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Stabilization of Rural Road Subgrade Using Soil-Cement

Achana Madhu[1], Amol Pawar[2], Anand Kumar[3], Arpit Kumar[4], Pramod Karmare[5], Manasvi Kumar[6], Nikhil Yokar[7]

[1,2,3,4,5,6]*Student, Department of Civil Engineering, Dr. D.Y. Patil Inst. of Tech., Pimpri, India*

[7]*Assistant Professor, Department of Civil Engineering, Dr. D.Y. Patil Inst. of Tech., Pimpri, India*

***Abstract*—Soil Cement with admixture can be used together to get the more stabilized subgrade on roads. When the soil is mixed with cement and then with admixture the properties of the soil get changed. The aim of the study is to review on stabilization of subgrade using soil cement with admixtures. In the experiment the soil sample has been taken from the Pune region, the soil is found granular soil with sufficient fines and many laboratory tests has been conducted on that soil sample and soil cement with admixtures with varying percentage of cement and admixture. The experiments which have performed are Standard Proctor Test, California Bearing Ratio Test (CBR) & Unconfined Compression Test (UCT) by adding 5 %, 10%, 15%, 20% of the cement content by volume of dry soil and the Admixture which has used is Lime of 5% by weight of the dry soil. Lime is chosen because lime alters the nature of the adsorbed layer and gives pozzolanic action.**

Index Terms—california bearing ratio, cement admixtures, stabilization techniques, Standard proctor

I. Introduction

The rural roads in India form a substantial portion of the Indian road network. Roads are the vital lifelines of the economy making possible trade and commerce. They are the most preferred modes of transportation and considered as one of the cost-effective modes. In India these roads are in poor shape, affecting the rural population's quality of life and Indian farmer's ability to transfer produce to market post-harvest. India has around 3.5 kilometers of roads per 1000 people, including all its paved and unpaved roads. These statistics showing that India has very low road densities. For the improvement of road densities, soil cement roads are one of the best option in terms of economy.

Soil-cement is an engineered material used as construction material for slope protection, and road construction as a sub base layer and protecting the subgrade. When the soil is mixed with cement and then with admixture the properties of the soil get changed & with these changes in properties, it can be used as a composite material for the construction of roads.

Soil is the foundation for any civil engineering structures. It is required to bear the loads without failure. In some places, soil may be weak which cannot resist the oncoming loads. In such cases, soil stabilization is needed. Through the use of stabilizing agents, low-quality materials can be economically upgraded to the extent that these may be effectively utilized in the pavement structure. Stabilized pavement materials are generally incorporated into the pavement structure as base courses and sub-bases.

II. Objectives

The main objective of this study are as follows:-

- To increase the load bearing capacity of roads.
- To avoid the early failure of the road subgrade.
- To make the pavement more flexible rather than rigid.
- To reduce the overall cost of construction of road by the use of locally available soil.
- To make the construction fast & in a very feasible manner.

III. Methodology

This project deals mainly with field soil stabilization using cement and fly–ash, and then using this stabilized soil as sub-base course and base course of pavement. The following steps are followed for the stabilization process,

- Evaluating the properties of field soil where we want to do stabilization.
- Checking the suitability of that soil for the cement stabilization.
- Designing the stabilized soil-cement mix by conducting strength tests.
- Considering the construction procedure by adequately compacting the stabilized layers and laying the road.

IV. Criteria for Chemical Selection

1. *Chemical Selection for Stabilization*

a) Lime: If PI > 10 and clay content (2μ) > 10%.
b) Cement: If PI ≤ 10 and < 20% passing No. 200.

Note: Lime shall be quicklime only.

2. *Chemical Selection for Modification*

a) Lime: PI ≥ 5 and > 35 % Passing No. 200
b) Fly ash and lime fly ash blends: 5 < PI < 20 and > 35 % passing No. 200
c) Cement and/ or Fly ash: PI < 5 and ≤ 35 % Passing No. 200.

