

Design of Bituminous Mix using Reclaimed Asphalt Pavement (RAP)

Prof. Prabhakar Kumar¹, Prof. Rajeev Kumar², Prof. Muhammad Aslam³

^{1,2,3}Assistant Professor, Gaya College of Engineering, Gaya, Bihar, India

Abstract – 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 inter-modal 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 be checked.

Key Words: Bituminous Mix, RAP Material, Marshal Test, Aggregate Testing, Bituminous Testing.

1. INTRODUCTION

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 inter-modal transport development, through links with airports, railway stations, and ports. Road network in India aggregates to about 4.2 million kilometers. This exclusive road network, the second largest in the world only after US, caters to about 65 per cent of the freight traffic and 87 per cent of the passenger traffic.

National Highways (NH) constitute about 70,934 kilometers which is only 2 percent of the total network. However, it caters to nearly 40% of the total road traffic. State Highways (SH) and Major District Roads (MDR) together constitute the secondary system of road transportation which contributes significantly to the development of the rural economy and industrial growth of the country. The conventional method of providing bituminous surfacing on flexible pavements require significant amount of energy for production of bituminous binder from crude petroleum. (T. Anil Pradyumna, et. al.) [7]

Studies have shown that up to 50% of RAP has been used as part replacement of granular sub-base and wet mix

macadam (WMM) in various projects of National Highway Development Plan (NHDP) in India. Recycling of milled bituminous material has been gaining popularity in India in recent times due to several successful trials in selected projects. (Brajesh Mishra) [3]

1.1 AIM OF STUDY

To use the Reclaimed Asphalt Pavement (RAP) material along with the new bitumen and aggregates in the construction of Flexible pavement.

- It will reduce the cost of the construction of pavement.
- Also it will help to solve the problem of the dumping and recycling of old Asphalt material.

1.2 OBJECTIVE OF STUDY

- To check the suitability of the bitumen and aggregates by various test as specified by MORTH.
- To prepare the different sample having various proportion of RAP material and new material.
- To determine the proportion of RAP at which the optimum bitumen content is achieved.
- To reduce the use of Fresh aggregates upto the possible extent.

2. LITERATURE REVIEW

An attempt has to be made to develop and adopt alternative technologies for road construction and maintenance to reduce consumption of fuel and aggregates. Recycling of pavements, particularly HMA recycling is one such technology which may be adopted for Indian conditions (Ministry of Finance, Govt. of India, 2009)[11]

Many studies are available on performance evaluation with conventional asphalt mixes (mix without RAP). Therefore, there is a necessity for study on mechanistic evaluation of hot recycled mixes with and without utilization of recycling agents. Among all the recycling techniques, hot mix recycling techniques have large number of advantages and is well suited for Indian conditions. (Mittal et.al,2010)[7]

Based on the laboratory testing work carried out on virgin mixes and mixes with 20 % RAP, it was found that addition of RAP improves all the properties of the bituminous mixes. This indicates that mixes with 20 % RAP would perform better than the virgin mixes under similar conditions. (Mittal et.al, 2010).[7]

Two different mix design procedures were used for designing bituminous pavement mixes with foamed bitumen. Mix design was carried out following the South African and Caltrans guidelines. The RAP materials used for mix design were collected from the NH-5, Chennai-Tada section. Using foamed bitumen produced from Wirtgen WLB 10 foaming equipment, a mix with RAP material, virgin aggregate and active filler were produced in the pug mill mixer. Marshall compaction effort was used for fabricating the samples. Using the indirect tensile strength test on dry and wet specimens, the optimum binder content was determined. It was seen that the two mix design procedure adopted showed different mix constituents despite using the same RAP source. (Rajeev Chandra et. al.) [6]

This Research concludes that 25.6 % of RAP in the mix don't worsen the mixture behaviour in terms of the Thermal Cracking. (Pietro leandri et. al.) [9]

Due to economic reasons and need for environmental conservation, there has been an increasing shift towards the use of Recycled asphalt pavement. This research focuses on evaluating effects of partial and total replacement of aggregates by RAP on the mechanical response of dense graded HMA mixtures.

Corresponding results suggest that highest indirect tensile strength (ITS) and Resilient Modulus values in both dry and wet condition were obtained for the HMA mixtures produced with 100% replacement of granular material by RAP (Reyes- Ortiz et. al.) [10]

Thus it was noted that mixtures with high RAP can be successfully used to meet local requirement that areas. (R. Izaks et. al.) [4]

RAP can also be utilized for certain other option as have

been tried out for the city of Surat in Gujarat. Study was carried out with the objective of using RAP in following ways:

- To use RAP material as GSB (Granular Sub Base) after analysis and adding missing sieve size material.
- To use RAP material as WMM (Wet Mix Macadam) after analysis and adding missing sieve size material.
- To analyze RAP and after carrying marshal test and recycle RAP material up to certain percentage.

