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Interpretation of CBR Test Consequences for Subgrade Soil Preserved Through Geo-Grid

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Abstract: The California Bearing Ratio (CBR) is a parameter for evaluation of the mechanical strength of sub grade, base course and other layers of a new carriage way. It depends on various factors and nature of soil. The service life of pavement on weaker soil sub grade is quite low due to the high compressibility and plasticity behavior of soils. Some soils possess less strength, CBR value and have high affinity to moisture content. Hence it is important to increase the strength of soil for sustainable performance of Indian roads. To increase the sub grade soil strength, geogrids are used in roads. Geogrids are cost effective polymeric materials used as soil reinforcement. It helps to increase the stability and bearing capacity of soil, enables good drainage and involves less maintenance. Increase in CBR value of the sample with use of geogrids leads to reduction in the thickness of pavement.

Two soil samples are collected from the nearby construction sites. Basic tests are to be conducted on the samples to determine its engineering and index properties followed by CBR test under optimum moisture content. This paper deals with the experimental results of CBR tests on different types of sub grade soil by increasing the number of geogrid layers in each trial. This gives the optimum number of geogrid layer to attain the maximum CBR value. This paper also includes the application of CBR value in the design of flexible pavements as per IRC recommendations.

Keywords: Geogrids, CBR, Subgrade Soil, Atterberg **limits**

I. INTRODUCTION

Highway construction is one of the main engineering design and construction for the infrastructural development of a country. Several challenges during road construction arise mainly due to topography of the site, inadequate subgrade soil and high water table. In all these worst conditions the nature of subgrade soil plays a major role in deciding the life of a pavement. Soil to be used as a subgrade does not satisfy the strength checks in many parts of the world. The service life of pavement on weaker soil subgrade is quite low due to their high compressibility, plasticity behavior, less strength and high affinity to moisture content of the soils. Strengthening of such subgrade soils is very important for the sustainability of roads. However the selection of stabilizer depends upon the type of sub-grade soil, type of soil improvement desired, availability of stabilizer, the required strength and durability of stabilized layer, various stabilizing techniques, and environmental conditions. Also economic constrain is a major issue in deciding the method of subgrade strengthening. One such remedy is the use of geogrid to improve the strength of soil subgrades. It is one of the commercial aids to improve the strength of weaker subgrades.

An appropriate value of CBR is required in subgrade soil in order to ensure adequate strength to support the imposed traffic load. CBR Strength of subgrade also affects the thickness of pavement layers placed over it. Subgrade with high CBR value results in reduction in design thickness of the pavement layers over it. In case of weaker soils the thickness of the subgrade should be increased to achieve higher CBR. It becomes a tiresome process of construction and involves high labour and construction costs. In order to decrease the thickness of pavement in an economical way we are going to increase the CBR value by stabilizing the soil with geogrid layers.

II. MATERIALS AND METHODS

A. METHODOLOGY

1. Collection of soil samples and geogrid
2. Basic tests on samples to determine its properties
3. Particle size determination by sieve analysis
4. Specific gravity test
5. Determination of soil index properties (Atterberg Limits)
   a. Liquid limit by Casagrande's apparatus
   b. Plastic limit
6. Determination of the maximum dry density (MDD) and the corresponding optimum moisture content (OMC) of the soil by Standard Proctor compaction test
7. CBR test on plain soil samples for 2.5 mm and 5 mm penetration
8. Preparation of soil samples reinforced wtih geogrid with increasing the number of geogrid layers in each trial
9. Conduction of CBR test on reinforced samples
10. Results
11. Determination of optimum number of geogrids for higher CBR value
12. Design of flexible pavement

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B. COLLECTION OF SOIL SAMPLES

Soil samples A and B are collected from the nearby construction excavation sites at two different locations around Erode by test pit method of sample collection.

- Sample A was collected from a construction site at Perundurai, Erode
- Sample B was collected from a construction site at Vellode, Erode.

