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Experimental Study of Laboratory Compaction and Sand Cone on Foundation Tub Soil

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Abstract: *Soil is a very important material, so it must be able to support the load on it, so the soil must have a good enough soil carrying capacity. In this study, soil compaction was compared to the method of compaction of laboratories with sand cone methods[1]. The purpose of this study is to know the characteristics of the soil and know the comparison of laboratory compaction with the compaction of the shell in the foundation tub. The soil is taken from the same point for the proctor test and sand cone test. These test results are used in foundation model testing. Testing of characteristics in the laboratory: moisture content, density, consistency limits (LL, PL), sift analysis, hydrometer, laboratory compaction, and shelling. The results found that the soil type based on AASHTO classification is A-7-5, and soil classification based on Unifield Soil Classification System (USCS) is MH. Laboratory compaction (Proctor Test) water content averages 32.26%, maximum γd 1,33 g/cm³, and compaction test sand cone, soil without foundation 0f 1,36 g/cm³, vertically arranged tire foundation of 1,36 g/cm³, horizontally arranged tire foundation of 1,36 g/cm³.*

Keywords: *Evaluation, Experiment, Laboratory Compaction, Sand Cone, Soil.*

I. INTRODUCTION

In general, foundation construction is built on basic land. The ability of the soil to shouldering this load is expressed as the bearing capacity of the soil, including the strong sliding of the soil. The land has always had an important role in every construction worksite. This is because the land is a load structure of the building to be erected on it [8]. Compaction of the soil is one of the mechanical efforts to get the grains of soil close; the volume of soil will decrease along with the reduced volume of pores. However, the volume of the item does not change. Compaction is done by grinding or mashing[2].

Compaction of land is one of the efforts in the existence of land has an important role in the construction of structures, highways, airports, and embankments on dams. Different compaction efforts are one of several other important factors that affect soil compaction[1]. Proctor (1933) states the relationship between density and moisture content in the graph, which can be seen in Fig. 1.

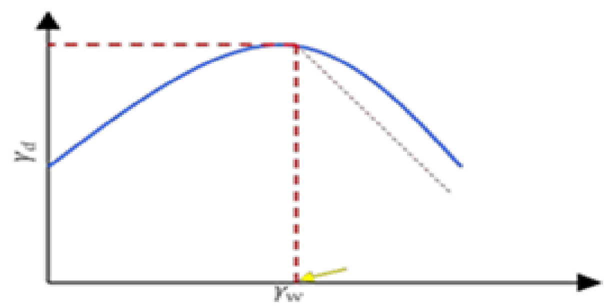

Fig 1: The relationship between density and water content

Frequent laboratory tests to obtain maximum dry volume weight and optimum moisture content are laboratory compaction (Procto Test). At the same time, field testing is often done to obtain field compaction using sand cone test. Laboratory compaction (proctor test) and sand cone test should not be much different. From the above reasons, this study evaluates the results of laboratory compaction tests and sand Cone test results on foundation-like soil, and then this study is titled " Experimental Study of Laboratory Compaction and Sand Cone on Foundation Tub Soil ."

According to Terzaghi, the soil is "soil consisting of grains resulting from massive weathering of rock masses, where the size of each grain can be as large as gravel-sand-clay-clay and contact between grains is not cemented, including organic matter [3]. The benefits of compaction aim to improve the technical properties to obtain the most populous soil state so as to:

1) Increase the strength of ground shear,
2} Reduce compatibility, i.e., reduce load,
3) Reduce permeability, and
4) Reduce the shrinkage and shrinkage properties of the soil.

II. MATERIALS AND METHODS

A. Materials

Soil material extraction, The landfill taken from the quarry of Pattalassang Village, Gowa Regency, as shown in Fig.2. The land is transported by a dump truck to the laboratory and then put into the foundation tub soil.

Fig 2: Location of Quarry Pattalassang Gowa

Sampling the soil in the foundation tub by inserting the pipe into the ground and the soil into the pipe and lifting the pipe.

B. Research sites

The research site was conducted in the Environmental Geotechnical Laboratory of the Faculty of Engineering, Hasanuddin University of Makassar, Gowa Regency, South Sulawesi.

