EXPERIMENTAL STUDIES ON LATERITE SOIL STABILIZED WITH CEMENT AND AGGREGATE

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Abstract

The subgrade must be able to support loads transmitted from pavement structure without excessive deformation under adverse climatic and traffic conditions to increase the life of the pavement. It is a well known fact that, all soils do not possess all the desirable qualities for using it as good quality pavement material. When such soils cannot be replaced, its subgrade performance should be increased by several modification techniques. The place where ground water table is high, the strength of subgrade is adversely affected by moisture infiltration to subgrade and base due to capillary action. The purpose of this paper is to evaluate the use of low contents of cement and aggregate in the modification of a lateritic soil properties concerning the behavior of mixtures to use in the base construction. In the present study an effort is made to obtain the optimum dosage of cement for stabilization of locally available lateritic soil. The study incorporates investigations on basic properties of soil. Then the investigations are carried out to study the effect of addition of 10 mm down aggregates to the soil properties added in addition to the obtained optimum cement content to evaluate the extent of modification on MDD, OMC and CBR of the soil. The experimental investigations shown that there is a tremendous increase in the CBR value of the soil treated with cement-aggregate modification. After conducting all the tests see whether it's strength is suitable for base coarse. In addition, the field cost analysis is also made to compare the cost of construction for various modifications used.

Keywords: *lateritic soil 1, Cement 2, Aggregates3, Stabilization4 and CBR5*

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1. INTRODUCTION

Shortage of crushed rock as pavement base course for road construction and an increase in fuel cost have prompted the search for alternative materials. In this regard, improvements of the lateritic soil cement (LSC) have been investigated. [1] Saravut Jaritngam, An investigation of lateritic Soil Cement for Sustainable Pavements. Lateritic soils are soil types rich in iron and aluminum, distributed in many areas of the world. The purpose of this paper to improvement of lateritic soil with cement and aggregate mixing was modified for base course materials to improve performance. . Lateritic soil was mixed with cement for economical and environmental propose, the cement content in the additive should be as low as possible. Cement treatment has become an accepted method for increasing the strength and durability of soils. Marginal aggregates are also used to reducing quantity of cement. The scope of this study is limited to the laboratory tests using laterite soil. Basic tests such as Atterberg limits test, grain size analysis test, compaction test, California Bearing Ratio test, Triaxial test and Unconfined Compressive Strength test are done to find out the properties of the laterite soil used. Compaction test, CBR test are done to find out the properties of the soil stabilized with cement using dosages of 1, 2, 3 and 6% of weight of soil. Also compaction test and CBR test are used to determine properties of soil stabilized with optimum cement and aggregates (10, 20, and 25%). From these results the optimum percentage of cement is selected to prepare the treated soil – aggregate mix with 10mm down aggregates. Cost analysis was done for cement treated soil and soil, cement, aggregate mixes also carried out to say whether it is economical or not.

2. MATERIALS AND METHODS

laterite soil collected from Orissa region at 1.0m depth is used for the study. The lateritic soil was sealed in the air tight plastic bags and transported to the college laboratory for testing. After collecting the soil is dried for 2 weeks. The index properties of the soils including Atterberg limits test, grain size analysis test, compaction test, California Bearing Ratio test, Triaxial test and Unconfined Compressive. Strength test were determined in accordance with IS: 2720 test procedures. The soil sample was later stabilized with 1%, 2%, 3%, and 6% portland cement by weight of soil. The MDD, OMC, and CBR of the soil were determined at each increase in cement content to ascertain the effect of the addition of varying quantities of cement. After finding the optimum percentage of cement 10mm downsize aggregates of 10, 20, and 25 % of weight of soil is added and ascertain its MDD, OMC, and CBR of the cement, aggregate mix treated soil.

3. RESULTS AND DISCUSSION

The Index Properties of laterite soil are presented in table-1.From Atterberg's limit test are as follows: LL=50% and PI=l5.8%. According to sieve analysis test the soil can be classified as well graded sand (sw) Grain size distribution curve of laterite soil is shown in fig 1.

