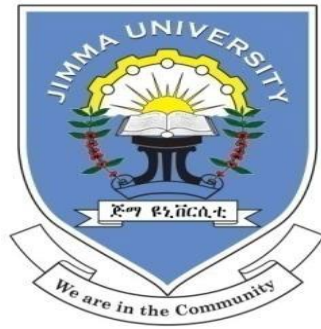




Jimma University
School of Graduate Studies
Jimma Institute of Technology
Faculty of Civil and Environmental Engineering
Geotechnical Engineering Stream

**Assessment of Diri-Masha (Gimbo - Konda) Road Subgrade Soil and Mitigation Measures
using Partial Replacement**

MSc. Thesis

By

Getinet Mihrete

Feb, 2021

Jimma Ethiopia

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School of Graduate Studies
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using Partial Replacement**

**A Thesis Submitted to the School of Graduate Studies of Jimma University in Partial
fulfillment of the requirements for the Degree of Masters of Science in Geotechnical
Engineering**

By

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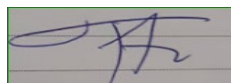
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ABSTRACT

Most Civil engineering structures is to be founded on soil. The soil on which the structure is to be built should be capable of withstanding the load to be imposed on it. However, naturally there exist problematic soils to be used as foundations or construction materials. Expansive soils present significant geotechnical and structural engineering challenges over all the world, with costs associated with expansive behavior estimated several billion annually. In Ethiopia, nearly 40% surface area of the country covered with expansive soils. The objective of this thesis is to investigate experimental road subgrade soil properties of Diri – Masha Road Project (Gimbo – Konda) and mitigation measure taken by partial replacement method for expansive soil. There are two main types of soil samples for this study: experimental road subgrade and suitable borrow material. Sampling method for experimental subgrade soil is dig or excavates by digging tools with labor to one point five-meter depth at three km interval & recovers the bore holes / trial pits after samples collected. For this study twenty experimental subgrade soils and two suitable borrow materials collected at near section of the road project to use for treatment of experimental expansive subgrade soil.

This research data was collected and organized both in numerical form and in words. After sorting out the effective data, the numerical portion of the data was analyzed using excel software, charts, tables& figures. From total twenty experimental subgrade soils tested by ASTM test method, only eight is expansive soil and need treatment. Test result of expansive soil are, LL: 61-76%, PI: 30-42%, CBR: 4.8-7%, Swell: 2.4-3.7%, free swell: 55-107.33% and Classification of soil: MH-CH. The optimum ratio for the expansive soils is 40% using both borrow materials. The analysis has been tried on four expansive experimental subgrade soils and two suitable borrow materials & taken as representative experiment for the remaining. The maximum improvements on engineering properties were observed on LL, PI, free swell and CBR. & minimum on Specific gravity. From this study, the thesis document can be used as a reference for geotechnical engineering investigation, higher institution, stack holders like contactors, consultant and ERA can use it when required.

Keywords: *Expansive soils, Partial replacement, Liquid limits, experimental subgrade soils, and CBR*

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ACRONYMS

ASTM	American Society of Testing Materials
CBR	California Bearing Ratio
ERA	Ethiopian Road Authority
JIT	Jimma University Institute of Technology
LL	Liquid Limit
MDD	Maximum Dry Density
NMC	Natural Moisture Content
OMC	Optimum Moisture Content
PL	Plasticity Limit
PI	Plasticity Index
SNNPR	Southern Nations, Nationalities and Peoples' Region
ERSM	Existing Road Subgrade Material
SBM	Suitable borrow Material

1. INTRODUCTION

1.1 Back Grounds of the Study

Most Civil engineering structures is to be founded on soil. The soil on which the structure is to be built should be capable of withstanding the load to be imposed on it. However, naturally there exist problematic soils to be used as foundations or construction materials, such as expansive soils, whose engineering characteristics are mainly affected by fluctuation of moisture content. Expansive soils originate from complex combination of conditions and processes that result in the formation of clay minerals having a particular chemical makeup which expands when it comes in contact with water. All clay soils are not expansive and the degree of expansion varies the degree of clay mineral predominantly present in the soil mass. The presence of montmorillonite contributes to high swell-shrink potentials [1].

Soft soils form problematic subgrade for pavements due to its low bearing capacity and strength. Pavement load coming on the soft subgrade soil may cause detrimental pumping actions when they are located in areas with high water table which causes both construction and in-service performance problems. The common solutions on encountering such problems include excavation and replacement of soil, lime treatment or chemical stabilization. Excavation and replacement of soil becomes very expensive especially when useable soils have to be hauled to significant distance [2].

In roads and high way constructions, not only the pavement or premix quality is given serious scrutiny, but the substructure below the pavement is also equally vital. The stability of the underlying soils needs serious attention so as to ensure that the pavement structures that have been constructed can enhance the durability of the pavements. It is important to provide the optimum performance for the pavement because the pavement structures are significantly impacted by the direct loading of the traffic. In order to meet such requirements, the subgrade material requires a treatment to stabilize the soils in the specified area to provide a stable subgrade and also a suitable working platform for the needs of the pavement constructions. As the materials used for road construction are getting more expansive, stabilizing the local soil and improved its physical properties through soil treatment is one of the alternatives [3].

The problems caused by issues related to expansive soils in civil engineering structures were first identified in the late 1930's. Since then many countries have been reporting negative consequence of expansive soil. The method of construction, maintenance and overall performance of structures constructed on expansive soil is depend on proper geotechnical investigations and result interpretation before any subsequent project design or construction work. Consequently, the cost incurred and damages caused by construction work founded in expansive soil would be reduces. The fundamental problem associated with expansive soil is notable volume change of the soil mass. This is caused by alternate swelling and shrinkage characteristics as a result of changes in moisture content. The character change is amplified within the depth of moisture fluctuation. The behavior of expansive soils and extent of swelling-shrinkage varies from place to place due to the variation in climate, topography and type of parent material from which the expansive soil is formed. These factors determine the type of clay mineralogy and have great influence on soil water chemistry that is responsible and directly related to shrinkage-swell properties of expansive soils. The expansive clays of Ethiopia are residual, derived mainly from the weathering of basic volcanic rocks and some trachyte. Due to the fact that the engineering properties of expansive soil of Ethiopia are different from the same soil in other localities, researches on the engineering properties of expansive soil is essentially done [4].

1.2 Statement of the Problem

Expansive Soils Present significant geotechnical and structural engineering challenges over all the world, with costs associated with expansive behavior estimated to run into several billion annually. Engineering problems related to expansive soils have been reported in many countries of world as 3% of the world land but are generally most serious in arid and semiarid regions. Consequently, many engineering structures suffer severe distress and damage. Cracked foundations, pavements, floors and basement walls are typical types of damage done by swelling soils. In Ethiopia, covering nearly 40% surface area of the country, expansive soils are observed in area such as central Ethiopia, most Southern, South – west and South – east part of the capital Addis Abeba area in which the most major recent construction are being carried out.

Soils that experience significant volume changes associated with changes in water content is expansive soil. These volume changes can either in the form of swell or in the form of shrinkage and this is why they are sometimes known as swell/shrinkage soils. Key aspects that need identification when dealing with expansive soils include: soil. Properties, suction/ water conditions, water content variations temporal and spatial, e.g. generated by trees, and the geometry/stiffness of foundations and associated structures [5].

In the present research thesis work, for Dirir – Masha Road project (Gimbo – Konda) has expansive subgrade soil similar to other places and the research mainly focused on investigation of subgrade soil properties for road construction of the study area and identification of suitable borrow material for partial replacement of the expansive soils during investigation. The study is carried out on investigation of a subgrade soil & partially replacement method, mixing suitable borrow material with expansive material by determining correct proportion under a constant moisture content to reduce expansion. The pavement structural generally consists of few layers of selected superior pavement materials laid over a prepared soil subgrade. The primary function of pavement is to transmit loads to the sub-base and underlying soil [6].

After this thesis, expansive soil treated and assure a safe road subgrade can be constructed when using partial replacement method. Expansive soil and partially replaced soil are greatly different as the expansive soil is unsuitable and cannot used as subgrade material but the partially replaced expansive soil is suitable and can be used as subgrade material. The main reason that makes me to initiate to study Dirir – Masha road project is: Repeatedly failure of existing road sub grade soil during rainy season at different stations of existing road. The type of failure is cracking during dry season and swell when gets moisture both horizontal & longitudinal, the type of soil for the failure section & existing road is reddish brown silty clay which is one of expansive soil type, it is a main question of the stakeholders like contractors, consultant and ERA to know the cause of failure and take remedial measure. The primary aim is to make my contribution for our country with my field of study. I have selected partial replacement than other methods because as compared with other methods this method is cost effective and can be done with locally available material safely.

1.3 Research Question

The research is aimed to answer the following main research question:

1. How existing subgrade material is investigated?
2. What is the optimum amount of borrow material required for partial replacement of expansive soil?
3. Which quality parameters differentiate expansive soil from other soils?
4. How stable subgrade material is achieved for the road project?

1.4 Objectives of the study

1.4.1 General Objective the Study

The general objective of this thesis is to study road subgrade soil properties of Dir-Masha Road Project (Gimbo – Konda) and mitigation measure taken by partial replacement method for expansive soil.

1.4.2 Specific Objective of the Study

- ✓ To investigate existing subgrade material for the study area
- ✓ To select optimum amount of borrow material required for partial replacement of expansive soils.
- ✓ To identify quality parameters differentiating expansive soil from other soils.
- ✓ To achieve stable subgrade material after using mitigation measures of partial replacement

1.5 Significance of the Study

This study focus on improvement of engineering properties of expansive soil after mitigating the problem using partial replacement method, with suitable borrow material. After this research work of, Dir – Masha Road Project (Gimbo – Konda), has completed, the study is very important as a source of information and base for the construction industry that can help to minimize the time, make safe and cost effective of mitigating expansive soil using locally available suitable borrow materials. Furthermore, the study is also very important for road projects when the project has high cut section with expansive soil, mountainous and rolling terrain, and having a limited spoil area, this research is applicable double fold or twice. Because the expansive soil can be used as construction of road subgrade by partial replacement and solve shortage of spoil area. Most essentially, other researchers will use the

findings as a reference for further research on improvement of engineering properties of expansive soil using partial replacement method for their study area.

1.6 Scope of the Study

The scope of the research supported by different types of literatures to study Diri – Masha Road Project (Gimbo – Konda) subgrade soil by a series of laboratory experiments. This study focus on this project incorporates sampling and testing the Atterberg limit & index properties, , CBR strength, shrinkage & swelling properties, compaction characteristics, and quality assurance tests suitable borrow material identification for partial replacement material and other related tests along the road stretch. The depth of investigation in this research is limited to the maximum depth of 1.5 meters. To achieve this twenty test pits excavated to represent samples along the road project and two suitable borrow sources for blending with expansive soil. Finally, result analysis, discussion, conclusion and recommendation will be discussed

1.7 The Layout of the Study

This study has consisted as stated the following component of the research main topics: Chapter 1 it is consists of introduction. It states the background of the study, the reasons of carrying out this research, the problem statement and objectives of the study. Chapter 2, where states the literature reviews of relating to expansive and red soils and their stabilization mechanisms. It focuses on the problems associated with this soil and alternative solutions using blending technique. In addition, some application cases of mixing soil with various soil types and its effect on the geotechnical engineering properties of expansive soil. Chapter 3 describes the methodology followed to achieve the objective of the study. Chapter 4 focuses on the analyses of the obtained test results as well as their discussion. The obtained results of non-stabilized soils are compared with the results after stabilization. Provide an overview of the effect of blending on properties of expansive soils and the last Chapter gives conclusions and recommendation briefly. In this Chapter, the recommendations resulting from the comparison of obtained results and the objectives of the study are mentioned. For beneficial use the material currently considered as a blending, recommendations for further researches were made.

1.8 Limitation of the study

The research is limited on existing subgrade soil investigation and partial replacement of expansive soil of Diri – Masha Road Project (Gimbo – Konda) for samples collected from test pit at three-kilometer interval of the road project. For detail investigation it has to be collected test pit samples at five-hundred-meter interval even a lesser for classification test. Moreover, additional suitable borrow material investigation is required to reduce overhaul distance of partially replaced expansive soil for the study area.

2. LITREATURE REVIEW

2.1 Road Subgrade Investigation

Investigations of the underground conditions at a site are prerequisite to the economical design of the substructure elements. It is also necessary to obtain sufficient information for feasibility and economic studies for a proposed project. An exploration program may be initiated on an existing structure where additions are contemplated. A key difficulty with expansive soils is that they often exhibit significant variability from one location to another (i.e. spatial variability). These proper, adequate; site investigations in areas of potentially expansive soils are often worth the cost. Essential to investigation of any expansive soils is a good knowledge of local geology and the use of maps provides a framework for this. These maps are particularly useful when constructing transportation networks. Mapping includes identification of expansive soil potential [7].

As with any site investigation field observation and reconnaissance can provide valuable data of the extent and nature of expansive soils and their associated problems. The condition, composition, depth, moisture content and density of subgrade soils directly influences the design and performance of the road ways. Fine-grained subgrades consisting of silts and clays are more susceptible to problems due to their sensitivity to the effects of water on their behavior. Expansive soils generally consist of clay and are most prominent in the world wide. The expansive nature of clay can also make the surface of the road way heave and shove causing permanent damage to the pavement, structures and other roadside infrastructure. The cost of damage to roadways is estimated to be greater than one billion dollars annually [8].

Expansive subgrades create a challenging scenario for road designers and, if not properly addressed, swelling and shrinkage of subgrade soils can create situations that range from troublesome to dangerous. The success, safety, and economy of the structure is strongly dependent on e situation of the rock and soil at the place as well as the interaction of the ground materials during and after the construction. Large amount of ground deformations is one of the most significant problems in expansive soils which is the result of swelling and shrinkage of the soil. The excessive movements can lead to both damage and negative impact on the structural performance in terms of cost and time [9].

Therefore, identifying the expansive soils can help researchers reduce the imposed damages resulted from the expansive soil to the structure. The most common way which foundations

can be damaged by is uplift which is caused by expansive soils. Swelling soils lift up and crack lightly-loaded, continuous strip footings, and frequently cause distress in floor slabs. The resultant uplift varies in different areas under the building due to the varies building on different portions of a structure's foundations. In buildings the outer corners of a uniformly-loaded rectangular slab foundation will only exert about one- fourth of the usual pressure on a swelling soil located at the central portion of the slab. Accordingly, the corners tend to be lifted up relative to the central portion. Moisture differentials with in soils located at the edges the slab intensify this incident. Such foundation differential movements can result in the distress to the framing of the structure [10].

2.2 Pavement When Expansive Soil is underneath

Pavements are particular vulnerable to expansive soil damage with estimates suggestion that approximately half of the overall costs from expansive soils are associated with pavements [11]. Their inherent vulnerability stems from their relative light weight nature extended over a relatively large area. For example, Cameron [12] described problems with railways built on expansive soils where poor drainage exists. Damage to pavements on expansive soils comes in four major terms: Severe unevenness along significant lengths-cracks may or may not be visible (particularly important for airport runways), longitudinal cracking, lateral cracking developed from significant localized deformations& localized pavement failure associated with disintegration of the surface [5].

Pavement design is essentially the same as that used for foundations. However, a number of different approaches are required as pavements cannot be isolated from the soils and it is impractical to make pavements stiff enough to avoid differential movements. Therefore, it is often more economical to treat subgrade soils. Pavement designs are considered based on an include sub-grade construction on embankments and in slopes. When dealing with expansive soils a number of approaches should be considered and include: Choose an alternative route and avoid expansive soil, Remove and replace expansive soil with a non-expansive alternative, Design for a low strength and allow regular maintenance, physically alter expansive soils through disturbance and re-compaction, Stabilization through chemical additives, such lime treatment , Control water content changes although very difficult over the life of pavement Expansive soils are generally found in highlands and low lands of the Ethiopia.

These soils undergo volumetric changes up on wetting and drying, thereby causing ground heave and settlement problems. This characteristic cause considerable construction defects if not adequately taken care of. Expansive soils are a worldwide problem that has several challenges for civil engineers. Such as swell when given an access to water and shrink when they dry out. The most common and economical method for stabilizing these soils is using mechanical stabilization that prevent volume changes. The presence of montmorillonite clay mineral in expansive soils imparts them high swell-shrink potentials. Low rainfall has hindered the weathering of the active montmorillonite mineral into low active clay types such as illite and Kaolinite. Further, the rainfall has not been sufficient to leach the clay particles far enough so that the overburden pressure can control the swell [13]. Some partial saturated clayey soils are very sensitive to variations in water content and show excessive volume changes. Such soils, when they increase in volume because of an increase in their water contents, are classified as expansive soils [14].

2.3 Clay Minerals

To understand various unique engineering behaviors of clay, it is most beneficial to study microstructures of clay particles first. The micro structural observation greatly helps to understand macro behavior. In nature, basically there are three types of clay minerals-namely, kaolinite clay, illite clay, and montmorillonite clay. These clay have different atomic structures and behave differently and are all made of two basic atomic-sheets-namely, silica tetrahedral sheets and aluminum octahedron sheets, as seen in figure 1, naturally abundant atom silica (Si) and aluminum atom (Al) occupy the center positions of the sheets, and oxygen atom (O²⁻) and hydroxyl (OH⁻) are strongly bonded to those core atoms, respectively. These bonds are either ionic or covalent, and actual bonds in silica and aluminum sheets are combinations of these two types of bonds [15].

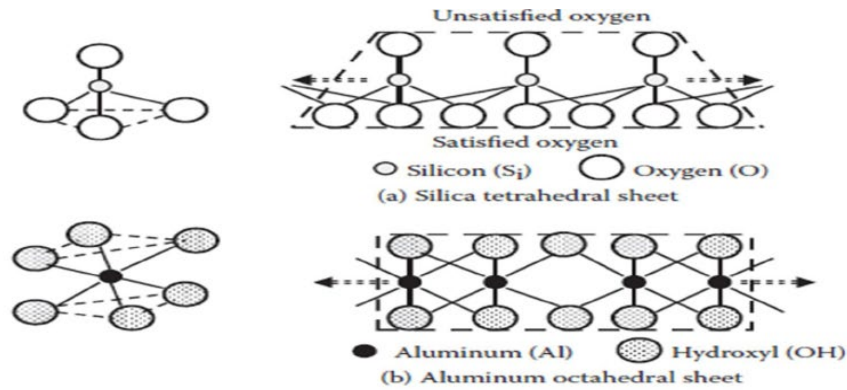


Figure 1 Silica tetrahedral sheets and Aluminum octahedral sheets [15].

Minerals are crystalline and makeup the solids constituent of a soil. The mineral particles of fine grained soils are platy. Minerals are classified according to chemical composition and structure. Most minerals of interest to geotechnical engineers are composed of oxygen and silicon. Silicates are a group of minerals with a structural unit called the Silica Tetrahedral. A central silica cation (positively charged ion) is surrounded by four oxygen anions (negatively charged ions), one at each corner of the tetrahedron. Silicate minerals are formed by addition of cat ions and interaction of tetrahedrons. Silica tetrahedrons combine to form sheets, called silicate sheets, which are thin layers of silica tetrahedrons in which three oxygen ions are shared between adjacent tetrahedrons. Silicate sheets may contain other structural units such as alumina sheets, Alumina sheets are formed by combination of alumina minerals, which consists of an aluminum ion surrounded by six oxygen or hydroxyl atoms in an octahedral [16].

Clay minerals in the soil determine the natural expansiveness of the soil, and include smectite, montmorillonite, nontronite, vermiculite, illite and chlorite. Generally, the larger the amount of these minerals presents in the soil, the greater the expansive potential. However, these expansive effects may become 'diluted' by the presence of other non-swelling minerals such as quartz and carbonate [17].

The key aspects of expansive soils behavior are a soil vulnerability of water induced volume change. When soils with a high expansive potential are present they will usually not cause a problem as long as their water content remains relatively constant. This is largely control by [18].

In a partially saturated soil changes in water content, or suction (increasing strength of the soil due to negative pore water pressures), increase the chances of damage occurring significantly. Changes in soil suction occur due to water movement through the soil due to evaporation, transpiration or recharge, which are often significantly influenced by interaction with trees through response to dried/wet periods of weather [19].

In a fully saturated soil the shrink-swell behavior is controlled by the clay mineralogy. Clay particles are very small and their shape is determined by the arrangement of the thin crystal lattice layers that they form, with many other elements which can become incorporated into the clay mineral structure (hydrogen, sodium, calcium, magnesium, sulphur). The presence and abundance of these dissolved ions can have a large impact on the behavior of the clay minerals. In expansive clay the molecular structure and arrangement of these clay crystal sheets has a particular affinity to attract and hold water molecules between the crystalline layers in a strongly bonded 'sandwich'. Because of the electrical dipole structure of water molecules, they have an electro-chemical attraction to the microscopic clay sheets. The mechanism by which these molecules become attached to each other is called adsorption. The clay mineral montmorillonite, part of the smectite family, can adsorb very large amounts of water molecules between its clay sheets, and therefore has a large shrink-swell potential, For further details of mineralogy of clay minerals and their influence of engineering properties of soils [20].

Clay mineralogy dictates the potential for clays to shrink and swell under various moisture levels. Although there are many types of expansive clays, most consists of Kaolinite, illite and smectites, with montmorillonite being a very common and important member of the smectites. The size of clay particles is directly related to its sensitivity to water, with larger clay particles being less sensitive to water. Kaolinite has the largest clay mineral crystal, lowest specific surface area, and typically low activity is defined as the plasticity index of the soil divided by the percent of clay-sized particles (soil particles less than 2 micrometers). An activity higher than 1.25 indicates that a soil is susceptible to larger changes in volume when wetted and dried. Montmorillonites have the smallest clay mineral crystal, greatest specific surface, and highest activity. Montmorillonites are generally considered the most susceptible to swelling as their water content increases. The swelling potential of illites varies from inactive to active [21].

2.4 Expansive Subgrade Soil

Expansive soil is a term generally applied to any soil or rock material that has a potential for shrinking or swelling under changing moisture conditions. Subsequent swelling and shrinkage of this soil due to change in moisture cause damages to different structures, particularly light weight buildings and pavements such as this road project when available during investigation [15].

Essential expansive soil is one that changes in volume in relation to change in water content. Here the focus is on soils that exhibit significant swell potential and in addition shrinkage potential also exists. There are a number of cases where expansion can occur through chemically induced changes (e.g. swelling of lime treated sulphate soils).

However, many soils that exhibit swelling and shrinkage behavior contain expansive clay minerals, such as smectite, that absorb water, the more of this clay a soil contain the higher its swell potential and the more water it can absorb. As a result, these materials swell, and thus increase in volume, when they get wet and shrink when they dry. The more water they absorb the more their volume increases, for most expansive clays expansions of 10% are not uncommon [11].

Many towns, cities, transport routes and buildings are founded on clay rich soils and rocks. The clay within these materials may be a significant hazard to engineering construction due to their ability to shrink or swell with changes in water content.

Changing water content may be due to seasonal variations (often related to rainfall and the evapo-transpiration of vegetation, or brought about by local site changes such as leakage from water supply pipes or drains, changes to surface drainage and landscaping (including paving) or following the planting, removal or severe pruning of trees or hedges, as man is unable to supply water to desiccated soil as efficiently as a tree originally extracted it through its root system [22].

Damage to foundations in expansive soils commonly results from tree growth. This occurs in two principal ways-physical disturbances of the ground and shrinkage of the ground by removal of water, physical disturbance of the ground caused by root growth is often seen, as damage to pavements and broken walls. An example of vegetation induced shrinkage causing differential settlement of building foundations. Vegetation induced changes to water profiles can also have a significant impact on other underground feature, including utilities [23].

The American society of Civil Engineers estimates that one in four homes have some damage caused by expansive soils. In atypical year expansive soils cause a great financial loss to property owners than earth quakes, floods, hurricanes and tornadoes combined. A summary of these issues is provided by Radevsky. R [24], in his review of how different countries deal with expansive soil problems.

Expansive soils are found throughout many regions of the world, particularly in arid and semi-arid regions, as well as where wet conditions occur after prolonged periods of drought. Their distribution is dependent on geology (parent material), climate, hydrology and vegetation. The literature is full of studies, from all over the world, concerned with problems associated with expansive clays [25].

Expansive soils occur and incur major construction costs around the world, with notable example found in USA, Australia, India and South Africa to name but a few. In these countries, or significant areas of them, the evaporation rate is higher than the annual rainfall so there is usually a moisture deficiency in the soil. Subsequently when it rains the ground swells and so increases the potential for heave to occur. In semi-arid regions a pattern of short periods of rain fall followed by long dry periods (drought) can develop, resulting in seasonal cycles of swelling and shrinkage. Excluding deep underground excavations (e.g. tunnels), shrinkage and swelling effects are restricted to the near-surface zone; significant activity occurs to about 3m depth, but this can vary depending on climatic conditions. The shrink-swell potential of expansive soils is determined by its initial water content; void ratio; internal structure and vertical stresses, as well as the type and amount of clay minerals in the soil [26].

California Bearing Ratio (CBR) is a common and comprehensive test at present practiced in the design of pavement to survey the stiffness modulus and shear quality of subgrade material. Nowadays, the CBR test is the most widespread method of determining the bearing strength of the pavement materials and is fundamental to pavement design practice in most countries. The CBR test can be performed both in the laboratory and field. It is essential that the standard test procedure should be strictly followed [27].

The main problems of expansive soil are summarized as: Volume changes, for this road as there is expansive soil, it will shrink and crack when dries out and swell when it gets wet. The cracks allow water to penetrate deep into the soil, hence causing considerable expansion.

This results in deformation of the road surface, since the expansion and the subsequent heave are never uniform. Furthermore, these volume changes may produce lateral displacements (“creep”) of the expansive clay, if the side slopes are not gentle enough. Seasonal wetting causes the road edges to wet and dry at a different rate than those under the surfacing. This mechanism in turn causes differential movements over the cross section of the road and associated crack developments, first occurring in the shoulder area, and subsequently developing in the carriageway, bearing capacity, for this road when unsuitable expansive soil appears as the moisture content increase, expansion occurs and the bearing strength of this expansive soil decreases dramatically. The CBR may be reduced to less than 2 if the soil becomes completely saturated, Susceptibility to erosion, Similarly as mentioned above for this road when unsuitable expansive soil appears when they are or become dry, this expansive soil may present a sand like texture. In this state, they are prone to erosion to a much greater extent than that normally anticipate from their plasticity and clay content [28]. There are many towns, transport routes and buildings which are located on clay-rich soil and rocks. The clay within these materials is so sensitive to shrinkage and swelling which is due to changes in the water content. This can lead to a significant hazard to engineering construction. Change in water content may due to seasonal effects which are based on rainfall and evapotranspiration of vegetation, or it might be due site changes such as leakage from water supplier or drains, changes to drainage of the surface and landscaping including paving, or following the planting, removal or severe pruning of trees or hedges, as man is unable to supply water to desiccated soil as efficiently as a tree originally extracted it through its root system [5].

2.5 Mitigation Measures for Expansive Soil

Expansive clay can lead to premature pavement failure and increased maintenance and rehabilitation costs for roads. Areas with significant moisture fluctuations and presence of expansive clays require special attention. Recommended strategies for mitigating expansive clay are discussed below [29], several of which have been tried in worldwide:

Remove and replace- may be feasible for thin clay layers near the surface, but becomes less cost-effective for deeper deposits, Extend road width- reduces fluctuations in moisture content, but will likely not stop the threat of water ingress altogether. It may also be impossible due to right-of-way or budgetary constraints. Increase road crown-reduces

infiltration but does not eliminate it. It also does not address water ingress from other sources such as ground water or nearby drainages, Partial or full encapsulation of the subgrade- the use of waterproofing membranes (e.g. sprayed asphalt emulsions, geosynthetics, etc.), Compact at moisture contents above optimum with kneading compaction- produces dispersed clay structure which swells less than flocculated clay structure, but does not eliminate the swell potential of the soil., Scarify, stabilize and compact with lime, flash, or port land cement-reduces volume change characteristics and may increase strength

Flexible pavements are constructed with several layers where unbound granular materials (UGMs), generally used as the base course and sub base layers, rest directly on the subgrade. The unbound layers provide the structural support for the overlaying asphalt concrete (AC) layers and protect the subgrade from excessive deformation by spreading the load and reducing the stresses. Hence the qualities of these materials are very important for the overall performance of the pavement structure. Soil stabilization can improve the properties of expansive soils considerably. Possible materials for the stabilization could include lime, suitable borrow, pozzolana, lime-pozzolana mixture, cement, resins or fly ash. The choice of a material or a combination of materials depends on the size and importance of the road & building (risk/damage acceptable) and economic consideration of the client. However, the need to strike a proper balance between quality and cost should not be overlooked [30].

2.6 Mix Design and Strength Characteristics

When using suitable borrow as a partially replacement of expansive soil, the goal of the mixture design is to find the optimum suitable borrow material to adequately make suitable the expansive subgrade soil to meet desired strength requirements [31] for the subgrade to support and stable the pavement properly without any failure.

2.7 Literature Survey from different laboratory experiments & Analysis on the study area

Reddy et al. [32] have worked on lime – stabilized black cotton soil and brick powder mixture as sub base material stated that the lime-stabilized black cotton soil proportion with brick powder will help to help to obtain the better CBR value. The mixture of 20% brick powder and 80% lime-stabilized black cotton soil under resulted in an increase in the CBR value by about 135% in comparison with lime-stabilized black cotton soil.) as it is the

promising material to use the mixture of brick powder and lime-stabilized black cotton soil as sub base material in flexible pavements. Therefore, from their statement the lime-stabilized of black cotton soil and bricks powder mixture used as sub base material. They have performed an experimental study on improvement of engineering characteristics of expansive clays by sand mixing. The result of the study showed that the mixing of sand in swelling clay remarkably reduces the swelling potential of expansive clay and improves its strength characteristics. The sample without mixing the sand content showed a swell potential of 3.5 % and this reduced to about 0.5% when the clay was mixed with 35% of sand. The CBR values increased from a value of 4% in case of pure clay sample to a value of 8% when the clay was mixed with 30-35% sand. These results are very promising and have application when clays are being used as highway sub-grade soil, where there is a requirement of mitigating their expansive nature along with improving their strength characteristics like CBR.

Madu, R. [33] has performed a laboratory investigation sand – laterite mixtures for road construction, the results obtained show that for all types of laterites tested, the paper sets out to investigate the improvements in the relevant properties of six samples of laterites when they are mixed with sand. The six samples are representative of the types of laterites occurring over the eastern parts of Nigeria are collected. The addition of sand to laterites has beneficial effects in reducing the liquid limit, the optimum moisture content, the plasticity index, the linear shrinkage and increasing the maximum dry density and the California Bearing Ratio of the lateritic soil. The results of his investigation indicate that the various engineering properties of lateritic soil normally relevant in road and pavement construction can be improved to a very appreciable extent by mixing laterites with sand.

Chithaiah [34] performed an experimental study on the performance of the lateritic soil mixed with black cotton soil in India. The design of mixed soil is required for appropriate use of soil mix for civil engineering works which may be black cotton and lateritic soil to get desirable compaction, permeability, and free swelling potential, the result revealed that mixed soil engineering properties have higher than the engineering properties of expansive soil which change the properties of the expansive soil; as the ratio of the lateritic soil increase such higher value of minimum dry density, low permeability and high free swelling potential

of the expansive soil properties decrease. After his experimental investigation, the result of compaction test indicates that the MDD black cotton soil increase as the lateritic soil increase mixed percentage weight increase and the optimum moisture content of the soil decrease as the ratio of lateritic soil ratio increase. Beside of this the swelling potential of the expansive soil decrease as the lateritic soil increase; it also increase the permeability of the soil as the percentage of the lateritic soil increase. Finally, he states that the use of the blended expansive soil with lateritic soil for dam construction, backfill with retaining structure, subgrade and minimize the dimension of foundation in soft soil depend on the mixing ratio of the lateritic soil.

2.8 Previously Done Research's In Different Location of Ethiopia

2.8.1 Bezza Tesfaye [35] (Ziway town)

According to Bezza investigation, she concluded the following results of based on laboratory tests. Grain size analysis tests revealed that, starting from few centimeters below the ground level to depth of investigation which is three meters, the soil in Ziway town is mostly silts and silty sand.

In which for silt soils of ziway town has clay content ranging from 6.72 to 10.93%, silt fraction 51.45 to 73.03%, sand fraction 15.16 to 40.4%, and gravel content from 0.84 to 1.88% and for silty sand soils clay content ranging from 0.66 to 4.41%, silt fraction 17.15 to 42.18%, sand fraction 52.02 to 81.3%, and gravel content from 0.89 to 1.6% within the depth of exploration, the specific gravity of the town ranges from 2.40 to 2.62. These values are low compared with Arora, 2003 this is because the soils are light weighted. From the consistency limit test results, liquid limit ranges from 27-37%, plastic limit from none plastic to limit ranges from 23-29% and plastic index from ranges 0-8%. Compaction tests carried out on samples collected from the study area revealed that the maximum dry density (MDD) ranges from 1.22 to 1.55 g/cm³ and the optimum moisture content ranges from 22.6 to 35.8percent.

2.8.2 Adem Ibrahim [36] (Debre markos town)

According to Adem investigation, he concluded the following results based on laboratory tests. Study of engineering properties such as the grain size distributions, consistency limit, compaction & USCS

The grain size analysis test result showed that the dominant proportion of soil particle in their research area is clay, which have clay content ranging from 50%-73%, silt fraction 15.88%-40.21 % and sand fraction 0.36%- 13.28%. The result of Atterberg Limit test on the soil in the research area showed a liquid limit ranging from 45%-68%, plastic limit ranges from 18%-38% and plastic index from 15% - 40%. The specific Gravity ranges from 2.69 to 2.84. The free swell test result on the samples collected shows range from 30 – 50%. From the compaction test results the maximum dry density (MDD) of Debre Markos soil ranges from 13.5KN/m³ to 14.2KN/m³ and the optimum moisture content ranges 28% to 36%. In Unified Soil Classification System, the soil is categorized as silty clay.

2.8.3 Tadesse Abebe [37] (Woldia Town)

According to Tadesse investigation, he concluded the following results of based on laboratory tests. To achieve the aim of the thesis disturbed and undisturbed samples from different parts of the town were collected and laboratory tests were done. The index property investigation in his study includes; natural moisture content, specific gravity, particle size distribution, Atterberg limits and free swell tests. The grain size analysis test result showed that the dominant proportion of soil particle in the research area is fine-grained soils, which have clay content ranging from 6-50%, silt fraction 40-63% sand fraction 2-20%.the result of Atterberg Limit test on the soil in the research area showed a liquid limit ranging from 34-97%, plastic limit ranging from 28-35% and plastic index from 5- 63%.

The specific gravity ranges from 2.65- 3.0. Free swell test conducted on the samples collected shows range from 39-130%. According to the Unified soil Classification System, the soil is categorized mainly as clay soils and partially silts soils. The AASHTO Classification System shows that the usual types of significant constituent material of the Woldiya soil are clayey soil.

2.9 Comparisons with Previously Done Researches

For the soil under investigation; Index property were studied and a comparison was made with soils with low plasticity inorganic silt. Adama low plastic silty soil and Ziway low plastic silty soil studied by Dagnachewu Debebe, and Bezza Tesfaye. Moreover, Fraol Amare and Ahmed Simeneh for Shashamena and Agaro respectively expansive soil also compared with the current study.

Table 1 Index property Test Results in different part of the country

Index property Test Results & location of study	Thesis by (Dagnachew Debebe, [38])	Thesis by (Bezza Tesfaye, [35])	Thesis by (Fraol Amare, [39])	Thesis by (Ahmed Simeneh, [40])	Current Thesis
Location	Adama	Ziway	Shashamene	Agaro	Gimbo -Konda
Clay content (%)	14-58	6.7-10.9	21.4-30.8	-	30.5-40.05
Silt Content (%)	14-61	51.4-73.0	40.1-62.5	-	40.05-56.01
Sand content (%)	25-56	15.2-40.4	12.1-25.1	-	3.45-35.74
Liquid Limit (%)	39-49	27-37	39-50	67-79	61-76
Plastic limit (%)	26-37	23-29	27-36	30-35	31-34
Plastic index (%)	10-15	4-8	8-16	32-49	30-42
Moisture content (%)	25-31	22.6-35.8	26-36	27.92- 28.8	30.5-47.2
Specific gravity	2.61-2.70	2.40-2.62	2.43-2.60	-	2.66-2.87
From Plasticity chart	ML	ML	ML	-	MH,CH & CL

From above table as shown the average values of various tests done at different parts of countries, i.e. sieve analysis, liquid limit, plastic index and specific gravities showing different properties. As indicated in the above table Ziway soils show lower plasticity (clay content) as compared to Adama soil. The data indicate that there is a considerable similarity in the physical properties of Adama and Ziway town soils

3. MATERIALS AND RESEARCH METHODOLOGY

In this section laboratory analysis of collected subgrade samples and partially replaced expansive soils were presented. Laboratory tests were done in Jimma University, Civil Engineering Laboratory. The materials used for this study were suitable borrow material was collected from near the road section. Secondary data which was used to describe geological condition of the study area was obtained from Geological Survey of Ethiopia (GSE).

3.1 Study Area Description

The study area (project) is found in Sothern Nations, Nationalities and peoples Region (SNNPR) and links two administrative zones Keffa and Sheka. The starting point of the project road Gimbo Town is located southwest of Addis Ababa capital city of Ethiopia. The topography of the study area is variable, that is rugged, hilly and mountainous at the middle part of the project whereas flat at the beginning and end of project. Elevation ranges from 1700m (middle parts) to 1500m (end parts) above sea level. The climate of road project is with a mean annual temperature of 18 degrees centigrade, and a mean annual rain fall of 1200-1600mm. The main rainy season in the area falls between June and mid-September which is winter. While the lesser rains of autumn fall between February and April which sometimes extends up to mid-May. Heavy and torrential rains that last from few minutes to several hours are common during both rainy seasons. According to the geological map of Ethiopia (second edition, 1996), the geological formation of the area is mainly dominated by Jimma volcanic. This formation cover most parts of southern Ethiopia has found in two forms i.e. the upper Jimma volcanic (Pjr) and lower Jimma volcanic (Pjb) formations. The Jimma volcanic almost always rest on the Precambrian basement, the unconformity being marked by a basal residual sandstone. The basalt flows form an unbroken succession several hundred meters thick in some places. In others felsic rocks are intercalated with basalt flow close to the base or form a thick succession just above the basal basalts. The upper part of Jimma volcanic (Pjr) also named as Magdalen group with Rhyolite, trachyte flows and tuff with minor basalt covers main part of the beginning of the project area (From Gimbo Town up to around 50km), and Precambrian with lower middle Proterozoic, lower complex undifferentiated (Pel) formations are common at the end of the project area As it was confirmed on site, the local geology of the area is dominated by reddish brown silty

CLAY mixed with local dark grey fresh to slight weathered BASALT which is mainly the weathering result(residue) of the mentioned parent rocks.

Location of the research area on the map of Ethiopia is shown in figure 2 below

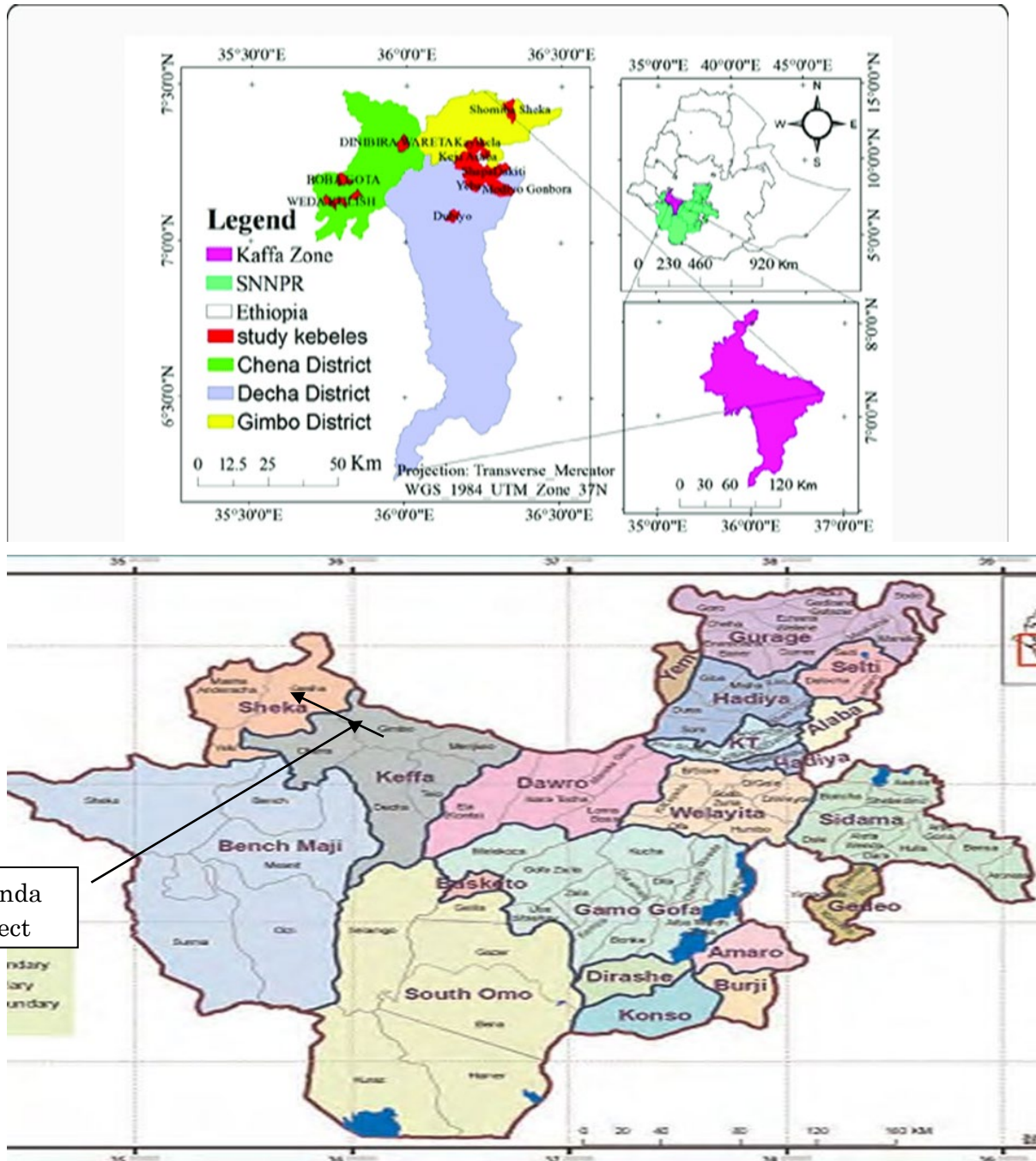


Figure 2 Geographic location Map of Keffa – Sheka Zone Link Road or Diri – Masha Road Project:-Gimbo – Konda [41].

The Road Project Route



Figure 3 Project Location Map of the study area [41].

3.2 Materials

3.2.1 Road subgrade soil

The soil sample used for the study from Gimbo – Konda Project from pit excavation of depth below 1.5m in order to avoid organic matter.

3.2.2 Suitable borrow material

Suitable borrow material sample used for the study collected from Gimbo – Konda project borrow site used for partially replacing expansive subgrade soil by correct proportion to mitigate the problem using partial replacement.

3.2.3 Partially replaced expansive soil

Both samples collected and make proportionally based on keeping the quality requirements of suitable subgrade.

3.3 Study Design

The study design for this research was an experimental type of study that was started by collecting samples from the study area. The laboratory test conducted for each individual soil

in order to identify the engineering properties of the soil; different laboratory tests took place to determine the physical and mechanical properties of all soil collected from the site. The process of blending expansive subgrade soil was started by 20%, 30%, and 40% of weight of the expansive subgrade. The research data was collected from the sample in the following ways: Visits the field to identify the representative sample for both suitable borrow and expansive soil (black cotton soil). Laboratory tests to determine the engineering properties of the suitable borrow and expansive soil. Laboratory tests of mixed expansive soil with suitable borrow soil with the different percentage was performed and their effect on the engineering property of expansive soil is analyzed. A comparison of results attained of the stabilized expansive soil with road design manual requirements for a material being used as the subgrade material was done using the ERA manual and reference with different design standards. After collecting the expansive and suitable borrow sample the targeted tests were done to determine the geotechnical properties of mixed soil. The tests were done according to ASTM standard manual; first specific gravity, particle size distribution, plasticity index, liquid limit, and linear shrinkage were done then compaction, and CBR test was performed for the collected sample.

3.4 Sampling Technique

There are two main types of soil samples dig or excavate by digging tools with labor to one point five-meter depth for experimental subgrade soil which can be recovered from bore holes or trial pits after samples collected. These are; -Existing road subgrade sample and suitable borrow material a) Existing road subgrade sample: - are samples where the structure of the natural soil has been disturbed to a considerable degree by the action of the boring tools or excavation equipment. Samples, however randomly collected, need to be truly representative of the study area. Disturbed samples are satisfactory for performing classification tests such as, sieve analysis, Atterberg limits, compaction test, etc. For this study twenty subgrade soils were randomly collected from the road project to check suitability. The collected samples for this study were disturbed samples. Standard requirements are based on ERA 2002 or 2013 will mentioned at reports.

b) Suitable borrow material: - are samples, which represent as closely as is practicable, near the road section to reduce hauling distance. For this study two suitable borrow sources were collected from the road project, the collected samples for this study were disturbed samples.

The visually identified Suitable borrow material soil was collected from two different locations of Gimbo – Konda road project. The representative soil samples were gathered from minimum depth of 1.5m. The sample taking care as the material does not mix with other material and soil. Moreover, all of the collected samples were disturbed sample.

3.5 Preparation of specimens

After the existing road subgrade specimen was collected and transported to the laboratory, the sample was air dry for a week and the mechanical splitter was used to obtain a uniform existing road subgrade soil. The test specimens were prepared for each individual soil and performed the test for all existing road subgrade soil. And the suitable borrow material specimens were collected and transported to the laboratory, the sample was air dry for a week and the mechanical splitter was used to obtain a uniform suitable borrow material. To mitigate expansive road subgrade soil by using partial method using a different amount of suitable borrow material are used based on the rate of replacement proportion by weight of mixed suitable borrow material. After taking a representative sample by weight the expansive road subgrade soil and mechanical splitting suitable borrow material, three expansive soil1 and one suitable material1 mixed sample was prepared with the percentage of 20/80%, 30/70%, and 40/60% and another one expansive soil2 with one suitable borrow2 with similar proportion 20/80%, 30/70%, and 40/60% respectively and the test was performed for those mixed soil. Totally twelve trial mixes will be made. Trials of partial replacements mainly focus both laboratory and site usage purpose. The trial begins from 20/80%, 30/70%, to 40/60% of suitable borrow with expansive soil respectively, the trial below 20% is not economical for practical application and after 40/60% the expansive nature does not have significance change on partial replacement, that means the result is near to expansively material, so the trial stop there. For intermediate values like 15/85%, 25/75%, 35/65% difficult for site activity after the research. Moreover, for practical application the procedure is dumped on site expansive soil and suitable borrow material with respective proportion and the grader windrow properly to mix it and compact by rollers keeping the moisture constant.

Sample preparation prior to treatment and testing, the sample will be prepared in accordance with the method described in ASTM C702-86 [42]. This method involves air drying of samples and/or oven drying at 60° or less; breaking up the soil aggregates by rubber covered mallet. Then, sieve analysis is performed to separate the dried soils into two groups. The first

group involves preparing uniform samples for Atterberg limits, free swell, classification, and free swell ratio, the other for compaction and California bearing ratio tests. Expansive road subgrade soil and suitable borrow material mixed by weight base manually to get a uniform mix ratio for each test. Based on the theories and laboratory test performed, the results obtained will be analyzed, compared and discussed thoroughly.



Figure 4 Typical Photos of sampling area

3.6 Standard Testing Procedure

The standard laboratory methods used for this study were adapted from ASTM standards.

Table 2 Tests required for existing subgrade, suitable borrow material & partially replaced expansive soil

Ser. No	Test Description	Standard Methods of Testing Procedure
1	Natural Moisture Content	ASTM D2216-98
2	Specific Gravity	ASTM D854-98
3	Grain Size Distribution Analysis(Wet Sieve Analysis)	ASTM D1140-97
4	Atterberg Limits Test	ASTM D4318-98
5	Shrinkage limit test	ASTM D4943-95
6	Free Swell	ASTM4546-96
7	Compaction Test	ASTM D698-98
8	California Bearing Ratio Test(CBR)	ASTM D1883-99
9	Soil classification	ASTM D2487-98

3.7 Study Variable

3.7.1 Independent Variables

The independent variable for this research are quality tests, natural moisture content, specific gravity, free swell, grain size analysis, liquid limit, plastic limit, plasticity index, OMC and MDD, CBR, Swell, Classification of soil.

3.7.2 Dependent variables

Effect of suitable borrows materials proportion on partial replacement of expansive subgrade soil performance.

3.8 Data collection process

The data used for this research was collected from primary data-samples were collected from each test pits, then different laboratory tests were conducted and the results were recorded. Secondary data- was collected from different journals, previous thesis, books, websites, and literature. During the field survey Preliminary visual survey were conducted road subgrade soil extension along the road project, engineering geological map from website of Ethiopian

Geological Survey ,that taken as secondary data was used during the investigation and visual identification of subgrade soils around the area were assessed.

3.9 Data Processing and Analysis

In this research data were collected and organized both in numerical form and in words. To unify out the relevant information supplying questions and notes, quality control checking is executed. After sorting out the effective data, the numerical portion of the data were analyzed using excel software, charts, tables& figures A comparison of results attained of the partially replaced expansive soil with road design manual requirements for a material being used as the subgrade material was done using the ERA manual and reference with different design standards. The quantitative data (material) that was gained from data collection was analyzed by experimental analysis method. In addition, the data processing starts by reading the previous findings. Then the disturbed samples were collected from the boreholes and laboratory tests were carried out, finally the observed results were recorded. Once the necessary data is collected, then the data was analyzed by soft war MS Word and Excel for the analysis laboratory data and using power point display research data were used.

3.10 Ethical Considerations

The data was collected after ethical permission is given from Jimma Institute of Technology, concerned local administrative and Ethiopian roads authority is acquired in order to conduct this research study. The data was collected based on the willingness of the authorities (kebele). Before the collection of the data the purpose of the data collection was clearly described to the peoples who live around the sampling area by the researcher. The data was kept confidential and it is used only for the research purpose. During the excavation of subgrade soils for data collection, the excavated area was backfilled according to the wish of the surrounding communities. The research was approved by an ethics review committee to make sure the study is not violating any of the above considerations. The data collected from either primary or secondary sources is confidential and used only for research purpose. The data have been collected based on the willingness of the organizations to give information.

3.11 Data Quality Assurance

In order to increase the quality of the data the laboratory equipment was calibrated; at least two experiments were done for one test in order to avoid error of data and results. The researcher prepares a lab checklist to check every day progress. The collected data was checked for reliability and accuracy. This research study Data was collected very imperatively to get appropriate results and this helps all Laboratory test and field work manual has been prepared in order to avoid fallacy determination and conclusion. The training was given for lab technicians or data collectors to handle the data carefully. The reliability and accuracy of data was checked. Quality Assurance manual for laboratory test and field work was prepared carefully in order to avoid error of data.

3.12 Plan for Dissemination of findings

Dissemination of findings is important so that results can be used to improve engineering and technological industries. The finding of the thesis will be presented for civil engineering department and Research, Publications, Graduate studies & Consultancy office as part of evaluation and it will be publically defended in the presence of examiners.

4. LABORATORY TEST RESULTS AND DISCUSSION

4.1 Introduction

All tests were conducted in accordance to the methodologies described in chapter three. In this chapter laboratory test outcomes are presented for expansive experimental road subgrade soil, suitable borrow material and partially replaced expansive soils. Natural moisture content, Grain size analysis, Atterberg limits, free swell, specific gravity, linear shrinkage, Soil classification, Compaction and California bring ratio of four-day soaking are types of tests performed. The percentage mix ratio was 20%, 30% and 40% for expansive experimental road subgrade soil (expansive soil) and 80, 70 and 60% respectively for suitable borrow materials. The analysis has been tried on four expansive experimental subgrade samples and two suitable borrow materials partially replacing & taken as representative experiment for the remaining.

4.2 Laboratory Test Results of Experimental Road Subgrade Soil Samples

4.2.1 Natural Moisture Content, Specific gravity& Grain Size Analysis

This test is performed according to ASTM D 2216; ASTM D 854&ASTM D 422-63 respectively. Detailed results of each test found in Appendix 4.2A, 4.2B &4.2C respectively.

Table 3 Natural Moisture content, Specific gravity & Grain Size Analysis of Experimental Road Subgrade Soil Samples

Serial no	Station (km)	Depth(m)	NMC (%)	Specific gravity	Particle size (%)		
					Gravely soil	sandy soil	Fine soil (Silty Clay)
1	3+000	1.5	36.6	2.72	0.54	3.45	96.01
2	6+000	1.5	46.8	2.72	2.36	9.15	88.49
3	9+000	1.5	41.4	2.79	0.89	12.16	86.95
4	12+000	1.5	41.3	2.81	0.65	12.50	86.85
5	15+000	1.5	30.5	2.87	1.32	12.28	86.40
6	18+000	1.5	34.4	2.66	0.41	8.58	91.01
7	21+000	1.5	38.9	2.67	1.04	12.85	86.11

8	24+000	1.5	47.0	2.69	0.00	5.91	94.09
9	27+000	1.5	38.9	2.68	3.21	35.74	61.05
10	30+000	1.5	36.6	2.68	0.50	9.48	90.02
11	33+000	1.5	30.5	2.68	1.81	14.04	84.15
12	36+000	1.5	41.4	2.84	0.58	14.34	85.08
13	39+000	1.5	40.4	2.87	0.00	5.91	94.09
14	42+000	1.5	34.8	2.84	0.52	4.41	95.07
15	45+000	1.5	39.3	2.87	1.02	13.98	85.0
16	48+000	1.5	39.4	2.66	0.41	9.57	90.02
17	51+000	1.5	40.1	2.68	2.35	14.67	82.98
18	54+000	1.5	30.5	2.66	0.52	5.48	94.0
19	57+000	1.5	47.2	2.69	0.51	5.49	94.0
20	60+000	1.5	41.3	2.66	0.00	5.00	95.0

The natural moisture content of experimental road subgrade soil samples as shown on table 3 result is in between 30.5% -47.2%. The variation of NMC is due to the difference in infiltration capacity of soils, and vegetation cover. For many soils, the water content may be an extreme important index used for establishing the relationship between the way the soil behaves and its properties. The consistency of a fine-grained soil largely depends on its water content. The water content is also used in expressing the phase relationships of air, water and solids in a given volume of soil. Investigation on natural water content used to express the consistency of clay soil in its natural content.

The experimental road subgrade soil samples also as shown on table above, specific gravity result is 2.66-2.87. it is within the limit of Sandy, Silt & Clay mixture as the values fall within a range of 2.6 to 2.9. Specific gravity is used to calculate parameters such as void ratio, porosity, soil particles distribution and degree of saturation. The specific gravity of the minerals affects the specific gravity of soils derived from them. The specific gravity of solids of light-colored sand, which is mostly made of quartz, may be estimated to be about 2.65; for clayey and silty soils, it may vary from accordance with ASTM D854-98.

For this study of grain size analysis, percentage gravel, sand, & Silty clay is found to be from 0%-3.21%, 3.45%-35.74%, & 61.05%-96.01%, respectively. The coarser the clay soil, the lesser the expansiveness. Since many separation processes and reactions depends on the amount of surface area relative to mass and that ratio increase as particle size decreases, the separation of different sized solid particles knowing the distribution of sizes can be very important. A soil consists of an assemblage of discrete particles of different of various shapes and sizes. For the other entire engineering test to be effective, determination of the particle sizes is important due to its strong relationship with the engineering behavior. Some relevant and useful information can be obtained from a grain size distribution curve. Such information includes the percentage larger or finer than a given size and their uniformity or the range in grain size distribution.

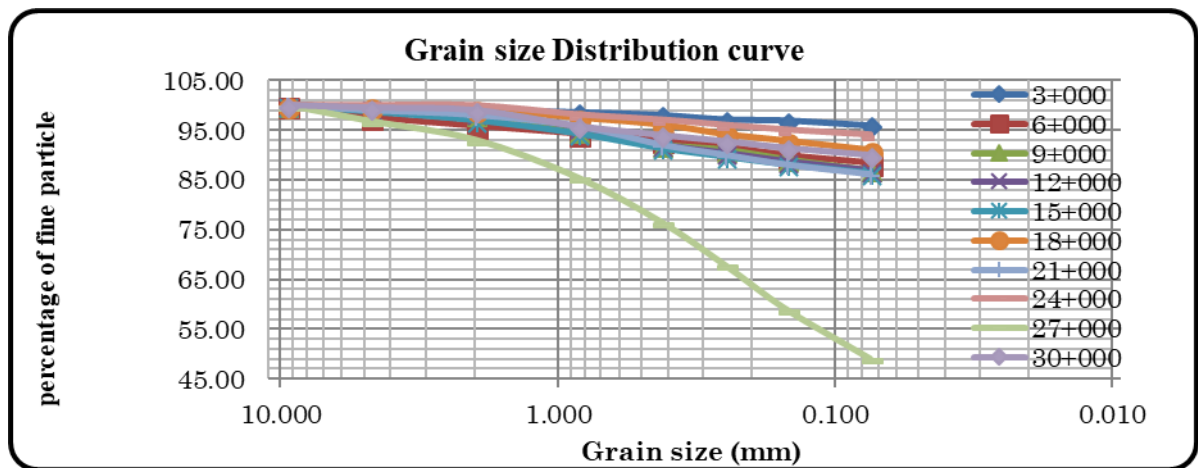


Figure 5 Grain Size Distribution Curve for listed test stations from Km3+00 to Km30+000

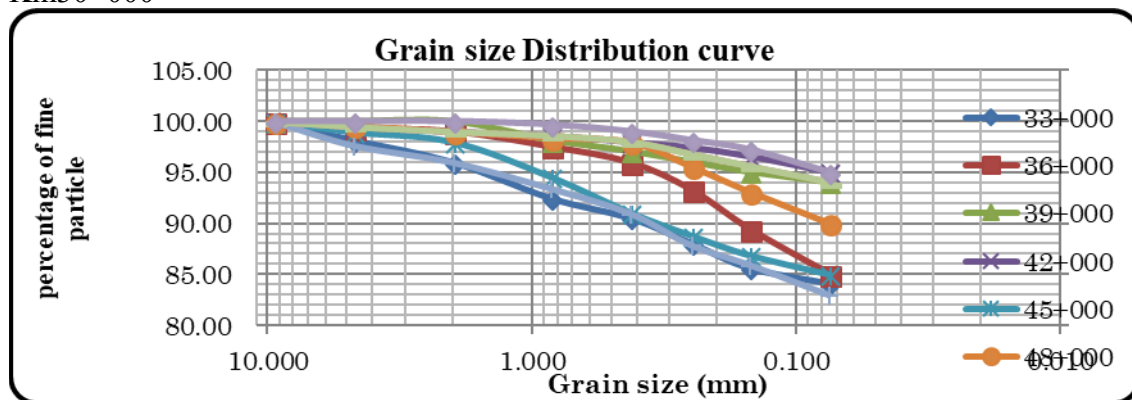


Figure 6 Grain Size Distribution Curve for listed test stations from Km33+00 to Km60+000

4.2.2 Atterberg Limits, Linear Shrinkage & Free swell Test: This test is performed according to ASTM D 4318 & Lab experimental books, detailed results of Atterberg limit & free swell is found in Appendix 4.2 D & 4.2E respectively.