C. Sampling Methods

In this research, sand cone testing is based on SNI 03-2828-1992, ASTM.D 1556-00, and proctor testing based on SNI-R-03-1742-1989, ASTM -D-698 in 2012.

The research method used in this research is based on the provisions on sand cone testing in accordance with SNI 03-2828-1992, ASTM.D 1556-00 (Field Density Testing Method with Sand Conus Tool), and the Proctor test is adjusted to AASHTO T 99 regulations. SNI- R-03-1742-1989. ASTM-D 698 the year 2012. Implementation is also based on calculation standards applicable in Indonesia, including:

1. SNI-03-1965-1990 soil water content testing method
2. SNI-03-1966-1990 plastic limit testing method
3. Compaction testing method (proctor) SNI-03-1966-1990
4. Field Density Testing Method with Conus Sand Tool (Sand cone) SNI-03-2828-1992.

After carrying out these two tests (proctor test and sand cone test) and having obtained these results, it is adjusted to the Indonesian National Standard (SNI), which is stipulated in the soil compaction test. The two tests were carried out to find the density value of the soil density (D). The final value on the Sand Cone Test is in the form of a table, while the Proctor Test is in the form of tables and graphs that can be used to compare compaction values between in the laboratory and in the field.

D. Research Stages Framework

Fig. 1 shows the Research Stages Framework. After compaction of the soil in the foundation tub, to determine the density of the soil, laboratory compaction testing and sand cone testing are carried out.

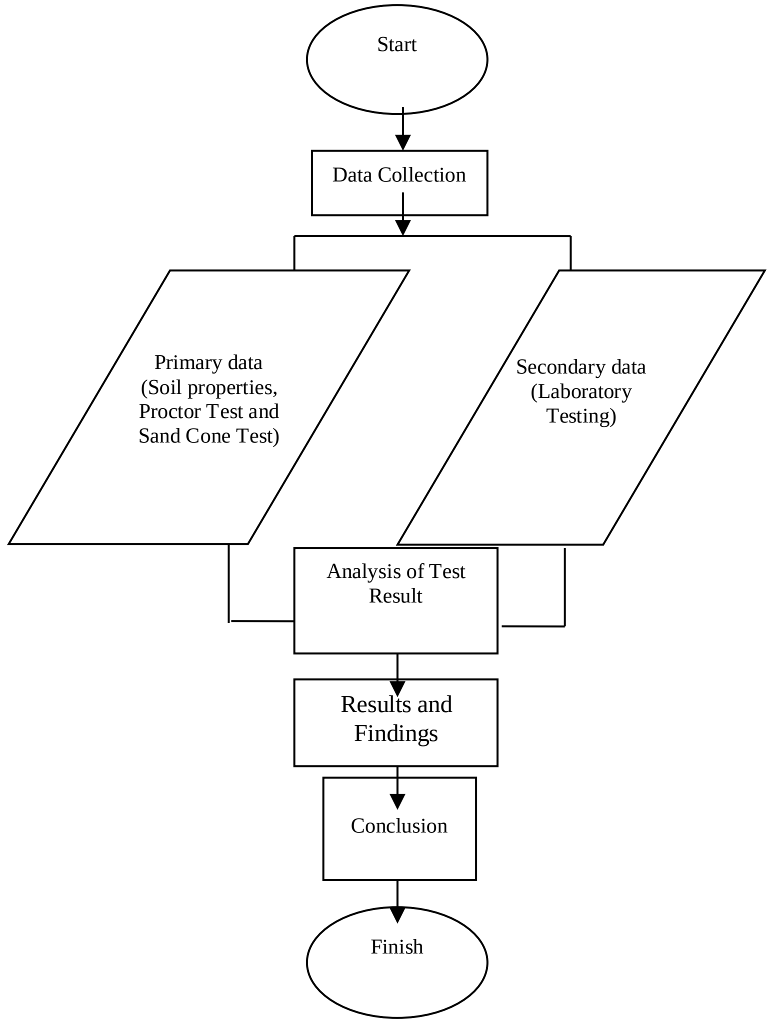

Fig.3: Research Stages Framework

E. Soil Compaction in Foundation Tub

To obtain soil density on the foundation body is done by compaction of the soil, as shown in Fig. 4, and Fig. 5 shows the results of soil extraction on the foundation body that has been compacted for physical properties testing and compaction testing.

