

# Geotechnical Characterization of Selected Soil for use as Sub base Materials for Low Volume Road Construction: A Case Study of Bilate Quarry Site, Southern Ethiopia

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**Abstract:** *This article presents a laboratory investigation on a soil sample from Bilate quarry site in relation to its use as sub base materials in low volume road connecting Keranso kebele to Langano kebele of Misrak Badwacho woreda of southern Ethiopia. Engineering tests such as, sieve size analyses, Atterberg limits, compaction and California Bearing Ratio were carried out on sample collected from the quarry site. All the analysis was carried out in line with the ASTM testing procedures. The results obtained showed that the soil investigated contains 8.96% fine, 43.71% sand and 47.33% gravel. The result of Atterberg limits analysis showed that the liquid limits is 46.57%, plastic limit is 35.74% and index of plasticity is 10.83%. From modified compaction test it is found that maximum dry density/MDD/ of the soil is 1.74g/cm<sup>3</sup> and optimum moisture content/OMC/ is 19.16%. California bearing ratio/CBR/ value at 95% MDD is found to be 25.5% and it is less than minimum standard CBR (30%) value for sub base material. Thus the soil from quarry site does not fulfill the strength criteria for sub base material in low volume roads construction.*

**Keywords:** California Bearing Ratio, Atterberg Limits, Sieve size Analysis, specific gravity

## 1. Introduction

Low volume roads in Ethiopia typically carry less than 300 vehicles per day and provide important links from homes, villages and farms to markets and offer the public access to health, education and other essential services [1]. Low volume roads are of significant importance to the economic development and advancement of rural communities. In Ethiopia the majority of the total road network can be considered as low volume roads. [2]

Construction materials cost is a major component of the costs of road construction. To minimize construction cost of low volume roads use of locally available materials is advocated by Ethiopian roads authority (ERA). To insure cost reduction in roads construction sources for locally available construction materials need to be identified within an economic haulage distance. Local materials must be available in sufficient quantity and of sufficient quality for the purposes intended. Cinder gravel is one of the locally available materials that can be used as construction materials in low volume roads. [3]

The importance of proper geotechnical investigation of soil to be used for road work cannot be over emphasized. Particle size distribution, Plasticity properties, Moisture density relation (Maximum dry density and optimum moisture content) and California Bearing Ratio (CBR) are some of the important geotechnical properties usually investigated before construction. The result of the investigation should be checked against national standard to ascertain materials usability as roads construction materials.

The particle size distribution gives an indication of the various particle sizes (i.e. fine, sand and gravel) present in the whole soil sample. According to Unified soil classification systems (USCS) gravels are soil fraction with particle size of greater than 4.75 mm, sand are soil fraction with particle size between 4.75 mm and 0.075 mm, while fines (silt and clay) are soil fraction with particle size of less than 0.075mm[4].

The plasticity of soil gives an indication of its sensitivity to water and a possibility of the type of clay mineral present in the soil [5]. Liquid limit is the higher limit establishing the state of consistency (degree of firmness) for fine-grained soils. Liquid limit divides the liquid state from the plastic state of the soil. The dividing line between plastic states and semi solid states of soil is termed as plastic limit [6]. Particle size distribution and the plasticity characteristic are used for soil classification.

Compaction of soil has great importance for practically achieving the desired strength, permeability and compressibility of soil during the construction. Standard compaction test and modified compaction test are two famous laboratory test methods to determine the compaction characteristics of soils worldwide. Compaction test is used to establish a dry density and moisture content relationship of a soil under controlled condition. The maximum dry density (MDD) and optimum moisture content (OMC) determined in the laboratory are used to simulate field conditions. The obtained OMC are used to compact soil from which the laboratory CBR will be obtained. The CBR value has been the most important parameter that engineers used to assess the suitability of soil for road pavement. Materials with high CBR are generally considered superior materials for

pavement construction [7].

## 2. Materials and Methods

Disturbed soil sample was collected from quarry site for geotechnical evaluation. Several of the required geotechnical analyses were carried out on the soil sample. These include particle size analysis, atterberg limits test, modified compaction test and 24 hours soaked California Bearing Ratio (CBR) test. All various tests were carried out according to ASTM standard test procedures.

## 3. Results And Discussion

### 3.1 Particle Size Analysis

The particle size distribution analysis shows the percentages of different soil fractions present in the soil. The results obtained showed that the soil investigated contains 47.33% gravel, 43.71% sand and 8.96% fine. The particle size distribution of the soil sample as compared with national specification is presented in Fig.1. As it can be seen in fig. 1, soil sample from quarry site do meets the requirements for the particle size distribution for the sub base material in low volume roads.