Table 4 Liquid limit, Plastic Index, Free swell and linear shrinkage of experimental Road Subgrade Soil Samples

Ser. no	Station (km)	Depth(m)	Liquid Limit LL (%)	Plasticity Index, PI (%)	Free swell (%)	Linear shrinkage, LS (%)	Remarks
1	3+000	1.5	76	42	100.91	10.46	Expansive ERS* soil section
2	6+000	1.5	71	33	107.33	10.28	Expansive ERS* soil section
3	9+000	1.5	68	34	103.08	10.68	Expansive ERS* soil section
4	12+000	1.5	71	35	102.5	10.32	Expansive ERS* soil section
5	15+000	1.5	53	25	11.11	6.08	Suitable ERS soil section
6	18+000	1.5	74	36	72.73	9.3	Expansive ERS* soil section
7	21+000	1.5	57	26	7.14	3.4	Suitable ERS soil section
8	24+000	1.5	46	21	30	5.5	Suitable ERS soil section
9	27+000	1.5	32	12	13.04	2.54	Suitable ERS soil section
10	30+000	1.5	65	30	61.54	10.18	Expansive ERS* soil section
11	33+000	1.5	41	20	25	2.75	Suitable ERS soil section
12	36+000	1.5	61	33	70	10.39	Expansive ERS* soil section
13	39+000	1.5	56	25	15	6.04	Suitable ERS soil section
14	42+000	1.5	56	27	23.81	7.1	Suitable ERS soil section
15	45+000	1.5	55	26	18.18	6.36	Suitable ERS soil section
16	48+000	1.5	49	20	23.81	5	Suitable ERS soil section
17	51+000	1.5	53	21	23.81	6.18	Suitable ERS soil section
18	54+000	1.5	51	19	13.64	2.71	Suitable ERS soil section
19	57+000	1.5	73	42	55	10.4	Expansive ERS* soil section
20	60+000	1.5	50	18	13.64	4.18	Suitable ERS soil section
ERA 2002 specification			<60	<30	<50		

ERS* Experimental Road Subgrade

From table 4 above the existing road subgrade soil, Liquid Limit, Plasticity Index and Linear Shrinkage result is in between 32%-76%, 12%-42%, and 2.54%-10.68% respectively. From total twenty experimental subgrade soils eight samples could not satisfy ERA 2002 specification both in LL and PI

From table 4 above also test result one can see that free swell of the soil under investigation ranges from 7.14% to 107.33%. Those soils having free swell less than 50%, (Km15+00, Km21+000, Km24+000, Km27+000, Km33+000, Km39+000, Km42+000, Km45+000, Km48+000, Km51+000, Km54+000 & Km60+000) are considered as non-expansive. Those soils having free swell between 50%-100% are considered as marginal, (Km18+000, Km30+000, Km36+000 and Km57+000). And those soils having free swell greater than 100% are considered as expansive. Therefore, Km3+000, Km 6+000, Km9+000 and Km12+000 are expansive. Highly expansive subgrade soils, undergoes volumetric changes leading to pavement distortion, cracking and general unevenness due to seasonal wetting and drying.

Moreover, from above table free swell and linear shrinkage values for eight experimental subgrade soil samples are higher than the requirement and they are classified as expansive soil, and need partial replacement treatment to use as subgrade. The remaining twelve samples satisfy the specification requirement of LL, PI, Free swell and linear shrinkage and classified as suitable subgrade soil and do not need partial replacement. Based on these result and the next CBR and swell values we will make twelve trials to treat the expansive subgrade soils, the water content of a soil along with its liquid and plastic limits is used to express its relative consistency termed as liquidity index. A soil which is very soft at a higher percentage of water content becomes very hard with a decrease in water content. However, it has been found that at the same water content, two samples of clay of different origins may possess different consistency. Clay may be relatively soft which the other may be hard. Further, a decrease in water content may have little effect on one sample of clay but may transform the other sample from almost a liquid to a very firm condition. Water content alone, therefore, is not an adequate index of consistency for engineering and many purposes. The physical properties of clays greatly differ at different water contents

Simple soil property tests Atterberg limit tests, linear shrinkage tests, and free swell tests can be used for the evaluation of the swelling potential of expansive soils. However, the free

swell test is very crude and was used in the early days when refined testing methods were not available. The Swedish soil scientist Albert Atterberge originally defined seven “ limits of consistency” to classify fine-grained soil, but in current engineering practice only two of the limits, the liquid and plastic limits, are commonly used.(A third limit, called the shrinkage limit, is used occasionally. The shrinkage limit is the dividing line between the semisolid and solid states. It is quantified for a given soil as specific water content, and from a physical stand point, it is the water content that is just sufficient to fill the voids when the soil is at the minimum volume it will attain on drying. Below the shrinkage limit, any water content change will not result in volume change; above the shrinkage limit, any water change will result in accompanying volume change.

4.2.3 Modified Proctor Compaction& CBR Test:

This test is performed according to ASTM D698&ASTM D1883-99 respectively. Detailed results of Compaction &CBR tests are found in Appendix 4.2G&2F respectively,

Table 5 Modified Proctor Compaction &CBR @95% of MDD result of Experimental Road Subgrade Soil Samples

Ser. no	Station (km)	Depth (m)	OMC (%)	MDD(gm/cm 3)	Swell (%)	CBR@95% of MDD (%)	Remarks
1	3+000	1.5	30	1.41	3.7	4.8	Expansive subgrade soil
2	6+000	1.5	27	1.46	3.2	4.9	Expansive subgrade soil
3	9+000	1.5	17	1.37	3.62	5.0	Expansive subgrade soil
4	12+000	1.5	33	1.42	3.52	5.6	Expansive subgrade soil
5	15+000	1.5	30	1.52	1.86	9.3	Suitable subgrade soil
6	18+000	1.5	30.5	1.45	3.7	6.2	Expansive subgrade soil
7	21+000	1.5	21.5	1.58	1.8	9.8	Suitable subgrade soil
8	24+000	1.5	27.5	1.54	1.9	9	Suitable subgrade soil
9	27+000	1.5	28	1.56	0.75	10.2	Suitable subgrade soil
10	30+000	1.5	34.4	1.39	3.3	7	Expansive subgrade soil
11	33+000	1.5	34.4	1.37	0.7	19	Suitable subgrade soil
12	36+000	1.5	29	1.49	2.4	5.4	Expansive subgrade soil

13	39+000	1.5	29	1.41	1.68	10.7	Suitable subgrade soil
14	42+000	1.5	28	1.45	1.67	16	Suitable subgrade soil
15	45+000	1.5	30.5	1.42	1.9	10.6	Suitable subgrade soil
16	48+000	1.5	24	1.56	1.88	12.0	Suitable subgrade soil
17	51+000	1.5	29	1.45	1.68	12.6	Suitable subgrade soil
18	54+000	1.5	30.4	1.45	1.63	14.4	Suitable subgrade soil
19	57+000	1.5	24.8	1.45	3.2	6.2	Expansive subgrade soil
20	60+000	1.5	28.6	1.55	1.70	11.2	Suitable subgrade soil
ERA 2002 specification					<2%	>5%	

From table 5 above as shown OMC, MDD, and Swell & CBR values are found to be 17%-34.4%, 1.37-1.58gm/cm³, 0.70-3.7%, &4.8%-19.0% respectively.

From above table swell and CBR values for eight experimental subgrade soil samples are higher than the requirement and they are classified as expansive soil, and need partial replacement method treatment to use as subgrade. The remaining twelve samples satisfy the specification requirement of Swell & CBR values, and so classified as suitable subgrade soil and do not need partial replacement for treatment. CBR is a penetration test for evaluating the strength of road subgrade and base course materials. The results obtained from these tests are used with the empirical curves to determine the thickness of pavement and its component layers. This is the most widely used methods for the design of flexible pavement. The CBR value for a soil depends up on its density, molding moisture content, and moisture content after soaking. CBR test was done to when subjected to loading. This was determined by measuring the relationship between force and penetration when a cylindrical plunger of cross-sectional area 19.635cm² is made to penetrate the soil at a given rate. The CBR –test was developed initially for the evaluation of the laboratory and in-situ subgrade strength. Presently, the laboratory CBR-test is used throughout the world as a quick means of characterizing qualitatively the bearing capacity of soils and unbound base and sub base materials. This test is performed by measuring the pressure required to penetrate soil or aggregate with a plunger of the standard area. The pressure up to a penetration of 10mm and

its ratio to the bearing value of a standard crushed rock is termed as the CBR. The sample is soaked to simulate its weakest condition in the field. Expansion of the sample is measured during soaking to check for potential swelling. To determine the strength and swelling potential of the samples, a test has been carried out by 4-days soaking three point CBR and loaded Swell testing procedure. The material strength has been used for design purpose by interpolating the CBR values at different compaction levels, with 10, 30 and 65 blows and compacting in 5 layers by heavy compaction. This procedure is necessary to obtain 98% of dry density as determined by laboratory compaction test. According to most specifications like ERA and ASTM a soil having CBR values less than 5% and swell values greater than 2% is expansive subgrade soil and cannot used as subgrade material & embankment fill. And hence to use the above eight expansive subgrade soils need partial replacement to treat.

4.2.4 Classification of Experimental Road Subgrade Soil Samples

This test is performed according to AASTO and USCS test methods.

Table 6 Classification of Experimental Road Subgrade Soil Samples based on AASHTO and USCS

Ser. no	Station (km)	Depth (m)	LL (%)	PI (%)	pass mesh#10 (2.0mm)	pass mesh#40 (0.425 mm)	pass mesh#4 (4.75m m)	pass mesh#200 (0.075mm)	Group Classification AASHTO	Group Classification on based on USCS
1	3+000	1.5	76	42	99.03	98.03	99.46	96.01	A-7-5(48)	CH
2	6+000	1.5	71	33	95.91	93.03	97.66	88.49	A-7-5(35)	CL
3	9+000	1.5	68	34	98.09	92.08	99.11	86.95	A-7-6(35)	CH
4	12+000	1.5	71	35	98.31	92.06	99.35	86.85	A-7-5(48)	CL
5	15+000	1.5	53	25	96.98	91.38	98.68	86.4	A-7-6(24)	CH
6	18+000	1.5	74	36	99.06	96.08	99.59	91.01	A-7-5(40)	CH
7	21+000	1.5	57	26	98.01	92.03	98.96	86.11	A-7-5(25)	MH
8	24+000	1.5	46	21	100	97.1	100	94.09	A-7-6(22)	CL
9	27+000	1.5	32	12	93.08	76.54	96.79	49.14	A-6(2)	SC
10	30+000	1.5	65	30	99	94	99.5	90.02	A-7-5(32)	MH
11	33+000	1.5	41	20	96.04	90.56	98.1	84.15	A-7-6(16)	CL
12	36+000	1.5	61	33	99.07	96.01	99.42	85.08	A-7-6(31)	CH

13	39+000	1.5	56	25	100	97.1	100	94.09	A-7-5(28)	CH
14	42+000	1.5	56	27	99.03	98	99.48	95.07	A-7-6(30)	CH
15	45+000	1.5	55	26	98.01	91.08	98.97	85	A-7-6(24)	CH
16	48+000	1.5	49	20	99.02	98	99.59	90.02	A-7-6(20)	ML
17	51+000	1.5	53	21	96	90.99	97.65	82.98	A-7-5(20)	MH
18	54+000	1.5	51	19	99	98	99.48	94	A-7-5(21)	MH
19	57+000	1.5	73	42	99.1	96.6	99.48	93	A-7-5(48)	MH
20	60+000	1.5	50	18	100	99.01	100	95	A-7-5(21)	MH

From above table experimental soil classification based on AASHTO; M145, is A-7-5 up to A-7-6 and experimental soil based on USCS classification the study area soil is found to be mainly silty soil (MH), some of it is lean clay (CL) and some of it is clay (CH) soil. To classify the material is either Silt(M) or clay © determined by plasticity chart of A line =0.73 (LL-20).If the value is below A line the soil is silt and if the value falls above A line it is clay on plasticity verse liquid limit values plotted curve.

From above table 6 usually types of significant constituent materials general rating as a soil A-7-5 up to A-7-6 soil with medium to higher, plasticity index & volume changes respectively.

Moreover under average condition good drainage and through compaction the support value of a material is an inverse ratio of group index. Group index value of 0 indicates good subgrade and group index value 20 or greater is a very poor subgrade. The purpose of any classification is to categorize soils by relating their appearance and behavior with previously established engineering properties and performance.

Remarks: In this study eight (8) experimental subgrade soil from the total collected twenty (20) experimental road subgrade samples are expansive soil that do not full fills the standards requirement in all the requirement's, which needs stabilization using partial replacement method. The rest twelve (12) are suitable subgrade material which do not need stabilization. Based on the literature review&experimental analysis the ratio of borrow material used for this study was from 60%-80% and for expansive soil from 20%-40%.

4.3 Laboratory Test Results of suitable borrow material Samples

4.3.1 Natural Moisture Content, Specific gravity& Grain Size Analysis

This test is performed according to ASTM D 2216; ASTM D 854&ASTM D 422-63 respectively. Detailed results of each test found in Appendix 4.3A, 4.3B &4.3C respectively Table 7 NMC, Specific gravity &Grain size Analysis of suitable Selected Borrow Material Samples

Serial no	Station (km)	NMC (%)	Specific gravity	Particle size (%)		
				Gravelly soil	sandy soil	Fine soil (Silty Clay)
1	4+200 RHS offset1.6Km	19.7	2.67	14.22	38.77	47.02
2	38+600 LHS offset800m	23.4	2.66	9.86	41.45	48.69

From above table, suitable borrow material samples NMC test result is in between 19.7%-23.4%. Most natural soils, which are sandy and gravelly in nature, may have water content up to about 15 to 20%. The variation of NMC is due to the difference in infiltration capacity of soils, and vegetation cover. Change in moisture content is the most influential parameter that affects the property of soils. Moisture content is defined as the ratio expressed as a percentage of water to mass of soil solids. The reference substance for liquids is nearly always water at its densest (at 4°C or 39.2 °F).

From above table, suitable borrow material samples specific gravity result is in between 2.66-2.67. In general, the term specific gravity is defined as the ratio of a given volume of a material to the mass of an equal volume of water. In effect, it tells us how much the material is heavier than (or lighter) than water. Most of the values fall within a range of 2.67to2.9 for most soil samples at different laboratory and researches depending on the soil is derived from the source.

For this study of grain size analysis, percentage gravel, sand, and silt clay is found to be 9.86%-14.22%, 38.77%-41.45% and 47.02%-48.69% respectively. Since the fine soil percentage is lower as compared with experimental subgrade soil, it indicates the borrow has gravel and sandy soil a certain amount and well graded to make it as suitable borrow material. The grain- size distribution of coarse-grained soils is determined directly by sieve analysis. However, determination of amount of materials finer than No200 (0.075mm) sieve

can be separated from coarser particles much more efficiently and completely by wet sieving method than through the use of the dry sieving [43]. The amount of material passing 0.075mm during washing process was obtained and recorded

4.3.2 Atterberg Limits, Linear Shrinkage & Free swell Test

This test is performed according to ASTM D 4318 & Lab experimental books, detailed results of Atterberg limit & free swell is found in Appendix 4.3 D & 4.3E respectively.

Table 8 Liquid limit, Plastic Index, Free swell and linear shrinkage of suitable Selected Borrow Material Samples

Ser.no	Station (km)	Liquid Limit LL (%)	Plasticity Index, PI (%)	Free swell (%)	Linear shrinkage, LS (%)	Remarks
1	4+200 RHS offset 1.6Km	34	9	2.73	1.29	Suitable material
2	38+600 LHS offset 800m	39	10	4.55	1.25	Suitable material
Specification requirement ERA 2002		<60	<30	<50		

The study from above table Liquid Limit, Plasticity Index and Linear Shrinkage result is in between 34%-39%, 9%-10%, and 1.25%-1.29% respectively. The test result has lower value of LL, PI and LS as compared with the specification & it indicates the soil is suitable borrow material. The liquid limit (LL) of a soil highly depends upon the clay mineral present. The plastic limit (PL) is the water content, expressed in percentage, below which the soil stops behaving as a plastic material and it begins to crumble when rolled in to a thread of soil of 3.0mm diameter. The soil in the plastic state can be remolded in to different shapes. When the water content is reduced the plasticity of the soil decreases changing in to semisolid state and it cracks when remolded.

For this study, the free swell results are found to be in a range of 2.73%-4.55%. And the results are considered as non-expensive. The free swell test is one of the most commonly used simple experiments in the field of geotechnical engineering for getting an estimate of soil swelling soil potential and to identify the degree of expansiveness of the soil sample. It is

the increase in volume of soil without any external constraint when subjected to submergence in water.

4.3.3 Modified Proctor Compaction & CBR Test

This test is performed according to ASTM D698-98 & ASTM D1883-99 respectively.

Detailed results of Compaction & CBR tests are found in Appendix 4.3G & 3F respectively.

Table 9 Modified Proctor Compaction & CBR @95% of MDD result of suitable Selected Borrow Material Samples

Serial no	Station (km) Depth(m)	OMC (%)	MDD(g m/cm ³)	Swell (%)	CBR@95% of MDD (%)	Remarks
1	4+200 RHS offset 1.6Km	17.5	1.65	1.13	25	Suitable material
2	38+600 LHS offset 800m	19	1.6	0.88	22	Suitable material
Specification requirement ERA 2002				<2	>5	

For this study, OMC and MDD values are found to be 17.5%-19% and 1.60gm/cm³ - 1.65gm/cm³, respectively. Compaction characteristics is obtained by determination of the maximum dry density and the optimum moisture content for the borrow material. It is often necessary to compact soil to improve its strength. (Proctor, 1933) developed a laboratory compaction test procedure to determine the maximum dry unit of compaction of soils which can be used for specification of field compaction. Water generally acts as a lubricant between solid particles during the soil compaction process. The maximum dry unit weight of compaction increases with increase in the compacting energy, and the optimum moisture content (OMC) decrease with the increase in energy of compaction.

For this study, CBR values are found to be 22-25% and swell value 0.88-1.13% respectively. The test result of CBR as per ERA standard (CBR > 5%). and Swell better than the specification fulfills the requirement and can be used for partial replacement of expansive soil. According to ERA low volume pavement manual specification it is not allowed to use CBR values less than 3% for subgrade soil, because from both a technical and economical perspective it would normally be inappropriate to lay a pavement on soils of such bearing capacity.

4.3.4 Classification of Selected Borrow Material Samples

This test is performed according to AASHTO and USCS.

Table 10 Classification of soils based on AASHTO of suitable Selected Borrow Material Samples

Serial no	Station (km) Depth (m)	LL (%)	PI (%)	pass mesh#10 (2.0mm)	pass mesh#40 (0.425m m)	pass mesh#4 (4.75m m)	pass mesh# 200 (0.075 mm)	Group Classification AASHTO	Group Classification based on USCS
1	4+200 RHS offset1.6Km	34	9	73.78	59.04	85.78	47.02	A-4(1)	CL
2	38+600 LHS offset800m	39	10	89.68	82.59	93.14	48.69	A-4(3)	CL
Specification requirement ERA 2002		<60	<30						

As shown from above table both borrow materials are classified as group A-4 based on AASHTO M145 [44] classification system and used as suitable borrow material. Group A-4, the typical material of this group is non-plastic to moderately plastic silty soil. The group includes also mixtures of fine silty soil and up to 64% of sand and gravel retained have moderate elastic behavior, because the liquid limit is medium as shown in table above and can be used as partial replacement of expansive soil.

As shown from above table also both borrow materials are classified as group symbol CL based on ASTM D2487-0, USCS classification system and used as soils for engineering purpose, suitable borrow material. Group symbol CL classification can be occurred when a soil have liquid limit is less than 50%, PI is greater than 7% and pass 0.075mm sieve is greater than 30%. This group symbol soil is characterized as lean clay with sand and gravel, similar to AASHTO classification because the liquid limit is medium and PI is very less as shown in table above and can be used as partial replacement of expansive soil. Soil classification is the arrangement of soils in to different groups such that the soils in a particular group have similar behavior. The AASHTO classification system, also called

public roads administration classification, is based on grain size distribution, liquid limit and plasticity index.

4.4 Laboratory Test Result of partially replaced expansive soil Samples

4.4.1 Specific gravity & Grain Size Analysis

This test is performed according to; ASTM D 854 & ASTM D 1140-97 respectively.

Detailed results of each test found in Appendix 4.4A, 4.4B & 4.4C respectively.

Table 11 Specific gravity & Grain Size Analysis of partially replaced expansive soil

Ser. no	Material Type/ Mixing proportion & Source station	Specific gravity	Particle size (%)		
			Gravelly soil	Sandy soil	Fine soil (Silt & Clay)
1	20%(Km3+000)+80%(Km4+200)	2.6	11.84	32.85	55.31
2	30 %(Km3+000) +70 %(Km4+200)	2.63	10.66	29.89	59.46
3	40 %(Km3+000) +60 %(Km4+200)	2.7	9.47	26.93	63.6
4	20 %(Km6+000) +80% (Km4+200)	2.59	11.84	32.85	55.31
5	30 %(Km6+000) +70% (Km4+200)	2.62	10.66	29.89	59.46
6	40 %(Km6+000) +60% (Km4+200)	2.57	9.47	26.93	63.6
7	20 %(Km9+000) +80% (Km4+200)	2.57	11.55	33.44	55
8	30 %(Km9+000) +70% (Km4+200)	2.60	10.22	30.78	59
9	40 %(Km9+000) +60% (Km4+200)	2.62	8.89	28.12	62.66
10	20%(Km36+000)+80%(Km38+600)	2.69	5.62	25.26	69.12
11	30%(Km36+000)+70%(Km38+600)	2.7	5.0	23.67	71.34
12	40%(Km36+000)+60%(Km38+600)	2.72	4.38	22.07	73.55

The Specific gravity of partially replaced expansive soil samples is in between 2.60-2.72. as shown in table above. This result indicates the soil fall on the behavior of the sand, clay & Silt according to Das [45] Soil Mechanics Lab. Manual Six Edition New York Oxford, Oxford University Press. According to this method of classification sand is usual from 2.63-2.67, silts from 2.65-2.7 and clay& silt from 2.67-2.9. This result also confirms indirectly the soil classification system USCS group symbol CL, lean clay with sand and gravel is acceptable.

For this study of grain size analysis, percentage gravel, sand, silt and clay is found to be 5.0%-11.84%, 22.07%-32.85% and 55.31%-73.55% respectively. Since the fine soil percentage is lower as compared with existing subgrade material, and the distribution of percentage of gravel and sand increase it makes better mixture of the material improves the behavior of the material, the group symbol and classification changed to the improved class. This makes the material suitable subgrade which is improved by the partial replacement method and can be used as suitable subgrade material.

4.4.2 Atterberg Limits, Linear Shrinkage & Free swell Test

This test is performed according to ASTM D 4318, ASTM D4943-95 & ASTM D4546-96 respectively, detailed results of Atterberg limit & free swell is found in Appendix 4.2 D & 4.2E respectively.

Table 12 Liquid limit, Plastic Index, Free swell and linear shrinkage of partially replaced expansive soil

Ser. no	Material Type/ Mixing proportion & Source station	Liquid Limit (%)	Plasticity Index, PI (%)	Free swell (%)	Linear shrinkage, LS (%)	Remarks
1	20%(Km3+000)+80%(Km4+200)	38	10	34.07	3.32	Suitable subgrade
2	30 % (Km3+000) +70 % (Km4+200)	39	11	40.33	5.54	Suitable subgrade
3	40 % (Km3+000) +60 % (Km4+200)	40	13	42.87	7.11	Suitable subgrade
4	20 % (Km6+000) +80 % (Km4+200)	36	9	29.32	2.06	Suitable subgrade
5	30 % (Km6+000) +70 % (Km4+200)	37	10	41.31	3.08	Suitable subgrade

6	40 %(Km6+000) +60% (Km4+200)	38	12	44.34	4.11	Suitable subgrade
7	20 %(Km9+000) +80% (Km4+200)	35	11	25.61	2.14	Suitable subgrade
8	30 %(Km9+000) +70% (Km4+200)	36	12	36.45	3.32	Suitable subgrade
9	40 %(Km9+000) +60% (Km4+200)	37	13	46.95	4.27	Suitable subgrade
10	20%(Km36+000)+80%(Km38+600)	35	10	29.1	3.32	Suitable subgrade
11	30%(Km36+000)+70%(Km38+600)	36	11	38.85	5.36	Suitable subgrade
12	40%(Km36+000)+60%(Km38+600)	37	12	48.42	7.11	Suitable subgrade
ERA 2002 Specification		<60	<30			

From the above table the partially replaced expansive soil changes from expansive soil to suitable subgrade requirement. The liquid limit, and plasticity index result is in between 35%-40%, and 9%-13% respectively. Both results satisfy the standard requirement. The optimum partially replacement is 40% of expansive soil and 60% suitable borrow material for both borrow materials. This partially replaced material can be used as suitable subgrade material. The liquid limit and plasticity Index of cohesive soils are important parameters for classification purpose. The presence of clay contributes to the plasticity of soil. The liquid limit of a soil change depending on the amount and type of clay minerals present in it. When a cohesive soil is mixed with an excessive amount of water, it will be in a somewhat liquid state and flows like a viscous liquid state .However when this viscous liquid is gradually dried, with the loss of moisture it will pass in to a plastic state.

From table12 above for partially replaced expansive soil sample, the free swell results are in a range of 29.1%-48.4%. Free swell test results for the study area by using air dried samples are summarized as shown on table 12 above. Those soils having free swell less than 50% (20%(3+000) +80%(4+200),30%(3+000) +70%(4+200), 40 %(3+000) +60 %(4+200), 20% (36+000) +80%(38+600), 30% (36+000) +70%(38+600), & 40%(36+000) +60%(38+600) are considered as non-expansive. Because of the results all partially replaced expansive soil are suitable subgrade.

From the above table the linear shrinkage value of the partially replaced materials is from 2.06% to 7.11% which is lower value as compared with the native experimental subgrade material and this result is almost equal to suitable subgrade material. And hence all the partially replaced materials are suitable subgrade material. The fundamental concept of shrinkage limit is a saturated clayey soil when gradually dried, will lose moisture and subsequently, there will be a reduction in the volume the soil mass. During the drying process, a condition will be reached when any further drying will result in a reduction of moisture content without any decreases in volume. The moisture content of the soil, in percent, at which the decrease in soil volume ceases, is defined as the shrinkage limit.

4.4.3 Modified Proctor Compaction & CBR Test

This test is performed according to ASTM D698-98 & ASTM D1883-99 respectively.

Detailed results of Compaction & CBR tests are found in Appendix 4.4G & 4F respectively,

Table 13 Modified Proctor Compaction & CBR @95% of MDD result of partially replaced expansive soil

Serial no	Material Type/ Mixing proportion & Source station	OMC (%)	MDD (gm./cm ³)	Swell (%)	CBR@ 95% of MDD (%)	Remarks
1	20%(Km3+000)+80%(Km4+200)	23	1.58	1.58	21.6	Suitable subgrade
2	30 % (Km3+000) +70 % (Km4+200)	22	1.57	1.76	17.4	Suitable subgrade
3	40 % (Km3+000) +60 % (Km4+200)	23.5	1.51	1.92	10.2	Suitable subgrade
4	20 % (Km6+000) +80% (Km4+200)	19.2	1.62	1.54	21.26	Suitable subgrade
5	30 % (Km6+000) +70% (Km4+200)	19	1.60	1.75	19.39	Suitable subgrade
6	40 % (Km6+000) +60% (Km4+200)	21	1.51	1.958	17.52	Suitable subgrade
7	20 % (Km9+000) +80% (Km4+200)	17.2	1.592	1.83	21.26	Suitable subgrade
8	30 % (Km9+000) +70% (Km4+200)	17.5	1.57	1.907	19.39	Suitable subgrade
9	40 % (Km9+000) +60% (Km4+200)	17.8	1.54	1.85	17.52	Suitable subgrade
10	20%(Km36+000)+80%(Km38+600)	19.5	1.58	1.61	22.5	Suitable subgrade
11	30%(Km36+000)+70%(Km38+600)	22.5	1.56	1.86	20.1	Suitable subgrade

12	40%(Km36+000)+60%(Km38+600)	23.5	1.53	1.96	14.7	Suitable subgrade
ERA 2002 specification requirement				<2	>5	

For this study, Compaction test result of partially replaced expansive soil samples is as shown in table above OMC and MDD values are found to be 19.0%-23.5% and 1.51gm/cm³-1.62gm/cm³ respectively. The results of optimum moisture content and maximum dry density showed for the partial replaced expansive soil, the value of optimum moisture content decreased but maximum dry density increased as compared with experimental expansive soil and vice versa for suitable borrow material. This concept is the same as (Solomon's 2011) concept he was concluded that addition of chemical stabilizers to subgrade soils has decreased the OMC and has increased MDD of stabilized subgrade expansive soils. The optimum water content is the water content that results in the greatest density for a specified comp active effort.

From above table for partially replaced expansive soil, CBR values are found to be 10.2%-22.5% and swell value found to be 1.54 -1.96 % respectively. Both CBR and swell values are within the specification requirement. The CBR & swell value of partially replaced expansive material highly improved as compared with experimental subgrade materials. After replacement CBR values increase and swell value decrease. Therefore, all eight trials can be used as suitable subgrade material. The optimum partial replacement is 40% expansive soil and 60% suitable material as other quality tests. Strength of the subgrade soil samples has been determined using CBR test. A three-point CBR tests at 10,30 and 65 blows were conducted according to ASTM D 1883-99 [46] and the CBR at 95 MDD was determined.in general, most engineering properties, such as the strength, stiffness, resistance to shrinkage, and imperviousness of the soil, will be improved by increasing the soil density.

4.4.4. Classification of Partially replaced expansive soil sample: This test is performed according to AASHTO M-145 and USCS.

Table 14 Classification of Partially replaced expansive Soil Samples based on AASHTO and USCS

Ser . no	Material Type/ Mixing proportion & Source station	LL (%)	PI (%)	pass mesh# 10 (2.0m m)	pass mesh# 40 (0.425 mm)	pass mesh# 4 (4.75m m)	pass mesh# 200 (0.075 mm)	Soil Classification	
				based on AASHTO	based on USCS				
1	20%(Km3+000)+80%(Km4+200)	38	10	78.21	65.84	88.16	55.31	A-6(4)	CL
2	30 %(Km3+000) +70 %(Km4+200)	39	11	80.42	69.23	89.34	59.46	A-6(5)	CL
3	40 %(Km3+000) +60 %(Km4+200)	40	13	82.63	72.63	90.53	63.6	A-6(7)	CL
4	20 %(Km6+000) +80% (Km4+200)	36	9	78.11	65.34	88.26	55.11	A-5(3)	CL
5	30 %(Km6+000) +70% (Km4+200)	37	10	80.12	69.16	89.24	59.36	A-6(5)	CL
6	40 %(Km6+000) +60% (Km4+200)	38	12	82.33	72.43	90.23	63.60	A-6(7)	CL
7	20 %(Km9+000) +80% (Km4+200)	35	11	78.64	65.65	88.45	55.0	A-6(4)	CL
8	30 %(Km9+000) +70% (Km4+200)	36	12	81.07	68.99	89.78	59.0	A-6(5)	CL
9	40 %(Km9+000) +60% (Km4+200)	37	13	83.51	72.26	91.11	62.99	A-6(7)	CL
10	20%(Km36+000)+80%(Km38+600)	35	10	91.41	84.48	94.38	69.12	A-5(6)	CL
11	30%(Km36+000)+70%(Km38+600)	36	11	92.27	85.43	95	71.34	A-6(7)	CL
12	40%(Km36+000)+60%(Km38+600)	37	12	93.13	86.38	95.62	73.55	A-6(8)	CL
ERA 2020 Specifications for Subgrade		<60	<30						

As shown from above table the partially replaced expansive soil is classified and used as subgrade material. Based on AASHTO M145 classification system, the soil falls in group A-5 up to A-6.

Group A-5, the typical material of this group is moderately plastic silty soil. The group includes also mixtures of fine silty soil and up to 64% of sand and gravel retained have moderate elastic behavior, because the liquid limit is medium and PI is very less as shown in table above and can be used as fair subgrade. Moreover, the partially replaced expansive soil

also have group A-6 soils. The typical material of this group is moderately plasticity clay because the material passing 0.075mm sieve is less than 75%. The group includes also a mixture of fine clay soil and up to 64% of sand and gravel retained on 0.075mm sieve. Therefore, the partially replaced expansive soil from 20%-40% of expansive soil and 60%-80% suitable borrow material damping, mixing and windrowing by grader partial replaced expansive material can be used as fairly subgrade. From the study more than 40% expansive soil replacement makes the subgrade group A-7-5 up to A-7-6 that makes poorly subgrade. Therefore, the optimum replacement of expansive soil is 40% and 60% suitable borrow material.

As shown from above table also all twelve lab. Trials of partially replaced expansive soil for the study is classified on the group symbol CL are based on ASTM D2487-0, USCS classification system and used as soils for engineering purpose, suitable subgrade material. Group symbol CL classified since the soil have liquid limit is less than 50%, PI is greater than 7% and pass 0.075mm sieve is greater than 30%. This group symbol soil is characterized as lean clay with sand and gravel, similar to AASHTO classification because the liquid limit is medium and PI is very less as shown in table above and can be used as suitable subgrade soil.

From this study as observed from the engineering properties of partially replaced expansive soil result, the optimum ratio for the expansive soils is at 40% using suitable borrow material 11 (Km4+200) at three trials and 40% using suitable borrow material 12 (Km38+600). Moreover after this study expansive soil and partially replaced soil have greatly different as the expansive soil is unsuitable and cannot used as subgrade material but the partially replaced soil is treated as suitable soil and can be used as subgrade material..

The percentage of suitable borrow material and expansive soil is achieved by many trials starting from atterberge limit test, first trying different proportions of liquid limit and plasticity index for each sample of two borrow and expansive soils then taking the successes proportion check other quality tests. This is how we achieve the known proportion.

Table 15 Summary and Comparison of Expansive subgrade soil, Suitable borrow material & Partially Replaced Expansive soil according to ERA 2002 specification.

Ser . No	Material Type/ Mixing proportion & Source station	LL	PI	Swell %	CBR % at 95% MDD	AASHTO Classification	USC S Classification	Remark
1	Km 3+000 (Experimental Subgrade Soil)	76	42	3.7	4.8	A-7-5(48)	CH	Expansive soil
2	Km 6+000 (Experimental Subgrade Soil.)	71	33	3.2	4.9	A-7-5(35)	CL	Expansive soil
3	Km 9+000 (Experimental Subgrade Soil)	68	34	3.62	5.0	A-7-6(35)	CH	Expansive soil
4	Km 36+000 (Experimental Subgrade Soil)	61	33	2.40	5.40	A-7-6 (31)	CH	Expansive soil
5	Km 4+200 (Suitable Borrow material)	34	9	1.13	25	A-4(2)	CL	Suitable
6	km38+600 (Suitable Borrow material)	39	10	0.88	22	A-5	CL	Suitable
7	20%(Km3+000)+80%(Km4+200)	38	10	1.58	21.6	A-6(4)	CL	Suitable subgrade
8	30 % (Km3+000) +70 % (Km4+200)	39	11	1.76	17.4	A-6(5)	CL	Suitable subgrade
9	40 % (Km3+000) +60 % (Km4+200)	40	13	1.96	10.2	A-6(7)	CL	Suitable subgrade
10	20 % (Km6+000) +80% (Km4+200)	36	9	1.52	16.6	A-5(3)	CL	Suitable subgrade
11	30 % (Km6+000) +70% (Km4+200)	37	10	1.86	12.3	A-6(5)	CL	Suitable subgrade
12	40 % (Km6+000) +60% (Km4+200)	38	12	1.97	9.2	A-6(7)	CL	Suitable subgrade
13	20 % (Km9+000) +80% (Km4+200)	35	11	1.8	14.8	A-6(4)	CL	Suitable subgrade
14	30 % (Km9+000) +70% (Km4+200)	36	12	1.9	12.7	A-6(5)	CL	Suitable subgrade
15	40 % (Km9+000) +60% (Km4+200)	37	13	1.75	10.2	A-6(7)	CL	Suitable subgrade
16	20%(Km36+000)+80%(Km38+600)	35	10	1.61	18.5	A-5(6)	CL	Suitable subgrade
17	30%(Km36+000)+70%(Km38+600)	36	11	1.86	14.1	A-6(7)	CL	Suitable subgrade
18	40%(Km36+000)+60%(Km38+600)	37	12	1.92	12.7	A-6(8)	CL	Suitable subgrade
ERA 2002 Specifications for Subgrade		<60	<30	<2%	>5%			

The comparison from above table confirms that all four experimental expansive soils did not full fill ERA 2002 standard requirements as subgrade soils. Therefore, those soils should be

treated with appropriate improving methods before using for subgrade materials. For this study partially replacement is considered. Suitable borrow material used for partially replacing experimental expansive soil. Because this soil has low load bearing capacity, and higher value of the plasticity index , percent swell of highly expansive soils (Little and Nair, 2009).

The above table is also summarization and comparison of partially replaced expansive material with experimental expansive soil and suitable borrow material by ERA [28] standard specification as observed from the summary partially replaced expansive soils satisfy all quality requirement similar to suitable borrow materials with respective proportions. This shows how effective is the method for construction of road subgrade. To make clear let us look each parameter with respect to the specification.

The liquid limit, and plasticity index result is in between 35%-40%, and 9%-13% respectively. Both results satisfy the standard requirement. The optimum partially replacement is 40% of expansive soil and 60% suitable borrow material for both borrow materials source. This partially replaced expansive soil can be used as suitable subgrade material.

From above table for partially replaced expansive soil, CBR values are found to be 10.2%-22.5% and swell value found to be 1.54 -1.96 %.respectively. Both CBR and swell values are within the specification requirement. The CBR & swell value of partially replaced expansive material highly improved as compared with experimental subgrade materials. After replacement CBR values increase and swell value decrease. Therefore all twelve trials can be used as suitable subgrade material. The optimum partial replacement is 40% expansive soil and 60% suitable material as already checked by quality tests. Strength of the subgrade soil samples has been determined using CBR test.

Based on AASHTO M145 classification system, the partially replaced expansive soil fall in group A-5 up to A-6. Group A-5, the typical material of this group is moderately plastic silty soil. The group includes also mixtures of fine silty soil and up to 64% of sand and gravel retained have moderate elastic behavior ,because the liquid limit is medium and PI is very less as shown in table above and can be used as fair subgrade .Moreover the partially replaced expansive soil also have group A-6 soils. The typical material of this group is

moderately plasticity clay because the material passing 0.075mm sieve is less than 75%.The group includes also a mixture of fine clay soil and up to 64% of sand and gravel retained on 0.075mm sieve.,

As shown from above table also all twelve lab. trials of partially replaced expansive soil for the study fall on the group symbol CL are based on ASTM D2487-0, USCS classification system and used as soils for engineering purpose, suitable subgrade material. Group symbol CL classified since the soil have liquid limit is less than 50%, PI is greater than 7% and pass 0.075mm sieve is greater than 30%.This group symbol soil is characterized as lean clay with sand and gravel, similar to AASHTO classification because the liquid limit is medium and PI is very less as shown in table above and can be used as suitable subgrade soil.

Trials of partial replacements mainly focus both laboratory and site usage purpose. The trial begins from 20/80, 30/70, to 40/60 of suitable borrow with expansive soil respectively, The trial below 20% is not economical for practical application and after 40/60 the expansive nature does not have significance change on partial replacement, that means the result is near to expansively material so the trial stop there .For intermediate values like 15/85,25/75,35/65 difficult for site activity after the research. More over for practical application on site expansive soil and suitable borrow material dumped with respective proportion and the grader windrow properly to mix it and compact by rollers keeping the moisture constant.

From the table 15 above as shown maximum improvements were observed on Atterberg limit, CBR, swell and classification of soil. The results indicate that the two borrow material sources were effective in improving strength parameters as well as index parameters. The improvements of borrow material 1 (Km4+200) was more in comparison to that of borrow 2 (Km38+600) in some properties and very near to the experimental expansive soils, which reduces hauling distance than borrow 2. That is why we take nine experiment on three expansive soils than borrow two only three experiment on one expansive soil. Moreover, there may be many factors that contribute to the difference in improvement of the two borrows might be the mineral composition of the soil samples . The partially replaced expansive soil up to optimum ratio were fulfilled the ERA2002 standard requirements as subgrade soils. Generally the changes on engineering properties of partially replaced expansive soil for the present study were summarized as follows:

- When suitable borrow material is used for partial replacement liquid limit of partially replaced expansive soil will decrease
- When suitable borrow material is used for partial replacement plastic index of partially replaced expansive soil will decrease
- When suitable borrow material is used for partial replacement CBR value of partially replaced expansive soil will increase
- When suitable borrow material is used for partial replacement CBR swell potential of partially replaced expansive soil will decrease
- When suitable borrow material is used for partial replacement free swell of partially replaced expansive soil will decrease
- When suitable borrow material is used for partial replacement linear shrinkage of partially replaced expansive soil will decrease
- When suitable borrow material is used for partial replacement improvement of soil classification of partially replaced expansive soil will occur.

5. CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusion: As mentioned at the objective part of the study we have arrived the following conclusions based on the study:

- The first objective of this study is to investigate existing subgrade soil for Diri-Mash road (Gimbo- Konda) project. Here we have sampled twenty experimental subgrade soils at 3km interval of the study road, and from the total eight experimental existing subgrade soils based on the quality tests and ERA [28] requirement specification found expansive subgrade soil, need improvement by partial replacement to become suitable subgrade soil and the remaining twelve experimental subgrade samples are suitable subgrade soil do not need partial replacement to improve it.
- The second objective of this study is to select optimum amount of borrow material required for partial replacement of expansive soil, from the study, trials of partial replacements mainly focus not only for laboratory but also after the research for practical site application purpose. The trial begins from 20/80, 30/70, & 40/60 of expansive soil and suitable borrow material respectively, The trial below 20% of expansive soil is not practical application at site and not effective, and after 40/60 the expansive nature does not significance changed by partial replacement, that means the result of partial replacement approaches to expansive soil, so the trial stop here .For intermediate values like 15/85,25/75,35/65 difficult for site management activity after the research is obtained so left to try. This is known by many trials and arrived at this conclusion. Therefore the optimum borrow material for the two borrow sources is 60% and the expansive soil 40% for this study as shown on the different quality tests of this research.
- The third objective is to identify quality parameters differentiating expansive soil from other soils. As this study is focused on road projects the quality tests required for road are mainly: Atterberge limit, CBR and swell, linear shrinkage, free swell, specific gravity, grain size analysis, compaction, soil classification and related tests. That is why in this study detail discuss and look the quality parameters for experimental subgrade soil, suitable borrow material and partially replaced expansive

soil evaluated according the standard specification to differential expansive soil with other soils.

- The fourth objective of the study is to achieve stable subgrade material after using mitigation measures of partial replacement, as observed from the above study test result, twelve trials show up to the optimum borrow material of 60% and expansive soil 40%,the partially replaced expansive soil can use as suitable subgrade, because the test result satisfies the requirement and verified from four expansive samples with two borrow sources.

Moreover, from the test results as showed that the sub grade soils considered for this study were found A-7-5 and A-7-6 as per AASHTO M-145 soil classification system and MH or CH as per USCS system. The eight existing sub grade soils mentioned before for this study have a very low load bearing capacity and high swelling potential which makes the soils expansive for sub grade without improvement. From this study as observed from the engineering properties of partially replaced expansive soil result, the optimum ratio for the expansive soils is at 40% using two suitable borrow materials. (Km4+200) and (Km38+600).The maximum improvements on engineering properties were observed on Atterberg limit (LL, PI and linear shrinkage), free swell, Particle size and CBR. Minimum improvements were on Specific gravity

5.2 Recommendation: Based on the present study results the following recommendations were forwarded:

- 1) In this research due to the limitation of budget, only twenty experimental subgrade test pits soil data were collected, and only two borrow source are used for partial replacing expansive soils .But if this is not a limitation collecting more number of pits a more representative and investigation suitable borrow source at reasonable hauling distance data will be collected and will serve as a design document and reference for other projects and researches.
- 2) Expansive soil and partially replaced soil have great different as the expansive soil cannot used as subgrade material but the partially replaced soil is suitable and can be used as

subgrade material. This shows how effective is the partial replacement method for the construction of road subgrade

- 3) For the practical applicability of this study, partially replaced expansive soils further need detail investigations including chemical and mineralogical analysis of the treated soils will of paramount.
- 4) This replacement method is more safe and has continuity for construction as the borrow material is available on the road side with in minimum hauling distance.
- 5) From this study on twelve trials as observed from the engineering properties of partially replaced expansive soil result, the optimum ratio for the expansive soils is at 40% using suitable borrow material¹¹ (Km4+200) for three expansive soil trials and one expansive soil using suitable borrow material¹² (Km38+600).
- 6) This study is very important for road projects when the project has high cut section, with mountainous and rolling terrain, and having a limited spoil area, this research is applicable double fold, because the method uses expansive soil by partial replacement as construction of subgrade and solve the shortage of spoil area.
- 7) For practical application on site expansive soil and suitable borrow material dumped with respective proportion and the grader windrow properly to mix it and compact by rollers keeping the moisture constant
- 8) From this study the document can be used as a reference for the concerned one, for geotechnical engineering investigation or higher institution, for the stack holders like contactors, consultant and ERA can use it when required.

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APPENDIX

(Laboratory test results and Analysis)

APPENDIX 4.2A: - Existing Road Subgrade Soil Samples

4.2 A Natural Moisture Content (ASTM D-2216)

Station, km	Trial	Wt. of Container, (g)	Wt. of container + wet soil, (g)	Wt. of containe r + dry soil, (g)	Moisture container, (%)	Average Moisture container, (%)
3+000	1	17.5	108.5	83.8	37.3	36.6
	2	17.8	124.9	96.4	36.3	
	3	17.4	91.2	71.6	36.2	

Station, km	Trial	Wt. of Container, (g)	Wt. of container + wet soil, (g)	Wt. of container + dry soil, (g)	Moisture container, (%)	Average Moisture container, (%)
6+000	1	36.6	208.8	153.9	46.8	46.8
	2	17.5	122.7	89	47.1	
	3	17.5	103.8	76.4	46.5	

Station, km	Trial	Wt. of Container, (g)	Wt. of container + wet soil, (g)	Wt. of container + dry soil, (g)	Moisture container, (%)	Average Moisture container, (%)
9+000	1	36.5	157.7	122.2	41.4	41.4
	2	32.7	156.3	120.2	41.3	
	3	17.3	100.6	76.1	41.7	

Station, km	Trial	Wt. of Contai ner, (g)	Wt. of container + wet soil, (g)	Wt. of container + dry soil, (g)	Moisture container, (%)	Average Moisture container, (%)
12+000	1	37.8	188.5	144.5	41.2	41.3
	2	18	106.8	80.8	41.4	

Station, km	Trial	Wt. of Container, (g)	Wt. of container + wet soil, (g)	Wt. of container + dry soil, (g)	Moisture container, (%)	Average Moisture container, (%)
15+000	1	29.6	167.4	135.5	30.1	30.5
	2	37.4	203.6	164.5	30.8	
	3	17.5	85.8	69.8	30.6	

Station, km	Trial	Wt. of Container, (g)	Wt. of container + wet soil, (g)	Wt. of container + dry soil, (g)	Moisture container, (%)	Average Moisture container, (%)
18+000	1	18.3	154	119.3	34.4	34.4
	2	25.3	180.9	141.2	34.3	
	3	24.1	168	131.1	34.5	
Station, km	Trial	Wt. of Container, (g)	Wt. of container + wet soil, (g)	Wt. of container + dry soil, (g)	Moisture container, (%)	Average Moisture container, (%)
21+000	1	35.7	193.4	148.8	39.4	38.9
	2	17.5	132.6	99.8	39.9	
	3	17.7	117.9	90.6	37.4	

Station, km	Trial	Wt. of Container, (g)	Wt. of container + wet soil, (g)	Wt. of container + dry soil, (g)	Moisture container, (%)	Average Moisture container, (%)
24+000	1	25.3	208.8	150.2	46.9	47.0
	2	17.5	122.7	89	47.1	
	3	18.2	103.8	76.4	47.1	

Station, km	Trial	Wt. of Container, (g)	Wt. of container + wet soil, (g)	Wt. of container + dry soil, (g)	Moisture container, (%)	Average Moisture container, (%)
27+000	1	35.7	193.4	148.8	39.4	38.9
	2	17.5	132.6	99.8	39.9	
	3	17.7	117.9	90.6	37.4	
Station, km	Trial	Wt. of Container, (g)	Wt. of container + wet soil, (g)	Wt. of container + dry soil, (g)	Moisture container, (%)	Average Moisture container, (%)
30+000	1	17.5	108.5	83.8	37.3	36.6
	2	17.8	124.9	96.4	36.3	
	3	17.4	91.2	71.6	36.2	

Station, km	Trial	Wt. of Container, (g)	Wt. of container + wet soil, (g)	Wt. of container + dry soil, (g)	Moisture container, (%)	Average Moisture container, (%)
33+000	1	29.6	167.4	135.5	30.1	30.5
	2	37.4	203.6	164.5	30.8	
	3	17.5	85.8	69.8	30.6	
Station, km	Trial	Wt. of Container, (g)	Wt. of container + wet soil, (g)	Wt. of container + dry soil, (g)	Moisture container, (%)	Average Moisture container, (%)
36+000	1	36.5	157.7	122.2	41.4	41.4
	2	32.7	156.3	120.2	41.3	
	3	17.3	100.6	76.1	41.7	

Station, km	Trial	Wt. of Container, (g)	Wt. of container + wet soil, (g)	Wt. of container + dry soil, (g)	Moisture container, (%)	Average Moisture container, (%)
39+000	1	39.8	189.5	146.5	40.3	40.4
	2	20	108.8	83.3	40.3	
	3	37.1	168.2	130.4	40.5	

Station, km	Trial	Wt. of Container, (g)	Wt. of container + wet soil, (g)	Wt. of container + dry soil, (g)	Moisture container, (%)	Average Moisture container, (%)
42+000	1	26.1	160.3	125.6	34.9	34.8
	2	29.2	165.3	130.2	34.8	
	3	25.1	145.3	114.3	34.8	

Station, km	Trial	Wt. of Container, (g)	Wt. of container + wet soil, (g)	Wt. of container + dry soil, (g)	Moisture container, (%)	Average Moisture container, (%)
45+000	1	36.1	160.1	125	39.5	39.3
	2	17.5	145.2	109.2	39.3	
	3	17.5	174.3	130.1	39.3	
Station, km	Trial	Wt. of Container, (g)	Wt. of container + wet soil, (g)	Wt. of container + dry soil, (g)	Moisture container, (%)	Average Moisture container, (%)
48+000	1	17.5	132.6	99.8	39.9	39.4
	2	17.5	132.6	99.8	39.9	
	3	17.7	117.9	90	38.6	

Station, km	Trial	Wt. of Container, (g)	Wt. of container + wet soil, (g)	Wt. of container + dry soil, (g)	Moisture container, (%)	Average Moisture container, (%)
51+000	1	21.2	108.9	83.8	40.1	40.1
	2	25.3	124.9	96.4	40.1	
	3	18.2	93	71.6	40.1	
Station, km	Trial	Wt. of Container, (g)	Wt. of container + wet soil, (g)	Wt. of container + dry soil, (g)	Moisture container, (%)	Average Moisture container, (%)
54+000	1	29.6	167.4	135.5	30.1	30.5
	2	37.4	203.6	164.5	30.8	
	3	17.5	85.8	69.8	30.6	

Station, km	Trial	Wt. of Container, (g)	Wt. of container + wet soil, (g)	Wt. of container + dry soil, (g)	Moisture container, (%)	Average Moisture container, (%)
57+000	1	36.5	137.7	105	47.7	47.2
	2	32.7	135.2	102.5	46.8	
	3	17.3	124.3	90.1	47.0	
Station, km	Trial	Wt. of Container, (g)	Wt. of container + wet soil, (g)	Wt. of container + dry soil, (g)	Moisture container, (%)	Average Moisture container, (%)
60+000	1	37.8	188.5	144.5	41.2	41.3
	2	18	106.8	80.8	41.4	
	3	37.1	168.2	129.9	41.3	

APPENDIX 4.2B: - Existing Road Subgrade Soil Samples

4.2 B Specific gravity, ASTM D-854

Specific gravity of soil at test Temperature ,G at $T_x^{\circ}C$ (ASTM D-854)			
Station:	3+000		
Trial No.	1	2	3
Mass of density bottle ,g	25	26.5	25.5
Mass of density bottle +dry soil, g	50	51.5	50.5
Mass of density bottle +dry soil +water at temperature $T_x^{\circ}C$, g	135.5	136.6	137.6
Test temperature(T_x), $^{\circ}C$	22	22	22
Density of water at T_x ,g/ml	0.9978	0.9978	0.9978
Mass of density bottle +water at temperature $T_i^{\circ}C$ (21 $^{\circ}C$),g	119.7	120.8	121.8
Density of water at T_i ,g/ml at 21 $^{\circ}C$	0.99802	0.99802	0.99802
Correction factor,k	0.99978	0.99978	0.99802
Specific gravity G at $T_x^{\circ}C$	2.72	2.72	2.72
Average specific gravity at $T_x^{\circ}C$	2.72		

Specific gravity of soil at test Temperature ,G at $T_x^{\circ}C$ (ASTM D-854)			
Station:km	6+000		
Trial No.	1	2	3
Mass of density bottle,g	26.6	25.2	27.1
Mass of density bottle+dry soil,g	51.6	50.2	52.1
Mass of density bottle+dry soil+water at temperature $T_x^{\circ}C$,g	139.2	133.6	137.9
Test temperature(T_x), $^{\circ}C$	22	22	22
Density of water at T_x ,g/ml	0.9978	0.9978	0.9978
Mass of density bottle+water at temperature $T_i^{\circ}C$ (21 $^{\circ}C$),g	122.8	117.4	121.5
Density of water at T_i ,g/ml at 21 $^{\circ}C$	0.99802	0.99802	0.99802
Correction factor,k	0.99978	0.99978	0.99978
Specific gravity G at $T_x^{\circ}C$	2.71	2.74	2.71
Average specific gravity at $T_x^{\circ}C$	2.72		

Specific gravity of soil at test Temperature, G at $T_x^{\circ}C$ (ASTM D-854)			
Station:	9+000		
Trial No.	1	2	3
Mass of density bottle, g	26.6	25.2	27.1
Mass of density bottle+dry soil, g	51.6	50.2	52.1
Mass of density bottle+dry soil+water at temperature $T_x^{\circ}C$, g	139.1	133.2	137.5
Test temperature(T_x), $^{\circ}C$	23	23	23
Density of water at T_x , g/ml	0.99757	0.99757	0.99757
Mass of density bottle+water at temperature $T_i^{\circ}C$ ($21^{\circ}C$), g	122.8	117.4	121.5
Density of water at T_i , g/ml at $21^{\circ}C$	0.99802	0.99802	0.99802
Correction factor, k	0.999549	0.999549	0.999549
Specific gravity G at $T_x^{\circ}C$	2.87	2.72	2.78
Average specific gravity at $T_x^{\circ}C$	2.79		

Specific gravity of soil at test Temperature, G at $T_x^{\circ}C$ (ASTM D-854)			
Station:	12+000		
Trial No.	1	2	3
Mass of density bottle, g	24.8	26.9	27
Mass of density bottle+dry soil, g	49.8	51.9	52
Mass of density bottle+dry soil+water at temperature $T_x^{\circ}C$, g	136.8	137.3	139.3
Test temperature(T_x), $^{\circ}C$	23	23	23
Density of water at T_x , g/ml	0.99757	0.99757	0.99757
Mass of density bottle+water at temperature $T_i^{\circ}C$ ($21^{\circ}C$), g	120.8	121.1	123.2
Density of water at T_i , g/ml at $21^{\circ}C$	0.99802	0.99802	0.99802
Correction factor, k	0.999549	0.999549	0.999549
Specific gravity G at $T_x^{\circ}C$	2.78	2.84	2.81
Average specific gravity at $T_x^{\circ}C$	2.81		

Specific gravity of soil at test Temperature, G at $T_x^{\circ}C$ (ASTM D-854)			
Station:	15+000		
Trial No.	1	2	
Mass of density bottle,g	22.3	26.9	26.6
Mass of density bottle+dry soil,g	47.3	51.9	51.6
Mass of density bottle+dry soil+water at temperature $T_x^{\circ}C$,g	133.6	136.3	138.4
Test temperature(T_x), $^{\circ}C$	23	23	23
Density of water at T_x ,g/ml	0.99757	0.99757	0.99757
Mass of density bottle+water at temperature $T_i^{\circ}C$ (21 $^{\circ}C$),g	117.3	120	122.1
Density of water at T_i ,g/ml at 21 $^{\circ}C$	0.99802	0.99802	0.99802
Correction factor,k	0.99955	0.99955	0.99955
Specific gravity G at $T_x^{\circ}C$	2.87	2.87	2.87
Average specific gravity at $T_x^{\circ}C$	2.87		

Specific gravity of soil at test Temperature, G at $T_x^{\circ}C$ (ASTM D-854)			
Station:	18+000		
Trial No.	1	2	3
Mass of density bottle,g	22	26.9	26.6
Mass of density bottle+dry soil,g	47	51.9	51.6
Mass of density bottle+dry soil+water at temperature $T_x^{\circ}C$,g	133.2	136.4	138.1
Test temperature(T_x), $^{\circ}C$	22	22	22
Density of water at T_x ,g/ml	0.9978	0.9978	0.9978
Mass of density bottle+water at temperature $T_i^{\circ}C$ (21 $^{\circ}C$),g	117.6	120.8	122.5
Density of water at T_i ,g/ml at 21 $^{\circ}C$	0.99802	0.99802	0.998
Correction factor,k	0.99978	0.99978	0.9998
Specific gravity G at $T_x^{\circ}C$	2.66	2.66	2.66
Average specific gravity at $T_x^{\circ}C$	2.66		

Specific gravity of soil at test Temperature, G at $T_x^{\circ}C$ (ASTM D-854)			
Station:	21+000		
Trial No.	1	2	3
Mass of density bottle, g	24	26.9	27
Mass of density bottle+dry soil, g	49	51.9	52
Mass of density bottle+dry soil+water at temperature $T_x^{\circ}C$, g	136.3	136.9	138.8
Test temperature (T_x), $^{\circ}C$	22	22	22
Density of water at T_x , g/ml	0.9978	0.9978	0.9978
Mass of density bottle+water at temperature $T_i^{\circ}C$ ($21^{\circ}C$), g	120.8	121.1	123.2
Density of water at T_i , g/ml at $21^{\circ}C$	0.99802	0.99802	0.99802
Correction factor, k	0.99978	0.99978	0.99978
Specific gravity G at $T_x^{\circ}C$	2.63	2.72	2.66
Average specific gravity at $T_x^{\circ}C$	2.67		

Specific gravity of soil at test Temperature, G at $T_x^{\circ}C$ (ASTM D-854)			
Station:	24+000		
Trial No.	1	2	3
Mass of density bottle, g	26.6	25.2	27.1
Mass of density bottle+dry soil, g	51.6	50.2	52.1
Mass of density bottle+dry soil+water at temperature $T_x^{\circ}C$, g	139.2	133.6	137.9
Test temperature (T_x), $^{\circ}C$	22	22	22
Density of water at T_x , g/ml	0.9978	0.9978	0.9978
Mass of density bottle+water at temperature $T_i^{\circ}C$ ($21^{\circ}C$), g	123.5	117.9	122.2
Density of water at T_i , g/ml at $21^{\circ}C$	0.99802	0.99802	0.99802
Correction factor, k	0.99978	0.99978	0.99978
Specific gravity G at $T_x^{\circ}C$	2.69	2.69	2.69
Average specific gravity at $T_x^{\circ}C$	2.69		

Specific gravity of soil at test Temperature, G at $T_x^{\circ}C$ (ASTM D-854)			
Station:	27+000		
Trial No.	1	2	3
Mass of density bottle, g	24	26.9	27
Mass of density bottle+dry soil, g	49	51.9	52
Mass of density bottle+dry soil+water at temperature $T_x^{\circ}C$, g	136.3	136.9	138.8
Test temperature(T_x), $^{\circ}C$	22	22	22
Density of water at T_x , g/ml	0.9978	0.9978	0.9978
Mass of density bottle+water at temperature $T_i^{\circ}C$ ($21^{\circ}C$), g	120.6	121.2	123.2
Density of water at T_i , g/ml at $21^{\circ}C$	0.99802	0.99802	0.99802
Correction factor, k	0.99978	0.99978	0.99978
Specific gravity G at $T_x^{\circ}C$	2.69	2.69	2.66
Average specific gravity at $T_x^{\circ}C$	2.68		

