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An Experimental Study on effect of Reclaimed Asphalt Pavement on Bituminous Concrete Mix

Puneeth M S¹, Kavyashree R R², Dhanush B³, Ananya Nadig⁴, Anupriya Chandrashekar⁵,

Varun Kumar T J⁶

Assistant Professor, Department of Civil Engineering, BIT, Bangalore, Karnataka, India^{1, 2}

UG Students, Department of Civil Engineering, BIT, Bangalore, Karnataka, India^{3, 4, 5, 6}

ABSTRACT: The demand for the original aggregates from pits and quarries has been reduced by Reclaimed asphalt pavement (RAP). The energy required to produce the original aggregates and the energy required to transport it will also be reduced. Green House gases are reduced by Recycling which conserves the energy. The amount of wastes going to landfill also gets reduced by reusing the waste aggregates. Costs-in many cases are reduced, Reclaimed asphalt mix costs less than original aggregates.

Present Study provides a comparative statement between traditional and RAP based bituminous concrete mix. This investigation deals with aggregates and bitumen will be tested to meet the MoRT&H and IS standards. Marshall Method of mix design for traditional and RAP based bituminous mix will be used to prepare the Hot mix. Asphalt mixes with RAP material as partial or full replacement of materials respectively by weight of total fresh aggregates are prepared. Both the mixes are inspected for Moisture Susceptibility and Marshall Stability. From the obtained result the optimum percentage of materials are identified. Using Marshall and Moisture susceptibility properties, comparison is made between both mixtures.

KEYWORDS: RAP, Bitumen, Bituminous mix, MoRT&H, AASHTO, ASTM, Stability.

I. INTRODUCTION

Reclaimed asphalt pavement (RAP) is the term given to removed and/or reprocessed pavement materials containing asphalt and aggregates. These materials are generated when asphalt pavements are removed for reconstruction, resurfacing, or to obtain access to buried utilities. When properly crushed and screened, RAP consists of high quality, well-graded aggregates coated by asphalt cement.

The demand for sustainable and environmentally sound roads will increase in the future. One way to construct environmentally sound roads is through the use of recycled materials. Recycled materials have seen increasingly more use in the past 20 years.

Dr A. Veeraragavan (Indian Road Congress 2012)(1), conducted an investigation on laboratory performance of bituminous mixes with RAP materials and concluded that use of RAP results in 78% of reduction in Optimum Bitumen Content (OBC) and also higher resistance to rutting when compared to conventional mix.

Dr R. Sathikumar (National Technological Congress 2011)(2), conducted on Reclaimed Asphalt Pavement Technology for a Sustainable Pavement and concluded that the resilient modulus and Marshall Stability values were higher for the virgin mixtures than the RAP mixtures. The cost of construction using recycled mix was economical compared to virgin mix.

II. MATERIALS AND METHODOLOGY

a) Sample collection

Aggregates of size 20 mm down, 12mm down, 6 mm down and dust were collected from Magadi Taluk, Ramanagara District. RAP is collected from Somanathapura, Nice Road.

The engineering properties of materials were justified according to the procedure specified by IS Code-2386, Part-IV and Part -III standards(8). Aggregates, dust and RAP are blended together to provide satisfactory gradation (varying the percentage of RAP starting from 0% at a further interval of 10%) for Marshall mix specimens as per Grade-I mix, Section 500, MoRT&H -2001(14).



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The engineering properties of bitumen were justified according to the procedure specified by IS Codestandards(9),(10),(11),(12),(13). In order to study the effect of RAP on the behaviour of bituminous mix, Marshall Test specimens were prepared with five different RAP (e.g. 0%, 10%, 20%, 30% & 40% by weight of total aggregate and filler) with 75 blows according to standard procedure. Optimum Bitumen Content (OBC)(3),(4),(5),(6). Were determined for each percentage of RAP mix.

b) Preparation of Marshall test specimen:

The coarse aggregates, fine aggregates and the filler materials were proportioned and mixed to obtain specified gradation of mineral aggregates and bitumen binder as per requirement of MoRT&H.

Test	Result	MoRT&H Specification	Remarks	
Aggregate Impact Value	22.76%	24% max	Satisfactory	
Los Angeles Abrasion	26.80%	30% max	Satisfactory	
Aggregate Crushing Value	29.45%	30% max	Satisfactory	
Specific Gravity				
• 20mm down	2.70			
• 12mm down	2.68	2522		
• 6mm down	2.67	2.5-3.2	Satisfactory	
• Dust	2.65			
• RAP	2.60			
Water absorption				
• 20mm down	1.9			
• 12mm down	1.8	not greater than 2%	Satisfactory	
• 6mm down	1.6			

Table 1: Basic Aggregate Test Result

 Table 2: Tests on Bitumen

Physical Properties of (80/100) Penetration Grade Bitumen (MoRT&H, 2001) Property Tested	Test Method	Results	Requirements as per MoRT&H
Penetration (100 gram, 5 seconds at 25°C) (1/10th of mm)	IS 1203-1978	89	80 - 100
Softening Point, °C(Ring & Ball Apparatus)	IS 1205-1978	56	Min 47
Ductility at 27°C (5 cm /minute pull), cm	IS 1208-1978	90	Min 75
Specific Gravity	IS 1202-1978	1.03	0.98-1.02
Flash point, °C	IS 1208-1978	256	min 220°c
Fire Point, °C	IS 1208-1978	280	-

The required quantity of the mix was taken so as to produce a compacted bituminous mix specimen of thickness 63.5mm approximately. Nearly 1100g of aggregates and filler was taken and heated to a temperature of 170°C to 190°C.



