International Journal of Engineering Technology and Management Sciences
Website: ijetms.in Issue: 5 Volume No.6 Aug-Sept – 2022
DOI:10.46647/ijetms.2022.v06i05.108 ISSN: 2581-4621

Evaluation of pavement materials for Dense Bituminous Macadam layer using Reclaimed Asphalt Pavement (RAP)

Dr Dwaitha Jagadish[1], Dimple Bahri[2], Dr Gopalakrishna[3], M.Durga[4], Dr Dasarathy A K[5]
[1] *Assistant Professor, Civil Engineering, FET, Jain Deemed to be University, Kanakpura Taluk, Ramnagara, Karnataka*
[2] *Assistant Professor, Civil Engineering, FET, Jain Deemed to be University, Kanakpura Taluk, Ramnagara, Karnataka*
[3] *Assistant Professor, Civil Engineering, FET, Jain Deemed to be University, Kanakpura Taluk, Ramnagara, Karnataka*
[4] *Assistant Professor, Civil Engineering, Samskruti college of engineering and technology, Kondapur, Telangana*
[5] *Professor, Civil Engineering, FET, Jain Deemed to be University, Kanakpura Taluk, Ramnagara, Karnataka*

ABSTRACT
As a sustainable and eco-friendly alternative to fresh or new materials for road construction and maintenance, recycled or reclaimed asphalt pavement (RAP) is being used more frequently. There are no specific criteria, norms, or methods for identifying recovered asphalt materials in India or other developing nations. Classifying the RAP materials that are now accessible for use in road construction is therefore urgently necessary. Costs associated with highway projects can be cut by 25–30% by reusing these materials. There have been some reported studies in India where new materials were swapped out for RAP in the binder course, but there are undoubtedly many more that have not yet been documented. The goal of the current experiment is to determine the aggregate mix percentage for DBM layers with various percentages of RAP. The RAP sample was taken from the NH209 Kanakpura Road.
Keywords—RAP, recycled aggregate, percentage, DBM

1. Introduction

The United States Federal Highway Administration (FHWA) estimates that 100.1 million tons of asphalt pavements are milled each year in rehabilitation and road widening projects [1]. Of this quantity, 80.3 million tones will be recovered and reused for road beds, shoulders and embankments [1]. In the US, more than 73 million tons of RAP are processed each year, most of which is reused in road construction [2]. RAP can be used as a granular base material in paved and unpaved roads, parking lots, bike lanes, gravel road reconstruction, shoulders, driveways, trench fill and culvert fill [3]. Peter Stephanos, Director of the FHWA Office of Pavement Technology, stated that most state TODs have recently been seriously considering the economic and environmental benefits of using RAP on a larger scale and addressing the challenges of maintaining quality road infrastructure. [4]. The United States National Highway System requires the construction and major remodeling of freeways to meet increasing traffic demands and keep drivers safe [5]. The maintenance and rehabilitation of this extensive network of highways uses large amounts of natural resources and energy, produces large amounts of waste, and generates significant amounts of greenhouse gas emissions [6].

A good road network is the key to the economic and social development of a country. In India there is a road network approximately 4.2 million kilometers in length, which ranks second in the world after US It is necessary to maintain the previously built roads along with new road construction. Both the construction and maintenance of roads lead to an overexploitation of the resources of aggregates [7]. Most of the roads in India are bituminous surfaced pavements. Apart from resource depletion and environmental problems, these roads are regularly re-paved as maintenance measures aimed at bringing the roads to a higher level than compared to the original level of roads and adjacent land and

International Journal of Engineering Technology and Management Sciences
Website: ijetms.in Issue: 5 Volume No.6 Aug-Sept – 2022
DOI:10.46647/ijetms.2022.v06i05.108 ISSN: 2581-4621

structures [8]. Recycled or Reclaimed Asphalt Pavement (RAP) is increasingly being used to replace fresh or new materials for road construction and maintenance as a sustainable and environmentally friendly solution to overcoming these problems. RAP can be used in different layers of flexible and rigid coatings [9].

