LABORATORY TESTS FOR CHARACTERIZATION OF ROAD EMBANKMENT LAYERS THROUGH BLENDED SAND/GRAVEL MIX PROPORTIONS MATERIALS

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ABSTRACT

Characterization of source materials for embankment layers' construction is based on analysis of properties and characteristics. The study influence and improves engineering properties of embankment existing materials and imported natural brownish silt sand gravel with low plasticity. To improve the suitable materials for construction of road embankment layers in water logged section. Characterization and determine suitable proportions of blended source materials for construction of road embankment layers. Imported natural gravel was then blended with sand at different mixing ratios, targeting to determine properties and characteristics of material. The blending proportion for this study could be performed according to the mix ratios of sand/gravel mixtures start at 5%, 10%, 15%, 20%, 30%, and 40%. The sieve analysis, Atterberg limits, proctor compaction and CBR are the required tests for checking and determination of properties and characteristics of materials. In this study, we have tested and make analysis of the blending mixtures of sand/gravel. The tests results would guide us on selection of an optimum data/result for further research studies. This paper evaluates the performance of a blended materials and its implementation in embankment fill materials. The results will support in determination of suitability of improved materials as a road embankment and subgrade layers. The improved materials can sustain the effect of water penetration through its layers and allow the effective upper pavement layers.

Keywords: Characterization of source materials, blending of materials, California bearing ratio, water logged, water penetration.

2.0 INTRODUCTION

Road construction sector is facing challenges particularly on failures of road on its surface due to different situation. Our study is based on effect water penetration to the embankment layers. The high stage of the deterioration has caused discomfort to road users. Traffic flow has been affected by uneven settlements and failures of road surface. The road has suffered from serious depressions, cracks, heaves, potholes and differential settlements of embankments. The soil water permeability, infiltration and capillarity raise through the embankment penetrate and weaken the road. This research has influenced improvement of suitable materials for construction of roads embankments in water logged area and making sure that materials met required design criteria and aspects. The previous research was based on forensic investigation to the failures of pavement layers and design review of asphalt concrete premix (Boateng *et al., 2015*). The soil samples were classified as Silt gravel, gravel silt sand mixtures (GM), Silt gravel, gravel silt sand Clay (SM) and and Inorganic clay of low to medium plasticity (CL were classified according to USCS. The materials collected and selected for tests with classification group as A-2–4, A-4 and A-2–6 as per AASHTO. Our study influenced on research on embankment layers' improvements in water logged. The study will come up with proper selection of improved suitable materials to resist the effects of water penetration in embankment. The collected samples from borrow pit were improved its properties and characteristics so that could be used as fill materials for embankment layers' construction in water logged area along Mlandizi - Ruvu road section. In which circumstances the prolonged presence of water in embankment affect the road pavement materials?

How does capillary action contribute to moisture penetration and causes road failures? This study has influenced improvement of suitable materials for construction of roads embankments fill materials in water logged areas. The study has based on improved materials for embankment and minimize costs of frequent maintenances of road in water logged areas. The study will come up with proper selection of improved suitable materials to resist the effects of water penetration to the road embankment. The outcome of this research is for provision of sustainable materials against the water penetration (Jjuuko *et al.,* 2014).

3. LITERATURE REVIEW

It is based on the historical back ground of theories and methodology relate to the problem and how the problems have already taken care and solved in engineering consideration measures. The contextual understanding on how the problem solved by different methodology of studies. Based on the case study of Mlandizi – Ruvu road section, particularly embankment failures due to an upstream impoundment that by the rainfall and river flows. Then also, to propose the method of how to overcome or use the materials which will withstand the effect of moisture infiltration, absorbing and capillarity action. The investigation for improvement of suitable materials for road construction gave us the basic information on the quality and standard of materials (Murthy, 2009). Performance of Red Soil Stabilized with Gravel and lime in Construction of low volume Roads has influenced type of improvement fill materials to the area of water-logged section (Hinga. (2021). Therefore, a proper thickness of materials is important for stable embankment which will with stand the effect of moisture penetration (Indian Roads Congress, 2011). This study employed quantitative research approach to give room for study to enter deeper and wide to understand the soil and roads knowledge and experience on soil investigation into water logged areas (Foster and Fell ,1999). The approach proposed for this study is planned to be further validated and improved more than applications from other case studies. The road construction sector's professionals have just made effort to improve the quality of pavement layers in order to maximize efficiencies, standard and quality of construction materials. The materials for pavement may be used according to the nature of road bed and the design requirements. Due to this water logging condition, pavement is facing serious hydraulic pressure specially, during moving of wheel load (Tohur and Amin, 2017). The problem of pavement layers in water logged is still growing even if the remedial measures were taken into account. This research on improvement of suitable materials for embankment construction in water logged area has been considering the road foundation. According to (Boateng *et al*., 2014) on the report concerning to "Forensic study on the causes of premature failures of road bituminous layers in Tanzania and review of the Tanzanian asphalt mix design methods" as far as road rehabilitation research is concerned. The research was based on the investigation of pavement layers and design review of asphalt concrete for pavement layers' condition particularly severe damaged of ruts, shoving, crack and potholes on the asphalt concrete. They have suggested different design method for treatment of the Asphalt concrete only but the case of road foundation was not discussed in their research. Our study has based on useful road embankment materials in order to address the effect of water in its layers. This scenario led to the understanding on the properties, characteristics and adequacy of the soil as road construction materials (SSRW, 2000).

4.0 MATERIALS AND METHOD

4.1 Description of The Study Area

Mlandizi – Ruvu road section is a mid-size place in the Region of Pwani in Tanzania, it is situated along Dar es salaam – Morogoro Trunk road. The area has a population of approximately 29,394 people (Source : The Tanzania Housing and Population Census, 2022) and is one of the growing centres in Tanzania. The area is a low land with river crossing and existence of high-water table. The road section has prolonged failures to the surface which indicate foundation in capacitance to with stand effect of water penetration. The road with defect of failures crossing a low land with natural water ponds caused by rains and crossing river. The fill materials excavated from existing road embankment through trial pits has proved effect of existence high water table. The Materials Tests Laboratory used for checking properties and characteristics of materials was TANROADS Regional Managers' Office – Pwani and Mbeya Regions. The Test for Permeability of borrow pit and existing fill materials was conducted at (BICO) at University of Dar es Salaam.

