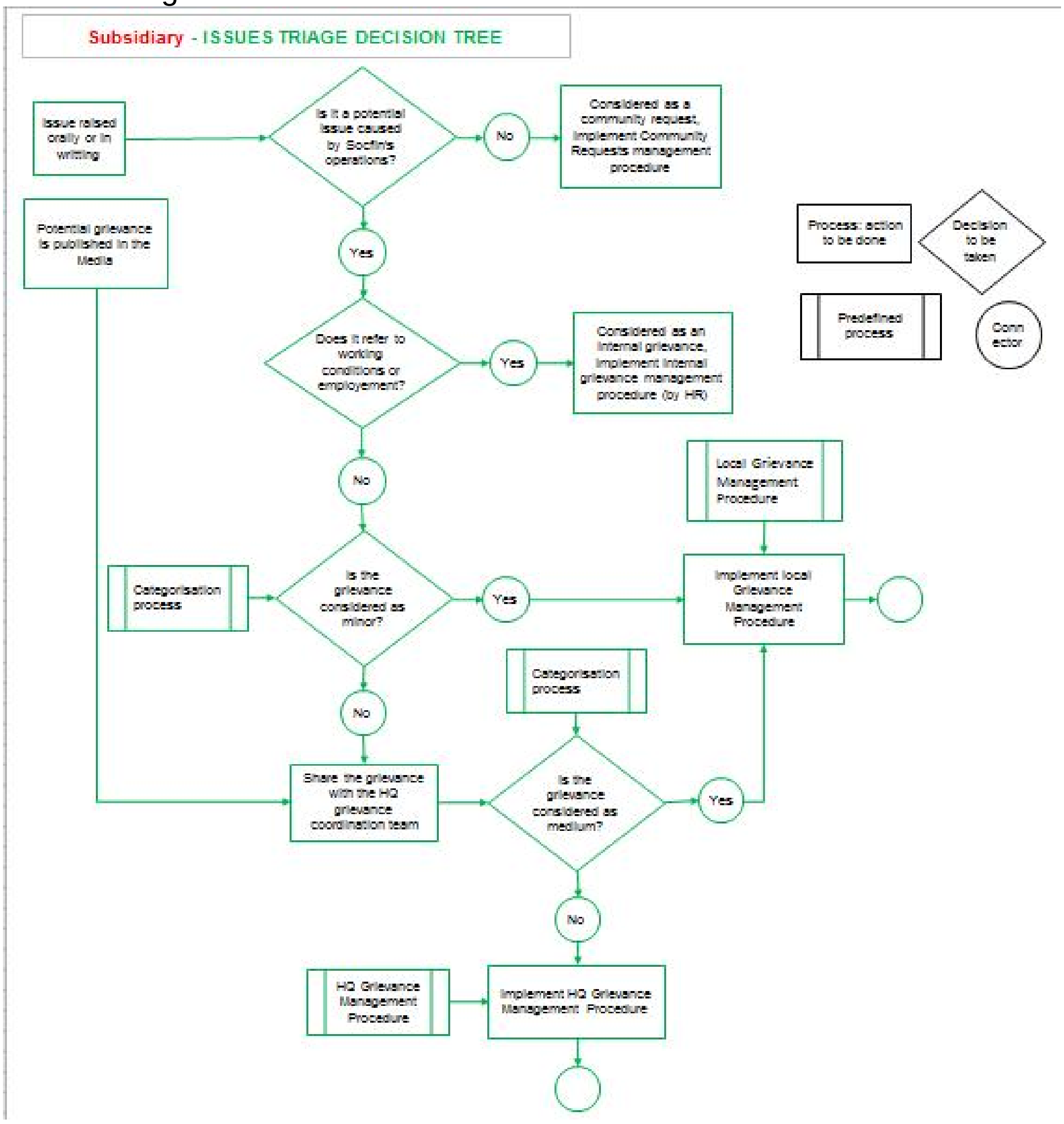
OOPC's grievance procedures and social and environmental standards shall be communicated to all interested and affected stakeholders through strategies identified in its stakeholder communication strategy.

