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Determining correlation between CBR, UCS and Triaxial test value of different subgrade soils

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ABSTRACT:Efficient transportation network is essential for safe, timely and economic conveyance of goods and passenger. In this regard's highway construction is very important activity for development of any region. Different types of vehicles are moving on the same right of way of highway section. The design of pavement section is mainly depending on repetition of heavy loaded vehicles like, trucks (single axle& multi axle). The overall thickness of pavement section also depends on strength of subgrade soil. IRC recommended California bearing ratio (CBR) test for subgrade soiling flexible pavement design CBR gives a penetration resistance value of subgrade soil.

Which represents indirectly shear strength of soil but this test is time consuming. However rutting failure in sub grade soil is due to excessive shear strain under wheel load. Hence evaluation of shear strength of sub grade soil is necessary for different moisture contents. This strength of sub grade soil may be obtained for unconfined i.e. for only axial loading and for confined i.e. for axial loading with lateral a fining pressure, means triaxial loading. The unconfined compressive strength (UCS) test of subgrade soil is one of the fastest and cheapest methods of measuring shear strength. Whereas triaxial testing determine modulus of deformation from stress-strain curves. This test also determines the required thickness of pavement layers. It is interesting to know whether there is any relation between CBR value, UCS value and Triaxial test value or not. Looking at the above this study is aimed to determine correlation between CBR (California bearing ratio) value, UCS (unconfined compressive strength) value and Triaxial test value on different types of soils available near by the Himmatanagar laboratory investigations will be carryout for the individual soil types and for the combination(mixing) of different soils. This relationship may be useful to estimate the CBR value &triaxial test value from the UCS (unconfined compressive strength) value of given soil sample.

***Keywords*-CBR (California bearing ratio), UCS (Unconfined compressive strength), triaxial test, Subgrade soils**

I. INTRODUCTION

1.1 General

An economy of country is dependent upon many factors, among which transportation network is one of the main factors. For a country to be stable and developed it needs a good, safe, economic and efficient transportation network. Transportation network may consist of mode of transportations such as railways, roadways, airways and waterways. Among all the modes of transportation, roadways are one of the most commonly used mode in daily life as it provides door to door service from origin to destination for passengers or freight. For management and administration, roads in India are divided in to the following five categories.

- National Highway (NH)
- State Highway (SH)
- Major District Road (MDR)
- Other District Road (ODR)
- Village Road (VR)

India is currently confronted with the tremendous test of safeguarding and upgrading the transportation framework, these require the interest of new material to enhance the security of soils. There are industrial and mechanical waste materials which can be contaminating the earth; however, if used for sub-grade, it enhances the quality of the soil, in this way decreasing the expense of development of the street. In this condition, important to enhance the treatment of soil stabilization. The state of Minnesota and many counties throughout Minnesota, along with other entities throughout the Midwest, are using a variety of stabilization techniques for various materials used in road construction. Such methods appear to improve constructability and lead to increased performance and reduced maintenance.

Problem Statement

The pavement thickness considered in CBR(California bearing ratio),UCS(Unconfined compressive strength) and Triaxial test are very importance test .The CBR test are more time consuming test .The UCS(Unconfined compression test) is by far the most popular method of soil shear Testing because it is one of the fastest and cheapest methods of measuring shear strength and Triaxial test is fast and cheapest test .The problem is time consuming test CBR and UCS are fast and cheapest and Triaxial test are fast so find relation because no one can find this relation. The relation most importance to find CBR value for considered another test UCS, Triaxial test to other value find.

Aim of Study

Determining correlation between CBR (California bearing ratio), UCS (Unconfined compressive strength) and triaxial test value of different subgrade soils.

Objectives of Study

- To determine the engineering properties of selected soil samples like, Liquid Limit, Plastic limit, Plasticity index, Optimum moisture content for MDD.
- To determine the CBR, UCS, Triaxial test value of the selected soil samples.
- To determine the correlation between CBR, UCS and Triaxial test value of the selected soil samples.
- To obtain the optimum mix of soils for the subgrade layer.

Scope of the study

This study is focused on to identify the correlation between CBR, UCS and Triaxial test value for different type of soil for strength of subgrade. The relation is most importance because any one no value finds to relation.