2. Objectives and Methodology

- To determine the design mix for DBM (Dense Bitumen Macadam) layer using Rothfutch method
- To determine the OBC (Optimum Binder Content) for the bitumen used for the DBM layer
- To study the performance of Reclaimed Asphalt Pavement when it is mixed with new Bitumen..

2.1 Methodology

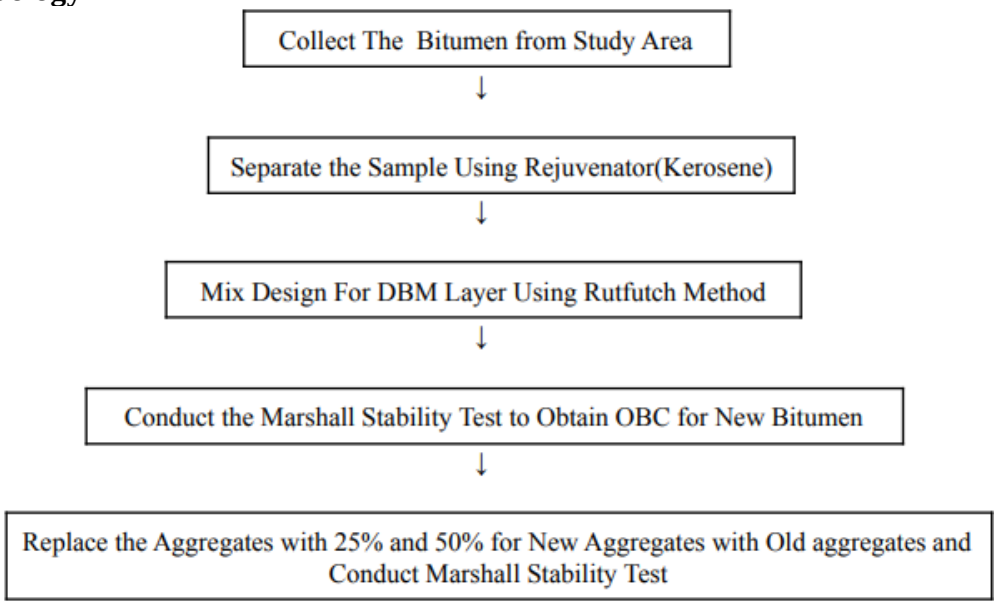

Fig. 1. Methodology

Collect the Bitumen mix sample from study area ie. Jain (The sports School), separate the aggregates and bitumen by using suitable rejuvenators ie. Kerosene for the collected sample after that we have done mix design for DBM layer (2nd Layer of road) using Rutfutch method and conduct Marshall Stability test for new bitumen mix as shown in fig 2

Fig. 2. Collecting Sample from TSS kanakapura road

2.2 Materials Used

2.2.1 Bitumen

Bitumen is a complex mixture of components with various chemical structures composed of Hydrocarbon, Oxygen, Sulphur and Nitrogen. The most common model used to describe the structure of bitumen is the Micellar Model and to understand this model, the hydrocarbon and heteroatom are further subdivided. This compound is classified as saturates, aromatics, resin or asphaltenes. This is

International Journal of Engineering Technology and Management Sciences
Website: ijetms.in Issue: 5 Volume No.6 Aug-Sept – 2022
DOI:10.46647/ijetms.2022.v06i05.108 ISSN: 2581-4621

an exciting development of growing importance due to the ability of modem technology to satisfy the demands of the bitumen market internationally.

2.2.2 Aggregates

Aggregate samples of sizes 26.5 mm down 19 mm, 12.5 mm down and Quarry dust are collected from the crusher and RAP materials from the field and sampled aggregates are characterized for the following properties as per MORTH specification.

2.2.3 Reclaimed Asphalt Pavement

Reclaimed Asphalt Pavement (RAP) is the term given to removed and or / processed materials containing asphalt and aggregate. These materials are generated when asphalt pavements are removed for construction, resurfacing, or to obtain access to buried utilities.