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The compaction mould assembly and rammer was cleaned and kept pre- heated to a temperature of 100° C to 145° C. The bitumen was heated to a temperature of 121° C to 138° C and the required quantity of first trial % of bitumen say, 3.0% by weight of mineral aggregate was added to the heated aggregate and thoroughly mixed using a mechanical mixer. The mixing temperature for 80/100 grade bitumen was around 154° C. The mix was placed in a mould and compacted by rammer, with 75 blows on either side. The compacting temperature was about 138° C. The compacted specimen thickness was 63.5mm. The weight of aggregate was taken may be suitably altered to obtain a thickness of 63.5 ± 3.0 mm. Three specimens were prepared at each trial. Bitumen content which may be varied at 0.5%, incremented up to about 3.0 to 5.5%. Marshall Stability test was performed under loading range 10N to maximum 25kN.

Then Marshall Specimens were prepared for non conventional mix by adding 0%, 10%, 20%, 30% and 40% RAP by the total weight of aggregate and filler. Three specimens were prepared for each percentage of RAP by varying bitumen content and OBC is determined for each percentage of RAP. Marshall Stability test was performed under loading range 10N to maximum 25kN.

Moisture susceptibility test were conducted (i.e. ITS- Indirect Tensile Strength and RTS- Retained Strength⁽¹⁵⁾, six specimens were prepared for each percentage of RAP mix at their respective OBC.



Figure 1: Prepared moulds for testing

II. RESULTS AND DISCUSSION

The study compared the performance of bituminous concrete mixtures: (1) Mix of conventional material (2) Mix of conventional with non conventional material.

On the basis of the literature review and laboratory testing conducted in this study, the following results were drawn and discussed.

- The OBC of samples prepared using Marshall Apparatus, for 100% conventional bituminous mixes were found to be 4.50% and for 10%, 20%, 30% & 40% non conventional bituminous mixes were found to be 4.42%, 3.7%, 4.09%, 3.9%.
- The air voids per cent is 4% for conventional mix and 4.01%, 6%, 4.8%, 2.4% for non conventional mixes at OBC. The value is well within the limit for conventional mix, as we go on increasing in the RAP content air voids is increased.
- The Marshall Stability is significantly increasing as we increase the percentage of RAP. But the values are falling well within the limit as per MoRT&H specifications. The Marshall stability of 10% RAP was found to be 1.166 times that of conventional mix, the Marshall stability of 20% RAP was found to be 1.208 times that of conventional mix, the Marshall stability of 30% RAP was found to be 1.518 times that of conventional mix, the Marshall stability of 20% reactions and the Marshall stability of 40% RAP was found to be 1.55 times that of conventional mix, when compared at OBC.
- Although the Marshall properties were better for the non conventional mixes. When subjected to Retained Strength test the performance of non conventional mixes was found to be slightly on the lower sides compared to conventional mix. The Retained Strength of 10% RAP was found to be 0.97 times conventional mix, the Retained Strength of 20% RAP was found to be 0.94 times that of conventional mix, the Retained Strength of 30% RAP was found to be 0.94 times that of conventional mix, the Retained Strength of 40% RAP was found to be 0.92 times that of conventional mix, the Retained Strength of 40% RAP was found to be 0.92 times that of conventional mix, the Retained Strength of 40% RAP was found to be 0.92 times that of conventional mix, when compared.



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• The Tensile Strength Ratio also was found to be decreasing for non conventional mixes when compared to conventional Mixes. The TSR of 10% RAP was found to be 0.967 times of that of conventional mix, the TSR of 20% RAP was found to be 0.945 times of that of conventional mix, the TSR of 30% RAP was found to be

0.89 times of that of conventional mix, the TSR of 40% RAP was found to be 0.835 times of that of conventional mix, when compared.

• It is found that Non Conventional mixes perform satisfactory in the normal condition when compared to Conventional mix. But from the results of TSR and RTS they seem to be little more susceptible in moisture.

Expected Marshall roperties at OBC	0% RAP or 100% Conventional material	10% RAP	20% RAP	30% RAP	40% RAP	MoRT&H Specification
Marshall Stability (kN)	15.8	18.43	19.1	24	24.6	min 8.2 kN
Density (gm/cc)	2.27	2.34	2.31	2.37	2.327	_
Volume of Voids,Vv (%)	4	4.01	6	4.8	2.4	2-4(%)
Vb (%)	10.03	9.98	10.8	12.8	14.2	_
VMA (%)	14.03	14	16.8	17.5	16.5	min 15 (%)
VFB (%)	71.48	71.4	65	73	85	65-78
Flow (mm)	5.14	4.25	4.2	3.5	3.4	2-4 (mm)

Table 3: Comparison of Marshall Properties

Table 4: Comparison of RTS and TSR (Tensile Strength Ratio)

Properties	0% RAP or 100% Conventional material	10% RAP	20% RAP	30% RAP	40% RAP	Specification
RTS (%)	90.01	88.03	85.17	85.05	83.42	> 80% as per ASTM D-075
TSR	0.91	0.88	0.86	0.81	0.76	>0.80 as per AASHTO T-283

III. CONCLUSION

RAP, up to 40% can be used without any major difficulties as most of the marshal properties were still well within the acceptable limits of MORTH. However maintaining the volume of voids is one of the major problem, since volume of voids is ever fluctuating, rutting and fatigue behaviour of the RAP specimens are to be considered before high percentage of RAP material is used in a live project. The present research recommends up to 40% of RAP usage subjected to rutting and fatigue performance. Further studies are highly recommended to identify the behaviour of RAP at higher percentages.

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