Table 1- Properties of geogrid

S.NO	Tests		Test Method	TGU – 200 Results	TGU – 200 Spec.
1	Sample received Date			18.04.2016	
	Date of testing			18.04.2016	
2	Sample no.			TG-028/16-17	
3	Material			Polyester	Polyester
4	*Rib per meter	MD		31	31
		CMD		26	26
5	Tensile strength	MD	ASTM D-6637	223	Min.200
		CMD	A-11	34.06	Min.30
6	*Aperture size	MD		30	30± 2
		CMD	-	23	23±2
7	Width			5.1	5.1

Fig: 1 Picture of Sample A

Fig: 2 Picture of Sample B

C. COLLECTION OF GEOGRID

The geogrid used in our project is knit type, biaxial geogrid. The properties of the geogrid used is tabulated below

Fig: 3 Biaxial geogrid

III. EXPERIMENTAL TESTS

A. PARTICLE SIZE DISTRIBUTION

Table 2- Grain size distribution results for sample A

S.No	I.S Sieve Size	Weight Retained(gms)	% Weight Retained	Cumulative % Retained	% Finer
1	4.75 mm	372	37.2	37.2	62.8
2	2.36 mm	117	11.7	48.9	51.1
3	1.18 mm	161	16.1	65	35
4	600 µ	73	7.3	72.3	27.7
5	300 µ	187	18.7	91	9
6	150 µ	54	5.4	96.4	3.6
7	75 µ	27	2.7	99.1	0.9
8	Pan	9	0.9	100	0

Table 3- Grain size distribution results for sample B

S.No	I.S Sieves Size	Weight Retained(gms)	% Weight Retained	Cumulative % Retained	% Finer
1	4.75 mm	60	6	6	94
2	2.36 mm	50	5	11	89
3	1.18 mm	40	4	15	85
4	600 µ	50	5	20	80
5	300 µ	30	3	23	77
6	150 µ	80	8	31	69
7	75 µ	150	15	46	54
8	Pan	540	54	100	0

B. SPECIFIC GRAVITY TEST

Table 4- Specific gravity test results for sample A and B

Specific gravity of the sample A =2.89

Specific gravity of the sample B =1.73

Description	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5
Weight of mould +compacted wet soil(W2)	5250	5500	5750	6200	5400

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Weight of compacted soil W=W2-W1 in gms	1200	1450	1700	2150	1350
Moisture content in percentange	6	8	10	12	14
Bulk density	1.2	1.45	1.7	2.15	1.35
Dry density	1.132	1.343	1.545	1.919	1.184
Zero air void	2.32	2.22	2.126	2.039	1.959

C. STANDARD PROCTOR COMPACTION TEST

Table 5-Standard proctor test results for Sample A

Description	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5
Weight of mould +compacted wet soil(W2)	5250	5500	5750	6200	5400
Weight of compacted soil W=W2-W1 in gms	1200	1450	1700	2150	1350
Moisture content in percentange	6	8	10	12	14
Bulk density	1.2	1.45	1.7	2.15	1.35
Dry density	1.132	1.343	1.545	1.919	1.184
Zero air void	2.32	2.22	2.126	2.039	1.959

Table 6- Standard proctor test results for Sample B

Description	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5
Weight of mould +compacted wet soil(W2)	5950	6200	6250	6300	6020
Weight of compacted soil W=W2-W1 in gms	1850	2100	2150	2200	1920
Moisture content in percentange	8	10	12	14	16
Bulk density	1.85	2.1	2.15	2.2	1.92
Dry density	1.713	1.909	1.92	1.93	1.655
Zero air voids	2.22	2.125	2.039	1.959	1.885

IV. CALIFORNIA BEARING RATIO TESTS

A. CBR TESTS ON SAMPLE A

The sample A with water content of optimum moisture content is filled in the mould and compacted in 5 layers giving 56 blows per layer. The mould is then clamped in the CBR testing machine. The load at penetration of 0.5, 1, 1.5, 2, 2.5, 3,4,5,7.5,10 and 12.5mm are noted.CBR was conducted on plain sample and with the addition of geogrid with increase in number of layers in each trial.

Fig: 4 Compaction of soil with geogrid layer

CBR TEST WITH GEOGRID LAYER

Table 7- Load values for Sample A with geogrid

Characteristics	No Layer	One layer	Two Layer	Three Layer	Four Layer
Penetration(mm)	Load in kg				
0	0	0	0	0	0
0.5	26.68	26.68	30.015	26.68	36.685
1	60.03	60.03	50.025	46.69	53.36
1.5	83.375	83.375	73.37	80.04	73.37
2	106.72	106.72	106.72	103.385	100.05
2.5	130.06	130.06	140.07	133.4	120.06
3	160.08	160.08	166.75	173.42	146.74
4	203.45	203.45	226.78	246.79	200.1
5	260.13	260.13	296.815	286.81	246.79
7.5	373.52	373.52	420.21	406.87	356.85
10	470.25	470.23	543.605	513.59	436.88
12.5	540.27	540.27	640.32	606.97	506.92

