Case Study - Evaluation of Laboratory and Field Density of Backfill materials

[1]Yimam Mohammed, [2]Eshetu Mathewos, [3]Prof.Dr.S.Moses Aranganathan,

[1]Lecturer, Civil Engineering, Wolaita Sodo University, Sodo, Ethiopia, email: yimam2003@gmail.com
[2] Head of Civil, Department of Civil Engineering, Wolaita Sodo University, Sodo, Ethiopia, eshetum90@gmail.com
[3]Professor, Department of Civil Engineering, Wolaita Sodo University, Sodo, Ethiopia , email:mosessomu@gmail.com

ABSTRACT

The main aim of this study is to determine the laboratory and field densities, and relative compaction of backfill materials. These fill materials were collected from the excavated site. The Samples were taken to to conduct tests in the laboratory. The test results obtained from the laboratory are grain size analysis, atterberg limit and proctor compaction tests. The soil type classified under this project is GC. For fill materials 1, 2 and 3; the average maximum dry density and optimum moisture contents are 1.665, 1.682 and 1.684$\mathbf{Mg/m^3}$, and 15.6, 17.22 and 18.1% respectively. The field compaction tests were also conducted according to sand cone method. The results obtained for average field dry density and moisture content are 1.638, 1.658 and 1.679$\mathbf{Mg/m^3}$, and 20.21, 22.76 and 20.3% respectively. Finally, the average relative compactions are 97, 98 and 101%. Therefore, this degree of compactions leads us to utilize these fill materials for different constructions purposes.

Keywords: *Backfill, Dry density, Moisture content, Relative compaction.*

I. INTRODUCTION

When fill materials are used, the engineering properties of the soil need to be improved by compacting it. The direct consequence of soil compaction is densification, which, in turn, results in higher strength, lower compressibility, and lower permeability. Most construction specifications for fill materials are based on laboratory compaction tests. These laboratory compaction tests are designed to represent the highest degree of compaction that ca.n be reasonably be achieved in the field. The most common of these laboratory tests are the standard and modified Proctor tests. Both of these tests utilize impact compaction, although impact compaction shows no resemblance to any type of field compaction and is relatively in effective for granular soils [1]. When fill materials are used, the Engineering properties of the soil need to be improved through compaction. The primary benefit of compacting soil is to increase its strength [4].Field exploration and sampling are extremely important to the design of foundations, selection of backfill, and planning for construction. A great amount of material will be available from required excavations, and the investigation for foundation conditions should include the sampling and evaluation of these materials for possible use as backfill [1.

Location of Backfill Material Site

The location of backfill materials are found in Wolaita Sodo town, South Nations Nationalities and Peoples Region, Ethiopia. The specific name of location of this area is Lintela.

II. METHODS AND MATERIALS

In order to quantify the degree of compaction, laboratory test has been established as a reference to compare with the field achievement. However, the procedures of such tests were arbitrarily established during its invention but have now been standardized in the earthworks specification worldwide. The famous laboratory compaction test is proctor test devised by proctor (1933) [2], which used mechanical drop rammer to compact the soil in sequence of thin layers within 1 litre cylindrical steel mould.

The back fill materials were collected from the Lintella site. All selected materials collected from the this site, were tested in laboratory using standard proctor test and in field using sand cone method. Though the analysis of dry density and moisture content were determined and collected in both test methods. The relative compactions have been determined and compare with different standards presented in Table 2.1 below.

When fill soils are used, testing is required in the laboratory first, in order to determine their maximum dry densities and their optimum moisture contents (OMC). Compacting fill at their optimum moisture content is the most economical technique that a contractor can use to reach the required density of the material [4].

2.1 Standard Proctor Compaction Test

According to ASTM, the test procedure covers laboratory compaction procedures used to determine the relationship between water content and dry unit weight of soils compacted in a 4 or 6 in. diameter mold with a 5.5 lb. A soil at a selected water content is placed in three layers into a mold of the given dimensions, with each layer compacted by 25 blows of the hammer [4].

2.2 Field Test by Sand Cone Method

Through the construction of structures and roads, the determinant parameter going to be determined or measured is dry density of soils. Knowing this, the field compaction tests are needed for determinations of dry density and moisture content.

The basic principle of sand replacement method is to measure the in-situ volume of hole from which the material was excavated from the weight of sand with known density filling in the hole. The in-situ density of material is given by the weight of the excavated material divided by the in-situ volume [5].

Table 2.1: The Minimum Standard of relative Compaction

Types of fill	Minimum Required Relative Compaction [8]	Types of fill [5]	Minimum Relative Density Required
Fill to support building or roadways	90%	Residential Fill	95%
Upper 150mm of sub grade below roadways	95%	Commercial fill to support floor loading up to 20kPa and isolated pad footing to 100kPa	98%
Aggregate base material below roadways	95%	Road Embankment (a) > 0.3m below pavement sub grade	95%
Earth Dams	100%	Road Embankment (b) < 0.3m below pavement sub grade	100%

III. TEST RESULTS AND DISCUSSION

The geotechnical properties were conducted in the laboratory and in the field. The tests conducted in the laboratory are grain size analysis, atterberg limit and compaction. But the soil parameters tested in the field are compaction tests.

