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Research Article

Effect of the Different Energy of Compaction on Subbse Course of Roads

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Abstract: Compaction of subbase is often the main load-bearing layer of a pavement. It is designed to evenly spread the load of the paving, it compacted with heavy equipment until the material forms a dense layer of interlocking aggregate. To perform well, subbase aggregates must be strong and durable, and must meet very specific graduation requirements. The main aim of this study is finding the effect of changing energy of compaction on the subbase. the sample of subbase is under class B after testing it by sieve analyses test, the physical properties as (specific gravity, elastic limit, plastic limit &max dry density) have been tested, the sample tested under different energy of compaction (modified proctor test and standard proctor test) and found the effect of energy on (dry density, void ratio, porosity).

Keywords: pavement layer, Subbase, compaction energy, standard proctor test. modified procter test.

INTRODUCTION

Compaction is defined as the process of increasing the density of a material by mechanical means. It is necessary to compact the material mechanically, to confer a high degree of density. This procedure increases the shear strength, reduces the permeability and water absorption, and reduces the tendency to settle under repeated loading The quality of subbase is very important for the useful life of the road and can outlive the life of the surface, which can be scrapped off and after checking that the subbase is still in good condition, a new layer can be applied. Compaction objective increasing the shear strength, Reduce void ratio thus reduce permeability reducing porosity, reducing drop, reducing volume changing, controlling the swell-shrinkage movement, Reduce settlement under working load, Prevent the buildup of large water pressure. The Factors affecting compaction is water content, type of soil, compaction energy or effort all these factors are shown in the figure1.

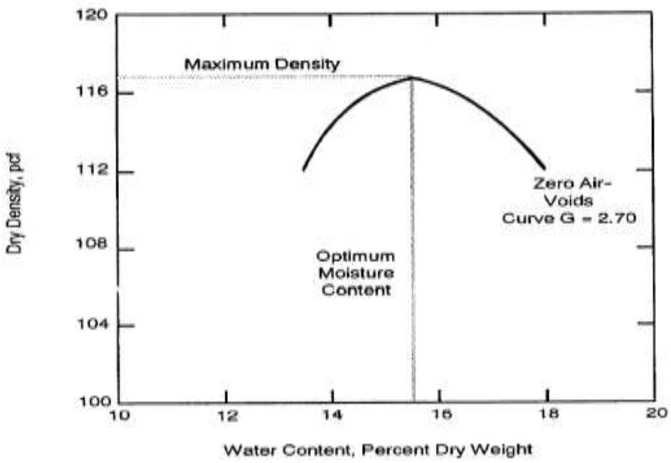

Fig-1: Water content and dry density curve

The main objectives of this study is finding the importance of compaction on subbase, Show the effect of compaction subbase under different energy and Show the effect of compaction on structure of the sample.

This study finds the max density and its suitable water content by the testing sample by sieve analyses test and make comparison with the classification also testing the physical properties of the sample subbase (specific gravity, plastic limit, elastic limit, compaction test).

MATERIALS AND EXPERIMENTAL WORK

At first, the standard Proctor compaction tests were conducted on the original subbase. The tests yielded dry unit weight versus moisture content relationships. The results of the standard Proctor compaction test used to establish a various moisture content and dry unit weight level at which subbase samples prepared and tested with the load tests.

A special split of three pieces of steel mold with (50.4 mm) in diameter and (100.8 mm) in height is manufactured locally in Plate (3-3) to prepare specimens that can be used for a load testing. The use of split mold is to get specimens of the same desired density because the use of a hydraulic extractor to remove the specimens from the mold will change the density of the specimens. Thus, the impact compaction method was used during the experimental work. Compaction is performed in five layers using a special hammer was manufactured locally as shown in Plate (3-4) in order to give a compaction effort equivalent to the standard Proctor compaction test, until the desired density has been achieved. In order to achieve the target density, a trial and error approach is used to determine the number of blows per layer which is changed for different soils and even for the same soil under different moisture content. Several trials were normally required before the correct blows per layer could be achieved. Table below shows Comparison between the dimension of the modified mold and hammer and standard proctor.

