"EVALUATION OF DENSE BITUMINOUS MACADAM (DBM) MIXTURE USING RECLAIMED ASPHALT PAVEMENT (RAP)"

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1.Introduction:

Road Transport in India accounts for 80% of passenger movement and 65% of freight movement. With 3.34 million km of roads, India has the second largest road network in the world.

The current state of our nation's transportation infrastructure is inadequate, and many state and city municipalities do not have the funds to rehabilitate their road networks to improve them to an acceptable level. National Highways Authority of India has prepared plans involving an outlay of Rs 2, 20,000 crores under National Highways Development Program (NHDP) and 10,000 km of expressways at a cost of Rs 1, 00,000 crores are being planned.

The eleventh plan investment in roads and bridges is about Rs 2, 78,658 crores which is about 13.57 % of total outlay. These mega road modernization projects throws up various concerns pertaining to depletion of resources like good soil and aggregates, long lead to get good quality aggregates and increase in fuel consumption etc.

Furthermore, the supply of Bitumen, whose cost keeps on increasing, is dependent on foreign sources, and energy that is needed for processing new materials is becoming costlier every day. Therefore recycling of existing bituminous mixes results in substantial savings through the reuse of aggregates and bitumen. Recycling of asphalt pavements is a technology developed to rehabilitate and/or replace pavement structures suffering from permanent deformation and evident structural damage.

Use of the recycled materials in the road construction has been favoured over virgin materials in the light of increasing cost of bitumen, scarcity of good quality aggregates and the priority towards preservation of the environment. Considering the material and construction cost alone, it is estimated that using recycled materials, saving ranging from 14 to 34% can be achieved.

In order to reduce the usage of natural aggregate, recycled asphalt pavement can be used as partially or fully replacement of new materials. The Reclaimed asphalt pavement (RAP) is the term used to collect from existing old pavements by milling equipment. RAP material is tested with the bitumen extraction test, identify bitumen percentage and aggregate gradation and the obtained material is reused by suitably blending with processed new aggregate and bitumen.

There has been considerable research carried out on the reusability of RAP over the past 1980s, this has grown considerably over the past years as the various agencies, Central, and State Governments have recognized the need for greater sustainability in construction.

As an example of Indian practice, Clause No.519.2.1, MORTH also recommends to reuse of RAP for production of bituminous macadam (BM) and dense bituminous macadam (DBM) by suitably blending with new bitumen and the aggregates subjected to the maximum proportion of RAP materials used is limited to not greater than 60%.

2. Objectives:

a) To study the suitability of RAP materials for production of DBM by partial replacement with natural aggregate by conducting required laboratory tests.
b) To determine the strength characteristics of the blended RAP material by conducting Marshall Stability Tests and determine its compliance with MORTH Specification (2013).
c) To determine the OBC (Optimum Binder Content) for the bitumen used for the DBM layer.
d) To study the performance of Reclaimed Asphalt Pavement when it is mixed with new Bitumen.

3. Literature Review:

1. C. Udayshankar & M. Varuna, "LABORATORY STUDIES OF DENSE BITUMINOUS MIXES-II WITH RECLAIMED PAVEMENT MATERIALS" R.V. College of Engineering, Bangalore, Karnataka, India.