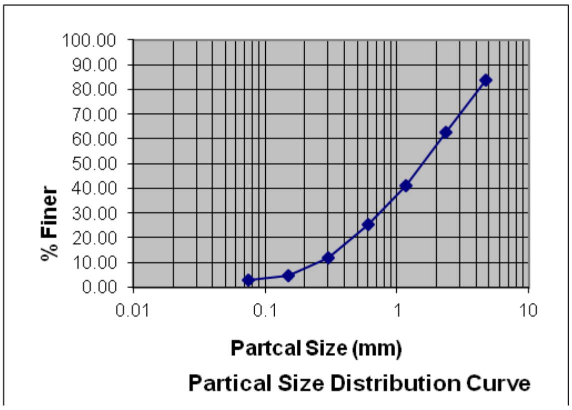

Fig-1: grain size distribution curve of laterite soil

Table 1 Index Properties of laterite soil

Tests	Results
1. Grain Size Distribution (%) a. Gravel b. Sand c. Silt d. Soil Classification	 17.2 80.4 2.9 SW
2. Atterberg Limits (%) a. Liquid Limit b. Plastic Limit c. Plasticity Index	 41.56 24.8 16.76
3. Standard Proctor Test a. Maximum dry density(g/cc) b. Optimum moisture content (%)	 1.82 14
4.Unconfined Compressive Strength (kPa)	72
5. Cohesion (c)	0.31
6. Angle of internal friction (ϕ)	36.8
7. California Bearing Ratio (%) a. Soaked b. Un soaked	 4 5.04

3.1 Standard Proctor Test

By compaction of soil, the particles are mechanically constrained to pack more closely, by expelling part of the air voids. Proper compaction of fills, subgrade, sub-base and base courses are considered essential for proper highway construction. There is optimum moisture content for a soil, at which maximum dry density is attained for a particular type and amount of compaction. To assess the amount of compaction and water content required in the field, compaction tests are conducted. In the present study Standard Proctor Compaction test as per IS: 2720 (Part VII), 1980 was conducted on soil without cement. The test is conducted on soil alone, soil with cement dosages (1, 2, 3, and 6%) and soil with optimum amount of cement (3%) and soil with aggregates (10,20 and 25%). The compaction test is done immediately after treating it with the stabilizer. The test results of compaction test with soil alone, soil with cement dosages (1, 2, 3, and 6%) and soil with optimum amount of cement (3%) and soil with aggregates (10,20 and 25%) were shown in Table 2 and 3. likewise the graphs were shown in fig 2, 3, and 4

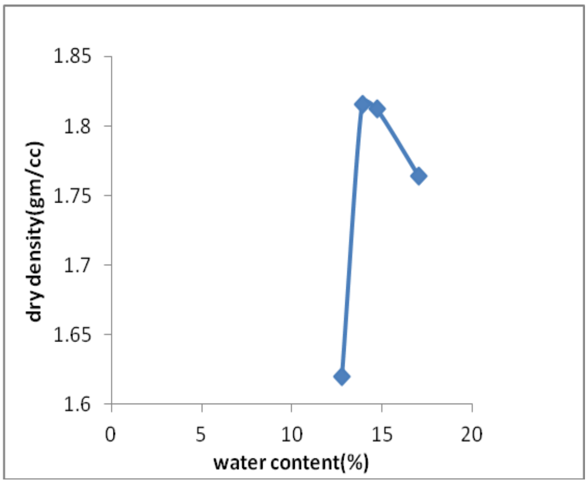

Fig-2:Variation of MDD and OMC for natural soil

Table 2 MDD and OMC of Various Cement

Sample	OMC (%)	MDD(gm/cc)
Natural soil	14	1.82
Soil+ 1% Cement	8.45	1.921
Soil+ 2% Cement	10	1.93
Soil+ 3% Cement	9.7	1.94
Soil+ 6% Cement	11.6	1.88

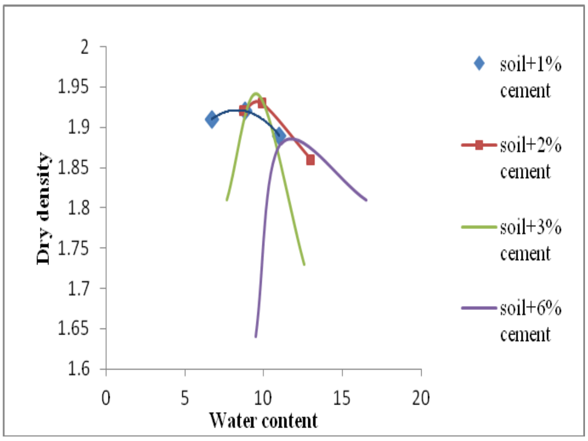

Fig-3: Variation of MDD and OMC for Various Cement Dosages

Table 3 Variation of MDD and OMC for optimum percentage of cement with Various aggregate percentages

Sample	OMC (%)	MDD(gm/cc)
Natural soil +3%cement+ 10%aggregates	9	1.93
Natural soil +3%cement+ 20%aggregates	8.7	1.97
Natural soil +3%cement+ 25%aggregates	9.1	2.02