B. CBR TESTS ON SAMPLE B

CBR TEST WITH GEOGRID LAYER

Table 8- Load values for Sample B with geogrid

Characteristics	No Layer	One layer	Two Layer	Three Layer	Four Layer
Penetration(mm)	Load in kg				
0	0	0	0	0	0
0.5	26.68	26.68	30.015	26.68	36.685
1	60.03	60.03	50.025	46.69	53.36
1.5	83.375	83.375	73.37	80.04	73.37
2	106.72	106.72	106.72	103.385	100.05
2.5	130.06	130.06	140.07	133.4	120.06
3	160.08	160.08	166.75	173.42	146.74
4	203.45	203.45	226.78	246.79	200.1
5	260.13	260.13	296.815	286.81	246.79
7.5	373.52	373.52	420.21	406.87	356.85
10	470.25	470.23	543.605	513.59	436.88
12.5	540.27	540.27	640.32	606.97	506.92

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V. RESULTS AND DISCUSSIONS

Table 9- Results of CBR% for sample A

Penetration (mm)	CBR Value (%)				
	No Geogrid	One Layer	Two Layers	Three Layers	Four Layers
For 2.5	6.82	9.74	12.9	21.42	5.84
For 5	9.74	12.98	21.42	29.86	15.90

Table 10- Results of CBR% for sample B

Penetration (mm)	CBR Value (%)				
	No Geogrid	One Layer	Two Layers	Three Layers	Four Layers
For 2.5	4.87	9.49	10.22	9.34	8.76
For 5	7.3	12.66	14.44	13.96	12

VI. DISCUSSIONS

The value of CBR% increase as the number of geogrid layer reinforcement is increased. But this increase is consistent till the use of three layers in sample A and till the use of two layers in sample B.The highest CBR% being 29.86% and 14.4% for sample A and B respectively. Hence two or three layers of geogrid are optimum and hence the thickness of subgrade can be relatively reduced. In most cases, CBR drops as the penetration increases. The ratio at 2.5 mm infiltration is used as the CBR. In some case, the proportion at 5 mm may be superior to that at 2.5 mm. If this occurs, the proportion at 5 mm must be used.

VII. DESIGN OF FLEXIBLE PAVEMENT

DESIGN FOR SAMPLE A

As per IRC 37-2001,

Number of commercial vehicles as per last count,P =120 vehicles/day

For single lane road, D =1

For Plain terrain, F =1.5

x=12 years r = 0.075 n=12 years

A =P 〖(1+r)〗^x

A =120x 〖(1+0.075)〗^12

A =286

N = (365 x [(1+0.075) ^ (12)-1])/0.075 x 286x1x1.5

N =3 msa

Calculation of thickness with no geogrid

CBR=10 %

From IRC 37-2011, Table 7.3,

Thickness of Granular sub base course=150 mm

Thickness of Granular base course =250 mm

Calculation of thickness with three layers of geogrid

The highest CBR value for sample A =30 %

As per IRC 37-2001, Table-7.3,

Take CBR =15 % (safe)

Thickness of Granular sub base course=100 mm

Thickness of Granular base course =225 mm

A. DESIGN FOR SAMPLE B

As per IRC 37-2001,

Number of commercial vehicles as per last count, P =80 vehicles/day

For single lane road, D =1

For plain terrain, F =1.5

x=10 years r = 0.075 n=10 years;

A=P 〖(1+r)〗^x

A=120x 〖(1+0.075)〗^10

A=247

N= (365X [(1+0.075) ^ (10)-1])/0.075 x247x1x1.5

N=2 msa

Calculation of thickness with no geogrid

CBR =7 %

From IRC 37-2001, Table 7.3,

Thickness of Granular sub base course=175 mm

Thickness of Granular base course =225 mm

Calculation of thickness with two layers of geogrid

The highest CBR value for sample B =30 %

As per IRC 37-2001, Table-7.3,

Thickness of Granular sub base course=100 mm

Thickness of Granular base course =225 mm

VIII. CONCLUSION

The study explored the request of geo-grids to subgrade quantifiable as an arrangement of strengthening to road construction. The presence of the geo-grid significantly growths the strong point of poor soils, which are replicated in the difficult CBR values. The study expressions that the strength of the subgrade is meaningfully altered positively by the locating of the geo-grid at different layers and in increasing numbers. However the highest strength is attained in three layers of geo-grid for sample A and in two layers of geo-grid for sample B. The pavement design using the maximum CBR values by IRC method shows a reduction in total pavement thickness after the placing of geo-grids. The usage of geo-grids as reinforcement to deprived soils recovers its strength. It is non-bio degradable and consequently durable; it also escalations the definitive service life of the road surface.

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