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A Study on Effects of Saturation on Soil Subgrade Strength

Imtiyaz Ali

Post Graduate Scholar, Department of Civil Engineering, Mewar University, Chittorgarh, Rajasthan, India 312901

Abstract: ***The design of the pavement layers to be laid over sub grade soil begins off with the estimation of sub grade strength and the quantity of traffic to be carried. Design of the various pavement layers are very lots depending on the strength of the subgrade soil over which they're going to be laid. Sub grade electricity is usually expressed in terms of CBR (California Bearing Ratio). Weaker sub grade essentially requires thicker layers whereas more potent sub grade goes nicely with thinner pavement layers. The sub grade is always subjected to trade in saturation stage because of precipitation, capillary motion, flood or abrupt upward push or subtidal of water table. Change in moisture level in sub grade reasons alternate inside the sub grade electricity. The traffic volume counts to be carried and the energy of the subgrade soil are used to design the various levels of pavement that ought to be positioned over it. The strength of the subgrade is usually expressed as a ratio known as the California Bearing Ratio, abbreviated as CBR. When the subgrade is weaker, thicker layers are required, whereas whilst the subgrade is stronger, thinner layers are sufficient. When we will come to know how the strength of these soils is affected from versions in moisture, it will likely be easier to design and maintain stronger systems. CBR resistance values for soils utilized within the subgrade may additionally vary to an extra quantity due to the saturation of the subgrade. Hence, at some stage in this work, variation in the soaking degree has been attempted and in flip the saturation stage in two types of soil, and engineering properties of soils and CBR at various stages of saturation are studied. The engineering properties that have been evaluated after the soaking of 3 days were worst and whereas for fine - grained soils, it is observed to be identical after the end of day 4***

Keywords: subgrade, California Bearing Ratio, moisture, traffic volume, engineering properties.

1. Introduction

Subgrade

The subgrade is the inner most part of pavement and material upon which the pavement structure is placed. However, there is a chance to look at pavement performance in terms of pavement structure and mix design alone, the subgrade can often be the overriding factor in pavement performance. [1]

The innermost part of a pavement, whether flexible or rigid, rests on a soil basis on an embankment or slicing, commonly called subgrade. Subgrade can be defined as a compacted layer, generally of clearly occurring nearby soil, assumed to be 500/300 hundred mm in thickness, simply below the pavement crust, supplying a suitable basis for the pavement. The subgrade in embankment is compacted in two layers, generally to a better preferred than the lower part of the embankment. The soil in subgrade is typically stressed to positive minimum level of stresses due to the traffic hundreds and the subgrade soil ought to be of right pleasant and appropriately compacted on the way to utilize its full power to face up to the stresses because of traffic hundreds. This ends in economization of the general pavement thickness. On the opposite hand, the subgrade soil is characterized for its power for the reason of evaluation and design of pavement.

Subgrade Performance

The performance of subgrade generally depends on following characteristics described below:

- Load bearing capacity: The subgrade must be capable of assist masses transmitted from the pavement shape. This load bearing capacity is regularly suffering from diploma of compaction, moisture content material, and soil kind. A subgrade which can aid a high quantity of loading without immoderate deformation is taken into consideration good.
- Moisture content material: Moisture has a tendency to affect some of subgrade residences including load bearing capability, shrinkage and swelling. Moisture content material can be inspired via a number of of factors which include drainage, groundwater table elevation, infiltration, or pavement porosity (which may be assisted by means of cracks inside the pavement). Generally, excessively moist subgrades will deform excessively beneath load.
- Shrinkage and/or swelling: Some soils cut back or swell relying upon their moisture content material. Additionally, soils with excessive fines content material can be vulnerable to frost heave in northern climates. Shrinkage, swelling and frost heave will have a tendency to deform and crack any pavement type built over them.

California Bearing Ratio Test

It is also known as load - deformation test that is conducted within the laboratory or in the fields and those outcomes are normally used to find the thickness of pavement layers, base direction and other layers of a given traffic loading by the use of empirical design chart. Initially it practiced for the design of surfaced and un - surfaced airfields which continues to be primarily based upon CBR nowadays. The CBR determines the thickness of various elements constituting the pavement. The CBR test is the ratio of pressure per unit region required to penetrate soil mass by means of a round plunger of 50mm on the fee of one.25mm/min. Observations are achieved between the load resistances (penetration) vs. Plunger penetration. The California bearing ratio, CBR is expressed because the ratio of the burden resistance (test load) of a given soil pattern to the same old load at 2.5mm or 5mm penetration, expressed in percent.

