International Journal on Emerging Technologies (Special Issue on NCRIET-2015) **6**(2): 287-290(2015)

ISSN No. (Print) : 0975-8364
ISSN No. (Online) : 2249-3255

Compaction and Fatigue Behavior of Cohesive Soils and its Rutting Effect on Sub grade

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(Published by Research Trend, Website: www.researchtrend.net)

ABSTRACT: This thesis is concerned with producing a simple method to design by means of which accounts for permanent deformation development in sub grade soil layers. Rutting is regards about the main distress mode in unsealed and thinly sealed pavements. Hence, it is desirable that it can be analytically approached rather than empirically, as in most of the design methods. In a systematic manner, the elements required to predict the Rut Depth in the simple mechanistic design procedure were calibrated. The study took as its basis an assessment of the proximity of the stresses which may occur in the pavement to the materials failure envelope. After conductingseries of basic experiments on the two types granular materials (Red soil and black Cotton soil) to know the state of the soil which is the base for all the pavement constructions activity and they play an important role in deciding the performance of the structures constructed over it. From the point of view of, all the three major criteria of structures founded on soils namely Strength, Stiffness and Stability the subsoil is expected to perform at its best. These factors may loose if the rutting is occurring on the pavement, as rutting will causes lower in the runoff, which makes the sub grade below wet and even reduces the skid resistance which may cause disasters in highways. The presence of the Voids in the soil makes the soil weak this will happen due to the Lack of compaction of the sub grade soil which is one of the reasons for the high initial rutting rates. So Compaction test was conducted using Standard Proctor Test and Modified Proctor test so that higher density is achieved. The strength of the soil in a precious parameter to be calculated, the bearing capacity of the soil provides the capacity of the soil against loading.

Keywords: Rutting, Fatigue, Compaction, Red Soil, Black Cotton Soil

I. INTRODUCTION

Understanding engineering properties of fine grained soils is of vital importance in Civil engineering practice. The study of fine grained soil is a fascinating subject in the field Geotechnical Engineering and has attracted the attention of many researchers. The engineering properties of fine grained soil are strongly dependent on water content and clay compositions. They are susceptible to changes in external pressure, chemistry of the pore medium, wetting and drying cycles and temperature. The complexity in the engineering behavior of fine grained soils is attributable mostly to the clay size of the soil. Many factors affect the compaction characteristics of fine soils such as type of soil represented by LL, stress history of soil, moulding condition of the specimen and percentage of clay content etc. It is very well known that the behavior of fine grained soils is very complex so there is need to study all the characteristics required in the construction of very good instrumental sub grade which provides good serviceability and last for a longer time period. As it is known that the major function of sub grade soils is to provide support to pavement structures under heavy traffic intensity. This accounts for sub grade deformation and contribute to distress in the overlying pavement structure. Prediction of the permanent deformation in the sub grade helps in improving the quality and thickness of the pavement based on the desired traffic conditions. Compaction this term is used to refer rapid reduction in voids produced by mechanical means during the construction process in the field or during the preparation of a sample in the laboratory. Factors affecting compaction are moisture content and the compactive effect of the soil. The moisture content that gives MDD is called as OMC. If compactive effort is increased, the optimum moisture content decreases but maximum dry density increases.

The use of automation in monitoring task will reduce the reliance on man power at the monitoring site thus reducing the cost.