2.3 Marshall Stability test

This test method is used in the laboratory mix design of bituminous mixtures. Specimens are prepared in accordance with the method and tested for maximum load and flow. Density and voids properties may also be determined on specimens prepared in accordance with the method. The testing section of this method can also be used to obtain maximum load and flow for bituminous paving specimens cored from pavements or prepared by other methods. These results may differ from values obtained on specimens prepared by this test method.

Marshall Stability test was carried out on bituminous concrete with varying bitumen Content for 80/100. It was adopted in investigations to determine the Optimum Binder Content (OBC) with emphasis on maximum stability, maximum unit weight and 4 percent voids or 75 percent voids filled with bitumen. In this test an attempt is made to obtain optimum binder content for bituminous concrete mix.

2.4 Preparation of the specimen for Marshall Stability Test

- **Aggregates selected:** Approximately 1200 g of aggregates are taken and heated to a temperature of 175º to 190ºC. The compaction mould assembly is cleaned and kept pre-heated to a temperature of 100ºC to 145ºC, as shown in fig 3.

Fig. 3. Weighing the proportioned aggregates for DBM

- **Mixing of aggregates with bitumen.** The required quantity of bitumen for the first trail is heated to a temperature of 121ºC to 138ºC and added to heated aggregate and thoroughly mixed with trowel.(To determine OBC), as shown in the fig 4
- **Place the mix in a mould.** Filter paper is placed in the bottom of the mould and the entire batch of heated material is added to the mould in one lift. Spade the material vigorously with a heated spatula; smooth the surface to a slightly rounded shape, place filter paper on top of mixture.
- **Manual Compactor.** After placing the mix in the mould the top surface was leveled, and immediately the mix was compacted by applying 75 blows on either side of the specimen by a rammer of 4.54 kg weight with 45.7 cm height of fall at a temperature varying from 100ºC to 160ºC for each binder as shown in the fig 5

International Journal of Engineering Technology and Management Sciences
Website: ijetms.in Issue: 5 Volume No.6 Aug-Sept – 2022
DOI:10.46647/ijetms.2022.v06i05.108 ISSN: 2581-4621

Fig. 4. Mixing of aggregates with bitumen

Fig. 5. Manual Compaction

- **Extraction of specimen from Mould.** The compacted specimens were removed after 24 hours using Hydraulic extractor. (fig 6)

Fig. 6. Extraction of specimen from Mould

3. Results and Discussion

3.1 Marshall Stability Test

Marshall Stability specimens were prepared with 80/100 plain bitumen by, varying the binder content from 4.0% to 6% by an increment of 0.5%. Three specimens were prepared for each binder content. Marshall Stability test was conducted and properties like stability, flow, bulk density, the volume of voids, and voids filled with bitumen were found for 80/100 plain bitumen. Using these properties, optimum binder content is calculated for maximum stability, maximum bulk density, and 4% volume of voids.

Also, Marshall Stability tests were conducted by varying the aggregate mix for 0%, 25%, and 50% using optimum bitumen content.

International Journal of Engineering Technology and Management Sciences
Website: ijetms.in Issue: 5 Volume No.6 Aug-Sept – 2022
DOI:10.46647/ijetms.2022.v06i05.108 ISSN: 2581-4621

Table 3.1: The Marshall Test parameters for ordinary bitumen 80/100 to Obtain OBC

	BITUMEN CONTENT	MARSHALL STABILITY VALUE	FLOW VALUE	BULK DENSITY (Gm)	AIR VOID %(Vv)	% OF BITUMEN (Vb)	VMA
1	4	1278.53	3.26	2.006	3.90	7.622	11.52
2	4.5	1452.48	3.36	2.010	3.26	8.560	11.82
3	5	1460.65	3.80	2.012	2.60	9.460	12.06
4	5.5	1550.58	3.80	2.020	1.46	10.340	11.80
5	6	1395.36	4.30	2.004	1.43	10.540	11.97

