Using Reclaimed Asphalt Pavements in Bituminous Mix

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ABSTRACT

Reclaimed Asphalt Pavements (RAP) obtained from demolished road utilized in hot mix asphalt blends has developed into a standard practice in numerous nations around the globe. Utilization of these materials in the past has end up being environment friendly as well as economical. Fusing RAP in virgin materials has been preferred over virgin materials in the light of the increasing cost of bitumen, shortage of good aggregates, shortage of bitumen binder and constraining need to safeguard the environment. The utilization of RAP is viable in improving the performance which is similar to fresh blends. . This study was done so as to learn quality of bituminous blend in surface course utilizing various percent of RAP and to discover optimum percent of RAP for BC course. For this study, RAP was collected from the road in the region of Bhilwara. At first the amount of RAP and new aggregates are to be mixed so that the resultant gradation of aggregates complies with the BC according to MORTH and the amount of bitumen binder are changed in accordance to fulfill the desired or ideal amount of the objective blend utilizing the soft grade bitumen without utilizing any rejuvenator.

To assess the strength and other designing attributes of RAP, like grading, binder content and so on, different laboratory tests were carried out. Preparation of test samples of bituminous blend for BC (Bituminous cement) were done with virgin material by Marshall Method by utilizing various extents of RAP percent as 25, 30, 35 and 40%. By and large from this study it was concluded that RAP 35% indicated results like that of virgin bituminous blend and best execution among other RAP percent.

1. INTRODUCTION

At present, incredible accentuation is set on sustainable infrastructure and construction. By utilizing RAP the expense of project is marginally diminished and it additionally favorably affects ecological effect. With expanded interest and constrained availability of aggregates and binder, HMA makers have started utilizing RAP as an important part in HMA. Thus, there has been reestablished enthusiasm for expanding the measure of RAP utilized in HMA.

The utilization of RAP additionally conserves energy, brings transportation costs required down to acquire quality virgin aggregates and binder. RAP is a rising technique in India which requires more consideration and testing. An attempt has been made in this study to determine the optimum percent of RAP in Bituminous Concrete and the cost reduction due to same.

2. RECLAIMED ASPHALT PAVEMENT:

RAP is characterized as evacuated pavement materials containing asphalt and binder. For resurfacing or reconstruction of pavement the removed asphalt pavement produces RAP. When appropriately squashed and screened, RAP comprises of well graded aggregates with asphalt coating on it. Sample collected for this study is shown in fig1.

Fig 1: RAP sample

The reclamation of asphalt material can be done using hot or cold process. Hot process reclamation is applicable only in Hot in-place recycling (HIR) while Cold Process reclamation can apply to all other recycling processes (*IRC:SP:120-2015*).

3. MARSHALL MIX DESIGN:

Reasonably designed bituminous mix will withstand substantial traffic load under antagonistic climatic conditions and furthermore satisfy the surface and structural characteristics of pavement. The target of the design of bituminous blend is to decide an affordable mix through a few preliminary blends. The binder content and gradation of aggregates ought to be with the end goal that the resultant mix ought to fulfill the following conditions.

- Adequate binder to guarantee a durable pavement by giving a water sealing covering on the aggregates and restricting them together under appropriate compaction.
- Enough stability for giving protection from disfigurement under sustained loads. This obstruction in the blend is acquired from aggregates interlocking and union which for the most part creates because of binder in the blend.
- Adequate flexibility to resist bending, deflection without any cracking in pavement and with appropriate amount of binder and its proper grade this flexibility can be achieved.
- Sufficient voids in the absolute compacted blend to give space to extra compaction under traffic stacking.
- Sufficient workability which helps in increasing efficiency of construction operation in laying the pavement.

There are three head bituminous mix design techniques. They are Marshall Method, Hveem Method and Superpave Method. Marshall Method is the generally utilized technique all through India. In this technique load is applied to a cylindrical specimen of bituminous blend and the specimen is observed till its failure as indicated in the ASTM standard (ASTM D1559). For this study, the bituminous mix is planned utilizing the Marshall Method and showed up at the volumetric properties.

Applicable standards

The Marshall test procedures have been standardized by the American Society for Testing and Materials (ASTM) and by the American Association of State Highway and Transportation Officials (AASHTO).