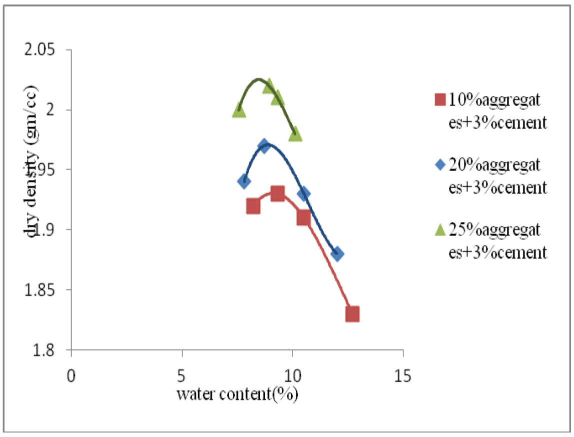

Fig- 4: Variation of MDD and OMC for Various aggregate percentages

3.2 California Bearing Ratio (CBR)

CBR value for untreated soil remained constant for most of the time. When soil treated with cement as the cement dosage was increased CBR values also increased for all curing periods. It can be explained like curing aids development of strength of cement because it reduces heat of hydration and development of tricalcium silicates and dicalcium silicates takes place and are responsible for strength of cement. In untreated soil there is no cementitious material so therefore there wasn't any development of strength. The test results of CBR test with soil alone, soil with cement dosages (1, 2, 3, and 6%) were shown in Table 4 and 5 likewise the graphs were shown in fig 5,6,7 and 8

Table 4 Soaked CBR Values for Various Cement dosages

Soaked CBR Values (%)				
Curing Period (days)	0	7	14	28
Soil + 1% cement	15	20	25	31
Soil + 2% cement	17	31	36	40
Soil + 3% cement	20	39	45	52
Soil + 6% cement	25	60	72	76

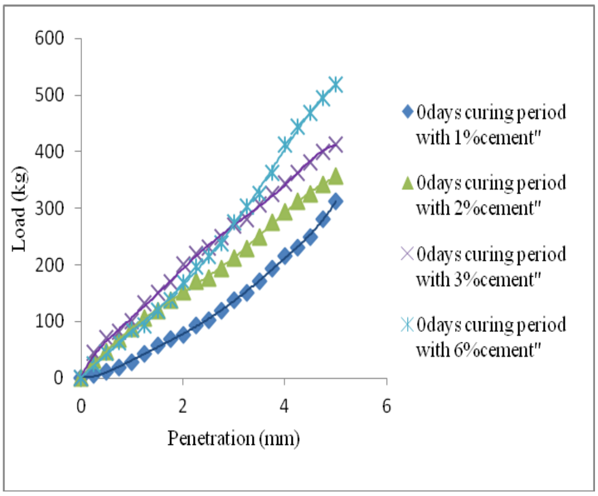

Fig- 5: Soaked CBR graphs for 0 days curing period with various Cement dosages.