Specific gravity of soil at test Temperature, G at $T_x^{\circ}C$ (ASTM D-854)			
Station:	30+000		
Trial No.	1	2	3
Mass of density bottle, g	25	26.5	25.5
Mass of density bottle+dry soil, g	50	51.5	50.5
Mass of density bottle+dry soil+water at temperature $T_x^{\circ}C$, g	135.5	136.6	137.6
Test temperature(T_x), $^{\circ}C$	22	22	22
Density of water at T_x , g/ml	0.9978	0.9978	0.9978
Mass of density bottle+water at temperature $T_i^{\circ}C$ ($21^{\circ}C$), g	119.8	120.9	122
Density of water at T_i , g/ml at $21^{\circ}C$	0.99802	0.99802	0.99802
Correction factor, k	0.99978	0.99978	0.99978
Specific gravity G at $T_x^{\circ}C$	2.69	2.69	2.66
Average specific gravity at $T_x^{\circ}C$	2.68		

Specific gravity of soil at test Temperature, G at $T_x^{\circ}C$ (ASTM D-854)			
Station:	33+000		
Trial No.	1	2	3
Mass of density bottle,g	22.3	26.9	26.6
Mass of density bottle+dry soil,g	47.3	51.9	51.6
Mass of density bottle+dry soil+water at temperature $T_x^{\circ}C$,g	133.6	136.3	138.4
Test temperature(T_x), $^{\circ}C$	23	23	23
Density of water at T_x ,g/ml	0.99757	0.99757	0.99757
Mass of density bottle+water at temperature $T_i^{\circ}C$ (21 $^{\circ}C$),g	117.9	120.6	122.8
Density of water at T_i ,g/ml at 21 $^{\circ}C$	0.99802	0.99802	0.99802
Correction factor,k	0.99955	0.99955	0.99955
Specific gravity G at $T_x^{\circ}C$	2.69	2.69	2.66
Average specific gravity at $T_x^{\circ}C$	2.68		

Specific gravity of soil at test Temperature, G at $T_x^{\circ}C$ (ASTM D-854)			
Station:	36+000		
Trial No.	1	2	3
Mass of density bottle,g	26.6	25.2	27.1
Mass of density bottle+dry soil,g	51.6	50.2	52.1
Mass of density bottle+dry soil+water at temperature $T_x^{\circ}C$,g	139.1	133.2	137.5
Test temperature(T_x), $^{\circ}C$	23	23	23
Density of water at T_x ,g/ml	0.99757	0.99757	0.99757
Mass of density bottle+water at temperature $T_i^{\circ}C$ (21 $^{\circ}C$),g	122.9	117	121.3
Density of water at T_i ,g/ml at 21 $^{\circ}C$	0.99802	0.99802	0.99802
Correction factor,k	0.999549	0.999549	0.999549
Specific gravity G at $T_x^{\circ}C$	2.84	2.84	2.84
Average specific gravity at $T_x^{\circ}C$	2.84		

Specific gravity of soil at test Temperature, G at $T_x^{\circ}C$ (ASTM D-854)			
Station:	39+000		
Trial No.	1	2	3
Mass of density bottle, g	24.8	26.9	27
Mass of density bottle+dry soil, g	49.8	51.9	52
Mass of density bottle+dry soil+water at temperature $T_x^{\circ}C$, g	136.8	137.3	139.3
Test temperature(T_x), $^{\circ}C$	23	23	23
Density of water at T_x , g/ml	0.99757	0.99757	0.99757
Mass of density bottle+water at temperature $T_i^{\circ}C$ ($21^{\circ}C$), g	120.5	121	123
Density of water at T_i , g/ml at $21^{\circ}C$	0.99802	0.99802	0.99802
Correction factor, k	0.999549	0.999549	0.999549
Specific gravity G at $T_x^{\circ}C$	2.87	2.87	2.87
Average specific gravity at $T_x^{\circ}C$	2.87		

Specific gravity of soil at test Temperature, G at $T_x^{\circ}C$ (ASTM D-854)			
Station:	42+000		
Trial No.	1	2	3
Mass of density bottle, g	22.3	26.9	26.6
Mass of density bottle+dry soil, g	47.3	51.9	51.6
Mass of density bottle+dry soil+water at temperature $T_x^{\circ}C$, g	133.2	136.4	138.1
Test temperature(T_x), $^{\circ}C$	22	22	22
Density of water at T_x , g/ml	0.9978	0.9978	0.9978
Mass of density bottle+water at temperature $T_i^{\circ}C$ ($21^{\circ}C$), g	117	120.2	121.9
Density of water at T_i , g/ml at $21^{\circ}C$	0.99802	0.99802	0.998
Correction factor, k	0.99978	0.99978	0.9998
Specific gravity G at $T_x^{\circ}C$	2.84	2.84	2.84
Average specific gravity at $T_x^{\circ}C$	2.84		

Specific gravity of soil at test Temperature, G at $T_x^{\circ}C$ (ASTM D-854)			
Station:	45+000		
Trial No.	1	2	3
Mass of density bottle,g	26.6	25.2	27.1
Mass of density bottle+dry soil,g	51.6	50.2	52.1
Mass of density bottle+dry soil+water at temperature $T_x^{\circ}C$,g	139.2	133.6	137.9
Test temperature(T_x), $^{\circ}C$	22	22	22
Density of water at T_x ,g/ml	0.9978	0.9978	0.9978
Mass of density bottle+water at temperature $T_i^{\circ}C$ (21 $^{\circ}C$),g	122.9	117.3	121.6
Density of water at T_i ,g/ml at 21 $^{\circ}C$	0.99802	0.99802	0.99802
Correction factor,k	0.99978	0.99978	0.99978
Specific gravity G at $T_x^{\circ}C$	2.87	2.87	2.87
Average specific gravity at $T_x^{\circ}C$	2.87		

Specific gravity of soil at test Temperature, G at $T_x^{\circ}C$ (ASTM D-854)			
Station:	48+000		
Trial No.	1	2	3
Mass of density bottle,g	24	26.9	27
Mass of density bottle+dry soil,g	49	51.9	52
Mass of density bottle+dry soil+water at temperature $T_x^{\circ}C$,g	136.3	136.9	138.8
Test temperature(T_x), $^{\circ}C$	22	22	22
Density of water at T_x ,g/ml	0.9978	0.9978	0.9978
Mass of density bottle+water at temperature $T_i^{\circ}C$ (21 $^{\circ}C$),g	120.7	121.3	123.2
Density of water at T_i ,g/ml at 21 $^{\circ}C$	0.99802	0.99802	0.99802
Correction factor,k	0.99978	0.99978	0.99978
Specific gravity G at $T_x^{\circ}C$	2.66	2.66	2.66
Average specific gravity at $T_x^{\circ}C$	2.66		

Specific gravity of soil at test Temperature, G at $T_x^{\circ}C$ (ASTM D-854)			
Station:	51+000		
Trial No.	1	2	3
Mass of density bottle, g	25	26.5	25.5
Mass of density bottle+dry soil, g	50	51.5	50.5
Mass of density bottle+dry soil+water at temperature $T_x^{\circ}C$, g	135.5	136.6	137.6
Test temperature (T_x), $^{\circ}C$	22	22	22
Density of water at T_x , g/ml	0.9978	0.9978	0.9978
Mass of density bottle+water at temperature $T_i^{\circ}C$ ($21^{\circ}C$), g	119.8	120.9	122
Density of water at T_i , g/ml at $21^{\circ}C$	0.99802	0.99802	0.99802
Correction factor, k	0.99978	0.99978	0.99978
Specific gravity G at $T_x^{\circ}C$	2.69	2.69	2.66
Average specific gravity at $T_x^{\circ}C$	2.68		

Specific gravity of soil at test Temperature, G at $T_x^{\circ}C$ (ASTM D-854)			
Station:	54+000		
Trial No.	1	2	3
Mass of density bottle, g	22.3	26.9	26.6
Mass of density bottle+dry soil, g	47.3	51.9	51.6
Mass of density bottle+dry soil+water at temperature $T_x^{\circ}C$, g	133.6	136.3	138.4
Test temperature (T_x), $^{\circ}C$	23	23	23
Density of water at T_x , g/ml	0.99757	0.99757	0.99757
Mass of density bottle+water at temperature $T_i^{\circ}C$ ($21^{\circ}C$), g	118	120.7	122.8
Density of water at T_i , g/ml at $21^{\circ}C$	0.99802	0.99802	0.99802
Correction factor, k	0.99955	0.99955	0.99955
Specific gravity G at $T_x^{\circ}C$	2.66	2.66	2.66
Average specific gravity at $T_x^{\circ}C$	2.66		

Specific gravity of soil at test Temperature, G at $T_x^{\circ}C$ (ASTM D-854)			
Station:	57+000		
Trial No.	1	2	3
Mass of density bottle, g	26.6	25.2	27.1
Mass of density bottle+dry soil, g	51.6	50.2	52.1
Mass of density bottle+dry soil+water at temperature $T_x^{\circ}C$, g	139.1	133.2	137.5
Test temperature (T_x), $^{\circ}C$	23	23	23
Density of water at T_x , g/ml	0.99757	0.99757	0.99757
Mass of density bottle+water at temperature $T_i^{\circ}C$ ($21^{\circ}C$), g	123.4	117.5	121.8
Density of water at T_i , g/ml at $21^{\circ}C$	0.99802	0.99802	0.99802
Correction factor, k	0.999549	0.999549	0.999549
Specific gravity G at $T_x^{\circ}C$	2.69	2.69	2.69
Average specific gravity at $T_x^{\circ}C$	2.69		

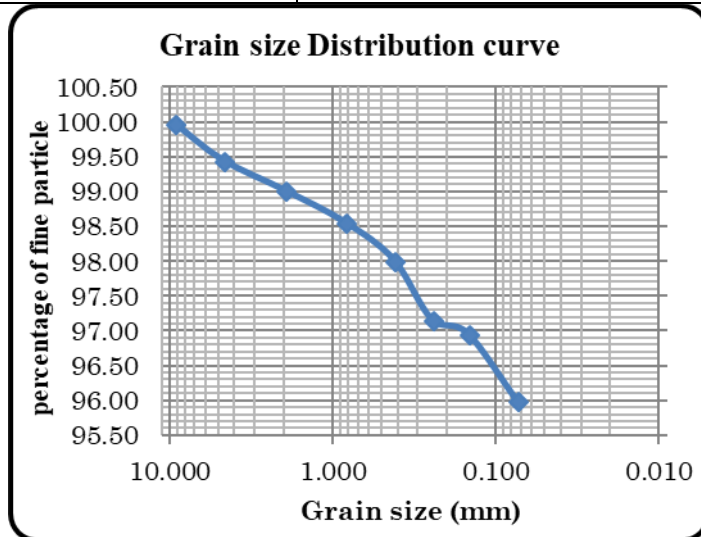
Specific gravity of soil at test Temperature, G at $T_x^{\circ}C$ (ASTM D-854)			
Station:	60+000		
Trial No.	1	2	3
Mass of density bottle, g	24.8	26.9	27
Mass of density bottle+dry soil, g	49.8	51.9	52
Mass of density bottle+dry soil+water at temperature $T_x^{\circ}C$, g	136.8	137.3	139.3
Test temperature (T_x), $^{\circ}C$	23	23	23
Density of water at T_x , g/ml	0.99757	0.99757	0.99757
Mass of density bottle+water at temperature $T_i^{\circ}C$ ($21^{\circ}C$), g	121.2	121.7	123.7
Density of water at T_i , g/ml at $21^{\circ}C$	0.99802	0.99802	0.99802
Correction factor, k	0.999549	0.999549	0.999549
Specific gravity G at $T_x^{\circ}C$	2.66	2.66	2.66
Average specific gravity at $T_x^{\circ}C$	2.66		

APPENDIX 4.2C: - Existing Road Subgrade Soil Samples

4.2C Grain Size Analysis

Table 4.2 C Grain Size Analysis for station km 3+000

Method of Testing:	Grain Size Analysis (ASTM D-1140)			
Method of Testing:	Wet Sieve Analysis			
Wt. of Sample: (g)	1 Kg			
Sample Station:	Gimbo-Konda Road Project			
Depth (m)	1.5m			
Station:km	3+000			
Sieve size (mm)	Mass of Retain on Each Sieve (g)	Percentage of Retained Soil	Percentage of cumulative Retained Soil	Percentage of Passing Soil Particle
9.500	0.000	0.00	0.00	100.00
4.750	5.400	0.54	0.54	99.46
2.000	4.300	0.43	0.97	99.03
0.850	4.600	0.46	1.43	98.57
0.425	5.400	0.54	1.97	98.03
0.250	8.500	0.85	2.82	97.18
0.150	2.100	0.21	3.03	96.97
0.075	9.600	0.96	3.99	96.01
Pan	960.100	96.01	100.00	0.00
Sum	1000.000			

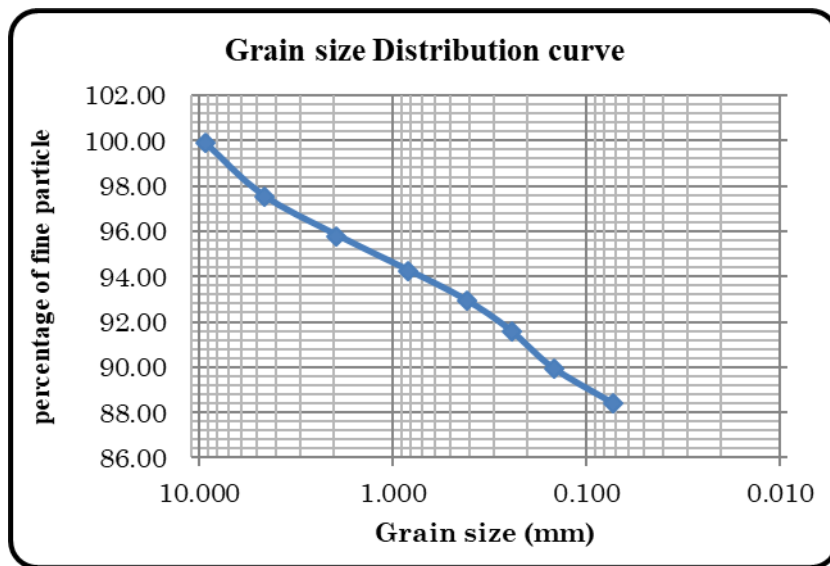


Percentage of Gravel Soil	0.54
Percentage of Sandy Soil	3.45
Percentage of Fine Soil	96.01

Fig4.2 C Grain size analysis curve for station km 3+000

Table 4.2 C Grain Size Analysis for station km 6+000

Method of Testing:	Grain Size Analysis (ASTM D-1140)			
Method of Testing:	Wet Sieve Analysis			
Wt. of Sample: (g)	1 Kg			
Sample Station:	Gimbo-Konda Road Project			
Depth (m)	1.5m			
Station: km	6+000			
Sieve size (mm)	Mass of Retain on Each Sieve (g)	Percentage of Retained Soil	Percentage of cumulative Retained Soil	Percentage of Passing Soil Particle
9.500	0.000	0.00	0.00	100.00
4.750	23.450	2.35	2.35	97.66
2.000	17.500	1.75	4.10	95.91
0.850	15.600	1.56	5.66	94.35
0.425	13.200	1.32	6.98	93.03
0.250	13.240	1.32	8.30	91.70
0.150	16.790	1.68	9.98	90.02
0.075	15.340	1.53	11.51	88.49
Pan	884.880	88.49	100.00	0.00
Sum	1000.000			

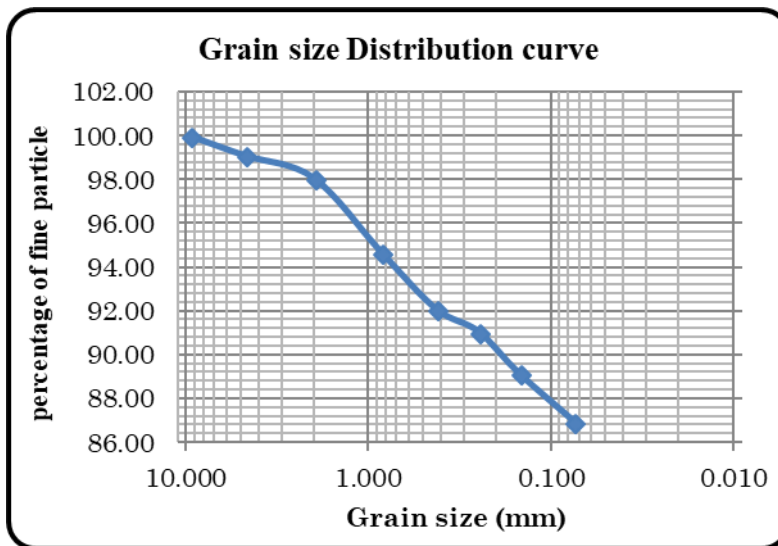


Percentage of Gravel Soil	2.36
Percentage of Sandy Soil	9.15
Percentage of Fine Soil	88.49

Fig4.2 C Grain size analysis curve for station km 6+000

Table 4.2 C Grain Size Analysis for station km 9+000

Method of Testing:	Grain Size Analysis (ASTM D-1140)			
Method of Testing:	Wet Sieve Analysis			
Wt. of Sample: (g)	1 Kg			
Sample Station:	Gimbo-Konda Road Project			
Depth (m)	1.5m			
Station:km	9+000			
Sieve size (mm)	Mass of Retain on Each Sieve (g)	Percentage of Retained Soil	Percentage of cumulative Retained Soil	Percentage of Passing Soil Particle
9.500	0.000	0.00	0.00	100.00
4.750	8.900	0.89	0.89	99.11
2.000	10.200	1.02	1.91	98.09
0.850	34.100	3.41	5.32	94.68
0.425	26.000	2.60	7.92	92.08
0.250	10.200	1.02	8.94	91.06
0.150	19.100	1.91	10.85	89.15
0.075	22.000	2.20	13.05	86.95
Pan	869.500	86.95	100.00	0.00
Sum	1000.000			



Percentage of Gravel Soil	0.89
Percentage of Sandy Soil	12.16
Percentage of Fine Soil	86.95

Fig4.2 C Grain size analysis curve for station km 9+000

Table 4.2 C Grain Size Analysis for station km 12+000

Method of Testing:	Grain Size Analysis (ASTM D-1140)			
Method of Testing:	Wet Sieve Analysis			
Wt. of Sample: (g)	1 Kg			
Sample Station:	Gimbo-Konda Road Project			
Depth (m)	1.5m			
Station:	12+000			
Sieve size (mm)	Mass of Retain on Each Sieve (g)	Percentage of Retained Soil	Percentage of cumulative Retained Soil	Percentage of Passing Soil Particle
9.500	0.000	0.00	0.00	100.00
4.750	6.500	0.65	0.65	99.35
2.000	10.400	1.04	1.69	98.31
0.850	26.700	2.67	4.36	95.64
0.425	35.800	3.58	7.94	92.06
0.250	16.800	1.68	9.62	90.38
0.150	16.900	1.69	11.31	88.69
0.075	18.450	1.85	13.16	86.85
Pan	868.450	86.85	100.00	0.00
Sum	1000.000			

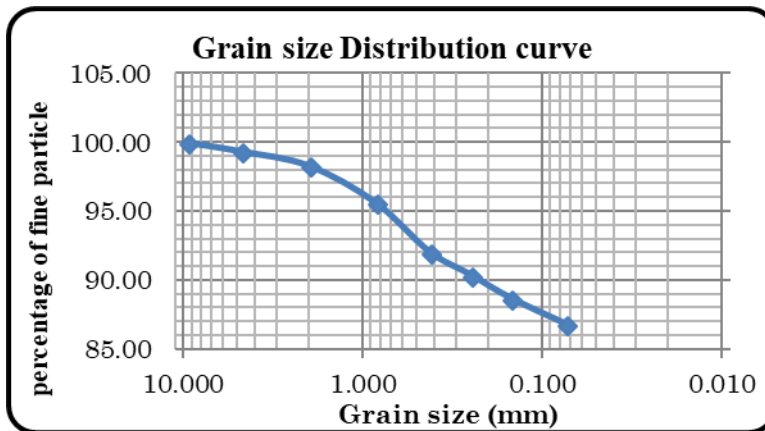
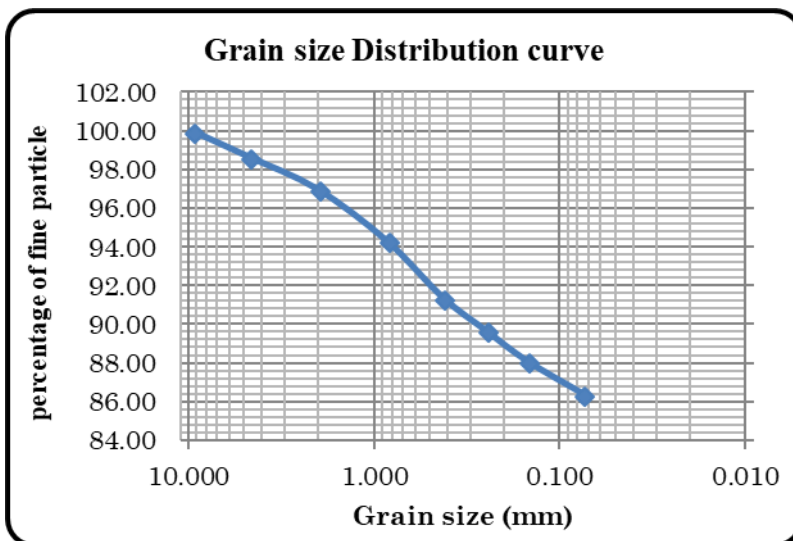


Fig4.2 C Grain size analysis curve for station km 12+000

Percentage of Gravel Soil	0.65
Percentage of Sandy Soil	12.51
Percentage of Fine Soil	86.85

Table 4.2 C Grain Size Analysis for station km 15+000

Method of Testing:	Grain Size Analysis (ASTM D-1140)			
Method of Testing:	Wet Sieve Analysis			
Wt. of Sample: (g)	1 Kg			
Sample Station:	Gimbo-Konda Road Project			
Depth (m)	1.5m			
Station:	15+000			
Sieve size (mm)	Mass of Retain on Each Sieve (g)	Percentage of Retained Soil	Percentage of cumulative Retained Soil	Percentage of Passing Soil Particle
9.500	0.000	0.00	0.00	100.00
4.750	13.230	1.32	1.32	98.68
2.000	17.000	1.70	3.02	96.98
0.850	26.700	2.67	5.69	94.31
0.425	29.300	2.93	8.62	91.38
0.250	17.000	1.70	10.32	89.68
0.150	15.800	1.58	11.90	88.10
0.075	17.000	1.70	13.60	86.40
Pan	863.970	86.40	100.00	0.00
Sum	1000.000			

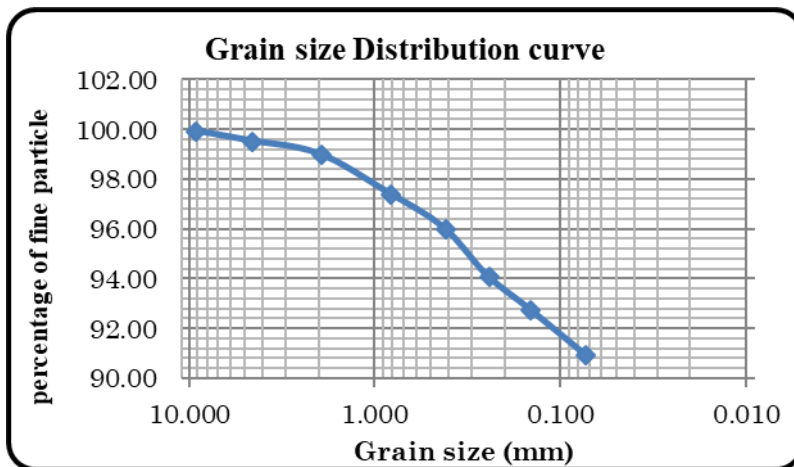


Percentage of Gravel Soil	1.32
Percentage of Sandy Soil	12.28
Percentage of Fine Soil	86.40

Fig4.2 C Grain size analysis curve for station km 15+000

Table 4.2 C Grain Size Analysis for station km 18+000

Method of Testing:	Grain Size Analysis (ASTM D-1140)			
Method of Testing:	Wet Sieve Analysis			
Wt. of Sample: (g)	1 Kg			
Sample Station:	Gimbo-Konda Road Project			
Depth (m)	1.5m			
Station:	18+000			
Sieve size (mm)	Mass of Retain on Each Sieve (g)	Percentage of Retained Soil	Percentage of cumulative Retained Soil	Percentage of Passing Soil Particle
9.500	0.000	0.00	0.00	100.00
4.750	4.100	0.41	0.41	99.59
2.000	5.300	0.53	0.94	99.06
0.850	15.600	1.56	2.50	97.50
0.425	14.200	1.42	3.92	96.08
0.250	19.100	1.91	5.83	94.17
0.150	13.200	1.32	7.15	92.85
0.075	18.400	1.84	8.99	91.01
Pan	910.100	91.01	100.00	0.00
Sum	1000.000			

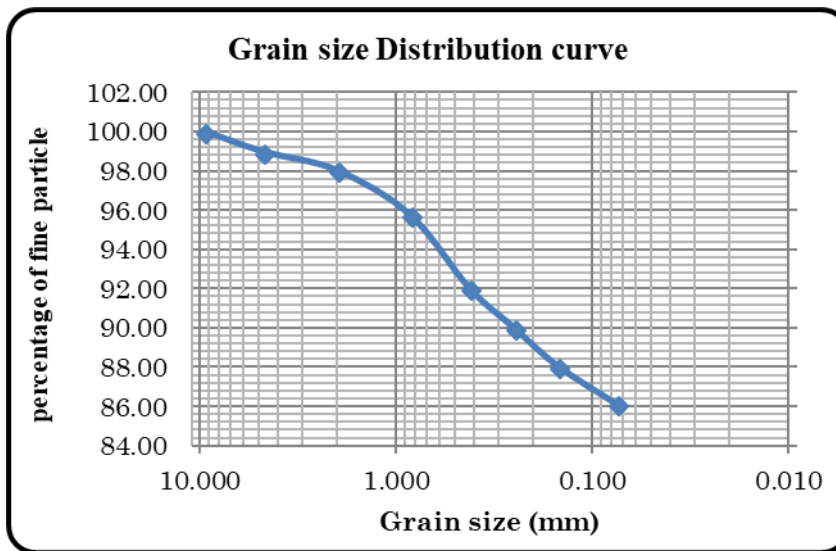


Percentage of Gravel Soil	0.41
Percentage of Sandy Soil	8.58
Percentage of Fine Soil	91.01

Fig4.2 C Grain size analysis curve for station km 18+000

Table 4.2 C Grain Size Analysis for station km 21+000

Method of Testing:	Grain Size Analysis (ASTM D-1140)			
Method of Testing:	Wet Sieve Analysis			
Wt. of Sample: (g)	1 Kg			
Sample Station:	Gimbo-Konda Road Project			
Depth (m)	1.5m			
Station:	21+000			
Sieve size (mm)	Mass of Retain on Each Sieve (g)	Percentage of Retained Soil	Percentage of cumulative Retained Soil	Percentage of Passing Soil Particle
9.500	0.000	0.00	0.00	100.00
4.750	10.400	1.04	1.04	98.96
2.000	9.500	0.95	1.99	98.01
0.850	22.600	2.26	4.25	95.75
0.425	37.200	3.72	7.97	92.03
0.250	20.430	2.04	10.01	89.99
0.150	19.400	1.94	11.95	88.05
0.075	19.400	1.94	13.89	86.11
Pan	861.070	86.11	100.00	0.00
Sum	1000.000			

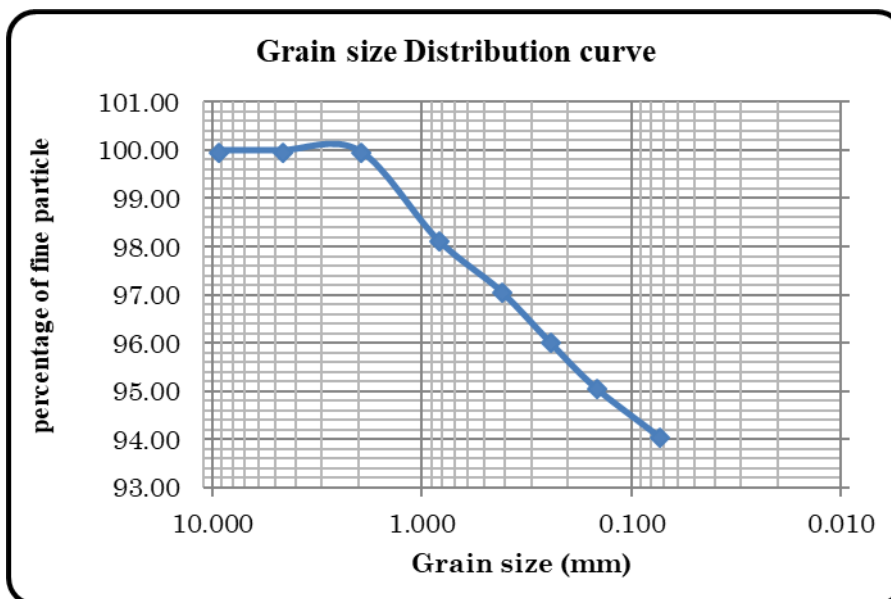


Percentage of Gravel Soil	1.04
Percentage of Sandy Soil	12.85
Percentage of Fine Soil	86.11

Fig4.2 C Grain size analysis curve for station km 21+000

Table 4.2 C Grain Size Analysis for station km 24+000

Method of Testing:	Grain Size Analysis (ASTM D-1140)			
Method of Testing:	Wet Sieve Analysis			
Wt. of Sample: (g)	1 Kg			
Sample Station:	Gimbo-Konda Road Project			
Depth (m)	1.5m			
Station:	24+000			
Sieve size (mm)	Mass of Retain on Each Sieve (g)	Percentage of Retained Soil	Percentage of cumulative Retained Soil	Percentage of Passing Soil Particle
9.500	0.000	0.00	0.00	100.00
4.750	0.000	0.00	0.00	100.00
2.000	0.000	0.00	0.00	100.00
0.850	18.300	1.83	1.83	98.17
0.425	10.700	1.07	2.90	97.10
0.250	10.400	1.04	3.94	96.06
0.150	9.650	0.97	4.91	95.10
0.075	10.100	1.01	5.92	94.09
Pan	940.850	94.09	100.00	0.00
Sum	1000.000			

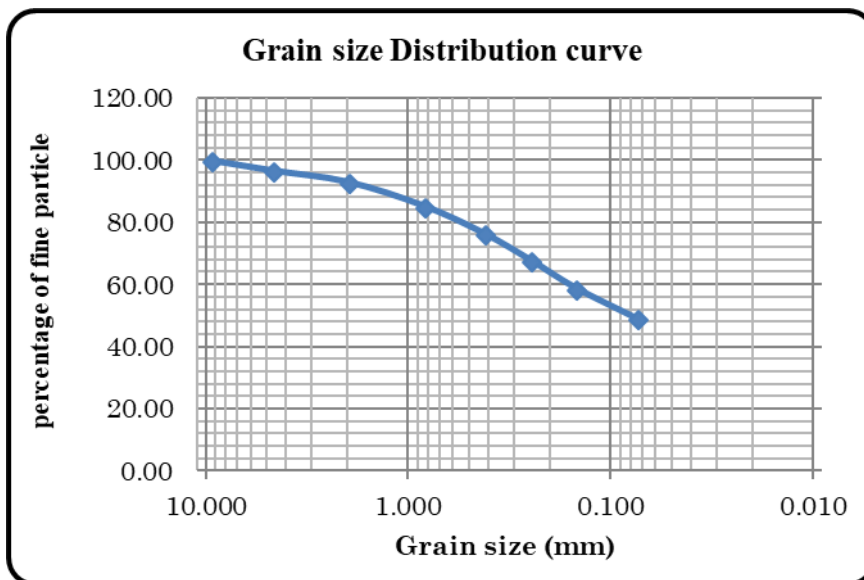


Percentage of Gravel Soil	0.00
Percentage of Sandy Soil	5.92
Percentage of Fine Soil	94.09

Fig4.2 C Grain size analysis curve for station km 24+000

Table 4.2 C Grain Size Analysis for station km 27+000

Method of Testing:	Grain Size Analysis (ASTM D-1140)			
Method of Testing:	Wet Sieve Analysis			
Wt. of Sample: (g)	1 Kg			
Sample Station:	Gimbo-Konda Road Project			
Depth (m)	1.5m			
Station:	27+000			
Sieve size (mm)	Mass of Retain on Each Sieve (g)	Percentage of Retained Soil	Percentage of cumulative Retained Soil	Percentage of Passing Soil Particle
9.500	0.000	0.00	0.00	100.00
4.750	32.100	3.21	3.21	96.79
2.000	37.100	3.71	6.92	93.08
0.850	76.100	7.61	14.53	85.47
0.425	89.300	8.93	23.46	76.54
0.250	86.600	8.66	32.12	67.88
0.150	89.000	8.90	41.02	58.98
0.075	98.400	9.84	50.86	49.14
Pan	491.400	49.14	100.00	0.00
Sum	1000.000			

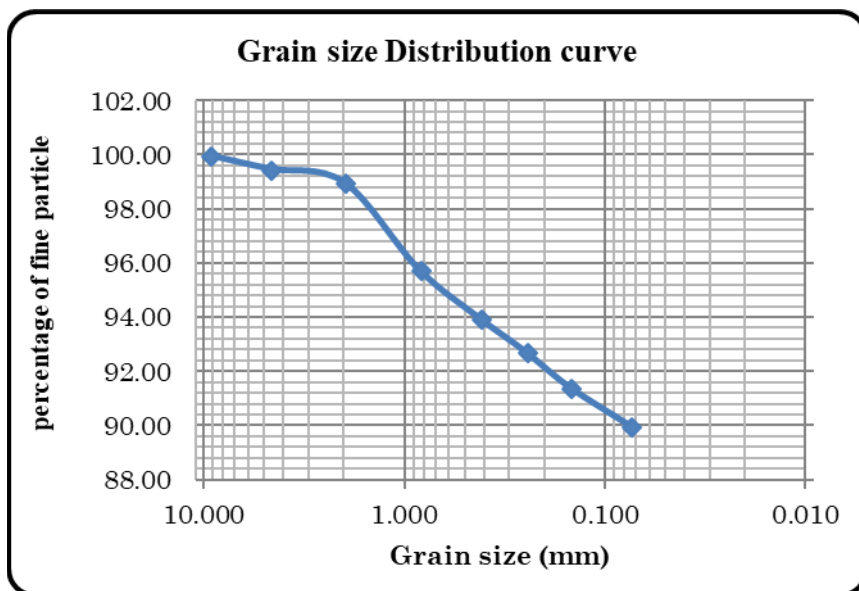


Percentage of Gravel Soil	3.21
Percentage of Sandy Soil	35.74
Percentage of Fine Soil	61.05

Fig4.2 C Grain size analysis curve for station km 27+000

Table 4.2 C Grain Size Analysis for station km 30+000

Method of Testing:	Grain Size Analysis (ASTM D-1140)			
Method of Testing:	Wet Sieve Analysis			
Wt. of Sample: (g)	1 Kg			
Sample Station:	Gimbo-Konda Road Project			
Depth (m)	1.5m			
Station:	30+000			
Sieve size (mm)	Mass of Retain on Each Sieve (g)	Percentage of Retained Soil	Percentage of cumulative Retained Soil	Percentage of Passing Soil Particle
9.500	0.000	0.00	0.00	100.00
4.750	5.000	0.50	0.50	99.50
2.000	5.000	0.50	1.00	99.00
0.850	32.000	3.20	4.20	95.80
0.425	18.000	1.80	6.00	94.00
0.250	12.400	1.24	7.24	92.76
0.150	13.200	1.32	8.56	91.44
0.075	14.200	1.42	9.98	90.02
Pan	900.200	90.02	100.00	0.00
Sum	1000.000			

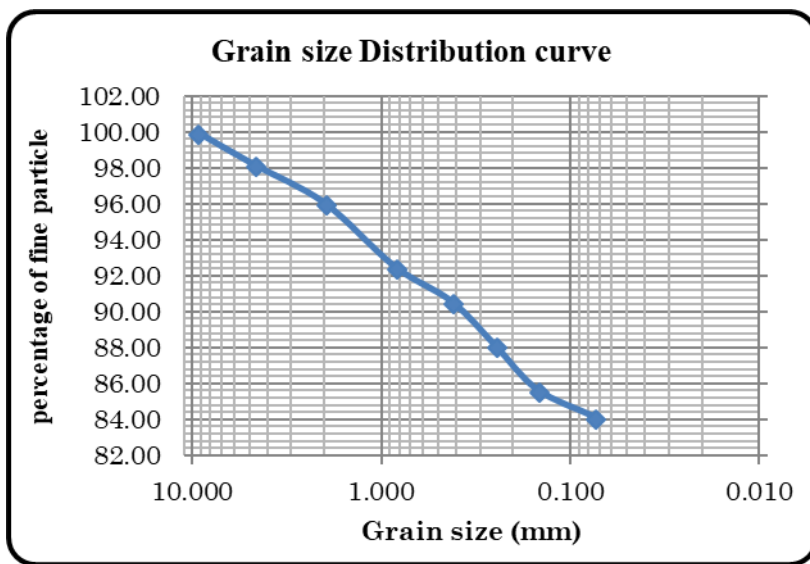


Percentage of Gravel Soil	0.50
Percentage of Sandy Soil	9.48
Percentage of Fine Soil	90.02

Fig4.2 C Grain size analysis curve for station km 30+000

Table 4.2 C Grain Size Analysis for station km 33+000

Method of Testing:	Grain Size Analysis (ASTM D-1140)			
Method of Testing:	Wet Sieve Analysis			
Wt. of Sample: (g)	1 Kg			
Sample Station:	Gimbo-Konda Road Project			
Depth (m)	1.5m			
Station:	33+000			
Sieve size (mm)	Mass of Retain on Each Sieve (g)	Percentage of Retained Soil	Percentage of cumulative Retained Soil	Percentage of Passing Soil Particle
9.500	0.000	0.00	0.00	100.00
4.750	18.100	1.81	1.81	98.19
2.000	21.500	2.15	3.96	96.04
0.850	35.400	3.54	7.50	92.50
0.425	19.400	1.94	9.44	90.56
0.250	24.500	2.45	11.89	88.11
0.150	24.500	2.45	14.34	85.66
0.075	15.100	1.51	15.85	84.15
Pan	841.500	84.15	100.00	0.00
Sum	1000.000			

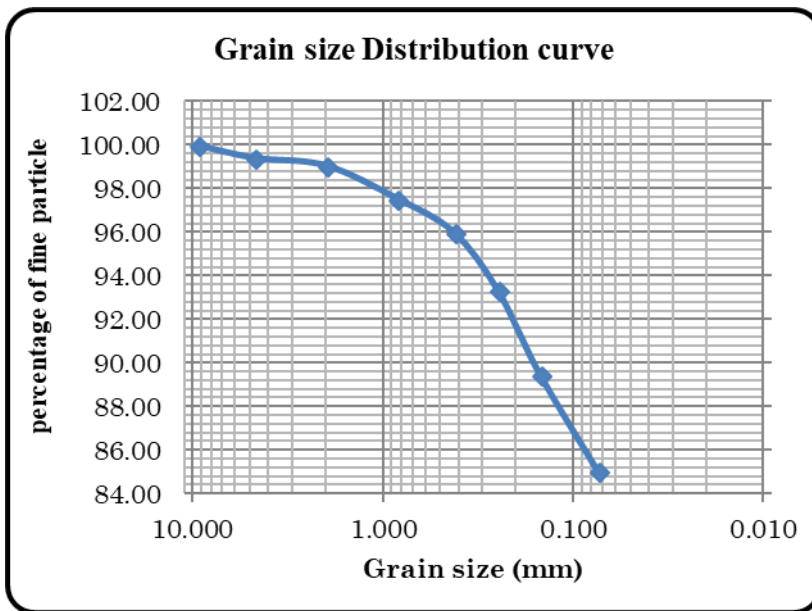


Percentage of Gravel Soil	1.81
Percentage of Sandy Soil	14.04
Percentage of Fine Soil	84.15

Fig4.2 C Grain size analysis curve for station km 33+000

Table 4.2 C Grain Size Analysis for station km 36+000

Method of Testing:	Grain Size Analysis (ASTM D-1140)			
Method of Testing:	Wet Sieve Analysis			
Wt. of Sample: (g)	1 Kg			
Sample Station:	Gimbo-Konda Road Project			
Depth (m)	1.5m			
Station:	36+000			
Sieve size (mm)	Mass of Retain on Each Sieve (g)	Percentage of Retained Soil	Percentage of cumulative Retained Soil	Percentage of Passing Soil Particle
9.500	0.000	0.00	0.00	100.00
4.750	5.800	0.58	0.58	99.42
2.000	3.500	0.35	0.93	99.07
0.850	15.000	1.50	2.43	97.57
0.425	15.600	1.56	3.99	96.01
0.250	26.500	2.65	6.64	93.36
0.150	38.800	3.88	10.52	89.48
0.075	44.000	4.40	14.92	85.08
Pan	850.800	85.08	100.00	0.00
Sum	1000.000			

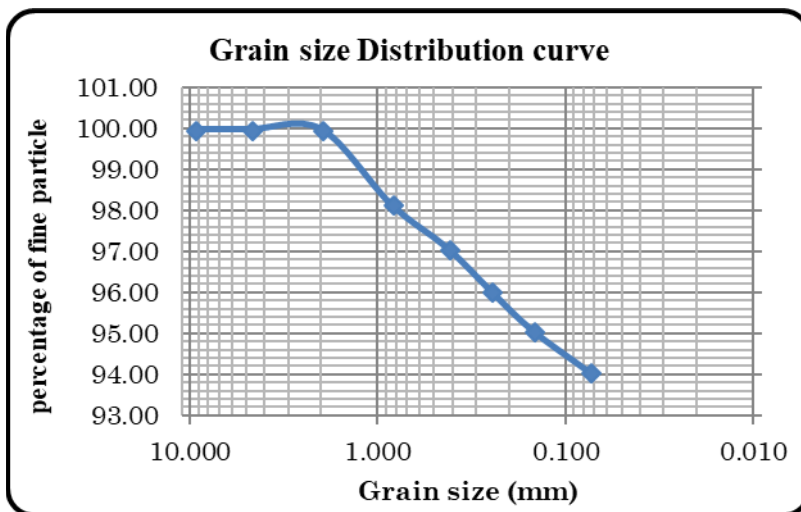


Percentage of Gravel Soil	0.58
Percentage of Sandy Soil	14.34
Percentage of Fine Soil	85.08

Fig4.2 C Grain size analysis curve for station km 36+000

Table 4.2 C Grain Size Analysis for station km 39+000

Method of Testing:	Grain Size Analysis (ASTM D-1140)			
Method of Testing:	Wet Sieve Analysis			
Wt. of Sample: (g)	1 Kg			
Sample Station:	Gimbo-Konda Road Project			
Depth (m)	1.5m			
Station:	39+000			
Sieve size (mm)	Mass of Retain on Each Sieve (g)	Percentage of Retained Soil	Percentage of cumulative Retained Soil	Percentage of Passing Soil Particle
9.500	0.000	0.00	0.00	100.00
4.750	0.000	0.00	0.00	100.00
2.000	0.000	0.00	0.00	100.00
0.850	18.300	1.83	1.83	98.17
0.425	10.700	1.07	2.90	97.10
0.250	10.400	1.04	3.94	96.06
0.150	9.650	0.97	4.91	95.10
0.075	10.100	1.01	5.92	94.09
Pan	940.850	94.09	100.00	0.00
Sum	1000.000			

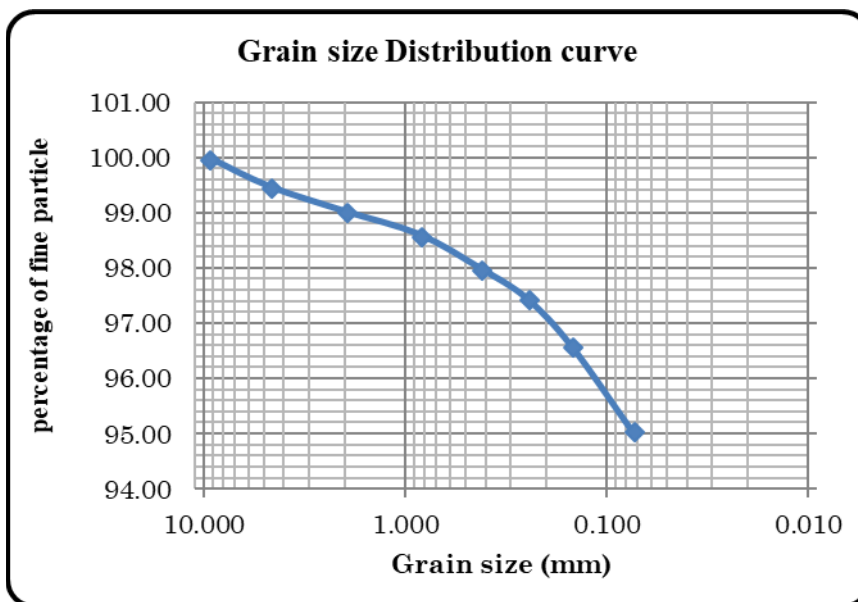


Percentage of Gravel Soil	0.00
Percentage of Sandy Soil	5.91
Percentage of Fine Soil	94.09

Fig4.2 C Grain size analysis curve for station km 39+000

Table 4.2 C Grain Size Analysis for station km 42+000

Method of Testing:	Grain Size Analysis (ASTM D-1140)			
Method of Testing:	Wet Sieve Analysis			
Wt. of Sample: (g)	1 Kg			
Sample Station:	Gimbo-Konda Road Project			
Depth (m)	1.5m			
Station:	42+000			
Sieve size (mm)	Mass of Retain on Each Sieve (g)	Percentage of Retained Soil	Percentage of cumulative Retained Soil	Percentage of Passing Soil Particle
9.500	0.000	0.00	0.00	100.00
4.750	5.200	0.52	0.52	99.48
2.000	4.500	0.45	0.97	99.03
0.850	4.200	0.42	1.39	98.61
0.425	6.100	0.61	2.00	98.00
0.250	5.400	0.54	2.54	97.46
0.150	8.600	0.86	3.40	96.60
0.075	15.300	1.53	4.93	95.07
Pan	950.700	95.07	100.00	0.00
Sum	1000.000			

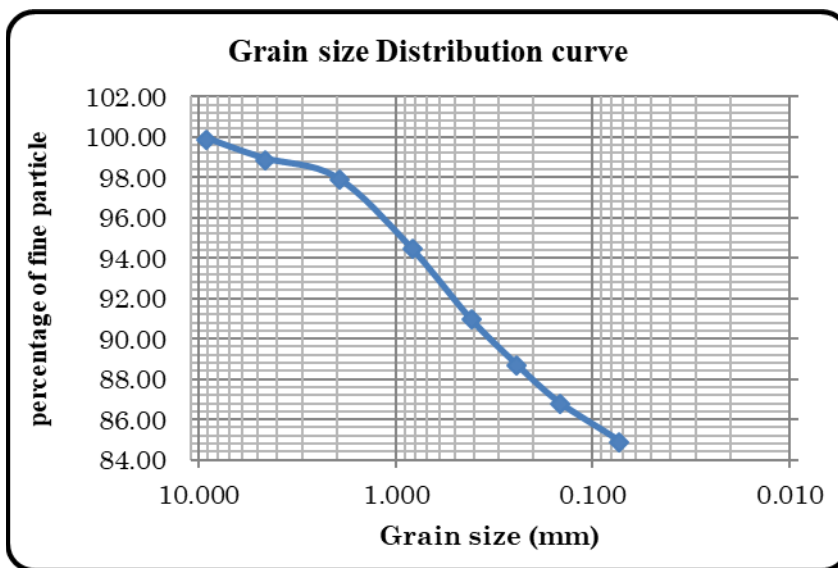


Percentage of Gravel Soil	0.52
Percentage of Sandy Soil	4.41
Percentage of Fine Soil	95.07

Fig4.2 C Grain size analysis curve for station km 42+000

Table 4.2 C Grain Size Analysis for station km 45+000

Method of Testing:	Grain Size Analysis (ASTM D-1140)			
Method of Testing:	Wet Sieve Analysis			
Wt. of Sample: (g)	1 Kg			
Sample Station:	Gimbo-Konda Road Project			
Depth (m)	1.5m			
Station:	45+000			
Sieve size (mm)	Mass of Retain on Each Sieve (g)	Percentage of Retained Soil	Percentage of cumulative Retained Soil	Percentage of Passing Soil Particle
9.500	0.000	0.00	0.00	100.00
4.750	10.300	1.03	1.03	98.97
2.000	9.650	0.97	2.00	98.01
0.850	34.200	3.42	5.42	94.59
0.425	35.100	3.51	8.93	91.08
0.250	22.500	2.25	11.18	88.83
0.150	19.400	1.94	13.12	86.89
0.075	18.900	1.89	15.01	85.00
Pan	849.950	85.00	100.00	0.00
Sum	1000.000			

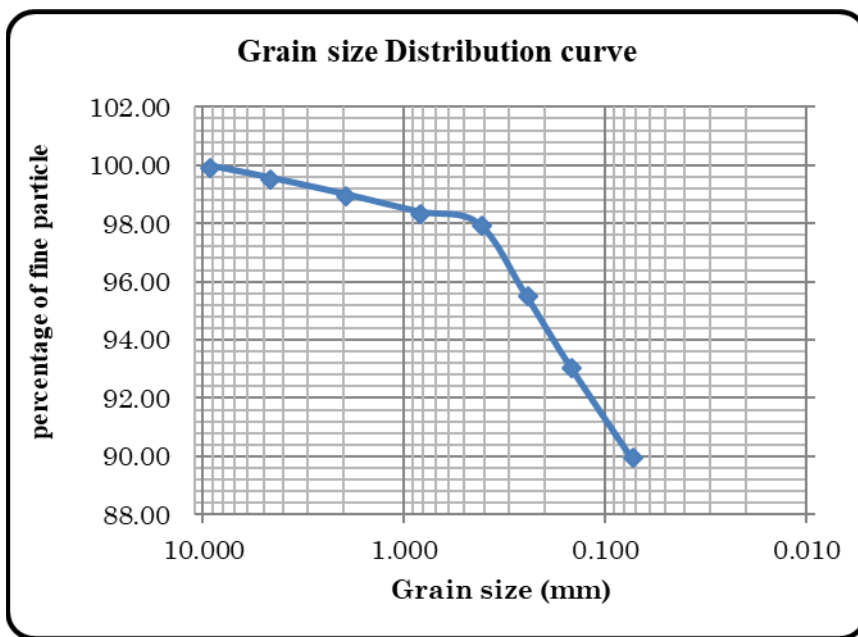


Percentage of Gravel Soil	1.02
Percentage of Sandy Soil	13.98
Percentage of Fine Soil	85.00

Fig4.2 C Grain size analysis curve for station km 45+000

Table 4.2 C Grain Size Analysis for station km 48+000

Method of Testing:	Grain Size Analysis (ASTM D-1140)			
Method of Testing:	Wet Sieve Analysis			
Wt. of Sample: (g)	1 Kg			
Sample Station:	Gimbo-Konda Road Project			
Depth (m)	1.5m			
Station:	48+000			
Sieve size (mm)	Mass of Retain on Each Sieve (g)	Percentage of Retained Soil	Percentage of cumulative Retained Soil	Percentage of Passing Soil Particle
9.500	0.000	0.00	0.00	100.00
4.750	4.100	0.41	0.41	99.59
2.000	5.700	0.57	0.98	99.02
0.850	6.100	0.61	1.59	98.41
0.425	4.100	0.41	2.00	98.00
0.250	24.100	2.41	4.41	95.59
0.150	24.700	2.47	6.88	93.12
0.075	31.000	3.10	9.98	90.02
Pan	900.200	90.02	100.00	0.00
Sum	1000.000			



Percentage of Gravel Soil	0.41
Percentage of Sandy Soil	9.57
Percentage of Fine Soil	90.02

Fig4.2 C Grain size analysis curve for station km 48+000

Table 4.2 C Grain Size Analysis for station km 51+000

Method of Testing:	Grain Size Analysis (ASTM D-1140)			
Method of Testing:	Wet Sieve Analysis			
Wt. of Sample: (g)	1 Kg			
Sample Station:	Gimbo-Konda Road Project			
Depth (m)	1.5m			
Station:	51+000			
Sieve size (mm)	Mass of Retain on Each Sieve (g)	Percentage of Retained Soil	Percentage of cumulative Retained Soil	Percentage of Passing Soil Particle
9.500	0.000	0.00	0.00	100.00
4.750	23.500	2.35	2.35	97.65
2.000	16.500	1.65	4.00	96.00
0.850	25.700	2.57	6.57	93.43
0.425	24.400	2.44	9.01	90.99
0.250	31.100	3.11	12.12	87.88
0.150	19.400	1.94	14.06	85.94
0.075	29.600	2.96	17.02	82.98
Pan	829.800	82.98	100.00	0.00
Sum	1000.000			

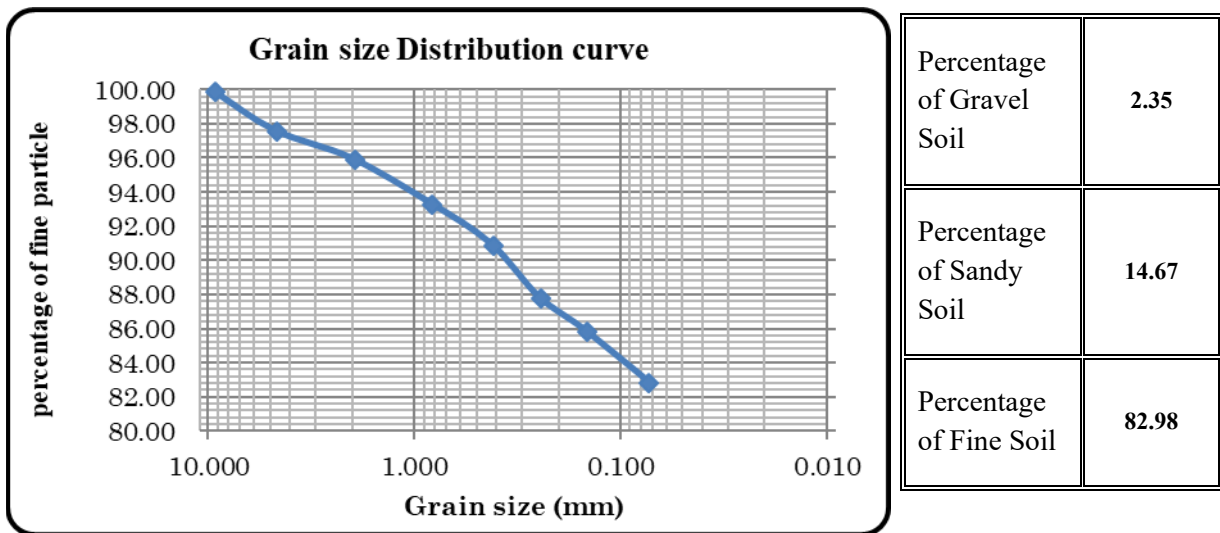
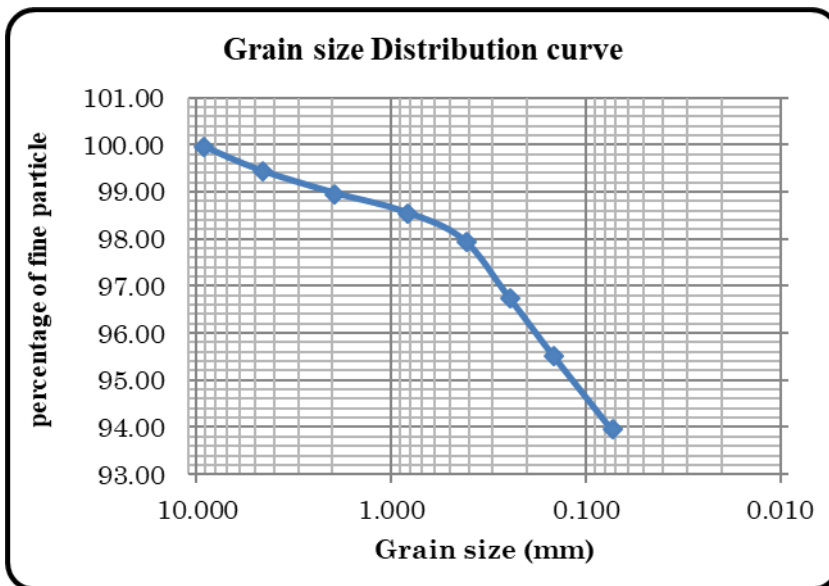


Fig4.2 C Grain size analysis curve for station km 51+000

Table 4.2 C Grain Size Analysis for station km 54+000

Method of Testing:	Grain Size Analysis (ASTM D-1140)			
Method of Testing:	Wet Sieve Analysis			
Wt. of Sample: (g)	1 Kg			
Sample Station:	Gimbo-Konda Road Project			
Depth (m)	1.5m			
Station:	54+000			
Sieve size (mm)	Mass of Retain on Each Sieve (g)	Percentage of Retained Soil	Percentage of cumulative Retained Soil	Percentage of Passing Soil Particle
9.500	0.000	0.00	0.00	100.00
4.750	5.200	0.52	0.52	99.48
2.000	4.800	0.48	1.00	99.00
0.850	4.100	0.41	1.41	98.59
0.425	5.900	0.59	2.00	98.00
0.250	12.100	1.21	3.21	96.79
0.150	12.100	1.21	4.42	95.58
0.075	15.800	1.58	6.00	94.00
Pan	940.000	94.00	100.00	0.00
Sum	1000.000			

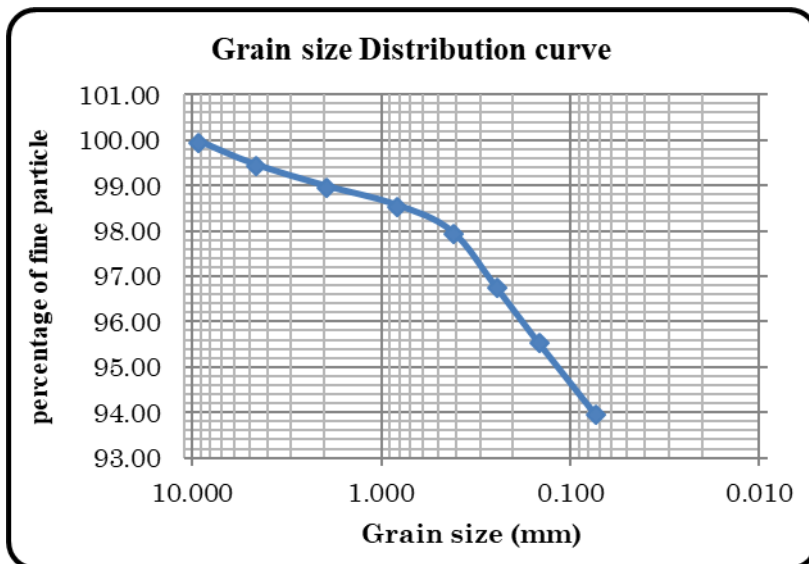


Percentage of Gravel Soil	0.52
Percentage of Sandy Soil	5.48
Percentage of Fine Soil	94.00