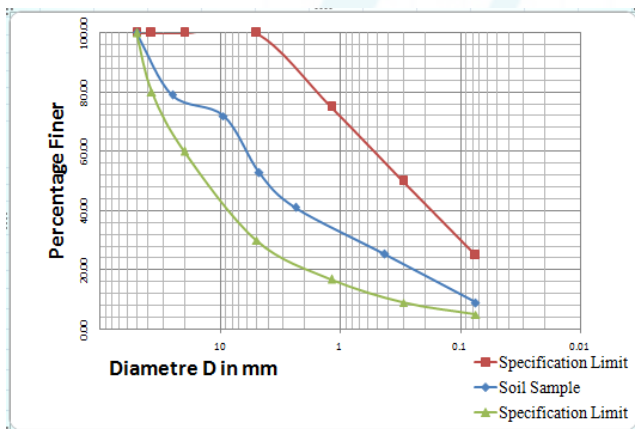


Figure 1: Grain size distribution

### 3.2 Atterberg Limit Test

Atterberg test results are summarized in Table 1. Liquid Limit (LL), Plastic Limit (PL) and Plasticity Index (PI) are valuable limits for identifying and classifying soils. The liquid limit of the investigated soil is 46.57%, its plastic limit is 35.74% and index of plasticity is 10.83%. According to USCS the soil investigated will be classified as GW-GM. The liquid limit of the studied soil exceeds the maximum specified liquid limit (45%) for sub base materials in low volume road construction in seasonally wet tropical areas [8].

Table 1: Result of Analysis

No	Test Type	Result
1	Liquid Limits (%)	46.57
2	Plastic Limits (%)	35.74
3	Plasticity Index (%)	10.83
4	MDD(g/cm <sup>3</sup> )	1.74
5	OMC (%)	19.16
6	CBR (%)	25.5

### 3.3 Compaction Test

Compaction test result is shown in fig. 2. Maximum dry density (MDD) and optimum moisture content (OMC) of soil are determined in the laboratory to simulate field conditions. [9] Under modified proctor test the optimum moisture content (OMC) and maximum dry density (MDD) of the tested soil are 19.16% and 1.74g/cm<sup>3</sup> respectively.

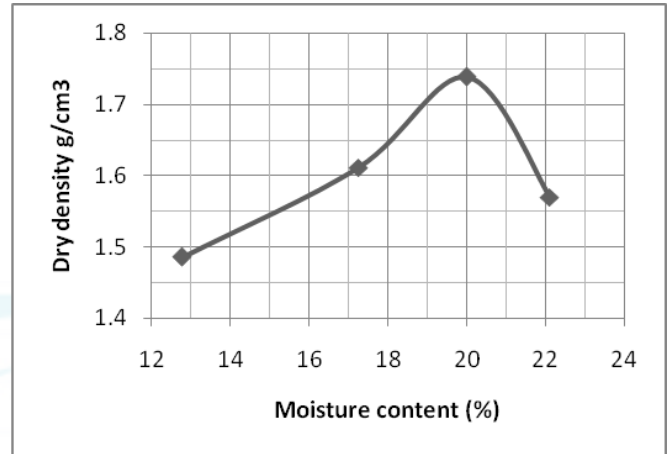


Figure 2: Compaction test result

### 3.4 California Bearing Ratio (CBR)

California bearing ratio (CBR) test is used to estimate bearing capacity of sub-grade, sub-base and base materials. A CBR value of the soil sample tested is found to be 25.5%. For soil to be used as sub base material in road construction minimum CBR of 30% is required at the highest anticipated moisture content when compacted to the specified field density [10]. Thus the soil sample tested does not meet strength requirement of sub base material.

## 4. Conclusion

Geotechnical investigation on soil sample from Bilate quarry site of southern Ethiopia has been carried out and the result of the tests were compared with Ethiopian roads authority specification for low volume roads sub base materials. The result showed that particle size distribution of the studied soil is in the range proposed for the use of sub base materials but samples do not satisfy the condition of LL < 45% for sub base material in seasonal wet tropical areas. CBR test result of 25.5% does not satisfy the minimum specified CBR (30%) for sub base material in low volume roads. This suggests that the cinder gravel from quarry site is of poor quality and do not satisfy the minimum requirement for sub base material in low volume roads.

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