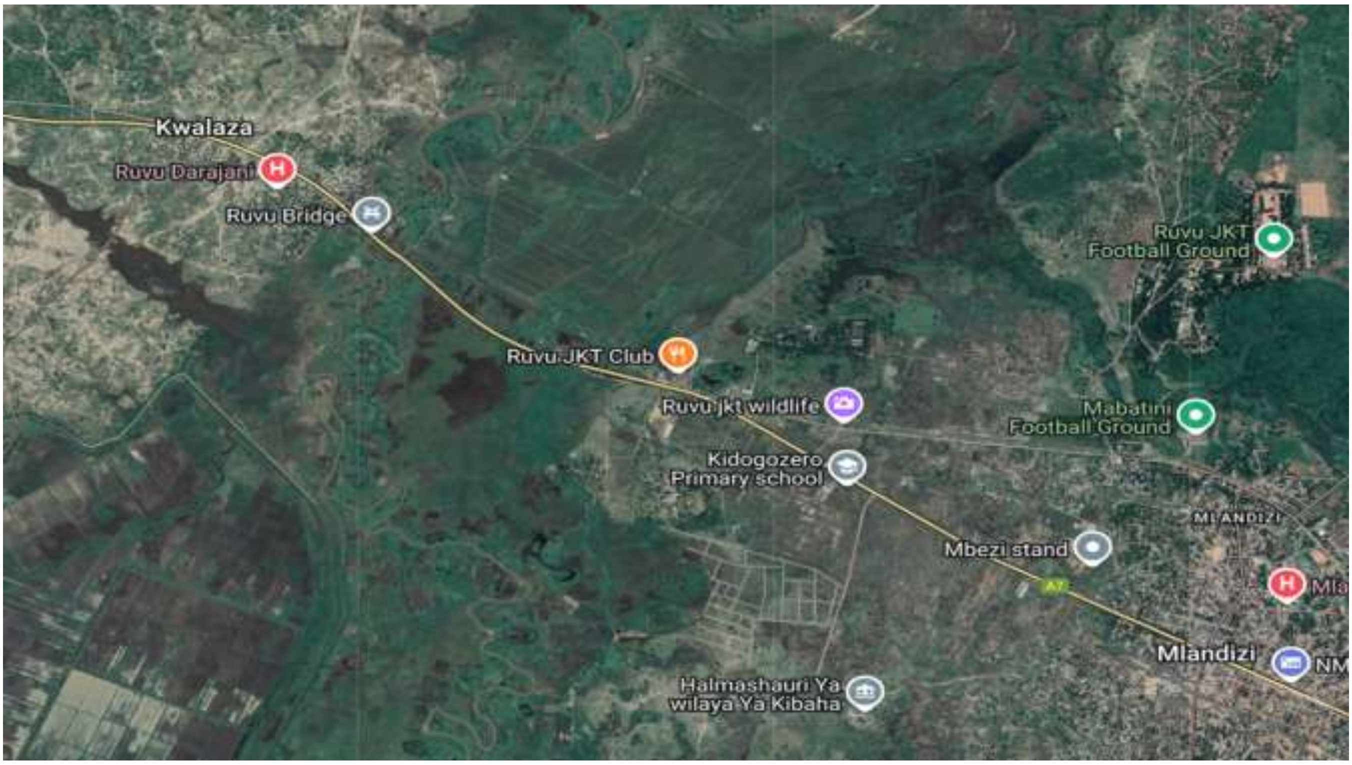

Figure 1: Map data © 2025 Imagery © 2025 Airbus, CNES/Airbus, Landsat /Copernicus, Maxar Technologies

Mlandizi area is approximately 22 km / 13 mi away from Kibaha District Centre. It is medium wet zone due to regular rainfall and river channel crossing the area meandering and causing prolonged wetness to the entire area (Coast region Investment Profile, 2015).

4.2 Data Collection

4.2.1 Sampling Strategies

The samples of natural gravel (G15) were collected from Kibwemwenda borrow pit in Soga village towards Mlandizi – Maneromango road and embankment layers were collected from existing road at trial pits of depth of 1m. According to American association of state highway and transportation officials (AASHTO) soil classification system, imported materials grouped as A-2-4, classified as silty sand gravels good for fill on road embankment. The embankment existing materials classified as A-2-6. However, the gravels met all the requirements for fill materials according to **Table 3602/1** of the Standard Specification (SSRW, 2000). The required tests for fill and improved subgrade layers in reference of the following tests: - Particle sizes distribution (PSD) Atterberg limit. Maximum dry density (MDD), California bearing ratio (CBR) and Swell.

4.2.2 Study Procedure

This study is based on the geotechnical test investigation and improving material parameters of embankment materials. The procedure was to conduct a study on the fill granular materials and its requirements. Bulk samples were collected from borrow pit and separated for checking properties as origin materials and then others blended in different proportions for laboratory tests (CML, 2000). The laboratory tests conducted for road existing materials and blended natural gravel in order to characterize materials. The laboratory tests were based on the following tests: -

a) Natural moisture content
b) Particle size analysis
c) Atterberg limit
d) Specific gravity
e) Proctor Compaction test (Maximum dry density (MDD)
f) California bearing ratio (CBR)
g) Swell
h) Permeability tests

4.3 Laboratory Testing

4.3.1 Granular Soil

Samples of existing fill and gravels and sand were taken from the sources and then laboratory tests were conducted to determine their engineering properties and characteristics. The laboratory tests were examining existing road fill materials, imported natural gravel and blending of sand/gravel mixtures in different proportions. The proportions of mixtures of sand with gravel will come up with up different characteristics and properties of materials. The parameters of mixed materials will influence the appropriate ratios for further stages of improvements.