Fig4.2 C Grain size analysis curve for station km 54+000

Table 4.2 C Grain Size Analysis for station km 57+000

Method of Testing:	Grain Size Analysis (ASTM D-1140)			
Method of Testing:	Wet Sieve Analysis			
Wt. of Sample: (g)	1 Kg			
Sample Station:	Gimbo-Konda Road Project			
Depth (m)	1.5m			
Station:	57+000			
Sieve size (mm)	Mass of Retain on Each Sieve (g)	Percentage of Retained Soil	Percentage of cumulative Retained Soil	Percentage of Passing Soil Particle
9.500	0.000	0.00	0.00	100.00
4.750	5.200	0.52	0.52	99.48
2.000	4.800	0.48	1.00	99.00
0.850	4.100	0.41	1.41	98.59
0.425	5.900	0.59	2.00	98.00
0.250	12.100	1.21	3.21	96.79
0.150	12.100	1.21	4.42	95.58
0.075	15.800	1.58	6.00	94.00
Pan	940.000	94.00	100.00	0.00
Sum	1000.000			

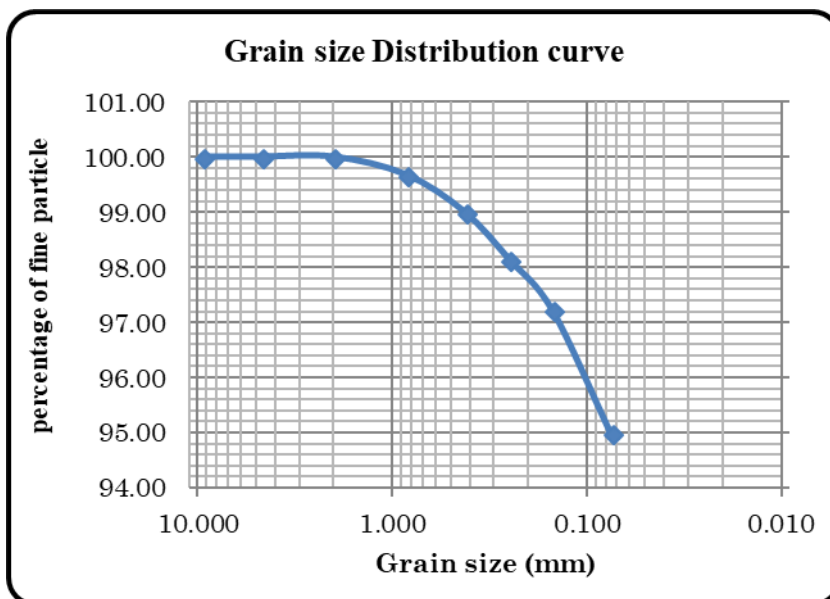


Percentage of Gravel Soil	0.52
Percentage of Sandy Soil	5.48
Percentage of Fine Soil	94.00

Fig4.2 C Grain size analysis curve for station km 57+000

Table 4.2 C Grain Size Analysis for station km 60+000

Method of Testing:	Grain Size Analysis (ASTM D-1140)			
Method of Testing:	Wet Sieve Analysis			
Wt. of Sample: (g)	1 Kg			
Sample Station:	Gimbo-Konda Road Project			
Depth (m)	1.5m			
Station:	60+000			
Sieve size (mm)	Mass of Retain on Each Sieve (g)	Percentage of Retained Soil	Percentage of cumulative Retained Soil	Percentage of Passing Soil Particle
9.500	0.000	0.00	0.00	100.00
4.750	0.000	0.00	0.00	100.00
2.000	0.000	0.00	0.00	100.00
0.850	3.200	0.32	0.32	99.68
0.425	6.700	0.67	0.99	99.01
0.250	8.600	0.86	1.85	98.15
0.150	9.200	0.92	2.77	97.23
0.075	22.300	2.23	5.00	95.00
Pan	950.000	95.00	100.00	0.00
Sum	1000.000			



Percentage of Gravel Soil	0.00
Percentage of Sandy Soil	5.00
Percentage of Fine Soil	95.00

Fig4.2 C Grain size analysis curve for station km 60+000

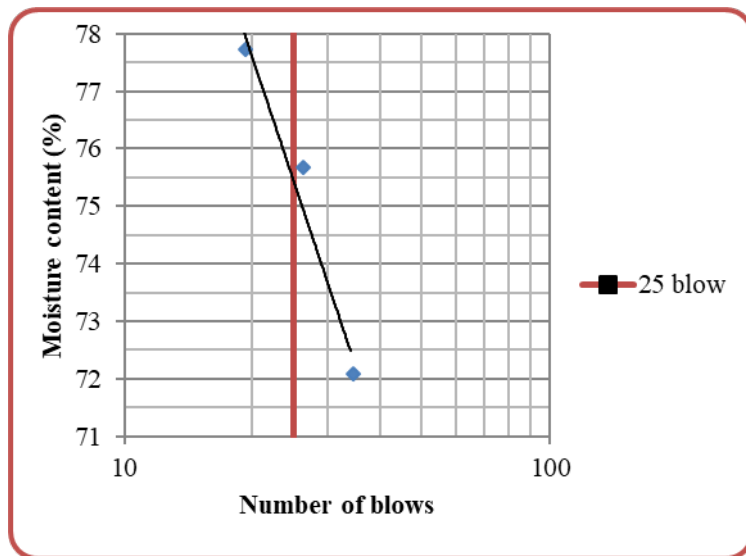
APPENDIX 4.2D: - Existing Road Subgrade Soil Samples

4.2D Atterberg Limits and Linear shrinkage

Table 4.2D Atterberg Limits and Linear shrinkage for station km 3+000

Material Station:	Gimbo-Konda Road Project				
Station;km	3+000				
Determination	Liquid Limit (D-4318)			Plastic Limit (D-4318)	
Number of blows	34	26	19		
Test No	01	02	03	01	02
Wt. of Container, (g)	35.50	37.00	41.10	18.70	5.70
Wt. of container + wet soil, (g)	46.00	49.30	52.30	33.60	16.70
Wt. of container + dry soil, (g)	41.60	44.00	47.40	29.80	13.90
Wt. of water, (g)	4.40	5.30	4.90	3.80	2.80
Wt. of dry soil, (g)	6.10	7.00	6.30	11.10	8.20
Moisture container, (%)	72.13	75.71	77.78	34.23	34.15
Average	76.00			34.19	

LINEAR SHRINKAGE (BS1377:Part 2:1990)		
Station;km	3+000	
Test No	1	2
Initial Length L0	140.00	140.00
Oven dried Length LD	125.40	125.30
Linear shrinkages	0.10	0.11
Percentage of Linear Shrinkage (%)	10.43	10.50
Average Percentage of Linear Shrinkage (%)	10.46	



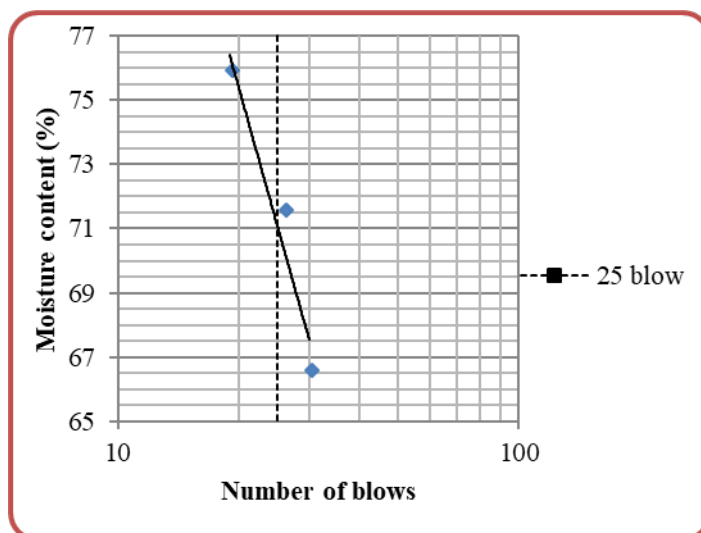
Determination of (PI) (LL - PL)	LL (%)	76
	PL (%)	34
	PI (%)	42
	LS (%)	10.46

Fig 4.2D Liquid limit graph for station 3+000km

Table 4.2D Liquid limit, plastic limit and linear shrinkage for station km 6+000

Material Station:	Gimbo-Konda Road Project				
Station;km	6+000				
Determination	Liquid Limit (D-4318)			Plastic Limit (D-4318)	
Number of blows	30	26	19		
Test No	01	02	03	01	02
Wt. of Container, (g)	33.00	36.50	36.50	5.70	6.40
Wt. of container + wet soil, (g)	43.00	48.00	49.70	11.90	13.90
Wt. of container + dry soil, (g)	39.00	43.20	44.00	10.17	11.83
Wt. of water, (g)	4.00	4.80	5.70	1.73	2.07
Wt. of dry soil, (g)	6.00	6.70	7.50	4.47	5.43
Moisture container, (%)	66.67	71.64	76.00	38.70	38.12
Average	71.00			38.41	

LINEAR SHRINKAGE (BS1377:Part 2:1990)		
Station;km	6+000	
Test No	1	2
Initial Length L ₀	140.00	140.00
Oven dried Length L _D	125.91	125.31
Linear shrinkage, L _s	0.10	0.10
Percentage of Linear Shrinkage(%)	10.06	10.49
Average Percentage of Linear Shrinkage(%)	10.28	



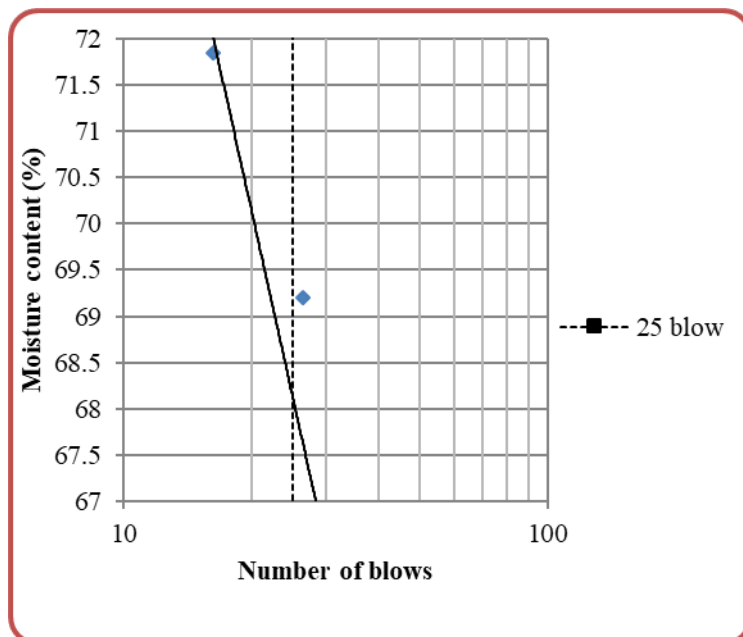
Determination of (PI) (LL - PL)	LL (%)	71
	PL (%)	38
	PI (%)	33
	LS(%)	10.28

Fig 4.2D Liquid limit graph for station km 6+000

Table 4.2D Liquid limit, plastic limit and linear shrinkage for station km 9+000

Material	Gimbo-Konda Road Project				
Station;km	9+000				
Determination	Liquid Limit (D-4318)			Plastic Limit (D-4318)	
Number of blows	29	26	16		
Test No	01	02	03	01	02
Wt. of Container, (g)	5.70	6.00	5.60	19.50	21.50
Wt. of container + wet soil, (g)	16.30	17.00	16.60	29.10	32.00
Wt. of container + dry soil, (g)	12.10	12.50	12.00	27.00	29.70
Wt. of water, (g)	4.20	4.50	4.60	2.10	2.30
Wt. of dry soil, (g)	6.40	6.50	6.40	7.50	8.20
Moisture container, (%)	65.63	69.23	71.88	34.00	34.05
Average	68.20			34.02	

LINEAR SHRINKAGE (BS1377:Part 2:1990)		
Station; km	9+000	
Test No	1	2
Initial Length L ₀	140.00	140.00
Oven dried Length LD	125.10	125.00
Linear shrinkage, L _s	0.11	0.11
Percentage of Linear Shrinkage (%)	10.64	10.71
Average Percentage of Linear Shrinkage (%)	10.68	



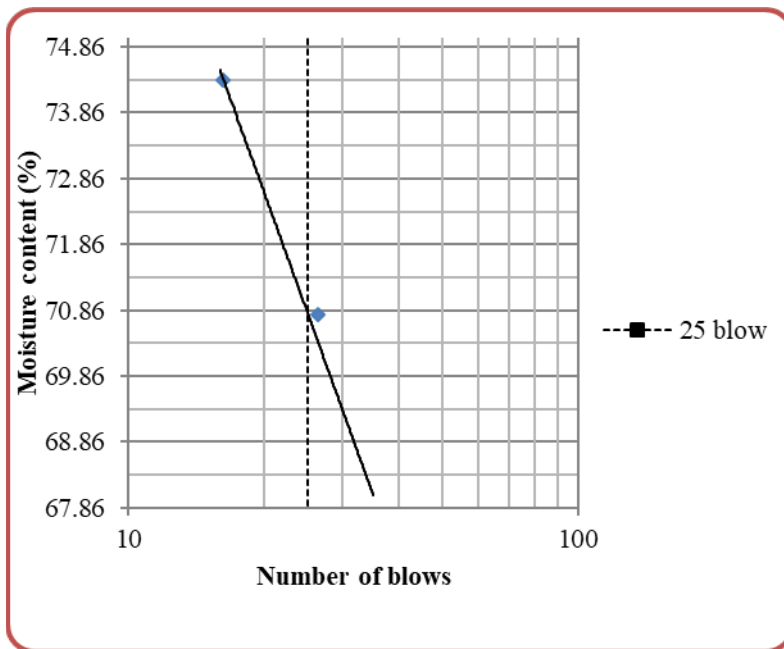
Determination of (PI) (LL - PL)	LL (%)	68
	PL (%)	34
	PI (%)	34
	LS(%)	10.68

Fig 4.2D Liquid limit graph for station km 9+000

Table 4.2D Liquid limit, plastic limit and linear shrinkage for station km 12+000

Material Station:	Gimbo-Konda Road Project				
Station;km	12+000				
Determination	Liquid Limit (D-4318)			Plastic Limit (D-4318)	
Number of blows	35	26	16		
Test No	01	02	03	01	02
Wt. of Container, (g)	6.40	16.20	5.80	23.30	17.15
Wt. of container + wet soil, (g)	15.80	28.50	20.10	37.60	25.30
Wt. of container + dry soil, (g)	12.00	23.40	14.00	33.85	23.15
Wt. of water, (g)	3.80	5.10	6.10	3.75	2.15
Wt. of dry soil, (g)	5.60	7.20	8.20	10.55	6.00
Moisture container, (%)	67.86	70.83	74.39	35.55	35.83
Average	70.86			35.69	

LINEAR SHRINKAGE (BS1377:Part 2:1990)		
Station;km	12+000	
tial 1	1	2
Initial Length L0	140.00	140.00
Oven dried Length LD	125.20	124.80
Linear shrinkage,Ls	0.11	0.11
Percentage of Linear Shrinkage(%)	10.27	10.36
Average Percentage of Linear Shrinkage(%)	10.32	



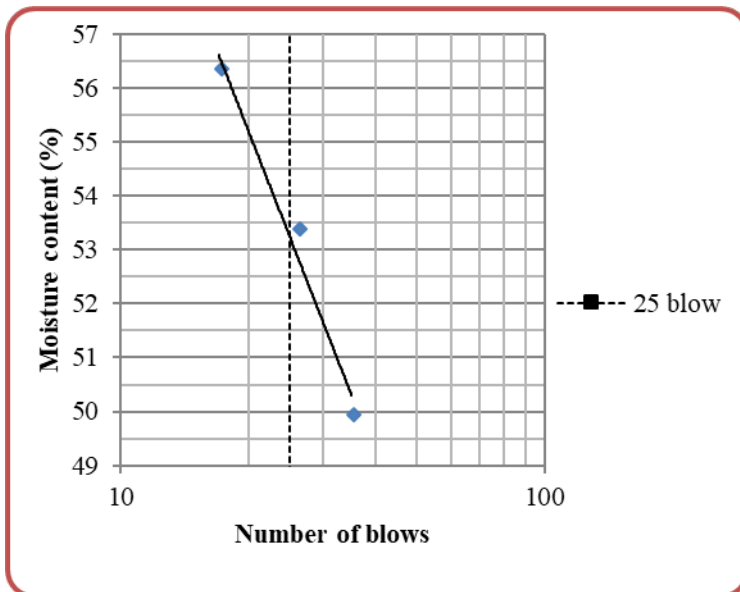
Determination of (PI) (LL - PL)	LL (%)	71
	PL (%)	36
	PI (%)	35
	LS(%)	10.32

Fig 4.2D Liquid limit graph for station km 12+000

Table 4.2D Liquid limit, plastic limit and linear shrinkage for station km 15+000

Material Station:	Gimbo-Konda Road Project				
Station; km	15+000				
Determination	Liquid Limit (D-4318)			Plastic Limit (D-4318)	
Number of blows	35	26	17		
Test No	01	02	03	01	02
Wt. of Container, (g)	6.60	17.90	17.60	16.00	5.50
Wt. of container + wet soil, (g)	20.10	29.10	29.80	27.80	21.90
Wt. of container + dry soil, (g)	15.60	25.20	25.40	25.20	18.30
Wt. of water, (g)	4.50	3.90	4.40	2.60	3.60
Wt. of dry soil, (g)	9.00	7.30	7.80	9.20	12.80
Moisture container, (%)	50.00	53.42	56.41	28.26	28.13
Average	53.00			28.19	

LINEAR SHRINKAGE (BS1377:Part 2:1990)		
Station;km	15+000	
Test No	1	2
Initial Length L0	140.00	140.00
Oven dried Length LD	131.54	131.44
Linear shrinkage, Ls	0.06	0.06
Percentage of Linear Shrinkage(%)	6.04	6.11
Average Percentage of Linear Shrinkage(%)	6.08	



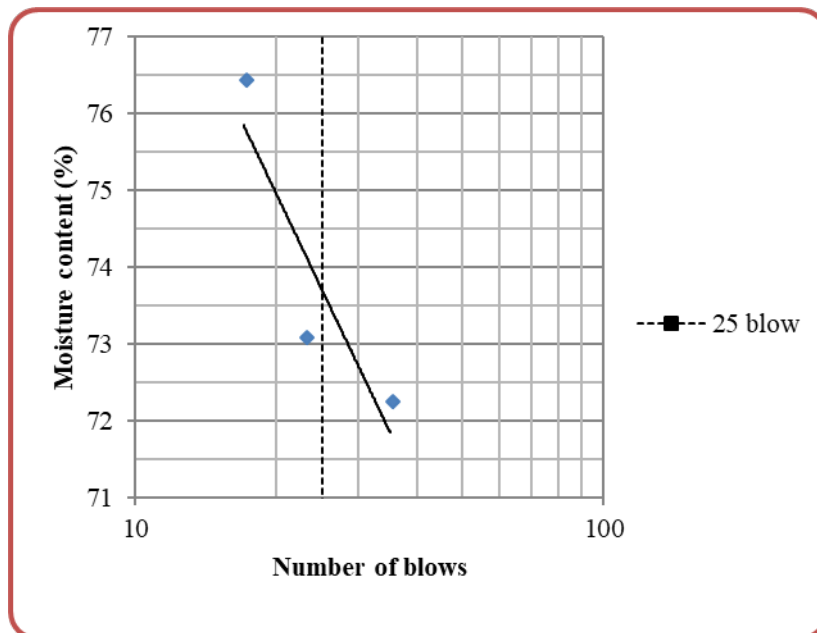
Determination of (PI) (LL - PL)	LL (%)	53
	PL (%)	28
	PI (%)	25
	LS(%)	6.08

Fig 4.2D Liquid limit graph for station Km15+000

Table 4.2D Liquid limit, plastic limit and linear shrinkage for station km 18+000

Material	Gimbo-Konda Road Project				
Station;km	18+000				
Determination	Liquid Limit (D-4318)			Plastic Limit (D-4318)	
Number of blows	35	23	17		
Test No	01	02	03	01	02
Wt. of Container, (g)	23.10	36.00	16.30	6.10	15.20
Wt. of container + wet soil, (g)	37.40	52.10	28.30	13.20	21.30
Wt. of container + dry soil, (g)	31.40	45.30	23.10	11.30	19.60
Wt. of water, (g)	6.00	6.80	5.20	1.90	1.70
Wt. of dry soil, (g)	8.30	9.30	6.80	5.20	4.40
Moisture container, (%)	72.29	73.12	76.47	36.54	38.64
Average	74.00			37.59	

LINEAR SHRINKAGE (BS1377:Part 2:1990)		
Station;km	18+000	
Test No	1	2
Initial Length L ₀	140.00	140.00
Oven dried Length L _D	127.00	127.10
Linear shrinkage, L _s	0.09	0.09
Percentage of Linear Shrinkage(%)	9.29	9.21
Average Percentage of Linear Shrinkage(%)	9.3	



Determination of (PI) (LL - PL)	LL (%)	74
	PL (%)	38
	PI (%)	36
	LS(%)	9.25

Fig 4.2D Liquid limit graph for station km 18+000

Table 4.2D Liquid limit, plastic limit and linear shrinkage for station km 21+000

Material Station:	Gimbo-Konda Road Project				
Station;km	21+000				
Determination	Liquid Limit (D-4318)			Plastic Limit (D-4318)	
Number of blows	35	21	16		
Test No	01	02	03	01	02
Wt. of Container, (g)	17.60	17.20	18.70	6.60	6.60
Wt. of container + wet soil, (g)	27.20	23.70	46.70	18.40	18.40
Wt. of container + dry soil, (g)	23.90	21.30	36.30	15.60	15.60
Wt. of water, (g)	3.30	2.40	10.40	2.80	2.80
Wt. of dry soil, (g)	6.30	4.10	17.60	9.00	9.00
Moisture container, (%)	52.38	58.54	59.09	31.11	31.11
Average	57.00			31.11	

LINEAR SHRINKAGE (BS1377:Part 2:1990)		
Station;km	21+000	
Test No	1	2
Initial Length L ₀	140.00	140.00
Oven dried Length LD	135.40	135.40
Linear shrinkage,Ls	0.03	0.03
Percentage of Linear Shrinkage(%)	3.29	3.29
Average Percentage of Linear Shrinkage(%)	3.29	

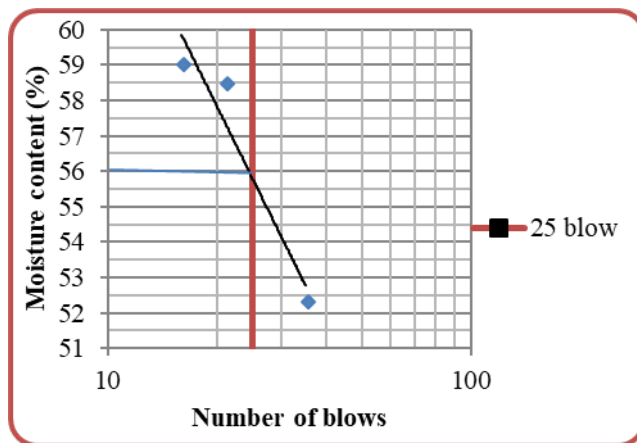


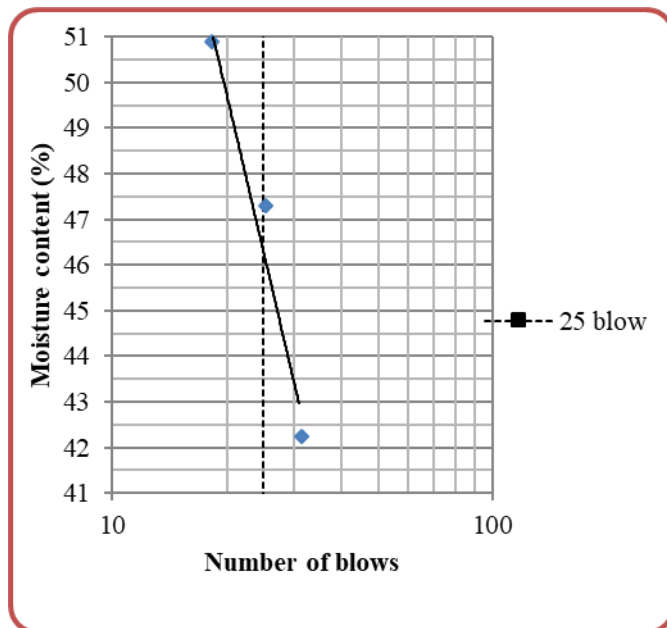
Fig 4.2D Liquid limit graph for station km 21+000

Determination of (PI) (LL - PL)	LL (%)	57
	PL (%)	31
	PI (%)	26
	LS(%)	3.29

Table 4.2D Liquid limit, plastic limit and linear shrinkage for station km 24+000

Material	Gimbo-Konda Road Project				
Station;km	24+000				
Determination	Liquid Limit (D-4318)			Plastic Limit (D-4318)	
Number of blows	31	25	18		
Test No	01	02	03	01	02
Wt. of Container, (g)	32.10	35.10	19.30	5.30	6.30
Wt. of container + wet soil, (g)	43.20	46.30	27.30	11.80	12.15
Wt. of container + dry soil, (g)	39.90	42.70	24.60	10.50	10.99
Wt. of water, (g)	3.30	3.60	2.70	1.30	1.16
Wt. of dry soil, (g)	7.80	7.60	5.30	5.20	4.69
Moisture container, (%)	42.31	47.37	50.94	25.00	24.73
Average	46.20			24.87	

LINEAR SHRINKAGE (BS1377:Part 2:1990)		
Station;km	24+000	
Test No	1	2
Initial Length L ₀	140.00	140.00
Oven dried Length L _D	132.50	132.10
Linear shrinkage, L _s	0.05	0.056
Percentage of Linear Shrinkage(%)	5.36	5.64
Average Percentage of Linear Shrinkage(%)	5.50	

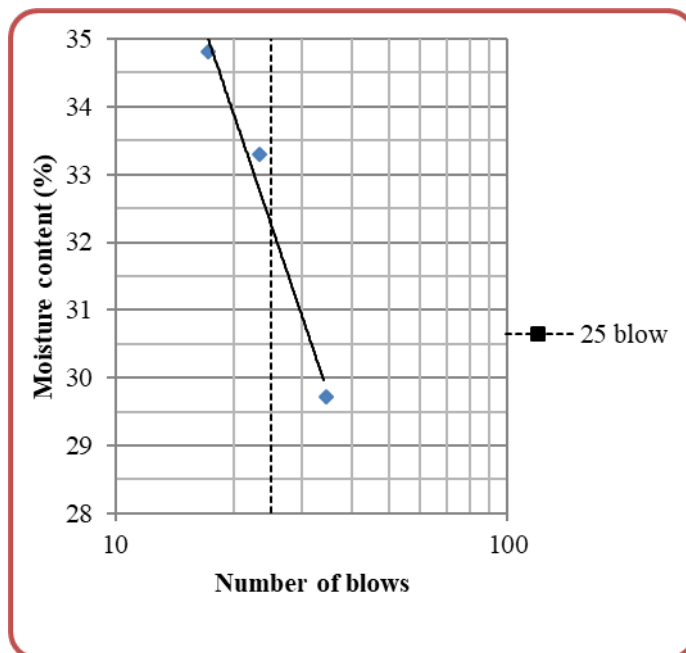


Determination of (PI) (LL - PL)	LL (%)	46
	PL (%)	25
	PI (%)	21
	LS(%)	5.50

Fig 4.2D Liquid limit graph for station km 24+000

Table 4.2D Liquid limit, plastic limit and linear shrinkage for station km 27+000

Material	Gimbo-Konda Road Project				
Station;km	27+000				
Determination	Liquid Limit (D-4318)			Plastic Limit (D-4318)	
Number of blows	34	23	17		
Test No	01	02	03	01	02
Wt. of Container, (g)	16.30	18.30	17.50	6.50	6.50
Wt. of container + wet soil, (g)	27.20	29.10	26.40	18.50	18.50
Wt. of container + dry soil, (g)	24.70	26.40	24.10	16.50	16.50
Wt. of water, (g)	2.50	2.70	2.30	2.00	2.00
Wt. of dry soil, (g)	8.40	8.10	6.60	10.00	10.00
Moisture container, (%)	29.76	33.33	34.85	20.00	20.00
Average	32.00			20.00	



LINEAR SHRINKAGE (BS1377:Part 2:1990)		
Station;km	27+000	
Test No	1	2
Initial Length L ₀	140.00	140.00
Oven dried Length LD	136.50	136.40
Linear shrinkage, L _s	0.03	0.03
Percentage of Linear Shrinkage(%)	2.50	2.57
Average Percentage of Linear Shrinkage(%)	2.54	

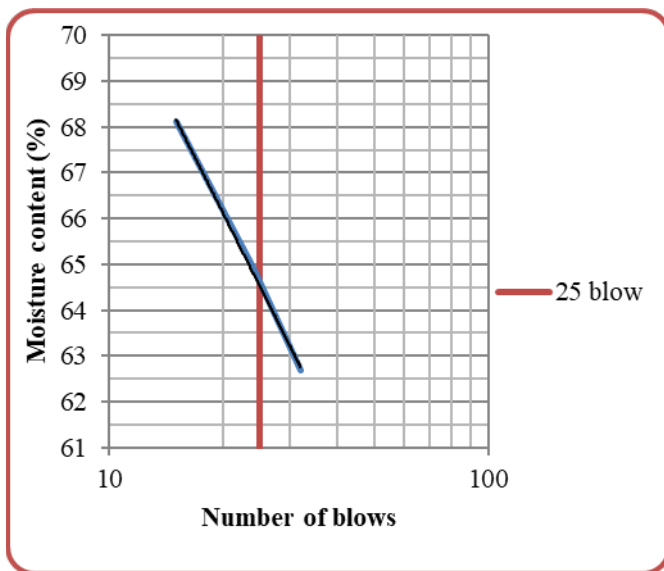
Determination of (PI) (LL - PL)	LL (%)	32
	PL (%)	20
	PI (%)	12
	LS(%)	2.54

Fig 4.2D Liquid limit graph for station km 27+000

Table 4.2D Liquid limit, plastic limit and linear shrinkage for station km 30+000

Material	Gimbo-Konda Road Project				
Station;km	30+000				
Determination	Liquid Limit (D-4318)			Plastic Limit (D-4318)	
Number of blows	32	24	15		
Test No	01	02	03	01	02
Wt. of Container, (g)	35.50	37.00	41.10	18.80	5.70
Wt. of container + wet soil, (g)	46.40	49.70	52.70	33.70	16.50
Wt. of container + dry soil, (g)	42.20	44.70	48.00	29.80	13.70
Wt. of water, (g)	4.20	5.00	4.70	3.90	2.80
Wt. of dry soil, (g)	6.70	7.70	6.90	11.00	8.00
Moisture container, (%)	62.69	64.94	68.12	35.45	35.00
Average	65.00			35.23	

LINEAR SHRINKAGE (BS1377:Part 2:1990)		
Station ;km	30+000	
Test No	1	2
Initial Length L ₀	140.00	140.00
Oven dried Length L _D	125.70	125.80
Linear shrinkage, L _s	0.10	0.10
Percentage of Linear Shrinkage(%)	10.21	10.14
Average Percentage of Linear Shrinkage(%)	10.18	



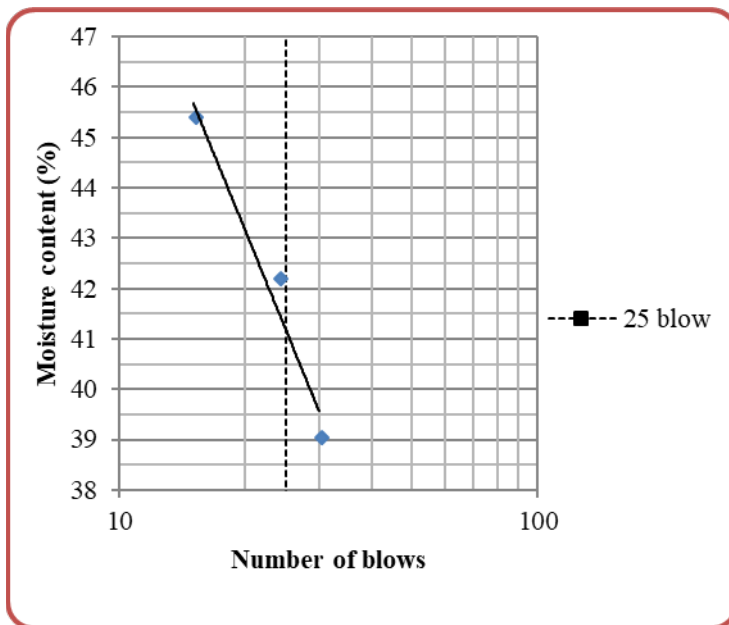
Determination of (PI) (LL - PL)	LL (%)	65
	PL (%)	35
	PI (%)	30
	LS(%)	10.18

Fig 4.2D Liquid limit graph for station km 30+000

Table 4.2D Liquid limit, plastic limit and linear shrinkage for station km 33+000

Material	Gimbo-Konda Road Project				
Station;km	33+000				
Determination	Liquid Limit (D-4318)			Plastic Limit (D-4318)	
Number of blows	30	24	15		
Test No	01	02	03	01	02
Wt. of Container, (g)	6.60	17.90	17.60	15.20	6.90
Wt. of container + wet soil, (g)	18.70	28.00	28.80	27.10	13.20
Wt. of container + dry soil, (g)	15.30	25.00	25.30	25.00	12.10
Wt. of water, (g)	3.40	3.00	3.50	2.10	1.10
Wt. of dry soil, (g)	8.70	7.10	7.70	9.80	5.20
Moisture container, (%)	39.08	42.25	45.45	21.43	21.15
Average	41.00			21.29	

LINEAR SHRINKAGE (BS1377:Part 2:1990)		
Station;km	33+000	
Test No	1	2
Initial Length L ₀	140.00	140.00
Oven dried Length L _D	136.10	136.20
Linear shrinkage, L _s	0.03	0.03
Percentage of Linear Shrinkage(%)	2.79	2.71
Average Percentage of Linear Shrinkage(%)	2.75	



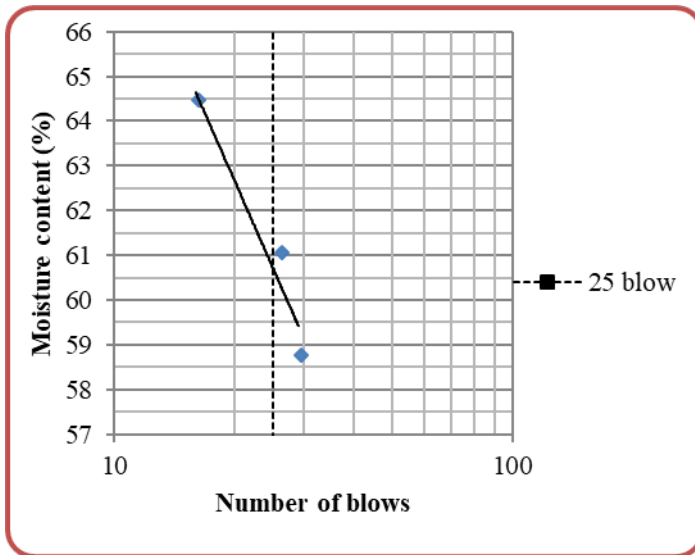
Determination of (PI) (LL - PL)	LL (%)	41
	PL (%)	21
	PI (%)	20
	LS(%)	2.75

Fig 4.2D Liquid limit graph for station km 33+000

Table 4.2D Liquid limit, plastic limit and linear shrinkage for station km 36+000

Material	Gimbo-Konda Road Project				
Station;km	36+000				
Determination	Liquid Limit (D-4318)			Plastic Limit (D-4318)	
Number of blows	29	26	16		
Test No	01	02	03	01	02
Wt. of Container, (g)	5.60	8.30	6.10	18.10	20.70
Wt. of container + wet soil, (g)	16.40	17.00	16.30	28.20	31.10
Wt. of container + dry soil, (g)	12.40	13.70	12.30	26.00	28.80
Wt. of water, (g)	4.00	3.30	4.00	2.20	2.30
Wt. of dry soil, (g)	6.80	5.40	6.20	7.90	8.10
Moisture container, (%)	58.82	61.11	64.52	27.85	28.40
Average	61.00			28.12	

LINEAR SHRINKAGE (BS1377:Part 2:1990)		
Station;km	36+000	
Test No	1	2
Initial Length L ₀	140.00	140.00
Oven dried Length LD	125.40	125.50
Linear shrinkage, L _s	0.10	0.10
Percentage of Linear Shrinkage(%)	10.43	10.36
Average Percentage of Linear Shrinkage (%)	10.39	



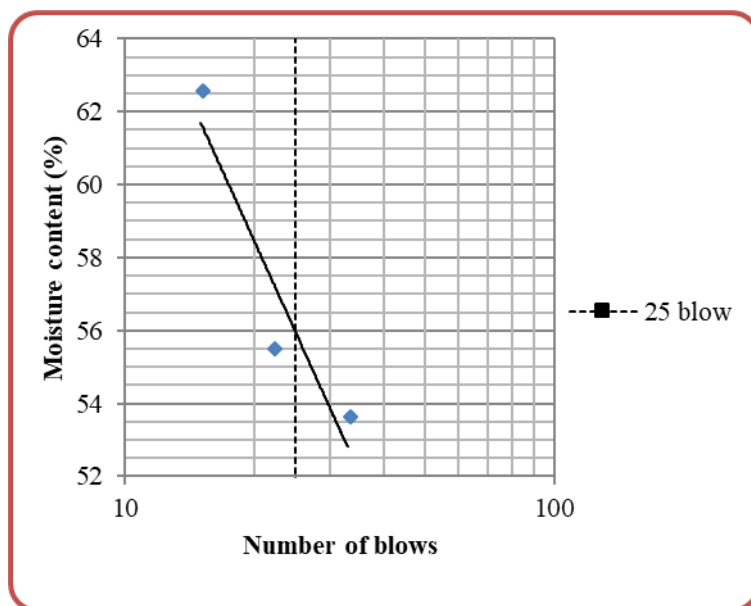
Determination of (PI) (LL - PL)	LL (%)	61
	PL (%)	28
	PI (%)	33
	LS(%)	10.39

Fig 4.2D Liquid limit graph for station km 36+000

Table 4.2D Liquid limit, plastic limit and linear shrinkage for station km 39+000

Material	Gimbo-Konda Road Project				
Station;km	39+000				
Determination	Liquid Limit (D-4318)			Plastic Limit (D-4318)	
Number of blows	33	22	15		
Test No	01	02	03	01	02
Wt. of Container, (g)	7.40	17.30	6.30	22.40	16.00
Wt. of container + wet soil, (g)	15.70	28.50	21.10	36.30	25.30
Wt. of container + dry soil, (g)	12.80	24.50	15.40	33.00	23.10
Wt. of water, (g)	2.90	4.00	5.70	3.30	2.20
Wt. of dry soil, (g)	5.40	7.20	9.10	10.60	7.10
Moisture container, (%)	53.70	55.56	62.64	31.13	30.99
Average	56.00			31.06	

LINEAR SHRINKAGE (ASTM4943 :)		
Station;km	39+000	
Test No	1	2
Initial Length L0	140.00	140.00
Oven dried Length LD	131.50	131.60
Linear shrinkage, Ls	0.06	0.06
Percentage of Linear Shrinkage(%)	6.07	6.00
Average Percentage of Linear Shrinkage(%)	6.04	



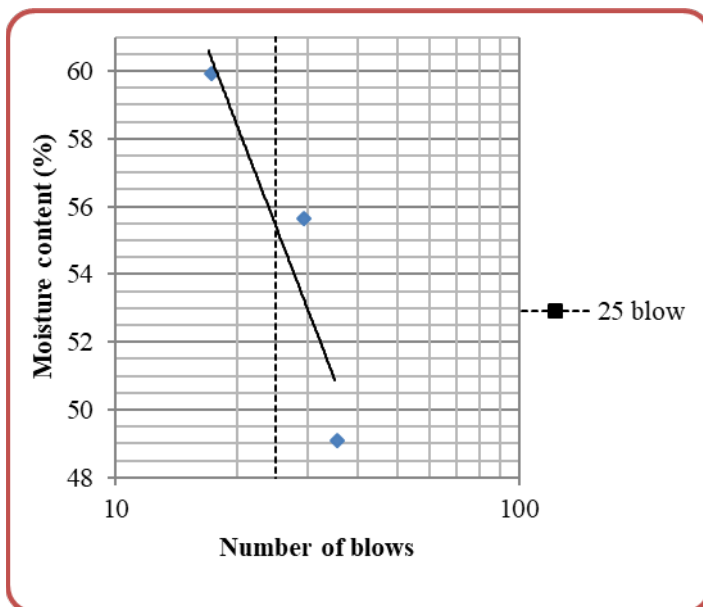
Determination of (PI) (LL - PL)	LL (%)	56
	PL (%)	31
	PI (%)	25
	LS(%)	6.04

Fig 4.2D Liquid limit graph for station km 39+000

Table 4.2D Liquid limit, plastic limit and linear shrinkage for station km 42+000

Material	Gimbo-Konda Road Project				
Station;km	42+000				
Determination	Liquid Limit (D-4318)			Plastic Limit (D-4318)	
Number of blows	35	29	17		
Test No	01	02	03	01	02
Wt. of Container, (g)	33.90	36.50	39.40	6.10	15.60
Wt. of container + wet soil, (g)	43.00	47.40	53.80	16.40	23.10
Wt. of container + dry soil, (g)	40.00	43.50	48.40	14.10	21.40
Wt. of water, (g)	3.00	3.90	5.40	2.30	1.70
Wt. of dry soil, (g)	6.10	7.00	9.00	8.00	5.80
Moisture container, (%)	49.18	55.71	60.00	28.75	29.31
Average	56.00			29.03	

LINEAR SHRINKAGE (ASTM4943)		
Station;km	42+000	
Test No	1	2
Initial Length L0	140.00	140.00
Oven dried Length LD	130.00	130.10
Linear shrinkage,Ls	0.07	0.07
Percentage of Linear Shrinkage(%)	7.14	7.07
Average Percentage of Linear Shrinkage(%)	7.1	



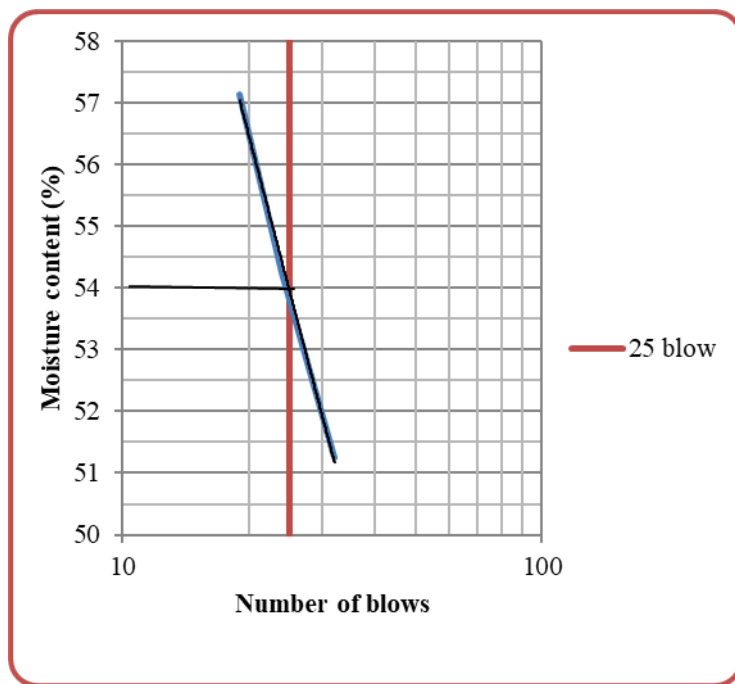
Determination of (PI) (LL - PL)	LL (%)	56
	PL (%)	29
	PI (%)	27
	LS(%)	7.11

Fig 4.2D Liquid limit graph for station km 42+000

Table 4.2D Liquid limit, plastic limit and linear shrinkage for station km 45+000

Material Station:	Gimbo-Konda Road Project				
Station;km	45+000				
Determination	Liquid Limit (D-4318)			Plastic Limit (D-4318)	
Number of blows	32	24	19		
Test No	01	02	03	01	02
Wt. of Container, (g)	24.00	33.00	36.50	5.80	5.40
Wt. of container + wet soil, (g)	36.10	42.10	49.70	11.60	13.40
Wt. of container + dry soil, (g)	32.00	38.90	44.90	10.30	11.60
Wt. of water, (g)	4.10	3.20	4.80	1.30	1.80
Wt. of dry soil, (g)	8.00	5.90	8.40	4.50	6.20
Moisture container, (%)	51.25	54.24	57.14	28.89	29.03
Average	55.00			29.0	

LINEAR SHRINKAGE (BS1377:Part 2:1990)		
Station;km	45+000	
Test No	1	2
Initial Length L ₀	140.00	140.00
Oven dried Length L _D	131.00	131.20
Linear shrinkage, L _s	0.06	0.06
Percentage of Linear Shrinkage(%)	6.43	6.29
Average Percentage of Linear Shrinkage(%)	6.36	



Determination of (PI) (LL - PL)	LL (%)	54
	PL (%)	29
	PI (%)	25
	LS(%)	6.36

Fig 4.2D Liquid limit graph for station km 45+000

Table 4.2D Liquid limit, plastic limit and linear shrinkage for station km 48+000

Material	Gimbo-Konda Road Project				
Station;	48+000				
Determination	Liquid Limit (D-4318)			Plastic Limit (D-4318)	
Number of blows	31	24	16		
Test No	01	02	03	01	02
Wt. of Container, (g)	16.40	17.90	17.40	11.80	5.55
Wt. of container + wet soil, (g)	27.20	24.30	24.30	19.40	14.40
Wt. of container + dry soil, (g)	23.70	22.20	21.90	17.70	12.40
Wt. of water, (g)	3.50	2.10	2.40	1.70	2.00
Wt. of dry soil, (g)	7.30	4.30	4.50	5.90	6.85
Moisture container, (%)	47.95	48.84	53.33	28.81	29.20
Average	49.00			29.01	

LINEAR SHRINKAGE (BS1377:Part 2:1990)		
Station;km	48+000	
Test No	1	2
Initial Length L0	140.00	140.00
Oven dried Length LD	133.00	132.90
Linear shrinkage,Ls	0.05	0.05
Percentage of Linear Shrinkage(%)	5.00	5.07
Average Percentage of Linear Shrinkage(%)	5.04	

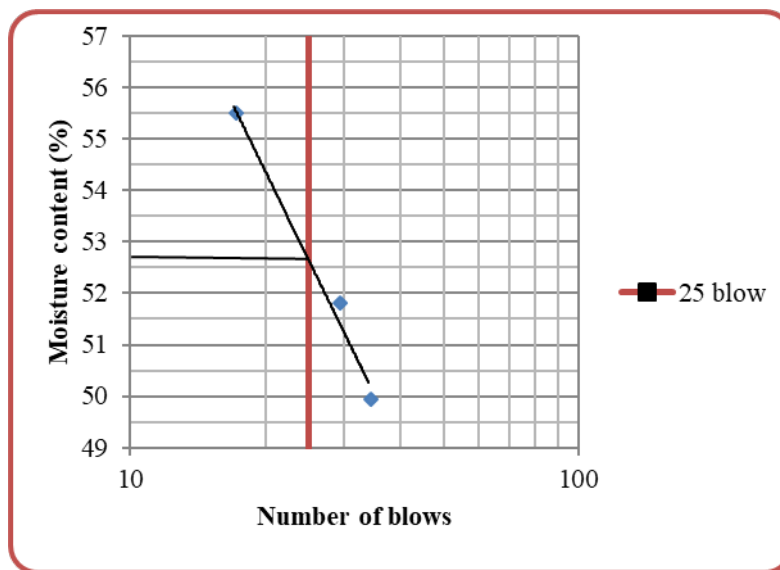
Determination of (PI) (LL - PL)	LL (%)	49
	PL (%)	29
	PI (%)	20
	LS(%)	5.04

Fig 4.2D Liquid limit graph for station km 48+000

Table 4.2D Liquid limit, plastic limit and linear shrinkage for station km 51+000

Material Station:	Gimbo-Konda Road Project				
Station;km	51+000				
Determination	Liquid Limit (D-4318)			Plastic Limit (D-4318)	
Number of blows	34	29	17		
Test No	01	02	03	01	02
Wt. of Container, (g)	35.50	37.00	41.10	18.90	6.40
Wt. of container + wet soil, (g)	46.00	49.30	52.30	33.40	13.60
Wt. of container + dry soil, (g)	42.50	45.10	48.30	29.90	11.85
Wt. of water, (g)	3.50	4.20	4.00	3.50	1.75
Wt. of dry soil, (g)	7.00	8.10	7.20	11.00	5.45
Moisture container, (%)	50.00	51.85	55.56	31.82	32.11
Average	53.00			32.0	

LINEAR SHRINKAGE (BS1377:Part 2:1990)		
Station;km	51+000	
Test No	1	2
Initial Length L ₀	140.00	140.00
Oven dried Length LD	131.30	131.40
Linear shrinkage, L _s	0.06	0.06
Percentage of Linear Shrinkage(%)	6.21	6.14
Average Percentage of Linear Shrinkage(%)	6.18	



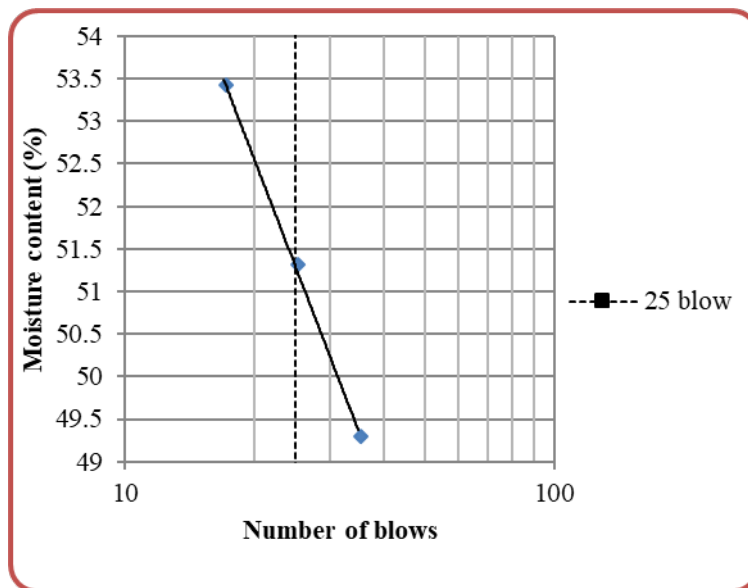
Determination of (PI) (LL - PL)	LL (%)	53
	PL (%)	32
	PI (%)	21
	LS(%)	6.18

Fig 4.2D Liquid limit graph for station km 51+000

Table 4.2D Liquid limit, plastic limit and linear shrinkage for station km 54+000

Material Station:	Gimbo-Konda Road Project				
Station;km	54+000				
Determination	Liquid Limit (D-4318)			Plastic Limit (D-4318)	
Number of blows	35	25	17		
Test No	01	02	03	01	02
Wt. of Container, (g)	17.90	17.20	19.50	16.00	6.50
Wt. of container + wet soil, (g)	29.10	28.40	28.40	27.80	21.90
Wt. of container + dry soil, (g)	25.40	24.60	25.30	24.90	18.10
Wt. of water, (g)	3.70	3.80	3.10	2.90	3.80
Wt. of dry soil, (g)	7.50	7.40	5.80	8.90	11.60
Moisture container, (%)	49.33	51.35	53.45	32.58	32.76
Average	51.35			32.67	

LINEAR SHRINKAGE (BS1377:Part 2:1990)		
Station;km	54+000	
Test No	1	2
Initial Length L ₀	140.00	140.00
Oven dried Length L _D	136.10	136.30
Linear shrinkage, L _s	0.03	0.03
Percentage of Linear Shrinkage(%)	2.79	2.64
Average Percentage of Linear Shrinkage(%)	2.71	

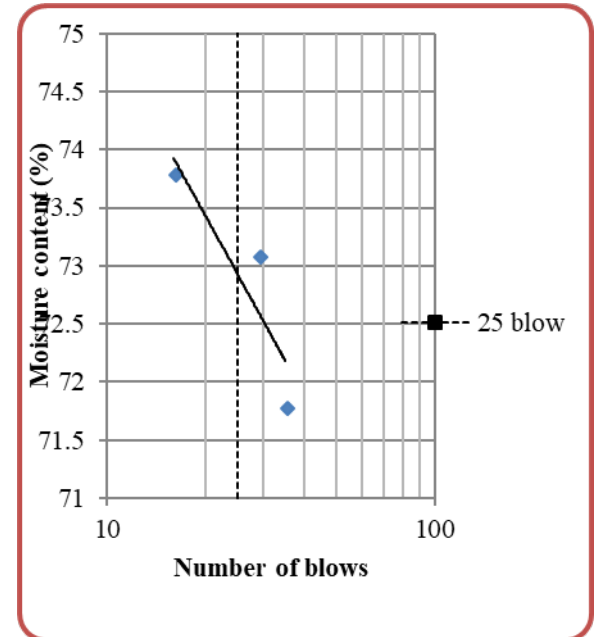


Determination of (PI) (LL - PL)	LL (%)	51
	PL (%)	33
	PI (%)	19
	LS(%)	2.71

Fig 4.2D Liquid limit graph for station km 54+000

Table 4.2D Liquid limit, plastic limit and linear shrinkage for station km 57+000

Material Station:	Gimbo-Konda Road Project				
Station;km	57+000				
Determination	Liquid Limit (D-4318)			Plastic Limit (D-4318)	
Number of blows	35	29	16		
Test No	01	02	03	01	02
Wt. of Container, (g)	5.60	6.00	7.10	8.50	8.50
Wt. of container + wet soil, (g)	16.60	17.40	16.60	16.30	16.30
Wt. of container + dry soil, (g)	11.80	12.30	12.30	14.10	14.10
Wt. of water, (g)	4.80	5.10	4.30	2.20	2.20
Wt. of dry soil, (g)	6.20	6.30	5.20	5.60	5.60
Moisture container, (%)	71.80	73.10	73.80	31.00	31.40
Average	73.00			31.20	



LINEAR SHRINKAGE (BS1377:Part 2:1990)		
Station;km	57+000	
tial 1	1	2
Initial Length L0	140.00	140.00
Oven dried Length	117.00	117.10
shrinkage, Ls	0.16	0.16
Percentage of Linear	10.34	10.36
Average Percentage of	10.4	

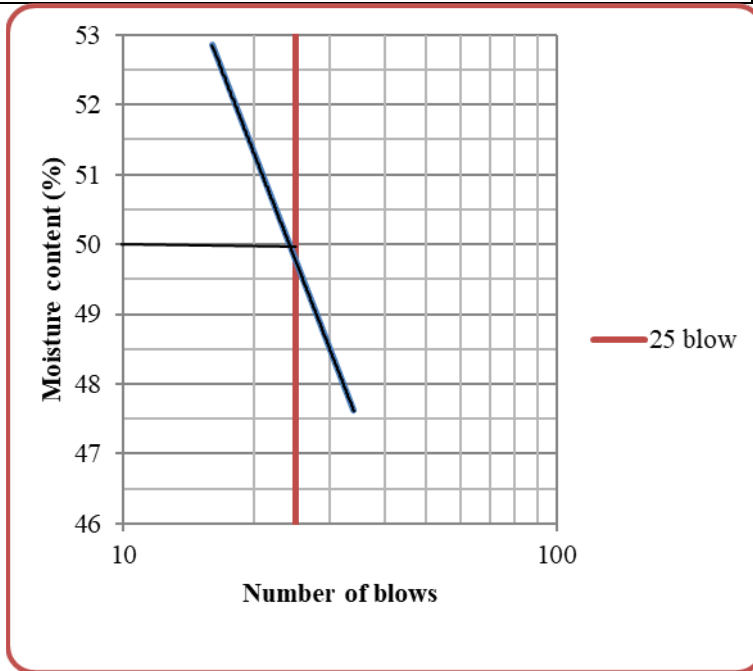
Determination of (PI) (LL - PL)	LL (%)	73
	PL (%)	31
	PI (%)	42
	LS (%)	10.35

Fig 4.2D Liquid limit graph for station km 57+000

Table 4.2D Liquid limit, plastic limit and linear shrinkage for station km 60+000

Material Station:	Gimbo-Konda Road Project				
Station:km	60+000				
Determination	Liquid Limit (D-4318)			Plastic Limit (D-4318)	
Number of blows	34	28	16		
Test No	01	02	03	01	02
Wt. of Container, (g)	6.40	5.80	6.50	20.90	17.30
Wt. of container + wet soil, (g)	15.70	20.10	17.20	29.20	25.10
Wt. of container + dry soil, (g)	12.70	15.40	13.50	27.20	23.20
Wt. of water, (g)	3.00	4.70	3.70	2.00	1.90
Wt. of dry soil, (g)	6.30	9.60	7.00	6.30	5.90
Moisture container, (%)	47.62	48.96	52.86	31.75	32.20
Average	50.00			32.0	

LINEAR SHRINKAGE (BS1377:Part 2:1990)		
Station;km	60+000	
Test No	1	2
Initial Length L0	140.00	140.00
Oven dried Length LD	134.20	134.10
Linear shrinkage, LS	0.04	0.04
Percentage of Linear Shrinkage (%)	4.14	4.21
Average Percentage of Linear Shrinkage (%)	4.18	



Determination of (PI) (LL - PL)	LL (%)	50
	PL (%)	32
	PI (%)	18
	LS(%)	4.18

Fig 4.2D Liquid limit graph for station km 60+000

APPENDIX 4.2E: - Existing Road Subgrade Soil Samples

4.2E Free swell Test

Table 4.2E free swell test for stations

Free swell of soil		
Station;km	3+000	
Trials	Initial volume (ml)	Final volume (ml)
	11.00	22.10
free swell in %	100.91	

Free swell of soil		
Station;km	6+000	
Trials	Initial volume (ml)	Final volume (ml)
	15.00	31.10
free swell in %	107.33	

Free swell of soil		
Station;km	9+000	
Trials	Initial volume (ml)	Final volume (ml)
	13.00	26.40
free swell in %	103.08	

Free swell of soil		
Station;km	12+000	
Trials	Initial volume (ml)	Final volume (ml)
	12.00	24.30
free swell in %	102.50	

Free swell of soil		
Station;km	15+000	
Trials	Initial volume (ml)	Final volume (ml)
	13.50	15.00
free swell in %	11.11	

Free swell of soil		
Station; km	18+000	
	Initial volume (ml)	Final volume (ml)
Trials		
	11.00	19.00
free swell in %	72.73	

free swell of soil		
Station; km	21+000	
	Initial volume (ml)	Final volume (ml)
Trials		
	14.00	15.00
free swell in %	7.14	

Free swell of soil		
Station; km	24+000	
	Initial volume (ml)	Final volume (ml)
Trials		
	10.00	13.00
free swell in %	30.00	

Free swell of soil		
Station; km	27+000	
	Initial volume (ml)	Final volume (ml)
Trials		
	11.50	13.00
free swell in %	13.04	

Free swell of soil		
Station;km	30+000	
	Initial volume (ml)	Final volume (ml)
Trials		
	13.00	21.00
free swell in %	61.54	

Free swell of soil		
Station;km	33+000	
	Initial volume (ml)	Final volume (ml)
Trials		
	10.00	12.50
free swell in %	25.00	

Free swell of soil		
Station;km	36+000	
	Initial volume (ml)	Final volume (ml)
Trials		
	10.00	17.00
free swell in %	70.00	

Free swell of soil		
Station;km	39+000	
	Initial volume (ml)	Final volume (ml)
Trials		
	10.00	11.50
free swell in %	15.00	

Free swell of soil		
Station;km	42+000	
	Initial volume (ml)	Final volume (ml)
Trials		
	10.50	13.00
free swell in %	23.81	

Free swell of soil		
Station;km	45+000	
	Initial volume (ml)	Final volume (ml)
Trials		
	11.00	13.00
free swell in %	18.18	