II. Review of Literature

Pinal. B. Adroja1 et.al. (2017) carried outProper construction and choice of suitable material for embankment are the main criterion to reduce the early distresses in the pavement structure. In flexible pavements, sub-grade is considered to be an ideal layer to resist wheel load and its California bearing ratio (CBR) value is considered as the strength measuring parameter. Conducting CBR test is an expensive and time-consuming test, moreover, it is very difficult to mould the sample at a desired in-situ density in the laboratory.In the present study, an attempt has been made to establish a relationship between different engineering properties of soil subgrade like DCPT value, CBR and Unconfined compressive strength (UCS).The developed relationships have been easy to get information about the strength of subgrade over the length of the road. Use of these correlations will prove cost effective and reduce considerable time.

Er Karmavirsinh M Sisodia1 et.al.(2017) carried out the performance of pavements depends to a large extent on the strength and stiffness of the subgrades. This paper presents the results of an extensive field and laboratory investigation of five PMGSY low volume road sections in the Gujarat state.Dynamic Cone Penetration tests (DCPT), California Bearing Ratio (CBR) tests, Maximum Dry Density (MDD) and Optimum Moisture Content (OMC) tests were performed to study the strength properties of the subgrade layer of pavements. The work described the correlations between the results obtained using the DCP and the results obtained using the CBR method for subgrade soils at various locations of PMGSY roads of Gujarat state in India. A correlation between the Maximum Dry Density (MDD) and Optimum Moisture Content (OMC) of subgrade and DCPI penetration index and CBR values were established. Regression models were developed as part of this study to enable the prediction of CBR values based on the average penetration-rates of DCPT performed for field density.

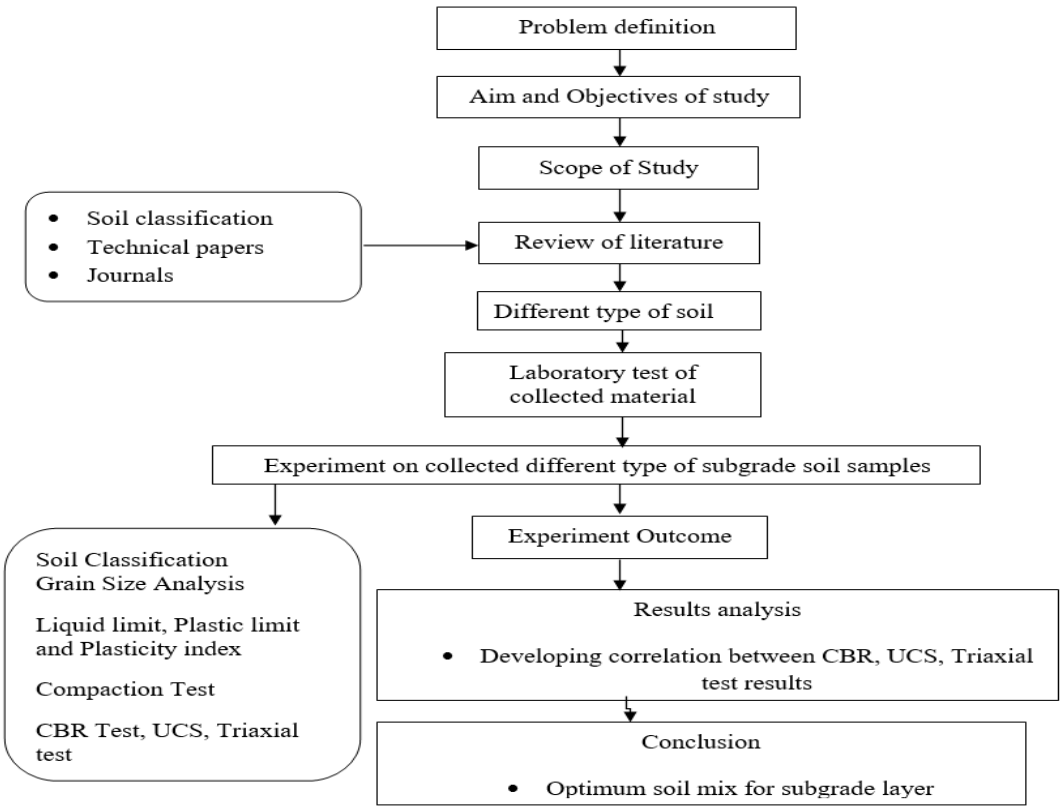
Kavish S. Mehta et. al. (2014) carried out Analysis of Engineering Properties of Black Cotton Soil & Stabilization Using by Lime Black cotton soil showing low to medium swelling potential from Rajkot Gujarat was used for determining the basic properties of the soil. Changes in various soil properties such as Liquid limit, Plastic Limit, Maximum Dry Density, Optimum Moisture Content, and California Bearing Ratio were studied. Lime-stabilization of geo-materials by producing cohesive materials in the soil increases the strength and decreases materials plastic properties. This is why these materials can be used for projects where high strength and high-performance materials are desirable.