4.3.2 Blending of Sand with Gravel Mixtures

The improvement of materials for this research has included an identification of source materials, locations and classification based on AASHTO classification system. Samples from one source materials available in Coastal region were taken to laboratory for investigation. The mixing of sand and natural gravel was done mechanically on a riffle boxes and metal tray. The gravel was blended with sand into proportions ratios of 5%,10%, 15%, 20%, 30% and 40%.

4.3.3 Atterberg Limits

The plasticity of soil includes the following combination tests as Atterberg limits (Liquid Limit, Plastic Limit, and Plasticity Index). The tests for determination of consistency limits of fine-grained soils (silts and clays) should be passed in 0.425mm sieve. The Laboratory tests is part of moisture content of soil at which changes from liquid state to plastic state. The Method as outlined in BS 1377-2:1990 or ASTM D4318 – 84 and CML test method 1.2 and 1.3.

4.3.4 Sieve Analysis

Sieve analysis or particle size distribution (PSD) of soil sample is the determination of soil particle size proportion in a sample. It involves passing the soil through a series of sieves with progressively smaller openings. The test determines the percentage passing and retains in each sieve. A logarithmic graph illustrates the proportions of materials in each sample. Method as outlined in BS1377- 2:1990 and CML test method 1.7.

4.3.5 Compaction

Compaction is a proves of increases the density of soil by reducing air voids. The test is known as Proctor compaction of soil. The test determines the maximum dry density and optimum moisture content that can be achieved through compaction. The tests show the strength and stability of soil to withstand external loading. The Proctor Compaction Method as outlined in BS Light and BS Heavy BS1377: Part 4:1990 and CML test method 1.9.

4.3.6 California Bearing Ratio (CBR)

The CBR test measures the strength of a soil in worst condition or saturated in water. It is a test which comparing soil resistance to penetration of standard loading by CBR equipment. The constant bearing strength penetration is taken at 2.5mm and 5.0mm depth of the test's specimen. The test is outlined in BS 1377–4: 1990 or ASTM D 1883 – 99 and CML test method 1.11.

4.4 Permeability

4.4.1 Permeability:

Permeability is a process or habit of measures the ability of water to flow through a soil. It is help in design purposes of drainage systems, filters, and earth dams. Categories of these tests are as follows: -

i. Constant-head permeability test. Suitable for granular soils like sands and gravels as illustrated by **BS 1377: Part 5: 1990, ASTM D2435 – 04 and CML test method 1.15.**
ii. Falling-head permeability test.

5.0 RESULTS

The tests results were arranged according to the specified materials tests requirements through Tables and graphs. The properties, characterization and bearing strength tests for existing embankment fill materials, non-blended and blending of sand/gravel mixture were conducted accordingly. The tests result of materials has been summarized in **Table 3**. The Laboratory tests conducted were as follows: - Natural moisture content, Atterberg Limits, Particle size analysis, specific gravity, compaction tests, and California bearing ratio tests were presented in tables and figures.

Figure 2: As detailed below:-

a) Materials sampling at Kibwemwenda Borrow pit at Mlandizi, Coastal Region.
b) Trial pit excavated for collection of fill materials G7 and G15 and outlined showing water table.
c) Mixture of Gravel with sand read for blending tests
d) CBR penetration reading at Laboratory of TANROADS Regional Managers' Office – Pwani
e) Dried Sample from Oven before sieve analysis test
f) Taking samples for natural moisture content

5.1 DISCUSSION

5.1.1 Consistency Limits

The Atterberg limits through cone penetration tests to different blends proportions were determined to find effect of moisture content to plasticity of materials. The Plastic Index's results of sand/gravel mixture were decreased due to mix ratios of 5%, 10%,15%, 20% sand; 30%, and 40% and produced plasticity index of 8%, 6.2%, 5.7%, 0%,0% and ,0% respectively. The addition of sand to gravel reduces the binding properties and its capacity to retain moisture content. The Laboratory tests results for consistency limits are as illustrated in **Table 1**.

Table 1: Plasticity Index for existing materials G7, G15, blended and non-blended materials

S/No	Existing materials and Blending of Sand/ Gravel (%)	Liquid Limit (%)	Plastic Limit (%)	PI (%)
1	Road existing materials Lower layer (G7) reddish gravel	30.6	14.9	15.8
2	Road existing materials Upper layer (G15) grey colour gravel	34	19.4	14.6

S/No	Existing materials and Blending of Sand/ Gravel (%)	Liquid Limit (%)	Plastic Limit (%)	PI (%)
3	Well graded gravel (GW)	22	14	8
4	Gravel blended with sand 5%	16	10	8
5	Gravel blended with sand 10%	16.8	8.8	6.2
6	Gravel blended with sand 15%	16.6	10.4	5.7
7	Gravel blended with sand 20%	-	-	Non-Plastic
8	Gravel blended with sand 30%	-	-	Non-Plastic
9	Gravel blended with sand 40%	-	-	Non-Plastic

5.1.2 Particle Size Distribution (PSD)

The particle size distribution (PSD) of soil samples were conducted to determine the particles sizes ingredients of materials. The existing road embankment materials G7 and G15 materials' particles distribution sizes were identified in and illustrated in **Figure 6** and summarized in **Table 3.** The results of particle size distribution for blending sand /gravel mixtures ratios of 5%, 10%,15%, 20%, 30% and 40% were indicated in a graph as illustrated in **Figure 7**. A Group index of zero (0) specifies gravel samples fair for road construction.