This work focuses on the use of multiple sensors as a device to check the water quality as an alternative method of monitoring the condition of the water resources. Several sensors that are able to continuously read some parameters that indicate the water quality level such as chemical substances, conductivity, dissolved oxygen, pH, turbidity etc will be used to monitor the overall quality level. As the monitoring is intended to be carried out in a remote area with limited access, signal or data from the sensor unit will then be transmitted wirelessly to the base monitoring station. A currently becoming popular and widely used technology based on wireless sensor network is extensively used in this work as it is able to provide flexibility, low cost implementation and reliability. A high power transmission with a relatively low power consumption RF based wireless sensor network technology is applied in this work. It is chosen due to its features that fulfill the requirement for a low cost, easy to use, minimal power consumption and reliable data communication between sensor nodes. The 16×2 LCD is used for monitoring purposes at the base monitoring station is another main component. The LCD should be able to display the parameters being monitored continuously in real time. The laboratory tests that are manually used for determining the optimum moisture content and maximum dry density of a given soil are standard proctor test and modified proctor test. Proctor introduced Standard proctor test in the year 1933. To study the soil moisture – density relationship and to evaluate a soil as to its suitability for making roads and other fills, the soil is subjected to a compaction test. The unconfined compression test is by far the most popular method of soil shear testing because it is one of the fastest and cheapest methods for measuring shear strength. The method is used primarily for saturated, cohesive soils recovered from thin-walled sampling tubes. The unconfined compression test is inappropriate for dry sands or crumbly clays because the materials would fall apart without some land of lateral confinement. Pore pressures are not measured in an unconfined compression test; consequently, the effective stress is unknown. So, the undrained shear strength measured in an unconfined test is expressed in terms of the total stress. The major function of sub grade soils is to provide support to pavement structures. Under heavy traffic loads, sub grade soils may deform and contribute to distress in the overlying pavement structure. In asphalt pavements this distress normally takes the form of cracking and rutting. It has been well documented that the sub grade soil plays a critical role in the initiation and propagation of permanent deformation of pavement structures and directly influences pavement performance (Huang, 1993). Permanent deformation is one of the most important type of load-associated distress occurring in bitumen pavement systems. It is associated with rutting in the wheel path, which develops as the number of load repetitions accumulates. In addition, it is the longitudinal variation of rut depth in the wheel path that is a main primary factor in the road roughness, affecting serviceability or IRI. Rutting normally appears as longitudinal depressions in the wheel paths accompanied by small upheavals to the sides. The width and depth of the rutting profile is highly dependent upon the pavement structure, traffic matrix and quantity as well as the environment at the design site.

Testing Procedure

A Haversine load pulse is used with load duration of 1.0 seconds and rest period of 0.9 seconds. No confining pressure is applied on the specimen. The unconfined conditions are applied for the sake of the weak soil and the worst case loading conditions simulated in the laboratory. Also realistically, there are usually not much of horizontal confining pressures acting on top of pavement sub grades. The prepared sample is placed in the cell between two rubber caps to hold the specimen and even to give a good grip to stand in the cell and even to distribute the load equally on the surface area of the specimen. The specimen is placed and with the help of hydraulic jack the loading equipment is lowered to touch the specimen and later the soil specimen is first Conditioned by applying 200 load pulses at a stress level of 6 psi. Following this conditioning, the specimens is subjected different stress levels which is been calculated by UCS test to determine the resilient modulus of sub grade at respective stress level. The tabular column below shows the Stress ratio applied to the specimen and the Number of load repetitions taken by the soil sample.

Table 1: Load repetitions at different stress ratio of Red Soil with zero days curing.

Repeated Load Test for ISH Red Soil			
Sl No	**Type of soil**	**Stress ratio**	**Load Repetition**
1	Red Soil, Zero days curing	30%	40,000 without failure
2	Red Soil, Zero days curing	50%	30,000 without failure
3	Red Soil, Zero days curing	70%	30,000 without failure

Table.2: Black Cotton Soil with Zero days curing.

Repeated Load Test for ISH Black Cotton Soil			
Sl No	**Type of soil**	**Stress ratio**	**Load Repetition**
1	BC Soil, Zero days curing	30%	Failure @ 31638
2	BC Soil, Zero days curing	50%	Failure @ 29450
3	BC Soil, Zero days curing	70%	Failure @ 16786

TEST RESULTS

Grain size analysis of the soils.

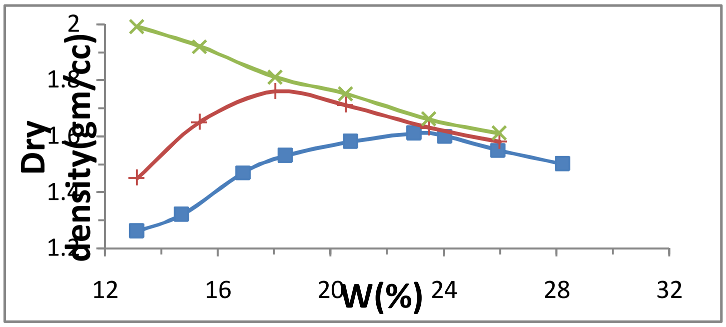

Fig. 1. Comparison of compaction Curves for both Light and Heavy Compaction of black cotton soil