P.G. Rakaraddi1at.al. (2013) carried out in the flexible pavements sub-grade is considered to be an ideal layer to resist wheel load and its CBR value is considered as the strength measuring parameter. Conducting CBR test is an expensive and time-consuming test, moreover it is very difficult to mould the sample at a desired in-situ density in the laboratory. Further, if the available soil is of poor quality, suitable additives are mixed with soil and resulting strength of soil is assessed by CBR value which is cumbersome. To overcome these problems, the other methods such as regression-based models (simple & multiple) are used in this study. The soil properties like liquid limit, plastic limit, plasticity index, optimum moisture content, maximum dry density and percentage fineness of the soil (passing 75micron sieve) are determined for the soil collected from different areas of Bagalkot district and the models are developed for correlating soaked CBR value.

Dr. Dilip Kumar Talukdar at al. (2014) carried out California Bearing Ratio (CBR) value is an important soil parameter for design of flexible pavements and runway of air fields. It can also be used for determination of sub grade reaction of soil by using correlation. It is one of the most important engineering properties of soil for design of sub grade of rural roads. CBR value of soil may depends on many factors like maximum dry density (MDD), optimum moisture content (OMC), liquid limit (LL), plastic limit (PL), plasticity index (PI), type of soil, permeability of soil etc. Besides, soaked or unoaked condition of soil also affects the value. Determination of CBR is a very lengthy and time-consuming process. An attempt has been made here to correlate soaked CBR value with MDD, OMC, LL, PL and PI of some soil sample collected from different locations of Nogaon District of Assam, India. These tests can easily be performed in the laboratory. Soaked CBR is considered as Assam is a flood prone state and some rural roads remain under water for two or three days. Correlation coefficient (r) of each of these properties with CBR is determined and their significance is tested by using statistical t- test. Finally, a linear multiple regression model was developed by using linex statistics of Microsoft Excel (version 13.0) for determination of CBR value involving the above-mentioned soil parameters.

III. Methodology

3.1 Methodology Chart



IV. Laboratory Data Collection& Analysis

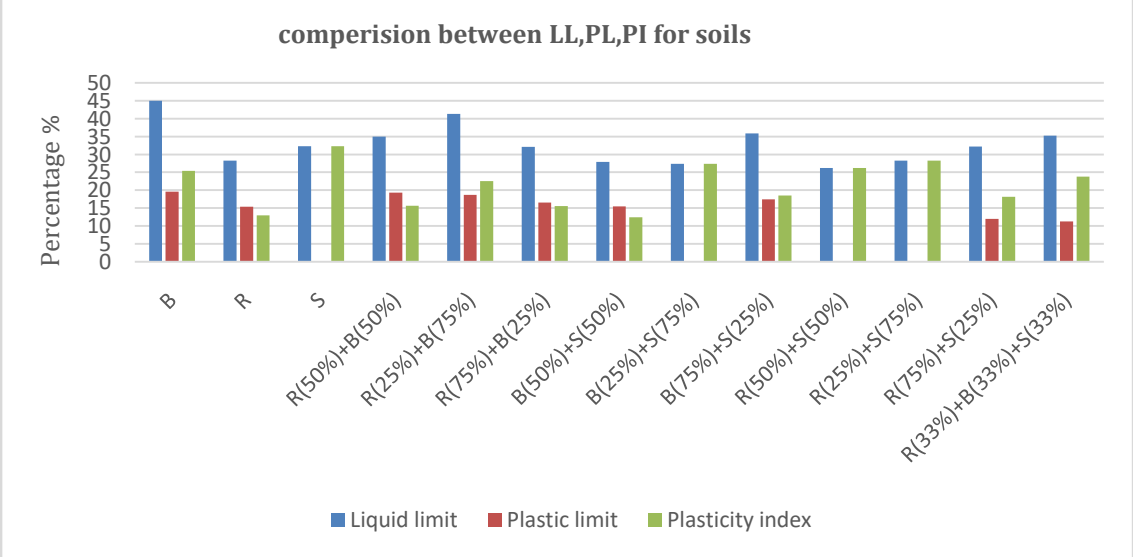
Laboratory Tests for Soil (As per Indian Standards)

To identify the engineering properties as per Indian Standard provision, various tests were performed which are enlisted as follows.

