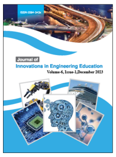

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Strength evaluation in sub-base material due to variation of fine particles in soil

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Abstract

For the development of road infrastructure and the various layers connected to it, soils must be compacted in order to increase their strength. Among many other variables, soil type, moisture content, and compaction energy have a significant impact on the compaction qualities of soil. Present study is done to evaluate strength of sub-base material with varying percentage of fines and also the variation of dry density, Optimum Moisture Content (OMC) and California Bearing Ratio (CBR) with fine content. The Standard Proctor Test was the technique used to determine the Maximum Dry Density (MDD) from various soils[1].On material recovered from the TikaBhairav and BhimPhedi quarries, several laboratory tests were performed. The objective of laboratory test is to find the gradation of aggregate mix followed by index properties of fine, compaction property and strength in terms of CBR. The MDD and strength of two types of aggregate were discovered through this study. For classification of aggregate mix the Unified Soil Classification System was used. For sub-base material obtained from TikaBhairab, at an OMC of 8.06% best compaction was achieved at 15% fine content. Similarly, for sub-base material obtained from BhimPhedi, best compaction was achieved at 10% fine content compacted at an OMC of 8.05%. Also the result indicates that for sample obtained from TikaBhairab, well graded gravel with silt has higher MDD and for materials obtained from BhimPhedi, poorly graded gravel has higher MDD.

1. Introduction

According to DoR's data on the road system, Nepal's National Road Network has a total length of 13060.25 km, including 6980.02 km of asphalt, 2045.18 km of gravel, and 4035.05 km of earth roads. Similar to this, 378.5 km of roads are being built, and in the upcoming ten years, GoN has planned a strategic road network of roughly 1965.20 km.[2].

Being a developing country the major portions of road network comprise of earthen roads. Road interconnectivity promotes economic development, improves accessibility, and increases agricultural productivity. Thus development of sustainable road is an important concern of every transportation and geotechnical engineers.

Sub-base layer is a compacted layer over a compacted sun-grade is an integral part of flexible pavement[3] . One of the primary structural elements of the pavement is found in the road sub-base layer, which is one of these layers and immediately follows the base layer. It is crucial in distributing the load equally throughout the surface and hence stresses communicated to subgrade don't exceed the permissible layers' capacity for support[4] . The layers should be very stiff and strong. Unbound granular, bituminous, and cemented materials are utilized to construct road sub-bases. The high stability of an unbound granular road sub-base is a result of particle interlocking and friction between the particles[5]. Aggregate gradation, their properties are important factors in this type of construction. When building an unbound granular sub-base, drainage capability is equally crucial to take into consideration. A dense continuously graded mix is preferable when stability is the main objective. This grading, though, might be incompatible with the permeability specifications. Molding moisture content is the ideal moisture level

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for a given grading at which maximal dry density and consequently stability are attained[6] .

The criteria that affect sustainability should be included in road construction at the lowest possible cost. The use of technology and materials that are recommended by standard procedures and specifications typically results in greater building costs. It is essential to do research on the compaction as well as strength phenomenon of locally accessible materials in order to develop roads that are cost-effective.

Limits are imposed on fine percentage, or material finer No. 200 (75 µm) sieve, in the majority of grading specifications. Additionally, the Plasticity Index is given a maximum value. Dry density, permeability and strength of unbound granular sub-base can be predicted to be affected by proportion of finer material 75 µm; the flexibility of fines is likely to affect strength characteristics[7]. The purpose of this research is to assess the influence of fines content on the strength and compaction characteristics of DoR road sub-base material.

2. Research objectives

This study's main goal is to assess the strength of sub-base material obtained from various quarries with differing amounts of fines.

3. Material and methods

To achieve the objective of the study, the primary data was obtained from laboratory test of two selected quarries. The sub-base material to be analyzed is collected from Bagmati zone area of selected quarries which includes Tikabhairab quarry and Bhimphedi quarry. Tikabhairab is located in Lalitupr district at a distance of 21.2 Km from Kathmandu and Bhimphedi is located in Makwanpur district at a distance of 59.7 Km from Kathmandu. The samples are obtained conforming to the DoR Standard Specification for Road and Bridge Works, Clause 1200[8]. Table 1 represents the sample used in this research:

With the samples obtained from the quarries, laboratory tests were performed in the Central Material Testing Laboratory, Pulchowk Campus. A variety of test findings were obtained after the aforementioned tests were carried out on aggregate samples with varied percentages of fines at a 5% increment. The soil was classified based on the obtained plasticity and grain size distribution test findings. A modified proctor test carried out in accordance with AASHTO T 180 D, in which samples were compacted in five layers, with each layer receiving 56 even blows from a hammer weighing 4.54 kg. A range of the maximum dry density and the ideal moisture content were derived from the modified Proctor test after graphing the moisture-density curve [9]. Similar to that, the Soaked CBR test was run on samples that had been remolded with OMC utilizing 10, 30, and 65 blows of modified proctor density [10].