CBR = (Test load/Standard load) ×one hundred (**A Study on**

Effects of Saturation on Soil Subgrade Strength Ripunjay Kumar Sharma1, N Manoj Kumar2)

The standard load for 2.5mm penetrations is 1370 kg and 5mm penetrations is 2055 kg. The CBR test is carried out on a small - scale penetration of dial reading with probing ring divisions. The proving ring divisions are taken corresponding to the penetrations at 0 to 12.5 and from which Test loads are calculated and hence CBR value of soil is being determined. The maximum. Load and penetration are recorded if it occurs for a penetration of less than 12.5 mm. The curve is mainly convex upwards however the initial portion of the curve may be concave upwards due to surface irregularities. A correction is then applied by drawing a tangent to the curve at the point of greatest slope. The right origin will be the point where the tangent meets the abscissa. The CBR values are usually calculated for penetrations of 2.5 mm and 5mm. Generally, the CBR values at 2.5mm penetration will be greater than 5mm penetration and in such a case the former is taken as the CBR value for design purposes. If the CBR value corresponding to a penetration of 5mm exceeds that for 2.5mm, the test is repeated. If identical results follow, the bearing ratio corresponding to 5mm penetration is taken for design.

Considering the above, it has been proposed in this project to study the various strength properties of different types of soil made at different moisture and density levels and conclude the general aspects of moisture conditions on determination of different strength parameters, so as to achieve the most viable and economical pavement design.

2. Literature Review

Alay Aki and Bajomo (2011) study the effect of moisture differences on the strength characteristics of laterite soil in Abeokuta, Ogun State, Nigeria. The result indicates that a rise in the soaking period of the compacted soil sample from 1to 5 days result in lessen in the CBR value of the soil. He notices that the top face of the soaking soil has a greater CBR value than that at the bottom face

Jaleel (2011) examined the effect of soaking on the top CBR and bottom CBR value of a sub - base material. He makes 14 CBR samples at 95% relative modified AASHTO compaction. The results indicates that, a remarkable drop in the CBR for top and bottom due to the soaking was noticed. Most of decrease in soaking CBR value was visible in the first days for top and bottom CBR, respectively. From the results of the testing done in this study on the effect of soaking period on top and bottom subbase for highway reason, he concluded that the load applied on the subbase layer decreases with increase of period soaking.

Amadu (2006) study the impact of water content on the CBR of a subgrade soil sample of soil from a study site was primed by laboratory compaction at the optimum water content using various levels of compaction to get samples of different densities. The remoulded samples were then subjected to different degree of wetting in a water tank and different level of drying in the laboratory and the CBR value was found. From the laboratory CBR value, test results on a subgrade material at different water contents for three different dry densities, it may be concluded that the rate of change in CBR per percentage change in water content during drying from them was 3 to 7 times larger than during wetting.

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

Ningsih et al. (2012) deliberated correlation between index properties and CBR tests of Pekanbaru (Indonesia) soils with soaking and without soaking. This finding aims to make contrast between CBR soaking test results for CBR un - soaking in some variant of clay content and make simple comparisons between CBR soaking for CBR unsoaking in view of the properties of soil. The results indicates that there was a linear connection between the CBR soaking and CBR unsoaking also effect by the nature of the index properties of the soil.

Rahman (2010) deliberated the relation between CBR results and physical properties of soil. Connection had been suggested in the study to project the CBR values at top face of the soil sample for Malaysia's type of soil based on the collected soil statistics and results from laboratory findings. These connections were developed based on the Maximum dry density (MDD), Optimum moisture content (OMC) and the number of blows (of CBR test).

Rashid Razya (2022) Studied variation inside the soaking degree has been tried and in flip the saturation stage in two soil types and engineering properties of soils and CBR at various level of saturation are studied. The engineering properties that have been evaluated after the soaking of 3 days were worst and thinking about fine - grained soils, its observed to be equal after the end of 4th day.

Testing and Methodology

Sample Collection
Disturbed from the locations within the UT of Ladakh. The collection of samples was done in OCTOBER of the year 2021. The top layer from the sample collection site was removed and then cleaned for the collection of undisturbed samples by using a core cutter, the core cutter is sampler for sample collection is used, then after the collection of samples these samples were properly sealed and carried to the laboratory to avoid change in structure and loss of water content of the sample.