Free swell of soil		
Station;km	48+000	
	Initial volume (ml)	Final volume (ml)
Trials		
	10.50	13.00
free swell in %	23.81	

Free swell of soil		
Station;km	51+000	
Trials	Initial volume (ml)	Final volume (ml)
	10.50	13.00
free swell in %	23.81	

Free swell of soil		
Station;km	54+000	
Trials	Initial volume (ml)	Final volume (ml)
	11.00	12.50
free swell in %	13.64	

Free swell of soil		
Station; km	60+000	
Trials	Initial volume (ml)	Final volume (ml)
	11.00	12.50
free swell in %	13.64	

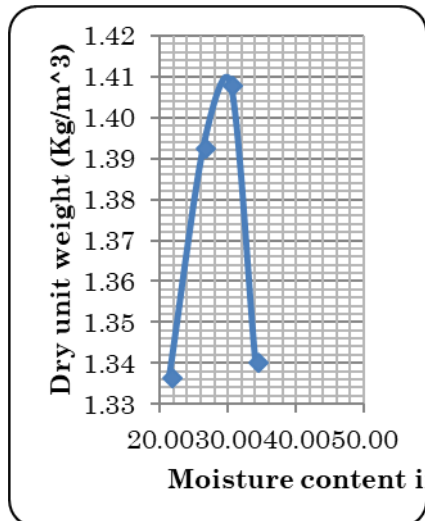
Free swell of soil		
Station; km	57+000	
Trials	Initial volume (ml)	Final volume (ml)
	10.00	15.50
free swell in %	55.00	

APPENDIX 4.2F: - Existing Road Subgrade Soil Samples

4.2F Modified proctor compaction

Table 4.2F Modified proctor compaction result for station km 3+000

Trial No.	Mass of compacted soil + mold, g	Wet unit weight (gm/cm ³)	Moisture content Determination				Average Moisture content, %	Dry unit weight (gm/cm ³)
			Mass of can, g	Mass of wet soil + can, g	Mass of dry soil + can, g	Moisture content, %		
1	10243.3	1.62	37.04	148.76	125.15	26.80	21.38	1.34
			24.5	65.2	59.6	15.95		
2	10560	1.76	29.4	124.5	104.5	26.63	26.43	1.39
			17.5	120	98.7	26.23		
3	10732.3	1.84	17.5	130.4	104	30.52	30.41	1.41
			17.3	120.5	96.5	30.30		
4	10643.1	1.80	18	77	62	34.09	34.09	1.34
			18	77	62	34.09		

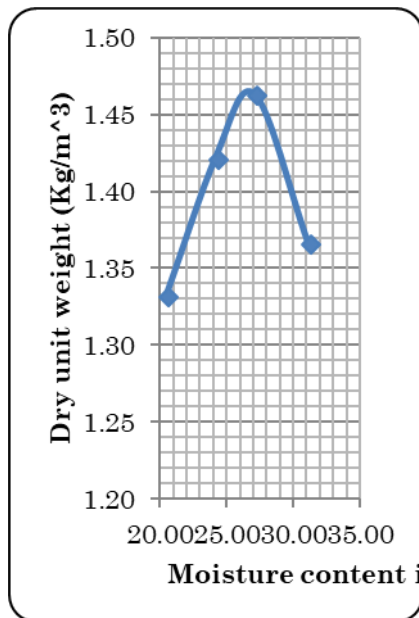


Test Type:	(ASTM D 1557, AASHTO T-180)			
Method of compaction:	Modified Proctor Compaction Test			
Wt. of mold + base plate:	6535.5 g			
Volume of mold:	2285 (cm ³)			
Number of sample:	Sample 1			
Type of Material	3+000			
Trial No.	Mass of compacted soil + mold, g	Wet unit weight (gm/cm ³)	Average Moisture content, %	Dry unit weight (gm/cm ³)
1	10243.3	1.62	21.38	1.34
2	10560	1.76	26.43	1.39
3	10732.3	1.84	30.41	1.41
4	10643.1	1.80	34.09	1.34
		OMC (%)		30
		MDD (gm/cm³)		1.41

Fig 4.2F Modified proctor compaction result for station km 3+000

Table 4.2F Modified proctor compaction result for station km 6+000

Trial No.	Mass of compacted soil + mold, g	Wet unit weight (gm/cm ³)	Moisture content Determination				Average Moisture content, %	Dry unit weight (gm/cm ³)
			Mass of can, g	Mass of wet soil + can, g	Mass of dry soil + can, g	Moisture content, %		
1	10320.2	1.61	37.04	148.76	130	20.18	20.48	1.33
			24.5	65.2	58.2	20.77		
2	10686.3	1.77	29.4	124.5	106	24.15	24.17	1.42
			17.5	56	48.5	24.19		
3	10900.9	1.86	35.3	118.7	101.1	26.75	27.09	1.46
			36.7	115.2	98.3	27.44		
4	10745.4	1.79	18	77	63	31.11	31.11	1.37
			18	77	63	31.11		

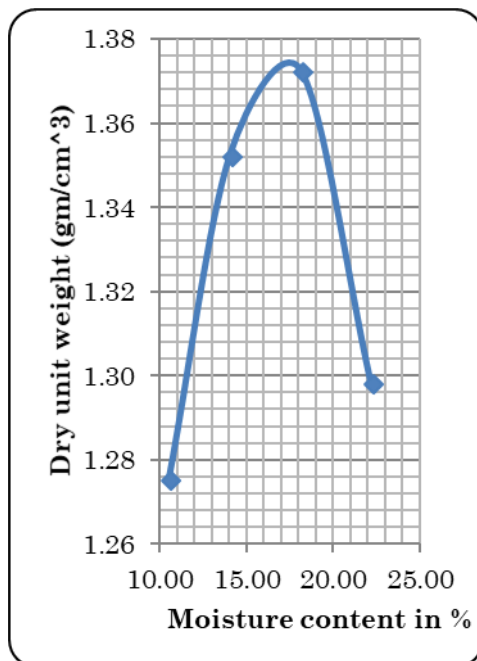


Test Type:	(ASTM D 1557, AASHTO T-180)			
Method of compaction:	Modified Proctor Compaction Test			
Wt. of mold + base plate:	6635.5 g			
Volume of mold:	2285 (cm ³)			
Number of sample:	Sample 1			
Type of Material	6+000			
Trial No.	Mass of compacted soil + mold, g	Wet unit weight (gm/cm ³)	Average Moisture content, %	Dry unit weight (gm/cm ³)
1	10320.2	1.61	20.48	1.33
2	10686.3	1.77	24.17	1.42
3	10900.9	1.86	27.09	1.46
4	10745.4	1.79	31.11	1.37
OMC (%)				27
MDD (gm/cm³)				1.46

Fig 4.2F Modified proctor compaction result for station km 6+000

Table 4.2F Modified proctor compaction result for station km 9+000

Trial No.	Mass of compacted soil + mold, g	Wet unit weight (gm/cm ³)	Moisture content Determination				Average Moisture content, %	Dry unit weight (gm/cm ³)
			Mass of can, g	Mass of wet soil + can, g	Mass of dry soil + can, g	Moisture content, %		
1	9857.3	1.41	36.5	205	189	10.49	10.53	1.28
			34.2	193.3	178.1	10.56		
2	10160.5	1.54	29.4	124.5	112.6	14.30	14.05	1.35
			17.5	120.6	108.1	13.80		
3	10340.5	1.62	35.5	198.3	173.4	18.06	18.13	1.37
			34.3	176.5	154.6	18.20		
4	10260.3	1.59	25.4	124.5	106	22.95	22.17	1.30
			24.9	146.7	124.6	22.17		

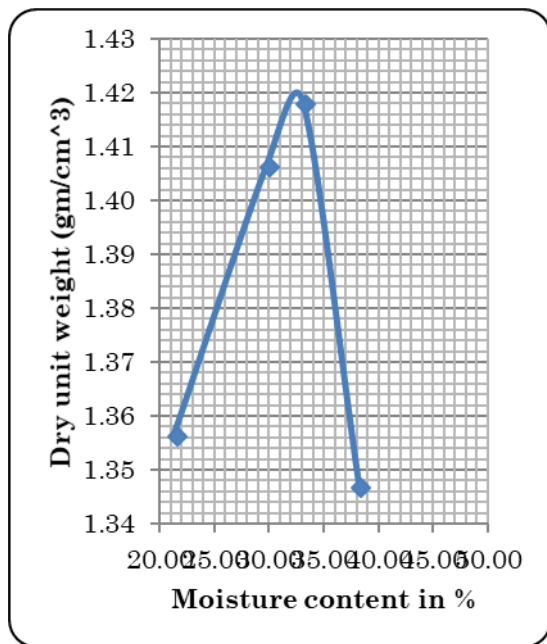


Test Type:	(ASTM D 1557, AASHTO T-180)			
Method of compaction:	Modified Proctor Compaction Test			
Wt. of mold + base plate:	6635.5 g			
Volume of mold:	2285 (cm ²)			
Number of sample:	Sample 1			
Type of Material	9+000			
Trial No.	Mass of compacted soil + mold, g	Wet unit weight (gm/cm ³)	Average Moisture content, %	Dry unit weight (gm/cm ³)
1	9857.3	1.41	10.53	1.28
2	10160.5	1.54	14.05	1.35
3	10340.5	1.62	18.13	1.37
4	10260.3	1.59	22.17	1.30
OMC (%)				17
MDD (gm/cm ³)				1.37

Fig 4.2F Modified proctor compaction result for station km 9+000

Table 4.2F Modified proctor compaction result for station km 12+000

Trial No.	Mass of compacted soil + mold, g	Wet unit weight (gm/cm ³)	Moisture content Determination				Average Moisture content, %	Dry unit weight (gm/cm ³)
			Mass of can, g	Mass of wet soil + can, g	Mass of dry soil + can, g	Moisture content, %		
1	10398.2	1.65	37.04	148.76	125.15	26.80	21.38	1.36
			24.5	65.2	59.6	15.95		
2	10808.4	1.83	29.4	124.5	102.6	29.92	29.82	1.41
			17.5	56	47.18	29.72		
3	10949.1	1.89	28.2	88.8	73.7	33.19	33.09	1.42
			17.3	69.7	56.7	32.99		
4	10890.2	1.86	34.1	165.3	129	38.25	38.21	1.35
			19.5	77.7	61.62	38.18		

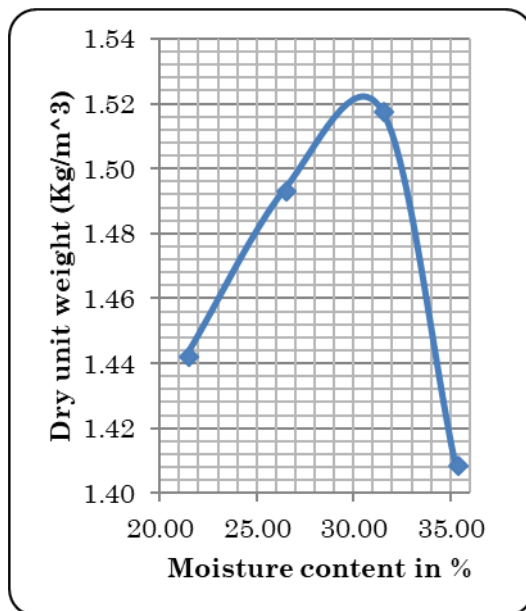


Test Type:	(ASTM D 1557, AASHTO T-180)			
Method of compaction:	Modified Proctor Compaction Test			
Wt. of mold + base plate:	6635.5 g			
Volume of mold:	2285 (cm ³)			
Number of sample:	Sample 1			
Type of Material	12+000			
Trial No.	Mass of compacted soil + mold, g	Wet unit weight (gm/cm ³)	Average Moisture content, %	Dry unit weight (gm/cm ³)
1	10398.2	1.65	21.38	1.36
2	10808.4	1.83	29.82	1.41
3	10949.1	1.89	33.09	1.42
4	10890.2	1.86	38.21	1.35
		OMC (%)		33
		MDD (gm/cm³)		1.42

Fig 4.2F Modified proctor compaction result for station km 12+000

Table 4.2F Modified proctor compaction result for station km 15+000

Trial No.	Mass of compacted soil + mold, g	Wet unit weight (gm/cm ³)	Moisture content Determination				Average Moisture content, %	Dry unit weight (gm/cm ³)
			Mass of can, g	Mass of wet soil + can, g	Mass of dry soil + can, g	Moisture content, %		
1	10636.7	1.75	37.04	148.76	125.15	26.80	21.38	1.44
			24.5	65.2	59.6	15.95		
2	10950.3	1.89	29.4	122	102.6	26.50	26.43	1.49
			17.5	55	47.18	26.35		
3	11195.3	2.00	28.5	102.5	84.9	31.21	31.45	1.52
			17.3	69	56.56	31.69		
4	10990.1	1.91	26.7	118.3	108	12.67	35.26	1.41
			18	77	61.62	35.26		

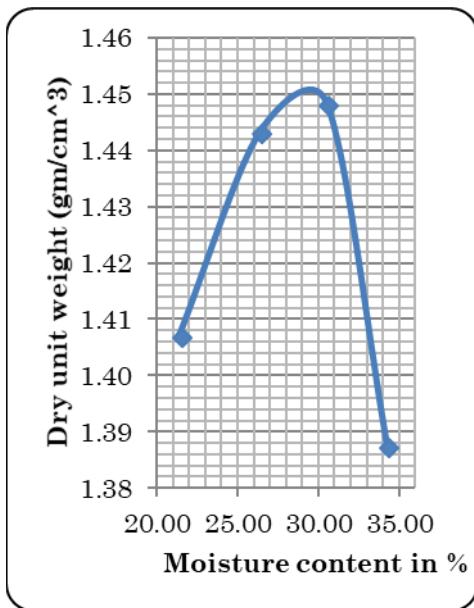


Test Type:	(ASTM D 1557, AASHTO T-180)			
Method of compaction:	Modified Proctor Compaction Test			
Wt. of mold + base plate:	6635.5 g			
Volume of mold:	2285 (cm ³)			
Number of sample:	Sample 1			
Type of Material	15+000			
Trial No.	Mass of compacted soil + mold, g	Wet unit weight (gm/cm ³)	Average Moisture content, %	Dry unit weight (gm/cm ³)
1	10636.7	1.75	21.38	1.44
2	10950.3	1.89	26.43	1.49
3	11195.3	2.00	31.45	1.52
4	10990.1	1.91	35.26	1.41
OMC (%)				30
MDD (gm/cm³)				1.52

Fig 4.2F Modified proctor compaction result for station km 15+000

Table 4.2F Modified proctor compaction result for station km 18+000

Trial No.	Mass of compacted soil + mold, g	Wet unit weight (gm/cm ³)	Moisture content Determination				Average Moisture content, %	Dry unit weight (gm/cm ³)
			Mass of can, g	Mass of wet soil + can, g	Mass of dry soil + can, g	Moisture content, %		
1	10950	1.71	37.04	148.76	125.15	26.80	21.38	1.41
			24.5	65.2	59.6	15.95		
2	11250.3	1.82	35.6	186.4	155	26.30	26.38	1.44
			35.5	180.3	150	26.46		
3	11420.9	1.89	24.5	98	80.9	30.32	30.50	1.45
			23.4	95.4	78.5	30.67		
4	11350	1.86	26.7	136.5	108.3	34.56	34.24	1.39
			32.4	145.3	116.5	34.24		

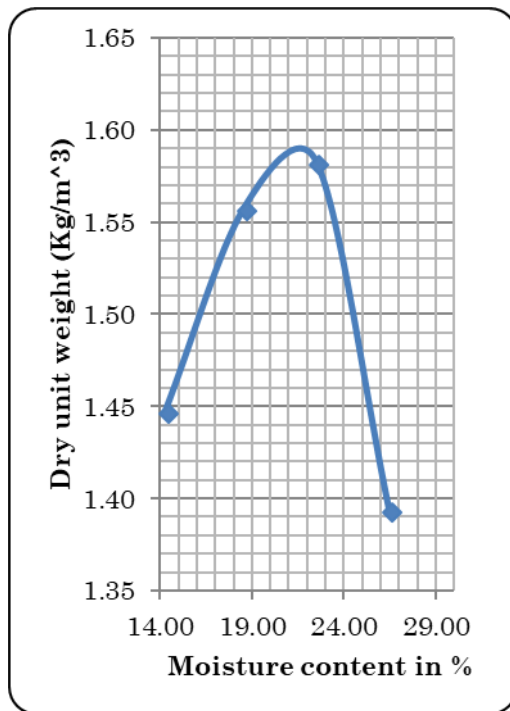


Test Type:	(ASTM D 1557, AASHTO T-180)			
Method of compaction:	Modified Proctor Compaction Test			
Wt. of mold + base plate:	6535.5 g			
Volume of mold:	2285 (cm ³)			
Number of sample:	Sample 1			
Type of Material	18+000			
Trial No.	Mass of compacted soil + mold, g	Wet unit weight (gm/cm ³)	Average Moisture content, %	Dry unit weight (gm/cm ³)
1	10950	1.71	21.38	1.41
2	11250.3	1.82	26.38	1.44
3	11420.9	1.89	30.50	1.45
4	11350	1.86	34.24	1.39
OMC (%)				30.5
MDD (gm/cm³)				1.45

Fig 4.2F Modified proctor compaction result for station km 18+000

Table 4.2F Modified proctor compaction result for station km 21+000

Trial No.	Mass of compacted soil + mold, g	Wet unit weight (gm/cm ³)	Moisture content Determination				Average Moisture content, %	Dry unit weight (gm/cm ³)
			Mass of can, g	Mass of wet soil + can, g	Mass of dry soil + can, g	Moisture content, %		
1	10320.7	1.65	32.4	160.2	144.3	14.21	14.30	1.45
			23.1	138.4	123.9	14.38		
2	10760.5	1.85	17.5	140.2	121	18.55	18.58	1.56
			17.5	120.1	104	18.61		
3	10970	1.94	17.5	120	101	22.75	22.52	1.58
			19.4	136.3	115	22.28		
4	10568.2	1.76	34.5	165.4	138	26.47	26.47	1.39
			18.5	124.6	102.4	26.46		

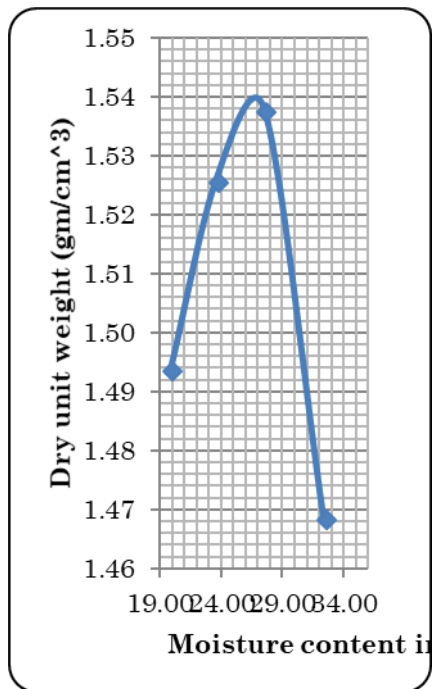


Test Type:	(ASTM D 1557, AASHTO T-180)			
Method of compaction:	Modified Proctor Compaction Test			
Wt. of mold + base plate:	6535.5 g			
Volume of mold:	2285 (cm ³)			
Number of sample:	Sample 1			
Type of Material	21+000			
Trial No.	Mass of compacted soil + mold, g	Wet unit weight (gm/cm ³)	Average Moisture content, %	Dry unit weight (gm/cm ³)
1	10320.7	1.65	14.30	1.45
2	10760.5	1.85	18.58	1.56
3	10970	1.94	22.52	1.58
4	10568.2	1.76	26.47	1.39
			OMC (%)	21.5
			MDD (gm/cm ³)	1.58

Fig 4.2F Modified proctor compaction result for station km 21+000

Table 4.2F Modified proctor compaction result for station km 24+000

Trial No.	Mass of compacted soil + mold, g	Wet unit weight (gm/cm ³)	Moisture content Determination				Average Moisture content, %	Dry unit weight (gm/cm ³)
			Mass of can, g	Mass of wet soil + can, g	Mass of dry soil + can, g	Moisture content, %		
1	10650.6	1.79	21.5	145.6	125.15	19.73	19.84	1.49
			17.5	68	59.6	19.95		
2	10868.6	1.89	17.5	137.3	114	24.15	23.57	1.53
			17.5	56	48.8	23.00		
3	11040.8	1.96	25.5	88.7	75.1	27.42	27.51	1.54
			17.5	136.3	110.6	27.60		
4	11002.6	1.94	25.5	125.4	101	32.32	32.39	1.47
			16.5	77	62.2	32.39		

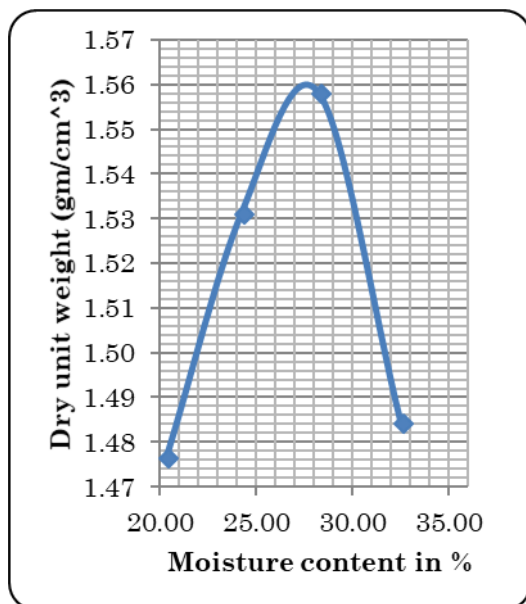


Test Type:	(ASTM D 1557, AASHTO T-180)			
Method of compaction:	Modified Proctor Compaction Test			
Wt. of mold + base plate:	6535.5 g			
Volume of mold:	2285 (cm ³)			
Number of sample:	Sample 1			
Type of Material	24+000			
Trial No.	Mass of compacted soil + mold, g	Wet unit weight (gm/cm ³)	Average Moisture content, %	Dry unit weight (gm/cm ³)
1	10650.6	1.79	19.84	1.49
2	10868.6	1.89	23.57	1.53
3	11040.8	1.96	27.51	1.54
4	11002.6	1.94	32.39	1.47
			OMC (%)	27.5
			MDD (gm/cm ³)	1.54

Fig 4.2F Modified proctor compaction result for station km 24+000

Table 4.2F Modified proctor compaction result for station km 27+000

Trial No.	Mass of compacted soil + mold, g	Wet unit weight (gm/cm ³)	Moisture content Determination				Average Moisture content, %	Dry unit weight (gm/cm ³)
			Mass of can, g	Mass of wet soil + can, g	Mass of dry soil + can, g	Moisture content, %		
1	10710.6	1.78	35.5	143.2	125.15	20.13	20.33	1.48
			25.5	66.6	59.6	20.53		
2	10997.8	1.90	17.5	123.2	102.6	24.21	24.24	1.53
			17.5	124.5	103.6	24.27		
3	11215.9	2.00	25.5	124.5	102.6	28.40	28.22	1.56
			17.5	55.5	47.18	28.03		
4	11145.6	1.97	26.6	145.5	116.5	32.26	32.51	1.48
			21.5	85.5	69.8	32.51		



Test Type:	(ASTM D 1557, AASHTO T-180)			
Method of compaction:	Modified Proctor Compaction Test			
Wt. of mold + base plate:	6535.5 g			
Volume of mold:	2285 (cm ³)			
Number of sample:	Sample 1			
Type of Material	27+000			
Trial No.	Mass of compacted soil + mold, g	Wet unit weight (gm/cm ³)	Average Moisture content, %	Dry unit weight (gm/cm ³)
1	10710.6	1.78	20.33	1.48
2	10997.8	1.90	24.24	1.53
3	11215.9	2.00	28.22	1.56
4	11145.6	1.97	32.51	1.48
			OMC (%)	28
			MDD (gm/cm³)	1.56

Fig 4.2F Modified proctor compaction result for station km 27+000

Table 4.2F Modified proctor compaction result for station km 30+000

Trial No.	Mass of compacted soil + mold, g	Wet unit weight (gm/cm ³)	Moisture content Determination				Average Moisture content, %	Dry unit weight (gm/cm ³)
			Mass of can, g	Mass of wet soil + can, g	Mass of dry soil + can, g	Moisture content, %		
1	10560	1.71	37.04	148.76	126	25.58	25.41	1.36
			24.5	65.2	57	25.23		
2	10750	1.79	29.4	124.5	102.6	29.92	29.82	1.38
			17.5	56	47.18	29.72		
3	10912.9	1.87	28.2	88.8	73.3	34.37	34.36	1.39
			17.3	69.7	56.3	34.36		
4	10850	1.84	17.5	131	99.9	37.74	38.38	1.33
			17.5	145.5	110	38.38		

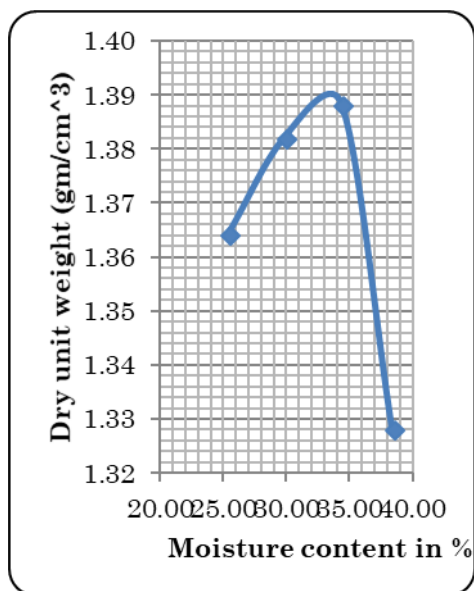
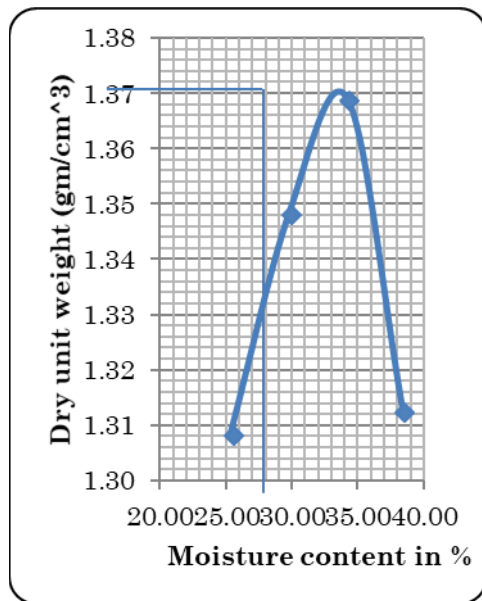


Fig 4.2F Modified proctor compaction result for station km 30+000

Test Type:	(ASTM D 1557, AASHTO T-180)			
Method of compaction:	Modified Proctor Compaction Test			
Wt. of mold + base plate:	6535.5 g			
Volume of mold:	2285 (cm ³)			
Number of sample:	Sample 1			
Type of Material	30+000			
Trial No.	Mass of compacted soil + mold, g	Wet unit weight (gm/cm ³)	Average Moisture content, %	Dry unit weight (gm/cm ³)
1	10560	1.71	25.41	1.36
2	10750	1.79	29.82	1.38
3	10912.9	1.87	34.36	1.39
4	10850	1.84	38.38	1.33
			OMC (%)	34.4
			MDD (gm/cm ³)	1.39

Table 4.2F Modified proctor compaction result for station km 33+000

Trial No.	Mass of compacted soil + mold, g	Wet unit weight (gm/cm ³)	Moisture content Determination				Average Moisture content, %	Dry unit weight (gm/cm ³)
			Mass of can, g	Mass of wet soil + can, g	Mass of dry soil + can, g	Moisture content, %		
1	10400	1.64	37.04	148.76	126	25.58	25.41	1.31
			24.5	65.2	57	25.23		
2	10650	1.75	29.4	124.5	102.6	29.92	29.82	1.35
			17.5	56	47.18	29.72		
3	10848.5	1.84	28.2	88.8	73.35	34.22	34.20	1.37
			17.3	69.7	56.35	34.19		
4	10800.9	1.82	17.5	131	99.9	37.74	38.38	1.31
			17.5	145.5	110	38.38		

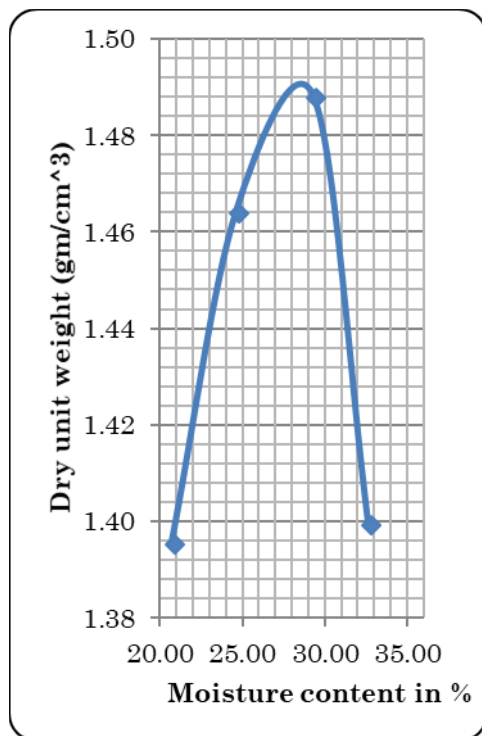


Test Type:	(ASTM D 1557, AASHTO T-180)			
Method of compaction:	Modified Proctor Compaction Test			
Wt. of mold + base plate:	6635.5 g			
Volume of mold:	2285 (cm ³)			
Number of sample:	Sample 1			
Type of Material	33+000			
Trial No.	Mass of compacted soil + mold, g	Wet unit weight (gm/cm ³)	Average Moisture content, %	Dry unit weight (gm/cm ³)
1	10400	1.64	25.41	1.31
2	10650	1.75	29.82	1.35
3	10848.5	1.84	34.20	1.37
4	10800.9	1.82	38.38	1.31
			OMC (%)	34.4
			MDD (gm/cm ³)	1.37

Fig 4.2F Modified proctor compaction result for station km 33+000

Table 4.2F Modified proctor compaction result for station km 36+000

Trial No.	Mass of compacted soil + mold, g	Wet unit weight (gm/cm ³)	Moisture content Determination				Average Moisture content, %	Dry unit weight (gm/cm ³)
			Mass of can, g	Mass of wet soil + can, g	Mass of dry soil + can, g	Moisture content, %		
1	10501.4	1.69	37.04	148.76	130	20.18	20.76	1.40
			24.5	70	62	21.33		
2	10821.3	1.83	17.6	145.4	120.3	24.44	24.66	1.46
			17.5	140	115.6	24.87		
3	11048.2	1.92	29.4	124.5	102.85	29.48	29.34	1.49
			17.5	56	47.3	29.19		
4	10892.3	1.86	17.5	128	100.5	33.13	32.64	1.40
			17.5	145.5	114	32.64		



Test Type:	(ASTM D 1557, AASHTO T-180)				
Method of compaction:	Modified Proctor Compaction Test				
Wt. of mold + base plate:	6535.5 g				
Volume of mold:	2285 (cm ³)				
Number of sample:	Sample 1				
Type of Material	36+000				
Trial No.	Mass of compacted soil + mold, g	Wet unit weight (gm/cm ³)	Average Moisture content, %	Dry unit weight (gm/cm ³)	
1	10501.4	1.69	20.76	1.40	
2	10821.3	1.83	24.66	1.46	
3	11048.2	1.92	29.34	1.49	
4	10892.3	1.86	32.64	1.40	
OMC (%)				29	
MDD (gm/cm ³)				1.49	

Fig 4.2F Modified proctor compaction result for station km 36+000

Table 4.2F Modified proctor compaction result for station km 39+000

Trial No.	Mass of compacted soil + mold, g	Wet unit weight (gm/cm ³)	Moisture content Determination				Average Moisture content, %	Dry unit weight (gm/cm ³)
			Mass of can, g	Mass of wet soil + can, g	Mass of dry soil + can, g	Moisture content, %		
1	10399.5	1.64	35.5	139	121.9	19.79	19.99	1.37
			17.5	84.8	73.5	20.18		
2	10602.5	1.73	35.4	110.1	95.2	24.92	24.43	1.39
			36.5	118.8	102.9	23.95		
3	10790	1.81	35.6	118.7	100.2	28.64	28.51	1.41
			35.6	115.2	97.6	28.39		
4	10850	1.84	17.5	118.3	93.5	32.63	32.43	1.39
			17.5	140	110	32.43		

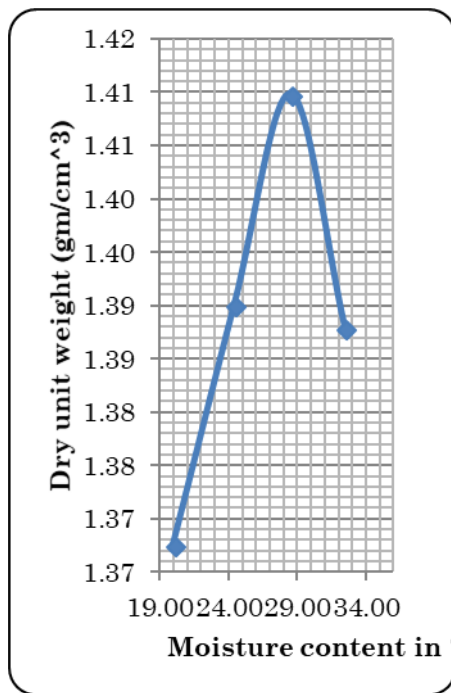


Fig 4.2F Modified proctor compaction result for station km 39+000

Test Type:	(ASTM D 1557, AASHTO T-180)			
Method of compaction:	Modified Proctor Compaction Test			
Wt. of mold + base plate:	6535.5 g			
Volume of mold:	2285 (cm ³)			
Number of sample:	Sample 1			
Type of Material	39+000			
Trial No.	Mass of compacted soil + mold, g	Wet unit weight (gm/cm ³)	Average Moisture content, %	Dry unit weight (gm/cm ³)
1	10399.5	1.64	19.99	1.37
2	10602.5	1.73	24.43	1.39
3	10790	1.81	28.51	1.41
4	10850	1.84	32.43	1.39
OMC (%)				29
MDD (gm/cm³)				1.41

Table 4.2F Modified proctor compaction result for station km 42+000

Trial No.	Mass of compacted soil + mold, g	Wet unit weight (gm/cm ³)	Moisture content Determination				Average Moisture content, %	Dry unit weight (gm/cm ³)
			Mass of can, g	Mass of wet soil + can, g	Mass of dry soil + can, g	Moisture content, %		
1	10850	1.67	17.5	150	127.5	20.45	20.32	1.39
			17.5	67.5	59.1	20.19		
2	11090.2	1.76	35.6	186.4	157	24.22	24.25	1.42
			35.5	180.3	152	24.29		
3	11331.6	1.86	25.6	135.3	111.3	28.00	28.00	1.45
			25.5	165.4	134.8	28.00		
4	11350.5	1.86	26.7	136.5	109.6	32.45	32.51	1.41
			32.4	145.3	117.6	32.51		

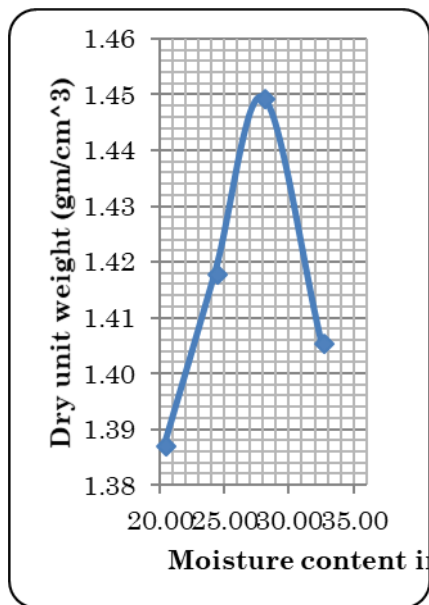


fig 4.2F Modified proctor compaction result for station km 42+000

Test Type:	(ASTM D 1557, AASHTO T-180)				
Method of compaction:	Modified Proctor Compaction Test				
Wt. of mold + base plate:	6635.5 g				
Volume of mold:	2285 (cm ³)				
Number of sample:	Sample 1				
Type of Material	42+000				
Trial No.	Mass of compacted soil + mold, g	Wet unit weight (gm/cm ³)	Average Moisture content, %	Dry unit weight (gm/cm ³)	
1	10850	1.67	20.32	1.39	
2	11090.2	1.76	24.25	1.42	
3	11331.6	1.86	28.00	1.45	
4	11350.5	1.86	32.51	1.41	
OMC (%)				28	
MDD (gm/cm ³)				1.45	

Table 4.2F Modified proctor compaction result for station km 45+000

Trial No.	Mass of compacted soil + mold, g	Wet unit weight (gm/cm ³)	Moisture content Determination				Average Moisture content, %	Dry unit weight (gm/cm ³)
			Mass of can, g	Mass of wet soil + can, g	Mass of dry soil + can, g	Moisture content, %		
1	10350.4	1.66	25.5	146.6	125.15	21.53	21.51	1.37
			17.5	190.5	159.9	21.49		
2	10609.6	1.77	25.6	150.3	123.8	26.99	27.03	1.40
			21.5	136.5	112	27.07		
3	10816.4	1.86	17.5	140.3	111	31.34	31.26	1.42
			17.5	98.7	79.4	31.18		
4	10764.5	1.84	25.5	176.6	136.9	35.64	35.18	1.36
			16.5	187.5	143	35.18		

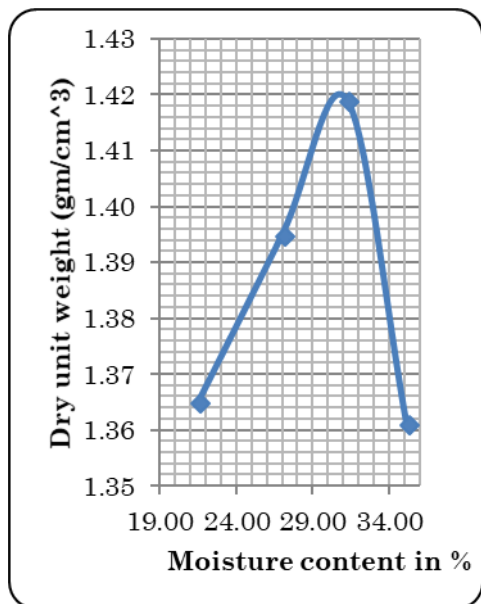


Fig 4.2F Modified proctor compaction result for station km 45+000

Test Type:	(ASTM D 1557, AASHTO T-180)			
Method of compaction:	Modified Proctor Compaction Test			
Wt. of mold + base plate:	6535.5 g			
Volume of mold:	2285 (cm ³)			
Number of sample:	Sample 1			
Type of Material	45+000			
Trial No.	Mass of compacted soil + mold, g	Wet unit weight (gm/cm ³)	Average Moisture content, %	Dry unit weight (gm/cm ³)
1	10350.4	1.66	21.51	1.37
2	10609.6	1.77	27.03	1.40
3	10816.4	1.86	31.26	1.42
4	10764.5	1.84	35.18	1.36
			OMC (%)	30.5
			MDD (gm/cm³)	1.42

Table 4.2F Modified proctor compaction result for station km 48+000

Trial No.	Mass of compacted soil + mold, g	Wet unit weight (gm/cm ³)	Moisture content Determination				Average Moisture content, %	Dry unit weight (gm/cm ³)
			Mass of can, g	Mass of wet soil + can, g	Mass of dry soil + can, g	Moisture content, %		
1	10510.6	1.69	35.5	143.2	128.3	16.06	16.21	1.45
			17.5	135.6	119	16.35		
2	10817.8	1.82	35.5	150.3	131	20.21	20.93	1.51
			36.5	145.5	126.1	21.65		
3	11020.9	1.91	17.5	123.2	102.6	24.21	24.24	1.54
			17.5	124.5	103.6	24.27		
4	10999.5	1.90	26.6	145.5	119.4	28.13	28.06	1.49
			21.5	85.5	71.5	28.00		

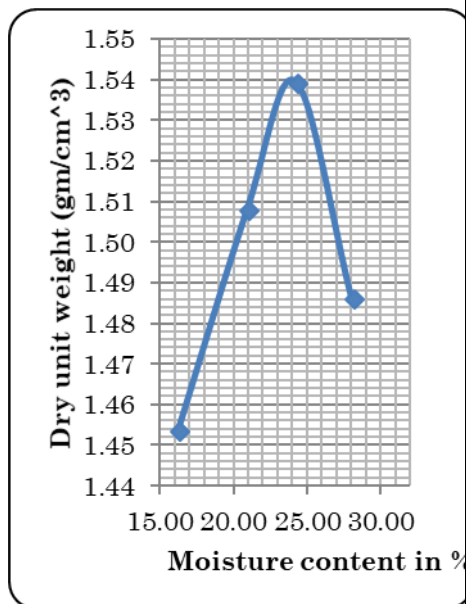


Fig 4.2F Modified proctor compaction result for station km 48+000

Test Type:	(ASTM D 1557, AASHTO T-180)			
Method of compaction:	Modified Proctor Compaction Test			
Wt. of mold + base plate:	6535.5 g			
Volume of mold:	2285 (cm ³)			
Number of sample:	Sample 1			
Type of Material	48+000			
Trial No.	Mass of compacted soil + mold, g	Wet unit weight (gm/cm ³)	Average Moisture content, %	Dry unit weight (gm/cm ³)
1	10510.6	1.69	16.21	1.45
2	10817.8	1.82	20.93	1.51
3	11020.9	1.91	24.24	1.54
4	10999.5	1.90	28.06	1.49
			OMC (%)	24
			MDD (gm/cm ³)	1.56

Table 4.2F Modified proctor compaction result for station km 51+000

Trial No.	Mass of compacted soil + mold, g	Wet unit weight (gm/cm ³)	Moisture content Determination				Average Moisture content, %	Dry unit weight (gm/cm ³)
			Mass of can, g	Mass of wet soil + can, g	Mass of dry soil + can, g	Moisture content, %		
1	10560	1.71	17.5	165.4	139.6	21.13	21.13	1.41
			17.5	146.5	124	21.13		
2	10750	1.79	37.04	148.76	126	25.58	25.22	1.43
			24.5	65.2	57.1	24.85		
3	10939.9	1.88	29.4	124.5	102.83	29.51	29.50	1.45
			17.5	56	47.23	29.50		
4	10950	1.88	35.6	131	107.3	33.05	33.17	1.41
			35.5	145.5	118.1	33.17		

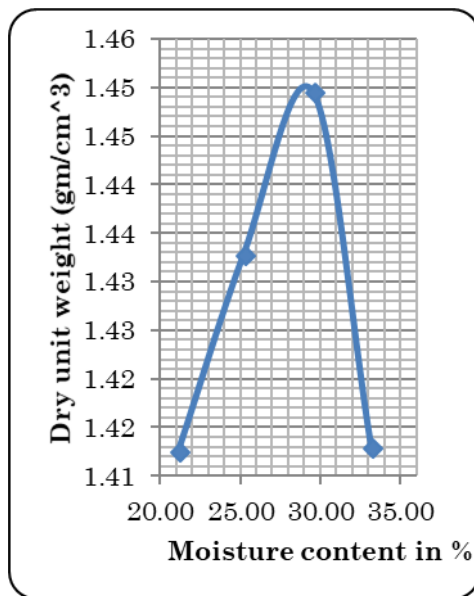


fig 4.2F Modified proctor compaction result for station km 51+0000

Test Type:	(ASTM D 1557, AASHTO T-180)			
Method of compaction:	Modified Proctor Compaction Test			
Wt. of mold + base plate:	6635.5 g			
Volume of mold:	2285 (cm ³)			
Number of sample:	Sample 1			
Type of Material	51+000			
Trial No.	Mass of compacted soil + mold, g	Wet unit weight (gm/cm ³)	Average Moisture content, %	Dry unit weight (gm/cm ³)
1	10560	1.71	21.13	1.41
2	10750	1.79	25.22	1.43
3	10939.9	1.88	29.50	1.45
4	10950	1.88	33.17	1.41
OMC (%)				29
MDD (gm/cm³)				1.45

Table 4.2F Modified proctor compaction result for station km 54+000

Trial No.	Mass of compacted soil + mold, g	Wet unit weight (gm/cm ³)	Moisture content Determination				Average Moisture content, %	Dry unit weight (gm/cm ³)
			Mass of can, g	Mass of wet soil + can, g	Mass of dry soil + can, g	Moisture content, %		
1	10417.4	1.65	25.5	146.6	125.15	21.53	21.51	1.36
			17.5	190.5	159.9	21.49		
2	10790.3	1.81	25.6	150.3	123.8	26.99	27.03	1.43
			21.5	136.5	112	27.07		
3	10997.7	1.90	17.5	140.3	110.8	31.62	31.40	1.45
			17.5	98.7	79.4	31.18		
4	10867.7	1.85	25.5	176.6	136.9	35.64	35.18	1.37
			16.5	187.5	143	35.18		

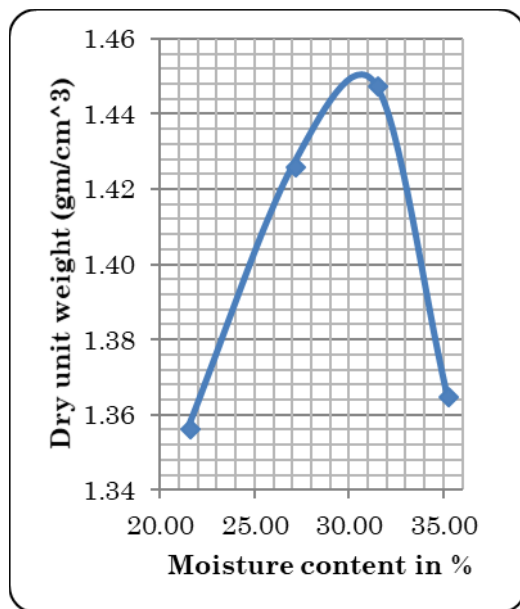


Fig 4.2F Modified proctor compaction result for station km54+000

Test Type:	(ASTM D 1557, AASHTO T-180)			
Method of compaction:	Modified Proctor Compaction Test			
Wt. of mold + base plate:	6635.5 g			
Volume of mold:	2285 (cm ³)			
Number of sample:	Sample 1			
Type of Material	54+000			
Trial No.	Mass of compacted soil + mold, g	Wet unit weight (gm/cm ³)	Average Moisture content, %	Dry unit weight (gm/cm ³)
1	10417.4	1.65	21.51	1.36
2	10790.3	1.81	27.03	1.43
3	10997.7	1.90	31.40	1.45
4	10867.7	1.85	35.18	1.37
			OMC (%)	30.4
			MDD (gm/cm ³)	1.45

Table 4.2F Modified proctor compaction result for station km 57+000

Trial No.	Mass of compacted soil + mold, g	Wet unit weight (gm/cm ³)	Moisture content Determination				Average Moisture content, %	Dry unit weight (gm/cm ³)
			Mass of can, g	Mass of wet soil + can, g	Mass of dry soil + can, g	Moisture content, %		
1	10301.4	1.60	36.6	156.7	139.9	16.26	16.31	1.37
			21.2	124.4	109.9	16.35		
2	10501.3	1.69	37.04	148.76	130	20.18	20.76	1.40
			24.5	70	62	21.33		
3	10781.3	1.81	17.6	145.4	120.28	24.46	24.80	1.45
			17.5	140	115.4	25.13		
4	10692.3	1.77	29.4	121.5	102.85	23.48	23.19	1.37
			16.5	183.5	143	22.18		

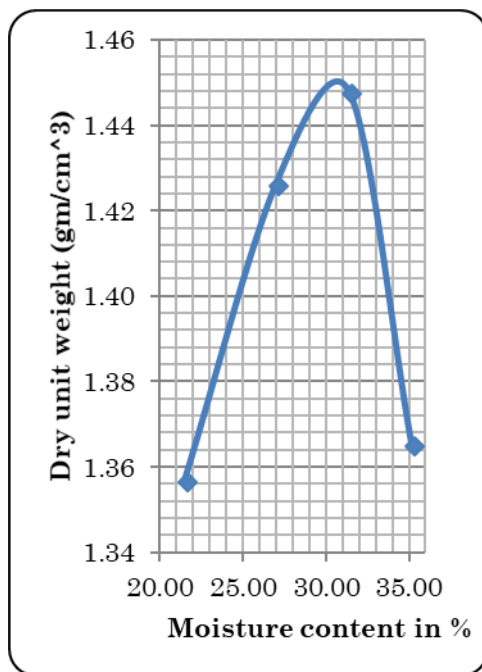


Fig 4.2F Modified proctor compaction result for station km 57+000

Test Type:	(ASTM D 1557, AASHTO T-180)			
Method of compaction:	Modified Proctor Compaction Test			
Wt. of mold + base plate:	6635.5 g			
Volume of mold:	2285 (cm ³)			
Number of sample:	Sample 1			
Type of Material	57+000			
Trial No.	Mass of compacted soil + mold, g	Wet unit weight (gm/cm ³)	Average Moisture content, %	Dry unit weight (gm/cm ³)
1	10417.4	1.65	21.51	1.36
2	10790.3	1.81	27.03	1.43
3	10997.7	1.90	31.40	1.45
4	10867.7	1.85	35.18	1.37
			OMC (%)	24.8
			MDD (gm/cm ³)	1.45

Table 4.2F Modified proctor compaction result for station km 60+000

Trial No.	Mass of compacted soil + mold, g	Wet unit weight (gm/cm ³)	Moisture content Determination				Average Moisture content, %	Dry unit weight (gm/cm ³)
			Mass of can, g	Mass of wet soil + can, g	Mass of dry soil + can, g	Moisture content, %		
1	10359.5	1.62	17.5	165.4	139.6	21.13	21.13	1.34
			17.5	146.5	124	21.13		
2	10552.5	1.71	37.04	148.76	126	25.58	25.22	1.36
			24.5	65.2	57.1	24.85		
3	10756.4	1.80	29.4	124.5	102.99	29.23	29.21	1.39
			17.5	56	47.3	29.19		
4	10800.3	1.82	35.6	131	107.3	33.05	33.17	1.36
			35.5	145.5	118.1	33.17		

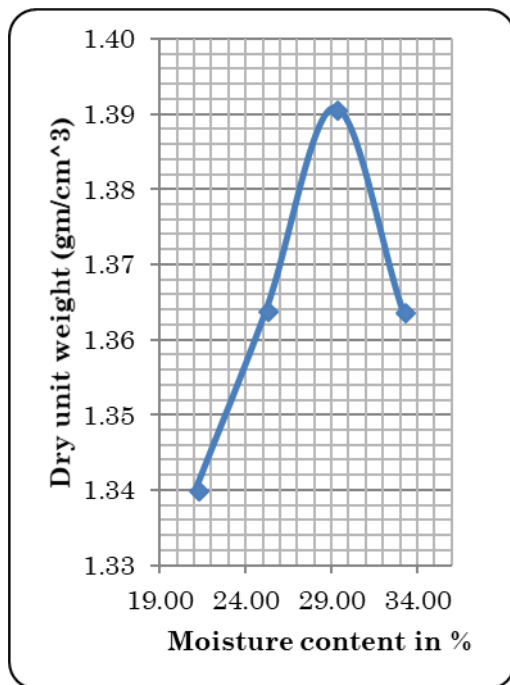


Fig 4.2F Modified proctor compaction result for station km 60+000

Test Type:	(ASTM D 1557, AASHTO T-180)				
Method of compaction:	Modified Proctor Compaction Test				
Wt. of mold + base plate:	6635.5 g				
Volume of mold:	2285 (cm ³)				
Number of sample:	Sample 1				
Type of Material	60+000				
Trial No.	Mass of compacted soil + mold, g	Wet unit weight (gm/cm ³)	Average Moisture content, %	Dry unit weight (gm/cm ³)	
1	10359.5	1.62	21.13	1.34	
2	10552.5	1.71	25.22	1.36	
3	10756.4	1.80	29.21	1.39	
4	10800.3	1.82	33.17	1.36	
OMC (%)				29.2	
MDD (gm/cm ³)				1.39	

APPENDIX 4.2G: - Existing Road Subgrade Soil Samples

4.2G CBR TEST

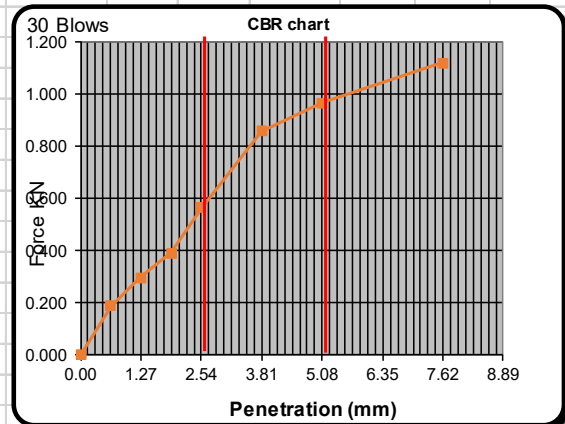
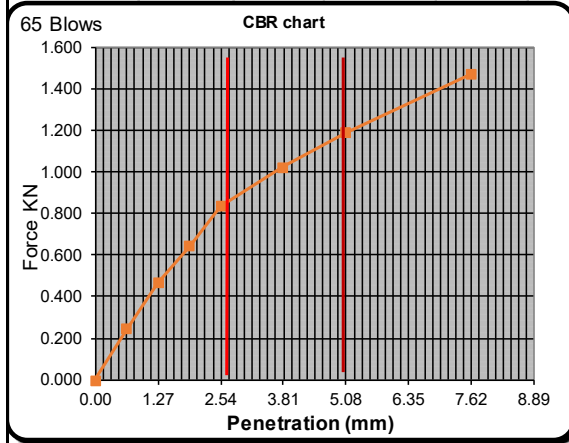
Table 4.2G CBR test result for station 3+000km

3+000km											
Compaction Determination											
COMPACTION DATA			65 Blows			30 Blows			10 Blows		
			Before soak	After soak		Before soak	After soak		Before soak	After soak	
Mould No.			N5	N5		N8	N8		N13	N13	
Mass of soil + Mould	g		10640.6	10746.8		10430.2	10597.2		10309.1	10402.7	
Mass Mould	g		6600	6600		6590	6590		6598.4	6598.4	
Mass of Soil	g		4040.6	4146.8		3840.2	4007.2		3710.7	3804.3	
Volume of Mould	g		2285	2285		2285	2285		2285	2285	
Wet density of soil	g/cc		1.768	1.815		1.681	1.754		1.624	1.665	
Dry density of soil	g/cc		1.414	1.399		1.339	1.355		1.304	1.291	
Moisture Determination											
MOISTURE CONTENT DATA			65 Blows			30 Blows			10 Blows		
			Before soak	After soak		Before soak	After soak		Before soak	After soak	
Container no.			4	J41		P4	D		P5	P66	
Mass of wet soil + Container	g		172.1	152.5		121.6	111.7		124.0	134.8	
Mass of dry soil + Container	g		145.0	125.0		100.5	93.0		103.0	113.0	
Mass of container	g		36.8	32.7		18.0	29.6		17.3	37.6	
Mass of water	g		27.1	27.5		21.1	18.7		21.0	21.8	
Mass of dry soil	g		108.3	92.3		82.5	63.5		85.7	75.4	
Moisture content	%		25.0	29.8		25.5	29.4		24.5	28.9	
CBR Penetration Determination											
Penetration after 96 hrs Soaking Period			Surcharge Weight:-4.55 KG								
65 Blows			30 Blows			10 Blows					
			Pen.mm	Load, KN	CBR %	Pen.mm	Load, KN	CBR %	Pen.mm	Load, KN	CBR %
			0.00	0.000		0.00	0.000		0.00	0.000	
			0.64	0.459		0.64	0.207		0.64	0.147	
			1.27	0.739		1.27	0.363		1.27	0.265	
			1.91	0.967		1.91	0.515		1.91	0.376	
			2.54	1.120	8.40	2.54	0.638	4.78	2.54	0.448	3.36
			3.81	1.392		3.81	0.818		3.81	0.527	
			5.08	1.526	7.63	5.08	0.936	4.68	5.08	0.589	2.95
			7.62	1.698		7.62	1.089		7.62	0.698	
Modified Max.Dry Density g/cc			1.410			OMC %			30.0		

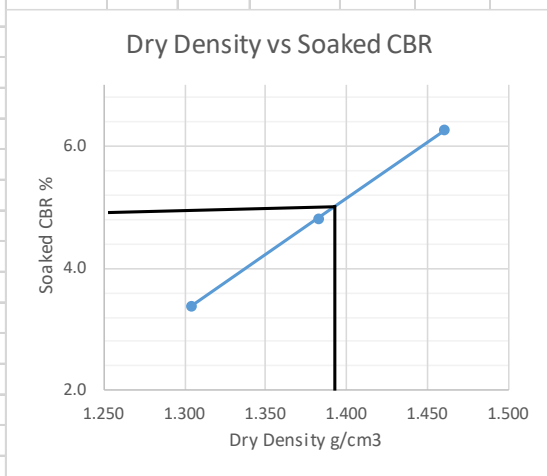
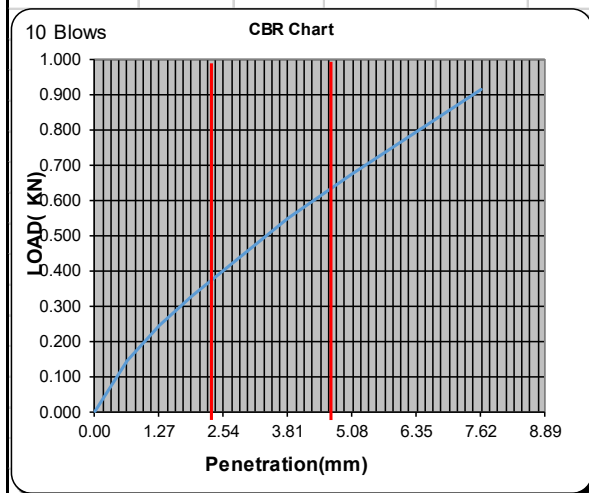
Table 4.2G CBR test result for station 6+000km

6+000km											
Compaction Determination											
COMPACTION DATA			65 Blows		30 Blows		10 Blows				
			Before soak	After soak	Before soak	After soak	Before soak	After soak			
Mould No.			1	1	2	2	N22	N22			
Mass of soil + Mould			10798.8	10876.7	10456.7	10644.3	10448.3	10551.8			
Mass Mould			6597.9	6597.9	6473.1	6473.1	6680.2	6680.2			
Mass of Soil			4200.9	4278.8	3983.6	4171.2	3768.1	3871.6			
Volume of Mould			2285	2285	2285	2285	2285	2285			
Wet density of soil			1.838	1.873	1.743	1.825	1.649	1.694			
Dry density of soil			1.461	1.403	1.382	1.359	1.304	1.204			
Moisture Determination											
MOISTURE CONTENT DATA			65 Blows		30 Blows		10 Blows				
			Before soak	After soak	Before soak	After soak	Before soak	After soak			
Container no.			P67	P66	J41	ZE	C3	G3T3			
Mass of wet soil + Container			153.09	158.93	179.37	112.42	152.90	160.22			
Mass of dry soil + Container			129.00	128.49	149.00	92.18	126.50	124.78			
Mass of container			35.86	37.63	32.66	33.16	26.70	37.85			
Mass of water			24.09	30.44	30.37	20.24	26.40	35.44			
Mass of drysoil			93.14	90.86	116.34	59.02	99.80	86.93			
Moisture content			25.87	33.50	26.10	34.29	26.45	40.77			
CBR Penetration Determination											
Penetration after 96 hrs Soaking Period			Surcharge Weight:-4.55 KG								
65 Blows			30 Blows			10 Blows					
Pen.mm	Load, KN	CBR %	Pen.mm	Load, KN	CBR %	Pen.mm	Load, KN	CBR %			
0.00	0.000		0.00	0.000		0.00	0.000				
0.64	0.245		0.64	0.190		0.64	0.143				
1.27	0.467		1.27	0.299		1.27	0.246				
1.91	0.645		1.91	0.392		1.91	0.328				
2.54	0.835	6.26	2.54	0.565	4.24	2.54	0.402	3.01			
3.81	1.023		3.81	0.860		3.81	0.550				
5.08	1.189	5.95	5.08	0.967	4.84	5.08	0.676	3.38			
7.62	1.469		7.62	1.120		7.62	0.912				
Modified Max.Dry Density g/cc			1.460			OMC %		27.0			