Procedures are given by:

- ASTM D6926, "Preparation of Bituminous Mixtures Using Marshall Apparatus";
- ASTM D6927, "Standard Test Method for Marshall Stability and Flow of Bituminous Mixtures";
- AASHTO T 245, "Resistance to Plastic Flow of Bituminous Mixtures Using Marshall Apparatus."

(SOURCE:MS 2,7thedition)

4. LITERATURE REVIEW

Jashanjot Singh et al. (2015) evaluated the mix to find optimum percent of rap which can be used with same physical and strength parameters as virgin bituminous mix. **Sunil S et al. (2014)**

conducted various laboratory tests and concluded that rap mixes shows comparable results with conventional mixes and ensured that recycling of pavement is a valuable approach for environmental, economic and technical benefits. **Munir D. Nazzal et al. (2014)** illustrated the rap binder use by evaluation of its properties on microstructure and its degree of blending with virgin binder. **Abdulshafi et al. (2002)** reported that the RAP binder totally mixes with virgin bitumen in the blend delivered. Different researchers have explored the best possible strategies for using RAP and the related execution of HMA fusing reused materials. Results have been broadly blended and no reasonable end can be drawn from past research ventures. While a few specialists have discovered that HMA fusing RAP give mediocre weakness and warm execution when contrasted and virgin blends **(Tam et al. 1992, McDaniel et al. 2000),** others have revealed that the utilization of RAP improves the rutting execution of HMA **(Sargious and Mushule 1991, Huang et al. 2004**). **Sireesh Saride et al. (2016)** studied on replacement of high percent of virgin aggregate with rap in base course of low volume roads. He concluded that it is economical to use RAP as thickness of base layer gets reduced by 50 % in comparison with conventional mix. A few studies have been completed with 100% reusing of materials. 100% reusing can give genuine sustainability by shutting the materials cycle and to permit utilization of reclaimed asphalt in a similar high worth application as that of traditional asphalt **(Mhlongo, S.M., et al. 2014)**. **Brajesh Mishra (2015)** reported 25 to 30% cost reduction is possible by reusing the recycled aggregate at the same site. Best results were obtained with 30% rap and 70% natural aggregate. **L.B. Zala et al.(2018)** mentioned the benefits of using rap materials, methods of recycling of existing bituminous pavement and the processing of rap materials.

Siksha Swaroopa KAR et al. (2017) concluded that the mix with 50% rap gave higher resilient modulus and tensile strength ratio. **Ashraf Elshahat et al.(2014)** Investigated the use of recycled aggregate material and found that with the higher % of rap in mix optimum asphalt content of mix decreases. 30% rap mix gives superior performance after construction. **Fereidoon Moghadas Nejad et al. (2014**) evaluated permanent deformation of warm mix asphalt with varying percent of rap from 0%,15%,30%,50%,60% and concluded that 50% rap replacement of virgin aggregate by rap satisfies the minimum permissible strength of 70%. **Kandhal et al. (1995)** contrasted the exhibition of reused with virgin HMA asphalts in the province of Georgia. A RAP rate between 10 to 25% use demonstrating that both reused and virgin blends performed similarly well. **Huang et al. (2004)** reported that the incorporation of RAP materials improved the fatigue life of HMA.

5. METHODOLOGY

5.1 COLLECTION OF SAMPLE

In this study the RAP sample was collected from the Gaurav Path road in Bhilwara city Rajasthan. This state highway was constructed 15 years ago connecting Bhilwara to Ajmer.The RAP sample was taken from surface course, bituminous concrete and the fresh material used in this study was taken from PWD department.

5.2 QUALIFICATION TESTS FOR MATERIALS USED

Test for the physical properties of fresh aggregate and the rap aggregates performed to check the suitability of recycling the rap aggregates. The rap binder was extracted from centrifuge extractor by extraction method and was tested for its physical properties to check the specifications required for bituminous mix.

5.3 GRADATION

Gradation table for bituminous concrete virgin mix prepared through job mix formula according to table 500-17 as given in "SPECIFICATIONS FOR ROAD AND BRIDGE WORKS", MORTH (fifth revision), 2013. Samples were prepared with varying percent of rap in virgin mix according to specification required for combined grading mix.