Laboratory Testing

The samples had been taken to the engineering laboratory at the National Institute of Technology Srinagar and all primary investigation for the characterization of soils were executed. Indian Standards (IS): 2720 is followed for the testing of sample, the standardized procedures are to be followed to perform various geotechnical laboratory tests on soils sample. For this work, geotechnical laboratory tests have been done in accordance with IS: 2720 (1973) and succeeding revised versions Initially experiments was performed in the lab to determine various Soil characteristics such as exponential characteristics and particle size distribution. After that, a hard compression test was done to find the optimum moisture content and the corresponding maximum dry density. CBR tests were then execute at various moisture levels, including OMC, and analyses were performed to examine CBR variability on different soaking days. From day 0 (not soaked) to the 5th day (soaked). In addition to different positions, the moisture content of various layers has also changed.

Soil properties such as Index properties and particle size distribution. After that, a compression test was brought about to find the optimum moisture content and the corresponding maximum dry density. CBR tests were then done at various moisture levels, including OMC, and analysis was performed to examine CBR variability on different soaking days. From day 0 (not soaked) to 5th day (soaked). In addition to different positions, the moisture content of various layers has also changed and changes in the water content were also observed depending on the different days of soaking.

Results and Analysis Index Properties of Soil

Index property	Experimental Value
Liquid Limits	54.95%
Plastic limit	33.80%
Plasticity Index	22.05%
Specific gravity	2.62%
Differential Swell Index	56%

Grain Size Distribution of Type Soil

I. S Sieve no.	Weight retained in gm	Percentage Weight retained	Percentage weight Passing
4.75	4.5	0.45	99.53
2	14.6	1.46	98.1
1	20.1	2.01	96.06
.6	5.1	.51	95.58
.425	9.7	.97	94.59
.300	5.1	.51	94.08
.212	21.1	2.11	91.17
.015	15.7	1.57	90.41
.075	30.50	3.05	87.362

Based on the above properties the IS Soil Classification for the soil is 'OH'

California Bearing Ratio Test Results

Compaction Conditions (M. C & D. D)	CBR (%)					
	Days Of Soaking					
	0	1	2	3	4	5
OMC &MDD (14.8, 1.85)	34.94	3.54	2.86	2.69	2.45	1.12
98% Density (dry side) (12.46, 1.82)	31.87	2.58	1.89	1.76	1.55	0.9
98% Density (wet side) (16.25, 1.82)	32.95	2.1	2.06	1.97	1.74	1.14
97% Density (dry side) (10.7, 1.794)	32.35	2.01	1.81	1.74	1.63	0.8
97% Density (wet side) (17.8, 1.794)	34.23	2.04	1.88	1.78	1.66	0.7

It has been found that there is a sudden decrease in CBR value from unsoaked condition as compare to 1 day soaking. But there are no noticeable changes of CBR from third to fourth day of soaking. It has been found that higher moisture contents result at top layers than compared to that in lower layers.

3. Conclusions

This whole examines done was meant to get the knowledge of influence of saturation that is soaking on the properties of strength of soil subgrade, like CBR which is frequently used parameter for designing all types of pavements. In this study the effect of soaking on the degree of saturation has also been considered on different parts of soil sample. Analyzing all the results and discussions that were proposed earlier, we come to the conclusions in nutshell. From the examination made we find that CBR of clayey soil sample with "OH" as BIS classification that was prepared at specific density shows rapid decrease with soaking time of up to 1 day and after which decreasing rate is very less. However, CBR value got reduced by near about 20 times in contrast to the unsoaked condition, 4 - day decrease of CBR value is only half in contrast to that of after one day. It can also be notice that there are least differences in values of CBR from day 3rd to day 4th of soaking. From the given CBR sample, when samples for observation are taken from different points and then examined for their moisture content, it can also be seen that moisture content variations are less notable in condition of unsoaking and one day of soaking. For longer time soaking, it is noticed that top layer shows more moisture content as in contrast to that of lower layers. It has been observed that as usual with decline in degree of compaction (either on wet or dry side) cohesion and angle of friction decreases. However, it is noticed that for a longer soaking time, more moisture contents result at top layer compared to that in the lower layers.

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