3.1 Grain Size Analyses for Back Fill Materials

The backfill materials grain size analyses are conducted by dry sieve analysis in the laboratory. These materials were collected from the same selected site and have nearly similar grain size. For all back fill materials half of the coarse fractions are larger than No.4 sieve size. For all fill materials the percentage finer passing No.200 sieve is less than 13.

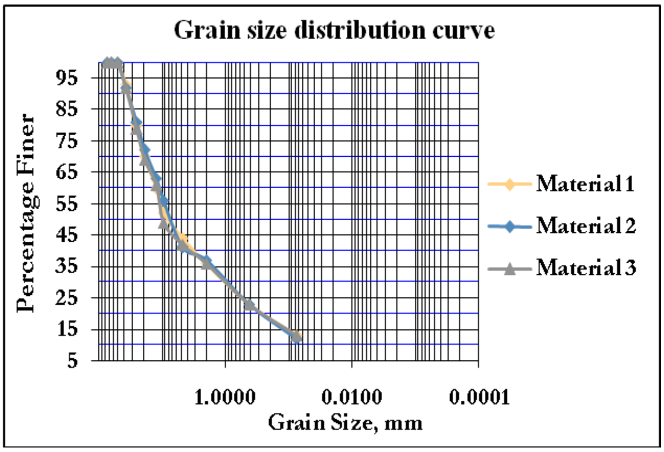


Figure 3.1: Grain size analysis graph

According to [8], the atterberg limit tests were done in the geotechnical laboratory. Then, the plasticity index of these materials was found within the range 11 to 12 % and these materials are classified as GC.

3.2 Determination of Dry density in laboratory

a.Dry Density

The dry densities of the backfill material were determined in the laboratory using standard Proctor test. Thus, the densities are calculated by:

$$\text{Dry density (gm/}cm^3\text{)} = \frac{\text{Wet density}}{1+w} \quad (1)\ [9]$$

Where: w= Moisture content in percent divided by 100
The values are presented in Table 3.1below.

a. Optimum Moisture Content

The compacted fill material must be at optimum moisture content during compaction. The tolerance on the optimum moisture content percentage must be ±3%, provided that the fill material is still capable of being compacted in accordance with the specified requirements to form stable areas of fill [8]. Well processed compaction procedure would give the required values for optimum moisture content. The average optimum moisture contents determined in the laboratory are varies from 15.6% to 18.1%.

Cone Method dry Density

According to ASTM 1556 [9], the sand cone test were conducted to determine the dry density of soils. This test method should be use uniform, dry and clean sands to get good results.

Figure 3.2: Typical arrangement of sand cone test apparatus [10].

Moisture Content

The values are determined in the field simultaneously with obtaining the dry density of this material. The average moisture contents are ranges from 20.21% to 22.76% and presented in Table 3.1.

Table 3.1: List of laboratory and field compaction test results.

Fill Materials	Laboratory Test		Field Test			
	Maximum Dry Density, Mg/m^3	Optimum Moisture Content	Dry Density Mg/m^3	Average Dry Density Mg/m^3	Moisture Content %	Average moisture content, %
Material 1	1.682	18.1	1.609	1.638	18.4	20.21
			1.672		19.91	
			1.614		22.35	
			1.657		20.19	
Material 2	1.684	17.22	1.677	1.658	18.11	22.76
			1.598		29.89	
			1.702		20.84	
			1.656		22.22	
Material 3	1.665	15.6	1.63	1.679	20.5	20.3
			1.719		19.92	
			1.676		21.51	
			1.689		19.28	

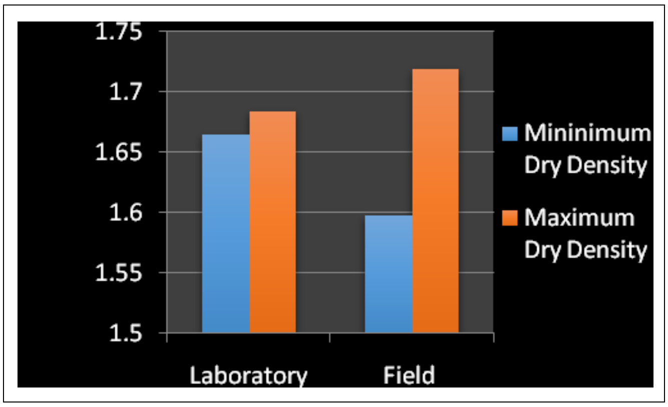


Figure 3.3: Minimum and maximum dry density for lab and field test

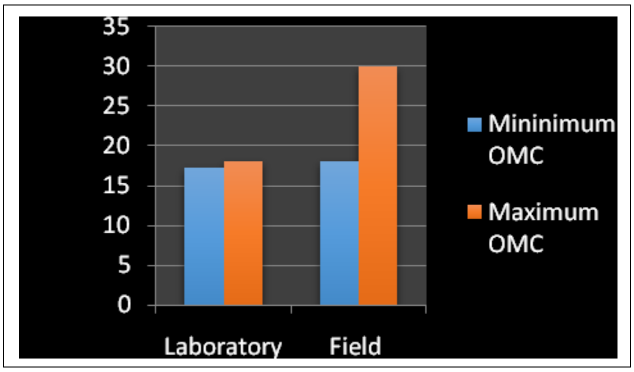


Figure 3.4: Moisture contents for lab and field test

3.3 Relative Compaction

It is the ratio of field density in the site to laboratory maximum density of coarse back fill materials which prepared for fills in embankments, building foundation, sub base and base materials of roads.