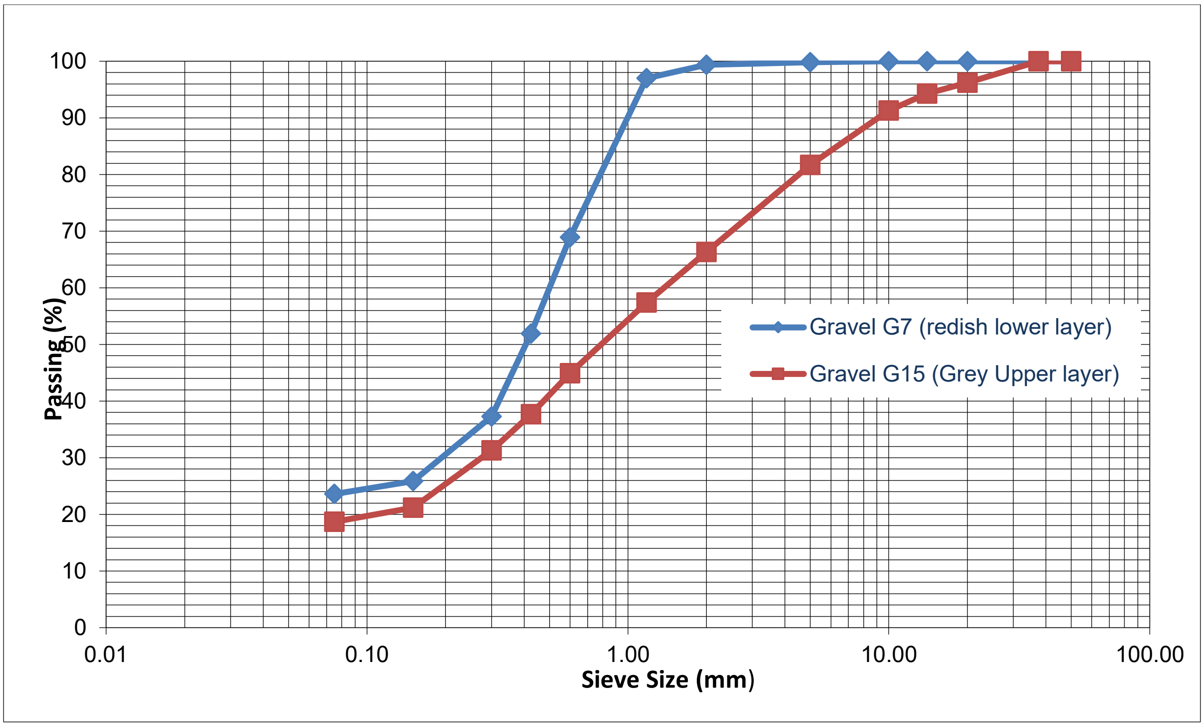

Figure 3: Particles size distribution of improved subgrade G7 and fill materials G15 materials

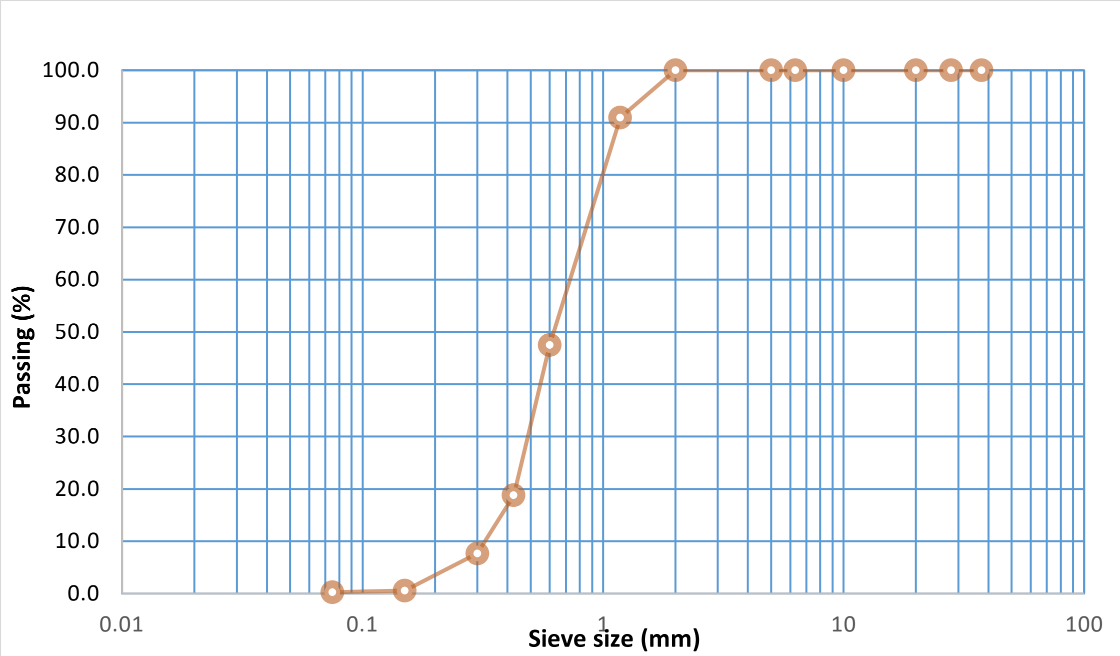

Figure: 4: Relationship of particles sizes distribution of natural sand

The natural sand results of particle size distribution (PSD) are indicated in as illustrated in **Figure 3.** Values for non-blended and blended sand/gravel mixture materials varies according to the percentage increment of sand in mixed proportions at 5%, 10%,15%,20%,30% and 40%. The results of sand/gravel mixture at 20% became lower than 30% and 40% proportions at materials passing at 0.075mm sieve (**Figure 4)**. The Particle size distribution values for non-blended and sand/gravel mixture blended materials vary according to the mix proportions. The particle-size distribution curves indicate not only the range of particle sizes present in a natural gravel or sand/gravel mixture but also the type of distribution curves of various size particles.