Table1: Measurement of modified and standard proctor test

Measurements	Modified Model		Standard Procter	
	English system	International system	English system	International system
Weight of hammer	1.8 Ib	0.8kg	5.5Ib	2.5 kg
Distance of the fall	8 inch	20.3cm	12 inch	30.5cm
Diameter of The Hammer	1 inch	2.5cm	2 inch	5.0cm
Diameter of the mold	2 inch	5.0cm	4.4 inch	10.13cm
Height of the mold	4 inch	10.1cm	4.6 inch	11.7cm
No. of compacted layers	5		3	
No. of blows/layer	15		25	

Source: ASTM D 698

A filmy tape is put inside the mold in order to decrease the cohesion between the mold and the soil specimens, thus, the specimens will be extruded without disturbs. The compacted lime-treated and cement-stabilized samples were sealed with polythene bags and kept in a moisture-controlled box for (3, 7 and 28) days curing times. The untreated subgrade samples were tested immediately after the compaction.

Proctor Experiment

A laboratory experiment conducted by the soil compaction by constant weight fall within the steel cylinder standards with fixed a specific order to keep the work required for a steady to monitor. This monitoring is being a fundamentalist way of customary consists of the experience of five experiments partial differ from each other moisture. As a result of the evaluation of the output we get curved linking each of the moisture w dry density (γ proctor) for ideal moisture (w optimum) fixed humidity: the ideal moisture either from the experience of the regular proctor w opt, or amended, is the moisture that if the sample on it possible access to vast dry density modified by compaction.

$$\gamma_d = \frac{\gamma}{1+w} \quad (\gamma = \text{volumetric weight, } W = \text{moisture}) \qquad (1)$$

Calculate water content

$$W = \frac{M_w}{M_d} \quad (M_w\text{: wet weight, } M_d\text{: dry weight}) \qquad (2)$$

Calculate the dry density

$$\gamma = \frac{m}{V} \quad (M = \text{weight of specimen, } V = \text{volume of specimen}) \qquad (3)$$

Calculation of dry density:

$\gamma_d = \frac{\gamma}{1+w}$ g\cm^3 (4)

$\gamma_{Wet} = \frac{w2-w1}{V}$ (5)

Which: W1: weight of under part from the empty mold, gm
W2: weight of compacted sample with mold, gm
V: volume of mold, cm^3

Water content= $\frac{weight\ of\ water\ in\ sample}{weight\ of\ solid\ part}$*100 % (6)

%w = 100*$\frac{Ww}{Ws}$

Dry density = $\frac{wet\ density}{1+water\ content}$ (7)

e =$\frac{G\ \gamma W-\gamma dry}{\gamma dry}$ (8)

G: for the subbase sample equal to 2.96.

n=$\frac{e}{1+e}$ (9)

S=$\frac{WG}{e}$ (10)

RESULTS AND CONCLUSION

Chemical test for the sample

Chemical properties of the sample of subbase consists of percent of sulfate content so$_3$ also percent of gypsum CaSo4.2HO. the test show that the subbase is -

Table 2: Chemical properties of the sample

Properties	Percent
Percent of Sulfate Content SO_3	1.99%
Percent of gypsum CaSo4.2HO	4.28%

Physical Test

The table below shows the results properties of subbase the liquid limit for it equal to 22.2 % and plastic limit equal to 16.7 % so the plastic index equal to (22.2-16.7)=5.5%

Table 3: Physical properties of the subbase

Subbase Properties	results
LL %	22.2%
PL %	16.7%
PI %	5.5%
Specific Gravity	2.69

The results of Atterberg limits tests conducted on fractions passing sieve No. 40 indicate that the subbase samples are low plastic soils. The Tables below describes the results of attreberg limits and the classification of soils according to the plasticity index. The specific gravity of the samples was determined and its equal to 2.69 .these results is under the classification of subbase (R6).

Sieve Analysis Test

The sieve analysis for the subbase sample is shown in table below from these results; the subbase specimen can be classified according to the as (class B).

Table 4: Classification of percent of passing

Sieve mm in	Percent of residents on each sieve	Weight of residents	Percent of passing	Classification
50 2	0	0	100	100
25 1	3168	10.6	89.4	95-75
9.5 3/8	12532	41.8	58.2	75-40
4.75 no.4	15016	50.1	49.9	60-30
2.36 no.8	17250	57.5	42.5	47-21
0.3 no.50	23980	79.9	20.1	28-14
0.075 no.200	28460	94.87	5.13	15-5