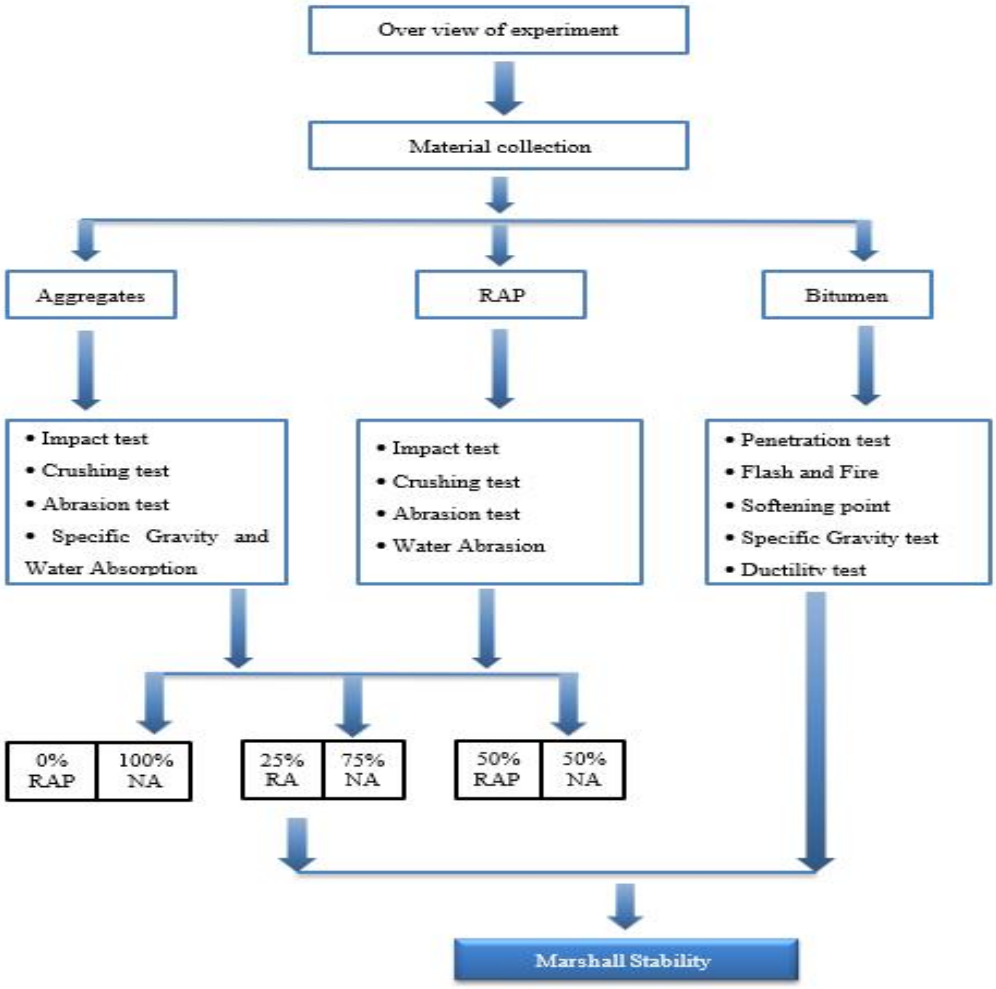
The present study addresses the issue of growing demand on our nation's roadways over that past couple of decades, decreasing budgetary funds, and the need to provide a safe, efficient, and cost effective roadway system has led to a dramatic increase in the need to rehabilitate our existing pavements and the issue of building sustainable road infrastructure in India. With these emergency of the mentioned needs and this are today's burning issue and has become the purpose of the study. In the present study, the samples of existing bituminous layer materials were collected from NH48(Devahalli to Hassan) site. The mixtures were designed by Marshall method as per Asphalt institute (MS-II) at 20% and 30% RAP. RAP material was blended with virgin aggregate such that all specimens tested for the DBM-II gradation as per MoRT&H(4TH revision). Mixtures containing RAP showed significant variability and the variability increased with the increase in RAP content. The finding of the study will help in development of sustainable road infrastructure for recycling in India.

2. Prof. Prabhakar Kumar, Prof. Rajeev Kumar, Prof. Muhammad Aslam, "DESIGN OF BITUMINOUS MIX USING RECLAIMED ASPHALT PAVEMENT (RAP)" Gaya College of Engineering, Gaya, Bihar, India.

A good road network is a critical infrastructure requirement for rapid economic growth. It provides connectivity to remote areas; provides accessibility to markets, schools, and hospitals; and opens up backward regions to trade and investment. Roads play an important role in intermodal transport development, through links with airports, railway stations, and ports.

