A STUDY ON EFFECTS OF SATURATION ON SOIL SUBGRADE STRENGTH: A REVIEW

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***ABSTRACT*: The design of the pavement layers to be laid over sub grade soil starts off with the estimation of sub grade strength and the volume of traffic to be carried. Design of the various pavement layers are very much dependent on the strength of the sub grade soil over which they are going to be laid. Sub grade strength is mostly expressed in terms of CBR (California Bearing Ratio). Weaker sub grade essentially requires thicker layers whereas stronger sub grade goes well with thinner pavement layers. The sub grade is always subjected to change in saturation level due to precipitation, capillary action, flood or abrupt rise or subsidal of water table. Change in moisture level in sub grade causes change in the sub grade strength. And it becomes quite essential for an engineer to understand the exact nature of dependence of sub grade strength on moisture variation. An understanding of the dependence of the CBR strength of local soils on water content will contribute towards better design and maintenance practices. Normally CBR test is an easy and well adopted method conducted on soil samples to measure the strength of sub grade. However, many other tests are also considered for assessing the sub grade strength.**

The strength of soil, used for sub grade may vary largely on the amount of saturation in it, *i.e.* amount of water exposed to the soil. Hence, in this study an attempt has been made to vary the degree of soaking and hence the saturation level in various types of soils and study the engineering properties of soils including CBR at different saturation levels.

It is observed that for coarse grained soil, worst engineering properties are observed after three days of soaking and for fine grained soils, the same is found at the end of four days.

Keywords*: *Sub grade soil, Moisture content, Compaction, Degree of saturation, CBR

INTRODUCTION

1.1 SUBGRADE

The crust of a pavement, whether flexible or rigid, rests on a soil foundation on an embankment or cutting, normally known as subgrade. Subgrade can be defined as a compacted layer, generally of naturally occurring local soil, assumed to be 500/300 mm in thickness, just beneath the pavement crust, providing a suitable foundation for the pavement. The subgrade in embankment is compacted in two layers, usually to a higher standard than the lower part of the embankment .The soil in subgrade is normally stressed to certain minimum level of stresses due to the traffic loads and the subgrade soil should be of good quality and appropriately compacted so as to utilize its full strength to withstand the stresses due to traffic loads. This leads to economization of the overall pavement thickness. On the other hand the subgrade soil is characterized for its strength for the purpose of analysis and design of pavement.

1.1.1 SubgradePerformance

A subgrade's performance generally depends on three of the basic characteristics, which are briefly described below:

1. Load bearing capacity: The subgrade must be able to support loads transmitted from the pavement structure. This load bearing capacity is often affected by degree of compaction, moisture content, and soil type. A subgrade that can support a high amount of loading without excessive deformation is considered good.
2. Moisture content: Moisture tends to affect a number of subgrade properties including load bearing capacity, shrinkage and swelling. Moisture content can be influenced by a number of things such as drainage, groundwater table elevation, infiltration, or pavement porosity (which can be assisted by cracks in the pavement). Generally, excessively wet subgrades will deform excessively under load.
3. Shrinkage and/or swelling: Some soils shrink or swell depending upon their moisture content. Additionally, soils with excessive fines content may be susceptible to frost heave in northern climates. Shrinkage, swelling and frost heave will tend to deform and crack any pavement type constructed over them.

BACKGROUND

Alayaki and Bajomo(2011) examined the effect of moisture variation on the strength characteristics of laterite soil in Abeokuta, Ogun State, Nigeria.The result showed that an increase in the soaking period of the compacted soil sample from 1to 5 days result in decrease in the CBR of the soil. He observed thatthe top face of the soaking soil has a CBR value greater than that at the bottom face.

Jaleel (2011)studied the effect of soaking on the top and bottom CBR value of a sub-base material. He prepared fourteen CBR samples at 95% relative modified AASHTO compaction. The results showed that, a significant drop in the CBR for top and bottom due tothe soaking was observed.Most of decrease in soaking CBR value was pronouncedinthe first days for top and bottom CBR, respectively. From the results of the testingconducted in this study on the effectof soaking period on top and bottomsubbase for highway purpose,he concluded that the load applied on thesubbase layer decreases withincrease of period soaking.

Ampadu (2006) examined the effect of water content on the CBR of a subgrade soil samples of soil from a study site were prepared by laboratory compactionat the optimum water content using different levels of compaction to obtain samplesat different densities. The remolded samples were then subjected to different levelsof wetting in a water tank and different degrees of drying in the laboratory and the CBR value were determined. From the laboratory CBR test results on a subgrade material at different watercontents for three different dry densities, it may be concluded that the rate ofchange in CBR per percentage change in water content during drying from theOMC was 3 to 7 times larger than during wetting from OMC.