- Determination of Grain Size Analysis (IS: 2720 (Part 4) – 1985)
- Determination of Liquid & Plastic Limit (IS: 2720 (Part 5) – 1986)
- Determination of Water Content - Dry Density Relation Using Light Compaction (IS:2720 (Part 8) – 1997)
- Laboratory Determination of California Bearing Ratio (IS: 2720 (Part 16) – 1987)
- Determination of Unconfined Compressive Strength (IS: 2720 (Part 10) – 1991)
- Determination of the shear strength parameters of a specimen tested in undrained Triaxial compression without the measurement of pore pressure (IS:2720 (Part 11) – 1993)

A. Soil classification & Atterberg's limit

Sr.no	samples	Liquid Limit	Plastic Limit	Plasticity Index	IS Classification
1	Black soil	45	19.58	25.42	CI
2	Red soil	28.30	15.35	12.94	CL
3	Silty soil	32.30	0	32.30	SW-SM
4	Red (50%) +Black (50%)	35	19.36	15.64	CI
5	Red (25%) +Black (75%)	41.30	18.725	22.56	CI
6	Red (75%) +Black (25%)	32.10	16.52	15.58	CI
7	Black (50%) +Silty (50%)	27.90	15.43	12.46	SC
8	Black (25%) +Silty (75%)	27.40	0	27.40	SM
9	Black (75%) +Silty (25%)	35.90	17.405	18.49	CI
10	Red (50%) +Silty (50%)	26.20	0	26.20	SM
11	Red (25%) +Silty (75%)	28.30	0	28.30	SM
12	Red (75%) +Silty (25%)	32.20	12	18.20	SC
13	Red (33%) +Black (33%) +Silty (33%)	35.20	11.25	23.79	SC



B proctor test for samples

Sr.no	Samples	Optimum moisture content (%)	Maximum dry density(g/cc)
1	Black soil	14.5	1.78
2	Red soil	12.5	1.88
3	Silty soil	13.8	1.63
4	Red (50%) +Black (50%)	12.4	1.85
5	Red (25%) +Black (75%)	14.5	1.8
6	Red (75%) +Black (25%)	14.0	1.87
7	Black (50%) +Silty (50%)	13.0	1.75
8	Black (25%) +Silty (75%)	14.0	1.73
9	Black (75%) +Silty (25%)	15.0	1.86
10	Red (50%) +Silty (50%)	13.115	1.76
11	Red (25%) +Silty (75%)	12.61	1.73
12	Red (75%) +Silty (25%)	12.3	1.93
13	Red (33%) +Black (33%) +Silty (33%)	13.01	1.89

C. CBR (California bearing ratio) results

Sr.no	Samples	CBR (California bearing ratio) in%	
		2.5 mm	5.0 mm
1	Black soil	2.21	2.02
2	Red soil	5.03	4.65
3	Silty soil	13.31	12.47
4	Red (50%) +Black (50%)	4.57	4.52
5	Red (25%) +Black (75%)	1.14	1.08
6	Red (75%) +Black (25%)	2.14	2.11
7	Black (50%) +Silty (50%)	7.67	7.43
8	Black (25%) +Silty (75%)	10.32	10.03
9	Black (75%) +Silty (25%)	4.78	4.70
10	Red (50%) +Silty (50%)	9.50	8.77
11	Red (25%) +Silty (75%)	11.45	10.86
12	Red (75%) +Silty (25%)	7.44	7.19
13	Red (33%) +Black (33%) +Silty (33%)	7.04	6.75