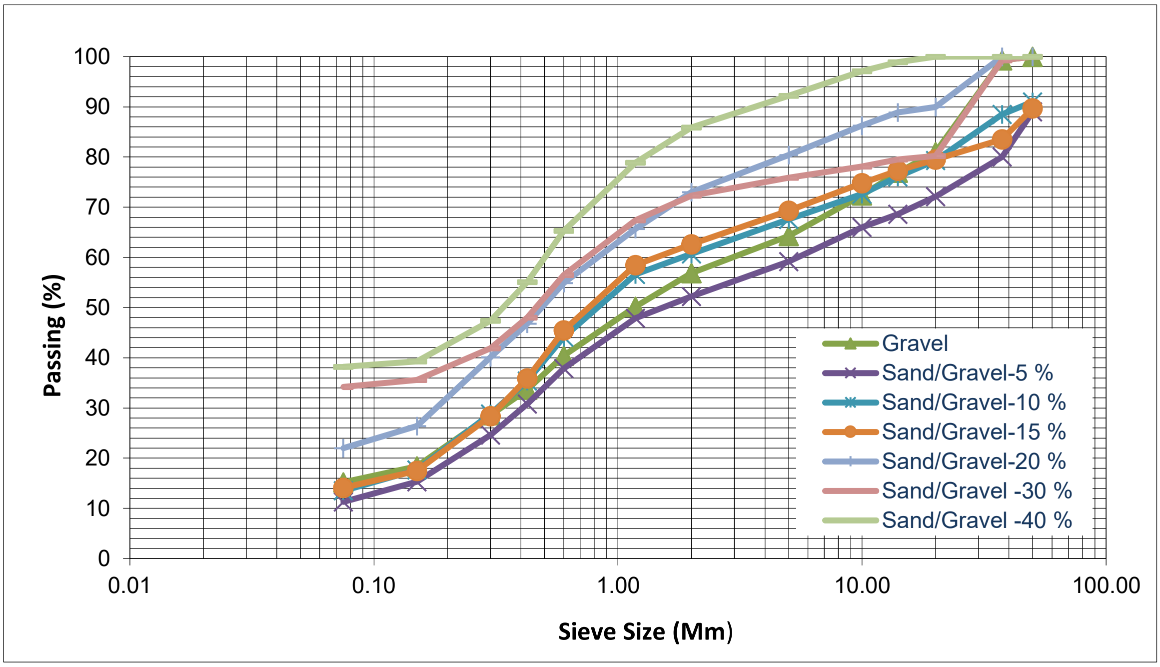

Figure 5: Particles size distribution of natural gravel and sand/gravel blended mixtures materials

5.1.3 Compaction

The modified proctor compaction tests data obtained from the laboratory provides information on the performance of the soils under mechanical remoulding, as envisaged during earthworks and road construction. The maximum dry density of the existing materials G7 and G15 samples ranged between 2065 kg/m^3 and 2095 kg/m^3 and optimum moisture content ranges between 9.8 and 8.1% as illustrated in **Figure 5**.

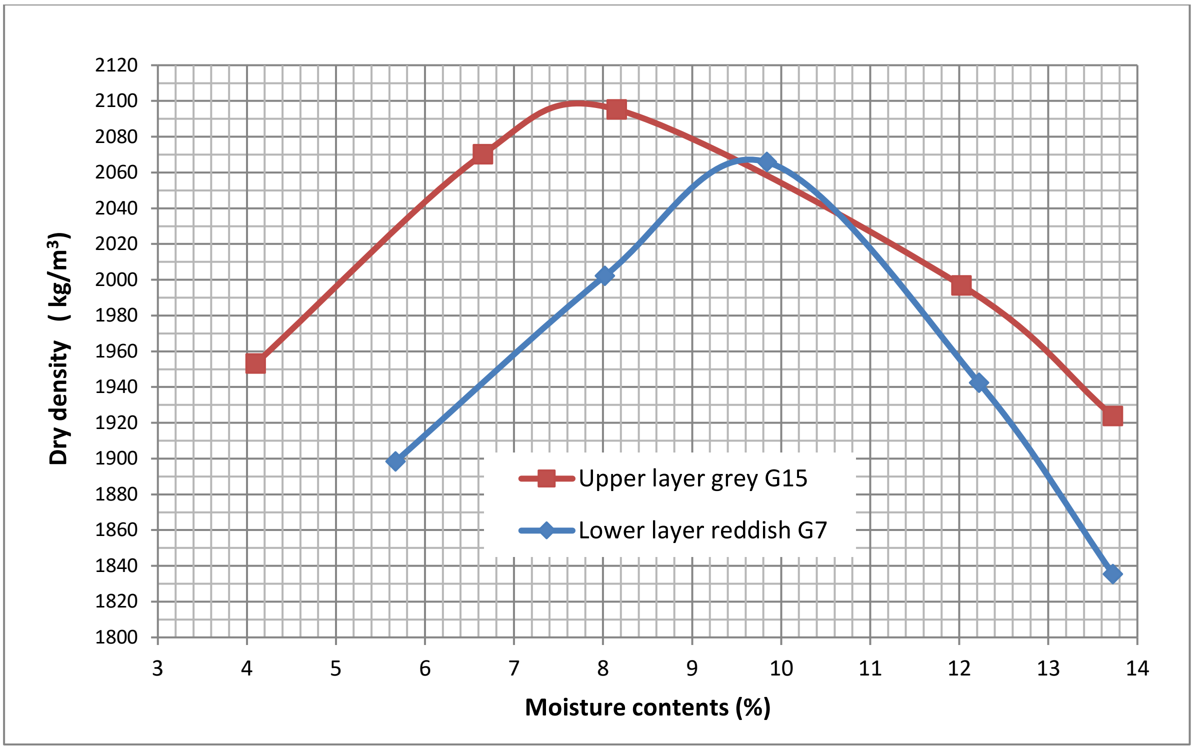

Figure 6: Relationship of maximum dry densities against optimum moisture content of improved subgrade G7 and fill materials G15

Then also. modified proctor compaction tests data of the maximum dry density were obtained from the blending mixing ratio of 5%, 10%,15%,20%,30% and 40% respectively. The value of maximum dry density of sand/gravel mixture at 20% became highest than 5%, 10%,15%,30% and 40% proportions. The maximum dry density of the 20% mix proportions blend is 2263.5 kg/m^3 and optimum moisture content ranges between 5.7 as illustrated in **Figure 7**.