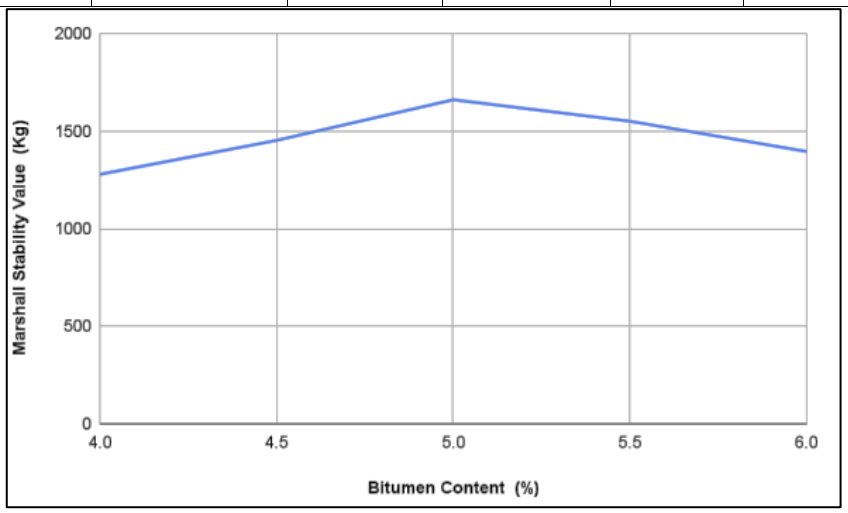

Fig. 6 Graph shows the relationship between stability vs Bitumen content

When reclaimed asphalt pavement is combined with new bitumen, the proportion of aggregate mix (0%, 25%, 50%) is changed, and a Marshall Stability test is undertaken. The experimental data are presented in table 3.2 below, and graphs are plotted according to the results.

Table 3.2: The Marshall Test parameters for Bitumen 80/100 for Different RAP Proportions

Properties	0%	25%	50%	MORTH Specification
OBC (%)	5	5	5	Min-5
Bulk density (gm/cc)	2.43	2.280	2.31	-
Stability (kg)	1232	1005.51	801.5	900
Flow (mm)	3.9	3.6	3.5	2-4
Air Voids (%)	2.36	6.02	5.24	3-6
VMA (%)	14.31	17.23	15.4	Min-16
VFB (%)	83.5	65.02	76.5	65-75

International Journal of Engineering Technology and Management Sciences
Website: ijetms.in Issue: 5 Volume No.6 Aug-Sept – 2022
DOI:10.46647/ijetms.2022.v06i05.108 ISSN: 2581-4621

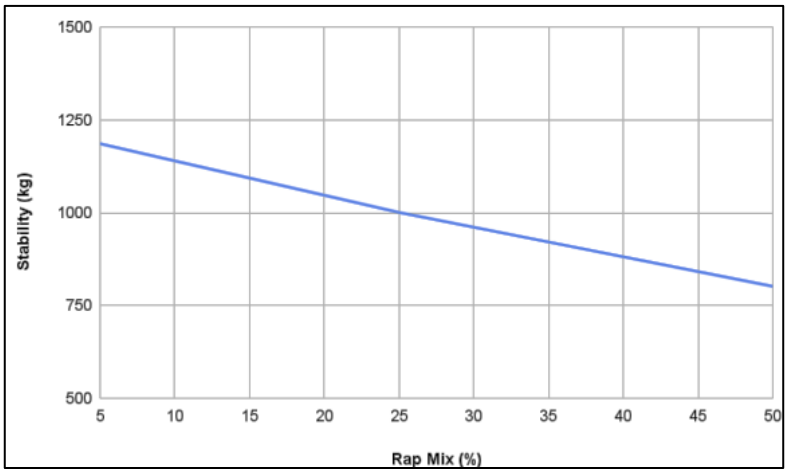

Fig. 7 Graph shows the Marshall Stability Vs different percentage of RAP

Conclusion

● The proportioning of aggregates with recovered aggregates at all specified percentages of 0%, 25%, and 50% resulted in accurate blending of aggregates that met the specification requirements.

● By performing a Marshall Test on control mix samples that were made by adding 4%, 4.5 percent, 5%, 5.5 percent, and 6% bitumen by weight of aggregate to make BC mix, OBC was determined to be 5%.

● Marshall Stability values for different aggregate mixes are 1232kg, 1005.51kg, and 801.5kg for 0 percent, 25%, and 50% RAP, respectively.