D.UCS (Unconfined compressive strength) results

Sr.no	samples	UCS (Unconfined compressive strength) kg/cm2
1	Black soil	0.626
2	Red soil	0.431
3	Silty soil	0
4	Red (50%) +Black (50%)	0.614
5	Red (25%) +Black (75%)	0.571
6	Red (75%) +Black (25%)	0.583
7	Black (50%) +Silty (50%)	0
8	Black (25%) +Silty (75%)	0
9	Black (75%) +Silty (25%)	0.607
10	Red (50%) +Silty (50%)	0
11	Red (25%) +Silty (75%)	0
12	Red (75%) +Silty (25%)	0
13	Red (33%) +Black (33%) +Silty (33%)	0

E Triaxial test value soils

Sr.no	Samples	Cohesion (C)	Phi (□)
1	Black soil	0.84	9.60
2	Red soil	0.78	19.29
3	Silty soil	0	0
4	Red (50%) +Black (50%)	1.75	13.04
5	Red (25%) +Black (75%)	1.34	6.15
6	Red (75%) +Black (25%)	1.55	6.33
7	Black (50%) +Silty (50%)	0.74	18.62
8	Black (25%) +Silty (75%)	0	0
9	Black (75%) +Silty (25%)	0.62	7.1
10	Red (50%) +Silty (50%)	0.30	24.65
11	Red (25%) +Silty (75%)	0	0
12	Red (75%) +Silty (25%)	0.58	14.5
13	Red (33%) +Black (33%) +Silty (33%)	0.84	16.98

F. Comparison of all reading

COMPARISION OF RESULTS														
SAMPLE	L.L	P.L	P. I	GRADIATION			IS CLASSIFIACATION	OMC %	MDD g/cc	CBR %		UCS kg/cm2	TRX	
				Silt Clay	Sand	gravels				2.5mm	5.0mm		C	Ø
BLACK	45	18.42	26.58	51.68	48.215	0.105	CI	14.5	1.78	2.21	2.02	0.626	0.84	9.6
RED	28.3	15.35	12.95	50.92	47.015	2.07	CL	12.5	1.88	5.03	4.65	0.431	0.78	19.29
SILTY	32.3	0	32.3	12.36	87.05	0.59	SW-SM	13.8	1.63	13.31	12.47	0	0	0
R (50) +B (50)	35	17.36	17.64	51.3	45.88	2.82	CI	12.4	1.85	4.57	4.52	0.614	1.17	13.04
R (25) +B (75)	41.3	18.72	22.58	55.245	40.295	4.46	CI	14.5	1.8	1.14	1.08	0.571	1.34	6.15
R (75) +B (25)	32.1	15.43	16.67	50.015	47.61	3.375	CI	14	1.87	2.14	2.11	0.583	1.54	6.33
B (50) +S (50)	27.9	15.43	12.47	42	55.58	2.42	SC	13	1.86	7.67	7.43	0	0.74	18.62
B (25) +S (75)	27.4	0	27.4	29.06	68.34	2.6	SM	14	1.73	10.32	10.03	0	0	0
B (75) +S (25)	35.9	17.4	18.5	53.23	42.74	4.03	CI	15	1.87	4.78	4.7	0.607	0.62	7.1
R (50) +S (50)	26.2	0	26.2	34.84	64.19	0.97	SM	13.25	1.87	9.5	8.77	0	0.29	24.65
R (25) +S (75)	28.3	0	28.3	24.9	74.16	0.94	SM	12.6	1.73	11.45	10.86	0	0	0
R (75) +S (25)	30.2	12	18.2	41.5	55.2	3.3	SC	12.3	1.93	7.44	7.19	0	0.58	14.5
R (33) +B (33) +S (33)	35.2	11.25	23.95	42.07	54.86	3.07	SC	13	1.89	7.04	6.75	0	0.84	16.97

VI. CONCLUSION

1. Determinig to Atterberg limits of different subgrade soil samples like Liquid limit, Plastic delimit, Plasticity index.

2. Determinig to Grain size distribution and IS classification for different subgrade soils.

3. Comparision of Atterberg limits.

4. Deterring CBR (California bearing ratio), UCS (Unconfined compressive strength) and Triaxle test value on different subgrade soil. This test value is most important parameter like subgrade strength, compressive strength and cohesion and internal friction so this parameter also uses in pavement design.

5.CBR (California bearing ratio), UCS (Unconfined compressive strength) and Triaxle test value gives important parameter so this test CBR, UCS and triaxle test to find relation and this relation is most important to find different parameter of soil and different properties of different subgrade soil.

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B. Codes

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