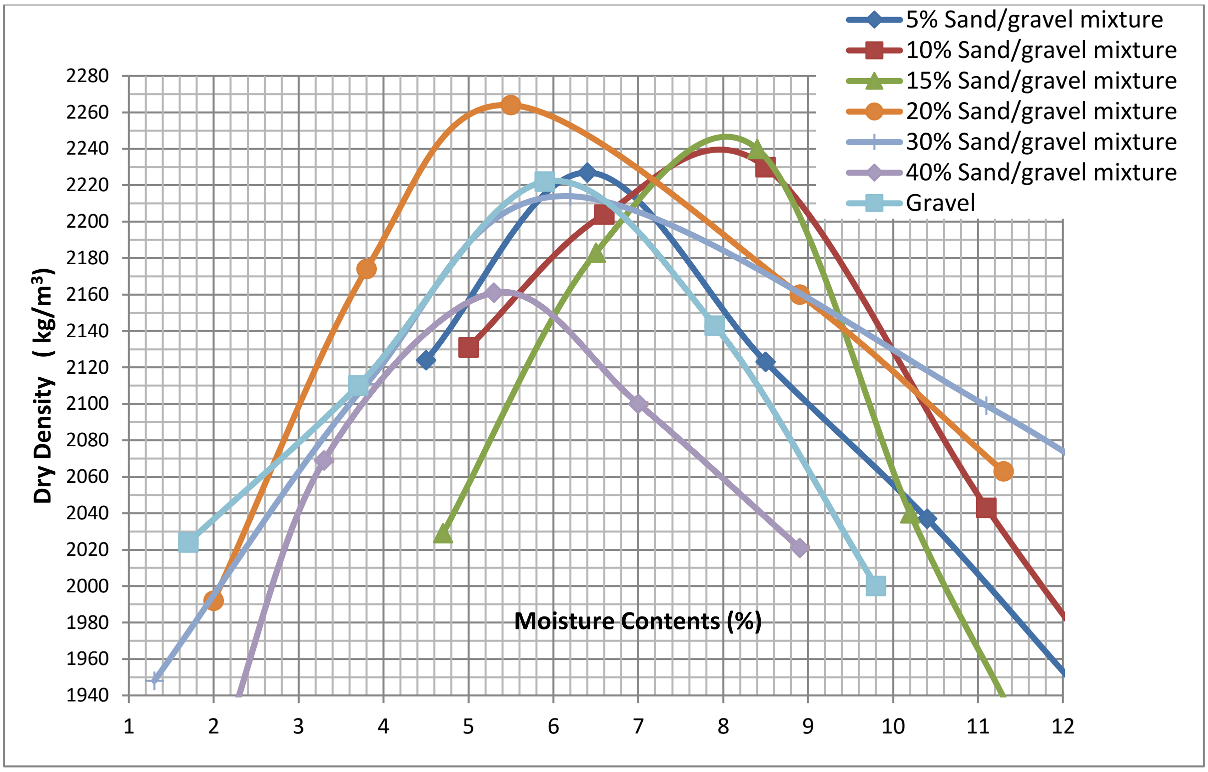

Figure 7: Relationship between dry densities against optimum moisture content of natural gravel and blended sand/gravel mixtures

The graph indicates a trend of sand mixing ratio in gravel against the results of Maximum dry density (MDD) values as illustrated in **Figure 8** varies according to the percentage increment of sand in proportions. Therefore, a rise of sand percentage in the sand/gravel mixture blended at 5%,10%,15%,30% and 40% produces maximum dry density less than sand/gravel mixture blended 20%. The value of maximum dry density of sand/gravel mixture blended at 20% became higher than MDD values from other blended and non-blended materials.

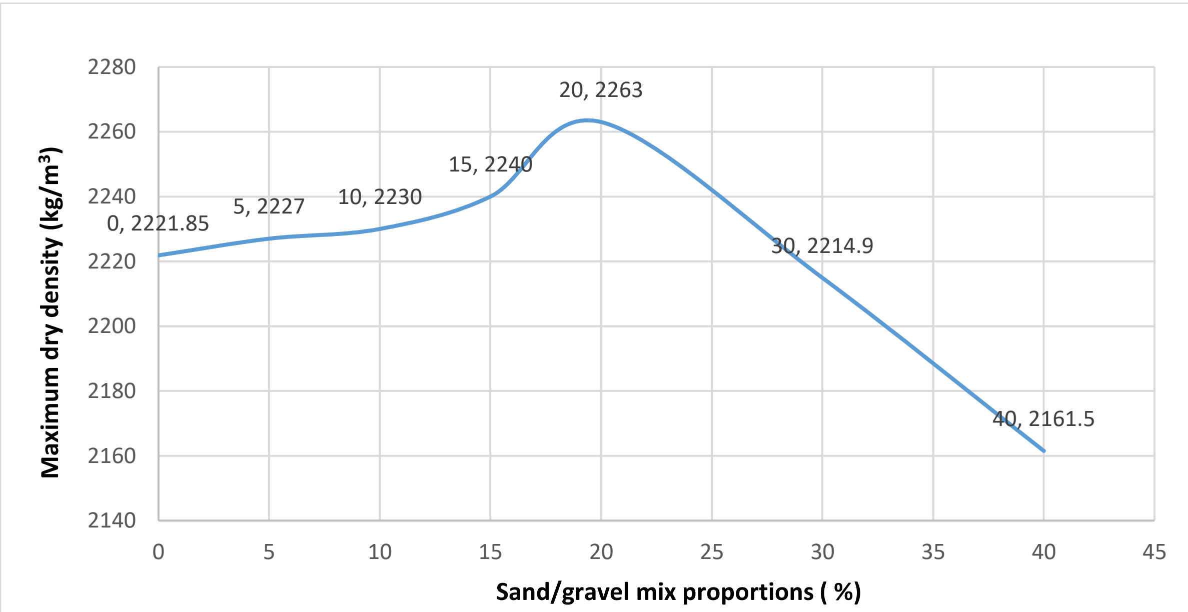

Figure 8: Relationship between maximum dry densities against sand/gravel mixture of blended materials