	95	
	101	
	98	
Material 3	98	101
	103	
	101	
	101	

Figure 3.5: Relative compaction of back fills materials

Structural fills on which foundations are to be placed shall be made with suitable materials for which an appropriate density, a 100% proctor density as an average and a 97% of Proctor density as a lower limit shall be assured and the risk of collapse and excessive differential settlements shall be prevented [7]. To achieve the relative compaction of these backfill materials, the relative moisture content are

The field density of the in place material is determined by Field density test "Sand cone method". The maximum density is determined by, Moisture-density test method "Proctor". Relative density is calculated by using the following formula [6]:

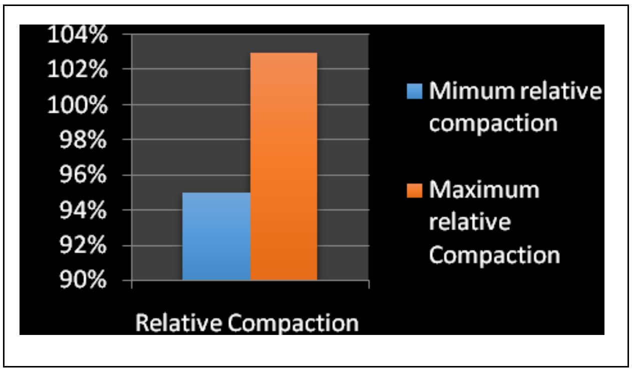
$$\text{Relative Density } (C_r)\ (\%) = \frac{\text{Field density}}{\text{Maximum density}} \times 100 \quad (1)$$

$$= \frac{\gamma_d}{\gamma_{d\,(max)}} \times 100 \quad (2)$$

Where: γ_d= Dry density obtained from the field
$\gamma_{d(max)}$= Maximum dry density obtained from Proctor test

Table 3.2: Relative density of backfill materials.

Fill Materials	Relative Compaction (%)	Average relative Compaction (%)
Material 1	96	97
	99	
	96	
	99	
Material 2	100	98



determinant. The average relative compaction ranges from 97% to 101% shows that the soil is well compacted in the field. These materials were moisturized with less percentage value of moisture contents. These coarser backfill materials are found near to the town. Having these, in construction areas which needs to be improved engineering properties of soils, can used Selected fill as construction materials.

IV CONCLUSION

The fill materials have an average relative compaction of 97%, 98% and 101% respectively. These values are greater than 95%. Besides this, it has an advantage in increasing shear strength, minimizing future settlement and decreasing in permeability within the soil mass. Based on the standards presented in Table 2.1, the materials are fulfilled the minimum requirements used as a fill for foundation of structures, sub grade, base materials and earth dams.

V. ACKNOWLEDGMENT

The author is appreciate and thanks to the financial support (cover) of Etete Construction for the tests was performed in the laboratory and field. I would like to appreciate also YTH Consultancy for their cooperation.

REFERENCE

[1] Virgil Ping, Ph.D., P.E. (2003), Laboratory simulation of field compaction characteristics, phase I, Summary of Final Report, Florida State University, USA.
[2] Proctor, R. R. (1933), The design and construction or rolled earth drains. Engineering News Record III, 31 August, 7, 21 and 28 September.
[3] AS 1289. (1999) Testing of Materials for Engineering Purposed (Standards Association of Australia, Sydney.
[4] W. V. Ping, P.E., Guiyan Xing, Michael Leonard, Zenghai Yang (2003), Evaluation of Laboratory Compaction Techniques for Simulating Field Soil Compaction (Phase II), Department of Transportation, Florida, USA.
[5] AS 1289. (1999), Testing of Materials for Engineering Purposed, Standards Association of Australia, Sydney.
[6] Pavement Engineering Section Grading & Base Unit (April, 2013), grading and base manual, Department of transportation, Minnesota, USA.
[7] Ministry of works and urban development (1995), Ethiopian Building Code Standards, Addis Ababa, Ethiopia.
[8] Vinay A, Hemanth Yadav M V (2015), Study and comparison of soil compaction between laboratory and field to simulate field compaction for rural roads, Karnataka, India.
[9] ASTM D 1556 (2015), Standard Test Method for Density and Unit Weight of Soil in Place by Sand-Cone Method.
[10] Brig Gen Md Gazi Ferooz Rahman , Major M. D. H. Talukder (2008), Assessment of soil compaction–a project study, Bangladesh.
[11] Departments of the army and the air force (1983), Backfill for subsurface structures, Washington
[12] DC, USA.