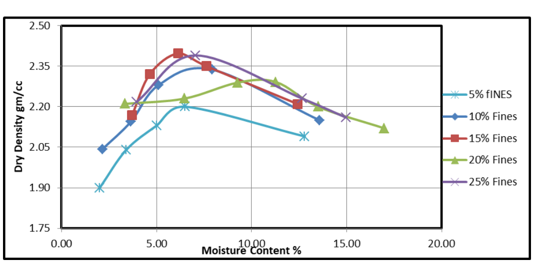

Figure 1: Comparision of Dry Density with Moisture Content for Tikabhairab Quarry

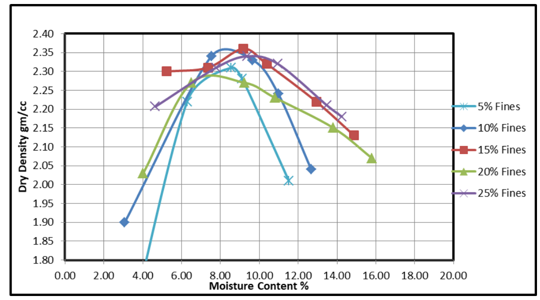

Figure 2: Comparision of Dry Density with Moisture Content for Bhimphedi Quarry

4. Results and discussion

The fines employed in this study are obtained from the Tikabhairab. Since 91.99% of the particles in the soil are smaller than 75 µm, it is categorized as fine-grained soil. The fineness modulus is 0.20, indicating that clay-sized particles make up the majority of the fines. A list of the engineering characteristics of the fines utilized in the investigation is provided in Table 2:

Natural hue of fine obtained was dark greyish. The USCS soil classification system's A-Line equation is used to classify fine based on Plasticity Index, resulting fine as ML, denoting Low Plastic Silt with a specific gravity of 2.58.

This fine is mixed with the aggregate samples obtained from the quarry with an increment of 5%. The summary on sieve analysis of soil aggregate mix is shown in Table 3 and Table 4 for Tikabhairab and Bhimphedi Quarry respectively:

After the gradation analysis and soil classification, heavy compaction test were conducted for different soil mix. The result of the heavy compaction test for both quarries

Table 1: Tests, Numbers of Samples and Method for Laboratory Test

SN	Tests	Number of Samples	Methods	Output	Remarks
1	Sieve Analysis	Fines = 1 nos Tikabhairab = 6 nos Bhimphedi = 6 nos	(ASTM D 422-63)	Soil type identification	Including fines & aggregate mix
2	Atterberg's Limit Test (LL, PL, PI)	Fines = 1 nos	(ASTM D 4318)	Determine LL, PL and PI value	For fines
3	Standard Proctor Compaction Test (MDD, OMC)	Tikabhairab = 5 nos Bhimphedi = 5 nos	(AASHTO T 180)	Determine MDD & OMC value	For both Quarries
4	CBR Test	Tikabhairab = 5 nos Bhimphedi = 5 nos	(AASHTO T 193)	CBR Value	For both Quarries
5	LAA Test	2	(ASTM D4318-III)	To determine % abrasion value	For both Quarries
6	AIV Test	2	(ASTM D4318-III)	To determine the aggregate impact value	For both Quarries
7	Specific Gravity and Water absorption Test	3	(AASHTO T 180)	To determine specific gravity of fines & aggregate	Including fines &both quarries

Table 2: Engineering characteristics of fines

S.N	Properties	Description
1	Color	Dark Grey
2	Atterberg's Limit	LL= 26.7% PL= 21.5% PI= 5.2% (PI= 0.73*(LL-20) Below A-Line)
3	Specific Gravity	2.58
4	Soil Classification (USCS)	ML i.e. Low Plastic Silt

Table 3: Result of gradation analysis of mix (Tikabhairab)

Sieve Size (mm)	% Fines Content				
	5%	10%	15%	20%	25%
	% Passing by Weight				
63.000	100.00	100.00	100.00	100.00	100.00
40.000	92.78	93.13	93.43	93.71	93.96
20.000	65.20	66.25	67.71	69.06	70.30
10.000	45.54	47.86	50.13	52.21	54.12
4.750	38.60	39.32	41.96	44.38	46.60
2.360	32.23	33.61	36.49	39.14	41.57
1.180	22.59	24.67	27.95	30.95	33.71
0.075	5.62	5.73	5.83	5.92	6.00

is shown in figure 1 and figure 2.