5.1.4 California bearing ratio (CBR

The California bearing ratio (CBR) value of natural gravel and sand/gravel mixture blending proportions of 0%, 5%,10%,15%,20%, 30% and 40% produced results of 37.9%, 35%, 42 %, 44%, 48.5%, 40%, and 32% respectively. Those results could be attributed to increased/decreased of bearing strength in the sand/gravel mix blends. This is due to an increased concentration mixture of sand in gravel. The materials were improved to meet 4-day soaked CBR requirement for use as G15 improved subgrade/fill type materials. The value of swell at the sand/gravel mixture blended at 20% became lower than values of non-blended materials and other blended materials at mixing ratio of 0%, 5%,10%,15%,30% an 40%. Therefore, a rise of sand percentage at 30% and 40 have caused the increment results value of swell. That means, increment of sand in gravel for mixing proportions of more than 20% has weaken the properties of natural gravel to sustain the effect of water penetration (swell results) as illustrated in **Table 3602/1** of standard specification (SSRW, 2000).

Table 2: CBR values for existing materials G7, G15, blended and non-blended materials

S/No	Materials	CBR (%)
1	Road existing materials Lower layer (G7) reddish gravel	12
2	Road existing materials Upper layer (G15) grey colour gravel	30
3	Natural Gravel	37.9
4	Gravel blended with sand at mix ratio of 5%	35
5	Gravel blended with sand at mix ratio of 10%	42
6	Gravel blended with sand at mix ratio of 15%	44
7	Gravel blended with sand at mix ratio of 20%	48.5
8	Gravel blended with sand at mix ratio of 30%	40
9	Gravel blended with sand at mix ratio of 40%	32

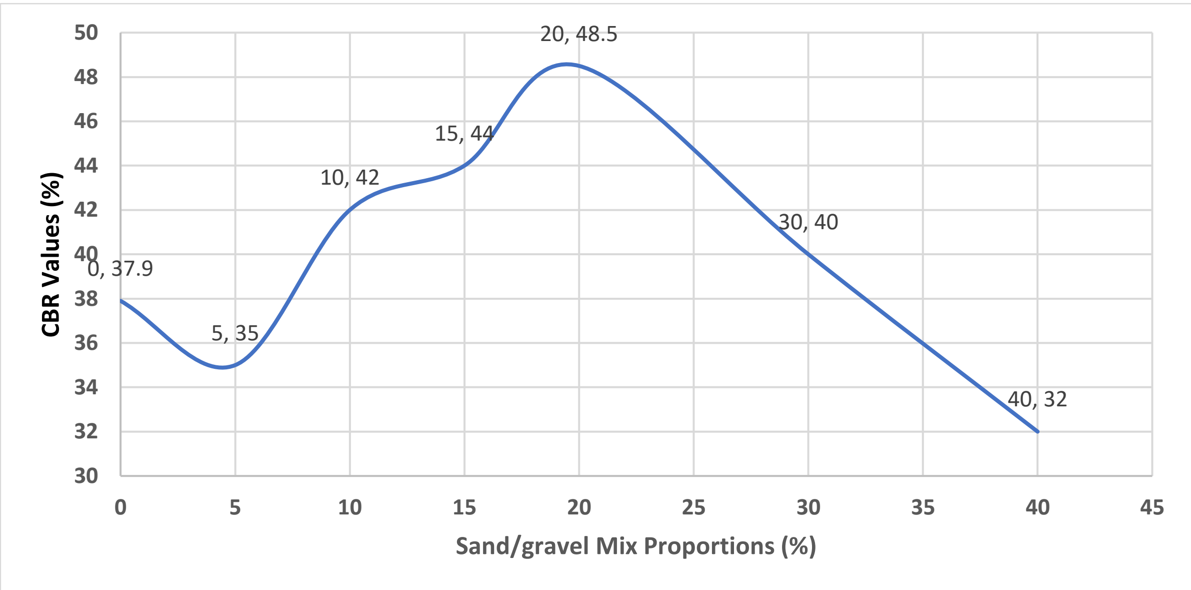

Figure 9: The graph of relationship of CBR values against Sand/gravel mixture

5.1.5 Permeability tests

The test of materials was carried out as per British Standard BS 1377: Part 5:1990 and CML 1.15 procedure. The test was carried out by falling head method for road embankment existing materials of lower layer G7, Upper layer G15, borrow pit materials and its stabilized materials of replacement of cement in GGBS materials samples. The specimens were compacted at their corresponding optimum moisture content to maximum dry density. Permeability values for existing materials G7 and G15 were indicated results as 4.40x10^{-4} cm/s and 8.5 x10^{-5} cm/s while for the imported materials non stabilized materials was 1.6x10^{-3} cm/s respectively. The test results have indicated that, imported materials have drainage property, which makes it suitable for the embankment construction and improved subgrade. The permeability results of materials were summarised in **Table 3.**

Table 3. Compilation of Mechanical Coefficients of Materials tested to determine Permeability

SAMPLE ID	British Soil Classification System			Densities					Consistency			Free Swell	Permeability
	Description		Silt .0002 to	Sand 0.063 to	Gravel 2.0 to	Bulk Density	Dry density	Natural water	Liquid Limit	Plastic Limit	Plasticity Index	%	Coefficient of Permeability
Symbols						r	rd	Wn	LL	PL	Ip		K
Units			%	%	%	mg/m^3	mg/m^3	%	%	%	%	%	cm/sec
BLACK	Very Silty Gravel	GCL	18.7	66.3	100	2316	2095	1.75	34	19.4	7.9	0.09	8.5X10^{-5}
REDISH	Very Silty Gravel	GCL	23.6	99	100	2269	2066	3.79	30.6	14.9	15.8	0.15	4.4X10^{-4}
Borrow pit **0%**	Very Silty Gravel	GCL	15.2	56.9	100	2352	2221.85	0.3	22	14	8	0.63	1.6X10^{-3}