3. *Laboratory Test Requirements*

a) Grain size analysis in accordance with AASTHO.
b) Atterberg limits.
c) Standard proctor on soil cement mixture for change in maximum dry unit weight.

d) California bearing strength.
e) Unconfined compression test.

V. Tests and Results

In the present project, the soil available in the premises Salunke Vihar road, Kondhwa was taken for the investigation purpose. The following tests were conducted on the field soil in the laboratory. Moisture content of field soil

- Grain size analysis using mechanical sieve shaker
- Standard proctor test to determine the optimum moisture content (OMC) and maximum dry density (MDD)

A. Grain Size Analysis

TABLE I
GRAIN SIZE ANALYSIS

S. No	Sieve Size	Mass of Soil Retain (g)	%Retained on each sieve (%)	%Cumulative Retain (%)	%Finer (%)
1.	4.75mm	175	8.4	8.4	91.6
2.	2	485	25	33.4	66.6
3.	1	294	16.85	50.25	49.75
4.	600µ	125	5	55.25	44.75
5.	425 µ	85	2	57.25	42.75
6.	300 µ	72	3.50	60.75	39.25
7.	212 µ	65	3.20	63.95	36.05
8.	150 µ	453	22.55	86.5	13.5
9.	75 µ	130	11.2	97.7	2.3
10.	pan	16	1	98.7	1.3
Total		2000	98.7		

From above test D60=1.55 mm, D30=0.2 mm, D10=0.12 mm Hence Cu=12.91 & Cc=0.21 Hence the soil is SM i.e. Silty Sand as per Indian Standard Soil Classification System.

B. Atterberg Limits

TABLE II
ATTERBERG LIMITS

Type of test	Casagrande cup liquid limit			Plastic limit	
Test number	1	2	3	1	2
No of blows	28	21	12		
Mass of wet soil+ container	21.71	25.64	27.54	18.53	18.42
Mass of dry soil+ container	18.11	20.13	22.04	15.74	15.65
Mass of container	9.31	9.33	9.44	8.44	8.34
Mass of water	3.6	4.51	5.5	1.79	1.77
Mass of dry soil	11.8	13.8	15.1	7.3	7.31
Moisture content	24.33	26.23	28.67	21.57	21.30

C. Standard Proctor Test

Aim of this test is to determine a relationship between moisture content and dry unit weight for a given soil sample. In this test we are conducting adding different ratio of cement adding with soil and determine the result which is shown in graph.

a) Soil + cement (0%) + Lime (0%)
Maximum dry density: 1.6 gm. /cm3
Optimum Moisture Content: 13 %

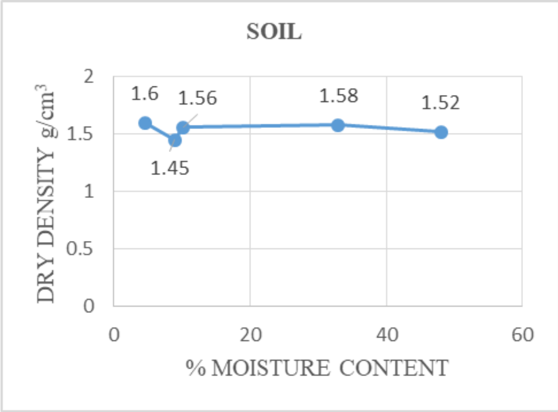

Fig. 1. Moisture content vs. Dry density (Case-a)

b) Soil + cement (5%) + Lime (5%)
Maximum dry density: 1.76 gm. /cm3
Optimum Moisture Content: 13 %

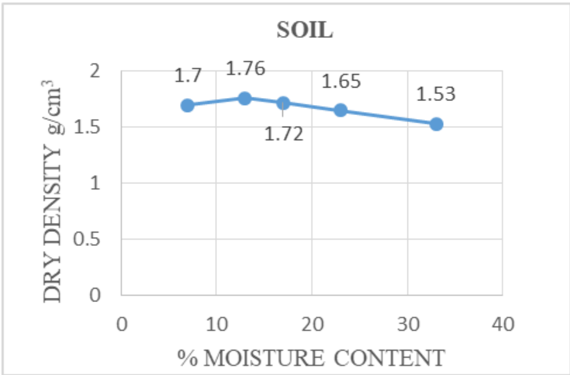

Fig. 2. Moisture content vs. Dry density (Case-b)

c) Soil + cement (10%) + Lime (5%)
Maximum dry density: 1.71 gm. /cm3
Optimum Moisture Content: 16 %

