Soil Stabilization Using Construction and Demolition Waste in Road Construction

S.P.Kanniyappan[1], S.Balakumaran[2], R.G.Dhilip Kumar[3], C.Lavanya[4]

[1,2,3]Assistant Professor, Department of Civil Engineering, R.M.K Engineering College, Kavaraipettai, Tamilnadu, India
[4]Assistant Professor, Department of Civil Engineering, PERI Institute of Technology, Chennai, Tamilnadu, India

[1]spk.civil@rmkec.ac.in

Abstract

Long term performance of pavement structures depends on the stability of sub-base and base soil. Stabilization of sub-base and base soil improves its properties and strength. Red soil is the third largest soil group in India and it possess lower strength compared to other soil due to its porous and fragile structure and it has a higher swelling capacity, thereby it requires stabilization. Red soil stabilization is usually done using lime, fly ash, granulated blast slag etc., of which construction & demolition waste is the major factor. This project aims to study the engineering properties of red soil & to determine the pavement thickness. The debris is added in varying percentage to the soil & the CBR value is calculated. The variation in CBR value may result in the reduction of pavement thickness.

Keywords: *Atterbergs limits, California Bearing Ratio test, Impact value, Natural coarse aggregate, Red soil, Recycled coarse aggregate, Specific gravity, Water absorption*

1. Introduction

1.1. General

In recent years, certain countries have considered the re-utilization of waste materials as a new construction material as being one of the main objectives with respect to sustainable construction activities. This study focuses on reuse of recycled concrete aggregate as coarse aggregate as partial replacement for soil in lean stabilization.

For any land-based structure, the foundation is very important and has to be strong to support the entire structure. In order for the foundation to be strong, the soil around it plays a very critical role. So, to work with soils, we need to have proper knowledge about their properties and factors which affect their behavior. The process of soil stabilization helps to achieve the required properties in a soil needed for the construction work.

From the beginning of construction work, the necessity of enhancing soil properties has come to the light. Ancient civilizations of the Chinese, Romans and Incas utilized various methods to improve soil strength etc., some of these methods were so effective that their buildings and roads still exist.

In India, the modern era of soil stabilization began in early 1970's, with a general shortage of petroleum and aggregates, it became necessary for the engineers to look at means to improve soil other than replacing the poor soil at the building site. Soil stabilization was used but due to the use of obsolete methods and also due to the absence of proper technique, soil stabilization lost favor. In recent times, with the increase in the demand for infrastructure, raw materials and fuel, soil stabilization has started to take a new shape. With the availability of better research, materials and equipment, it is emerging as a popular and cost-effective method for soil improvement.

1.2. Soil Stabilization

Stabilization is the process of altering some soil properties by different methods, mechanical or chemical in order to produce an improved soil material which has all the desired engineering properties.

Soils are generally stabilized to increase their strength and durability or to prevent erosion and dust formation in soils. The main aim is the creation of a soil material or system that will hold under the design use conditions and for the designed life of the engineering project.

The properties of soil vary a great deal at different places or in certain cases even at one place; the success of soil stabilization depends on soil testing. Various methods are employed to stabilize soil and the method should be verified in the lab with the soil material before applying it on the field.