(a)

(b)

Fig 4: Soil compaction procedure in foundation tub soil, (a) soil compaction, (b) finish soil compaction

Fig 5: Taking soil in the foundation tub that has been compacted for testing physical characteristics and compaction testing

III. RESULTS AND FINDINGS

A. Physical Characteristics of Soil

The results of testing the physical characteristics of the soil are summarized in Table 1.

Table 1. Recapitulation of soil physical characteristics examination

Parameter	**Symbol**	**Value**	**Unit**
Volumetric Soil			
Specific Gravity	GS	2,68	-
Limit of Land Consistency			
1.Liquid Limits	LL	65,46	%
2. Plastic Limits	PL	44,03	%
3. Plastic Index	PI	21,43	%
Sieve Analysis and Hydrometer			
1.Sand		29,8	%
2. Silt		57,4	%
3. Clay		12,8	%
Sand Cone Test			
Soil without foundatioan	ɣdry	1,36	gr/cm³
Vertically arranged tire foundatioan	ɣdry	1,36	gr/cm³
Horizontally arranged tire foundatioan	ɣdry	1,36	gr/cm³
Proctor Test			
Optimum moisture content	OMC	32,26	%
Maximum density	ɣdry	1,33	gr/cm³

Based on the sieve and hydrometer analysis test on the soil used, filter no.200 or 0.075 mm is more than 50%. The results of testing the physical characteristics of the soil are summarized in Table 1. The results of the sieve analysis percentage of soil that passes the # 200 sieve are more than 50%. To produce a value between clay and silt, a hydrometer analysis was performed. The results of the hydrometer analysis showed that the percentage of silt and clay, namely silt, respectively, was obtained as a percentage of 57,4%. While the clay fraction was 12.8%. With the results of this analysis, it is concluded that the soil used is classified as fine-grained soil, AASHTO (American Association of State Highway Classification System and Transportation Officials), as shown in Table 2, and the USCS (Unified Soil Classification) classification system), as shown in Table 3.

Table 2. Soil Classification for Basic Soil (AASHTO) system

General classification		Grained soil					
	(35% or less of all soil samples passed No. 200 sieve)						
Group classification	A - 1				A 2		
	A-1-a	A-1-b	A - 3	A -2-4	A-2-5	A-2-6	A-2-7
Sieve analysis							
(% get away)							
No.10	Max 50						
No.40	Max 30	Max 50	Min 51				
No.200	Max 15	Max 25	Max 10	Max 35	Max 35	Max 35	Max 35
The nature of the							
faction that escaped							
Sieve No. 40							
Liquid limit (LL)				Max 40	Min 41	Max 10	Min 11
Plasticity Index (PI)	Max 6		Np	Max 10	Max 10	Min 11	Min 11
The most dominant	Broken stone,		Fine	Silt or loamy gravel and sand			
type of material	gravel and sand		sand				
Appraiser as a		So good to good					
subgrade material							

General classification	**Silt soil - Clay (more than 35% of all soil samples passed No. 200 sieve)**			
Group classification	A - 4	A - 5	A - 6	A-7 A-7-5 A-7-6
Sieve analysis (% getaway)				
No.10				
No.40				
No. 200	Min 36	Min 36	Min 36	Min 36
The nature of the fraction that escaped				
sieve No. 40				
Liquid limit (LL)	Max 40	Max 41	Max 40	Min 41
Plasticity Index (PL)	Max 10	Max 10	Min 11	Min 11
The most dominant type of material	Silt soil		Clay soil	
Appraiser as a subgrade material	Normal to ugly			

For A-7-5, PI ≤ LL – 30
For A-7-6, PI > LL –30

USCS to obtain a classification of land. Based on the liquid boundary value, the soil can be classified as inorganic lanau soil or fine sand diatomae itandai with a liquid limit value above 50%. As for distinguishing between clay and lanau, used A-line. If the soil plasticity index value falls below the A-line, then the soil is classified as lanau, while if it is above the A-line, then the soil is classified as clay.