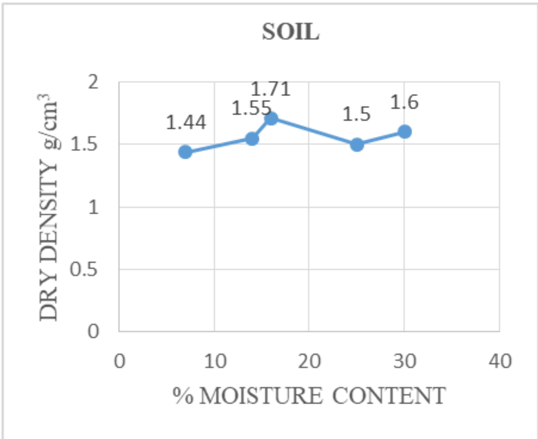

Fig. 3. Moisture content vs. Dry density (Case-c)

d) Soil + cement (15%) + Lime (5%)
Maximum dry density: 1.8 gm. /cm3
Optimum Moisture Content: 12 %

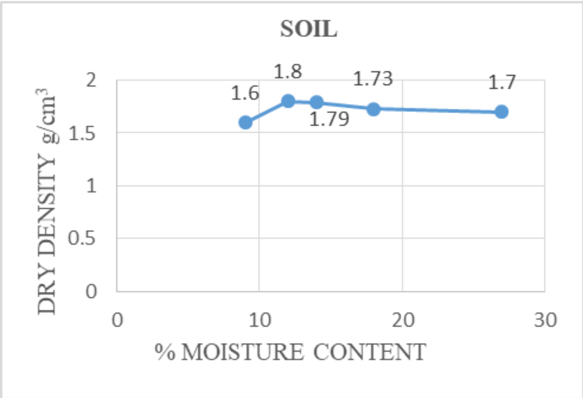

Fig. 4. Moisture content vs. Dry density (Case-d)

D. *California Bearing Ratio Test*

It is use for determine a relation between force and penetration when a cylindrical plunger with standard cross-section area is made to penetrate the soil at a given rate. In this test we are conducting adding different ratio of cement adding with soil and determine the result which is shown in graph.

a) Soil + cement (0%) + Lime (0%)
CBR value at 2.5mm penetration: 15.1%
CBR value at 5mm penetration: 14.12%
b) Soil + cement (5%) + Lime (5%)
CBR value at 2.5mm penetration: 17.12%
CBR value at 5mm penetration: 18.25%
c) Soil + cement (10%) + Lime (5%)
CBR value at 2.5mm penetration: 24.52%
CBR value at 5mm penetration: 24.25%
d) Soil + cement (15%) + Lime (5%)
CBR value 2.5mm penetration: 18.78%
CBR value at 5mm penetration: 17.178%

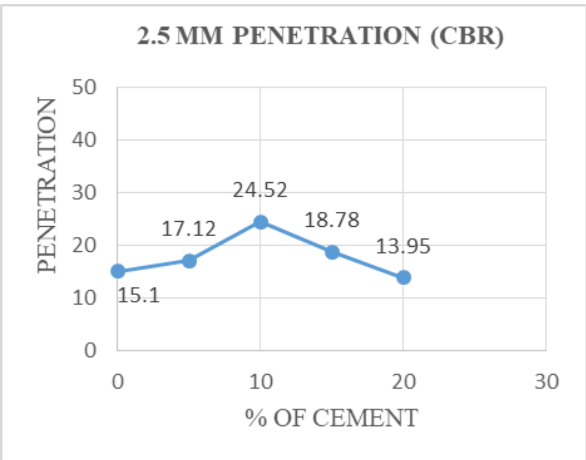

Fig. 5. % of cement vs. Penetration (2.5 mm)

