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A STUDY ON DESIGN OF SOIL CEMENT ROAD

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ABSTRACT

The soil cement roads are economical and provide a better way to connect various rural areas and also facilitates rural roads where traffic volume is very low. The rural area forms an important part of the country and constitutes a large portion of Indian road network. In India we have less then 3.8kilometers of roads per 1000 people. The charcoal roads present today in the rural areas are in a very poor condition. The Indian farmers harvest spoil because of the poor road infrastructure. The total length of roads in rural areas is 33,37,255km's.

Soil cement is an engineered material which is designed and constructed for various pavement applications and enhancing material properties. It is one of the simplest products made by using Portland cement. It is made by mixing Portland cement and soil and other aggregates with water which is further compacted to make pavement. The study is on making the use of soil cement for pavement construction. The final results will show that the soil cement used for base and sub base course of flexible pavements where traffic volume is low. Unconfined compressive test, moisture-density relation on different proportions of soil cement mixes have been performed in the research paper.

1. INTRODUCTION

The soil cement mortar is prepared using Portland cement and other aggregates mixing together with water. In the present development, where the supply of sand is declining short of meeting the demand, it becomes important to find a different alternative. Mud mortar was generally used for low rise masonry buildings in the past. When the soil is used for mortar consists of clay, difficulties like volume instability due to its high affinity towards water are faced. To negate this effect, stabilization of clay is important. Cement is used as a binding agent.

Including all the paved and unpaved roads India has less than 3.8 kms of roads per 1000 people. India has less than 0.07kms of highway per 1000 people according to 2010 survey, which is among some of the lowest highway density in the world. Hence a solution is needed for the betterment of road densities in India in an economical way. Soil cement is frequently used as a construction material for pipe bending, slope protection and road construction as a sub base layer which provides reinforcement to the sub grade. Its compressive strength is high so the cracks are formed more frequently.

2. MATERIALS

Types of Soil Cement

Soil Cement Base (SCB): *It contains relatively high proportion of Portland cement. It is used as pavement base in streets, parking lots, airports, roads and material handling areas. Equipments used are mechanical cement spreader and stabilizer. To lock the moisture and to prevent the moisture out a seal coat is provided.*

Cement-Modified Soil(CMS): *A cement modified soil contains low proportions of Portland cement as compared to soil cement base. The final result is like a soil cake, but with improved properties like lower plasticity, increased bearing ratio and shearing strength and decreased volume change.*

Cement-Treated Base: *A cement treated base is a mixture of granular soil mixed with Portland cement and water. Its uses are same as that of soil cement base.*

Advantages of Soil Cement

- *Superior performance*
- *Stiffness*
- *Fast construction*
- *Stiffness*
- *Recycling of existing materials*
- *Low initial cost*
- *Great strength*

Limitations of soil Cement

- *The results may not work properly if the standards are not followed strictly.*
- *A little high proportion of cement can cause cracks as it is too brittle.*
- *Water can penetrate easily if the voids are large.*

3. METHODOLOGY

This project is based on the use of field soil which is stabilized using cement and is further used as sub base course and base course of pavement.

Steps for soil stabilization are:

- *To check the soil properties which is to be used for stabilization.*
- *To evaluate the suitability of soil for cement stabilization*
- *Conducting strength test on soil cement mix.*
- *Compacting the stabilized layers sufficiently and laying the road.*

Evaluating the Properties of Soil

A mix containing soil which have high plasticity index, results in poor stabilization under soaking conditions. The various properties affect the performance of the mix. Therefore the evaluation of soil properties for which mix is to be prepared is an important task.

Check for Suitability

The soil should possess a plasticity index of 10 to 20 range as per IRC SP 89-2010 for stabilizing a soil with cement. The other specifications like uniformity coefficient and coefficient of curvature should also be checked.

Design of the Soil-Cement Mix

Various soil-cement mix has to be prepared using different cement content. According to IRC for the stabilization of soil cement a minimum of 2% cement is required. On these samples the strength tests are performed to find the best cement soil ratio. The most commonly used method for mix design is British method. As per this method the mix which gives 7 days strength as 17kg/cm^2 is known as the best mix.