Based on laboratory analysis, the plastic limit value was 44,03 %, and the plasticity index was 21,43% in atterberg boundary testing. According to the Classification system USCS (Unified Soil Classification System) and ASTM (American Standard for Testing and Material). From the Unified Soil Classification System plasticity diagram) connecting the plastic boundary values and plasticity indexes in the plasticity diagram, the MH type of soil is obtained, as shown in Fig. 6.

Table 3. Unified Classification System

Main Division			Symbol Group	Common Name
Tanah berbutir kasar lebih dari 50% butiran tertahan pada ayakan No. 2000*	Sand more than 50% coarse fraction passes sieve No.4	Clean pebbles (only pebbles)	GW	Well-graded gravel and sand-gravel mixture, containing little or no fine grains
			GP	Poorly spaced gravel and sand-gravel mixture, containing little or no fine grains
		Gravel with fine grains	GM	Silt gravel, gravel-sand-silt mixture
			GC	Clay gravel, clay sand mixture
	Gravel 50% or more of the coarse fraction is retained in the No. 4	The sand is clean (only sand)	SW	Well-drained sand, gravel sand, containing little or no fine grains
			SP	Poorly fragmented sand and gravel sand, containing little or no fine grains
		Fine grained sands	SM	The sand is silty, a mixture of silt sand
			SC	Clay sand, a mixture of sand - loam
Fine grained soil 50% or more fine-grained soil passes the No. sieve. 200	Silt and clays have a liquid limit of 50% or less		ML	Inorganic clays with low to moderate plasticity gravel clays, sandy clays, silty clays, lean clays
			CL	Inorganic clays with low to moderate plasticity gravel clays, sandy clays, silty clays, lean clays
			OL	Silt - organic and organic silty clays with low plasticity
	Silt and clay liquid limit more tha 50%		MH	Inorganic silt or fine sand diatomae or silt diatomae elastic silt
			CH	Inorganic clays with high plasticity, fat clays
			OH	Organic clays with moderate to high plasticity
Soil with very high organic oil content and very high organic content			PT	Peat (gut) muck, and other soils with high organic content

According to ASTM (1982)

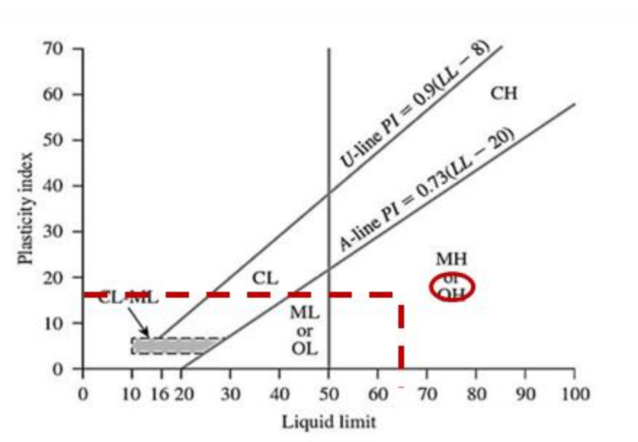

Fig 6: Plasticity diagram of the Unified Soil Classification System

B. Laboratory compaction (Proctor Test)

The compaction test is intended to determine the relationship between moisture content and soil weight by compacting in a cylinder mold of a certain size using a 2.5 kg or 5.5 lb grower and a drop height of 30 cm or 12". The test object that has been prepared is then carried out compaction using the Modified Proctor compaction test instrument. This compaction is carried out according to the ASTM-D 698 standard of 2012. The specimen is compacted in a cylindrical mold with a volume of 1004 cm. The mold diameter is 6 inches (15 cm). Test object compacted in 3 layers using a 10 lb (4.54 kg) pounder, the tumbler height was 18 inches (45 cm), the number of collisions of the layer was 25 times for each layer [10]. This test is shown in Fig. 7.

Fig 7: Laboratory Compaction Testing (Proctor test).

The compacting test that needs to be considered is the filling of wet soil into a mold that has 3 layers of the same size or thickness, and the number of collisions is 25 times per layer. This compacting test is not only on one mold with three layers but several molds of one to three molds to determine the dry weight ratio of each. After the laboratory compaction test, a calculation analysis is carried out.

