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Improvement on CBR Strength of Soil Modified with Brick Dust using Geogrid Reinforcement

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Abstract

This study deals with improving the CBR strength of soil using Geogrid as a reinforcing material. A sample was taken from the problematic location. Various laboratory tests were conducted to Engineering properties of soil and CBR test by providing the geogrid at varying depths in a single layer under the soaked and unsoaked conditions. The geogrid was placed in different heights of soil sample that are 0.1H, .2H, .3H, .4H,.5H and .6H from top of soil sample. The test result shows that the CBR value of the soil sample is considerably improved by using geogrid reinforcement. The result shows that geogrid placed at .2H height from the top of soil shows a higher unsoaked CBR value of 4.54% for 2.5 mm penetration and 5.90% for 5 mm penetration which is 228% and 289% higher than the unsoaked CBR value of unreinforced soil for the respective penetration. Similarly, geogrid added at .2H height from the top shows a higher soaked CBR value of 2.27% for 2.5 mm penetration and 2.52% for 5 mm penetration which is 156.5% and 130.4% higher than the CBR value of unreinforced soil for the respective penetration, %, it is still insufficient to meet the requirements of the Flexible Pavement Design Guideline (2nd Revision, 2021), so the soil is modified with brick dust in addition to geogrid reinforcement. Unsoaked CBR value of soil mixed with 20% BD are 5.01% and 8.00 % which are 261% and 430% more than unsoaked CBR of natural soil without BD at 2.5mm and 5mm penetration respectively. CBR value of soil sample after adding 20% of brick dust and providing geogrid at 0.2H from the top of soil sample, increases to 8.3% and 10.51 % at 2.5mm and 5mm penetration respectively which are 837% and 860% more than untreated soil at their respective penetration.

Keywords

Geogrid,CBR, Soaked CBR, Unsoaked CBR, Subgrade, reinforcement, Brick Dust

1. Introduction

One of the basic materials used in the construction of civil engineering projects is soil. Soils are used in civil engineering projects in various ways, including but not limited to the sub-base course of roads, unpaved roads, and soil embankments. The thickness of the pavement layers laid over a subgrade depends on their Strength. High compressive and shear strengths, the durability of Strength under all weather and loading condition, ease and permanence of compaction, ease of drainage, and minimum susceptibility to volume changes and frost action are all desirable properties of subgrade. Even though soft, organic soil does not meet practically all these characteristics, it can still be modified to change certain aspects. Different techniques are available for soil stabilization that are soil compaction, pre-consolidation, drainage, grouting, chemical stabilization, heat treatments, stone columns, densification with vibratory equipment, and reinforcing using geosynthetics materials.

The performance and lifespan of pavement are significantly influenced by the type of materials used in the subgrade, subbase, and base. The properties of the soil used for subgrade has the most significant effect among other materials. Construction of flexible pavement over a soil having very low is a serious worry. Thus, the constructed pavements for such cases must be thicker. There is a need for finding cost-effective methods to compensate for the scarcity of suitable pavement construction materials such as subgrade and subbase. Because pavements' service life and performance are heavily dependent on the properties of subgrade, there is a need to focus on subgrade quality. The CBR is the indicators of the

Strength of the soil which determine the bearing capacity of subgrades by the strength of well-graded high-quality crushed stone aggregate. It is well known that in road construction, one of the prime parameters for designing roads is the CBR value of subgrade soil. This study focuses on changes in CBR strength of soil modified with brick dust using geogrid under unsoaked and soaked conditions.

2. Objectives of the Study

The following specific objectives are presented in this research;

- To investigate the Strength of sub-grade soil by introducing geo-grid mesh at the various heights of the soil sample.
- To find out the optimum position of geogrid reinforcement where CBR value is higher.
- To investigate the change in CBR value of soil modified with the varying percentage of brick dust.
- To find out the optimum Brick Dust content at which the CBR value of soil is maximum.

3. Literature Review

Laboratory CBR test was conducted on Clayey Soil reinforced with geogrid, both in soaked and unsoaked conditions with and without geogrid. The geogrid was placed in at different heights from the top surface: 20%, 40%, 60%, and 80% of the height of soil sample. When soil is strengthened with a single layer of geogrid, its CBR value increases by 50 to 100%. The improvement depends on the soil type and the geogrid's location[1].

The experimental investigation conducted on a geogrid reinforced subbase over soft soil, claiming that interacting with soil with a geogrid increases penetration resistance and CBR strength in both soaked and unsoaked conditions. As a result, inclusion of geogrid improves the performance of a subgrade material in a pavement system. Soil CBR value increased by 50 to 100%. We can reduce the thickness of the base course by incorporating geogrids into the soil[2].

