International Journal of Engineering and Advanced Technology (IJEAT)
ISSN: 2249-8958 (Online), Volume-8 Issue-5, June 2019

Stabilization of Subgrade Soil using Reclaimed Asphalt Pavement (RAP)

Ahmed Arqam Ruknuddin, Nischitha C S, Chethan L, Manoj P

Abstract: ***A good road network is a basic infrastructure required for rapid economic growth, and this road network fails mainly due to weak subgrade, less infiltration capacity, landslide etc., Due to awareness to a greener environment, ecological concern has become a global issue and all industries are trying to use of eco-friendly materials and technology. Use of reclaimed asphalt material has become popular in the construction industry. At present, one of the key challenges is to concentrate on reusing natural resources for future generations while bringing a balance between environmental preservation and costs. In this case study, an attempt is being made to stabilize the subgrade soil using Reclaimed Asphalt Pavement (RAP) for the subgrade soil collected from the Sampaje region near Madikeri on NH 275 towards Mangalore where road failure was observed. Qualification tests were conducted on the collected materials. The characteristics of the materials collected like, gradation, modified Proctor compaction test, CBR, Specific gravity, Atterberg's limits, Tri-axial tests were conducted. From this study, the penetration resistance of subgrade soil is maximum when added with 25% of RAP, which could be used to stabilize subgrade soil.***

Index Terms: ***Reclaimed Asphalt Pavement, Subgrade Soil, Stabilization.***

I. INTRODUCTION

India has a road network of over 59,03,293 kilometers, the second largest road network in the world after the USA. Most of the roads are bituminous surfaced pavements. These roads require regular maintenance work. During this resurfacing or rehabilitation process, Reclaimed Asphalt Pavement (RAP) is generated in large quantities. About 40% - 50% of RAP is recycled and used in hot mix asphalt plant and remaining is left unused and dumped in landfill sites. If these left RAP materials are used, results in waste management and reduce the environmental impact [4]. The traffic loads are transmitted to the subgrade through the base and subbase layers of a pavement, without causing undue stress or damage to the subgrade. For the construction of these layers, the materials used must have specified properties in terms of strength and durability. During construction mechanical methods such as rolling are used to improve the stability and when questionable soils are encountered, removal and replacement with better materials are usually employed. Stabilization is another method which is employed to improve the strength of the weak soil. Stabilization of subgrade provides more uniform support compared to remove and replace, for the pavement structure [6, 11]. Reclaimed Asphalt Pavement (RAP) is an emerging technique in India, and the use of RAP is gradually gaining popularity. RAP addition is new technique in which aggregates from an existing pavement are reused in the construction of a new pavement. Using RAP does not only help in minimizing the cost of the project but also ensures proper utilization of resources. The other benefits of using recycled materials are increasing the life cycle of pavement material, reducing energy consumption and reduce greenhouse gas emission and also the carbon footprints of road. Due to the scarcity of high-quality quarry aggregates, alternative recycled aggregates are in use, large quantities of Reclaimed Asphalt Pavement materials are produced during highway maintenance and construction. A part of this can be used in new hot mix asphalt concrete and rest is available for other uses. If these materials could be reused in base or sub-base of the roads, resulting in minimization of environmental impact, reduce the waste stream and also transportation costs connected with road maintenance and construction activities. About 25% - 30% of the cost of the project is reduced if these recycled materials are used at the same site [5].

II. MATERIALS AND METHODOLOGY

A. Materials

Subgrade Soil

The subgrade soil used in this research work was procured from the NH 275, Sampaje village, Madikeri taluk, Kodagu district, Karnataka (12°30'35.5"N 75°31'22.2"E). The subgrade soil was collected and sealed in plastic bags for use in the laboratory. The collected sample was air-dried and pulverized into the required particle size for various tests.

Manuscript published on 30 June 2019.
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Figure 1. Location of Sampling Point

Plate 1. Sampling Point

Reclaimed Asphalt Pavement

The RAP which was left unused was also collected from the same region where subgrade soil was collected. The RAP materials are crushed into particle size passing 20mm sieve before laboratory tests were carried out.

Plate 2. Reclaimed Asphalt Pavement

B. Methodology

The methodology adopted in this research work is as per "Bureau of Indian Standard" Specifications. All the experiments were conducted in the Engineering Geotechnical Laboratory, Department of Civil Engineering, VVCE, Mysore.