Singh et al.(2011) developed regression-based models for estimating soaking and unsoaking California Bearing Ratio (CBR) values for fine-grained subgrade soils .Five locally available soils werecollected from different zones of West Bengal. The samples were compacted at four different levels of compaction (i.e.,50, 56, 65, and 75 blows) and at five different levels of moisture contents on dry and wet sides of an optimum moisturecontent (OMC) of a soil (i.e., ± 2% OMC, ± 1% OMC, and OMC).Regression models were developedconsidering different independent parameters namely, index properties of soils, degree of compaction, and moisturecontent.It was observed that the CBR value, both soaking and unsoaking significantly affected by change inmoisture content and compaction effort.

Ningsih et al.(2012) studied correlation between index properties and CBR tests of Pekanbaru (Indonesia)soils with and without soaking.This research aims to make comparisons between CBR soaking test results for CBR un-soaking in somevariation of clay content and make simple comparisons between CBR soaking for CBR unsoaking by considering the soil properties. The results showed that there was a linear correlation between the CBR soaking and CBR unsoaking also influenced by the nature of the index (the properties of the soil).

Rahman(2010) studied the correlation between CBR results and physical properties of soil. Correlation had been proposed in the study to predict the CBR values at top face of the soil sample for Malaysia's type of soil based on the collected soil data and results from laboratory works. These correlations were developed based on the Maximum dry density (MDD), Optimum moisture content(OMC) and the number of blows(of CBR test).

Hussain(2008) correlated between CBR value and Undrained Shear Strength from Vane Shear Test. Several soil samples with different Plasticity Index and moisture content were compacted and tested using CBR test and Vane Shear test to obtain the data to establish the correlation. He found that CBR value and Undrained shear strength increases with increase of Plastic index. CBR value and Undrained shear strength from Vane shear test of soil samples are inversely proportional with the moisture content.

Cokca et al.(2003) studied the effects of compaction moisture contenton the shear strength of an unsaturated clay. In this study, the effects of compaction moisture content and soaking on the unsaturatedshear strength parameters ofclay were investigated. Experiments weredone on samples compacted at optimum moisture content , on the dry side of optimum and on the wet side of optimum .He found that angle of friction decreases rapidly with increasing moisture contents , the cohesion component of shear strength attains its peak value at around optimum Moisture content and then decreases.

ERES Division(2001) studiedcorrelation of CBR values withsoil index properties.The objective of this study was to develop general correlations that describe the relationshipbetween Soil Index Properties and the California Bearing Ratio (CBR) and Resilient Modulus(*MR*) of unbound materials such as base, subbase, and subgrade layers in pavement systems. Yasinet al. studied the Effect of Submergence on Subgrade Strength. His study aimed at determining the effects of depth of submergence and duration of submergence on the subgrade strength of soil samples collected from the Dhaka-Aricha highway. CBR tests were performed with different heights of submergence after normal soaking period and also after prolonged submergence. For the studied depth and duration of submergence, no effect of submergence on sub-grade CBR strength could be found for any of the three types of soils tested.

Razouki et al.(2003) examined Long–term soaking effect on strength and deformation characteristics of a gypsiferous subgrade soil. The behaviour during long-term soaking of the California Bearing Ratio (CBR), the resilient modulus and the deformation of compacted Iraqi gypsiferous soil containing about 34% gypsum was studied.Sixteen (CBR) samples compacted at optimum moisture content and 95% of the maximum dry density of the modified AASHTO compaction test were prepared.The paper reveals that a soaking period of four days can lead to misleading and unsafe results regarding strength, stiffness and deformation of gypsiferous soils.

EXPERIMENTAL INVESTIGATIONS

Soils are classified with different engineering properties which affect the behavior of soil under different conditions. These properties are described briefly here.

3.1.1 Liquid Limit

The liquid limit (LL) is the water content at which a soil changes from plastic to liquid behavior. At this limit, the soil possesses a small value of shear strength, losing its ability to flow as a liquid. In other words, the liquid limit is the minimum moisture content at which the soil tends to flow as a liquid.

3.1.2 Plastic Limit

Plastic limit (PL) is the arbitrary limit of water content at which the soil tends to pass from the plastic state to the semi-solid state of consistency. Thus, this is the minimum water content, at which the change in shape of the soil is accompanied by visible cracks, i.e., when worked upon, the soil crumbles.

3.1.3 Plasticity Index

Plasticity Index (PI) is the range of water content within which the soil exhibits plastic properties, that is, it is the difference between liquid and plastic limits. Plasticity Index (**IP**) = Liquid Limit(**WL)** -Plastic Limit (**WP)**

3.1.4 Differential Free Swell

Free Swell Index is the increase in volume of a soil, without any external constraints, on submergence in water.

$$\text{Free swell index} = \frac{V_d - V_k}{V_k} \times 100\%$$

Where, V_d = volume of soil specimen read from the graduated cylinder containing distilled water.

V_k = volume of soil specimen read from the graduated cylinder containing kerosene.

3.1.5 Specific Gravity

Specific gravity of soil solids is defined as the ratio of unit weight of solids to the unit weight of water at the standard temperature (4°C).