Date		65 Blows		30 Blows		10 Blows	
		Gauge rdg	Swell in %	Gauge rdg	Swell in %	Gauge rdg	Swell in %
		mm		mm		mm	
2013/1/12	Initial	0.70	3.01	0	3.20	5.80	3.31
2013/1/16	Final	4.20		3.73		9.65	



Penetration (mm)	Load KN		Corr. CBR %	Swell %	Penetration (mm)	Load KN		Corr. CBR %	Swell %
	Top	Bottom				Top	Bottom		
2.54mm		0.8	6.3	3.01	2.54mm		0.6	4.2	3.20
5.08mm		1.2	5.9		5.08mm		1.0	4.8	



				Dry Density at 95% of MDD:		1.387			
Penetration (mm)	Load KN		Corr. CBR %	Swell %	No. of blows	MCBS %	DDBS g/cm3	Correct CBR %	% OF Compaction
	Top	Bottom							
2.54mm		0.4	3.0	3.31	10	26.5	1.304	3.4	89
5.08mm		0.7	3.4		30	26.1	1.382	4.8	95
					65	25.9	1.461	6.3	100
					CBR % at 95 % MDD		4.9	Swell %	3.20

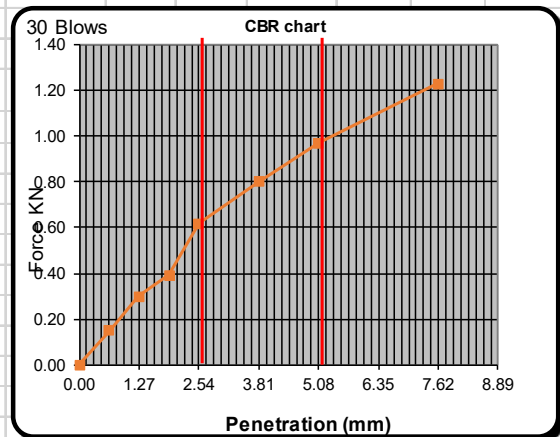
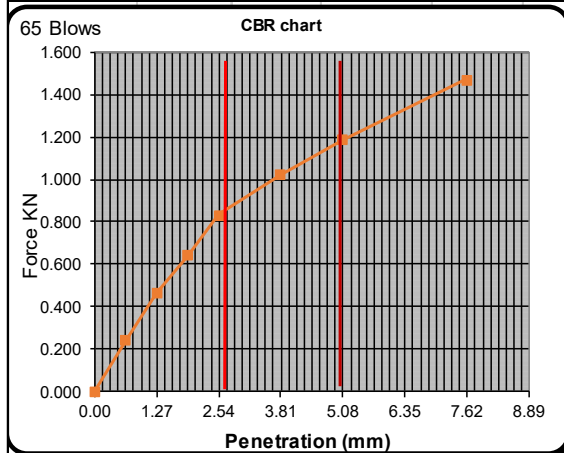
Table 4.2G CBR test result for station 9+000km

9+000km											
Compaction Determination											
COMPACTION DATA			65 Blows		30 Blows		10 Blows				
			Before soak	After soak	Before soak	After soak	Before soak	After soak	Before soak	After soak	
Mould No.			TN	TN	N6	N6	N22	N22			
Mass of soil + Mould			g	10592.9	10687.6	10593.3	10697.3	10254.2	10386.9		
Mass Mould			g	6971.3	6971.3	7036	7036	6971.1	6971.1		
Mass of Soil			g	3621.6	3716.3	3557.3	3661.3	3283.1	3415.8		
Volume of Mould			g	2285	2285	2285	2285	2285	2285		
Wet density of soil			g/cc	1.585	1.626	1.557	1.602	1.437	1.495		
Dry density of soil			g/cc	1.370	1.303	1.324	1.286	1.220	1.187		
Moisture Determination											
MOISTURE CONTENT DATA			65 Blows		30 Blows		10 Blows				
			Before soak	After soak	Before soak	After soak	Before soak	After soak	Before soak	After soak	
Container no.			G3T3	P67	G3T2	P3	G3T1	G19			
Mass of wet soil + Container			g	125.0	130.0	155.0	115.0	151.0	142.0		
Mass of dry soil + Container			g	113.2	111.2	137.0	99.4	133.9	120.1		
Mass of container			g	37.7	35.4	34.8	35.8	37.8	35.9		
Mass of water			g	11.85	18.84	17.97	15.62	17.08	21.87		
Mass of dry soil			g	75.46	75.77	102.25	63.60	96.12	84.23		
Moisture content			%	15.70	24.86	17.57	24.56	17.77	25.96		
CBR Penetration Determination											
Penetration after 96 hrs Soaking Period			Surcharge Weight:-4.55 KG								
65 Blows			30 Blows			10 Blows					
Pen.mm	Load, KN	CBR %	Pen.mm	Load, KN	CBR %	Pen.mm	Load, KN	CBR %			
0.00	0.000		0.00	0.000		0.00	0.000				
0.64	0.245		0.64	0.182		0.64	0.236				
1.27	0.467		1.27	0.428		1.27	0.299				
1.91	0.645		1.91	0.623		1.91	0.342				
2.54	0.835	6.26	2.54	0.718	5.38	2.54	0.375			2.81	
3.81	1.023		3.81	0.883		3.81	0.418				
5.08	1.189	5.95	5.08	0.994	4.97	5.08	0.463			2.32	
7.62	1.469		7.62	1.204		7.62	2.015				
Modified Max.Dry Density g/cc			1.370			OMC %		17.0			

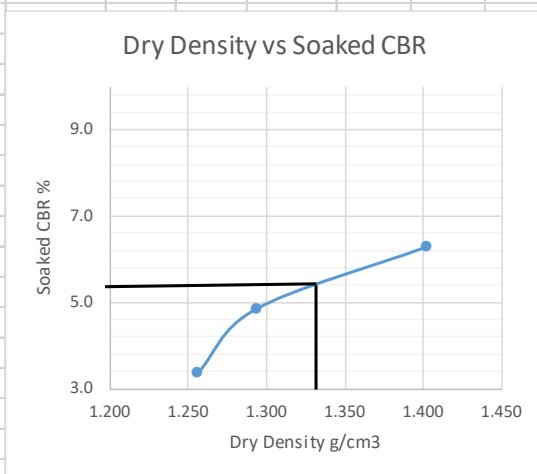
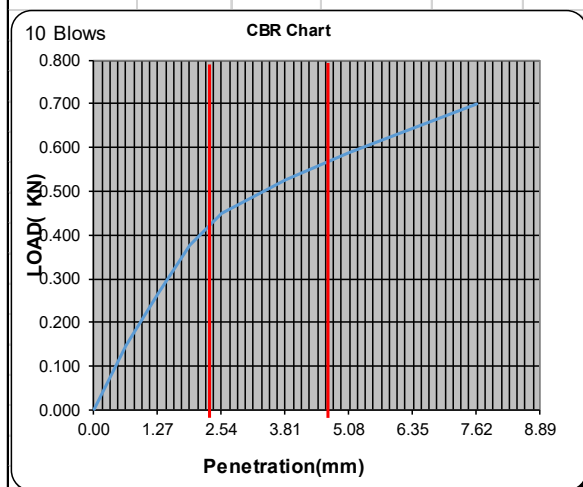
Table 4.2G CBR test result for station 12+000km

12+000Km											
Compaction Determination											
COMPACTION DATA			65 Blows		30 Blows		10 Blows				
			Before soak	After soak	Before soak	After soak	Before soak	After soak	Before soak	After soak	
Mould No.			1	1	2	2	N22		N22		
Mass of soil + Mould			10764.4	10808.9	10600.7	10758.2	10334		10424.6		
Mass Mould			6543	6543	6707	6707	6554		6554		
Mass of Soil			4221.4	4265.9	3893.7	4051.2	3780		3870.6		
Volume of Mould			2285	2285	2285	2285	2285		2285		
Wet density of soil			g/cc	1.847	1.867	1.704	1.773	1.654		1.694	
Dry density of soil			g/cc	1.401	1.345	1.293	1.271	1.256		1.203	
Moisture Determination											
MOISTURE CONTENT DATA			65 Blows		30 Blows		10 Blows				
			Before soak	After soak	Before soak	After soak	Before soak	After soak	Before soak	After soak	
Container no.			P67	P66	J41	ZE	C3		G3T3		
Mass of wet soil + Container			g	153.09	158.93	179.37	112.42	152.90		160.22	
Mass of dry soil + Container			g	127.00	125.00	144.00	90.00	121.00		124.78	
Mass of container			g	45.00	37.63	32.66	33.16	20.50		37.85	
Mass of water			g	26.1	33.9	35.4	22.4	31.9		35.4	
Mass of dry soil			g	82.0	87.4	111.3	56.8	100.5		86.9	
Moisture content			%	31.8	38.8	31.8	39.4	31.7		40.8	
CBR Penetration Determination											
Penetration after 96 hrs Soaking Period			Surcharge Weight:-4.55 KG								
65 Blows			30 Blows			10 Blows					
Pen.mm	Load, KN	CBR %	Pen.mm	Load, KN	CBR %	Pen.mm	Load, KN	CBR %	Pen.mm	Load, KN	CBR %
0.00	0.000		0.00	0.00		0.00	0.000				
0.64	0.245		0.64	0.15		0.64	0.147				
1.27	0.467		1.27	0.30		1.27	0.265				
1.91	0.645		1.91	0.39		1.91	0.376				
2.54	0.835	6.26	2.54	0.62	4.63	2.54	0.448				3.36
3.81	1.023		3.81	0.80		3.81	0.527				
5.08	1.189	5.95	5.08	0.97	4.85	5.08	0.589				2.95
7.62	1.469		7.62	1.23		7.62	0.698				
Modified Max.Dry Density g/cc			1.420			OMC %		33.0			

Date		65 Blows		30 Blows			10 Blows		
		Gauge rdg	Swell in %	Gauge rdg	Swell in %	Gauge rdg	Swell in %		
		mm		mm		mm			
2013/1/23	Initial	9.29	3.45	0.43	3.52	7.21	3.64		
2013/1/27	Final	13.30		4.53		11.45			



Penetration (mm)	Load KN		Corr. CBR %	Swell %	Penetration (mm)	Load KN		Corr. CBR %	Swell %
	Top	Bottom				Top	Bottom		
2.54mm		0.8	6.3	3.45	2.54mm		0.6	4.6	3.52
5.08mm		1.2	5.9		5.08mm		1.0	4.9	



					Dry Density at 95% of MDD:				1.349	
Penetration (mm)	Load KN		Corr. CBR %	Swell %	No.of blows	MCBS %	DDBS g/cm3	Correcrt CBR %	% OF Compaction	
	Top	Bottom			10	31.7	1.256	3.4	88	
	2.54mm	0.4	30		31.8	1.293	4.9	91		
	5.08mm	0.6	2.9		65	31.8	1.401	6.3	99	
					CBR % at 95 % MDD			5.6	Swell %	3.52

Table 4.2G CBR test result for station km 36+000

36+000km											
Compaction Determination											
COMPACTION DATA			65 Blows		30 Blows		10 Blows				
			Before soak	After soak	Before soak	After soak	Before soak	After soak			
Mould No.			T4	T4	N22	N22	N12	N12			
Mass of soil + Mould			g 10894.4	10968.9	10710.7	10840.2	10434	10524.6			
Mass Mould			g 6680	6680	6640	6640	6520	6520			
Mass of Soil			g 4214.4	4288.9	4070.7	4200.2	3914	4004.6			
Volume of Mould			g 2285	2285	2285	2285	2285	2285			
Wet density of soil			g/cc 1.844	1.877	1.781	1.838	1.713	1.753			
Dry density of soil			g/cc 1.440	1.424	1.392	1.383	1.341	1.281			
Moisture Determination											
MOISTURE CONTENT DATA			65 Blows		30 Blows		10 Blows				
			Before soak	After soak	Before soak	After soak	Before soak	After soak			
Container no.			C3	G3T2	10G	P3	G53	G3T3			
Mass of wet soil + Container			g 182.1	179.1	124.6	166.7	105.0	152.3			
Mass of dry soil + Container			g 148.0	144.3	101.2	129.7	86.0	121.5			
Mass of container			g 26.7	34.8	17.7	17.1	17.4	37.7			
Mass of water			g 34.1	34.8	23.4	37.1	19.0	30.9			
Mass of drysoil			g 121.3	109.5	83.6	112.6	68.6	83.8			
Moisture content			% 28.1	31.8	28.0	32.9	27.7	36.8			
CBR Penetration Determination											
Penetration after 96 hrs Soaking Period			Surcharge Weight:-4.55 KG								
65 Blows			30 Blows			10 Blows					
Pen.mm	Load, KN	CBR %	Pen.mm	Load, KN	CBR %	Pen.mm	Load, KN	CBR %			
0.00	0.00		0.00	0.00		0.00	0.00				
0.64	0.50		0.64	0.21		0.64	0.15				
1.27	0.70		1.27	0.41		1.27	0.30				
1.91	0.92		1.91	0.60		1.91	0.39				
2.54	1.19	8.92	2.54	0.88	6.57	2.54	0.62				4.63
3.81	1.43		3.81	1.11		3.81	0.80				
5.08	1.71	8.55	5.08	1.30	6.50	5.08	0.97				4.85
7.62	1.82		7.62	1.62		7.62	1.23				
Modified Max.Dry Density g/cc		1.490			OMC %		29.0				

4.3J LOS ANGELES ABRASION TEST ASTM C 131

Table 4.3k Los Angeles Abrasion Test for station 4+200km

				Grading of Test Samples			
Sieve Size				Mass of Indicated Sizes (gm), Grading & Type			
Passing		Retained on		A	B	C	D
mm	Inch	mm	Inch			-	-
75	(3")	63.5	(2 1/2")	-	-	-	-
63.5	(2 1/2")	50.8	(2")	-	-	-	-
50	(2")	37.5	(1 1/2")	-	-	-	-
37.5	(1 1/2")	25	(1")	1250±25	-	-	-
25	(1")	19	(3/4")	1250±25	-	-	-
19	(3/4")	12.5	(1/2")	1250±10	2500±10	-	-
12.5	(1/2")	9.5	(3/8")	1250±10	2500±10	-	-
9.5	(3/8")	6.3	(1/4")	-	-	2500±10	-
6.3	(1/4")	4.75	(No 4)	-	-	2500±10	-
4.75	(No4)	2.36	(No 8)	-	-	-	5000±10
Total				5000±10	5000±10	5000±10	5000±10
Number of Spheres							
Number of Revolutions							
GRADING TYPE				Trial - 1		Trial - 2	
INITIAL WEIGHT= w1		gm		5000		5000	
WEIGHT RETAINED On 1.70mm sieve after Test =w2		gm		2250		2230	
% PASSING 1.70mm Sieve (w1-w2)/w1*100		%		55.0		55.4	
AVERAGE		%		55.2			

Table 4.3k Los Angeles Abrasion Test for station 38+600km

				Grading of Test Samples			
Sieve Size				Mass of Indicated Sizes (gm), Grading & Type			
Passing		Retained on		A	B	C	D
mm	Inch	mm	Inch			-	-
75	(3")	63.5	(2 1/2")	-	-	-	-
63.5	(2 1/2")	50.8	(2")	-	-	-	-
50	(2")	37.5	(1 1/2")	-	-	-	-
37.5	(1 1/2")	25	(1")	1250±25	-	-	-
25	(1")	19	(3/4")	1250±25	-	-	-
19	(3/4")	12.5	(1/2")	1250±10	2500±10	-	-
12.5	(1/2")	9.5	(3/8")	1250±10	2500±10	-	-
9.5	(3/8")	6.3	(1/4")	-	-	2500±10	-
6.3	(1/4")	4.75	(No 4)	-	-	2500±10	-
4.75	(No4)	2.36	(No 8)	-	-	-	5000±10
Total				5000±10	5000±10	5000±10	5000±10
Number of Spheres							
Number of Revolutions							
GRADING TYPE				Trial - 1		Trial - 2	
INITIAL WEIGHT= w1			gm	5000		5000	
WEIGHT RETAINED On 1.70mm sieve after 1 test =w2			gm	2125		2140	
% PASSING 1.70mm Sieve (w1-w2)/w1*100			%	57.5		57.2	
AVERAGE			%	57.4			

Appendices 4.4 Partially Replaced Expansive Subgrade Soil Sample

4.4B Specific gravity (ASTM D-854)

Table 4.4B Specific gravity for station 20%3+000km+80%4+200km

Specific gravity of soil at test Temperature, G at $T_x^{\circ}C$ (ASTM D-854)			
<i>Station:</i>	20% 3+000+80%(4+200)		
Trial No.	1	2	3
Mass of density bottle,g	23.16	26.56	26.7
Mass of density bottle+dry soil,g	48.16	51.56	51.7
Mass of density bottle+dry soil+water at temperature $T_x^{\circ}C$,g	134.4	135.84	138.06
Test temperature(T_x), $^{\circ}C$	22	22	22
Density of water at T_x ,g/ml	0.9978	0.9978	0.9978
Mass of density bottle+water at temperature $T_i^{\circ}C$ (21 $^{\circ}C$),g	119.12	120.44	122.7
Density of water at T_i ,g/ml at 21 $^{\circ}C$	0.9980	0.9980	0.9980
Correction factor,k	0.9998	0.9998	0.9998
Specific gravity G at $T_x^{\circ}C$	2.58	2.61	2.60
Average specific gravity at $T_x^{\circ}C$	2.60		

Table 4.4B Specific gravity for station for station 30%3+000km+70%4+200km

Specific gravity of soil at test Temperature, G at $T_x^{\circ}C$ (ASTM D-854)			
<i>Station</i>	30% 3+000+70%(4+200)		
Trial No.	1	2	3
Mass of density bottle,g	23.59	26.39	26.75
Mass of density bottle+dry soil,g	48.59	51.39	51.75
Mass of density bottle+dry soil+water at temperature $T_x^{\circ}C$,g	135	135.56	138.04
Test temperature(T_x), $^{\circ}C$	23	23	23
Density of water at T_x ,g/ml	0.9978	0.9978	0.9978
Mass of density bottle+water at temperature $T_i^{\circ}C$ (21 $^{\circ}C$),g	119.58	120.06	122.55
Density of water at T_i ,g/ml at 21 $^{\circ}C$	0.99802	0.99802	0.99802
Correction factor,k	0.99978	0.99978	0.99978
Specific gravity G at $T_x^{\circ}C$	2.62	2.64	2.64
Average specific gravity at $T_x^{\circ}C$	2.63		

Table 4.4B Specific gravity for station for station 40%3+000km+60%4+200km

Specific gravity of soil at test Temperature, G at $T_x^{\circ}C$ (ASTM D-854)			
<i>Station:</i>	40% 3+000+60%(4+200)		
Trial No.	1	2	3
Mass of density bottle,g	24.02	26.22	26.8
Mass of density bottle+dry soil,g	49.02	51.22	51.8
Mass of density bottle+dry soil+water at temperature $T_x^{\circ}C$,g	135.6	135.28	138.02
Test temperature(T_x), $^{\circ}C$	23	23	23
Density of water at T_x ,g/ml	0.9978	0.9978	0.9978
Mass of density bottle+water at temperature $T_i^{\circ}C$ (21 $^{\circ}C$),g	120.04	119.68	122.4
Density of water at T_i ,g/ml at 21 $^{\circ}C$	0.99802	0.99802	0.99802
Correction factor,k	0.99978	0.99978	0.99978
Specific gravity G at $T_x^{\circ}C$	2.66	2.67	2.68
Average specific gravity at $T_x^{\circ}C$	2.67		

Table 4.4B Specific gravity for station for station 20%6+000km+80%4+200km

Specific gravity of soil at test Temperature, G at $T_x^{\circ}C$ (ASTM D-854)			
<i>Station:</i>	20%(6+000)+80%(4+200)		
Trial No.	1	2	3
Mass of density bottle,g	23.16	26.56	26.7
Mass of density bottle+dry soil,g	48.16	51.56	51.7
Mass of density bottle+dry soil+water at temperature $T_x^{\circ}C$,g	134.4	135.84	138.06
Test temperature(T_x), $^{\circ}C$	22	22	22
Density of water at T_x ,g/ml	0.9978	0.9978	0.9978
Mass of density bottle+water at temperature $T_i^{\circ}C$ (21 $^{\circ}C$),g	119.12	120.44	122.7
Density of water at T_i ,g/ml at 21 $^{\circ}C$	0.9980	0.9980	0.9980
Correction factor,k	0.9998	0.9998	0.9998
Specific gravity G at $T_x^{\circ}C$	2.57	2.60	2.59
Average specific gravity at $T_x^{\circ}C$	2.59		

Table 4.4B Specific gravity for station 30%6+000km+70%4+200km

Specific gravity of soil at test Temperature, G at $T_x^{\circ}C$ (ASTM D-854)			
<i>Station</i>	30%(6+000)+70%(4+200)		
Trial No.	1	2	3
Mass of density bottle,g	23.59	26.39	26.75
Mass of density bottle+dry soil,g	48.59	51.39	51.75
Mass of density bottle+dry soil+water at temperature $T_x^{\circ}C$,g	135	135.56	138.04
Test temperature(T_x), $^{\circ}C$	23	23	23
Density of water at T_x ,g/ml	0.9978	0.9978	0.9978
Mass of density bottle+water at temperature $T_i^{\circ}C$ (21 $^{\circ}C$),g	119.58	120.06	122.55
Density of water at T_i ,g/ml at 21 $^{\circ}C$	0.99802	0.99802	0.99802
Correction factor,k	0.99978	0.99978	0.99978
Specific gravity G at $T_x^{\circ}C$	2.61	2.63	2.63
Average specific gravity at $T_x^{\circ}C$	2.62		

Table 4.4B Specific gravity for station 40%6+000km+60%4+200km

Specific gravity of soil at test Temperature, G at $T_x^{\circ}C$ (ASTM D-854)			
<i>Station:</i>	40%(6+000)+60%(4+200)		
Trial No.	1	2	3
Mass of density bottle,g	24.02	26.22	26.8
Mass of density bottle+dry soil,g	49.02	51.22	51.8
Mass of density bottle+dry soil+water at temperature $T_x^{\circ}C$,g	135.6	135.28	138.02
Test temperature(T_x), $^{\circ}C$	23	23	23
Density of water at T_x ,g/ml	0.9978	0.9978	0.9978
Mass of density bottle+water at temperature $T_i^{\circ}C$ (21 $^{\circ}C$),g	121.1	119.68	122.4
Density of water at T_i ,g/ml at 21 $^{\circ}C$	0.99802	0.99802	0.99802
Correction factor,k	0.99978	0.99978	0.99978
Specific gravity G at $T_x^{\circ}C$	2.38	2.66	2.67
Average specific gravity at $T_x^{\circ}C$	2.57		

Table 4.4B Specific gravity for station 20%9+000km+80%4+200km

Specific gravity of soil at test Temperature, G at $T_x^{\circ}C$ (ASTM D-854)			
Station: (Km)	20%(9+000)+80%(4+200)		
Trial No.	1	2	3
Mass of density bottle, g	23.16	26.56	26.7
Mass of density bottle+dry soil, g	48.16	51.56	51.7
Mass of density bottle+dry soil+water at temperature $T_x^{\circ}C$, g	134.38	135.76	137.98
Test temperature(T_x), $^{\circ}C$	22	22	22
Density of water at T_x , g/ml	0.9978	0.9978	0.9978
Mass of density bottle+water at temperature $T_i^{\circ}C$ ($21^{\circ}C$), g	119.12	120.44	122.7
Density of water at T_i , g/ml at $21^{\circ}C$	0.9980	0.9980	0.9980
Correction factor, k	0.9997	0.9997	0.9997
Specific gravity G at $T_x^{\circ}C$	2.61	2.62	2.63
Average specific gravity at $T_x^{\circ}C$	2.62		

Table 4.4B Specific gravity for station 30%9+000km+70%4+200km

Specific gravity of soil at test Temperature, G at $T_x^{\circ}C$ (ASTM D-854)			
Station: Km	30%(9+000)+70%(4+200)		
Trial No.	1	2	3
Mass of density bottle, g	23.59	26.39	26.75
Mass of density bottle+dry soil, g	48.59	51.39	51.75
Mass of density bottle+dry soil+water at temperature $T_x^{\circ}C$, g	134.97	135.44	137.92
Test temperature(T_x), $^{\circ}C$	22	22	22
Density of water at T_x , g/ml	0.99773	0.99773	0.997731
Mass of density bottle+water at temperature $T_i^{\circ}C$ ($21^{\circ}C$), g	119.58	120.06	122.55
Density of water at T_i , g/ml at $21^{\circ}C$	0.9980	0.9980	0.9980
Correction factor, k	0.9997	0.9997	0.9997
Specific gravity G at $T_x^{\circ}C$	2.60	2.60	2.60
Average specific gravity at $T_x^{\circ}C$	2.60		

Table 4.4B Specific gravity for station 40%9+000km+60%4+200km

Specific gravity of soil at test Temperature, G at $T_x^{\circ}C$ (ASTM D-854)			
<i>Station: km</i>	40%(9+000)+60%(4+200)		
Trial No.	1	2	3
Mass of density bottle, g	24.02	26.22	26.8
Mass of density bottle+dry soil, g	49.02	51.22	51.8
Mass of density bottle+dry soil+water at temperature $T_x^{\circ}C$, g	135.56	135.12	137.86
Test temperature(T_x), $^{\circ}C$	22	22	22
Density of water at T_x , g/ml	0.9977	0.9977	0.9977
Mass of density bottle+water at temperature $T_i^{\circ}C$ (21 $^{\circ}C$), g	120.04	119.68	122.4
Density of water at T_i , g/ml at 21 $^{\circ}C$	0.9980	0.9980	0.9980
Correction factor, k	0.9997	0.9997	0.9997
Specific gravity G at $T_x^{\circ}C$	2.59	2.60	2.59
Average specific gravity at $T_x^{\circ}C$	2.59		

Table 4.4B Specific gravity for station 20%36+000km+80%38+600km

Specific gravity of soil at test Temperature, G at $T_x^{\circ}C$ (ASTM D-854)			
<i>Station: (Km)</i>	20%(36+000)+80%(38+600)		
Trial No.	1	2	3
Mass of density bottle, g	24.56	26.98	27
Mass of density bottle+dry soil, g	49.56	51.98	52
Mass of density bottle+dry soil+water at temperature $T_x^{\circ}C$, g	138	137.14	139.54
Test temperature(T_x), $^{\circ}C$	22	22	22
Density of water at T_x , g/ml	0.9978	0.9978	0.9978
Mass of density bottle+water at temperature $T_i^{\circ}C$ (21 $^{\circ}C$), g	122.32	121.42	123.84
Density of water at T_i , g/ml at 21 $^{\circ}C$	0.9980	0.9980	0.9980
Correction factor, k	0.9997	0.9997	0.9997
Specific gravity G at $T_x^{\circ}C$	2.68	2.70	2.69
Average specific gravity at $T_x^{\circ}C$	2.69		

Table 4.4B Specific gravity for station 30%36+000km+70%38+600km

Specific gravity of soil at test Temperature, G at $T_x^{\circ}C$ (ASTM D-854)			
<i>Station: Km</i>	30% (36+000)+70%(38+600)		
Trial No.	1	2	3
Mass of density bottle, g	24.59	26.97	27
Mass of density bottle+dry soil, g	49.59	51.97	52
Mass of density bottle+dry soil+water at temperature $T_x^{\circ}C$, g	137.85	137.16	139.51
Test temperature(T_x), $^{\circ}C$	22	22	22
Density of water at T_x , g/ml	0.99773	0.99773	0.997731
Mass of density bottle+water at temperature $T_i^{\circ}C$ (21 $^{\circ}C$), g	122.13	121.38	123.76
Density of water at T_i , g/ml at 21 $^{\circ}C$	0.9980	0.9980	0.9980
Correction factor, k	0.9997	0.9997	0.9997
Specific gravity G at $T_x^{\circ}C$	2.69	2.71	2.70
Average specific gravity at $T_x^{\circ}C$	2.70		

Table 4.4B Specific gravity for station 40%36+000km+60%38+600km

Specific gravity of soil at test Temperature, G at $T_x^{\circ}C$ (ASTM D-854)			
<i>Station: km</i>	40% 36+000+60%(38+600)		
Trial No.	1	2	3
Mass of density bottle, g	24.62	26.96	27
Mass of density bottle+dry soil, g	49.62	51.96	52
Mass of density bottle+dry soil+water at temperature $T_x^{\circ}C$, g	137.7	137.18	139.48
Test temperature(T_x), $^{\circ}C$	22	22	22
Density of water at T_x , g/ml	0.9977	0.9977	0.9977
Mass of density bottle+water at temperature $T_i^{\circ}C$ (21 $^{\circ}C$), g	121.94	121.34	123.68
Density of water at T_i , g/ml at 21 $^{\circ}C$	0.9980	0.9980	0.9980
Correction factor, k	0.9997	0.9997	0.9997
Specific gravity G at $T_x^{\circ}C$	2.71	2.73	2.72
Average specific gravity at $T_x^{\circ}C$	2.72		

4.4C Grain Size Analysis (ASTM D-1140-97)

Table 4.4C Grain size analysis of partially replaced expansive soil sample

Table 4.4C Grain size analysis for station 20%3+000km+80%4+200km

Method of Testing:	Grain Size Analysis (ASTM D-421)			
Method of Testing:	Wet Sieve Analysis			
Wt. of Sample: (g)	1 Kg			
Sample Station:	Gimbo-Konda Road Project			
Station:km	20% 3+000+80%(4+200)			
Sieve size (mm)	Mass of Retain on Each Sieve (g)	Percentage of Retained Soil	Percentage of cumulative Retained Soil	Percentage of Passing Soil Particle
9.500	61.120	6.11	6.11	93.89
4.750	57.314	5.73	11.84	88.16
2.000	99.500	9.95	21.79	78.21
0.850	61.064	6.11	27.90	72.10
0.425	62.640	6.26	34.16	65.84
0.250	37.232	3.72	37.89	62.11
0.150	28.158	2.82	40.70	59.30
0.075	39.868	3.99	44.69	55.31
pan	553.104	55.31	100.00	0.00
sum	1000.000			

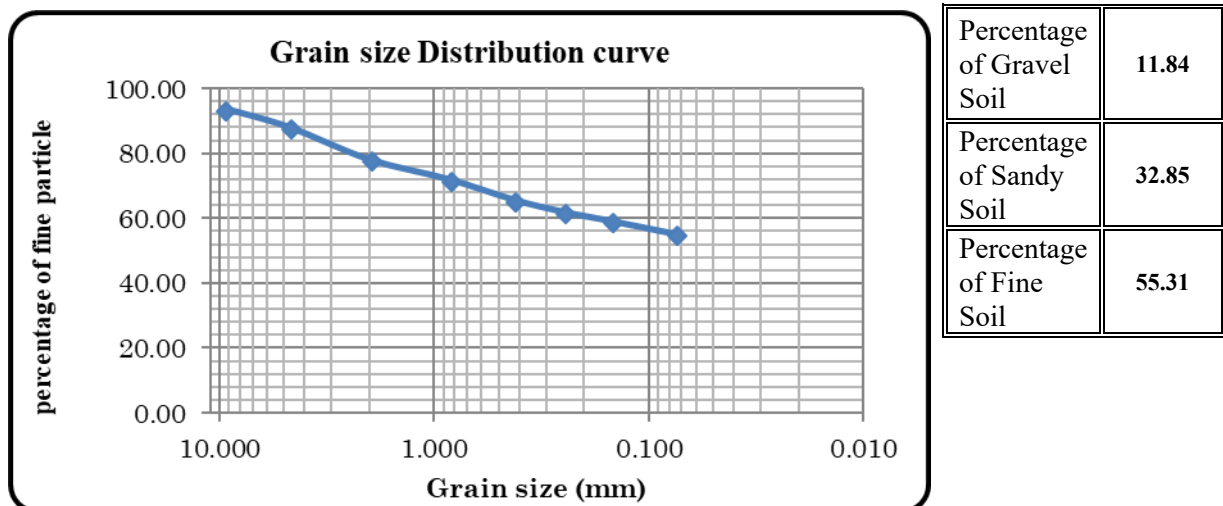


Fig C.2.1 Grain size analysis for station 20%3+000km+80%4+200km

Table 4.4C Grain size analysis for station 30%3+000km+70%4+200km

Method of Testing:	Grain Size Analysis (ASTM D-421)			
Method of Testing:	Wet Sieve Analysis			
Wt. of Sample: (g)	1 Kg			
Sample Station:	Gimbo-Konda Road Project			
Station;km	30% 3+000+70%(4+200)			
Sieve size (mm)	Mass of Retain on Each Sieve (g)	Percentage of Retained Soil	Percentage of cumulative Retained Soil	Percentage of Passing Soil Particle
9.500	53.480	5.35	5.35	94.65
4.750	53.081	5.31	10.66	89.34
2.000	89.250	8.93	19.58	80.42
0.850	55.381	5.54	25.12	74.88
0.425	56.460	5.65	30.77	69.23
0.250	34.233	3.42	34.19	65.81
0.150	26.737	2.67	36.86	63.14
0.075	36.802	3.68	40.54	59.46
pan	594.576	59.46	100.00	0.00
sum	1000.000			

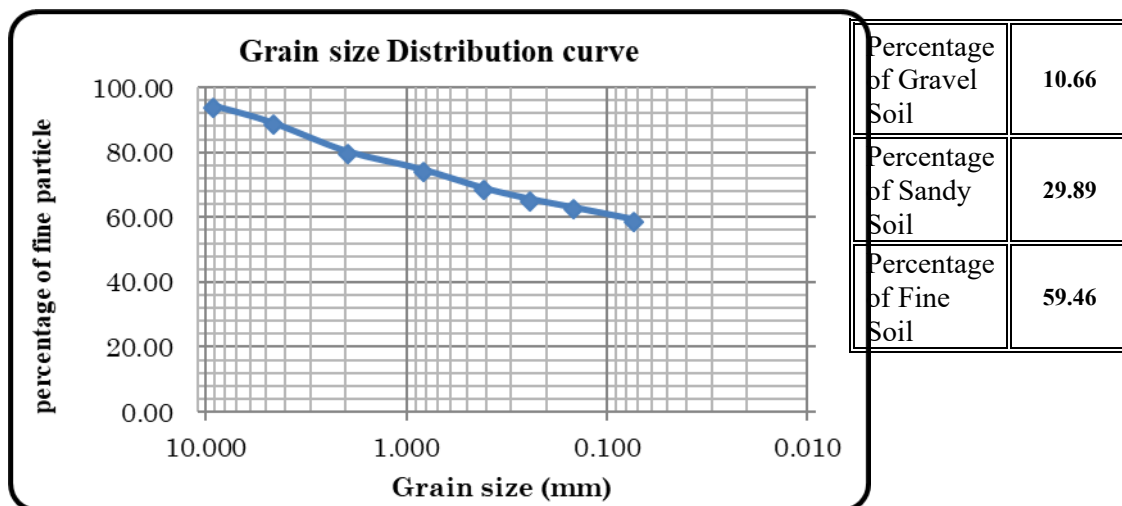
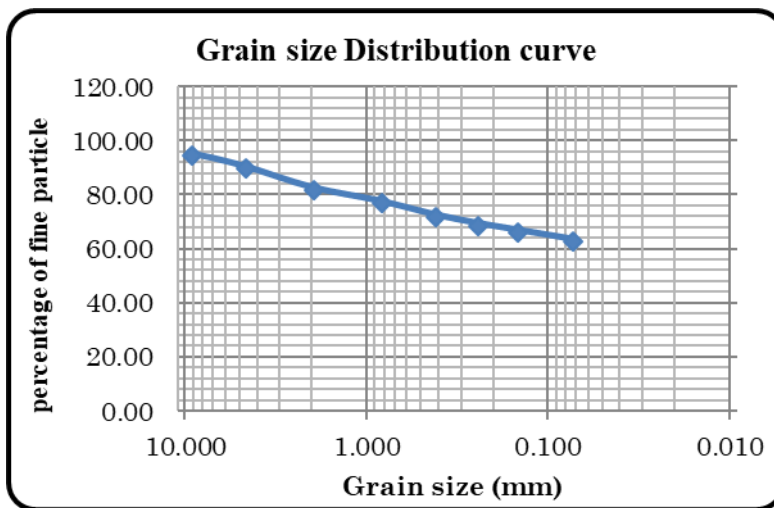


Fig C.2.2 Grain size analysis for station 30%3+000km+70%4+200km

Table 4.4C Grain size analysis for station 40%3+000km+60%4+200km

Method of Testing:	Grain Size Analysis (ASTM D-421)			
Method of Testing:	Wet Sieve Analysis			
Wt. of Sample: (g)	1 Kg			
Sample Station:	Gimbo-Konda Road Project			
Station;km	40% 3+000+60%(4+200)			
Sieve size (mm)	Mass of Retain on Each Sieve (g)	Percentage of Retained Soil	Percentage of cumulative Retained Soil	Percentage of Passing Soil Particle
9.500	45.840	4.58	4.58	95.42
4.750	48.848	4.88	9.47	90.53
2.000	79.000	7.90	17.37	82.63
0.850	49.698	4.97	22.34	77.66
0.425	50.280	5.03	27.37	72.63
0.250	31.234	3.12	30.49	69.51
0.150	25.316	2.53	33.02	66.98
0.075	33.736	3.37	36.40	63.60
pan	636.048	63.60	100.00	0.00
sum	1000.000			



Percentage of Gravel Soil	9.47
Percentage of Sandy Soil	26.93
Percentage of Fine Soil	63.60

Fig C.2.3 Grain size analysis for station 40%3+000km+60%4+200km

Table 4.4C Grain size analysis for station 20%6+000km+80%4+200km

Method of Testing:	Grain Size Analysis (ASTM D-421)			
Method of Testing:	Wet Sieve Analysis			
Wt. of Sample: (g)	1 Kg			
Sample Station:	Gimbo-Konda Road Project			
Station:	20%(6+000)+80%(4+200)			
Sieve size (mm)	Mass of Retain on Each Sieve (g)	Percentage of Retained Soil	Percentage of cumulative Retained Soil	Percentage of Passing Soil Particle
9.500	61.120	6.11	6.11	93.89
4.750	57.314	5.73	11.84	88.16
2.000	99.500	9.95	21.79	78.21
0.850	61.064	6.11	27.90	72.10
0.425	62.640	6.26	34.16	65.84
0.250	37.232	3.72	37.89	62.11
0.150	28.158	2.82	40.70	59.30
0.075	39.868	3.99	44.69	55.31
pan	553.104	55.31	100.00	0.00
sum	1000.000			

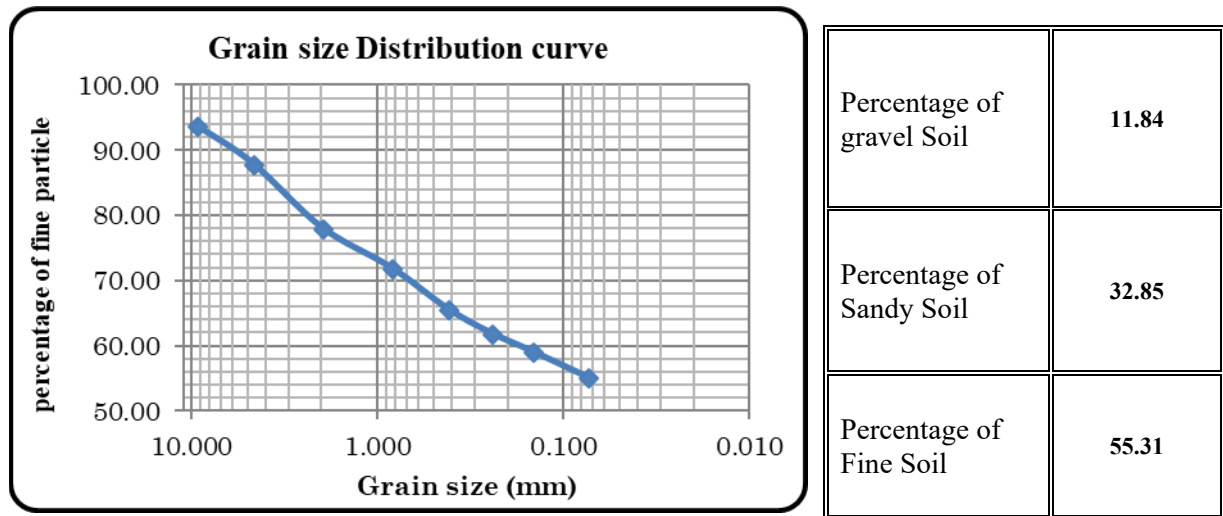
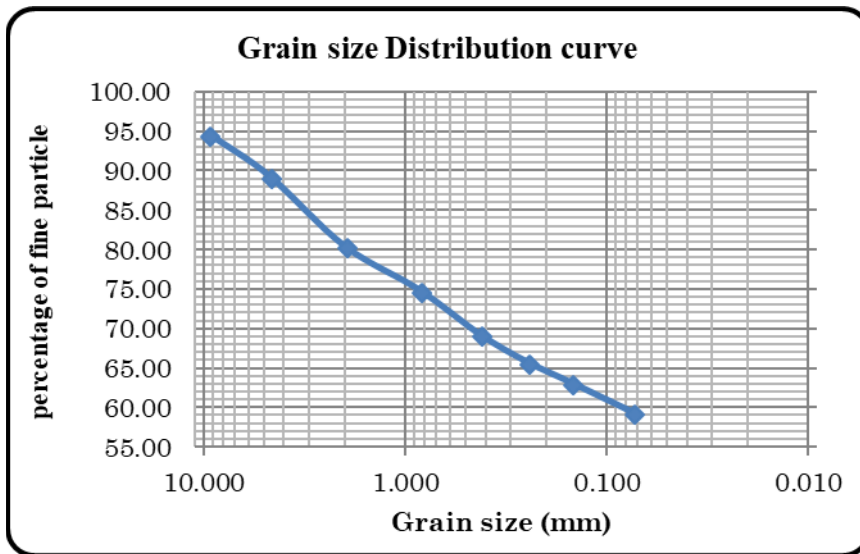


Fig C.2.7 Grain size analysis for station 20%6+000km+80%4+200km

Table 4.4C Grain size analysis for station 30%6+000km+70%4+200km

Method of Testing:	Grain Size Analysis (ASTM D-421)			
Method of Testing:	Wet Sieve Analysis			
Wt. of Sample: (g)	1 Kg			
Sample Station:	Gimbo-Konda Road Project			
Station	30%(6+000)+70%(4+200)			
Sieve size (mm)	Mass of Retain on Each Sieve (g)	Percentage of Retained Soil	Percentage of cumulative Retained Soil	Percentage of Passing Soil Particle
9.500	53.480	5.35	5.35	94.65
4.750	53.081	5.31	10.66	89.34
2.000	89.250	8.93	19.58	80.42
0.850	55.381	5.54	25.12	74.88
0.425	56.460	5.65	30.77	69.23
0.250	34.233	3.42	34.19	65.81
0.150	26.737	2.67	36.86	63.14
0.075	36.802	3.68	40.54	59.46
pan	594.576	59.46	100.00	0.00
sum	1000.000			

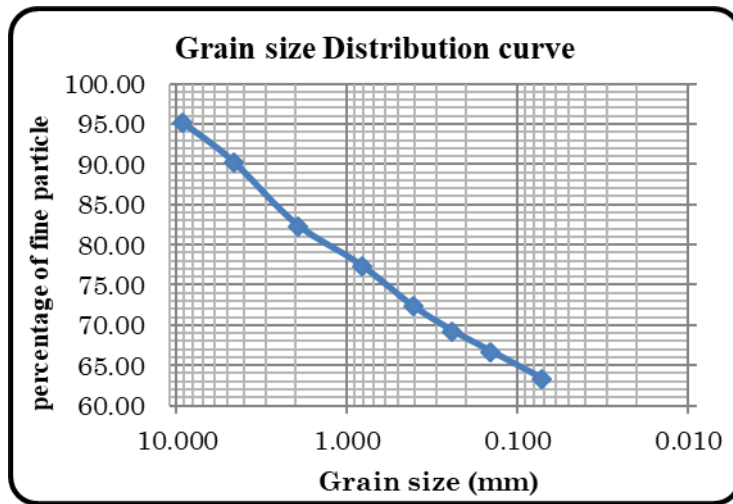


Percentage of gravel Soil	10.66
Percentage of Sandy Soil	29.89
Percentage of Fine Soil	59.46

Fig C.2.8 Grain size analysis for station 30%6+000km+70%4+200km

Table 4.4C Grain size analysis for station 40%6+000km+60%4+200km

Method of Testing:	Grain Size Analysis (ASTM D-421)			
Method of Testing:	Wet Sieve Analysis			
Wt. of Sample: (g)	1 Kg			
Sample Station:	Gimbo-Konda Road Project			
Station:	40%(6+000)+60%(4+200)			
Sieve size (mm)	Mass of Retain on Each Sieve (g)	Percentage of Retained Soil	Percentage of cumulative Retained Soil	Percentage of Passing Soil Particle
9.500	45.840	4.58	4.58	95.42
4.750	48.848	4.88	9.47	90.53
2.000	79.000	7.90	17.37	82.63
0.850	49.698	4.97	22.34	77.66
0.425	50.280	5.03	27.37	72.63
0.250	31.234	3.12	30.49	69.51
0.150	25.316	2.53	33.02	66.98
0.075	33.736	3.37	36.40	63.60
pan	636.048	63.60	100.00	0.00
sum	1000.000			



Percentage of gravel Soil	9.47
Percentage of Sandy Soil	26.93
Percentage of Fine Soil	63.60

Fig C.2.9 Grain size analysis for station 40%6+000km+60%4+200km

Table 4.4C Grain size analysis for station 20%9+000km+80%4+200km

Method of Testing:	Grain Size Analysis (ASTM D-421)			
Method of Testing:	Wet Sieve Analysis			
Wt. of Sample: (g)	1 Kg			
Sample Station:	Gimbo-Konda Road Project			
Station:(Km)	20%(9+000)+80%(4+200)			
Sieve size (mm)	Mass of Retain on Each Sieve (g)	Percentage of Retained Soil	Percentage of cumulative Retained Soil	Percentage of Passing Soil Particle
9.500	61.12	6.11	6.11	93.89
4.750	54.404	5.44	11.55	88.45
2.000	98.04	9.80	21.36	78.64
0.850	64.764	6.48	27.83	72.17
0.425	65.2	6.52	34.35	65.65
0.250	36.624	3.66	38.02	61.98
0.150	28.62	2.86	40.88	59.12
0.075	41.2	4.12	45.00	55.00
pan	550.028	55.00	100.00	0.00
sum	1000.000			

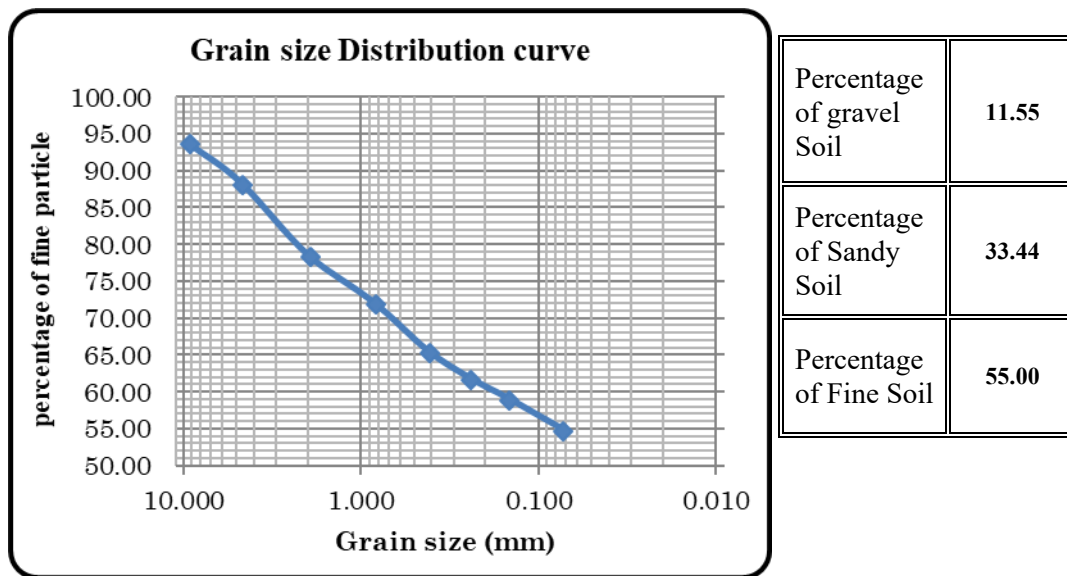
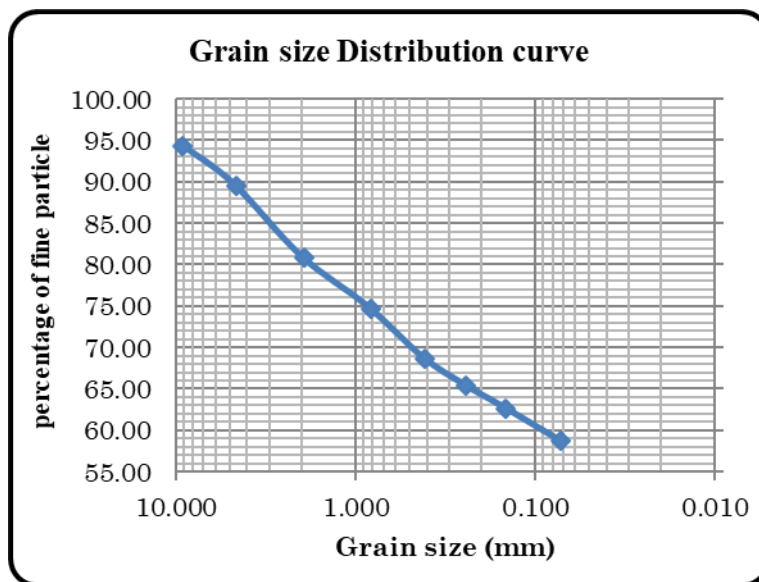


Fig C.2.10 Grain size analysis for station 20%9+000km+80%4+200km

Table 4.4C Grain size analysis for station 30%9+000km+70%4+200km

Method of Testing:	Grain Size Analysis (ASTM D-421)			
Method of Testing:	Wet Sieve Analysis			
Wt. of Sample: (g)	1 Kg			
Sample Station:	Gimbo-Konda Road Project			
Station:Km	30%(9+000)+70%(4+200)			
Sieve size (mm)	Mass of Retain on Each Sieve (g)	Percentage of Retained Soil	Percentage of cumulative Retained Soil	Percentage of Passing Soil Particle
9.500	53.480	5.35	5.35	94.65
4.750	48.716	4.87	10.22	89.78
2.000	87.060	8.71	18.93	81.07
0.850	60.931	6.09	25.02	74.98
0.425	60.300	6.03	31.05	68.95
0.250	33.321	3.33	34.38	65.62
0.150	27.430	2.74	37.12	62.88
0.075	38.800	3.88	41.00	59.00
pan	589.962	59.00	100.00	0.00
sum	1000.000			

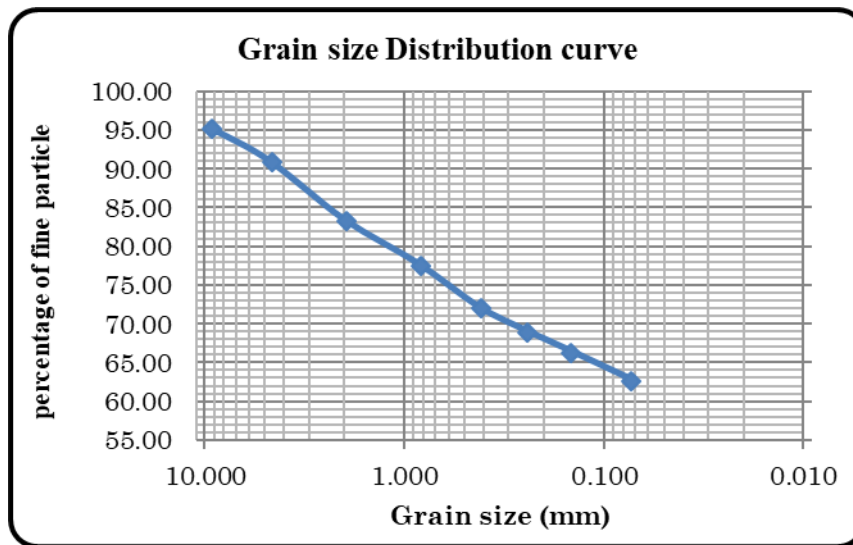


Percentage of gravel Soil	10.22
Percentage of Sandy Soil	30.78
Percentage of Fine Soil	59.00

Fig C.2.11 Grain size analysis for station 30%9+000km+70%4+200km

Table 4.4C Grain size analysis for station 40%9+000km+60%4+200km

Method of Testing:	Grain Size Analysis (ASTM D-1140)			
Method of Testing:	Wet Sieve Analysis			
Wt. of Sample: (g)	1 Kg			
Sample Station:	Gimbo-Konda Road Project			
Station:km	40%(9+000)+60%(4+200)			
Sieve size (mm)	Mass of Retain on Each Sieve (g)	Percentage of Retained Soil	Percentage of cumulative Retained Soil	Percentage of Passing Soil Particle
9.500	45.840	4.58	4.58	95.42
4.750	43.028	4.30	8.89	91.11
2.000	76.080	7.61	16.49	83.51
0.850	57.098	5.71	22.20	77.80
0.425	55.400	5.54	27.74	72.26
0.250	30.018	3.00	30.75	69.25
0.150	26.240	2.62	33.37	66.63
0.075	36.400	3.64	37.01	62.99
pan	629.896	62.99	100.00	0.00
sum	1000.000			

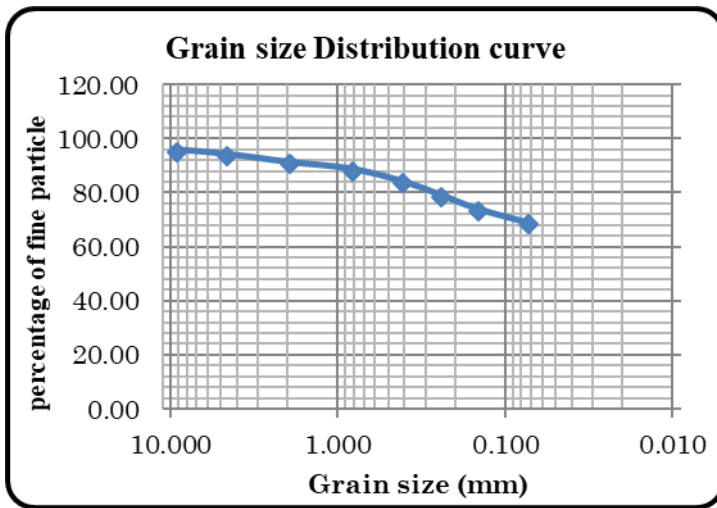


Percentage of gravel Soil	8.89
Percentage of Sandy Soil	28.12
Percentage of Fine Soil	62.99

Fig C.2.12 Grain size analysis for station 40%9+000km+60%4+200km

Table 4.4C Grain size analysis for station 20%36+000km+80%38+600km

Method of Testing:	Grain Size Analysis (ASTM D-421)			
Method of Testing:	Wet Sieve Analysis			
Wt. of Sample: (g)	1 Kg			
Sample Station:	Gimbo-Konda Road Project			
Station:(Km)	20%(36+000)+80%(38+600)			
Sieve size (mm)	Mass of Retain on Each Sieve (g)	Percentage of Retained Soil	Percentage of cumulative Retained Soil	Percentage of Passing Soil Particle
9.500	40.240	4.02	4.02	95.98
4.750	15.940	1.59	5.62	94.38
2.000	29.760	2.98	8.59	91.41
0.850	24.940	2.49	11.09	88.91
0.425	44.280	4.43	15.52	84.48
0.250	50.080	5.01	20.52	79.48
0.150	52.420	5.24	25.77	74.23
0.075	51.130	5.11	30.88	69.12
pan	691.210	69.12	100.00	0.00
sum	1000.000			



Percentage of Gravel Soil	5.62
Percentage of Sandy Soil	25.26
Percentage of Fine Soil	69.12

Fig C.2.4 Grain size analysis for station 20%36+000km+80%38+600km

Table 4.4C Grain size analysis for station 30%36+000km+70%38+600km

Method of Testing:	Grain Size Analysis (ASTM D-421)			
Method of Testing:	Wet Sieve Analysis			
Wt. of Sample: (g)	1 Kg			
Sample Station:	Gimbo-Konda Road Project			
Station:Km	30% (36+000)+70%(38+600)			
Sieve size (mm)	Mass of Retain on Each Sieve (g)	Percentage of Retained Soil	Percentage of cumulative Retained Soil	Percentage of Passing Soil Particle
9.500	35.210	3.52	3.52	96.48
4.750	14.760	1.48	5.00	95.00
2.000	27.340	2.73	7.73	92.27
0.850	25.160	2.52	10.25	89.75
0.425	43.220	4.32	14.57	85.43
0.250	45.920	4.59	19.16	80.84
0.150	47.980	4.80	23.96	76.04
0.075	47.045	4.70	28.66	71.34
pan	713.365	71.34	100.00	0.00
sum	1000.000			

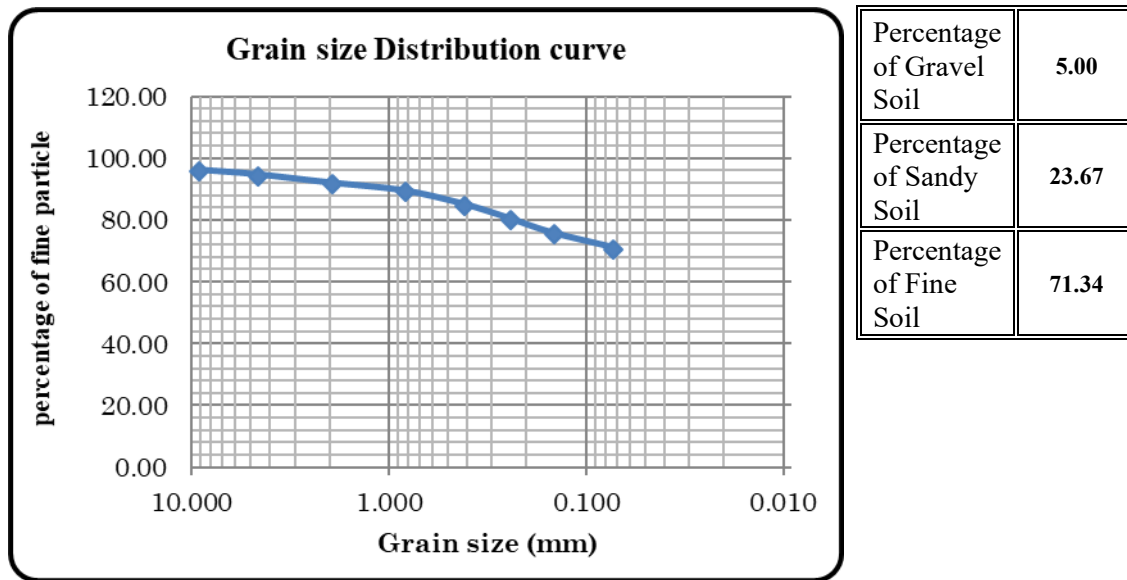
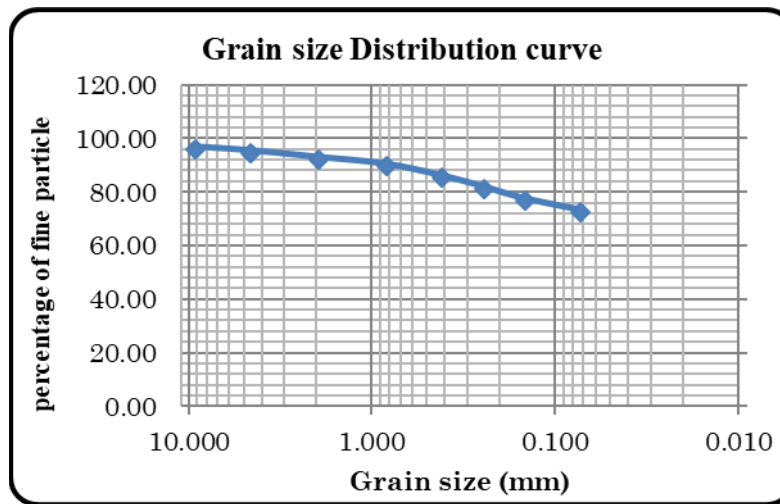