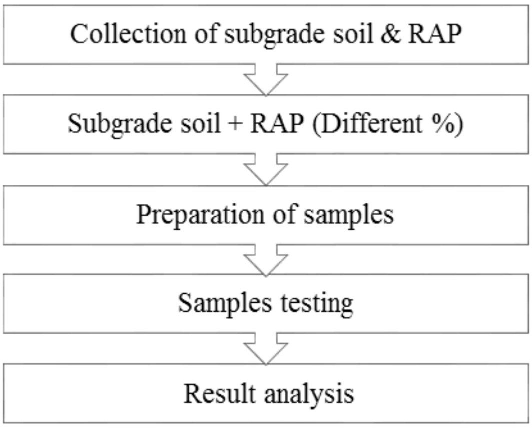

Figure 2. Flowchart of Methodology

C. Tests Performed

RAP was added and blended with the subgrade soil with varying proportions i.e., 0%, 5%, 10%, 15%, 20%, 25%. The tests performed are as follows

- Modified Proctor Compaction Test
- California Bearing Ratio Test
- Tri-Axial Shear Strength Test

III. RESULTS AND ANALYSIS

Test Results on Subgrade Soil

The test results obtained on the characteristics of the subgrade soil are tabulated in Table 1

Table 1. Properties of Subgrade Soil

Parameters	Results
Specific Gravity	2.3
Liquid Limit (%)	39.2
Plastic Limit	Nil
Optimum Moisture Content (%)	15.03
Maximum Dry Density (g/cc)	1.92
Maximum Bulk Density (g/cc)	2.21

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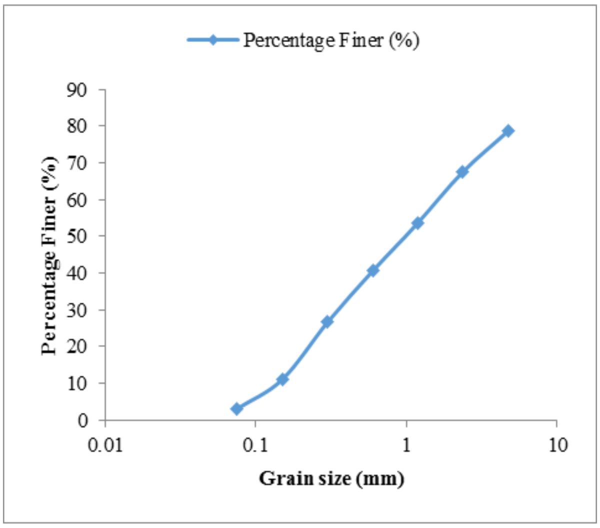

Figure 3. Grain Size Distribution curve

Modified Proctor Compaction Test

The test results are tabulated in Table 2. The variation of the maximum dry density (MDD) of subgrade soil with RAP is as shown in Figure 4. The test was performed up to 25% addition of RAP at an interval of 5%. Initially, the MDD value decreased from 1.92g/cc to 1.79g/cc for 5% addition of RAP content. Later it increases to 1.95g/cc at 25% RAP content. The initial decrease in MDD after adding RAP is due to a change in volume.

Table 2. Test Results of Modified Proctor Compaction

Particulars	MDD (g/cc)	OMC (%)
Subgrade Soil + 0% RAP	1.92	15.03
Subgrade Soil + 5% RAP	1.79	16.95
Subgrade Soil + 10% RAP	1.84	16.73
Subgrade Soil + 15% RAP	1.85	17.65
Subgrade Soil + 20% RAP	1.86	17.26
Subgrade Soil + 25% RAP	1.95	15.09

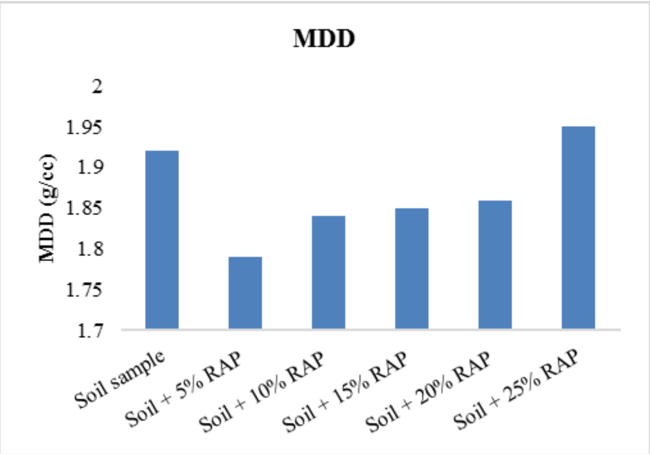

Figure 4. Variation of MDD

California Bearing Ratio Test

Table 3. Test Results of CBR

The test results are as tabulated in Table 3. The penetration resistance increases with increase in RAP content thereby indicating the less penetration due to heavy wheel load and hence more stability. The variation between penetration resistance and penetration are expressed in Figure 5.