EXTERNAL GRIEVANCE MANAGEMENT PROCESS



8.5.1.1 Interpretation of the External Grievance Management Process

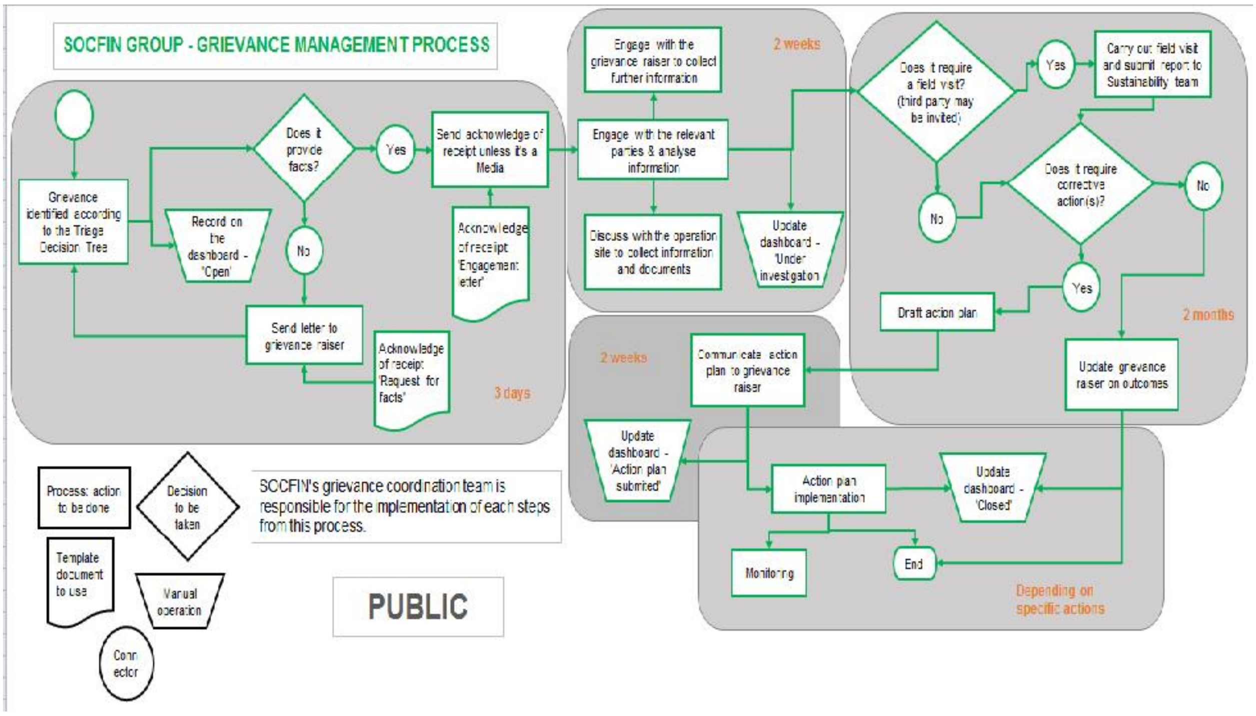
A Complaint/evidence is received from stakeholders through the recognized channels (see 8.5), with an initial review done by the HSEM, CO or CLOs and acknowledged by the HSEM, who will forward all to the MD to indicate whether to proceed. If "**NO,**" the grievance will be clarified to the complainant by the HSEM and closed, but if complainant is not satisfied it will be referred back to the MD for further decision. If "**YES**", the grievance investigation will proceed using the fact finding approach by conducting various interviews (witnesses inclusive), meetings with stakeholders and stakeholders' engagement, if necessary. In addition to grievances submitted through the official channels listed in 8.5 above, issues raised through unofficial channels, such as the media and the internet, will be recorded as grievances on request by either TFT or Socfin, as per described in the following chart.