Fig C.2.5 Grain size analysis for station 30%36+000km+70%38+600km

Table 4.4C Grain size analysis for station 40%36+000km+60%38+600km

Method of Testing:	Grain Size Analysis (ASTM D-421)			
Method of Testing:	Wet Sieve Analysis			
Wt. of Sample: (g)	1 Kg			
Sample Station:	Gimbo-Konda Road Project			
Station:km	40% 36+000+60%(38+600)			
Sieve size (mm)	Mass of Retain on Each Sieve (g)	Percentage of Retained Soil	Percentage of cumulative Retained Soil	Percentage of Passing Soil Particle
9.500	30.180	3.02	3.02	96.98
4.750	13.580	1.36	4.38	95.62
2.000	24.920	2.49	6.87	93.13
0.850	25.380	2.54	9.41	90.59
0.425	42.160	4.22	13.62	86.38
0.250	41.760	4.18	17.80	82.20
0.150	43.540	4.35	22.15	77.85
0.075	42.960	4.30	26.45	73.55
pan	735.520	73.55	100.00	0.00
sum	1000.000			



Percentage of Gravel Soil	4.38
Percentage of Sandy Soil	22.07
Percentage of Fine Soil	73.55

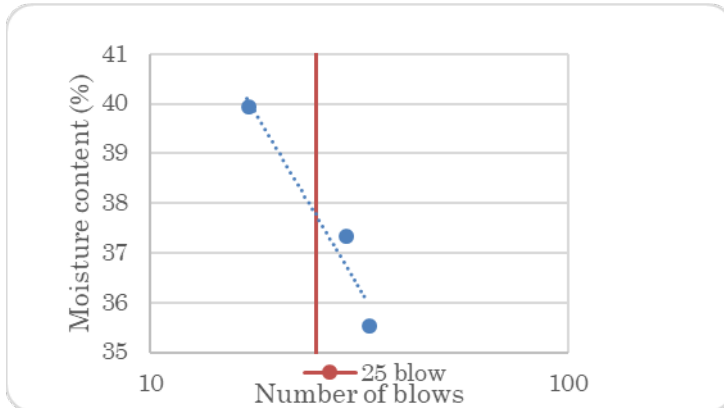
Fig C.2.6 Grain size analysis for station 40%36+000km+60%38+600km

4.4D Atterberg Limits and Linear shrinkage of partially replaced expansive soil samples

Table 4.4D Liquid limit, plastic limit and linear shrinkage for station 20%3+000km+80%4+200km

Material Station:	Gimbo-Konda Road Project					
Station,km	20%(3+000)+80%(4+200)					
Determination	Liquid Limit (D-4318)			Plastic Limit (D-4318)		
Number of blows	33	29	17			
Test No	01	02	03	01	02	
Wt. of Container, (g)	37.00	32.70	18.00	16.40	18.90	
Wt. of container + wet soil, (g)	51.10	48.50	31.30	24.70	27.20	
Wt. of container + dry soil, (g)	47.40	44.20	27.50	22.90	25.40	
Wt. of water, (g)	3.70	4.30	3.80	1.80	1.80	
Wt. of dry soil, (g)	10.40	11.50	9.50	6.50	6.50	
Moisture container, (%)	35.58	37.39	40.00	27.69	27.69	
Average	37.80			27.69		

LINEAR SHRINKAGE (BS1377:Part 2:1990)		
Station;km	20%(3+000)+80%(4+200)	
Test No	1	2
Initial Length L0	140.00	140.00
Oven dried Length LD	135.50	135.20
Linear shrinkage, Ls	0.03	0.03
Percentage of Linear Shrinkage(%)	3.21	3.43
Average Percentage of Linear Shrinkage(%)	3.32	



Determination of (PI) (LL - PL)	LL (%)	38
	PL (%)	28
	PI (%)	10
	LS(%)	3.32

Fig C.3.1 Liquid limit 20%3+000km+80%4+200km

Table 4.4D Liquid limit, plastic limit and linear shrinkage for station
30%3+000km+70%4+200km

Material Station:	Gimbo-Konda Road Project				
Station,km	30%(3+000)+70%(4+200)				
Determination	Liquid Limit (D-4318)			Plastic Limit (D-4318)	
Number of blows	26	24	20		
Test No	01	02	03	01	02
Wt. of Container, (g)	25.10	19.70	17.00	19.80	6.50
Wt. of container + wet soil, (g)	37.10	33.80	26.50	30.40	15.30
Wt. of container + dry soil, (g)	33.80	29.75	23.60	28.10	13.40
Wt. of water, (g)	3.30	4.05	2.90	2.30	1.90
Wt. of dry soil, (g)	8.70	10.05	6.60	8.30	6.90
Moisture container, (%)	37.93	40.30	43.94	27.71	27.54
Average	39.00			27.62	

LINEAR SHRINKAGE (BS1377:Part 2:1990)		
Station;km	30%(3+000)+70%(4+200)	
Test No	1	2
Initial Length L ₀	140.00	140.00
Oven dried Length L _D	130.10	130.00
Linear shrinkage, L _s	0.05	0.05
Percentage of Linear Shrinkage(%)	5.54	5.54
Average Percentage of Linear Shrinkage(%)	5.54	

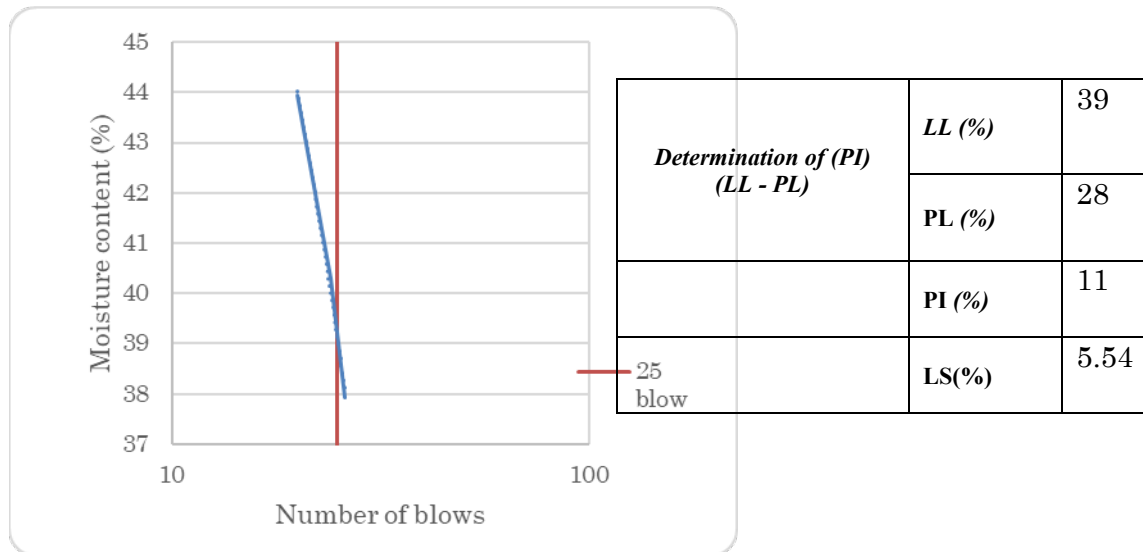
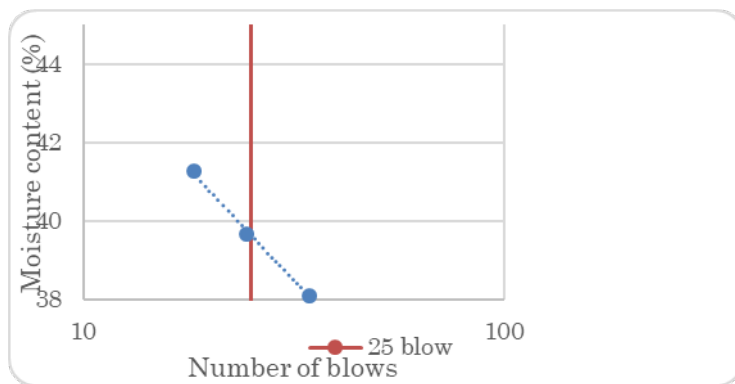


Fig C.3.2 Liquid limit 30%3+000km+70%4+200km

Table 4.4D Liquid limit, plastic limit and linear shrinkage for station
40%3+000km+60%4+200km

Material Station:	Gimbo-Konda Road Project						
Station,km	40%(3+000)+60%(4+200)						
Determination	Liquid Limit (D-4318)			Plastic Limit (D-4318)		LINEAR SHRINKAGE (BS1377:Part 2:1990)	
Number of blows	34	24	18				
Test No	01	02	03	01	Station;km	40%(3+000)+60%(4+200)	
Wt. of Container, (g)	6.40	6.10	20.20	6.10	Test No	1	2
Wt. of container + wet soil, (g)	21.60	17.00	30.80	16.30	Initial Length L0	140.00	140.00
Wt. of container + dry soil, (g)	17.40	13.90	27.70	14.10	Oven dried Length LD	130.10	130.00
Wt. of water, (g)	4.20	3.10	3.10	2.20	Linear shrinkage,Ls	0.07	0.07
Wt. of dry soil, (g)	11.00	7.80	7.50	8.00	Percentage of Linear Shrinkage(%)	7.07	7.14
Moisture container, (%)	38.18	39.74	41.33	27.50	Average Percentage of Linear Shrinkage(%)	7.11	
Average	39.80			27.27			



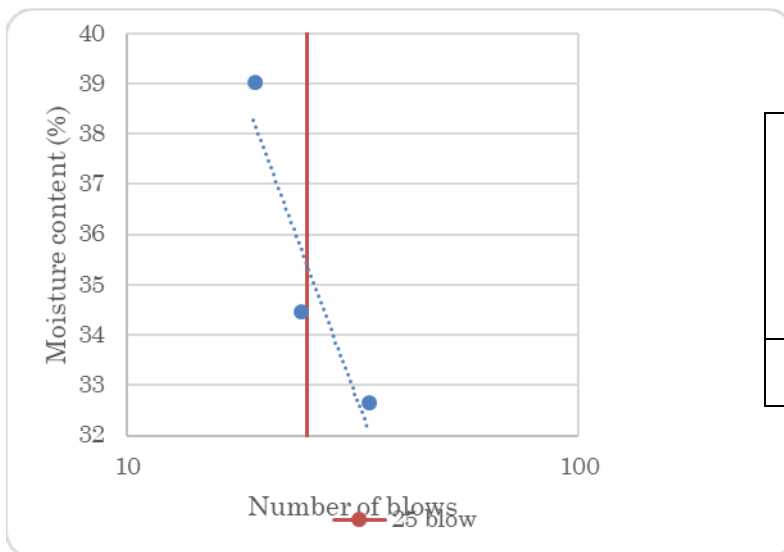
Determination of (PI) (LL - PL)	LL (%)	40
	PL (%)	27
	PI (%)	13
	LS(%)	7.11

Fig C.3.3 Liquid limit 40%3+000km+60%4+200km

Table 4.4D Liquid limit, plastic limit and linear shrinkage for station
20%6+000km+80%4+200km

Material Station:	Gimbo-Konda Road Project				
Station,km	20%(6+000)+80%(4+200)				
Determination	Liquid Limit (D-4318)			Plastic Limit (D-4318)	
Number of blows	34	24	19		
Test No	01	02	02	01	02
Wt. of Container, (g)	9.61	16.06	16.46	6.04	6.22
Wt. of container + wet soil, (g)	26.85	31.45	32.38	14.06	12.55
Wt. of container + dry soil, (g)	22.60	27.50	27.91	12.40	11.23
Wt. of water, (g)	4.25	3.95	4.47	1.66	1.32
Wt. of dry soil, (g)	13.00	11.44	11.45	6.36	5.01
Moisture container, (%)	32.71	34.52	39.07	26.16	26.23
Average	35.50			26.19	

LINEAR SHRINKAGE (BS1377:Part 2:1990)		
Station;km	20%(6+000)+80%(4+200)	
Test No	1	2
Initial Length L0	140.00	140.00
Oven dried Length LD	137.18	137.06
Linear shrinkage, Ls	0.02	0.02
Percentage of Linear Shrinkage(%)	2.01	2.10
Average Percentage of Linear Shrinkage(%)	2.06	



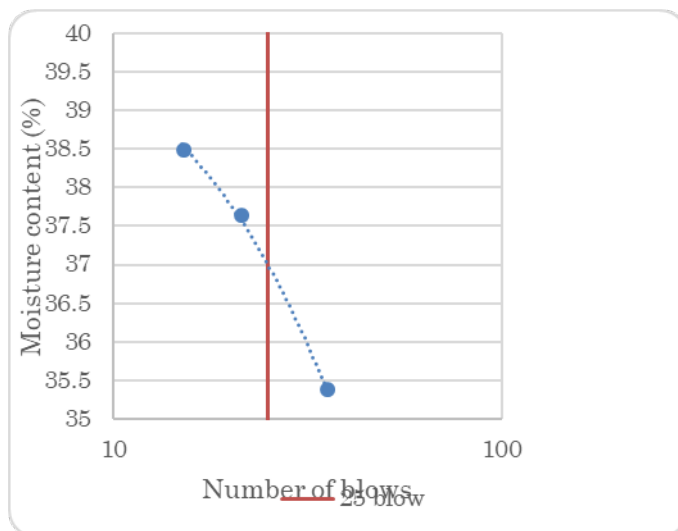
Determination of (PI) (LL - PL)	LL (%)	36
	PL (%)	26
	PI (%)	9
	LS(%)	2.06

Fig C.3.6 Liquid limit 20%6+000km+80%4+200km

Table 4.4D Liquid limit, plastic limit and linear shrinkage for station
30%6+000km+70%4+200km

Material Station:	Gimbo-Konda Road Project				
Station,km	30%(6+000)+70%(4+200)				
Determination	Liquid Limit (D-4318)			Plastic Limit (D-4318)	
Number of blows	35	21	15		
Test No	01	02	02	01	02
Wt. of Container, (g)	6.00	5.50	16.50	6.00	19.50
Wt. of container + wet soil, (g)	25.50	24.50	33.40	12.10	29.00
Wt. of container + dry soil, (g)	20.40	19.30	28.70	11.20	26.46
Wt. of water, (g)	5.10	5.20	4.70	0.90	2.54
Wt. of dry soil, (g)	14.40	13.80	12.20	5.20	6.96
Moisture container, (%)	35.42	37.68	38.52	17.31	36.51
Average	37.00			26.91	

LINEAR SHRINKAGE (BS1377:Part 2:1990)		
Station;km	30%(6+000)+70%(4+200)	
Test No	1	2
Initial Length L0	140.00	140.00
Oven dried Length LD	135.77	135.59
Linear shrinkage, Ls	0.03	0.03
Percentage of Linear Shrinkage(%)	3.02	3.15
Average Percentage of Linear Shrinkage(%)	3.08	



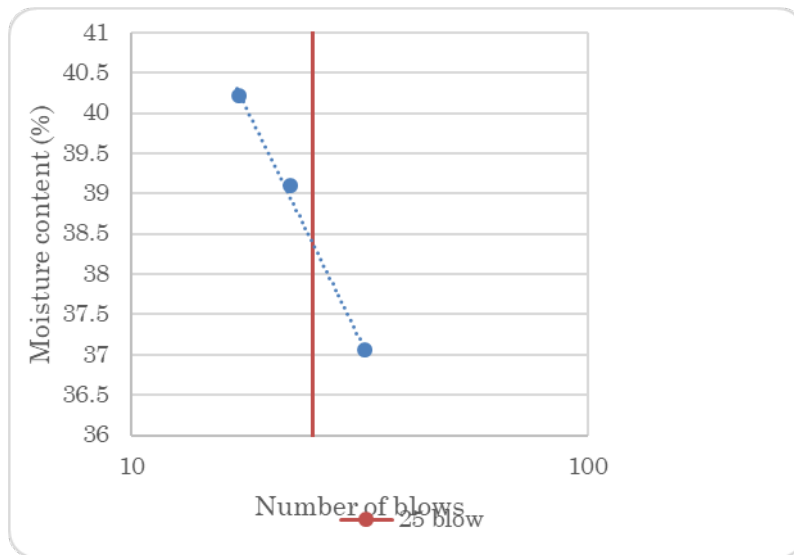
Determination of (PI) (LL - PL)	LL (%)	37
	PL (%)	27
	PI (%)	10
	LS(%)	3.08

Fig C.3.6 Liquid limit 30%6+000km+70%4+200km

Table 4.4D Liquid limit, plastic limit and linear shrinkage for station
40%6+000km+60%4+200km

Material Station:	Gimbo-Konda Road Project				
Station,km	40%(6+000)+60%(4+200)				
Determination	Liquid Limit (D-4318)			Plastic Limit (D-4318)	
Number of blows	32	22	17		
Test No	01	02	02	01	02
Wt. of Container, (g)	5.60	19.60	6.00	6.10	6.50
Wt. of container + wet soil, (g)	14.10	29.20	17.50	15.00	17.30
Wt. of container + dry soil, (g)	11.80	26.50	14.20	13.15	15.05
Wt. of water, (g)	2.30	2.70	3.30	1.85	2.25
Wt. of dry soil, (g)	6.20	6.90	8.20	7.05	8.55
Moisture container, (%)	37.10	39.13	40.24	26.24	26.32
Average	38.30			26.28	

LINEAR SHRINKAGE (ASTM D4943-95)		
Station;km	40%(6+000)+60%(4+200)	
Test No	1	2
Initial Length L0	140.00	140.00
Oven dried Length LD	134.36	134.12
Linear shrinkage, Ls	0.04	0.04
Percentage of Linear Shrinkage(%)	4.03	4.20
Average Percentage of Linear Shrinkage(%)	4.11	



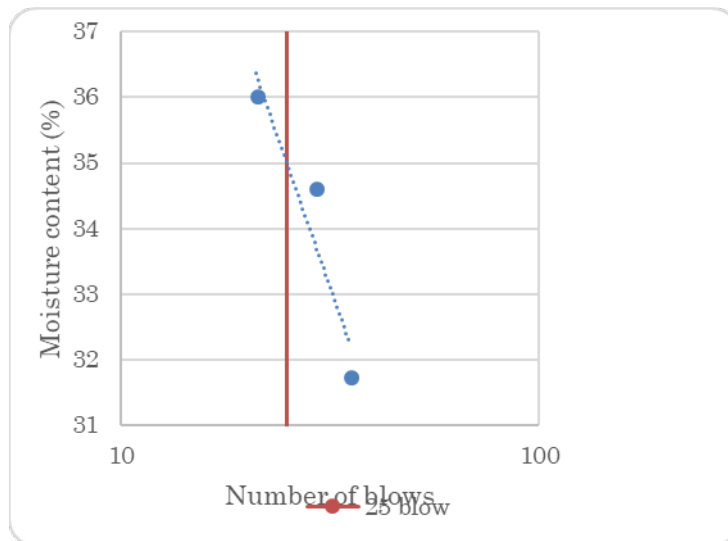
Determination of (PI) (LL - PL)	LL (%)	38
	PL (%)	26
	PI (%)	12
	LS(%)	4.11

Fig C.3.6 Liquid limit 40%6+000km+60%4+200km

Table 4.4D Liquid limit, plastic limit and linear shrinkage for station
20%9+000km+80%4+200km

Material Station:	Gimbo-Konda Road Project				
Station,km	20%(9+000)+80%(4+200)				
Determination	Liquid Limit (D-4318)			Plastic Limit (D-4318)	
Number of blows	35	29	21		
Test No	01	02	02	01	02
Wt. of Container, (g)	17.00	27.50	28.00	28.00	17.00
Wt. of container + wet soil, (g)	35.50	45.50	46.00	37.00	24.50
Wt. of container + dry soil, (g)	31.04	40.87	41.23	35.25	23.04
Wt. of water, (g)	4.46	4.63	4.77	1.75	1.46
Wt. of dry soil, (g)	14.04	13.37	13.23	7.25	6.04
Moisture container, (%)	31.77	34.63	36.05	24.14	24.17
Average	35.00			24.16	

LINEAR SHRINKAGE (BS1377:Part 2:1990)		
Station;km	20%(9+000)+80%(4+200)	
Test No	1	2
Initial Length L0	140.00	140.00
Oven dried Length LD	137.02	137.00
Linear shrinkage, Ls	0.02	0.02
Percentage of Linear Shrinkage(%)	2.13	2.14
Average Percentage of Linear Shrinkage(%)	2.14	



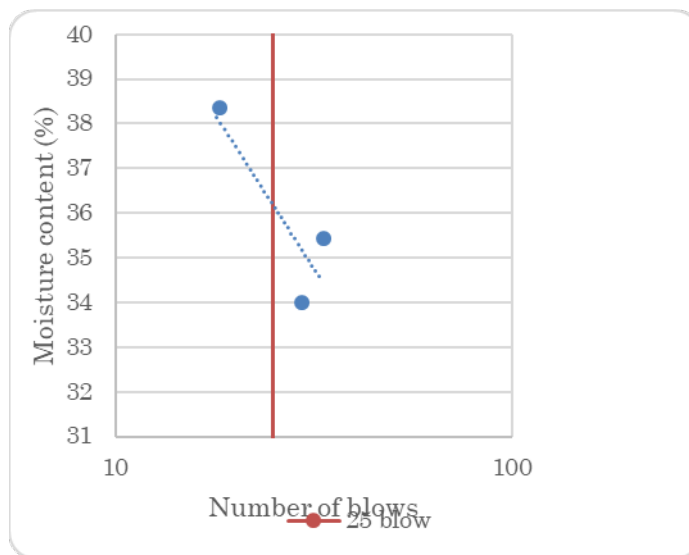
Determination of (PI) (LL - PL)	LL (%)	35
	PL (%)	24
	PI (%)	11
	LS(%)	2.14

Fig C.3.6 Liquid limit 20%9+000km+80%4+200km

Table 4.4D Liquid limit, plastic limit and linear shrinkage for station
30%9+000km+70%4+200km

Material Station:	Gimbo-Konda Road Project				
Station,km	30%(9+000)+70%(4+200)				
Determination	Liquid Limit (D-4318)			Plastic Limit (D-4318)	
Number of blows	33	29	18		
Test No	01	02	02	01	02
Wt. of Container, (g)	18.78	16.30	6.49	5.76	17.37
Wt. of container + wet soil, (g)	37.45	35.08	28.10	11.50	24.00
Wt. of container + dry soil, (g)	32.56	30.31	22.10	10.40	22.70
Wt. of water, (g)	4.89	4.77	6.00	1.10	1.30
Wt. of dry soil, (g)	13.78	14.01	15.61	4.64	5.33
Moisture container, (%)	35.48	34.06	38.41	23.72	24.40
Average	36.10			24.06	

LINEAR SHRINKAGE (BS1377:Part 2:1990)		
Station;km	30%(9+000)+70%(4+200)	
Test No	1	2
Initial Length L0	140.00	140.00
Oven dried Length LD	135.53	135.50
Linear shrinkage, Ls	0.03	0.03
Percentage of Linear Shrinkage(%)	3.19	3.21
Average Percentage of Linear Shrinkage(%)	3.20	



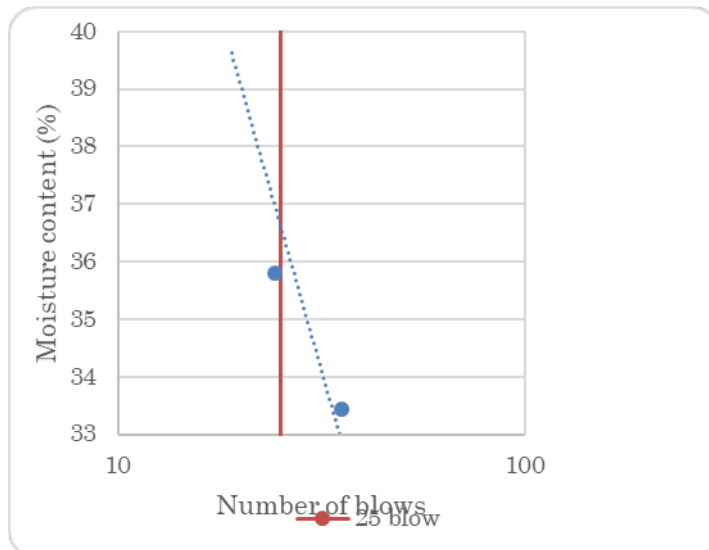
Determination of (PI) (LL - PL)	LL (%)	36
	PL (%)	24
	PI (%)	12
	LS(%)	3.20

Fig C.3.6 Liquid limit 30%9+000km+70%4+200km

Table 4.4D Liquid limit, plastic limit and linear shrinkage for station
40%9+000km+60%4+200km

Material Station:	Gimbo-Konda Road Project				
Station,km	40%(9+000)+60%(4+200)				
Determination	Liquid Limit (D-4318)			Plastic Limit (D-4318)	
Number of blows	35	24	19		
Test No	01	02	02	01	02
Wt. of Container, (g)	6.41	19.32	5.54	17.30	5.78
Wt. of container + wet soil, (g)	24.82	39.40	22.47	25.84	13.03
Wt. of container + dry soil, (g)	20.20	34.10	17.60	24.18	11.61
Wt. of water, (g)	4.62	5.30	4.87	1.66	1.42
Wt. of dry soil, (g)	13.79	14.79	12.06	6.88	5.83
Moisture container, (%)	33.49	35.84	40.40	24.12	24.29
Average	36.90			24.21	

LINEAR SHRINKAGE (BS1377:Part 2:1990)		
Station;km	40%(9+000)+60%(4+200)	
Test No	1	2
Initial Length L0	140.00	140.00
Oven dried Length LD	134.04	134.00
Linear shrinkage, Ls	0.04	0.04
Percentage of Linear Shrinkage(%)	4.26	4.29
Average Percentage of Linear Shrinkage(%)	4.27	



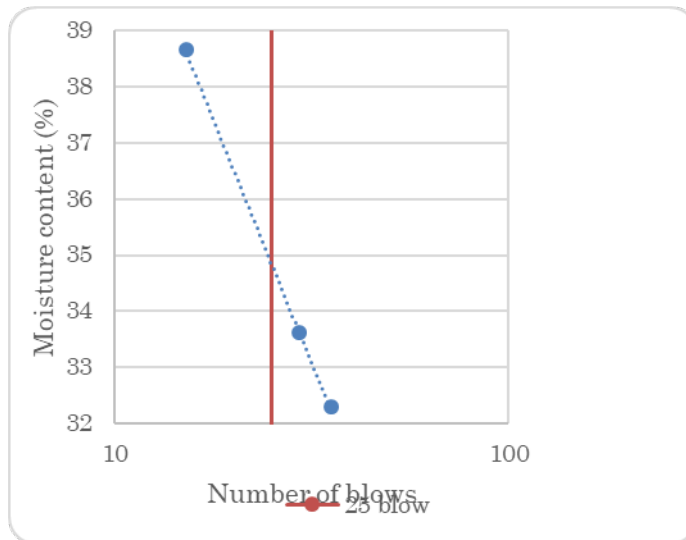
Determination of (PI) (LL - PL)	LL (%)	37
	PL (%)	24
	PI (%)	13
	LS(%)	4.27

Fig C.3.6 Liquid limit 40%9+000km+60%4+200km

Table 4.4D Liquid limit, plastic limit and linear shrinkage for station
20%36+000km+80%38+600km

Material Station:	Gimbo-Konda Road Project				
Station,km	20% (36+000)+80%(38+600)				
Determination	Liquid Limit (D-4318)			Plastic Limit (D-4318)	
Number of blows	35	29	15		
Test No	01	02	03	01	02
Wt. of Container, (g)	41.20	35.50	17.50	5.60	5.50
Wt. of container + wet soil, (g)	54.70	49.00	30.40	18.70	21.90
Wt. of container + dry soil, (g)	51.40	45.60	26.80	16.06	18.62
Wt. of water, (g)	3.30	3.40	3.60	2.64	3.28
Wt. of dry soil, (g)	10.20	10.10	9.30	10.46	13.12
Moisture container, (%)	32.35	33.66	38.71	25.24	25.00
Average	34.80			25.12	

LINEAR SHRINKAGE (BS1377:Part 2:1990)		
Station;km	20% (36+000)+80%(38+600)	
Test No	1	2
Initial Length L0	140.00	140.00
Oven dried Length LD	135.50	135.20
Linear shrinkage, Ls	0.03	0.03
Percentage of Linear Shrinkage(%)	3.21	3.43
Average Percentage of Linear Shrinkage(%)	3.32	



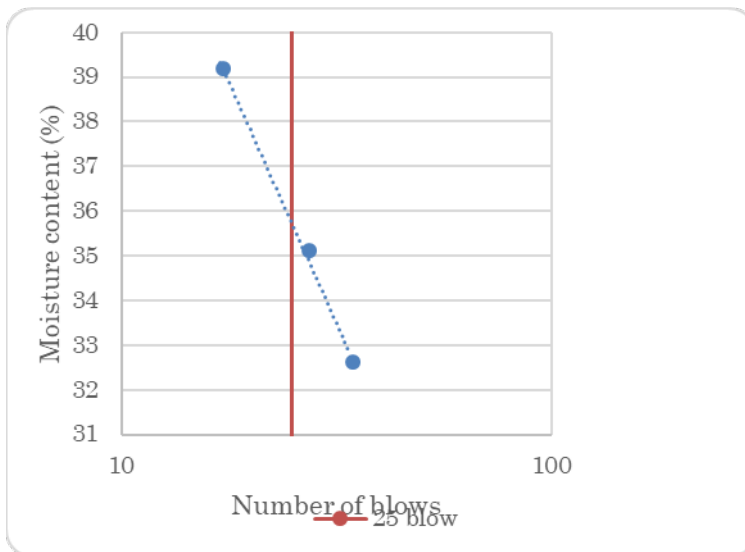
Determination of (PI) (LL - PL)	LL (%)	35
	PL (%)	25
	PI (%)	10
	LS(%)	3.32

Fig C.3.6 Liquid limit 20%36+000km+80%38+600km

Table 4.4D Liquid limit, plastic limit and linear shrinkage for station
30%36+000km+70%38+600km

Material Station:	Gimbo-Konda Road Project				
Station,km	30% (36+000)+70%(38+600)				
Determination	Liquid Limit (D-4318)			Plastic Limit (D-4318)	
Number of blows	34	27	17		
Test No	01	02	03	01	02
Wt. of Container, (g)	17.50	18.00	28.70	5.80	6.30
Wt. of container + wet soil, (g)	31.30	32.60	39.70	15.70	16.00
Wt. of container + dry soil, (g)	27.90	28.80	36.60	13.70	14.05
Wt. of water, (g)	3.40	3.80	3.10	2.00	1.95
Wt. of dry soil, (g)	10.40	10.80	7.90	7.90	7.75
Moisture container, (%)	32.69	35.19	39.24	25.32	25.16
Average	36.00			25.24	

LINEAR SHRINKAGE (BS1377:Part 2:1990)		
Station;km	30% (36+000)+70%(38+600)	
Test No	1	2
Initial Length L0	140.00	140.00
Oven dried Length LD	132.50	132.50
Linear shrinkage, Ls	0.05	0.05
Percentage of Linear Shrinkage(%)	5.36	5.36
Average Percentage of Linear Shrinkage(%)	5.36	



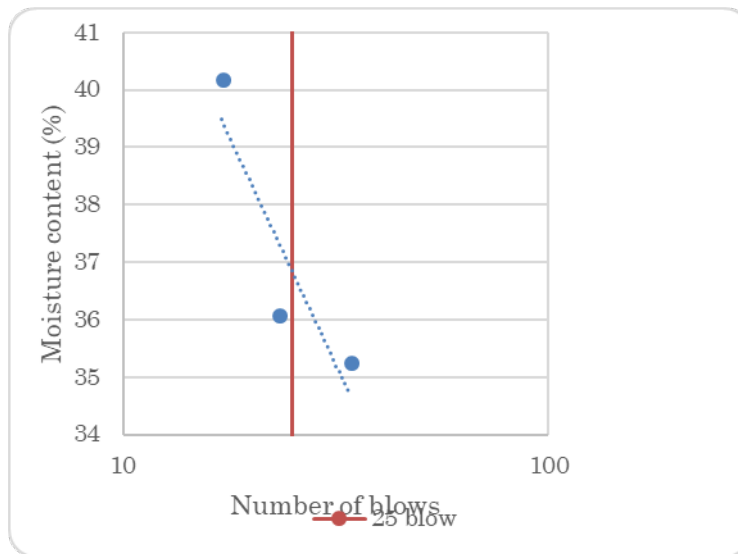
Determination of (PI) (LL - PL)	LL (%)	36
	PL (%)	25
	PI (%)	11
	LS(%)	5.36

Fig C.3.6 Liquid limit 30%36+000km+70%38+600km

Table 4.4D Liquid limit, plastic limit and linear shrinkage for station
40%36+000km+60%38+600km

Material Station:	Gimbo-Konda Road Project				
Station,km	40% (36+000)+60%(38+600)				
Determination	Liquid Limit (D-4318)			Plastic Limit (D-4318)	
Number of blows	34	23	17		
Test No	01	02	03	01	02
Wt. of Container, (g)	33.40	17.90	17.30	5.90	17.00
Wt. of container + wet soil, (g)	47.20	32.30	30.20	11.80	24.20
Wt. of container + dry soil, (g)	43.60	28.48	26.50	10.60	22.75
Wt. of water, (g)	3.60	3.82	3.70	1.20	1.45
Wt. of dry soil, (g)	10.20	10.58	9.20	4.70	5.75
Moisture container, (%)	35.29	36.11	40.22	25.53	25.22
Average	36.90			25.37	

LINEAR SHRINKAGE (BS1377:Part 2:1990)		
Station;km	40% (36+000)+60%(38+600)	
Test No	1	2
Initial Length L0	140.00	140.00
Oven dried Length LD	130.10	130.00
Linear shrinkage, Ls	0.07	0.07
Percentage of Linear Shrinkage(%)	7.07	7.14
Average Percentage of Linear Shrinkage(%)	7.11	



Determination of (PI) (LL - PL)	LL (%)	37
	PL (%)	25
	PI (%)	12
	LS(%)	7.11

Fig C.3.6 Liquid limit 40%3+000km+60%4+200km

4.4E Free Swell Test

Table 4.4E free swell of partially replaced expansive soil samples

Free swell of soil		
Station;km	20% 3+000+80%(4+200)	
	Initial volume (ml)	Final volume (ml)
Trials	11.80	15.82
free swell in %	34.07	

Free swell of soil		
Station;km	30% 3+000+70%(4+200)	
	Initial volume (ml)	Final volume (ml)
Trials	12.20	17.73
free swell in %	45.33	

Free swell of soil		
Station;km	40% 3+000+60%(4+200)	
	Initial volume (ml)	Final volume (ml)
Trials	12.60	19.64
free swell in %	48.87	

Free swell of soil		
Station;km	20%(6+000)+80%(4+200)	
	Initial volume (ml)	Final volume (ml)
Test No	11.80	15.26
free swell in %	29.32	

Free swell of soil		
Station;km	30%(6+000)+70%(4+200)	
	Initial volume (ml)	Final volume (ml)
Test No	12.20	17.24
free swell in %	41.31	

Free swell of soil		
Station;km	40%(6+000)+60%(4+200)	
	Initial volume (ml)	Final volume (ml)
Test No	12.60	19.22
free swell in %	49.54	

Free swell of soil		
Station;km	20%(9+000)+80%(4+200)	
	Initial volume (ml)	Final volume (ml)
Test No	11.40	14.32
free swell in %	25.61	

Free swell of soil		
Station;km	30%(9+000)+70%(4+200)	
	Initial volume (ml)	Final volume (ml)
Test No	11.60	15.83
free swell in %	36.47	

Free swell of soil		
Station;km	20%(36+000)+80%(38+600)	
	Initial volume (ml)	Final volume (ml)
Trials	11.20	14.46
free swell in %	29.11	

Free swell of soil		
Station;km	40%(9+000)+60%(4+200)	
	Initial volume (ml)	Final volume (ml)
Test No	11.80	17.34
free swell in %	46.95	

Free swell of soil		
Station;km	30% (36+000)+70%(38+600)	
	Initial volume (ml)	Final volume (ml)
Trials	11.30	15.69
free swell in %	38.85	

Free swell of soil		
Station;km	40% 36+000+60%(38+600)	
	Initial volume (ml)	Final volume (ml)
Trials	11.40	16.92
free swell in %	48.42	

4.4F. Modified Proctor Compaction Test (ASTM D 698)

Table 4.4F Modified proctor compaction result of partially replaced expansive soil samples

Table 4.4F Modified proctor compaction result for station 20%3+000km+80%4+200km

Trial No.	Mass of compacted soil + mold, g	Wet unit weight (gm/cm ³)	Moisture content Determination				Average Moisture content, %	Dry unit weight (gm/cm ³)
			Mass of can, g	Mass of wet soil + can, g	Mass of dry soil + can, g	Moisture content, %		
1	10421.2	1.67	17.9	87.9	77.9	16.67	17.80	1.42
			37.8	162.2	142.4	18.93		
2	10977.3	1.91	36.6	179.1	152.9	22.53	22.46	1.56
			17.2	108.5	91.8	22.39		
3	10884.5	1.87	17.4	77.4	64.7	26.85	25.95	1.49
			17.7	122.5	101.5	25.06		
4	10045.3	1.51	26.7	127.3	104.3	29.64	29.67	1.16
			18	77	63.5	29.67		

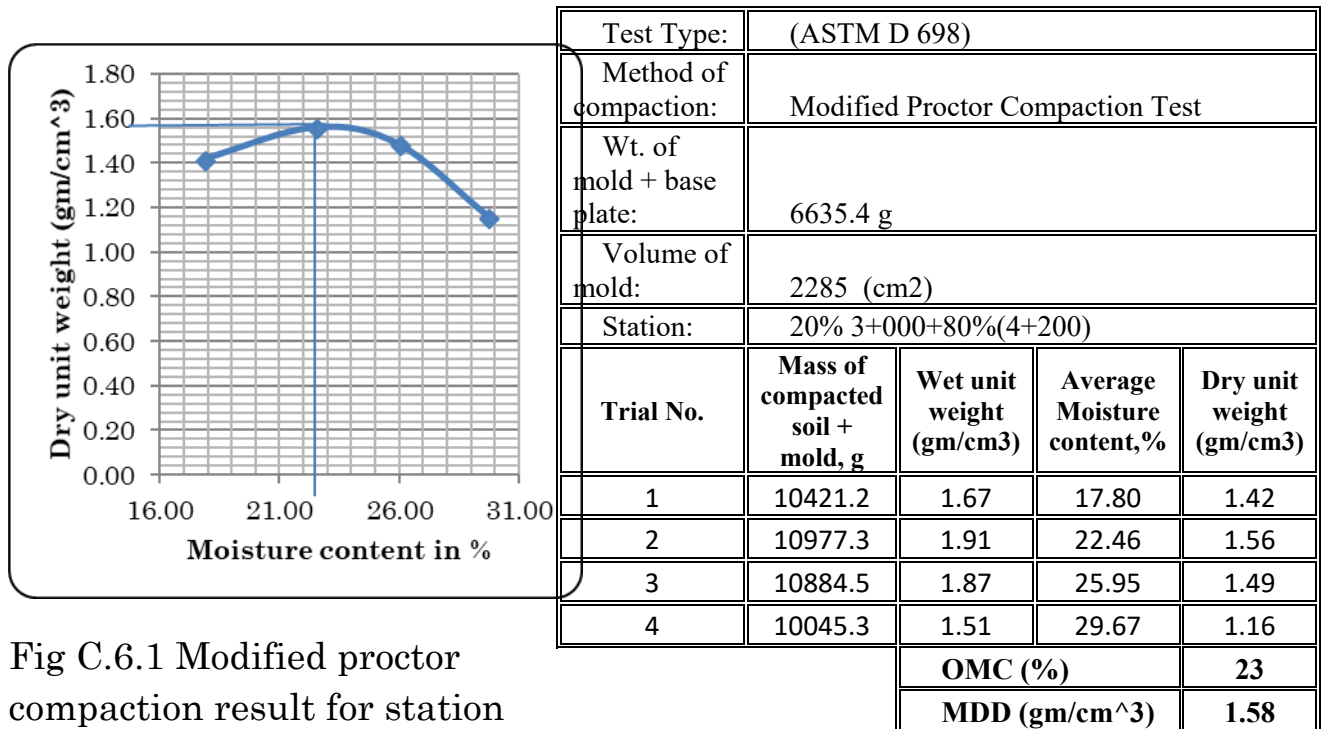
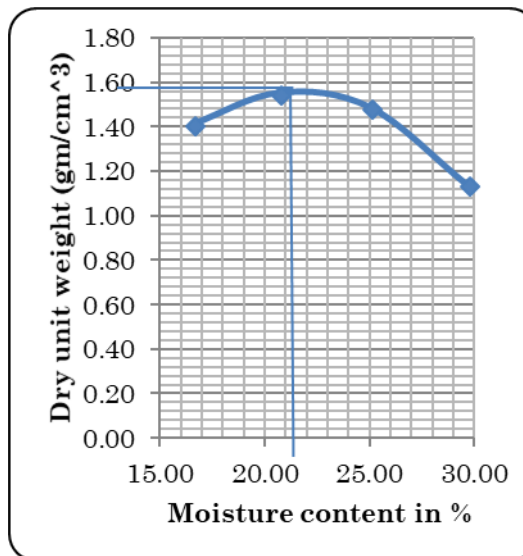


Fig C.6.1 Modified proctor compaction result for station 20%3+000km+80%4+200km

Table 4.4F Modified proctor compaction result for station 30%3+000km+70%4+200km

Trial No.	Mass of compacted soil + mold, g	Wet unit weight (gm/cm ³)	Moisture content Determination				Average Moisture content, %	Dry unit weight (gm/cm ³)
			Mass of can, g	Mass of wet soil + can, g	Mass of dry soil + can, g	Moisture content, %		
1	10401.2	1.65	17.6	103	91	16.35	16.60	1.41
			37.8	150.1	133.9	16.86		
2	10917.3	1.87	17.2	108.5	93	20.45	20.71	1.55
			17.4	77.4	67	20.97		
3	10884.5	1.86	16.8	126.1	104	25.34	25.03	1.49
			20.1	121	101	24.72		
4	10015.3	1.48	17.6	140	112	29.66	29.67	1.14
			18	77	63.5	29.67		

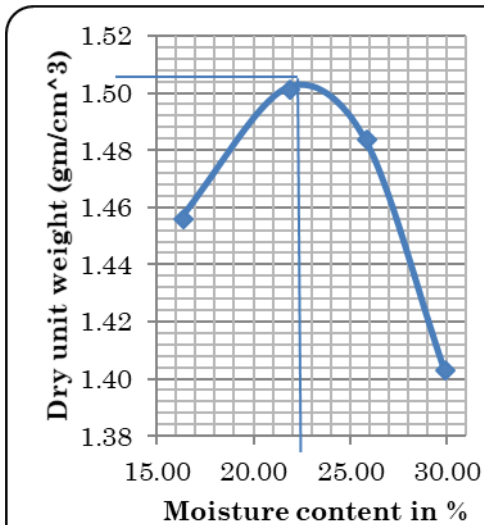


Test Type:	(ASTM D 1557, AASHTO T-180)			
Method of compaction:	Modified Proctor Compaction Test			
Wt. of mold + base plate:	4044 g			
Volume of mold:	2285 (cm ²)			
Station	30% 3+000+70%(4+200)			
Trial No.	Mass of compacted soil + mold, g	Wet unit weight (gm/cm ³)	Average Moisture content, %	Dry unit weight (gm/cm ³)
1	10401.2	1.65	16.60	1.41
2	10917.3	1.87	20.71	1.55
3	10884.5	1.86	25.03	1.49
4	10015.3	1.48	29.67	1.14
			OMC (%)	22
			MDD (gm/cm ³)	1.57

Fig C.6.2 Modified proctor compaction result for station 30%3+000km+70%4+200km

Table 4.4F Modified proctor compaction result for station 40%3+000km+60%4+200km

Trial No.	Mass of compacted soil + mold, g	Wet unit weight (gm/cm ³)	Moisture content Determination				Average Moisture content, %	Dry unit weight (gm/cm ³)
			Mass of can, g	Mass of wet soil + can, g	Mass of dry soil + can, g	Moisture content, %		
1	10505.5	1.69	17.6	106.2	93.8	16.27	16.27	1.46
			17.6	106.2	93.8	16.27		
2	10813.4	1.83	25.2	158.4	135.8	20.43	21.73	1.50
			17.3	110.8	93.3	23.03		
3	10899.9	1.87	17.7	120	99.4	25.21	25.73	1.48
			17.7	106.2	87.8	26.25		
4	10800	1.82	25.3	130.2	106.3	29.51	29.82	1.40
			21.3	95.3	78.3	29.82		



Test Type:	(ASTM D 1557, AASHTO T-180)			
Method of compaction:	Modified Proctor Compaction Test			
Wt. of mold + base plate:	6635.4 g			
Volume of mold:	2285 (cm ³)			
Station:	40% 3+000+60%(4+200)			
Trial No.	Mass of compacted soil + mold, g	Wet unit weight (gm/cm ³)	Average Moisture content, %	Dry unit weight (gm/cm ³)
1	10505.5	1.69	16.27	1.46
2	10813.4	1.83	21.73	1.50
3	10899.9	1.87	25.73	1.48
4	10800	1.82	29.82	1.40
			OMC (%)	23.5
			MDD (gm/cm ³)	1.51

Fig C.6.3 Modified proctor compaction result for station 40%3+000km+60%4+200km

Table 4.4F Modified proctor compaction result for station 20%36+000km+80%38+600km

Trial No.	Mass of compacted soil + mold, g	Wet unit weight (gm/cm ³)	Moisture content Determination				Average Moisture content, %	Dry unit weight (gm/cm ³)
			Mass of can, g	Mass of wet soil + can, g	Mass of dry soil + can, g	Moisture content, %		
1	10650	1.76	17.4	94.5	84.4	15.07	15.17	1.53
			17.7	97	86.5	15.26		
2	10956	1.89	17.5	71	62.4	19.15	19.41	1.58
			17.7	75.5	66	19.67		
3	10989	1.91	17.5	87.5	73.9	24.11	24.07	1.54
			17.9	84.5	71.6	24.02		
4	10860	1.85	18	77	63.9	28.54	28.54	1.44
			18	77	63.9	28.54		

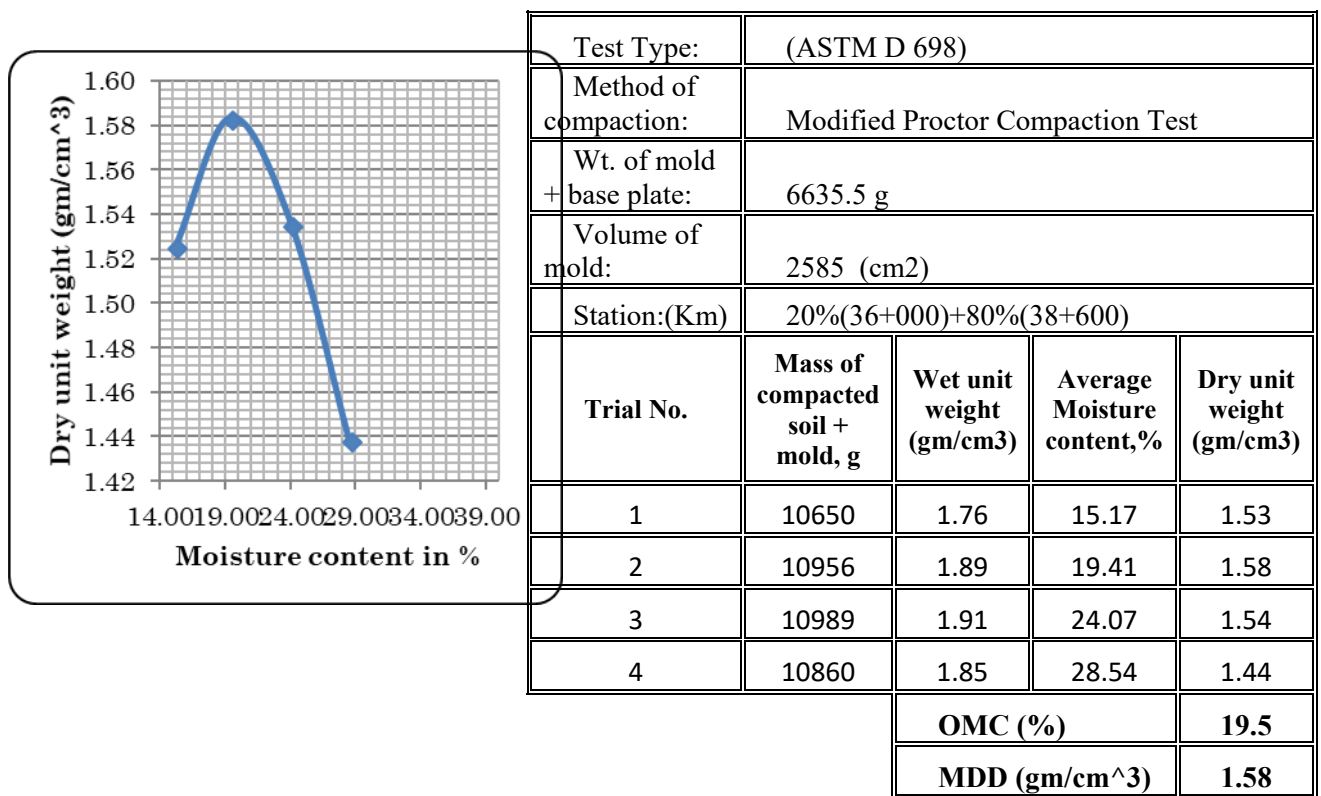
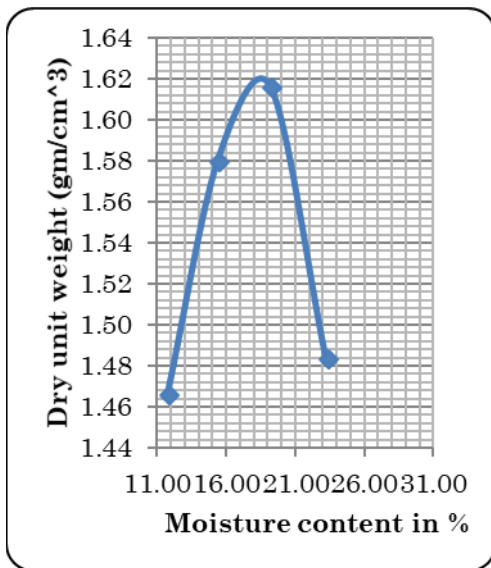


Fig C.6.4 Modified proctor compaction result for station 20%36+000km+80%38+600km

Table 4.4F Modified proctor compaction result for station 20%6+000km+80%4+200km

Trial No.	Mass of compacted soil + mold, g	Wet unit weight (gm/cm ³)	Moisture content Determination				Average Moisture content, %	Dry unit weight (gm/cm ³)
			Mass of can, g	Mass of wet soil + can, g	Mass of dry soil + can, g	Moisture content, %		
1	10322.6	1.64	30.04	141.76	129.64	12.17	11.73	1.47
			20.5	112.65	103.3	11.29		
2	10744.6	1.82	31.8	153.06	136.64	15.66	15.37	1.58
			21.98	121.92	108.82	15.09		
3	10980.6	1.93	17.06	131.9	113.5	19.08	19.16	1.62
			25.34	123.12	107.34	19.24		
4	10757.3	1.83	17.6	111.4	93.4	23.75	23.21	1.48
			19.12	124.44	104.6	23.21		

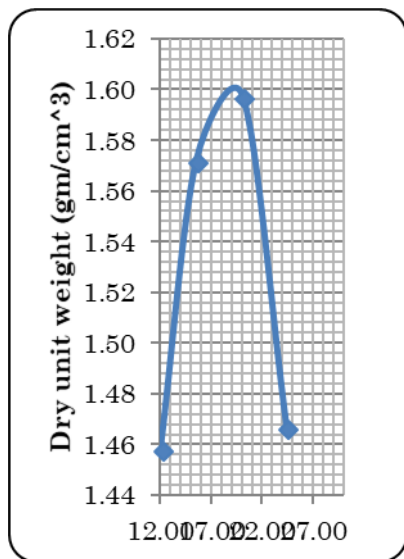


Test Type:	(ASTM D 698)			
Method of compaction:	Modified Proctor Compaction Test			
Wt. of mold + base plate:	6635.5 g			
Volume of mold:	2285 (cm ²)			
Station:	20%(6+000)+80%(4+200)			
Trial No.	Mass of compacted soil + mold, g	Wet unit weight (gm/cm ³)	Average Moisture content, %	Dry unit weight (gm/cm ³)
1	10322.6	1.64	11.73	1.47
2	10744.62	1.82	15.37	1.58
3	10980.58	1.93	19.16	1.62
4	10757.32	1.83	23.21	1.48
			OMC (%)	18.5
			MDD (gm/cm³)	1.62

Fig 4.4F Modified proctor compaction result for station 20%6+000km+80%4+200km

Table 4.4F Modified proctor compaction result for station 30%6+000km+70%4+200km

Trial No.	Mass of compacted soil + mold, g	Wet unit weight (gm/cm ³)	Moisture content Determination				Average Moisture content, %	Dry unit weight (gm/cm ³)
			Mass of can, g	Mass of wet soil + can, g	Mass of dry soil + can, g	Moisture content, %		
1	10322.3	1.63	27.03	138.34	125.81	12.68	12.08	1.46
			20.50	106.14	97.32	11.48		
2	10737.3	1.82	25.50	144.50	128.81	15.19	15.55	1.57
			23.50	115.65	103.00	15.91		
3	10970.6	1.92	20.84	131.75	113.24	20.03	20.09	1.60
			23.26	118.63	102.64	20.14		
4	10755.8	1.82	17.65	107.10	89.60	24.32	24.37	1.47
			20.98	120.51	101.01	24.37		

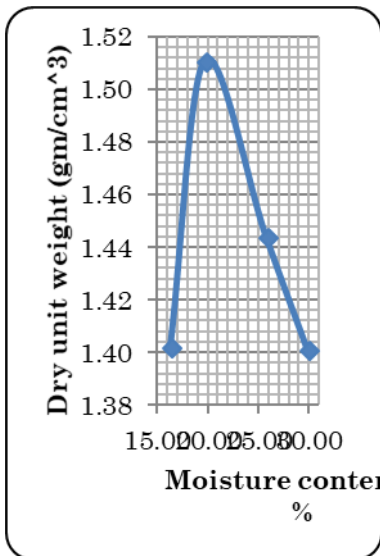


Test Type:		(ASTM D 698)		
Method of compaction:		Modified Proctor Compaction Test		
Wt. of mold + base plate:		6635.4 g		
Volume of mold:		2285 (cm ³)		
Station		30%(6+000)+70%(4+200)		
Trial No.	Mass of compacted soil + mold, g	Wet unit weight (gm/cm ³)	Average Moisture content, %	Dry unit weight (gm/cm ³)
1	10322.3	1.63	12.08	1.46
2	10737.33	1.82	15.55	1.57
3	10970.62	1.92	20.09	1.60
4	10755.83	1.82	24.37	1.47
OMC (%)				19
MDD (gm/cm ³)				1.6

Fig 4.4F Modified proctor compaction result for station 30%6+000km+70%4+200km

Table 4.4F Modified proctor compaction result for station 40%6+000km+60%4+200km

Trial No.	Mass of compacted soil + mold, g	Wet unit weight (gm/cm ³)	Moisture content Determination				Average Moisture content, %	Dry unit weight (gm/cm ³)
			Mass of can, g	Mass of wet soil + can, g	Mass of dry soil + can, g	Moisture content, %		
1	10322.0	1.63	17.6	106.2	93.8	16.27	16.27	1.40
			17.6	106.2	93.8	16.27		
2	10730.0	1.81	17.5	158.4	135.8	19.10	19.72	1.51
			17.3	110.8	95	20.33		
3	10800.0	1.82	17.7	120	99.4	25.21	25.73	1.44
			17.7	106.2	87.8	26.25		
4	10754.3	1.82	25.3	130.2	106.3	29.51	29.82	1.40
			21.3	95.3	78.3	29.82		

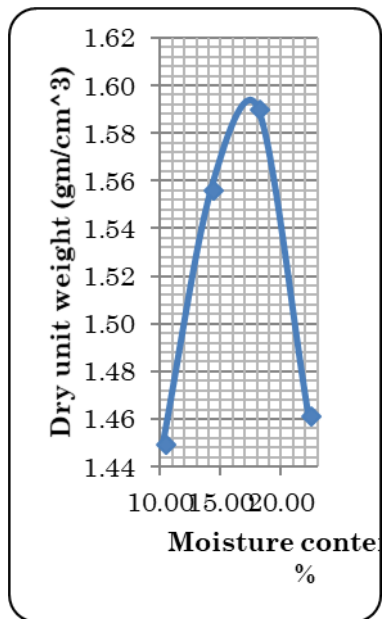


Test Type:	(ASTM D 698)				
Method of compaction:	Modified Proctor Compaction Test				
Wt. of mold + base plate:	6635.4 g				
Volume of mold:	2285 (cm ³)				
Station	40%(6+000)+60%(4+200)				
Trial No.	Mass of compacted soil + mold, g	Wet unit weight (gm/cm ³)	Average Moisture content, %	Dry unit weight (gm/cm ³)	
1	10322.3	1.63	12.08	1.46	
2	10737.33	1.82	15.55	1.51	
3	10970.62	1.92	20.09	1.52	
4	10755.83	1.82	24.37	1.47	
OMC (%)				20	
MDD (gm/cm ³)				1.52	

Fig C.6.9 Modified proctor compaction result for station 40%6+000km+60%4+200km

Table 4.4F Modified proctor compaction result for station 20%9+000km+80%4+200km

Trial No.	Mass of compacted soil + mold, g	Wet unit weight (gm/cm ³)	Moisture content Determination				Average Moisture content, %	Dry unit weight (gm/cm ³)
			Mass of can, g	Mass of wet soil + can, g	Mass of dry soil + can, g	Moisture content, %		
1	10230.0	1.60	36.93	160.01	148.44	10.37	10.29	1.45
			26.44	142.18	131.46	10.21		
2	10639.5	1.78	31.80	153.06	137.96	14.22	14.25	1.56
			21.98	134.84	120.74	14.28		
3	10868.5	1.88	21.10	151.82	131.72	18.17	18.09	1.59
			20.86	131.38	114.52	18.00		
4	10660.3	1.79	19.08	120.90	102.00	22.79	22.26	1.46
			20.50	138.38	116.92	22.26		



Test Type:	(ASTM D 698)				
Method of compaction:	Modified Proctor Compaction Test				
Wt. of mold + base plate:	6635.4 g				
Volume of mold:	2285 (cm ³)				
Station	40%(6+000)+60%(4+200)				
Trial No.	Mass of compacted soil + mold, g	Wet unit weight (gm/cm ³)	Average Moisture content, %	Dry unit weight (gm/cm ³)	
1	10322.3	1.63	12.08	1.46	
2	10737.33	1.82	15.55	1.56	
3	10970.62	1.92	20.09	1.59	
4	10755.83	1.82	24.37	1.47	
OMC (%)				17	
MDD (gm/cm ³)				1.59	