Tri-Axial Test

The test results are as expressed in Figure 6. The shear stress of soil sample without RAP is maximum when compared to a shear stress of the samples with RAP; this variation in results is may be due to the RAP size (20mm), which is responsible for crack development.

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Particulars	CBR at 2.5mm penetration (%)	CBR at 5mm penetration (%)	CBR at 7.5mm penetration (%)	CBR at 10mm penetration (%)
Subgrade Soil + 0% RAP	2.8	4.81	6.91	8.14
Subgrade Soil + 5% RAP	5.6	8.55	10.89	12.46
Subgrade Soil + 10% RAP	7.01	11.11	14.15	16.17
Subgrade Soil + 15% RAP	8.24	13.37	16.75	31.47
Subgrade Soil + 20% RAP	9.47	15.48	18.51	21.75
Subgrade Soil + 25% RAP	9.84	15.87	20.37	23.02

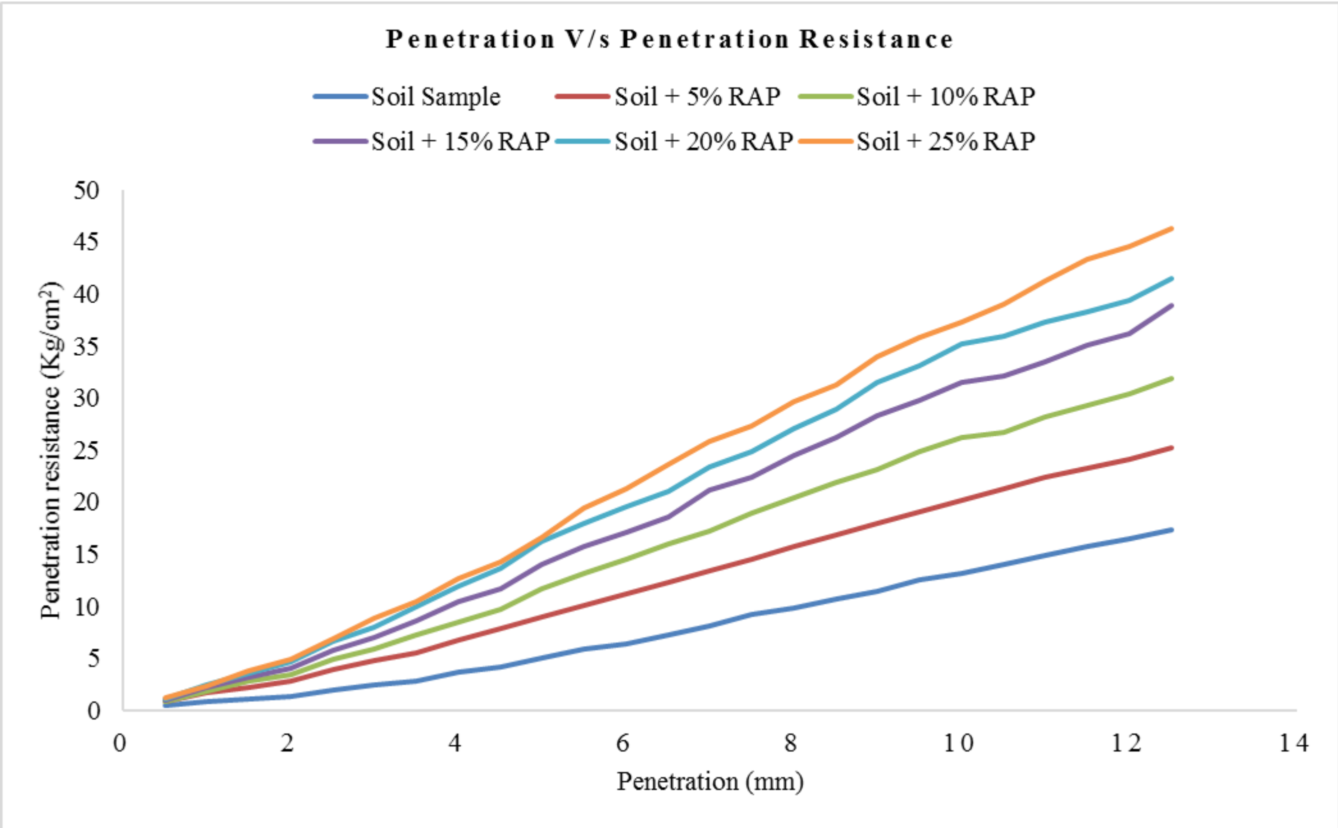

Figure 5. Penetration (mm) v/s Penetration Resistance (kg/cm^2)