2. Methodology

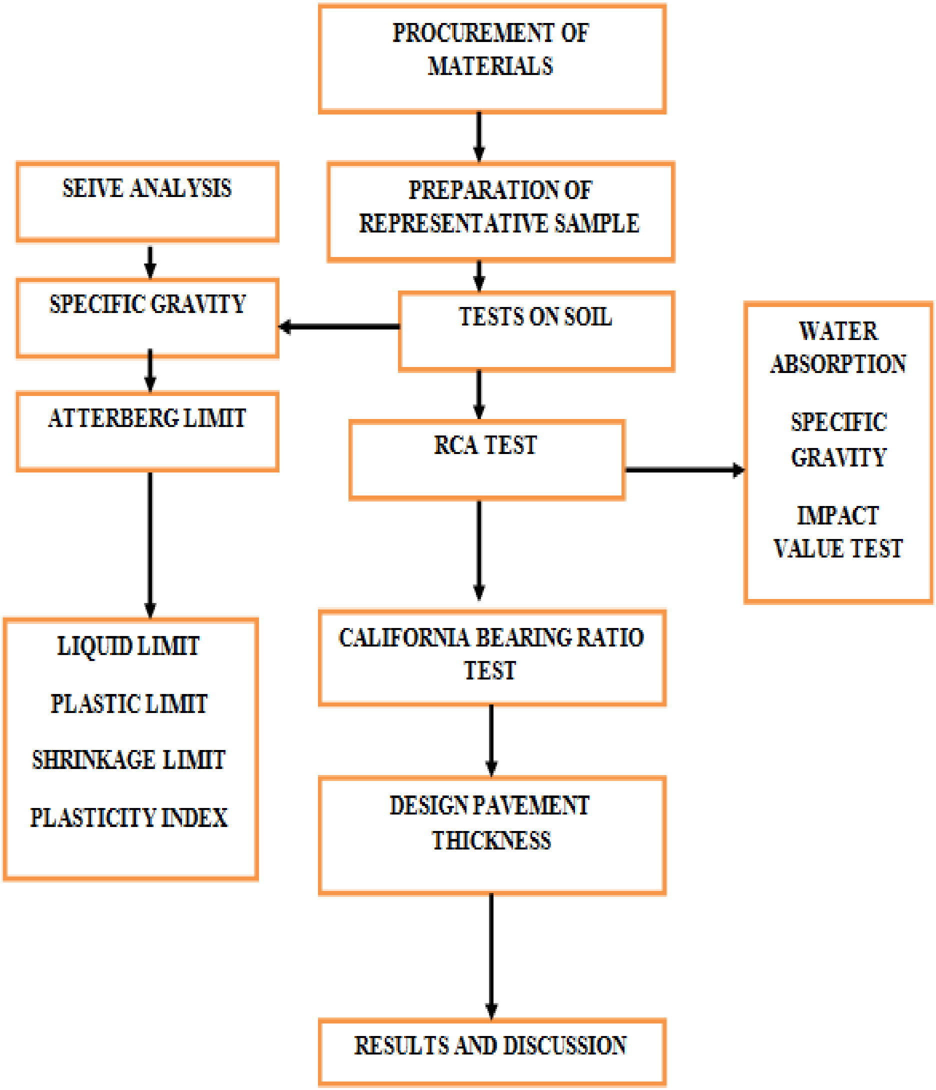

Figure 1. Methodology of the Project

3. Material and its Properties

3.1. General

In general stabilization of soil is a mixture of soil sample, recycled coarse aggregate for taking in waste building materials and water content. In order to improve the qualities of the stabilization to going produce the low cost of stabilization of soil materials. In this research the following materials has been used to design the soil mix.

3.2. Materials used

a) Red Soil

Red soils are highly leached soils of the humid tropics having a high content of sesquioxides. In the current system of U. S. Soil Taxonomy, red soils are usually designated under the orders of Oxisols, Ultisols, and occasionally Alf sols, Mollisols and even Inceptisols.Red soils as shown in Fig. 2 are predominantly found in South America, Central Africa, South and Southeast Asia, China, India, Japan and Australia. In general, these soils have good physical conditions for plant growth although they often have very low water-holding capacity.Applications of lime and fertilizers are important strategies for replenishing soil fertility and improving crop yields on these soils. In addition, cultural practices such as appropriate crop rotation, improvement of organic matter content, use of nutrient efficient or acid tolerant plant species or cultivars and control of soil erosion can optimize nutrient use efficiency and improve crop yields on these soils. In China, utilization of red soils for crop production by farmers depends not only upon the employment of such practices but also upon socio-economic factors and the availability of adequate incentives.

Figure 2. Red Soil Sample

Table 1. Physical properties of Red soil sample

Sl.No	Properties	Results	Acceptable Limit	Codal Reference
1.	Specific Gravity	**2.58**	2.52-2.70	IS 2720 (PART III)
2.	Liquid Limit (%)	**43.37**	30-50	IS2720 (PART V)
3.	Plastic Limit (%)	**19.41**	19-23	IS2720 (PART V)
4.	Plasticity Index (%)	**23.96**	18-21	IS2720 (PART V)
5.	CBR Value (%)	**6.56**	5–9	IRC : 37 - 2001

b) Recycled Coarse Aggregate

Crushed concrete as shown in Fig.3 is available nowadays in large quantities, which results from the demolition of old structures and waste concrete from new structures. A report presented in 1999 to the European Commission estimated the amount of no recycled construction waste to be 130 million ton/year. A decrease in the compressive strength was generally observed in all concretes in which the natural coarse aggregate was replaced with recycled aggregate prepared by the crushing of old concrete. The mechanical properties of the concrete decreased with the increase in the proportion of aggregate replaced. In that only 20% of the natural aggregate can be replaced with recycled coarse aggregate in the preparation of new concrete of all strength classes, and limited the concrete classes when100% recycled construction waste is used in the Pavement Construction.

