International Journal of Enhanced Research in Science, Technology & Engineering
ISSN: 2319-7463, Vol. 6 Issue 5, May-2017

Experimental Analysis and Performance Evaluation of Saturation on bearing ability of Subgrade Soil

Anuj Dalal[1], Mrs. Monika[2]
[1]PG Student, Department of Civil Engineering, Sat Priya Group of Institution, Rohtak, Haryana
[2]Asst. Professor, Department of Civil Engineering, Sat Priya Group of Institution, Rohtak, Haryana

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 of water table and frost action due to climate. Change in sub grade causes change in the sub grade strength. And it becomes utterly 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 value 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 in-situ or in laboratory to measure the strength of sub grade. However, many other tests are also considered for assessing the sub grade bearing capacity.

Keywords: Sub-Grade Soil, Sub-Grade Bearing Capacity, Moisture Variation, CBR Test.

INTRODUCTION

The general effect of temperature on the strength of subgrade soils is summarized in tabular form. The strength parameters are in terms of consistency, compressibility, permeability, and modulus. It is suggested that information contained therein is to be used with caution because of the possible modifying or counteracting effects due to geometric, granulometric, and soil-structure factors. The sub-grade on embankment is compacted in two layers, usually to a higher standard than the lower part of the embankment. At cuttings, the cut formation, which serves as the subgrade, is treated similarly to provide a firm foundation for the pavement. Where the naturally occurring local subgrade soils have poor engineering properties and low strength in terms of CBR, for example in Black Cotton/clay soil areas, improved sub-grades are provided by way of lime/cement/bitumen treatment or by mechanical stabilization and other similar techniques. The subgrade, whether at cutting or in embankment, should be well compacted to utilize its full strength and to economize on the overall pavement thickness by getting 96%To 98%.

It would be impossible within the frame of this paper to organize and analyze the large body of knowledge available on this subject. All that can be done is to point out the most important general relationships. These are concerned with the influence of particle size composition or granulometry, presence or absence of a granular bearing skeleton, secondary structure of silt-clay aggregations and the mechanical, thermal, and moisture history of the soil system especially if it is of a cohesive nature. At high moisture contents increase in density produced only a slight increase in tensile strength; however, at low moisture contents the tensile strength increased sharply with an increase in density. Higher tensile strength existed on the dry-side of the optimum moisture content. Then CBR tests were made at different moisture contents including OMC and analysis made to investigate the variation of CBR with respect to different days of soaking, i.e. from unsoaked (day 0) to soaked (day 5). The variations were also made with regard to moisture content at different layers along with different positions (east, west, north, south, centre positions) and also the variations of moisture content with respect to different days of soaking were observed. Direct Shear Test was also conducted on the soil samples.

EXPERIMENTAL WORK & ANALYSIS

The effect of temperature change at constant moisture (or liquid) content and of change of moisture (or liquid) content at constant temperature is illustrated by experimental data on different components of soil-pavement systems. The combined effect of moisture and temperature changes is shown for various sections of the AASHO test road. Reference is made to the fact that most component layers of a road cross section belong to the large class of collameritic systems and to the many practically important analogies deriving from this for apparently widely differing construction materials.

Initially experiments are conducted to find out different properties of soil such as index properties, grain size distribution and differential free swelling index. Later on heavy compaction tests are conducted to find out the optimum moisture content & corresponding maximum dry density. Then CBR tests are made at different moisture contents including OMC and analysis made to investigate the variation of CBR with respect to different days of soaking.

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

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.

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.

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)

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).

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.

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.

California Bearing Ratio (CBR)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.

Direct Shear Test

A direct shear test is a laboratory or field test used by geotechnical engineers to measure the shear strength properties of soil or rock material, or of discontinuities in soil or rock masses.

Table 1: Moisture content for test – 3, type – 2 soil for soaked (day - 1) condition

Vertical Positions	MOISTURE CONTENTS%				
	Horizontal Positions				
	EAST	WEST	NORTH	SOUTH	CENTRE
TOP	17.36	18.37	17.49	18.22	18.74
MIDDLE	16.37	16.56	17.08	16.33	16.58
BOTTOM	16.03	16.25	16.44	17.02	17.09

Table 2: Moisture content for test – 3, type – 2 soil for soaked (day - 2) condition

Vertical Positions	MOISTURE CONTENTS%				
	Horizontal Positions				
	EAST	WEST	NORTH	SOUTH	CENTRE
TOP	18.23	19.37	18.22	18.81	19.06
MIDDLE	17.76	16.99	17.25	18.08	17.33
BOTTOM	16.88	16.82	16.35	17.24	17.49

Table 3: Moisture content for test – 3, type – 2 soil for soaked (day - 3) condition

Vertical Positions	MOISTURE CONTENTS%				
	Horizontal Positions				
	EAST	WEST	NORTH	SOUTH	CENTRE
TOP	20.96	21.35	20.44	20.97	21.29
MIDDLE	19.95	19.32	20.03	18.54	19.63
BOTTOM	18.85	17.24	18.36	17.83	17.52