5.4 MARSHALL STABILITY TESTS

samples with varying bitumen content and different percent of rap prepared and detailed analysis conducted to determine the variation of volumetric properties of mix according to change in percent of rap and along with the optimum asphalt content for designing the pavement determined.

6. RESULTS AND DISCUSSION

6.1 MARSHALL TEST:

Test conducted on all the samples (S1, S2, S3, S4, S5) for the mix design and with the help of graphs results and comparisons between all the mix are explained further.

6.1.1 DENSITY:

It is seen that fresh bituminous mix has the greatest density of all the samples with varying RAP percentages. It is likewise observed that the Optimum Binder Content was not changed in any of RAP blends and for fresh bituminous blend as well i.e at 5.8 %. This demonstrates the binder in RAP materials entirely mixed with virgin binder. At 5.8% binder content density of virgin bituminous blend is seen a 2.369 when contrasted with 2.364 which is the maximum value

of density in all samples with RAP which is of 35% RAP mix and the variation is considerable. the variation in maximum density is between 2.356 to 2.363 which is again insignificant. Marginally more than density of RAP 35 % by 0.21%.

The relationship between mix density content and RAP % (R) is as follows:-

$y = -3.613x^3 + 2.497x^2 - 0.448x + 2.369$ $R^2 = 0.985$

Where,Y=desnsity X=rap%

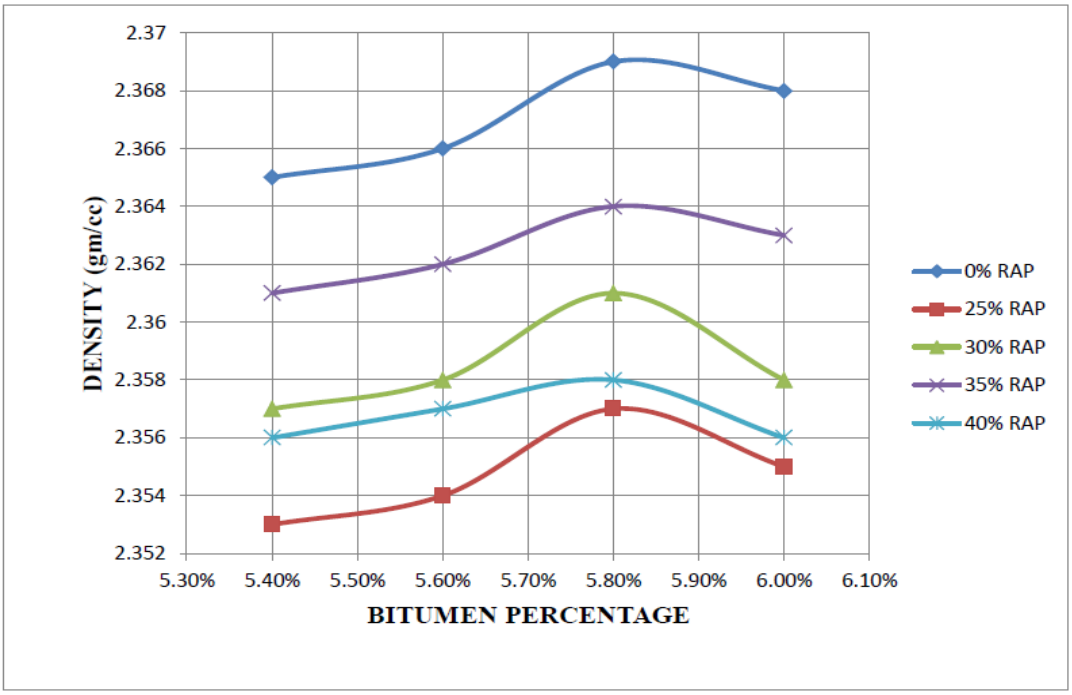

Fig 2: Density v/s Bitumen percentage

6.1.2 MARSHALL STABILITY:

It is seen that the Marshall Stability esteems for fresh bituminous mix are more than any of RAP mix. RAP 35% has values almost equivalent to that of virgin bituminous blend and has best density values among all other RAP blends. At 5.8% bitumen content the Marshall Stability estimation of new bituminous blend was seen as 1460 kg when contrasted with 1429 kg which was the highest value determine correspondingly to RAP content 35%. This distinction is immaterial. The general variation of maximum stability values for different RAP samples s was between 1188 kg to 1429 kg, which is again not a huge difference. All the stability values of all the samples (S1, S2, S3, S4, S5) were over the base required range (least 9kN) which is mentioned in table 500-11 in SPECIFICATIONS FOR MORTH (fifth modification), by Indian Roads Congress. The relationship between blend stability and reused percent is as per the following:

$y = -10898x^3 + 75434x^2 - 13125x + 1460$ $R^2 = 0.998$

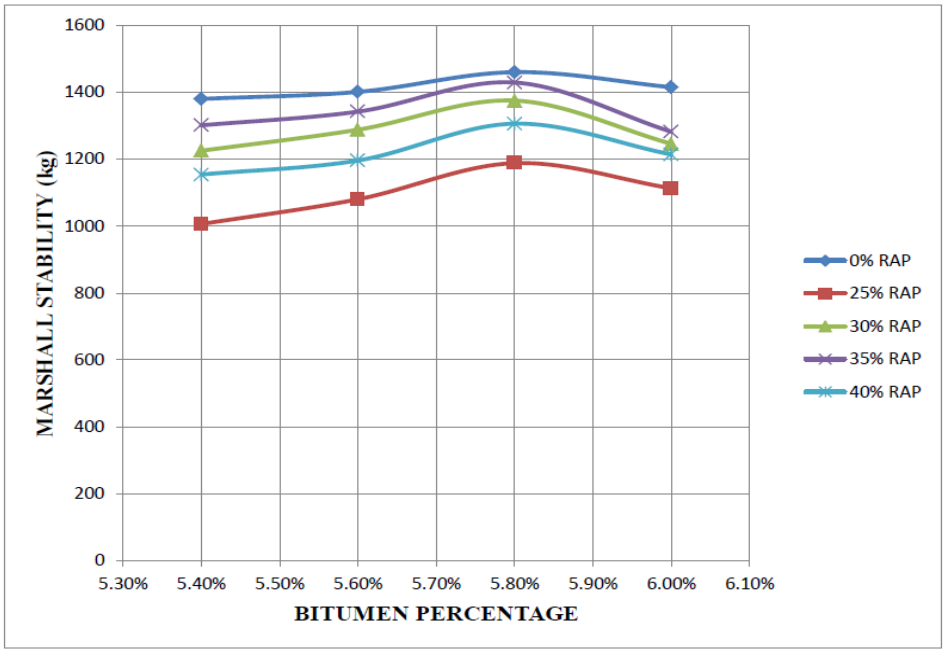

Fig 3: Marshal Stability v/s Bitumen Content

6.1.3 FLOW VALUE:

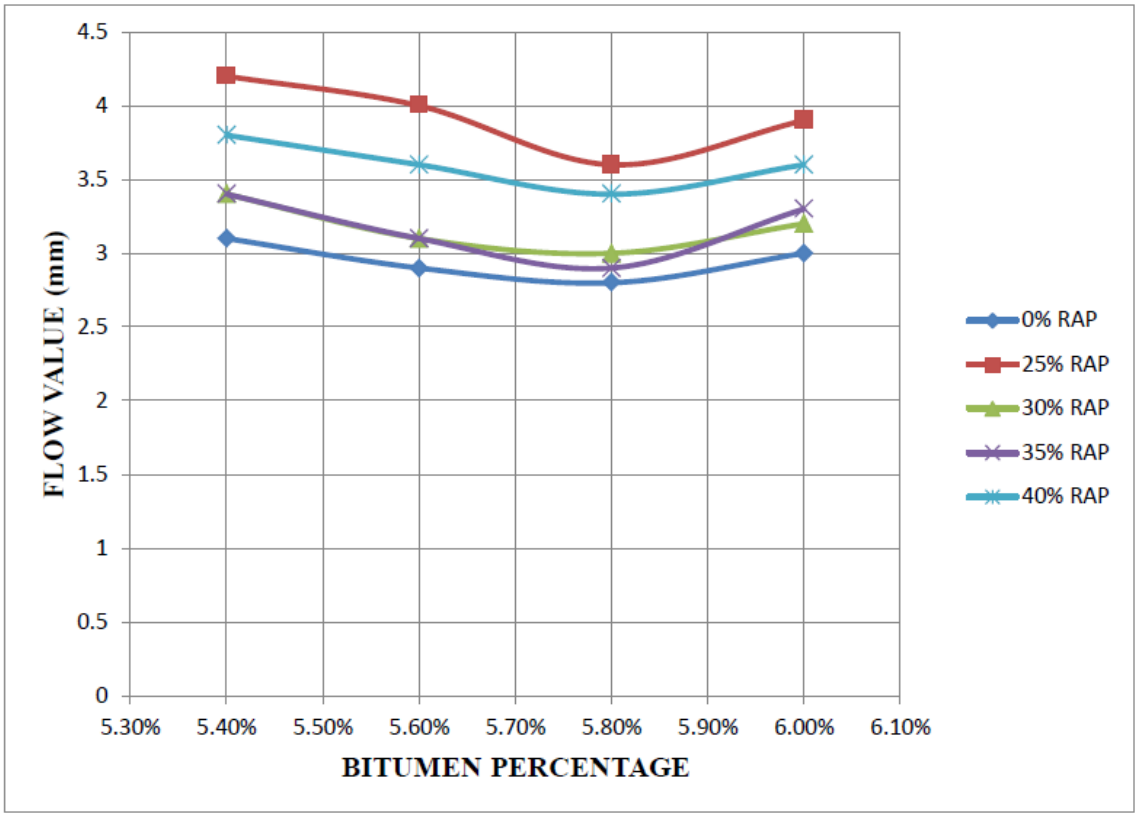

Fig 4: Flow Value V/S Bitumen percentage

It is seen that RAP 25 % had maximum flow value among all samples followed by RAP 40%, RAP 30%, RAP 35 % and virgin bituminous blend. Virgin bituminous blend had least flow value out of all blends. At 5.8% bitumen content the flow value of virgin bituminous mix was seen as 2.8mm when contrasted with 2.9 mm which was the base value estimated correspondingly to RAP content 35%. This distinction is less. Additionally, all the flow values of virgin bituminous blend and RAP blends aside from RAP 25% were inside the necessary range (2mm - 4mm) as determined in table 500-11 in SPECIFICATIONS FOR MORTH (fifth modification), by Indian Roads Congress. The connection between blend flow value and RAP percent is as per the following.

$y = 369.4x^3 - 251.0x^2 + 42.82x + 2.800$ $R^2 = 0.996$

Where, Y= Flow Value & X= RAP %

7. CONCLUSIONS

It is seen that the RAP materials in mix to virgin aggregates in various extents can be successfully used in the wake of blending to facilitate the fundamental assessing as indicated by MORTH in the surface course of pavement. The optimum bitumen content for RAP blends was same as that of virgin blend. This plainly shows there is no change in optimum bitumen content for RAP Mixes. Densities of virgin blend were marginally higher than that of RAP 35%(2.363g/cc) by 0.21% followed by RAP 30 %(2.360g/cc), RAP 40% (2.357g/cc) and RAP 25%(2.356g/cc). The Marshall Stability estimations of virgin blends were seen as more noteworthy than RAP 35% (1429 kg) followed by RAP 30%(1375 kg), RAP 40%(1306 kg) and RAP 25%(1188 kg). At optimum bitumen content it is seen that RAP 25% (3.6mm) had the greatest flow value followed by RAP 40%(3.4 mm), RAP 30%(3 mm), RAP 35%(2.9 mm) and virgin bituminous blend. Virgin bituminous blend had least value out of all blends. Over all the issue of removal of RAP squanders can be effortlessly settled and unfavorable impact on condition may be kept away from by utilizing the RAP materials in pavement development.