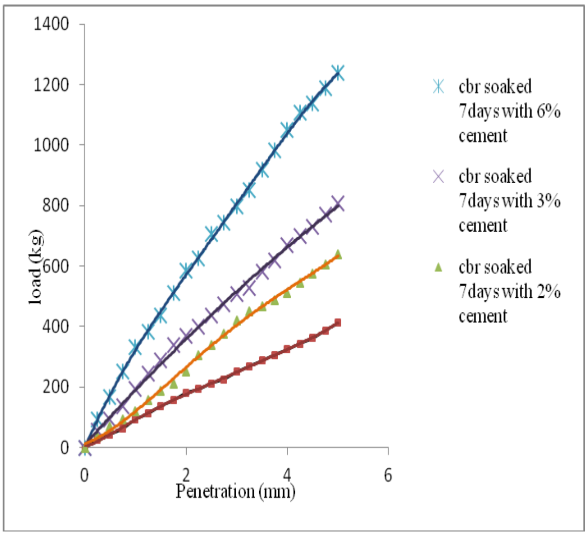

Fig- 6: Soaked CBR graphs for 7 days curing period with various Cement dosages

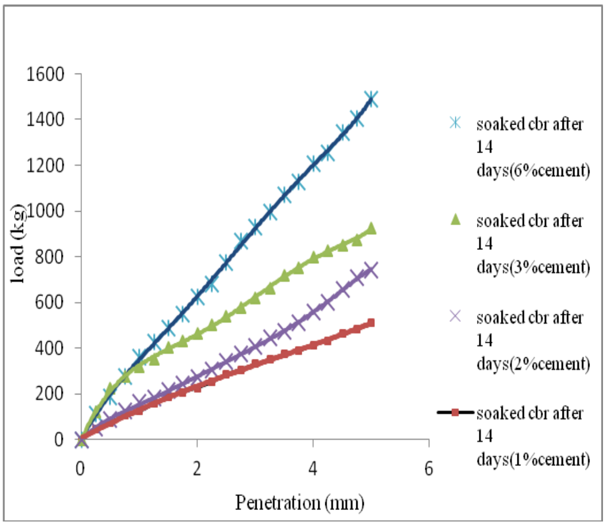

Fig- 7: Soaked CBR graphs for 14 days curing period with various Cement dosages

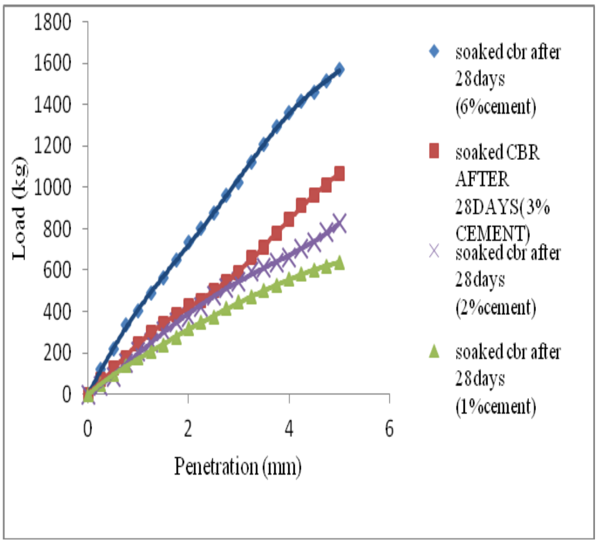

Fig- 8: Soaked CBR graphs for 28 days curing period with various Cement dosages

After finding optimum percentage of cement addition of 10mm downsize aggregates of 10, 20, and 25 % of weight of soil compaction and CBR tests were conducted. CBR value for soil treated with optimum percentage of cement as the aggregate percentage increases CBR values also increases for all curing periods. The soaked CBR values of Various aggregate percentages with optimum percentage of cement were mentioned in table 5 and it's graphs were indicated in fig 9, 10, 11 and 12

Table 5 Soaked CBR Values for Various aggregate percentages with optimum percentage of cement

Soaked CBR Values (%)				
Curing Period (days)	0	7	14	28
NaturalSoil+3%Cement+ 10%aggregates	33.4	61	72	80
NaturalSoil+3%Cement+ 20%aggregates	35.8	70	85	92
NaturalSoil+3%Cement+ 25%aggregates	38.3	77	92	98

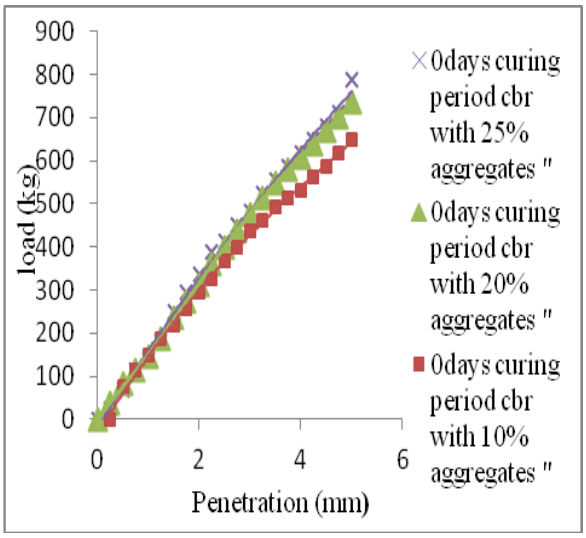

Fig- 9: Soaked CBR graphs for for 0 days curing period with Various aggregate percentages and optimum percentage of cement

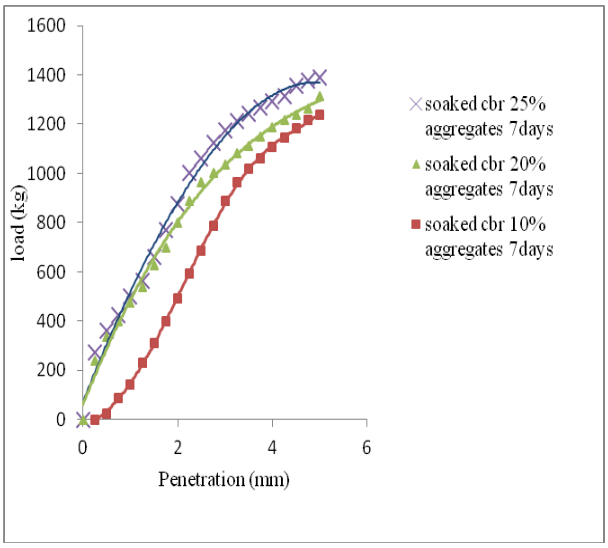

Fig- 10: Soaked CBR graphs for for 7 days curing period with Various aggregate percentages and optimum percentage of cement

