STUDY ON EFFECT OF RECLAIMED ASPHALT PAVEMENT ON RESILIENCE MODULUS OF SUBGRADE

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Abstract: Due to awareness to greener environment, use of reclaimed asphalt material has become popular in asphalt pavement industry. The use of ReclaimedAsphalt Pavement (RAP) materials in sub-grade soil can be an additional scope of utilizing RAP. This study investigates the effect of RAP on the ResilienceModulus (M_R) of subgrade soil. Resilience Modulus is the ratio of deviator stress to the resilient strain.This paper presents the basic properties of subgrade soil and the reclaimed asphalt pavement.
For the subgrade soil standard proctor test was conducted to determine the Optimum Moisture Content (OMC). Further, laboratory triaxial test was conducted for the soil sample without adding RAP at OMC obtained from standard proctor test. Also, triaxial test was conducted for same subgrade soil by adding varied percentage of RAP at OMC of subgrade soil. Then, the M_R of these subgradesoil without RAP and soil with RAP were determined as per AASHTO T 307 (1999) guidelines for constant confining pressure.Result shows that the M_R of RAP mixed with subgrade soil increases at OMC of soil at certain percentage.The M_R values of RAP mixed subgrade soil, as determined by the current study, can be used for subgrade design and stabilization using RAP for better pavement design.

Keywords: Reclaimed Asphalt Pavement (RAP), Resilience Modulus (M_R), Deviator Stress, Resilient Strain.

1. INTRODUCTION

The conventional method of providing bituminous surfacing of flexible pavement requires significant amount for production of bituminous binder. Many studies are available on performance evaluation with conventional asphalt mix without utilizing recycling agents. By using of Reclaimed Asphalt Pavement (RAP) materials obtained from the removal of existing asphalt pavement materials during resurfacing of reconstruction operations in pavement construction is increasing day by day. According to literature review, a max 35% RAP can be mixed with virgin aggregate for preparing base course. Although there has not been any limits for using RAP in subgrade materials. But nowadays also RAP materials have not been used in subgrade soil because design parameters and characteristics of RAP mixed subgrade are not known. It results in vast amount of RAP material end up at pits or landfills.
Excess asphalt concrete is disposed of in landfills. The property of RAP are largely dependent on the properties of the constituent materials and asphalt concrete type used in the old pavement. Milled or crushed RAP can be used in a number of highway construction applications. RAP can be used as an aggregate substitute material, but in this application, it also provides additional asphalt cement binder, thereby reducing the demand for asphalt cement in new or recycled asphalt mixes containing RAP
Therefore, development of new scope of RAP materials is much needed. This study evaluate the design data and characteristics of RAP in subgrade soils.Some of the studies investigated the effect of RAP content in base materials on the resilience modulus (M_R). They found that M_R increases with RAP content. Permanent deformation was compared for specimen containing different percentages of RAP to evaluate the M_R.
From the above discussion, RAP can cause increase in the M_R of base materials and also the effect of RAP in natural soil is almost unknown and also this might be another scope of RAP utilization. Evaluation of engineering performance of subgrade material mixed with RAP is important for pavement design and new constructions. This study evaluates the modulus of subgrade considering the effect of RAP and moisture content at different stress levels in the laboratory.

2. LITERATURE SURVEY

2.1.Subgrade

The soil subgrade literature review presents a performance of optimum moisture content of the subgrade and the stabilization of the subgrade. For the purpose of this project, and based on the recent industry development.

2.1.1. Performance of Optimum Moisture Content of Subgrade

Muthupriya.P et al. (2017), observed, there is an appreciable improvement in the optimum moisture content and maximum dry density for the soil subgrade treated with the construction waste. In terms of material cost, the use of less costly admixtures can reduce the required amount of construction waste. subgrade soils had the greatest improvement with all soils becoming non plastic with addition of sufficient amounts of construction waste

2.2. Reclaimed Asphalt Pavement

The Reclaimed Asphalt Pavement literature review presents a physical property of the Reclaimed Asphalt Pavement, with the properties of asphalt content, asphalt penetration, CBR value.

2.2.1. Physical Properties of RAP

Brajesh Mishra, et al . (2909)studied a data relating the physical properties of RAP which is shown in Table 2.1

Table 2.1 Physical Properties of RAP

Unit Weight (Kg/m^3)	1900-2250
Asphalt Content	5-6%
Asphalt Penetration (%) at 25^{0}C	10-80
Compacted Unit Weight (Kg/m^3)	1500-1950
California Bearing Ratio	100% RAP:20-25%

2.2. Resilience Modulus of Pavement

The Resilience Modulus of Pavement literature review presents a fundamental property of resilience modulus, performance characteristics, relationship between RAP and resilience modulus, property of subgrade towards resilience modulus, variation of resilience modulus with respect to varied stress and load.