Figure 3. Recycled Coarse Aggregate

Table 2. Physical properties of Recycled Coarse Aggregate

Sl.No	Properties	Results	Acceptable Limit	Codal Reference
1.	Specific Gravity	**2.68**	2.4 - 2.9	IS2720(PART III)
2.	Impact Value (%)	**10.17**	-	-
3.	Water Absorption (%)	**1.02**	0.1 - 2% of Max	IS2720(PART II)

Table 3. Physical properties of Natural Coarse Aggregate

Sl. No	Properties	Results	Acceptable Limit	Codal Reference
1.	Specific Gravity	**2.67**	2.4 - 2.9	IS 2720 (PART III)
2.	Impact Value (%)	**9.81**	-	-
3.	Water Absorption (%)	**1.50**	0.1 - 2% of Max	IS 2720 (PART II)

Table 4. Comparison of RCA and NCA

Sl. No	Properties	RCA	NCA	Acceptable Limit	Codal Reference
1.	Specific Gravity	**2.68**	**2.67**	2.4 - 2.9	IS 2720 (PART III)
2.	Impact Value (%)	**10.17**	**9.81**	-	-
3.	Water Absorption (%)	**1.02**	**1.50**	0.1 - 2% of Max	IS 2720 (PART II)

4. Experiment Test Results

Table 5. Test results on Red Soil

Sl. No	Description of Items	Results
1.	Specific Gravity of Red Soil	**2.58**
2.	Liquid Limit Test (%)	**43.37**
3.	Plastic Limit Test (%)	**19.41**
4.	Plasticity Index (%)	**23.96**

4.1. Grain Size Analysis

The grain size analysis of soil is very useful in the present geotechnical world. The results of this analysis are widely used for soil classification, design of filters, and construction of earth dams, highway embankments and determining the model of bearing capacity computations and for construction of building.

Table 6. Grain Size Analysis

Description	Gravel	Sand	Silt	Clay
Red Soil (%)	0	11	34	55

4.2. California Bearing Ratio Test

California bearing ratio is the ratio of force per unit area required to penetrate in to a soil mass with a circular plunger of 50mm diameter at the rate of 1.25mm / min.

$$\text{CBR} = \frac{Load\ carried\ by\ specimen}{Load\ carried\ by\ standard\ speciemen} \times 100$$

Table 7. California Bearing Ratio Test Results

Sl.No	Total Standard Load	Unit Standard Load	CBR (%)
1.	1370	90	**6.56**
2.	1540	105	**6.81**
3.	1612	160	**9.93**
4.	1867	385	**20.63**
5.	1941	562	**28.95**

Table 8. Replacement of Red Soil with RCA in Various Proportions

Sl.No	Sample Name	Proportion of Sample Replaced	CBR Value
1.	Normal Red Soil	-	6.56%
2.	RS + P-1	5% of RCA	6.81%
3.	RS + P-2	10% of RCA	9.93%