Table 4: CBR values of first type of soil

Compaction Conditions (M.C&D.D)	**CBR (%)**					
	DAYS OF SOAKING					
	0	1	2	3	4	5
OMC &MDD (16.4,1.85)	48	2.9	2.2	1.9	1.6	1.5
98% Density(wet side) (17.8,1.8)	37.47	2.22	1.97	1.82	1.59	1.26
98% Density(dry side) (12.89,1.8)	35.03	1.98	1.87	1.82	1.77	1.54

From the above tests and results for the two type of soils, it has been found that for the first and second type of soil the decrease in strength (CBR Value) is quite similar. There is a sudden decrease in CBR from unsoaked condition to that with one day soaking. But there is no significant variation of CBR from third to fourth day of soaking. It has been observed that higher moisture contents result at top layers than compared to that in lower layers.

Table 5: CBR values of second type of soil

Compaction Conditions (M.C&D.D)	CBR (%)					
	DAYS OF SOAKING					
	0	1	2	3	4	5
OMC &MDD (14.8,1.85)	35.39	3.57	2.9	2.67	2.5	1.13
98% Density(dry side) (12.46,1.82)	31.77	2.6	1.96	1.87	1.56	0.9
98% Density(wet side) (16.25,1.82)	33.05	2.12	2.08	1.95	1.78	1.12

CONCLUSION

The effect of soaking on degree of saturation on different parts of the soil sample has also been considered in this study. 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. 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.

REFERENCES

[1]. Density, Voids, Absorption, Bulking", Bureau of Indian Standards, New Delhi.
[2]. IS: 2386 (1963), "Methods of Test for Aggregates for Concrete (Part- I): Particle Size and Shape", Bureau of Indian Standards, New Delhi.
[3]. The Asphalt Handbook (1989) Manual Series No. 4 (MS-4). The Asphalt Institute, Lexington, KY.
[4]. The Hot-Mix Asphalt Paving Handbook (2000). AC 150/5370-14A, U.S. Army Corps of Engineers, Washington D.C.
[5]. ASTM D 4402 (2006). "Standard Test Method for Viscosity Determination of Asphalt at Elevated Temperatures Using a Rotational Viscometer."
[6]. "Bituminous Tack Coat." Unified Facilities Guide Specification (UFGS) 02744N.
[7]. Chehab, G., Medeiros, M., and Solaimanian, M. (2008). "Evaluation of bond performance of FastTack Emulsion for Tack Coat applications." Pennsylvania Department Of Transportation, Report No. FHWA-PA-2008-017-PSU021, Pennsylvania Transportation Institute.
[8]. CPB 03-1 Paint Binder (Tack Coat) Guidelines (2003), California Department of Transportation, Construction Bulletin.

[9]. Cross, S. A. and P. P. Shrestha (2004). "Guidelines for Using Prime and Tack Coats." Report No. FHWA-CFL-04-001, Central Federal Lands Highway Division, FHWA, Lackwood, CO.
[10]. IS: 2386 (1963), "Methods of Test for Aggregates for Concrete (Part-III): Specific Gravity.
[11]. West, R.C., J. Zhang, and J. Moore. (2005). "Assessment of Bond Strength Between Pavement Layers." NCAT Report No.
[12]. National Bituminous Pavement Association and Research Roffe, J.-C. and F. Chaignon. (2002) "Characterization Tests on Bond Coats: Worldwide.
[13]. Roberts, F.L., Kandhal, P.S., Brown, E.R., Lee, D., and Kennedy, T.W. (1996). Hot Mix Bituminous Materials, Mixture Design, Construction, 2nd Edition, Lanham, Maryland, Education Foundation.
[14]. Sangiorgi C., Collop, A.C., and Thom, N.H. (2002). "Laboratory Assessment of Bond Condition using the Leutner Shear Test." Proceeding of 3rd International Conference on Bituminous Mixtures and Pavements,, pp 315-324, Thessaloniki, Greece.
[15]. West, R.C., J. Zhang, and J. Moore. (2005). "Evaluation of Bond Strength Between Pavement Layers." NCAT Report No. 05-08, National Center for Asphalt Technology, Auburn, AL.
[16]. Plum, R. L. and Esrig, M. I. (1969). Some temperature effects on soil compressibility and pore water pressure, Highway Research Board, Special Report 103, pp. 231-242.
[17]. Schiffman, R. L., Ladd, C. C. and Chen, A. T. (1966). Secondary Consolidation Of Clay, Proc., Rheology and Soil Mechanics Symposium, Grenoble, Springer-Verlag.
[18]. Sherif, M. A. and Burrous, C. M. (1969). Temperature effect on the unconfined shear strength of saturated cohesive soil, Highway Research Board, Special Report 103, pp. 267-272.
[19]. Winterkorn, H. F. and Baver, L. D~ (1934). Absorption of liquids by soil colloids: i. liquid intake and swelling by soil colloidal materials, Soil Science, Vol. 39, No.4, pp. 291-298, October.