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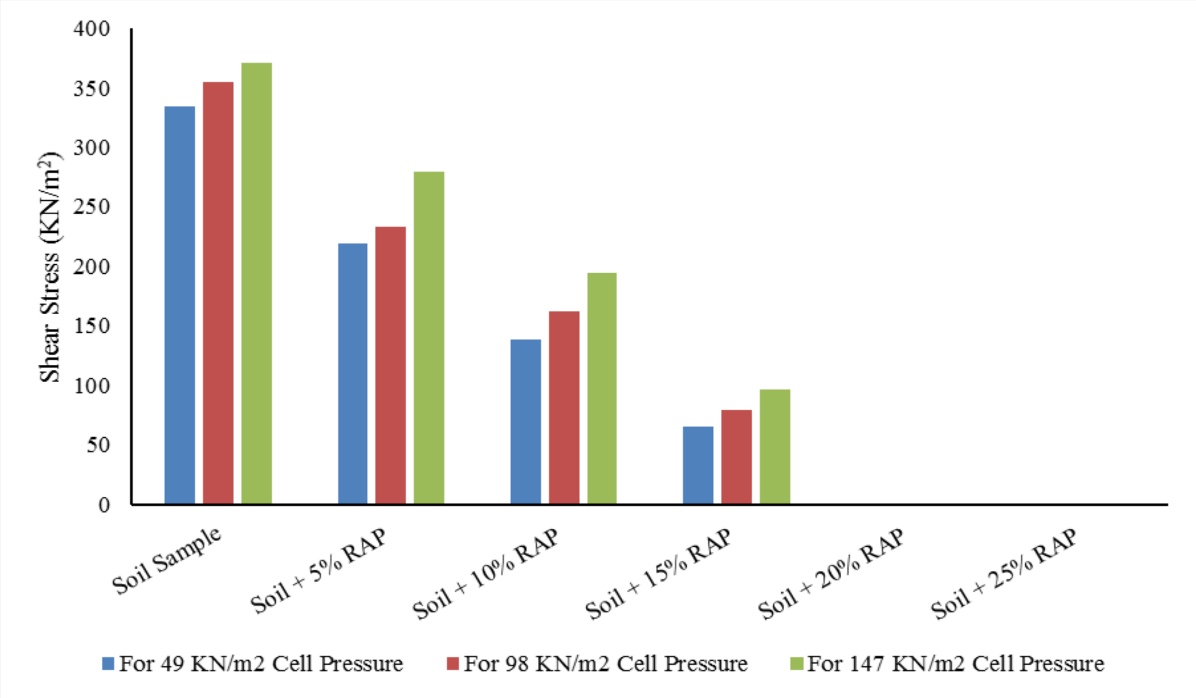

Figure 6. Variation of shear strength

IV. CONCLUSIONS

Based on the analysis made and results obtained, the following conclusions are drawn,

- Density increases with the addition of RAP which increases the stability
- Shear stress decreases with increase in RAP content, could be because of the particle size of RAP (20mm) which was responsible for cracks development
- Penetration resistance increases with increase in RAP content resulting in more stability
- If the pavement failure is due to the shear, smaller size of RAP materials is used with minimal replacement
- If the pavement failure is due to load, the maximum percentage of RAP can be added in order to increase the bearing capacity

The above-mentioned conclusions are with respect to subgrade soil and RAP from a western Sampaje region, Karnataka, India. For further generalization, wide varieties of soil and RAP possess different properties. The above conclusions can be helpful for early understanding of the effect of RAP in subgrade soil.

V. ACKNOWLEDGMENT

It is our privilege to express our sincere gratitude to Dr. DAYANANDA H S, Professor and Head, Department of Civil Engineering, Vidyavardhaka College of Engineering, Mysore, for his valuable advice, constant guidance and encouragement during our research study.

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