Table 5: Types of subbase

Sieve size		Percent of passing			
In	mm	Type A	Type B	Type C	Type D
2	50	100-95	100		
1	25		95-75	100	100
3/8	9	65-30	75-40	85-50	100-60
No.4	4.75	55-25	60-30	65-35	85-50
No.8	2.36	42-16	47-21	52-26	72-42
No.50	0.3	18-7	28-14	28-14	42-23
No.200	0.075	8-2	15-5	15-5	20-5

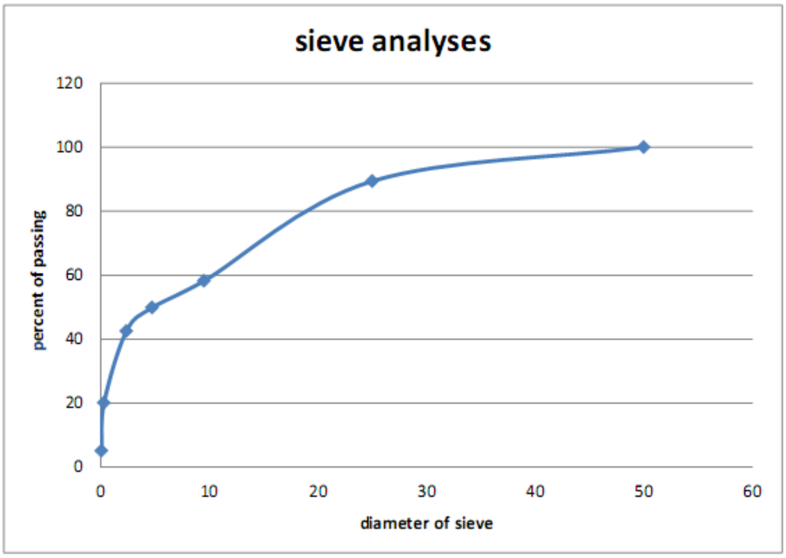

Fig-2: Sieve analysis distribution of the subbase

Comparison between Standard and Modified Proctor Test

The results of the standard Procter test of the sample are shown in table .The optimum moisture content and maximum dry density of the subbase sample are (6.22%), (2.221gm/cm^3), respectively. The results of the modified Procter tests of the sample are shown below. The optimum moisture content and maximum dry density of the subbase sample are (6.68%), (2.427gm/cm^3), respectively. Tables below list the initial properties of specimens at same water content and same compaction type (dynamic) with different compaction energy (standard and modified) simples at same water content and different void ratio are tested .

Table 6: Properties of specimens

Compacted subbase sample	Standard proctor test			Modified proctor test		
Wet density γ_w	2.221	2.359	2.383	2.297	2.476	2.387
Dry density γ_d	2.145	2.221	2.176	2.278	2.427	2.277
e (void ratio)	1.78	1.85	1.944	1.71	1.69	1.81
n (porosity)	0.64	0.64	0.66	0.63	0.62	0.64

The results of samples are shown in table .the initial void ratio of standard compact is higher the initial void ratio of modified compaction because of the energy of modified compaction is higher than the standard compaction ,the percosolidation pressure of modified compaction is higher than standard compaction.

The compaction energy can be calculated as following equation

Compaction energy= (No. of layers *No. of bowls *weight of hammer*height of fall)/ volume of mold.

So the compaction energy for two tests showed in table below .the results shows that the energy of modified proctor test is higher than the energy of standard proctor test.

Table 7: The energy properties of specimens

tests	No. of layers	No. of bowls	Volume of mold	Hammer	Height of fall	energy
Standard proctor test	3	25	792.8 cm^3	24.5 N	30.5cm	594.8KJ/m^3
Modified proctor test	5	25	376.9cm^3	44.5 N	20.3cm	2698KJ/m^3

Standard and Proctor Test

The results showed that the maximum dry density for the modified proctor test is higher than the maximum dry density at the same water content. The maximum dry density for modified proctor test is equal to 2.427 and the maximum dry density for standard proctor test is equal to 2.227.