The steps of the calculation analysis are the calculation of the weight of the wet soil, the calculation of the weight of the wet soil, then the calculation of the moisture content, the calculation of the weight of the dry soil, and the calculation of the weight of the contents when there is no air in the pores (zero air void).

To find out the final moisture content, the weight of the five plates must be the same, and in determining the dry bulk density (γd), the highest value of each dry bulk density is taken, then plotted according to the graph.

Based on the weight of the aggregate divided by the volume of the aggregate, the weight of the aggregate volume is obtained (γ), then the weight of the aggregate volume is obtained the dry bulk weight (γd). Then based on these data, a graph of the relationship between the optimum moisture content and dry bulk density (γd) was made. The soil density is usually assessed by determining its dry bulk density (ɤdry). The optimum water content is determined by conducting a compaction experiment in the laboratory (proctor test). The relationship curve between water content and volume weight is shown in Figure 8, showing that the peak of the curve is the value of the maximum dry volume weight with the optimum moisture content. From the graph, it is obtained that the average water content is 32.26 %, the maximum γd is 1,33 g / cm^3.

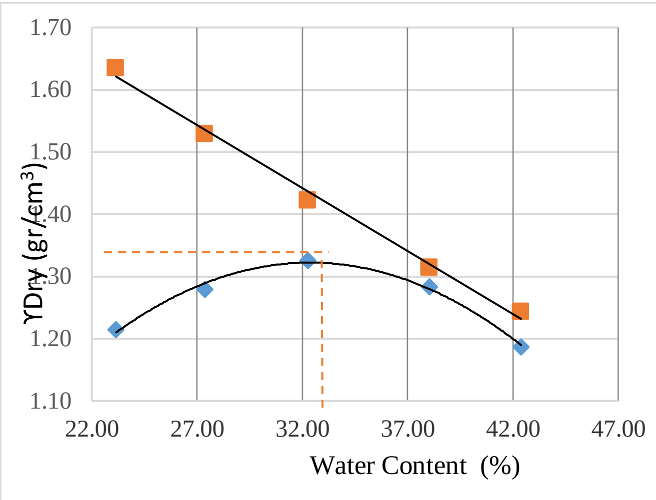

Fig 8: Graph of Relationship between Moisture Content and Dry Content Weight of Soft Soil.

After compaction testing in the laboratory (compaction) and laboratory compaction data analysis (compaction), Sand Cone testing on foundation tub soil.

C. Sand Cone test

The sandstone test in this study was conducted to knowing the density of the soil like the foundation that has been compacted. The tools described here are limited on soil containing coarse grains no more than 5 cm, and this test refers to or conforms to ASTM. D 1556-00. Sand cone experiments are one type of testing conducted in the field to determine the density of dry bulk (density) of native soils or the results of compaction work carried out on cohesive soils and incoherent soils.

Sand cones consist of plastic or glass bottles with metal cones attached to them. These glass bottles and cones are filled with dry, poorly graded Ottawa sand, whose weight is known. If you use other sand, first look for the weight of the sand. In the field, small holes are dug at the sand cone consists of a plastic or glass bottle with a metal cone attached to it. These glass bottles and cones are filled with poorly graded dry Ottawa sand, the weight of which is known. If using other sand, first find the weight of the content of the sand. In the field, a small hole was dug in the compacted soil surface[11]. If the weight of the soil that has been excavated from the hole can be determined (Wwet) and the water content of the excavated soil is also known, then the dry weight of the soil (Wdry) can be found by the equation:

$$W_{dry} = W_{wet} / (1 + (w / 100)) \quad (1)$$

Where w = moisture content.

After the hole has been dug (the original soil is weighed entirely), a cone with a sand-filled bottle is placed on top of the hole. The sand is allowed to flow out of the bottle filling all the holes and cones. After that, the weight of the bottle, cone, and the remaining sand in the bottle is weighed. The volume of soil excavated can be determined by the following equation:

$$V = (W_{ch} - W_c) / \gamma_{dry} \quad (2)$$

Where:
Wch = weight of sand filling cones and holes in the soil,
Wc = weight of sand filling the cone,
ϒdry = dry bulk weight (sand).