3.1.6 Sieve Analysis

About 1kg of soil was taken and it was washed thoroughly with water on 75 micron sieve ,soilretained on sieve was dried and weighed and used for sieve analysis .These dried soils werepassed through stack of sieves like 4.75mm,2.36mm,1.18mm,600µm,300 µm,150 µm, 0.75 µm.

3.1.7 Modified Proctor Test

The Proctor compaction test is a laboratory method of experimentally determining the optimal moisture content at which a given soil type will become most dense and achieve its maximum dry density. The term Proctor is in honor of R. R. Proctor, who in 1933 showed that the dry density of a soil for a given compactive effort depends on the amount of water the soil contains during soil compaction. His original test is most commonly referred to as the standard Proctor compaction test; later on, his test was updated to create the modified Proctor compaction test.

3.1.8 California Bearing Ratio Test

The CBR is a measure of resistance of a material to penetration of standard plunger under controlled density and moisture conditions. The test procedure should be strictly adhered if high degree of reproducibility is desired. The CBR test may be conducted in re-moulded or undisturbed specimens in the laboratory. The test has been extensively investigated for field correlation of flexible pavement thickness requirement.

Briefly, the test consists of causing a cylindrical plunger of 50mm diameter to penetrate a pavement component material at 1.25mm/minute. The loads, for 2.5mm and 5mm are recorded. This load is expressed as a percentage of standard load value at a respective deformation level to obtain CBR value.

CONCLUSIONS

An attempt has been made in this project work to explore the effect of saturation, i.e., soaking on the strength properties of subgrade soil, namely CBR which is widely used as a measure of design of all types of pavements. For this three types of soils have been considered .The effect of soaking on degree of saturation on different parts of the soil sample have also been considered in this study. From the results and discussions presented earlier, following conclusions are drawn :

1. It is observed that the CBR value of the given clayey soil sample with BIS classification "OH" prepared at a particular density decreases rapidly with time of soaking up to 1day after which the rate of decrease is small.While the CBR value reduces by about 20 times compared to the unsoaked conditions, the loss of CBR value in 4 days is about half compared to that after 1 day.It is also observed that there are not much significant variations in CBR values from 3rd day to 4th day of soaking.When soil samples are taken from different points of the CBR sample and tested for its moisture content, it is also observed that there variations in moisture content in a given layer are not significant in unsoaked conditions and 1 day of soaking.However, it is observed that for a longer soaking time, higher moisture contents result at top layer compared to that in the lower layers.

2. For the 2nd type of soil considered and found to be of "CI" classification, the trend is almost similar to the first type of soil used.

3. For the 3rd type of soil classified as 'GM', the rate of decrease of strength is very less. Although there is decrease in CBR value with increase in number of days of soaking but the rate of decrease is not as much as in 1st type and 2nd type of soil considered.

4. For 1st type and 2nd type of soil wet side of Optimum Moisture Content (CBR values) gives better results than that dry side. However this trend was not observed 3rd type soil.
5. It has been observed that as usual with decrease in degree of compaction (either on wet or dry side) cohesion and angle of friction decreases.

Future Scope of Work

1. Other engineering properties such as direct shear, unconfined compression and triaxial test should also be considered for different levels of saturation.
2. Effect of stabilization with weak (clayey) soil on engineering properties at different levels of saturation needs to be explored.
3. The considerations on engineering properties as stated above may be applied to a variety of soils, so that a database may be prepared to justify the period of soaking of a soil for deciding the CBR value or any such engineering property that may be used for pavement design.

References

[1] Alayaki, F. M., Bajomo, O. S. (2011), Effect of Moisture Variation on the Strength Characteristics of Laterite soil. Proceedings of the *Environmental Management Conference*, Federal University of Agriculture, Abeokuta, Nigeria.
[2] Ampadu,S,I.K. (2006) , "Laboratory Investigation into the Effect of Water Content on the CBR of a Subgrade soil".
[3] Blazejcak,D.,Horn.R.,Pytka.J.(1995), "Soil tensile strength as affected by time, water content and bulk density".*Int.Agrophysics*,pp179-188.
[4] Cokca,E.,Erol,O., Armangil. (2004), "Effects of compaction moisture content on the shear strength of an unsaturated clay", *Geotechnical and Geological Engineering 22*,pp285-297.
[5] Chauhan.(2010)," a laboratory study on effect of test conditions on subgrade strength". Unpublished B.Tech Thesis,N.I.T Rourkela.
[6] ERES Division (2001), **"**Correlation of CBR values with soil index properties", Illinois.
[7] Hussain,N.A.B.(2008), "Correlation between CBR value and undrained shear strength from vane shear test",Malaysia.
[8] Jaleel,Z.T.(2011), Effect of Soaking on the CBR-Value of Subbase Soil. *Eng. and Tech. journal*, vol.29.
[9] Kim,Y.T., Shin.H.,Park.D.K .(2011), "Variation of shear strength of weathered granite soil with water content".pp253-258.