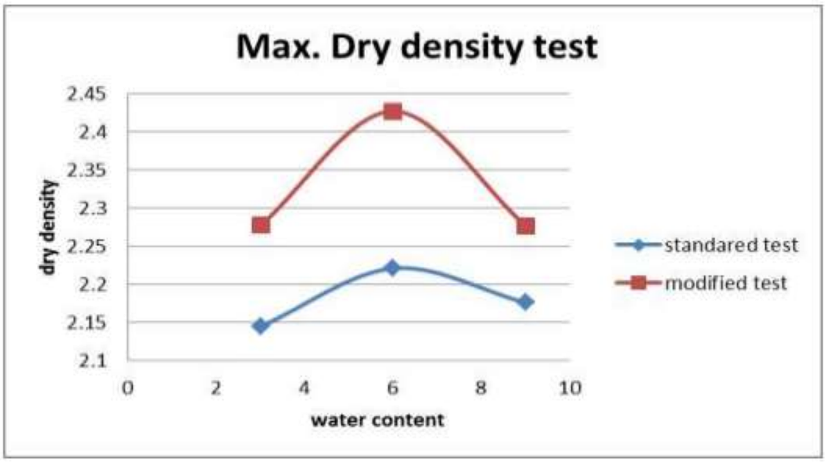

Fig-3: Max. dry density for the modified proctor &standard Procter test

The results showed that void ratio for the modified proctor test is less than void ratio for standard Procter test at the same water content.

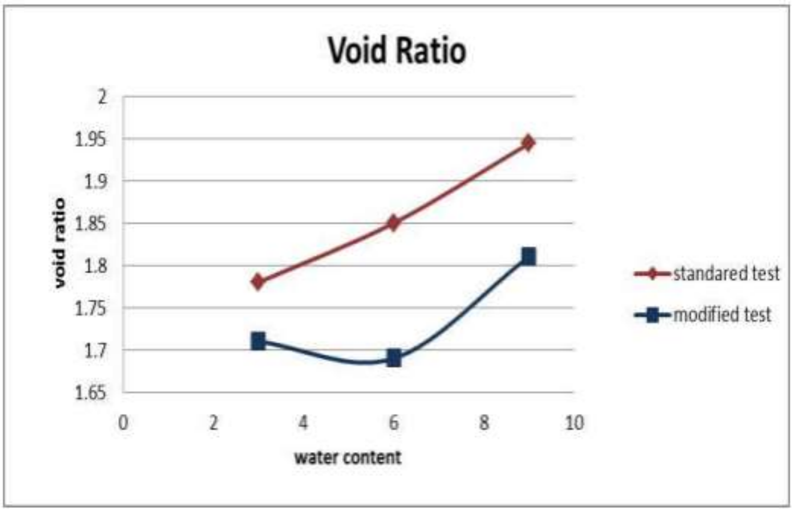

Fig-4: Void ratio for the modified proctor &standard Procter test

The results showed that the porosity for the modified proctor test is less than the porosity at the same water content.

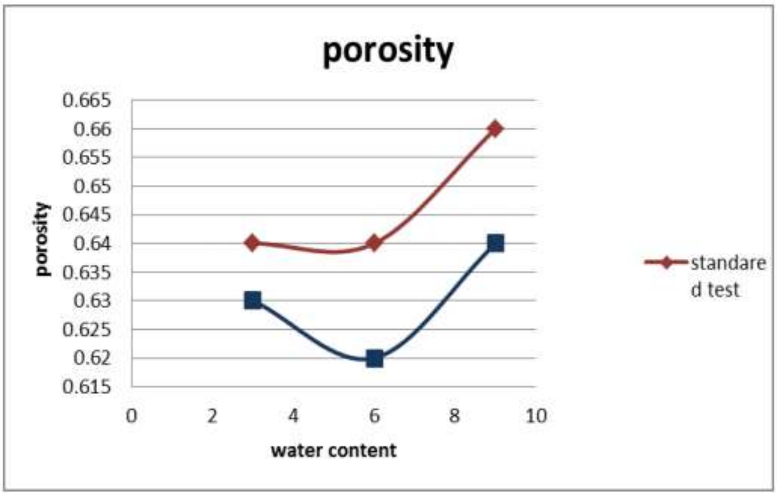

Fig-5: Porosity for the modified proctor &standard Procter test

CONCLUSIONS

In this paper we study the energy effect of compaction on subbase layer under roads also find that when we loaded the sample of subbase under different energy (modified and standard proctor test) the maximum dry density for the modified proctor test is higher than the maximum dry density at the same water content .The maximum dry density for modified proctor test is equal to 2.427 and the maximum dry density for standard proctor test is equal to 2.227also The void ratio for the modified proctor test (1.69) is less than void ratio for standard proctor test (1.85) at the same water content and the porosity for the modified proctor test is less than the porosity for standard proctor test at the same water content.

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