2.3.1. Fundamental Property of Resilience Modulus

Robert P. Elliot et al. (1986), describedResilience Modulus is a fundamental material property. It relates to pavement design and performance for the same reason that surface deflection relates. It provides a measure of the load-induced stress strain behaviour of the soil and granular base layers which in turn governs the load response of the pavement system

3. OBJECTIVES

To compare the Resilience Modulus of Soil for Subgrade without replacement of ReclaimedAsphalt Pavement and with replacement of ReclaimedAsphalt Pavement.

4. METHODOLOGY

Identifying the required representative soil or particular soil sample i.e., weak soil which is subjected to landslide, deformation, weak in strength and stability, undulations. Extraction of reclaimed asphalt pavement takes place by the milling process. Milling process includes removing/ extracting, crushing, screening and stockpiled. Milling is the controlled removal of an existing pavement materials.

Conduction of basic laboratory tests on representative soil sample and selected RAP includes Specific Gravity test according to IS:2720 (part 3) is needed in calculation of soil properties like void ratio, degree of saturation, bulk density, field density etc. Grain Size Analysis according to IS:2720 (part 4) is a practice to assess the particle size distribution or gradation of a granular material by allowing the material to pass through a series of sieves and weighing the amount of material that is stopped by each sieve as a fraction of the whole mass. It is conducted using mechanical sieve shaker.

Atterberg's limit test according to IS:2720 (part 5) a basic measure of the critical water contents of a fine-grained soil i.e., shrinkage limit, liquid limit, plastic limit. The consistency and behaviour of soil is determined. Proctor compaction test according to IS:2720 (part 8) method of experimentally determining the optimal moisture content at which a representative soil type will become most dense and achieve its maximum dry density. It is conducted compacting soil at known moisture content into a cylindrical mould of standard dimensions.

Further, for the Preparation of the sample for the laboratory triaxial test, representative soil sample is mixed at optimum moisture content where maximum dry density is achieved with varied RAP content like increasing 5%,10% 15% etc., for laboratory triaxial test according to AASHTO T-307 (American Association State Highway Transportation Officials) guidelines.

The triaxial test is carried out in a cell on a cylindrical soil sample having a length to diameter ratio of 2. The usual sizes are 76 mm x 38 mm and 100 mm x 50 mm. Three principal stresses are applied to the soil sample, out of which two are applied water pressure inside the confining cell and are equal. The third principal stress is applied by a loading ram through the top of the cell and is different to the other two principal stresses

Finally, analyzing test results and comparing the resilience modulus of soil for subgrade without replacement of reclaimed asphalt pavement and with replacement of reclaimed asphalt pavement and recommending optimum RAP content.

5. MATERIALS

It was necessary to undertake testing on the materials to check their suitability for use in the highway subgrade. This section contains the details regarding the procurement of materials and the various basic test conducted on the subgrade soil and reclaimed asphalt pavement.

5.1 Subgrade Soil

The sub-grade soil is excavated to a depth of 1 meter and collected near Varuna lake, T Narsipur Road, Mysore and simultaneously the basic test conducted on soil sample results is reported in Table 5.1

Table 5.1 Basic Test Results of Subgrade Soil

Basic Laboratory Tests	Results	IS Standards
1. Moisture content	8.24%	IS 2720[PART 2]- 1973
2. Grain size analysis Gravel Sand Silt and Clay	 34% 32% 34%	IS 2720[PART 1 AND 2]- 1980-1992
3. Specific gravity	2.56	IS 2720[PART 1 AND 2]- 1980-1992
4. Liquid limit (%)	30.5	IS 2720[PART 5]-1985
5. Plastic limit (%)	22.39	IS 2720[PART 5]-1985
6. Plasticity index	8.11	IS 2720[PART 5]-1985
7. Standard proctor test Maximum dry density (KN/m^3) OMC (%)	 19.42 10.4	IS 2720[PART 7]-1980/1987

5.2 Reclaimed Asphalt Pavement

The recycled asphalt pavement (RAP) is collected at(NH-150A) Pandavapura is shown in Fig 5.1 and the laboratory basic test results are tabulated in Table 5.2

Fig 5.1. Recycled Asphalt Pavement

Table 5.2 Basic Test Results of Recycled Asphalt Pavement

Basic Laboratory Tests	**Results**
Moisture Content	6.5
Specific Gravity	2.54

6.SAMPLE PREPARATION

Subgrade soil and RAP were collected as specified in materials. The triaxial test is carried out in a cell on a cylindrical soil sample having a length to diameter ratio of 2. The usual sizes are 76 mm x 38 mm and 100 mm x 50 mm. Where representative soil sample is mixed at optimum moisture content where maximum dry density is achieved with varied RAP content like increasing 5%,10% 15%, 20%, 25%, 30% by a certain number of blows for laboratory triaxial test according to AASHTO T-307 (American Association State Highway Transportation Officials) guidelines.