Table 4: Materials names and classification according to ASTM and AASHTO for existing materials G7, G25 and G45 blended and non-blended materials

S/No	Materials description	Group Symbol (ASTM)	Typical name	Soil classification (AASHTO)
1	Existing materials lower layer-reddish gravel	CL – Inorganic clay of low to medium plasticity, gravelly/sand/silt/lean clay	G7	A-2-6
2	Existing materials upper layer-grey colour gravel	CL – Inorganic clay of low to medium plasticity, gravelly/sand/silt/lean clay	G25	A-2-6
3	Light brown gravel	GM – Silt gravel, gravel silt sand mixtures	G25	A-2-4
4	Gravel blended with sand at 5% proportions	GM – Silt gravel, gravel silt sand mixtures	G25	A-2-4
5	Gravel blended with sand at 10% proportions	GM – Silt gravel, gravel silt sand mixtures	G25	A-2-4
6	Gravel blended with sand at 15% proportions	GM – Silt gravel, gravel silt sand mixtures	G25	A-2-4

S/No	Materials description	Group Symbol (ASTM)	Typical name	Soil classification (AASHTO)
7	Gravel blended with sand at 20% proportions	GM – Silt gravel, gravel silt sand mixtures	G45	A-2-4
8	Gravel blended with sand at 30% proportions	SM – Silt gravel, gravel silt sand Clay Materials	G25	A-4
9	Gravel blended with sand at 40% proportions	SM – Silt gravel, gravel silt sand Clay Materials	G25	A-4

5.1.6 Materials and classification according to ASTM and AASHTO

According to AASHTO soil classification system, imported natural gravel was grouped as A-2-4, classified as silty sand which classified as GM. A Group Index of zero (-34) specifies sand samples. The red soil was identified was described as ‘silty clayey gravel which classified as CL and was grouped as A-2-6, after USCS AASHTO soil classification systems. Similarly, the greyish natural gravel was identified as G15 materials of the existing embankment, it is was described as ‘silty gravel’ which classified as CL and good subgrade material A-2-6 according to the two respective classification systems as illustrated in **Table 4.** The materials blended at the ratio more than 30% sand- gravel mixing proportions has lie on the silt-clay materials > 35% passing the 0.075mm sieve as a fair to poor according to the USCS AASHTO soil classification systems. Hence the blended materials at the mixing proportions have been discarded as a proper material for stabilization.

5.1.7 Results descriptions

The value of CBR at 20% sand/gravel proportions outlined a CBR value of 48.5% and has produced a swell result of 0.08% as outlined in **Table 3**. Therefore, a rise of sand percentage at 30% and 40% has affected a swell result which is 0.54 and 0.32 respectively. The Laboratory tests results have been affected with sand/gravel mixtures and change properties and characteristics of materials as follows: -

- The sand/gravel mix proportions ratios of 5%, 10%, 15%, 20%, 30% and 40% by weights were examined to specified requirements and the mixed ratio of 20% tests results indicate improvements particularly to Maximum dry density (MDD, CBR and swell as illustrated in **Table 3**.
- However, the decreasing plasticity would consequently result in decreasing swell of the soil samples. All the resulting blends has liquid limit less than 25%, evidence of lower plasticity. Such blends are suitable for fill materials (Jjuuko et al., 2011).
- The blended materials having mixing concentration between 5% to 40 % have their Maximum dry density (MDD) greater than 2000 kg/m^3 and Optimum Moisture Content (OMC) less than 10%, that would perform under saturated moisture content excellently as a fill material above G15 requirements.
- The existing fill materials plasticity is 14.6% while imported natural gravel is 8%. The blended materials plasticity has fall to 5% as non-plasticity materials.
- Due to the remarkable improvements from blended materials, the bearing strengths (CBR) at the sand /gravel mix proportions of 5%,10%,15%,20%, 30% and 40% have improved for G15 materials requirement.

6.0 CONCLUSION AND RECOMMENDATION

The aim of the study was to understand the physical properties and characteristics of the embankment materials. The research was based on testing the road embankment materials properties and characteristics by making comparison with imported materials from borrow pit. A study has based on assessing effective properties, characteristics and drainage properties of natural gravel and existing embankment fill materials. Sand/gravel mixture materials BLENDED have shown improvement regarding to consistency limits, particle size distribution (PSD), proctor compaction, California bearing ratio tests (CBR) and Permeability. According to AASHTO soil classification system, all the four blended materials samples were grouped as A-2-4 for sand/gravel mix ratio of 5%,10%,15% and 20% while 30% and 40% classified as A-4. The materials blended at the ratio of more than 30% and 40% sand/gravel mixing proportions lies on silt-clay materials > 35% passing the 0.075mm sieve as a fair to poor according to the USCS AASHTO soil classification systems. The gravel/ sand blended materials samples at mix ratio of 20% has selected as proper materials for fill as improved according to specified requirements for fill materials. The blended materials met all the requirements for improved subgrade and fill materials as illustrated in (SSRW, 2000). The utilization of sand/gravel mixture blended materials to the water-logged area road construction may hinder the effect of water penetration to the pavement layers. We recommend application of blending of materials with different properties to enhance the effect of water penetration. Further research is recommended to analyses the more different materials with different characteristics in order to implement the fill materials for embankment. The study recommends the need for the use laboratory investigated and improved materials for construction in water logged areas. The utilization of sand/gravel mixture blended materials to the water-logged area road construction may hinder the effect of water penetration to the pavement layers. However, a study recommends the need for the use laboratory investigated and improved materials for construction in water logged areas. Furthermore, sustainability development of construction works of the country shall be based on the proper use of local oriented potential materials to reduce cost. Future research should be widened based more in application of use different materials for road embankment construction.

DECLARATIONS

Data Availability

Statement The data presented in this study are available on request from the corresponding author.

Conflict of interest

The authors declare no conflict of interest.

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