Construction of roads consumes a large amount of bitumen and aggregates. To produce such materials a large amount of energy is required. Also the dumping of old extracted layer of asphalt pavement is of major concern. So here the concept of using Recycled asphalt pavement has been implemented in the work. Use of RAP aggregates along with the new/ fresh aggregates will reduce the use of new material for construction of flexible pavement. Also it will cut down the cost of construction. So by checking the suitability of RAP new pavement structure will be constructed by adding various amount of RAP and suitability of each proportion mix will checked.

4. Methodology:



The methodology has adopted the various tests to investigate the properties of aggregates like Impact test, Crushing test, Specific gravity test and Water absorption, Abrasion test.

The various tests are conducted to investigate the properties of bitumen like Penetration test, softening test, Ductility test, Flash and fire point test, Specific gravity test.

The blends using aggregates and bitumen were prepared along with use of different percentage

of RAP in it separately. Later these blends were tested under Marshall Stability apparatus to

check its stability of road pavements.

- Perform stability tests on the specimens.
- Calculate the percentage of voids, and percent voids filled with Bitumen in each Specimen.
- Select the optimum binder content from the data obtained.

4.1 MATERIALS USED

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

4.1.2 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.

4.1.3 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.

4.2 MARSHALL STABILITY TEST

Preparation of the specimen for Marshall Stability Test

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

Fig.1 Weighing the proportioned aggregates for DBM

- **Mixing of aggregates with bitumen:** The required quantity of bitumen for the first trail is heatedto a temperature of 121°C to 138°C 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 batchof 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 100°C to 160°C for each binder.

Fig.2 Mixing of aggregates with bitumen

- **Extraction of specimen from Mould:** The compacted specimens were removed after 24 hoursusing Hydraulic extractor.

5. Results and discussions

5.1 Marshall Stability Test

Marshall Stability specimens were prepared with 50/60 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 50/60 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.

Table 1 : The Marshall Test parameters for ordinary bitumen 50/60 to Obtain OBC

Sl. No	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

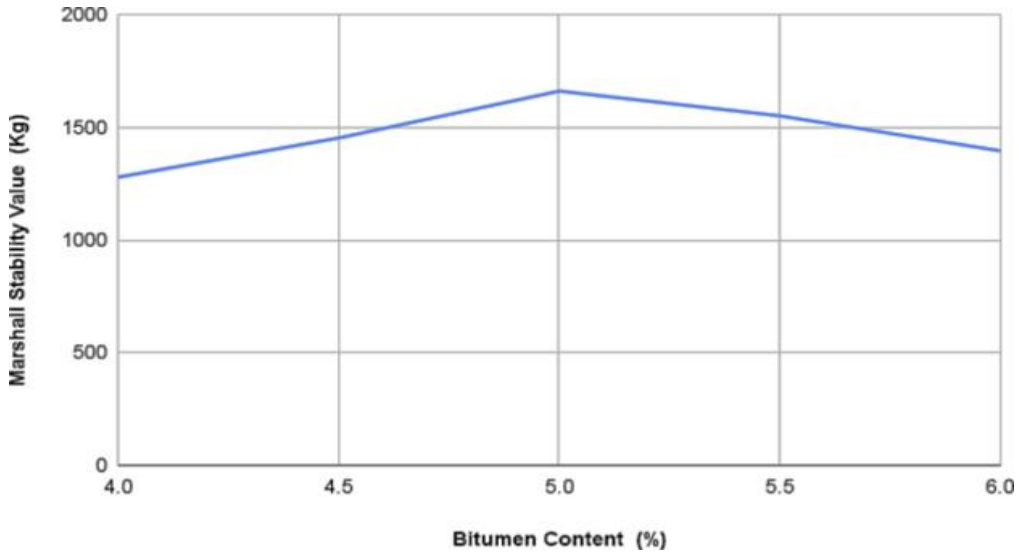


Fig. 1 Graph shows the relationship between stability vs Bitumen content

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.