The effect of geogrids on the CBR of compacted clay subgrade was investigated. The soil specimen was compacted into four layers, one with and one without geogrid sheets. The CBR test was carried out in soaking conditions. The test results shows that the position and the number of sheets used in the soil specimen significantly impact the CBR value. When a geogrid sheet was placed on the first layer, the CBR value increased by 26%. When geogrid sheets were placed at all four layers, the CBR value increased by 62%[3].

Laboratory CBR test was conducted with geogrid was placed in a single layer at different heights from the top surface: 20%, 40%, 60%, and 80% of the specimen height. This study found that placing the geogrid at 0.2H from the top of the soil sample yielded the greatest improvement in CBR[4].

Kazmi[5] investigate how to improve weak soil by using Brick Kiln Dust and Calcium Chloride to improve the soil and achieve the desired strength. Different soil samples were created by altering the amounts of calcium chloride and brick kiln dust, and the samples were then examined to assess the soil's strength. The outcomes demonstrated that the soil's strength may be enhanced to satisfy the required standards by adding calcium chloride and brick kiln dust. Liquid limit, plastic limit, unconfined compression test, California bearing ratio test, and free swell index test were among the tests used in this study. The results show that 22% of brick dust is the ideal amount for maximizing CBR and UCS improvement.

Flexible Pavement Design Guideline (2nd Revision, 2021)[6] states that for roads expected to handle more than 450 commercial vehicles per day (cvpd) (two-way) in the year of construction, the effective sub-grade CBR should be greater than 5%.

4. Material and Methodology

4.1 Study Area

The research site consists of soft soil deposits. Several remedial measures have been implemented to address the problem associated with the soft soil subgrade. The soil deposit in the valley's core is characterized by expansive soil in some places. The primary properties of the soil that will be used as a subgrade are studied, as are the properties after modification.

Figure 1: Site Location

4.2 Materials

Soil:

For this study, disturbed sampling was collected as a test sample. Disturbed samples contain all the constitutions in their proper proportion, but the soil structure is not the same as in situ conditions. The primary properties of soil that will be used as subgrade are studied, and properties after modification are studied and compared.

Table 1: Geotechnical Properties of soil

S.N.	Property	Value
1	Specific gravity	2.57
2	Liquid Limit	83
3	Plastic Limit	38
4	Plasticity Index	45
5	Classification of Soil	MH
6	OMC (%)	22.5%
7	MDD (kN/m3)	10.99
9	UCS,(kPa)	63.49

Geogrid: A geogrid is a geosynthetic material composed of parallel sets of tensile ribs connected by apertures large enough to allow strike-through of the surrounding soil, stone, or other geotechnical material. They are widely used in civil engineering applications and are made from polymers such as polypropylene, polyethylene, or polyester. For this study, Secugrid 30/30 is used.

4.3 Methodology

During the testing, the Indian Standard codes were followed. Figure 2 depicts the methodology used and the research organization in flow chart form.

Table 2: Properties of Secugrid 30/30

S.N.	Properties	Unit	Value
1	Raw Material		Polyester (PET)
2	Tensile Strength		
a	Nominal Tensile Strength	KN/m	30
b	Tensile Strength at 2 percent Elongation	KN/m	13.5
3	Elongation at Nominal Tensile Strength	%	less than 7
4	Extensional Stiffness at 1 % Strain	KN/m	750
5	Radial Stiffness at 0.5 %e strain	KN/m	greater than 286
6	Max. creep Strain at 30 % degree of utilization	%	less than 0.50
7	Aperture size	mm	32*32
8	Roll Dimensions	m	4.75*100

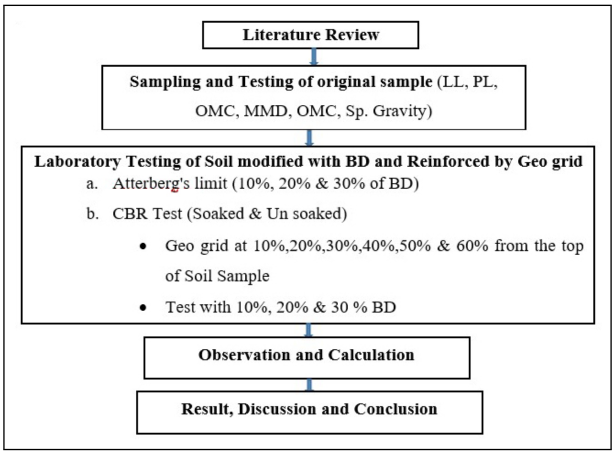

Figure 2: Flow chart showing the methodology.