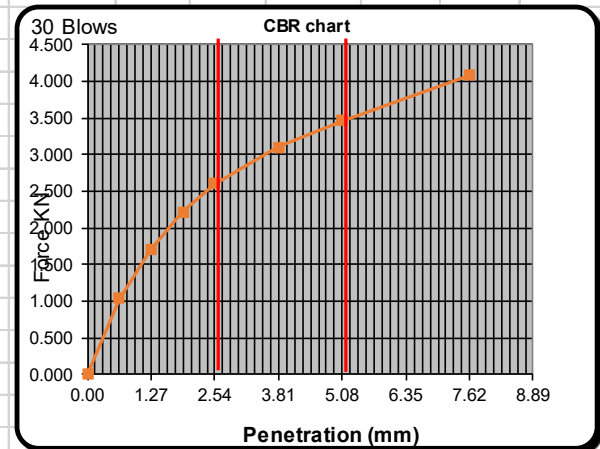
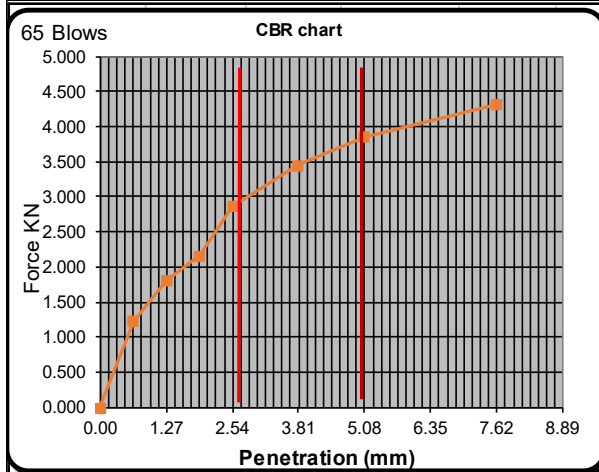
Fig C.6.10 Modified proctor compaction result for station 20%9+000km+80%4+200km

4.4G CBR test result of partially replaced expansive soil samples

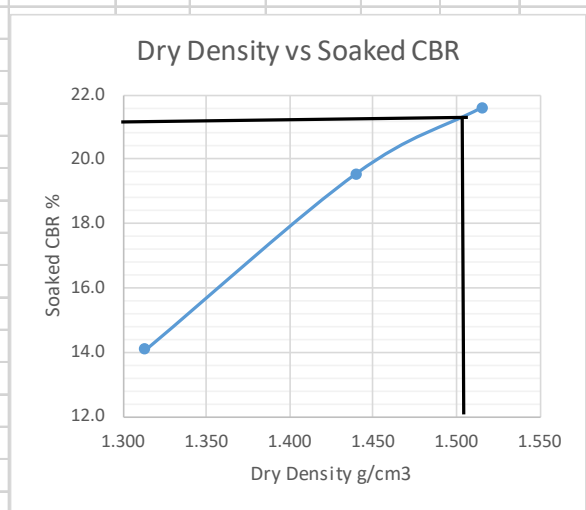
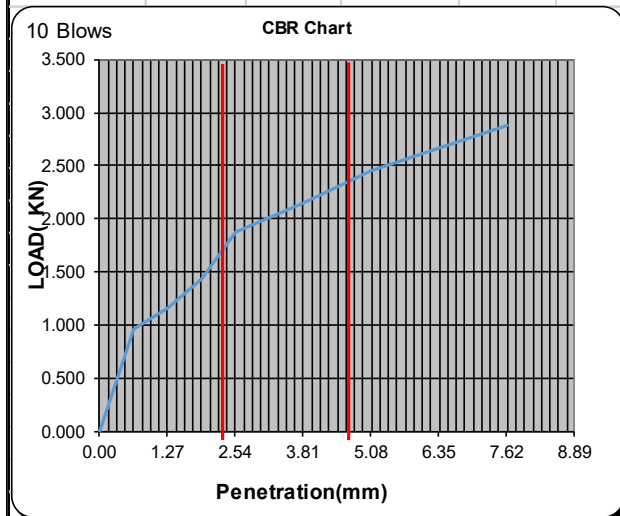
Table 4.4G CBR test result for station 20%(3+000)+80%(4+200)km

20%3+000+80%(4+200)											
Compaction Determination											
COMPACTION DATA			65 Blows		30 Blows		10 Blows				
			Before soak	After soak	Before soak	After soak	Before soak	After soak			
Mould No.			1	1	2	2	3	3			
Mass of soil + Mould	g		10824	10987	10597.3	11024.7	10266.7	10631.8			
Mass Mould	g		6616.9	6616.9	6608.1	6608.1	6605.6	6605.6			
Mass of Soil	g		4207.1	4370.1	3989.2	4416.6	3661.1	4026.2			
Volume of Mould	g		2285	2285	2285	2285	2285	2285			
Wet density of soil	g/cc		1.841	1.913	1.746	1.933	1.602	1.762			
Dry density of soil	g/cc		1.515	1.538	1.440	1.543	1.313	1.398			
Moisture Determination											
MOISTURE CONTENT DATA			65 Blows		30 Blows		10 Blows				
			Before soak	After soak	Before soak	After soak	Before soak	After soak			
Container no.			P1	15-2	E	2	C	NC-1			
Mass of wet soil + Container	g		87.7	240.1	169.6	205.4	117.0	147.7			
Mass of dry soil + Container	g		75.3	198.0	146.5	171.0	101.8	120.8			
Mass of container	g		17.7	25.0	37.8	34.7	32.8	17.5			
Mass of water	g		12.4	42.1	23.1	34.4	15.2	26.9			
Mass of dry soil	g		57.6	173.0	108.7	136.3	69.0	103.3			
Moisture content	%		21.5	24.3	21.3	25.2	22.0	26.0			
CBR Penetration Determination											
Penetration after 96 hrs Soaking Period			Surcharge Weight:-4.55 KG								
65 Blows			30 Blows			10 Blows					
Pen.mm	Load, KN	CBR %	Pen.mm	Load, KN	CBR %	Pen.mm	Load, KN	CBR %			
0.00	0.000		0.00	0.000		0.00	0.000				
0.64	1.230		0.64	1.040		0.64	0.967				
1.27	1.802		1.27	1.701		1.27	1.157				
1.91	2.160		1.91	2.215		1.91	1.431				
2.54	2.870	21.51	2.54	2.599	19.48	2.54	1.876				14.06
3.81	3.456		3.81	3.104		3.81	2.145				
5.08	3.856	19.28	5.08	3.469	17.35	5.08	2.456				12.28
7.62	4.316		7.62	4.076		7.62	2.876				
Modified Max.Dry Density g/cc			1.580			OMC %		23.0			

Date		65 Blows			30 Blows		10 Blows	
		Gauge rdg	Swell in %		Gauge rdg	Swell in %	Gauge rdg	Swell in %
		mm			mm		mm	
2013/2/3	Initial	7.96	1.49		12.56	1.58	2.62	1.79
2013/2/7	Final	9.70			14.40		4.70	



Penetration (mm)	Load KN		Corr. CBR %	Swell %	Penetration (mm)	Load KN		Corr. CBR %	Swell %
	Top	Bottom				Top	Bottom		
2.54mm		2.9	21.6	1.49	2.54mm		2.6	19.5	1.58
5.08mm		3.9	19.3		5.08mm		3.5	17.3	



Dry Density at 95% of MDD: 1.501

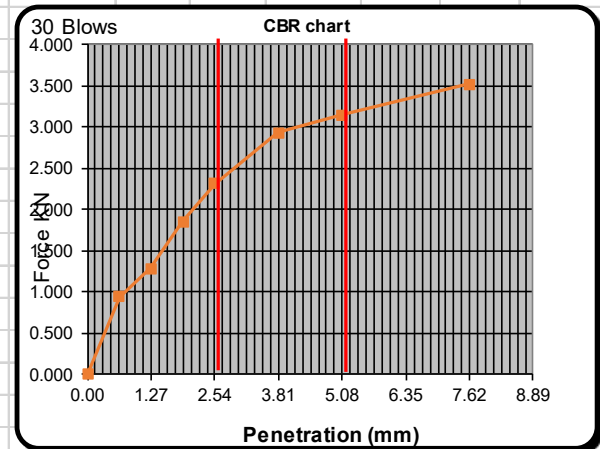
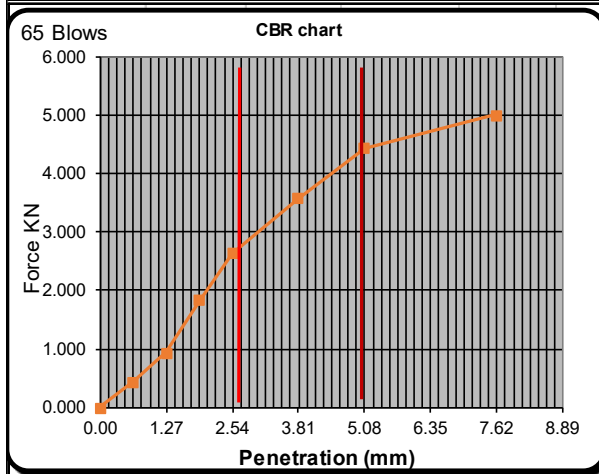
Penetration (mm)	Load KN		Corr. CBR %	Swell %	No. of blows	MCBS %	DDBS g/cm3	Correct CBR %	% OF Compaction
	Top	Bottom							
2.54mm		1.9	14.1	1.79	10	22.0	1.313	14.1	83
5.08mm		2.5	12.3		30	21.3	1.440	19.5	91
					65	21.5	1.515	21.6	96

CBR % at 95 % MDD	21.6	Swell %	1.58
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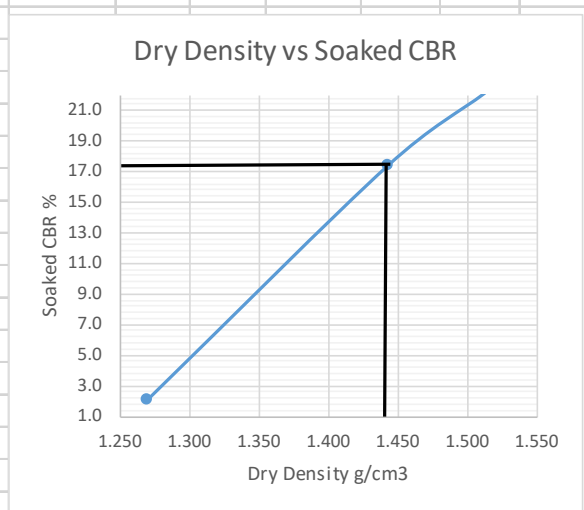
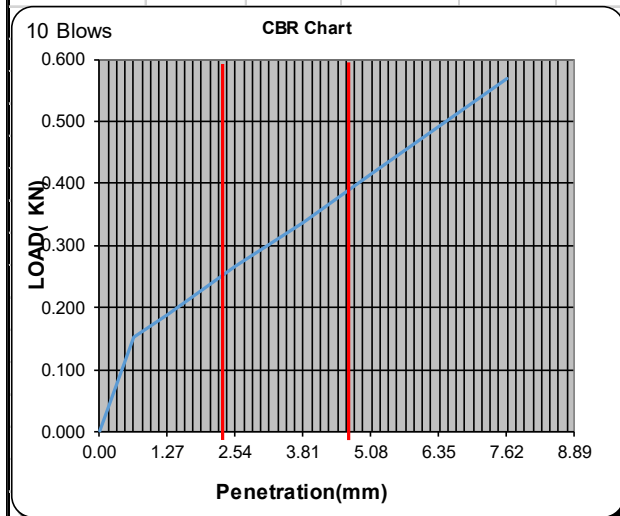
Table 4.4G CBR test result for station 30%(3+000)+70%(4+200)km

30%3+000+70%(4+200)km											
Compaction Determination											
COMPACTION DATA			65 Blows			30 Blows			10 Blows		
			Before soak	After soak		Before soak	After soak		Before soak	After soak	
Mould No.			1	1		2	2		3	3	
Mass of soil + Mould	g		10786	11030.1		10691	10966.3		10172.7	10648.5	
Mass Mould	g		6574.2	6574.2		6682.2	6682.2		6639.5	6639.5	
Mass of Soil	g		4211.8	4455.9		4008.8	4284.1		3533.2	4009	
Volume of Mould	g		2285	2285		2285	2285		2285	2285	
Wet density of soil	g/cc		1.843	1.950		1.754	1.875		1.546	1.754	
Dry density of soil	g/cc		1.512	1.554		1.443	1.478		1.269	1.379	
Moisture Determination											
MOISTURE CONTENT DATA			65 Blows			30 Blows			10 Blows		
			Before soak	After soak		Before soak	After soak		Before soak	After soak	
Container no.			B3	33		P2	T1		P65	P5	
Mass of wet soil + Container	g		103.3	148.6		111.8	191.1		175.7	130.9	
Mass of dry soil + Container	g		87.8	122.0		95.0	158.6		151.0	106.5	
Mass of container	g		17.0	17.5		17.3	37.7		37.8	17.0	
Mass of water	g		15.5	26.6		16.8	32.5		24.7	24.4	
Mass of dry soil	g		70.8	104.5		77.7	120.9		113.2	89.5	
Moisture content	%		21.9	25.5		21.6	26.9		21.8	27.3	
CBR Penetration Determination											
Penetration after 96 hrs Soaking Period			Surcharge Weight:-4.55 KG								
65 Blows			30 Blows			10 Blows					
Pen.mm	Load, KN	CBR %	Pen.mm	Load, KN	CBR %	Pen.mm	Load, KN				CBR %
0.00	0.000		0.00	0.000		0.00	0.000				
0.64	0.437		0.64	0.945		0.64	0.151				
1.27	0.936		1.27	1.289		1.27	0.189				
1.91	1.842		1.91	1.853		1.91	0.227				
2.54	2.645	19.83	2.54	2.317	17.37	2.54	0.267				2.00
3.81	3.583		3.81	2.930		3.81	0.337				
5.08	4.432	22.16	5.08	3.150	15.75	5.08	0.416				2.08
7.62	5.000		7.62	3.518		7.62	0.568				
Modified Max.Dry Density g/cc			1.570			OMC %			22.0		

Date		65 Blows			30 Blows		10 Blows	
		Gauge rdg	Swell in %		Gauge rdg	Swell in %	Gauge rdg	Swell in %
		mm			mm		mm	
2013/1/28	Initial	7.60	1.55		3.65	1.76	8.08	1.99
2013/2/2	Final	9.40			5.70			



Penetration (mm)	Load KN		Corr. CBR %	Swell %	Penetration (mm)	Load KN		Corr. CBR %	Swell %
	Top	Bottom				Top	Bottom		
2.54mm		2.6	19.9	1.55	2.54mm		2.3	17.4	1.76
5.08mm		4.4	22.2		5.08mm		3.2	15.8	

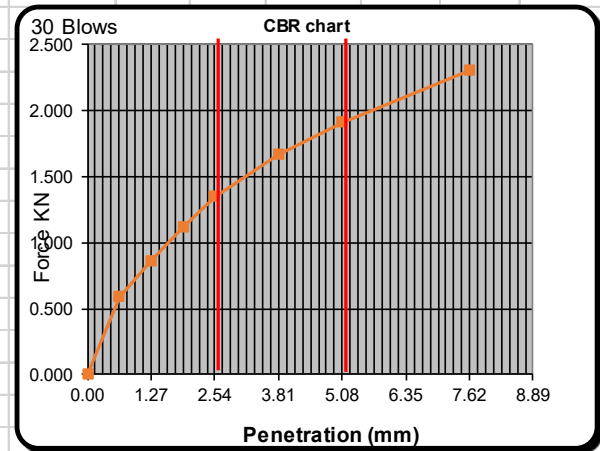
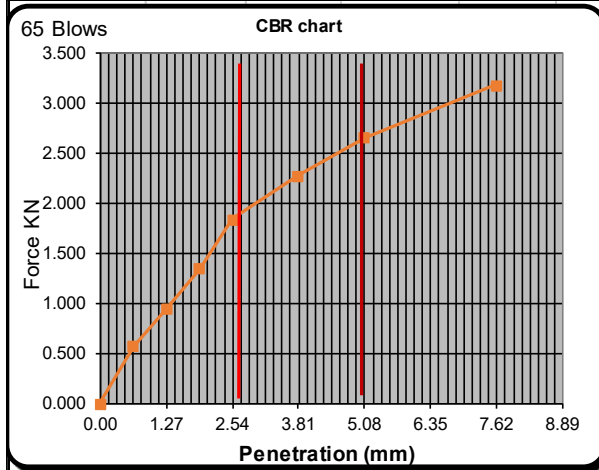


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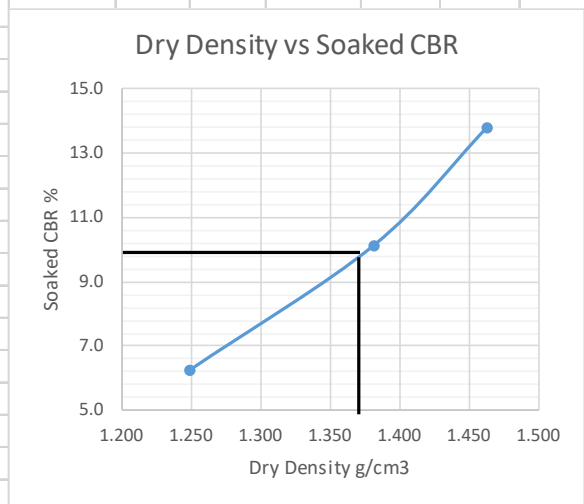
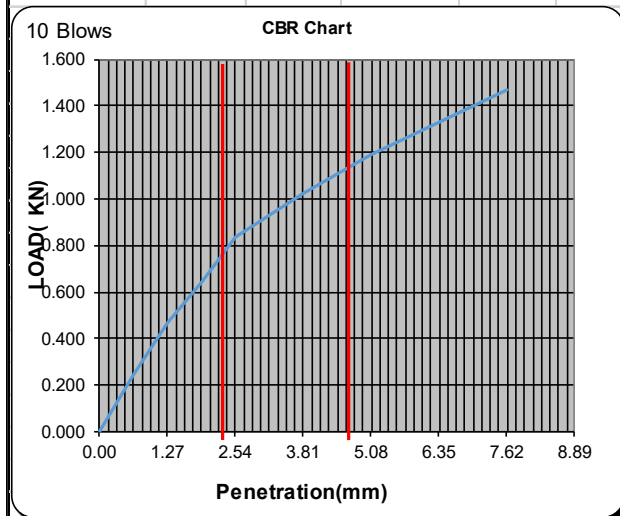
Table 4.4G CBR test result for station 40%(3+000)+60%(4+200)km

40% 3+000+60%(4+200)											
Compaction Determination											
COMPACTION DATA			65 Blows		30 Blows		10 Blows				
			Before soak	After soak	Before soak	After soak	Before soak	After soak	Before soak	After soak	After soak
Mould No.			1	1	2	2	3		3		
Mass of soil + Mould			10708.8	10976.7	10356.7	10844.3	10127.2		10634.2		
Mass Mould			6597.9	6597.9	6473.1	6473.1	6614.2		6614.2		
Mass of Soil			4110.9	4378.8	3883.6	4371.2	3513		4020		
Volume of Mould			2285	2285	2285	2285	2285		2285		
Wet density of soil			g/cc	1.799	1.916	1.700	1.913	1.537		1.759	
Dry density of soil			g/cc	1.463	1.521	1.382	1.504	1.249		1.357	
Moisture Determination											
MOISTURE CONTENT DATA			65 Blows		30 Blows		10 Blows				
			Before soak	After soak	Before soak	After soak	Before soak	After soak	Before soak	After soak	After soak
Container no.			10G	E	K4	T3	4		12		
Mass of wet soil + Container			g	124.6	216.3	132.2	193.1	108.0		268.0	
Mass of dry soil + Container			g	104.6	179.5	110.8	159.4	91.0		216.1	
Mass of container			g	17.6	37.8	17.8	35.6	17.5		41.1	
Mass of water			g	20.0	36.8	21.4	33.7	17.0		51.9	
Mass of dry soil			g	87.0	141.7	93.0	123.8	73.5		175.0	
Moisture content			%	23.0	26.0	23.0	27.2	23.1		29.7	
CBR Penetration Determination											
Penetration after 96 hrs Soaking Period			Surcharge Weight:-4.55 KG								
65 Blows			30 Blows			10 Blows					
Pen.mm	Load, KN	CBR %	Pen.mm	Load, KN	CBR %	Pen.mm	Load, KN	CBR %	Pen.mm	Load, KN	CBR %
0.00	0.000		0.00	0.000		0.00	0.000				
0.64	0.569		0.64	0.588		0.64	0.245				
1.27	0.946		1.27	0.859		1.27	0.467				
1.91	1.349		1.91	1.118		1.91	0.645				
2.54	1.835	13.76	2.54	1.35	10.12	2.54	0.835				6.26
3.81	2.276		3.81	1.666		3.81	1.023				
5.08	2.652	13.26	5.08	1.911	9.56	5.08	1.189				5.95
7.62	3.178		7.62	2.303		7.62	1.469				
Modified Max.Dry Density g/cc			1.510			OMC %			23.5		

Date		65 Blows			30 Blows		10 Blows	
		Gauge rdg	Swell in %		Gauge rdg	Swell in %	Gauge rdg	Swell in %
		mm			mm		mm	
2013/1/28	Initial	0.85	1.76		15.07	1.92	11.84	2.11
2013/2/2	Final	2.90			17.30			



Penetration (mm)	Load KN		Corr. CBR %	Swell %	Penetration (mm)	Load KN		Corr. CBR %	Swell %
	Top	Bottom				Top	Bottom		
2.54mm		1.8	13.8	1.76	2.54mm		1.4	10.2	1.92
5.08mm		2.7	13.3		5.08mm		1.9	9.6	



Dry Density at 95% of MDD: 1.435

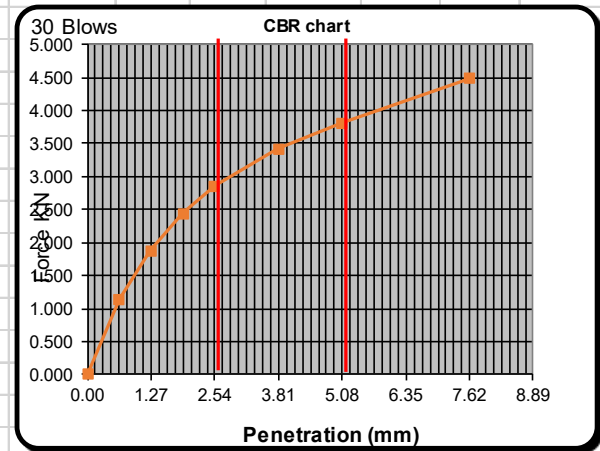
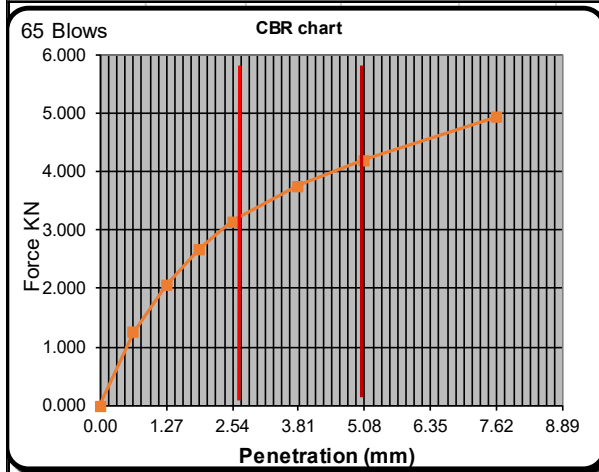
Penetration (mm)	Load KN		Corr. CBR %	Swell %	No. of blows	MCBS %	DDBS g/cm³	Correct CBR %	% OF Compaction
	Top	Bottom							
2.54mm		0.8	6.3	2.11	10	23.1	1.249	6.3	83
5.08mm		1.2	5.9		30	23.0	1.382	10.2	92
					65	23.0	1.463	13.8	97

CBR % at 95 % MDD	10.2	Swell %	1.92
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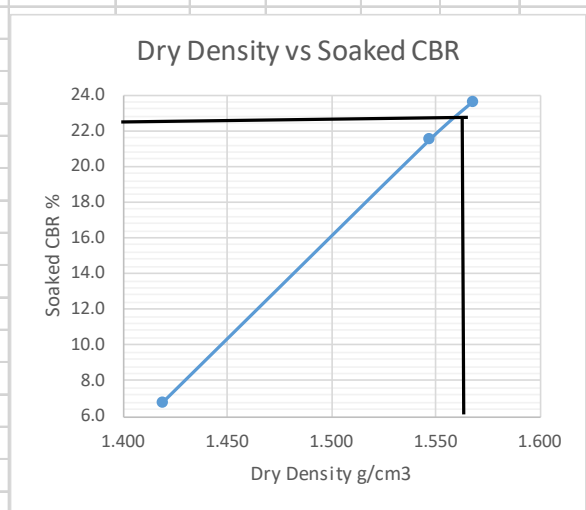
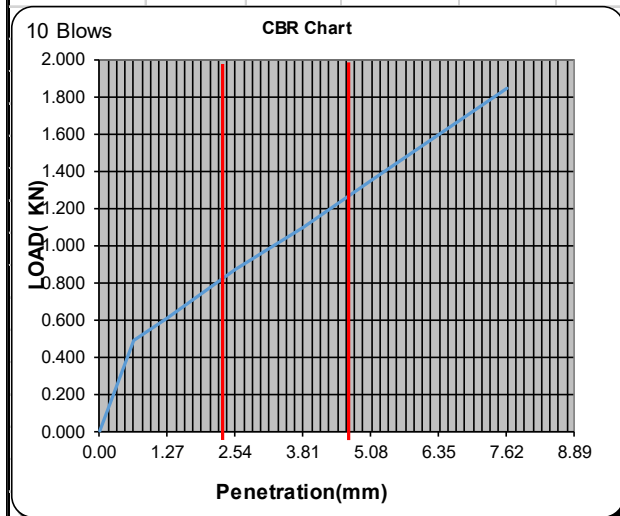
Table 4.4G CBR test result for station 20%(6+000)+80%(4+200)km

20% 6+000+80%(4+200)											
Compaction Determination											
COMPACTION DATA			65 Blows		30 Blows		10 Blows				
			Before soak	After soak	Before soak	After soak	Before soak	After soak			
Mould No.			1	1	2	2	3			3	
Mass of soil + Mould			10903.2	11087.1	10807.3	10975.1	10466.7			10631.8	
Mass Mould			6650	6650	6608.1	6608.1	6605.6			6605.6	
Mass of Soil			4253.2	4437.1	4199.2	4367	3861.1			4026.2	
Volume of Mould			2285	2285	2285	2285	2285			2285	
Wet density of soil			1.861	1.942	1.838	1.911	1.690			1.762	
Dry density of soil			1.568	1.562	1.547	1.526	1.419			1.398	
Moisture Determination											
MOISTURE CONTENT DATA			65 Blows		30 Blows		10 Blows				
			Before soak	After soak	Before soak	After soak	Before soak	After soak			
Container no.			P1	15-2	E	2	C			NC-1	
Mass of wet soil + Container			121.1	240.1	168.2	205.4	120.1			147.7	
Mass of dry soil + Container			107.6	198.0	147.2	171.0	106.1			120.8	
Mass of container			35.5	25.0	35.5	34.7	32.8			17.5	
Mass of water			13.5	42.1	21.0	34.4	14.0			26.9	
Mass of drysoil			72.1	173.0	111.7	136.3	73.3			103.3	
Moisture content			18.7	24.3	18.8	25.2	19.1			26.0	
CBR Penetration Determination											
Penetration after 96 hrs Soaking Period			Surcharge Weight:-4.55 KG								
65 Blows			30 Blows			10 Blows					
Pen.mm	Load, KN	CBR %	Pen.mm	Load, KN	CBR %	Pen.mm	Load, KN			CBR %	
0.00	0.000		0.00	0.000		0.00	0.000				
0.64	1.258		0.64	1.144		0.64	0.491				
1.27	2.058		1.27	1.871		1.27	0.614				
1.91	2.680		1.91	2.437		1.91	0.738				
2.54	3.145	23.57	2.54	2.859	21.43	2.54	0.868			6.50	
3.81	3.756		3.81	3.414		3.81	1.095				
5.08	4.197	20.99	5.08	3.816	19.08	5.08	1.352			6.76	
7.62	4.932		7.62	4.484		7.62	1.846				
Modified Max.Dry Density g/cc			1.620			OMC %		19.2			

Date		65 Blows			30 Blows		10 Blows	
		Gauge rdg	Swell in %		Gauge rdg	Swell in %	Gauge rdg	Swell in %
		mm			mm		mm	
2013/4/4	Initial	0.00	1.42		0	1.54	0.00	1.99
2013/4/8	Final	1.65			1.79			
					1.54			



Penetration (mm)	Load KN		Corr. CBR %	Swell %	Penetration (mm)	Load KN		Corr. CBR %	Swell %
	Top	Bottom				Top	Bottom		
2.54mm		3.1	23.6	1.42	2.54mm		2.9	21.5	1.54
5.08mm		4.2	21.0		5.08mm		3.8	19.1	

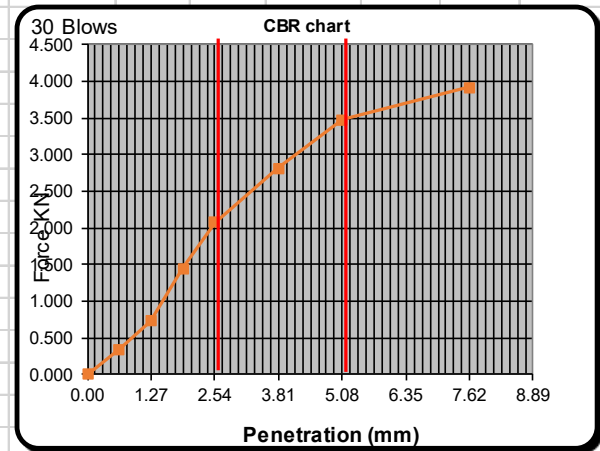
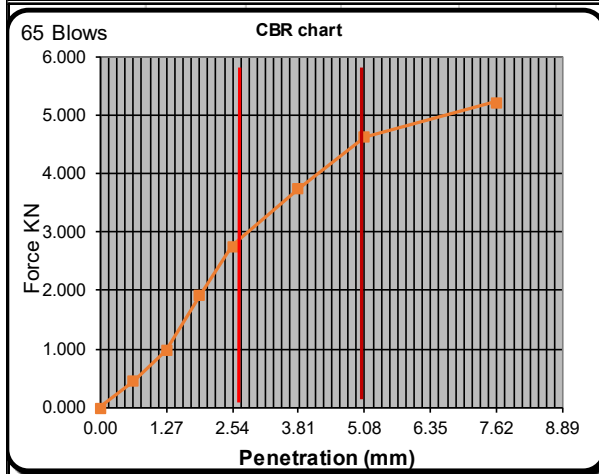


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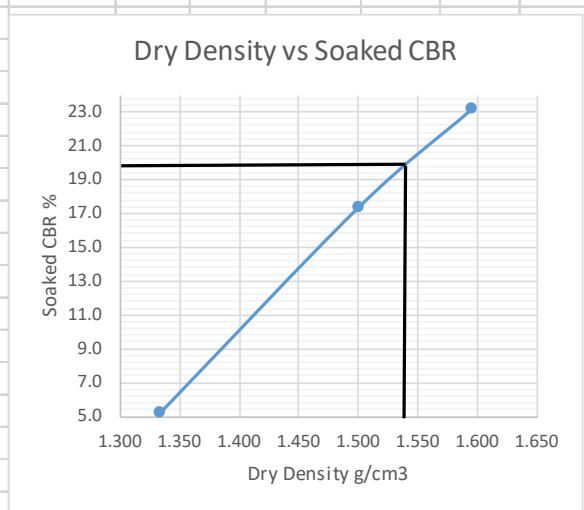
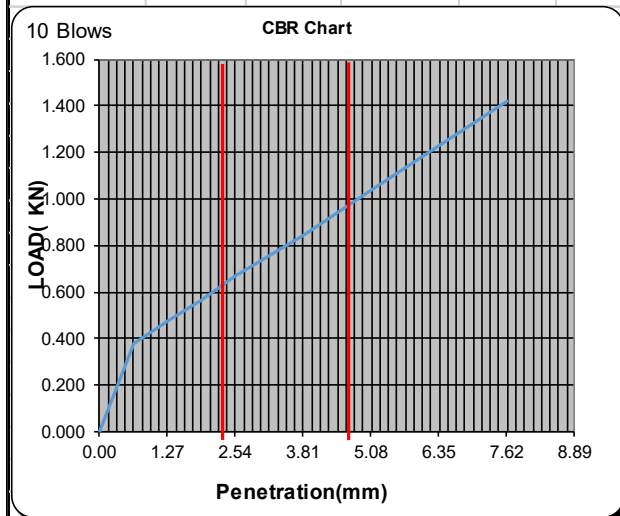
Table 4.4G CBR test result for station 30%(6+000)+70%(4+200)km

30% 6+000+70%(4+200)km											
Compaction Determination											
COMPACTION DATA			65 Blows		30 Blows		10 Blows				
			Before soak	After soak	Before soak	After soak	Before soak	After soak			
Mould No.			1	1	2	2	3	3			
Mass of soil + Mould			10886	10930.1	10750	10966.3	10272.7	10648.5			
Mass Mould			6574.2	6574.2	6682.2	6682.2	6639.5	6639.5			
Mass of Soil			4311.8	4355.9	4067.8	4284.1	3633.2	4009			
Volume of Mould			2285	2285	2285	2285	2285	2285			
Wet density of soil			1.887	1.906	1.780	1.875	1.590	1.754			
Dry density of soil			1.595	1.520	1.500	1.478	1.333	1.379			
Moisture Determination											
MOISTURE CONTENT DATA			65 Blows		30 Blows		10 Blows				
			Before soak	After soak	Before soak	After soak	Before soak	After soak			
Container no.			B3	33	P2	T1	P65	P5			
Mass of wet soil + Container			102.3	148.6	112.0	191.1	176.5	130.9			
Mass of dry soil + Container			89.1	122.0	97.1	158.6	154.1	106.5			
Mass of container			17.0	17.5	17.3	37.7	37.8	17.0			
Mass of water			13.2	26.6	14.9	32.5	22.4	24.4			
Mass of drysoil			72.1	104.5	79.8	120.9	116.3	89.5			
Moisture content			18.3	25.5	18.7	26.9	19.3	27.3			
CBR Penetration Determination											
Penetration after 96 hrs Soaking Period			Surcharge Weight:-4.55 KG								
65 Blows			30 Blows			10 Blows					
Pen.mm	Load, KN	CBR %	Pen.mm	Load, KN	CBR %	Pen.mm	Load, KN				CBR %
0.00	0.000		0.00	0.000		0.00	0.000				
0.64	0.457		0.64	0.343		0.64	0.378				
1.27	0.979		1.27	0.734		1.27	0.473				
1.91	1.926		1.91	1.444		1.91	0.568				
2.54	2.765	20.73	2.54	2.074	15.55	2.54	0.668				5.00
3.81	3.746		3.81	2.810		3.81	0.843				
5.08	4.634	23.17	5.08	3.475	17.38	5.08	1.040				5.20
7.62	5.228		7.62	3.921		7.62	1.420				
Modified Max.Dry Density g/cc		1.600			OMC %		19.0				

Date		65 Blows			30 Blows		10 Blows	
		Gauge rdg	Swell in %		Gauge rdg	Swell in %	Gauge rdg	Swell in %
		mm			mm		mm	
2013/4/4	Initial	0.00	1.61		4.65	1.75	2.10	2.07
2013/4/8	Final	1.87			6.69			
					1.75			



Penetration (mm)	Load KN		Corr. CBR %	Swell %	Penetration (mm)	Load KN		Corr. CBR %	Swell %
	Top	Bottom				Top	Bottom		
2.54mm		2.8	20.8	1.61	2.54mm		2.1	15.6	1.75
5.08mm		4.6	23.2		5.08mm		3.5	17.4	

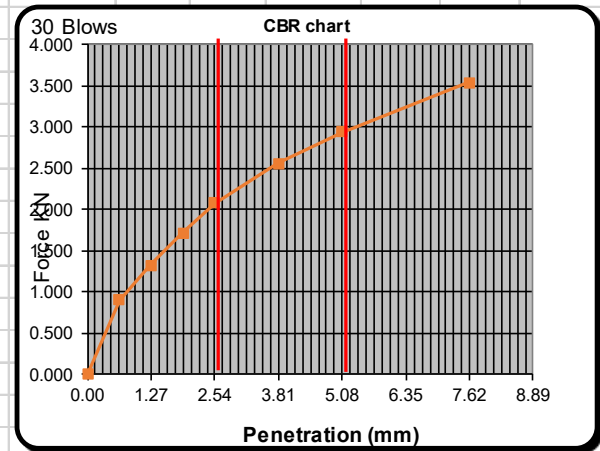
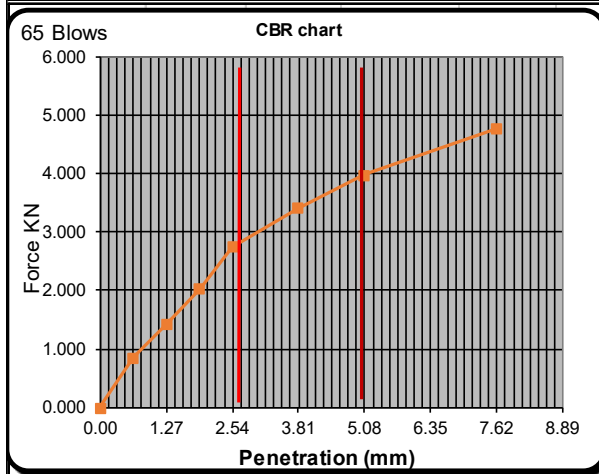


						Dry Density at 95% of MDD:			1.520	
Penetration (mm)	Load KN		Corr. CBR %	Swell %	No.of blows	MCBS %	DDBS g/cm3	Correect CBR %	% OF Compaction	
	Top	Bottom			10	19.3	1.333	5.2	83	
2.54mm		0.7	5.0	2.07	30	18.7	1.500	17.4	94	
5.08mm		1.0	5.2		65	18.3	1.595	23.2	100	
200					CBR % at 95 % MDD			19.4	Swell %	1.75

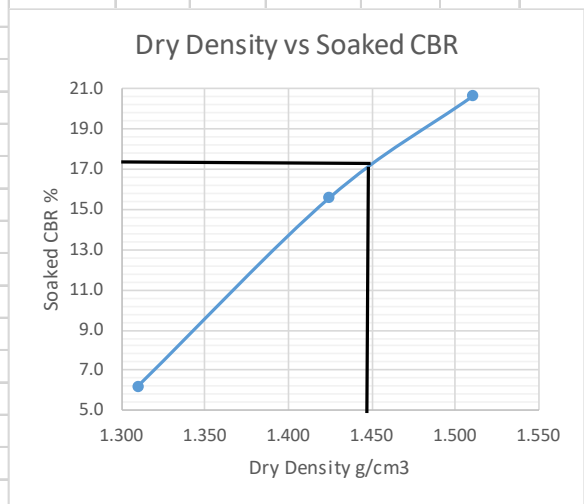
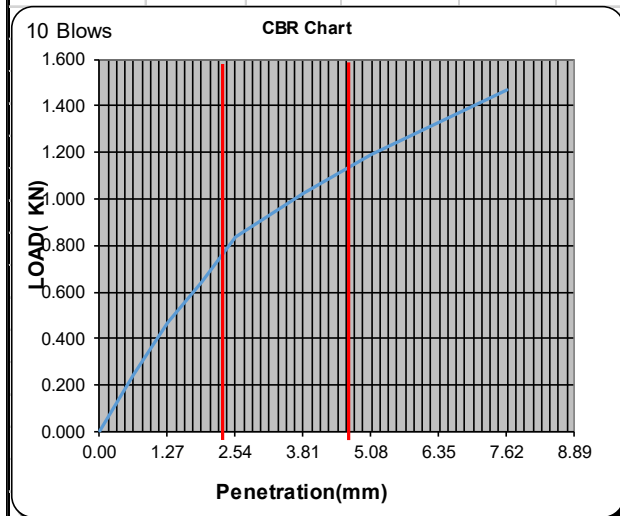
Table 4.4G CBR test result for station 40%(6+000)+60%(4+200)km

40% 6+000+60%(4+200)											
Compaction Determination											
COMPACTION DATA			65 Blows		30 Blows		10 Blows				
			Before soak	After soak	Before soak	After soak	Before soak	After soak			
Mould No.			1	1	2	2	3		3		
Mass of soil + Mould			10738.8	10976.7	10406.7	10544.3	10227.2		10334.2		
Mass Mould			6565.4	6565.4	6473.1	6473.1	6614.2		6614.2		
Mass of Soil			4173.4	4411.3	3933.6	4071.2	3613		3720		
Volume of Mould			2285	2285	2285	2285	2285		2285		
Wet density of soil			1.826	1.931	1.721	1.782	1.581		1.628		
Dry density of soil			1.511	1.484	1.424	1.400	1.310		1.256		
Moisture Determination											
MOISTURE CONTENT DATA			65 Blows		30 Blows		10 Blows				
			Before soak	After soak	Before soak	After soak	Before soak	After soak			
Container no.			10G	E	K4	T3	4		12		
Mass of wet soil + Container			121.1	214.0	130.2	193.1	106.2		268.0		
Mass of dry soil + Container			103.2	173.2	110.8	159.4	91.0		216.1		
Mass of container			17.6	37.8	17.8	35.6	17.5		41.1		
Mass of water			17.9	40.8	19.4	33.7	15.2		51.9		
Mass of drysoil			85.6	135.4	93.0	123.8	73.5		175.0		
Moisture content			20.9	30.1	20.9	27.2	20.7		29.7		
CBR Penetration Determination											
Penetration after 96 hrs Soaking Period			Surcharge Weight:-4.55 KG								
65 Blows			30 Blows			10 Blows					
Pen.mm	Load, KN	CBR %	Pen.mm	Load, KN	CBR %	Pen.mm	Load, KN		CBR %		
0.00	0.000		0.00	0.000		0.00	0.000				
0.64	0.854		0.64	0.904		0.64	0.245				
1.27	1.419		1.27	1.321		1.27	0.467				
1.91	2.024		1.91	1.719		1.91	0.645				
2.54	2.753	20.63	2.54	2.076	15.56	2.54	0.835			6.26	
3.81	3.414		3.81	2.561		3.81	1.023				
5.08	3.978	19.89	5.08	2.938	14.69	5.08	1.189			5.95	
7.62	4.767		7.62	3.541		7.62	1.469				
Modified Max.Dry Density g/cc		1.510			OMC %		21.0				

Date		65 Blows	Swell in %	30 Blows		10 Blows	
		Gauge rdg		Swell in %	Gauge rdg	Swell in %	
		mm			mm		
2013/4/4	Initial	4.56	1.61	3.2	1.958	2.10	2.11
2013/4/8	Final	6.43		5.48		4.56	



Penetration (mm)	Load KN		Corr. CBR %	Swell %	Penetration (mm)	Load KN		Corr. CBR %	Swell %
	Top	Bottom				Top	Bottom		
2.54mm		2.8	20.7	1.61	2.54mm		2.1	15.6	1.96
5.08mm		4.0	19.9		5.08mm		2.9	14.7	



Dry Density at 95% of MDD: 1.435

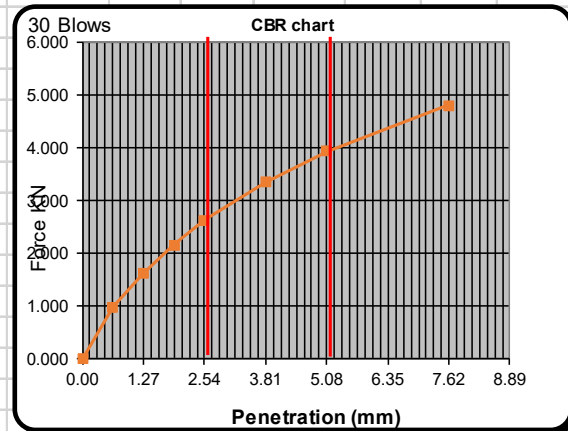
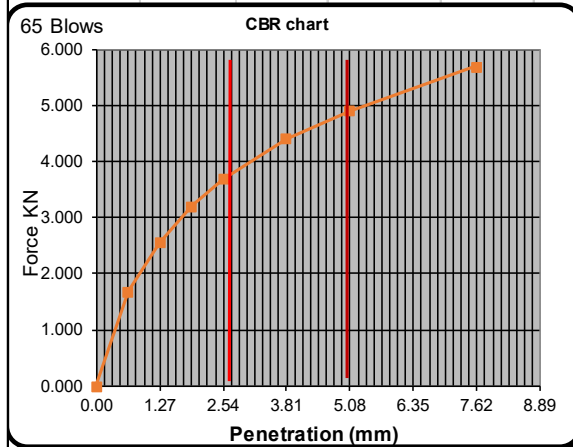
Penetration (mm)	Load KN		Corr. CBR %	Swell %	No. of blows	MCBS %	DDBS g/cm3	Correct CBR %	% OF Compaction
	Top	Bottom							
2.54mm		0.8	6.3	2.11	10	20.7	1.310	6.3	87
5.08mm		1.2	5.9		30	20.9	1.424	15.6	94
					65	20.9	1.511	20.7	100

CBR % at 95 % MDD	17.5	Swell %	1.96
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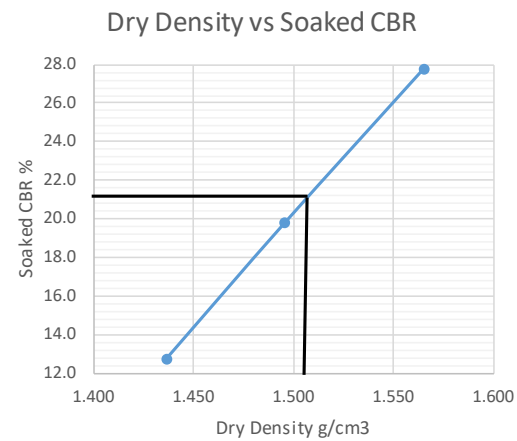
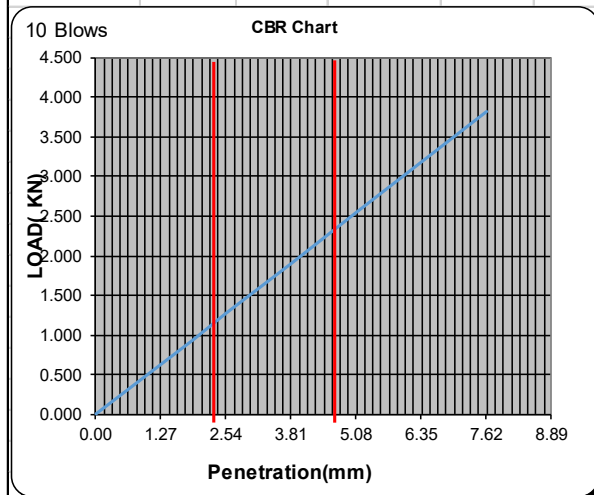
Table 4.4G CBR test result for station 20%(9+000)+80%(4+200)km

20% 9+000+80%(4+200)											
Compaction Determination											
COMPACTION DATA			65 Blows			30 Blows		10 Blows			
			Before soak	After soak	Before soak	After soak	Before soak	After soak			
Mould No.			1	1	2	2	3	3			
Mass of soil + Mould			10835.5	10980.2	10592.7	10867.7	10429.4	10585.5			
Mass Mould			6650.4	6650.4	6590.2	6590.2	6594.3	6594.3			
Mass of Soil			4185.1	4329.8	4002.5	4277.5	3835.1	3991.2			
Volume of Mould			2285	2285	2285	2285	2285	2285			
Wet density of soil			1.832	1.895	1.752	1.872	1.678	1.747			
Dry density of soil			1.565	1.579	1.496	1.528	1.436	1.424			
Moisture Determination											
MOISTURE CONTENT DATA			65 Blows			30 Blows		10 Blows			
			Before soak	After soak	Before soak	After soak	Before soak	After soak			
Container no.			A	WE	FG	P6	G3	P10			
Mass of wet soil + Container			182.0	212.6	175.3	164.9	178.2	155.6			
Mass of dry soil + Container			156.0	184.0	153.4	141.0	156.3	133.5			
Mass of container			3.4	41.2	25.5	34.8	26.4	35.9			
Mass of water			26.0	28.6	21.9	23.9	21.9	22.1			
Mass of drysoil			152.6	142.8	127.9	106.2	129.9	97.6			
Moisture content			17.0	20.0	17.1	22.5	16.9	22.6			
CBR Penetration Determination											
Penetration after 96 hrs Soaking Period			Surcharge Weight:-4.55 KG								
65 Blows			30 Blows			10 Blows					
Pen.mm	Load, KN	CBR %	Pen.mm	Load, KN	CBR %	Pen.mm	Load, KN				
0.00	0.000		0.00	0.000		0.00	0.000				
0.64	1.688		0.64	0.985		0.64	0.320				
1.27	2.553		1.27	1.623		1.27	0.635				
1.91	3.200		1.91	2.168		1.91	0.955				
2.54	3.691	27.67	2.54	2.629	19.71	2.54	1.270				9.52
3.81	4.403		3.81	3.351		3.81	1.905				
5.08	4.909	24.54	5.08	3.937	19.69	5.08	2.540				12.70
7.62	5.690		7.62	4.813		7.62	3.810				
Modified Max.Dry Density g/cc			1.592			OMC %		17.2			

Date		65 Blows	Swell in %	30 Blows		10 Blows	
		Gauge rdg		Gauge rdg	Swell in %	Gauge rdg	Swell in %
		mm		mm		mm	
2013/4/2	Initial	9.29	1.55	0	1.83	7.21	1.88
2013/4/6	Final	11.10		2.13		9.40	



Penetration (mm)	Load KN		Corr. CBR %	Swell %	Penetration (mm)	Load KN		Corr. CBR %	Swell %
	Top	Bottom				Top	Bottom		
2.54mm		3.7	27.8	1.55	2.54mm		2.6	19.8	1.83
5.08mm		4.9	24.5		5.08mm		3.9	19.7	

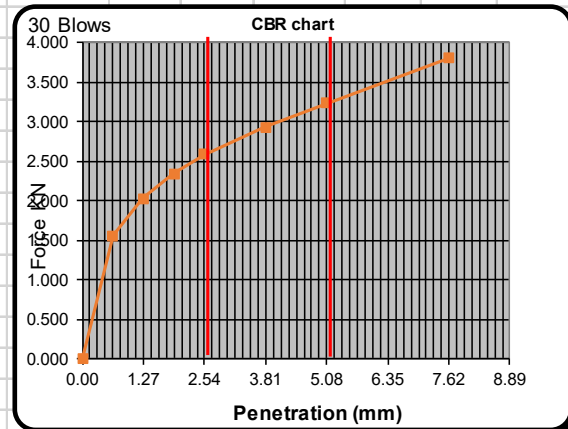
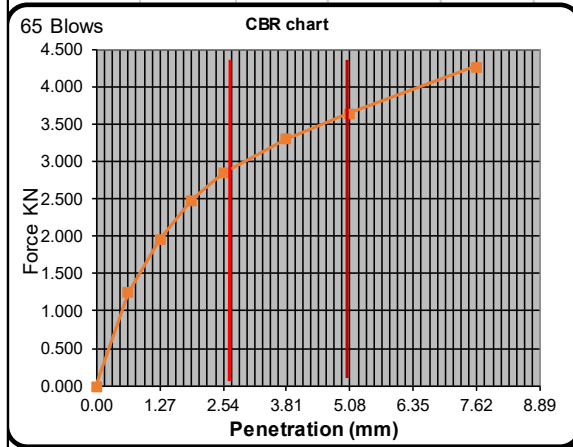


						Dry Density at 95% of MDD:			1.512	
Penetration (mm)	Load KN		Corr. CBR %	Swell %	No.of blows	MCBS %	DDBS g/cm3	Correcrt CBR %	% OF Compaction	
	Top	Bottom								
2.54mm		1.3	9.5	1.88	10	16.9	1.436	12.7	90	
					30	17.1	1.496	19.8	94	
5.08mm		2.5	12.7		65	17.0	1.565	27.8	98	
					CBR % at 95 % MDD			21.26	Swell %	1.83

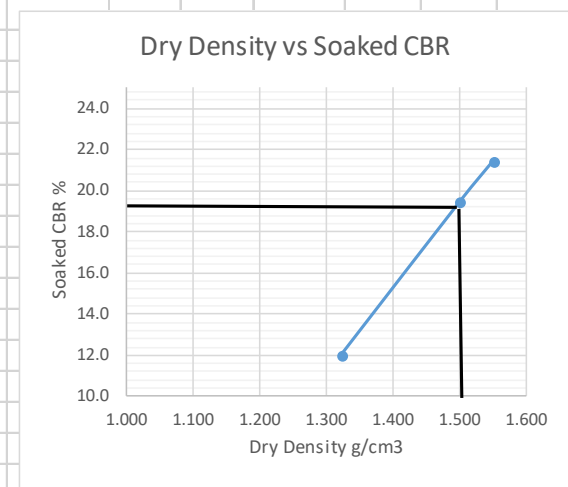
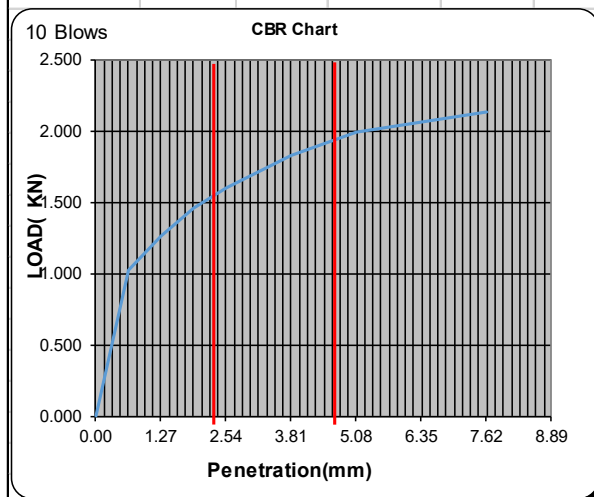
Table 4.4G CBR test result for station 30%(9+000)+70%(4+200)km

30% 9+000+70%(4+200)											
Compaction Determination											
COMPACTION DATA			65 Blows		30 Blows		10 Blows				
			Before soak	After soak	Before soak	After soak	Before soak	After soak	Before soak	After soak	After soak
Mould No.			1	1	2	2	3		3		
Mass of soil + Mould			10807.9	10987.7	10698.3	10737.8	10202.4		10319.7		
Mass Mould			6650.3	6650.3	6670.5	6670.5	6655.4		6655.4		
Mass of Soil			4157.6	4337.4	4027.8	4067.3	3547		3664.3		
Volume of Mould			2285	2285	2285	2285	2285		2285		
Wet density of soil			1.820	1.898	1.763	1.780	1.552		1.604		
Dry density of soil			1.550	1.535	1.500	1.434	1.323		1.293		
Moisture Determination											
MOISTURE CONTENT DATA			65 Blows		30 Blows		10 Blows				
			Before soak	After soak	Before soak	After soak	Before soak	After soak	Before soak	After soak	After soak
Container no.			A	B	D	F	G		GI9		
Mass of wet soil + Container			185.3	162.0	160.3	198.6	167.5		198.6		
Mass of dry soil + Container			142.0	135.8	141.7	166.7	145.3		166.8		
Mass of container			25.4	25.2	35.5	34.6	17.5		34.6		
Mass of water			20.3	26.2	18.6	31.9	22.2		31.8		
Mass of dry soil			116.6	110.6	106.2	132.1	127.8		132.2		
Moisture content			17.4	23.7	17.5	24.1	17.4		24.1		
CBR Penetration Determination											
Penetration after 96 hrs Soaking Period			Surcharge Weight:-4.55 KG								
65 Blows			30 Blows			10 Blows					
Pen.mm	Load, KN	CBR %	Pen.mm	Load, KN	CBR %	Pen.mm	Load, KN				CBR %
0.00	0.000		0.00	0.000		0.00	0.000				
0.64	1.249		0.64	1.560		0.64	1.022				
1.27	1.961		1.27	2.032		1.27	1.264				
1.91	2.489		1.91	2.348		1.91	1.458				
2.54	2.852	21.38	2.54	2.589	19.41	2.54	1.602				12.01
3.81	3.309		3.81	2.934		3.81	1.824				
5.08	3.652	18.26	5.08	3.235	16.18	5.08	1.995				9.98
7.62	4.274		7.62	3.806		7.62	2.134				
Modified Max.Dry Density g/cc			1.570			OMC %		17.5			

Date		65 Blows	Swell in %	30 Blows		10 Blows	
		Gauge rdg		Gauge rdg	Swell in %	Gauge rdg	Swell in %
		mm		mm		mm	
2013/4/2	Initial	0.50	1.80	0	1.90	3.60	2.15
2013/4/6	Final	2.60		2.21		6.10	



Penetration (mm)	Load KN		Corr. CBR %	Swell %	Penetration (mm)	Load KN		Corr. CBR %	Swell %
	Top	Bottom				Top	Bottom		
2.54mm		2.9	21.4	1.80	2.54mm		2.6	19.5	1.90
5.08mm		3.7	18.3		5.08mm		3.2	16.2	



						Dry Density at 95% of MDD:			1.492	
Penetration (mm)	Load KN		Corr. CBR %	Swell %	No.of blows	MCBS %	DDBS g/cm3	Correcrt CBR %	% OF Compaction	
	Top	Bottom								
	2.54mm	1.6	12.0		2.15	10	17.4	1.323	12.0	84
	5.08mm	2.0	10.0			30	17.5	1.500	19.5	96
				65	17.4	1.550	21.4	99		
					CBR % at 95 % MDD			19.4	Swell %	1.90

Appendix H soil bore log for typical samples & stations

1. Expansive subgrade soil

Field Soil Description				Summary of Laboratory Test Result												
Station km	Depth (cm)	Log	Material Description	Depth Sampled	% pass this sieve (mm)			LL	PL	PI	AASHTO	OMC	MDDT- 180	CBR%		Swell
					2	0.425	0.08							2.54 (mm)	5.08 (mm)	
	35		Brown to reddish brown silty clay													
3+000	75															
	100				99	98	96	76	34.2	42	A-7-5(48)	30	1.41			
	125												10 blows	3.4	2.9	3.89
	140		Red brown high plasticity silt										30 blows	4.8	4.7	3.7
	150												65 blows	8.4	7.6	3.44
	35															
6+000	75		Red silty clay		96	93	88	71	38	33	A-7-5(35)					
	100											27	1.46			
	125												10 blows	3	3.4	3.31

	140		Red brown high plasticity silt									30 blows	4.2	4.8	3.2
	150											65 blows	6.3	5.9	3

2. suitable subgrade soil

Field Soil Description				Summary of Laboratory Test Result												
Station km	Depth (cm)	Log	Material Description	Depth Sampled	% pass this sieve (mm)			LL %	PL %	PI %	AASHTO Soil class	OMC %	MDDT-180 g/cm3	CBR%		Swell %
					2	0.425	0.08							2.54 (mm)	5.08 (mm)	
21+000	35	Orange	Light brown silty clay	Grey												
	75															
	100															
	125	Red			98	92	86	57	31	26	A-7-5(25)	21.5	1.58			
	140												10 blows	3	3.4	1.96
	150												30 blows	10.4	8.4	1.8
		ML(low plasticity silt)										65 blows	11.8	14	1.49	
	35	Orange		Grey												
27+000	75		Red silty clay		93	77	49	32	20	12	A-6(2)	28	1.56			
	100												10 blows	6.3	5.9	0.91
	125												30 blows	10.2	9.6	0.75
	140	CL(Low plasticity silt)											65 blows	13.8	13	0.73
	150															

Appendix I:- Photos Captured During Sampling And Laboratory Testing