8. REFRENCES

- Al-Qadi, I.L., Elseifi, M. and Carpenter, S.H., 2007. *Reclaimed asphalt pavement—a literature review*.
- Dal Ben, M. and Jenkins, K.J., 2014. Performance of cold recycling materials with foamed bitumen and increasing percentage of reclaimed asphalt pavement. *Road Materials and Pavement Design*, *15*(2), pp.348-371.

- Kamariya, U., Zala, L.B. and Amin, A.A., 2018. Utilization of Reclaimed Asphalt Pavement (RAP) Materials: A Synthesis Report.

- Kar, S.S., Swamy, A.K., Tiwari, D. and Jain, P.K., 2018. Impact of recycled asphalt pavement on properties of foamed bituminous mixtures. *Baltic Journal of Road and Bridge Engineering*, *13*(1), pp.14-22.
- Kennedy, T.W., Tam, W.O. and Solaimanian, M., 1998. *Effect of reclaimed asphalt pavement on binder properties using the superpave system* (No. FHWA/TX-98/1250-1). University of Texas at Austin. Center for Transportation Research.
- Kuna, K., Airey, G. and Thom, N., 2017. Mix design considerations of foamed bitumen mixtures with reclaimed asphalt pavement material. *International Journal of Pavement Engineering*, *18*(10), pp.902-915.
- Mishra, B., 2015. A Study on Use of Reclaimed Asphalt Pavement (RAP) Materials in Flexible Pavements. *International Journal of Innovative Research in Science, Engineering and Technology*, *4*(12), pp.12170-12177.
- Mohamady, A., Elshahat, A., Abd-Elmaksoud, M.F. and Abdallah, H.A., 2014. Effect of Using Reclaimed Asphalt Pavement on Asphalt Mix Performance. *IOSR Journal of Computer Engineering (IOSR-JCE)*, *16*(6), pp.55-67..
- Musselman, J., 2009. High RAP Performance in Florida. *HMA Recycling Expert Task Group, Department of Transportation, Washington, DC. Obtained from: http://www. morerap. us/12-09/Musselman. High_RAP_Performance_Florida. pdf. Site last accessed July*, *24*, p.2012.
- Rao, M. and Shah, N.C., 2014. Utilisation of RAP (Reclaimed Asphalt Pavement) Material Obtained By Milling Process: With Several Options in Urban Area at Surat, Gujarat, India. *International Journal of Engineering Research and Applications., ISSN*, pp.2248-9622.
- Robinson Jr, G.R., Menzie, W.D. and Hyun, H., 2004. Recycling of construction debris as aggregate in the Mid-Atlantic Region, USA. *Resources, Conservation and Recycling*, *42*(3), pp.275-294
- Singh, J. and Duggal, A.K., 2015. An Experimental Study on Reclaimed Asphalt Pavement In Bituminous Concrete. *International Journal of Modern Trends in Engineering and Research (IJMTER)*, *2*(08).

- Sunil, S., Mallesh, K.M. and Chandrasekaraiah, T., 2014. Experimental investigations on the performance of bituminous mixes with reclaimed asphalt pavement (RAP) materials (case study Tumkur to Chitradurga-NH4). *International journal of Research in Engineering and Technology*, *3*(6), pp.297-303.

- West, R., 2008, July. Summary of NCAT survey on RAP management practices and RAP variability. In *Meeting of the FHWA RAP Expert Task Group, Phoenix, AZ*.
- West, R.C. and Willis, J.R., 2014. *Case Studies on Successful Utilization of Reclaimed Asphalt Pavement and Recycled Asphalt Shingles in Asphalt Pavements* (No. NCAT Report 14-06).
- "SPECIFICATIONS FOR ROAD AND BRIDGE WORKS",MORTH (fifth revision), published by Indian Road Congress
- ASTM D 6927, " Test Method for Marshall Stability and Flow of Bituminous Mixtures", American society for testing and materials
- Indian Standard, " Paving Bitumen Specification (4th revision)" , IS 73:2013, Bureau of Indian Standard , New Delhi
- Indian Standard, " Method for Test for aggregates for Concrete", IS 2386 (Part 1 and part 2), Bureau of Indian Standard, New Delhi
- Indian Road Congress, "Aggregate Grading and Bitumen Content", IRC 111:2009, Indian Road Congress, New Delhi.