5. Results and Discussion

5.1 Result of Unsoaked CBR Test

The soil sample was compacted into 5 layers in a CBR mould. First geogrid is provided at different location from the top of soil sample (0.1H, 0.2H, 0.3H, 0.4H, 0.5H and 0.6H) from top of soil sample and un soaked CBR test is conducted. The test result is presented in Figure 3 as a load penetration curve with and without the inclusion of a geogrid at various heights of the sample.

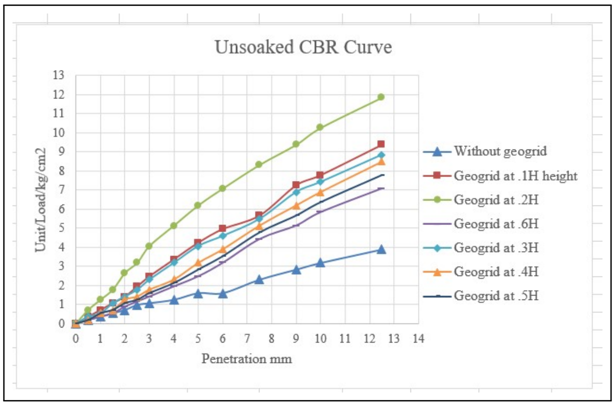

Figure 3: Load penetration curve of unsoaked CBR test with and without the inclusion of geogrid at various sample heights.

Table 3: Increase in unsoaked CBR by adding geogrid at different heights as compared to CBR of natural soil

Position of Geogrid	CBR % at 2.5 mm	% increase	CBR% at 5mm	% Increase
natural	1.39		1.51	
Geogrid at 0.1	2.77	100.0%	4.04	166.6%
Geogrid at 0.2	4.54	227.8%	5.90	289.2%
Geogrid at 0.3	2.53	82.5%	3.87	155.3%
Geogrid at 0.4	2.01	45.4%	3.03	99.9%
Geogrid at 0.5	1.77	27.8%	2.70	77.9%
Geogrid at 0.6	1.64	18.6%	2.35	55.3%

It is found that there is a significant increase in the unsoaked CBR value of soil after providing geogrid. The optimum position of geogrid for maximum in CBR of soil is 0.2H from the top of the soil sample. This may be due to the mechanical interactions between soil particles and reinforcing elements caused by surface friction and interlocking. By mobilizing the tensile strength of the reinforcing materials, the bond's purpose is to shift stress from the soil to the reinforcing elements, reducing tensile strain and increasing the load carrying capacity of reinforced soil. Similarly, 10%, 20% and 30% brick dust was added to the natural soil and unsoaked CBR test is conducted. The test result is presented table with and without adding brick dust to the soil sample. It is found that there is considerable increase in unsoaked CBR value of soil modification with brick dust. The large contribution of BD to the CBR performance of the samples is what is responsible for the rise in CBR value brought on by the addition of BD. Furthermore, the bearing capacity of the entire samples rose as the 20% BD gaps between soil grains were filled. Additionally, raising the MDD with percentages of BD increases the CBR values of the soil samples. These traits also suggest that the samples with 20% BD have higher frictional resistance, which raises the CBR value.

Table 4: Increase in soaked CBR for 2.5mm and 5mm penetration by adding different % of brick dust as compared to CBR of natural soil

BD %	BD %	CBR % at 2.5 mm	% increase	CBR% at 5mm	% Increase
Natural Soil	0	1.39		1.51	
10% BD	10	3.87	179%	5.7	278%
20% BD	20	5.01	261%	8	430%
30% BD	30	4.07	193%	6.74	347%
20% BD + Geogrid	20	13.97	905%	18.1	1098%

5.2 Result of Soaked CBR Test

The soil sample was compacted into 5 layers in a CBR mold. Geogrid sheets were placed at different depths of the soil specimen. Then the mold is soaked in water for 96 hours. Geo grid is placed at 0.1H, 0.2H, 0.3H, 0.4H,0.5H and 0.6H from the top of the soil sample, where H is the total height of the soil sample and soaked CBR test is conducted. The test result is presented in Figure 4 as a load penetration