The value of dry soil fill weight (ɣd) obtained from this experiment is used to evaluate the results of compaction in the field, namely the ratio between the ɣd results of trough compaction with the ɣd results of compaction experiments in the laboratory. Embankment soil is soil that is more than 35% through the 200% sieve, AASHTO classification A-7-5. Sand cone testing is carried out by the three foundation tub for foundation tub 1 (soil without foundation) width of 300 cm length of 250 cm soil, the thickness of cm, second foundation tub (vertically arranged tire foundation) width of 250 cm length of 300 cm soil thickness of 140 cm, the third foundation tub (horizontally arranged tire foundation) width of 250 cm length 300 cm soil thickness of 140 cm, compaction testing foundation tub soil, as shown in Fig. 9.

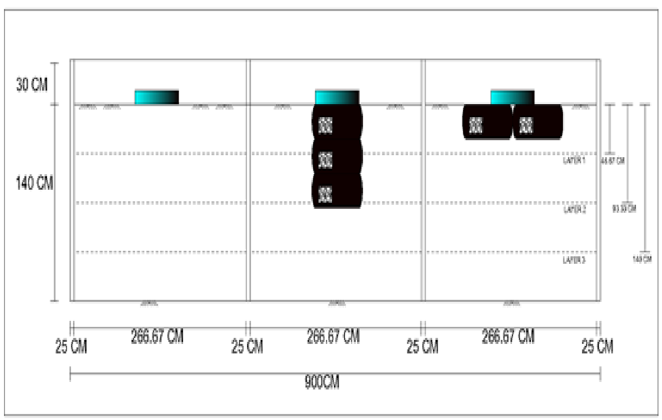

Fig 9: Foundation Tub Soil Model

Compaction of soil for each foundation body is the same three layers, and the first layer of soil filling after compaction is 46.67 cm, the second layer of soil filling after compaction is 46.67 cm or a soil thickness of 93.33 cm. The third layer is the filling of the soil after compacting with foundation soil as thick as 46.66 cm or 140 cm. Figure 10 are shown testing of sand cones every three layers for each tub of foundation, Fig. 10 (a) testing the first sand cones on the ground surface of each tub that is 140 cm thick, Fig.10 (b) testing the second sand cone on each tub of soil foundation as thick as 93.33 cm, Fig. 10 (c) the third sand cone test on each soil thickness of 46.67 cm.

(a)

(b)

(c)

Fig 10: SandCone Testing on Foundation Tub Soil, (a) testing the first sand cones on the ground surface of each tub that is 140 cm thick, (b)) testing the second sand cone on each tub of soil foundation as thick as 93,33, cm, (c) the third sand cone test on each soil thickness of 46,67 cm

The steps taken in analyzing the calculation of the results of sand cone testing are the calculation of the weight of the sand content, the calculation of the weight of wet soil in the hole, the calculation of the remaining sand in the hole, the calculation of the weight of sand in the hole. The weight of sand in the hole. The volume of sand left in the hole calculates the weight of the wet soil, then calculates the weight of the dry soil and calculates it. Degree of density according to the respective formulas in ASTM. D 1556-00. While the results of the compaction of sand cones foundation tub model 1 ground without foundation average γd = 1, 36 g / cm³, the results of compaction test model 2 is vertically arranged tire foundation average γd = 1, 36 g / cm³, The results of compaction of sand cones model 3 is horizontally arranged tire foundation average γd = 1, 36 g / cm³, as shown in Table 4.

Tabel 4. Sand Cone Testing Recapitulation

Foundation Tub Soil	γd (g/cm³)	Average γd (g/cm³)
Foundation Tub Soil 1 (Soil without foundation)		
Top layer	1,35	
Middle Layer	1,36	1,36
Bottom layer	1,37	
Foundation Tub Soil 2 (Vertically Arranged Tire Foundation)		
Top layer	1,36	
Middle Layer	1,37	1,36
Bottom layer	1,35	
Foundation Tub Soil 3 (Horizontally Arranged Tire Foundation)		
Top layer	1,37	
Middle Layer	1,35	1,36
Bottom layer	1,36	