All information required to effectively process and investigate the grievance will also be entered in the database (see OOPC/Form 1.55).

During investigation and resolution processes:

- Communicate by arranging a meeting with the complainant and all affected stakeholders. Discuss the investigation process and solutions and get complainants consent to the intervention.
- Set priorities by indicating if complaint is Minor, Medium or Major as defined.
- Verify findings by reviewing and updating the action plan/corrective and preventive action. Each case is expected to be addressed within 15 working days, beginning from the date of receipt. Depending on the procedural complexity of the case, the time frame for each stage could be adjusted by the head of the investigation team and a new time frame communicated to the stakeholder and MD. Also review all relevant supporting documents, determine the underlying cause, engage all impacted stakeholders and coordinate with the respective department and/or a specialist responsible for addressing the complaints properly.
- Monitor by continuously reviewing internal reports, and recommendations-recommendations may be an operational action plan, corrective actions, and improvements to existing policies and/or continuous engagements with stakeholders.
- Resolution options can require a one-off action or warrant ongoing procedures depending on the nature of the complaint or concern. The complainant may not always be satisfied with the resolution on offer, which is why in some instances, several resolutions are advisable.
- Open communication with the complainant during the grievance process is important to present information transparently and in an appropriate format. Once presented with a set of responses, the complainant must decide whether to accept or reject the resolution. If the resolution is accepted then it must be recorded in the database with the grievance signed off as resolved. The complainant will also receive a written record of the resolution to ensure that all parties are in agreement.
- Close case if complainant and affected stakeholders are satisfied with the action taken.
- If the response is rejected, then additional responses will either be required or the grievance escalated to more senior management (MD). Alternatively, the complainant has the right to escalate the complaint to a third party outside the company, for assistance and finding a resolution.
- OOPC will make every effort, to the extent appropriate, to resolve grievances amicably. If grievances are not resolved, OOPC will seek the expertise of a neutral third party outside OOPC for assistance in finding a resolution in line with the third party’s grievance management mechanism or framework.
- All proposed actions to be taken must be presented to the MD for approval before implementation.
- Major grievances will be handled according to the below chart in conjunction with the Socfin Grievance Coordination Team



9. RECORDS

a) OOPC/Form 1.53
b) OOPC/Form 1.54
c) OOPC/Form 1.55
d) OOPC/Form 1.47
e) OOPC/Form 1.47 (Annex 1)
f) OOPC/Form 1.47 (Annex 2)
g) Grievance letter
h) Statements/evidence (if available)
i) Form GF15 (minutes)

10. REFERENCE

a) RSPO Criteria 6.3, 1.3
b) ISO 14001:2004 Clause 4.4.3
c) Socfin Group Grievance Management Process
d) EBRD(2012) Grievance Management Guidance Note
e) CAO (2008) The Office of the Compliance Advisor Ombudsman: A Guide to Designing and Implementing Grievance Mechanisms For Development Projects.
f) IFC (2007) Stakeholder Engagement: A Good Practice Handbook for Companies Doing Business in Emerging Markets.
g) IFC (2012) Performance Standard 1: Assessment and Management of Environmental and Social Risks and Impacts

h) IFC (2009) Good Practice Note: Addressing Grievances from Project-Affected Communities: Guidance for Projects and Companies on Designing Grievance Mechanisms.
i) FSC Criteria 4.3, 4.4, 4.5.

11. REVISION STATUS

Rev.	Date	Details
0	17/09/15	Initial Release
1	24/05/17	Changed ISO 14001:2004 Clause 4.4.3 to ISO 14001:2015 Clause 7.4 Changed logo in header Added a verifier in front page Changed HRC to HRM in Section 5 – Responsibility Change HRM mail address and company's website in § 8.4
2	11/05/18	Changed sentences in Section 8