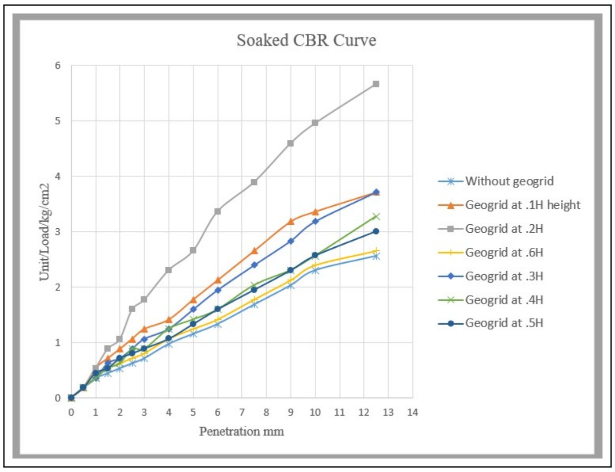

Figure 4: Load penetration curve of soaked CBR test with and without the inclusion of geogrid at various heights of the sample.

curve with and without the inclusion of geo geogrid at various heights of the sample. It is found that there is a considerable increase in the CBR value of soil after the inclusion of geogrid. The optimum position of geogrid for maximum reinforcement is 0.2H from the top of the soil sample.

Table 5: Increase in Soaked CBR by adding geogrid at different heights as compared to CBR of natural soil

Position of Geogrid	CBR % at 2.5mm	% increase	CBR % at 5mm	% increase
natural	0.89		1.10	
Geogrid at 0.1	1.51	71.0%	1.69	53.9%
Geogrid at 0.2	2.27	156.5%	2.52	130.4%
Geogrid at 0.3	1.26	41.9%	1.51	38.3%
Geogrid at 0.4	1.26	41.9%	1.34	22.6%
Geogrid at 0.5	1.14	28.3%	1.26	15.3%
Geogrid at 0.6	1.01	14.5%	1.18	7.8%

Similarly, 10%, 20% and 30% brick dust is added to the natural soil and soaked CBR test is conducted. The test result is presented in table with and without adding brick dust to the soil sample.

Table 6: Increase in soaked CBR for 2.5mm and 5mm penetration by adding different % of brick dust as compared to CBR of natural soil.

BD %	CBR % at 2.5 mm	% increase	CBR% at 5mm	% Increase
natural	0.89		1.1	
10% BD	1.91	116%	3.1	183%
20% BD	4.16	369%	5.93	442%
30% BD	2.07	134%	3.78	245%
20% BD + Geogrid	8.3	837%	10.51	860%

Soaked CBR value for 2.5mm and 5mm penetration of natural soil is 0.89 % and 1.1%. CBR value of soil sample after adding 20% of brick dust and providing geogrid at 0.2H from the top of soil sample, increases to 8.3% and 10.51 % at 2.5mm and 5mm penetration respectively which are 837 % and 860% more than untreated soil at their respective penetration.

6. Conclusion

- The optimum value of CBR is obtained when geogrid is provided at 0.2 H from the top of the sample both in soaked and unsoaked condition.
- Soaked CBR value for 2.5 mm penetration of unreinforced soil is 0.89% and for 5mm penetration is 1.1%. The Soaked CBR value for 2.5 mm penetration after adding geogrid at 0.2h from the top of the sample is 2.27 % and for 5mm penetration is 2.52% which is 156.5% and 130.4% more than that of unreinforced soil.
- The unsoaked CBR value for 2.5 mm penetration of unreinforced soil is 1.39% and for 5mm penetration is 1.51%. The Soaked CBR value for 2.5 mm penetration after adding geogrid at 0.2h from the top of the sample is 4.54% and 5mm penetration is 5.9% which is 227.8% and 289.2% more than that of unreinforced soil.
- The optimum content of brick dust for a given soil for maximum improvement in CBR is 20% for both soaked and unsoaked condition.
- Soaked CBR value of soil mixed with 20% BD are 4.16% and 5.93 % which are 369% and 442% more than soaked CBR of natural soil without BD at 2.5mm and 5mm penetration respectively.
- Unsoaked CBR value of soil mixed with 20% BD are 5.01% and 8.00 % which are 261% and 430% more than unsoaked CBR of natural soil without BD at 2.5mm and 5mm penetration respectively.
- CBR value of soil sample after adding 20% of brick dust and providing geogrid at 0.2H from the top of soil sample, increases to 8.3% and 10.51 % at 2.5mm and 5mm penetration respectively which are 837 % and 860% more than untreated soil at their respective penetration. Hence the subgrade soil having very low CBR value can be modified with brick dust and reinforced with geogrid to obtain desired strength and stability.

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