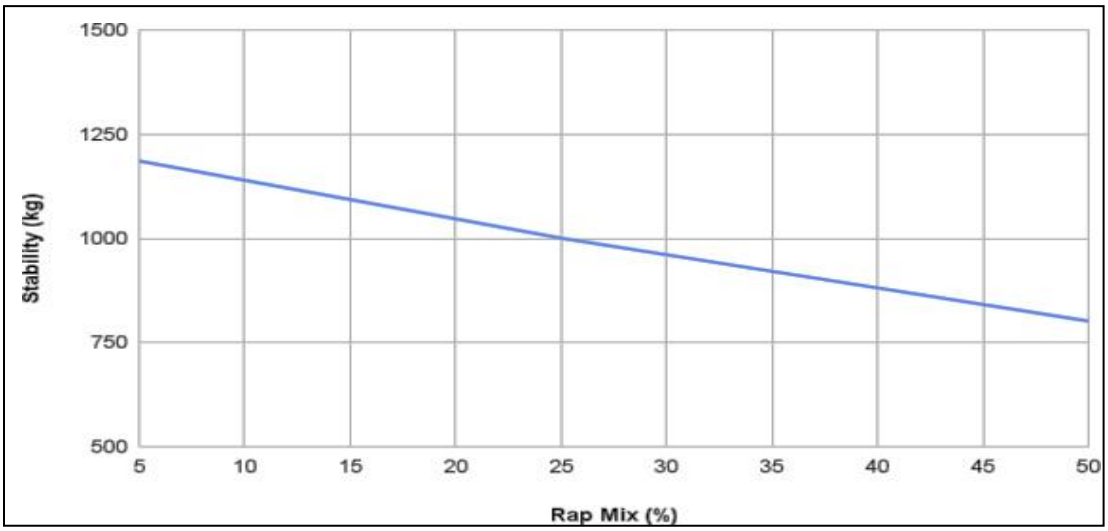


Fig.2 Graph shows the Marshall Stability Vs different percentage of RAP

Table 2: The Marshall Test parameters for Bitumen 50/60 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

Fig. 2 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

Scope for future work

1) Performance Evaluation: Assess the performance characteristics of dense bituminous macadam (DBM) mixtures containing reclaimed asphalt pavement (RAP) through laboratory testing and field performance evaluations.

2) Mechanical Properties: Investigate the mechanical properties of DBM mixtures with RAP, such as stiffness, fatigue resistance, rutting resistance, and moisture susceptibility, to determine their suitability for different traffic loads and environmental conditions.

3) Optimal RAP Content: Determine the optimal percentage of RAP to be incorporated into the DBM mixture, considering factors like binder properties, aggregate gradation, and performance requirements, to achieve a balance between sustainability and pavement performance.

4) Binder Aging: Analyze the effect of RAP on binder aging and rejuvenation characteristics by conducting laboratory tests to assess the long-term performance of the DBM mixture.

5) Environmental Impact: Evaluate the environmental benefits of using RAP in DBM mixtures, including reductions in energy consumption, greenhouse gas emissions, and virgin aggregate consumption, compared to conventional DBM mixtures.

6) Field Trials: Conduct field trials to validate the laboratory findings and assess the performance of DBM mixtures with RAP under real-world traffic and environmental conditions, considering factors like pavement distress, surface texture, and ride quality.

References

- MoRT&H (Ministry of Road, Tansport, Highways).
- IS Code-2386(Part -IV)-1963(Aggregate).
- Highway Engineering, S.k.Khanna, C.E.Justo.
- IS Code 1208-1978(Bitumen).
- IRC-94-1986 Specification of DBM.
- IRC-SP-11-Handbook of quality control for construction.
- Use of different types of additives in DBM, Nayeem Ahmed ,O.P. Mittal.