● Because the Marshal value for DBM mix is 900kg, it is clear that up to 25% of aggregates can be replaced based on the given figures.

● Based on the laboratory studies, it can be concluded that more than 10% and less than 25% RAP can be suitably adopted in the construction of new roads with RAP in this current project work.

● Using the RAP with a proper process has clearly demonstrated to the study that approximately 20% to 30% of the cost of the wearing courses or binder courses can be effectively reduced with all other liabilities.

Acknowledgment

We would like to thank 8th sem FET Jain University students, Mr Manish Patel.K and Mr Kotish N helped in collecting the sample.

References

1. Missouri Asphalt Pavement Association (MAPA): Recycling of asphalt pavement (Retrieved from <http://www.moasphalt.org/facts/environmental/recycling.htm> on July 29. (2012)
2. Kelly, T.: Crushed cement concrete substitution for construction aggregates—a material flow analysis, U.S. Department of the Interior, U.S. Geological Survey Circular 1177; 1998 (Retrieved from <http://pubs.usgs.gov/circ/1998/c1177/> on July 30. (2012).
3. User Guidelines for Byproducts and Secondary Use Materials in Pavement Construction, FHWA Publication No.: FHWA-RD-97-148 (Retrieved from <http://www.rmrc.unh.edu/tools/uguidelines/rap134.asp> on July 30. (2012)
4. Copeland, A., Jones, C., Bukowski, J.: Reclaiming roads—the public roads, 2010 Mar–Apr; Publication Number FHWA-HRT-10-001; vol. 73, No. 5 (Retrieved from <http://www.fhwa.dot.gov/publications/publicroads/10mar/06.cfm> on July 30. (2012)
5. Lee, J.; Edil, T.B.; Benson, C.H.; Tinjum, J.M. Building Environmentally and Economically Sustainable Transportation Infrastructure: Green Highway. J. Constr. Eng. Manag. 2013, 139

DOI:10.46647/ijetms.2022.v06i05.108 ISSN: 2581-4621

6. Lee, J.C.; Edil, T.B.; Tinjum, J.M.; Benson, C.H. Quantitative Assessment of Environmental and Economic Benefits of Recycled Materials in Highway Construction. Transp. Res. Rec. 2010, 2158, 138–142.
7. Ahmad M. Abdo, Utilizing Reclaimed Asphalt Pavement (RAP) Materials in New Pavements. International Journal of Thermal & Environmental Engineering, Volume 12, No.1 (2016), pp. 61-66.
8. Albert M. Bleakley, Improving the Properties of Reclaimed Asphalt Pavement for Roadway Base application through Blending and Chemical stabilization. Transportation Research Record Journal of the Transportation Research Board, 2335 (-1) pp. 20-28, December 2013.(https://www.researchgate.net /publication /270209060).
9. Aravind K. and Animesh Das, Bituminous Pavement Recycling, https://www.researchgate.net/publication/238523374, January 2006.
10. Dr. Dwaitha Jagadish-*"A Review on Advanced Smart Technology in Transportation System",* ECS transactions, volume 107, issue 1,p-16961, April 2022.
11. Ministry for Road Transportation and Highways (MORT&H), "Specifications for Road and Bridge Works (Section 504)", Fourth Revision.
12. Indian Roads Congress, "Guidelines on Use of Polymer and Rubber Modified Bitumen in Road Construction", IRC: SP-53- 2002. Indian Roads Congress, New Delhi.
13. Dr. Dwaitha Jagadish, M.Durga "Effect of Compacting Temperature on Marshall Properties in 80/100 Grade and PMB Bituminous Concrete Mixes", IARJSET, 2021, Volume 8, Issue 8, ISSN: 2393-8021.
14. Asphalt Recycling and Reclaiming Association, Basic Asphalt Recycling Manual, ARRA, Annapolis, (2001)
15. Synthesis of Recycled Asphalt Pavement (RAP) Material, Minnesota Department of Transportation, St. Paul,K. Kuehl, J. Korzilius, M. Marti,, (2016)