4.	RS + P-3	15% of RCA	20.63%
5.	RS + P-4	20% of RCA	28.95%

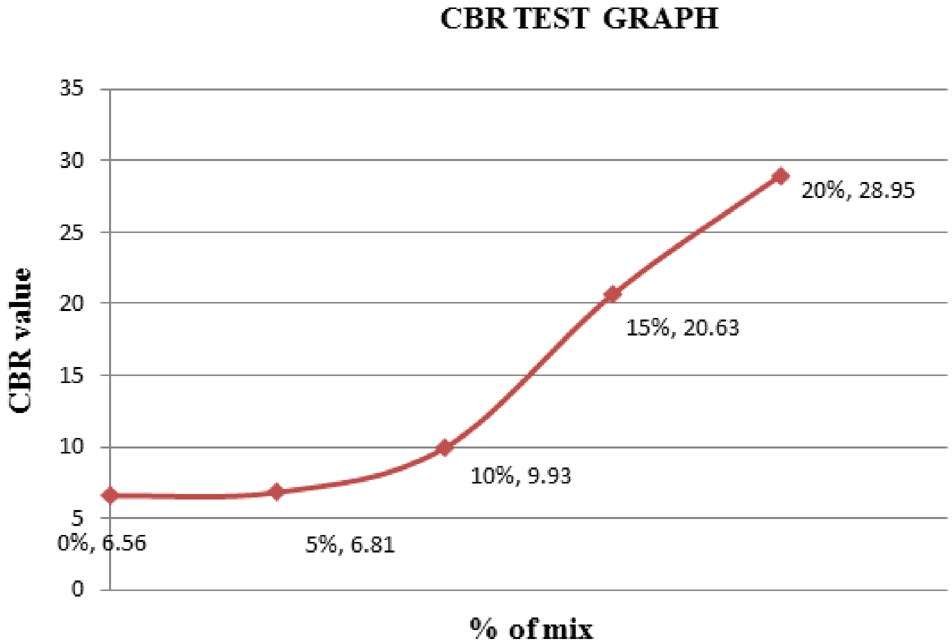

Figure 4. Graph between % of mix and CBR Value

4.3. Design of Pavement Thickness according to IRC: 37 –2001

Table 9. Design of Pavement Thickness

CBR % Value	Pavement thickness (mm)
6.56%	**480 mm**
6.81%	**451 mm**
9.93%	**380 mm**
20.63%	**250 mm**
28.95%	**195 mm**

5. Conclusion

Based on the Experimental Results and the Pavement Design as per IRC: 37-2001the following conclusions were made,

- The RCA is mixed with Red Soil of different mix proportions i.e., (5%, 10%, 15% and 20%); as a result there is an increase in CBR Value with increase in % of RCA replaced.
- The increase in CBR Value leads to decrease in Pavement Thickness which reduces the construction cost of the Pavement.
- Further, C&D waste is properly recycled as a Coarse aggregates in pavement which increases environmental benefits.

References

Journal Article

[1] *Emery J.J, "Slag Utilization in Pavement Construction", Extending Aggregate Resources.ASTM Special Technical Publication 774, American Society for Testing and Materials, Washington, DC,* ***(1982)***.

[2] *Hartlen J., Carling. M and Nagasaka. Y, "Recycling or reuse of waste materials geotechnical applications", Proceedings of the second International Congress of Environmental Geotechnics, Osaka, Japan,* ***(1997)***.

[3] *KowalskiT.E and Starry (Jr.), D.W, Modern Soil Stabilization Techniques, Paper prepared for presentation at the "Characterization and Improvement of Soils and Materials Session", 2007 Annual Conference of the Transportation Association of Canada, Saskatchewan.* ***(2007).***

[4] *Brooks. R.M., "Soil Stabilization with Fly Ash and Rice Husk Ash", International Journal of Research and Reviews in Applied Sciences (IJRRAS),* ***(2009)***.

[5] *Istrate. R and Calimente. A, "Slag – Utilization in Road Construction – Experience and Solutions", Journal of Engineering Annals of Faculty of Engineering, Hunedoara,* ***(2009)***.

[6] *Monica Malhotra and Sanjeev Naval, "Stabilization of Expansive Soils Using Low Cost Materials", International Journal of Engineering and Innovative Technology (IJEIT),* ***(2013)***.

[7] *AshangoA.A. and Patra, N.R., "Static and Cyclic Properties of Clay Sub grade Stabilized with Rice Husk Ash and Portland Slag Cement", International Journal of Pavement Engineering (IJPE),* ***(2014)***.

[8] *Abhijith B.S, Vivek S Murthy and Kavya S.P, "Study of the Effectiveness in Improving Montmorillonite Clay Soil by Construction and Demolition Waste", Journal of Civil Engineering and Environmental Technology (JCEET),* ***(2014)***.

Code Books and Standards

[9] ***IS: 2720 (Part – II)*** *"Determination of Water Content", 1973.*

[10] ***IS: 2720 (Part – III)*** *"Determination of Specific Gravity", 1974.*

[11] ***IS: 2720 (Part – IV)*** *"Method of Test for Grain Size Analysis", 1975.*

[12] ***IS: 2720 (Part – V)*** *"Determination of Liquid and Plastic Limits", 1970.*

[13] ***IS: 2720 (Part–VII)*** *"Determination of Moisture Content – Dry Density Relation Using Light Compaction", 1974.*

[14] ***IS: 2720 (Part–XI)*** *"Determination of the shear strength parameter of a specimen tested trial compression without the measurement of pore water pressure", 1971.*

[15] ***IS: 37-2001****, "The Indian Road Congress, Guidelines for the design of Flexible Pavements", New Delhi, 2001.*