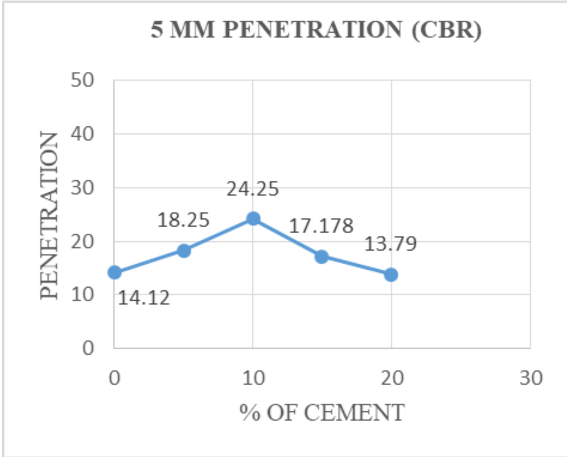

Fig. 6. % of cement vs. Penetration (5 mm)

E. *Unconfined Compressive Strength*

The aim to determine the unconfined compressive strength of the soil, test to obtain the shear strength parameters of cohesive soil either in undisturbed or remoulded state, it is not applicable to cohesion less or coarse-grained soils. In this test we are conducting adding different ratio of cement adding with soil and determine the result which is shown in graph,

Soil + cement, where, Qu= Unconfined compression strength of soil, c = Shear strength of soil.

a) Soil + cement (0%)
Qu = 170.74 KN/M2
c = 85 KN/M2
b) Soil + cement (5%)
Qu = 500.25 KN/M2
c = 270 KN/M2
c) Soil + cement (10%)
Qu = 203.32 KN/M2
c = 426 KN/M2
d) Soil + cement (15%)
Qu= 310.95 KN/M2
c = 652 KN/M2

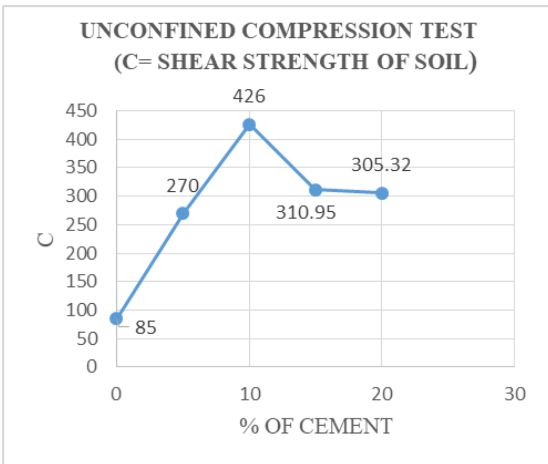

Fig. 7. % of cement vs. Shear strength of soil

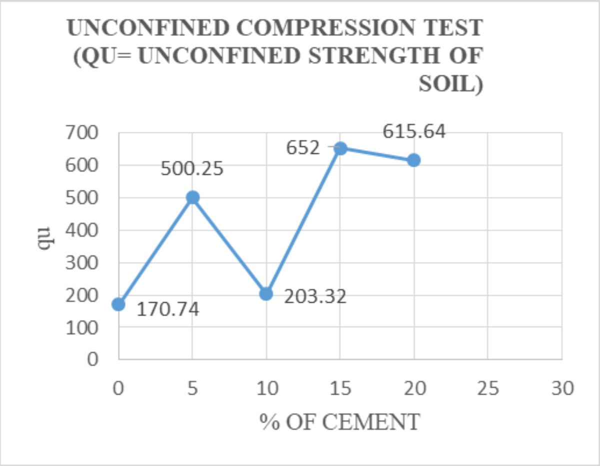

Fig. 8. % of cement vs. unconfined strength of soil

VI. Conclusion

From the above analysis and discussion, it can be inferred that 6% to 10% addition of cement to the sample with an addition of 5% of lime as an additive result in PI, LL& CBR values that satisfies the IRC specifications for the both the base and sub-base courses. It is therefore concluded that cement stabilization improves the engineering properties of the soil sample for the road construction.

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