7.RESULTS AND DISCUSSION

Based on the triaxial test, the performance and characteristics of soil sample with replacement of RAP and without replacement of RAP, the comparative values of resilient of modulus with 0%, 5%, 10%, 15%, 20%, 25%, 30% of RAP is represented in Table 7.1

Table 7.1 Resilience Modulus with varied Percentage of RAP

Percentage of RAP	**Sample 1 (Kg/cm^2)**	**Sample 2 (Kg/cm^2)**	**Sample 3 (Kg/cm^2)**	**Average Resilience Modulus (Kg/cm^2)**
0%	30.63	36.32	26.58	31.18

5%	27.27	20.97	28.63	25.62
10%	27.25	26.39	28.95	27.53
15%	31.62	32.86	34.09	32.85
20%	24.42	22.30	26.23	24.35
25%	17.38	18.50	18.62	18.16
30%	14.53	16.13	13.55	13.55

7.1 Graphical Representation of Triaxial Test Results

The graphical Representation of the comparative values of Resilience Modulus with 0%, 5%, 10%, 15%, 20%, 25%, 30% of RAP is represented in fig 7.1.

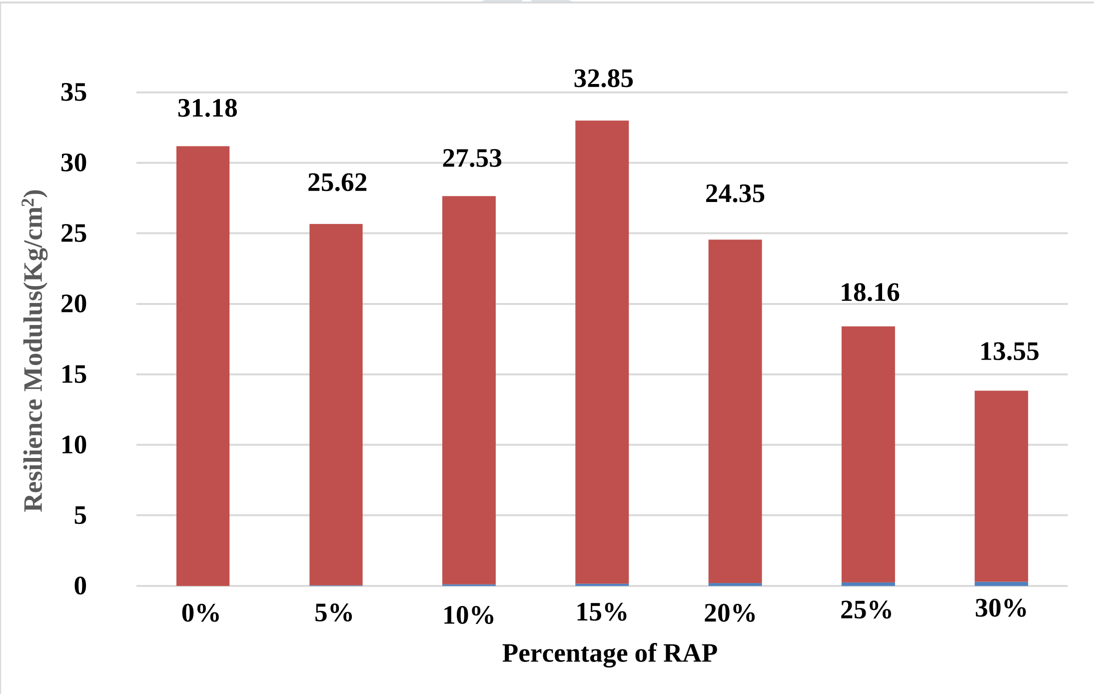

Fig 7.2 Graphical Representation of Resilience Modulus with varied RAP Content

8.FORMULA AND CALCULATIONS

Resilient Modulus = Deviator Stress / Resilient Strain

$$M_R = \frac{\sigma_1 - \sigma_3}{\Delta L/_L}$$

Where, σ_1 = Major Principal Stress

σ_2 = Minor Principal Stress

ΔL = Change in Length

L = Original Length

Calculations

Example 1: for 0% of RAP

$M_R = \frac{3.42-1}{\frac{0.6}{7.6}} = 30.63$

Example 2: For 15% of RAP

$M_R = \frac{3.14-1}{\frac{1.1}{7.6}} = 32.32$

8. Conclusions

The study evaluates the modulus of resilience considering the effect of RAP and moisture content at different stress levels in the laboratory. Based on the finding of the study the following conclusions are made:

- Improvement of stability of soil is achieved by adding RAP.
- Use of RAP in subgrade is cost effective than any other conventional materials.

The above-mentioned conclusions are based on laboratory test results conducted on a only one type of soil and RAP material of one source. For further generalization, wide variety of soils and RAP sources can be selected and tested in a study that can be pursued in a future research. The above findings can be useful to the researchers and practicing pavement engineers for initial understanding of effect of RAP in subgrade soil.

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