The maximum dry density at the ideal moisture content can be seen on the graph between dry density and moisture content with varied percentages of fines. According to the graph, an ideal moisture level of 8.05% with a fine content of 15% is reached for Tikabhairab Quarry to produce a maximum dry density of 2.4 gm/cc.

Similarly for Bhimphedi Quarry, the graph plotted between dry density and moisture content at varying percentage of fine content revels that maximum dry density of 2.39 gm/cc is achieved at an OMC of 8.06% at fine content of 10%. To find the strength of the mix at varying fine content, soaked CBR test is carried out. The test results of soaked CBR for both quarries are shown in Table 6 and Table 7 below.

The CBR Test revealed that for sub-base material of Tikabhairab Quarry, the maximum value of CBR i.e. 60% is achieved at the maximum dry density of 2.4 compacted at an OMC of 8.05% with 15% fine content. Also for sub-base material obtained from Bhimphedi Quarry, the maximum CBR of 60% is achieved when the material is compacted at an OMC of 8.06% with 10% fine content.

Table 4: Result of gradation analysis of mix (Bhimphedi)

Sieve Size (mm)	% Fines Content				
	5%	10%	15%	20%	25%
	% Passing by Weight				
63.000	100.00	100.00	100.00	100.00	100.00
40.000	92.72	93.50	93.79	94.05	94.28
20.000	62.35	64.40	65.95	67.37	68.67
10.000	44.29	46.41	48.74	50.88	52.84
4.750	37.51	38.35	41.03	43.48	45.75
2.360	32.02	32.34	35.28	37.98	40.46
1.180	26.80	27.70	30.84	33.72	36.38
0.075	10.36	10.49	10.39	10.29	10.20

Table 5: Soil Mix Classification

S.N.	Fine %	D60	D30	D10	Cu	Cc	USCS Soil Classification
Tikabhairab Quarry	No Fines	18	3.50	0.220	81.81	3.09	GP
	5	17.5	3.20	0.120	92.36	2.06	GP
	10	17	1.80	0.150	113.33	1.27	GW-GM
	15	16	1.60	0.130	123.00	1.23	GM
	20	15	1.16	0.120	125.00	0.75	GM
	25	14	0.80	0.110	127.27	0.42	GM
Bhimphedi Quarry	No Fines	20	3.80	0.075	266.67	9.62	GP
	5	19	2.60	0.075	256.34	2.42	GP
	10	18	1.80	0.075	240.00	2.40	GW-GM
	15	18	1.20	0.075	240.00	1.06	GM
	20	16	0.79	0.070	228.60	0.56	GM
	25	15	0.60	0.070	214.28	0.34	GM
GP – Poorly Graded Gravel GW – Well Graded Gravel GM- Silty Gravel GW-GM- Well Graded Gravel with Silt							

Table 6: Results of CBR Test on Soil Aggregate Mix for Tikabhairab Quarry

Fines %	MDD (gm/cc)	OMC (%)	CBR Value (%)
5	2.17	8.60	35
10	2.34	8.53	50
15	2.40	8.05	60
20	2.28	8.92	55
25	2.36	8.62	43

Table 7: Results of CBR Test on Soil Aggregate Mix for Bhimphedi Quarry

Fines %	MDD (gm/cc)	OMC (%)	CBR Value (%)
5	2.31	8.00	27
10	2.39	8.06	60
15	2.34	8.28	55
20	2.28	6.39	31
25	2.33	9.18	17

5. Conclusion

This study was aimed to evaluate the strength in terms of CBR due to varying percentage of fines in two selected quaries. From the results and discussion, it can be concluded that:

1. For sub-base material obtained from Tikabhairab Quarry the MDD of 2.4 gm/cc is obtained at OMC of 8.05% with 15% fine content. The literature review suggests that the strength of the material should be high at MDD compacted at an OMC. CBR Test result also revealed that the strength of the sub-base material is high i.e. 60% when compacted at optimum moisture content with 15% fine content.

2. For sub-base material obtained from Bhimphedi Quarry the MDD of 2.39 gm/cc is obtained at OMC of 8.06% with 10% fine content. CBR Test result also revealed that the strength of the sub-base material is high i.e. 60% when compacted at optimum moisture content with 10% fine content.

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