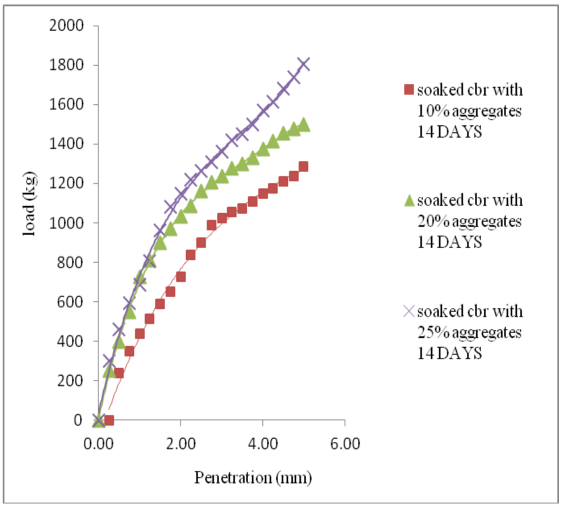

Fig- 11: Soaked CBR graphs for for 14 days curing period with Various aggregate percentages and optimum percentage of cement

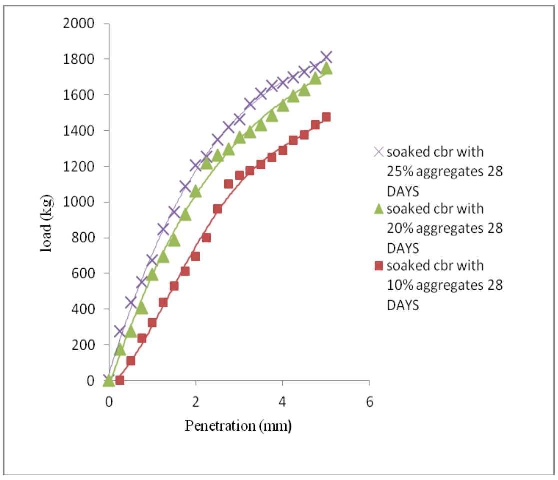

Fig- 12:. Soaked CBR graphs for for 28 days curing period with Various aggregate percentages and optimum percentage of cement

4. COST ANALYSIS

In a developing country like India, the materials used for construction should be cost effective. Hence a cost comparison is required for recommending any new material. Through this study it was found that cement increases the CBR value of lateritic soil and optimum dosage of cement was found. Before recommending cement for practical purpose for stabilizing weak subgrade soils, a cost comparison was to be done to ascertain whether it proves cost effective on the longer run. Any new material or method will be accepted only if it is cost effective. It is observed that, with the optimum cement content as the percentage of aggregates increases, the cost of soil per unit volume increases. Hence, soil treated with 10% of aggregates in addition to optimum cement content is preferred.

Table 6 Cost of different combination of treated soil Cost Analysis of the Treated Lateritic Soil

CBR values and Cost of different combination of treated soil Cost Analysis of the Treated Lateritic Soil		
Property	**CBR (%)**	**Cost the soil per m3**
Natural Soil	4	Rs.600
Soil+3% Cement	52	Rs.706
Soil+3% Cement+10% Aggregates	80	Rs.976
Soil+3% Cement+20% Aggregates	92	Rs. 1081
Soil+3% Cement+25% Aggregates	98	Rs. 1093

5. CONCLUSION

Stabilization is the process of mixing ordinary Portland cement and aggregate with a lateritic soil to produce strength which is greater than that of the original soil. The soaked CBR at 3 percentages of cement increased up to 48% at 28days curing period when compared to that of untreated soil. Likewise unsoaked CBR increased up to 15%. When soaked CBR is conducted with optimum percentage of cement (3%) with 10% aggregate, it's strength increased up to 76%. Likewise unsoaked CBR increased up to 28.36%. In conclusion, stabilized lateritic soil can be used as road base course. Only about 3% by weight of the Portland cement and 10% aggregate is enough to stabilize lateritic soil to meet the Department of Highways specification. Furthermore, the use of stabilized lateritic soil decreases environmental problems in decreasing demand on crushed rock.

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