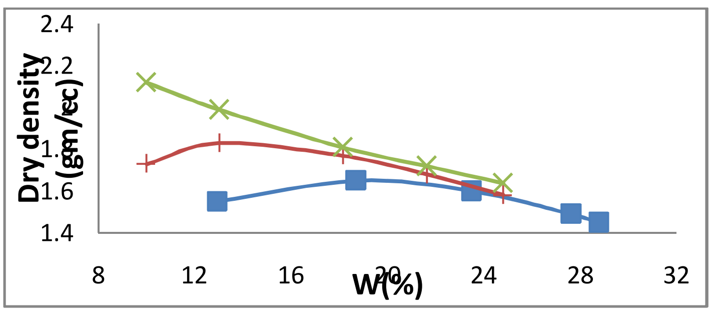

Fig. 2. Comparison of compaction Curves for both Light and Heavy Compaction of red soil

CONCLUSIONS

Grain Size Distribution

By visual observation and the grain size analysis conducted on the two soils taken is tabulated in table 1 which shows that the amount of fines especially silt and clay content is comparatively higher in case of Black Cotton soil (Bhalki soil) than in that of Red soil (Kaplapur soil).

Atterberg limits – LL, PL and PI

There is marginal difference in the values Liquid Limit, Plastic Limit and Plasticity Index between these two soils, but there is a slightest increase in variation of about 4% in shrinkage limit in case of Black Cotton soil compared to Red soil.

Compaction – Standard Proctor and Modified Proctor

Figures 1and 2 present the compaction curves for both light and heavy compaction for the soils under study.

It can be observed from these figures that higher dry density at lower water content were obtained with higher compactive energy levels with relative comparison to light compactive efforts for both Red and Black cotton soils.

California Bearing Ratio

The red soil has a higher CBR value than the black cotton soil when done under standard proctor and modified proctor.

Unconfined Compression Strength

The red soil has a better compressive strength than black cotton soil (Bhalki).

Repeated Load Test

Comparison of results of un-stabilized Red soil at different stress ratios.

It is observed that, for specimens compacted at ISH Energy Level(OMC) the Elastic Strain is 1447µ at 30% stress ratio,5000µ at 50% stress ratio and 4210µ at

70% stress ratio after 12000 cycles. It is observed that, for specimens compacted at ISH Energy Level (OMC) the Total Plastic Strain is3026µ at 30% stress ratio, 8289µ at 50% stress ratio and 20657µ at 70% stress ratio after 12000 cycles. It is observed that, for specimens compacted at ISH Energy Level (OMC) the Resilient Modulusis80.66Mpa at 30% stress ratio, 38.91Mpa at 50% stress ratio and 64.69Mpa at 70% stress ratio after 12000 cycles. It is observed that, for specimens compacted at ISH Energy Level the Total number of Load repetitions at all the stress level is more than 30000 cycles.

Comparison of results of un-stabilized Black Cotton soil at different stress ratios.

It is observed that, for specimens compacted at ISH Energy Level(OMC) the Elastic Strain is 5263.15µ at 30% stress ratio, 8132µ at 50% stress ratio and 14371µ at 70% stress ratio after 12000 cycles. It is observed that, for specimens compacted at ISH Energy Level (OMC) the Total Plastic Strain is10789µ at 30% stress ratio, 20198µ at 50% stress ratio and 24081µ at 70% stress ratio after 12000 cycles. It is observed that, for specimens compacted at ISH Energy Level (OMC) the Resilient Modulusis11.66Mpa at 30% stress ratio, 13.82Mpa at 50% stress ratio and 11.43Mpa at 70% stress ratio after 12000 cycles.It is observed that, for specimens compacted at ISH Energy Level the Total number of Load repetitions is 31638 at 30% stress ratio, 29450at 50% stress ratio and 16786 at 70% stress ratio.

Design of the Flexible Pavement according to IRC 37:2001.

The design of the flexible pavement is done based on the CBR of the soil for considered traffic intensities. As the CBR of the red soil is higher the thickness of the pavement is considerably reduced than the black cotton soil. Wearing course and the granular base course thickness is the same for both the soils at respective traffic intensities, only the binder course and granular sub course thickness varies accordingly.

Prediction of Permanent Deformation in the Sub grade using Design Model 2002 from AASHTO

The deformation in the sub grade for different traffic intensities and at varying stress ratios. The rut depth calculated from this model shows that the red sub grade soil undergoes higher rutting than that in the black cotton sub grade soil. The rut depth in red sub grade soil is more than twice the rut depth of black cotton sub grade soil at 50% stress ratio, but almost same at 30% and 70% stress ratio.

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