Construction

After selecting the mix ratio, the mix is prepared and stabilized by plant mix method or mix-in-place method. The project is based on mix in place method. The steps involved in mix in place method are:

- *Preparing of sub grade*
- *Pulverizing of soil*
- *Adding cement and dry mixing*
- *Wet mixing by adding water*
- *Spreading and grading*
- *Compacting*
- *Soil cement is cured by covering with wet soil or by some other means to prevent water from escaping*
- *Conducting tests in field*
- *Laying surface coat of thin bitumen layer*

4. TESTS ON SOIL

In this project the soil present in the college premise is used for the purpose. The various tests given under were performed on the soil in the laboratory:

- *Moisture content test of field soil*
- *Grain size analysis using mechanical shaker*
- *Liquid limit and plastic limit test*
- *Density of soil using sand replacement method*
- *Optimum moisture content (OMC) and maximum dry density (MDD) using standard proctor test*

TABLE 1

Test	***Results***
Moisture content	*12.56%*
Grain size analysis	*Shape of the curve- Hump shape* *Type of soil-coarse grained* *Uniformity coefficient- 11.62* *Coefficient of gradation-0.62*
Consistency limits	*Liquid limt-18.46%* *Plastic limt-13.22%* *Plasticity Index-5.24%*
Dry density	*2.02gm/cc*
Standard proctor test	*OMC-6.21%* *MDD at OMC-1.63gm/cc*

For cement stabilization plasticity index of sol should be less than 20 as per Indian standards specified in IRC SP 89-2010 and the results are appropriate. As the plasticity index for the soil we had taken is 5.24%. Also as per IRC the uniformity coefficient of soil used should be greater than 10 and the sample taken have a uniformity coefficient of 11.62%.

5. DESIGN OF SOIL CEMENT MIX

This is main task performed in this project. The various percentage of cement is added to make different samples starting from 3%, 5%, 7%, 8% ,9%, 10%. The mixes are formed as per IRC guidelines. The tests are then performed on the various mixes as discussed above.

Results of standard proctor test on soil+cement mixes

Table 2

S.no.	***Details of mix***	***Optimum moisture content***	***Maximum dry density***
1	*Soil+3% cement*	*6.37*	*1.96*
2	*Soil+5% cement*	*8.52*	*1.92*
3	*Soil+7% cement*	*9.19*	*1.94*
4	*Soil+8% cement*	*11.26*	*1.90*
5	*Soil+9% cement*	*11.82*	*1.97*
6	*Soil+10% cement*	*11.96*	*1.89*

Results of unconfined compressive strength test on soil cement mixes after 7 days of curing

Table 3

S. no.	***Details of mix***	***Unconfined compressive stress N/mm^2***
1	*Soil+3% cement*	*1.562*
2	*Soil +5% cement*	*1.575*
3	*Soil+7% cement*	*1.592*
4	*Soil+8% cement*	*1.534*
5	*Soil+9% cement*	*1.671*
6	*Soil+10% cement*	*1.689*

Durability Test

Two methods are available to check the durability of stabilized mix for the pavement suitability as per IS SP 89-2010.We can adopt any of the two methods. Here method 2 is adopted provided in the code. Method 2 is done as per ASTM standard no. ASTM D 559. The results are as follows:

- *Change in volume after 12 cycles of wetting and drying=5.3%*
- *Change in mass after 12 cycles of wetting and drying=13.46%*
- *Change in volume after 12 cycles of drying and abrasion=14%*

After durability test is completed the liquid limit, plastic limit and SO4 content test were performed on sample. The results are shown below:

Table 4

Test	***Results***	***Limitation as per code***
Liquid limit test	*28.54%*	*<40%*
Plastic limit test	*17.96%*	*<20%*
SO4 content test	*0.11%*	*<0.2%*
Organic content	*1.32%*	*<2%*

6. CONCLUSION

We concluded from the research work that the soil is good for stabilization as it is slightly plastic and also its uniformity coefficient is greater than 10. From the studied that we have done it is observed that OMC and MDD value increases with increase in cement content and hence the unconfined compressive strength of the soil increases. The suitable mix was identified as per British method and according to the guidelines of IRC SP 89-2010 and the suitable mix was formed by addition of 5% cement. The unconfined compressive strength of this sample was found to be 1.575 N/mm2. Hence the soil selected for stabilization is suitable for construction of roads.

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