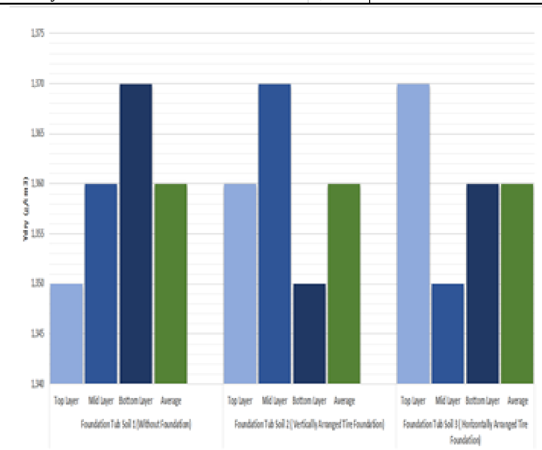

Fig 11: Sand Cone Testing Recapitulation

Based on Table 4 and Fig. 11, the method of sand cone testing for each is not much different, so that the dry is not much different and has a dry weight, the same average of 1, 36 gr / cm³.

D. Results of Laboratory Compaction Evaluation (proctor test) and Compaction with Sand Cone test on Foundation Tub Soil

This experiment is usually carried out to evaluate the results of compaction work in the field, which is expressed in degrees of compaction, which is the ratio between the field ɣd (sand cone) and the ɣd max. Results of compaction experiments in the laboratory in the percentage of the field. The value of the dry bulk density for laboratory compaction (compaction) should not be much different from the dry bulk density in the Sand Cone test.

The value of dry soil bulk density (ɣd) obtained from this experiment is used to evaluate the results of compaction in the field, namely the ratio between ɣd of laboratory compaction results (proctor test) and ɣd results. Compaction of the tub. (sand cone Test). And evaluation results. The comparison between the ɣd compaction of the tub (sand cone) and the d results of compaction in the laboratory (proctor test), as shown in Table 5.

Table 5. The results of the evaluation of the comparison between the compaction of the tub (sand cone) and the results of the laboratory compaction (proctor test)

Density (ɣd)	SandCone Test (Ɣd) (g/cm³)	Average (Ɣd) (g/cm³	Laboratory Compaction (Proctor Test) (Ɣd) (g/cm³)
Soil Without Foundation			
Top Layer :	ɣd =1,35	1.36	ɣd= 1,33
Middle Layer	ɣd =1,36		
Botton layer	ɣd =1,37		
Vertically Arranged Tire Foundation			
Top Layer	ɣd =1,36	1.36	ɣd= 1,33
Middle Layer	ɣd= 1,37		
Botton layer	ɣd = 1,35		
Horizontally Arranged Tire Foundation			
Top Layer	ɣd = 1,37	1.36	ɣd= 1,33
Middle Layer:	ɣd = 1,35		
Botton layer	ɣd = 1,36		

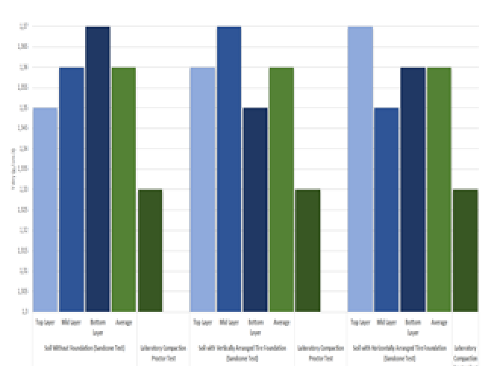

Fig 12: The results of the evaluation of the comparison between the compaction of the tub (sand cone) and the results of the laboratory compaction (proctor test)

Based on Table 5 and Fig. 12, showing the soil density, the dry content weight of the sand cone test is greater than the compaction test; the difference is 0.03 g / cm³.

IV. CONCLUSION

This research to determine the density of landfills with laboratory compaction and sand cone foundation tub soil. Conclusion :

- Soil types are based on the AASHTO classification. Was A-7-5, and the soil classification based on the Unifield Soil Classification System (USCS) was MH.
- The maximum dry volume weight value with optimum moisture content. From the graph, it is obtained that the average water content was 32.26%, the maximum γd was 1, 33 g / cm³, and the sand cone compaction of model foundation test of soil without foundation ɣd was 1, 36 g / cm³, vertically arranged tire foundation ɣd was 1, 36 g / cm³, horizontally arranged tire foundation ɣd was 1, 36 g / cm³.

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