After test and analysis, it was concluded that overall 25% savings can be done while using for GSB grade-II and 35% for WMM by using RAP in the mix, simultaneously achieving the design requirements. (Maulik Rao. et. al.) [5]

Also Research was carried out to know the effect of RAP on the properties of asphalt binder by checking the various properties of the residual binder obtained from the RAP material. RAP was collected from two sites mandra and nowhere along the national highway N-5, Pakistan. Based on the various test results, it was concluded that increasing the amount of RAP increases the stiffness but it decreases with the increase in temperature. Also creep stiffness and viscosity increases. (Arshad Hussain et. al.) [8].

3. METHODOLOGY

3.1. MATERIALS USED

The various material which is to be used for bitumen mix design can be listed as follow.

- Bitumen
- Coarse aggregate
- Recycled Asphalt Pavement (RAP)

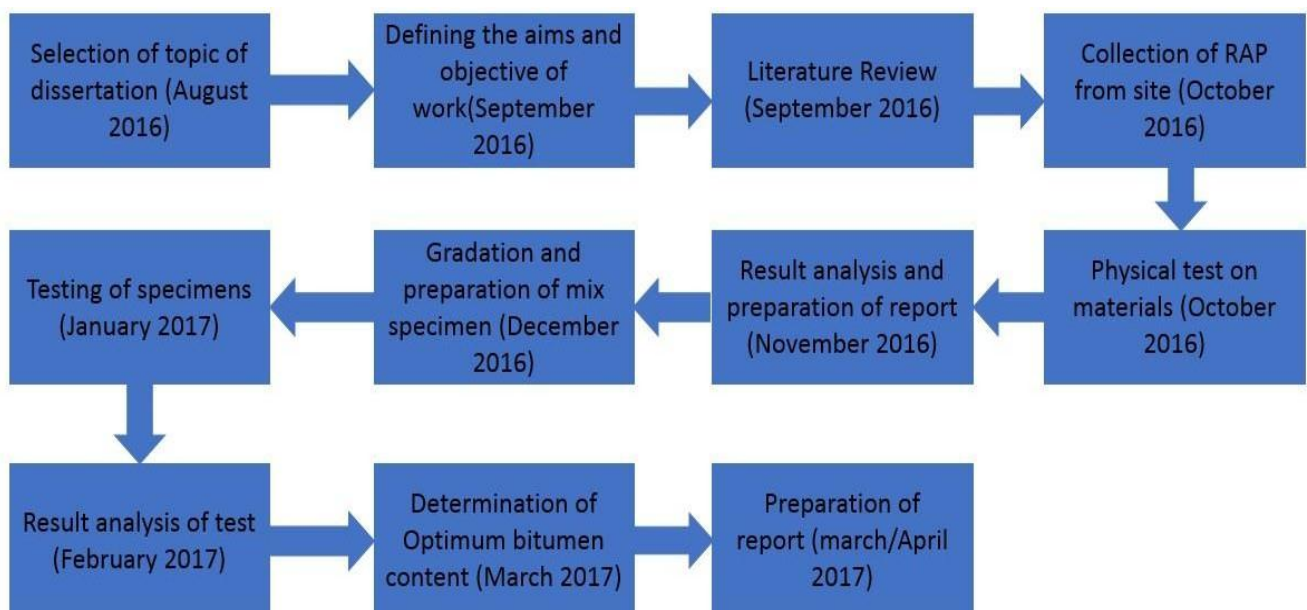


Table No.1: Recommended VG grades of bitumen for use in India.

Viscosity Grades (VG)	General Application
VG-40	Use in high stressed areas like intersections, toll plazas, truck terminals, truck lay-byes.
VG-30	Paving application in most of part of India
VG-20	Paving application in cold climatic conditions of North India and in high altitude regions.
VG-10	Spraying application and paving application in cold regions.

Coarse Aggregates

Aggregates form a major portion of pavement structure and they form the prime material used in the construction of different pavement layers. The aggregates of pavement have to resist,

- Wear due to abrasion action of traffic
- Deterioration due to weathering
- Highest magnitude of wheel load stresses.

Aggregates are used in the construction of various pavement layers such as

- Bituminous pavement layers of flexible pavement.
- Cement concrete mixes for CC pavement slab.
- Granular sub base or lean concrete sub base layer.
- Drainage layer.

Aggregates are specified based on their grain size, shape, texture and its gradation. The grading, test and specification for different road making purposes have been specified by various agencies like IRC, BIS, ASTM and BSI.

The various desirable properties which aggregates should possess can be summarized as follow,

- Resistance to impact (toughness)
- Resistance to abrasion (hardness)
- Resistance from getting polished (smoothness/slippery)
- Good shape factor (to avoid too flaky and elongated aggregates)
- Resistance to weathering (durability)

• Good adhesion to bituminous materials in presence of water.

Table No.2: Typical Properties of RAP.

Sr. No.	Parameters	Values
1	Unit Weight (Kg/m3)	1900-2250
2	Moisture Content	Max. 3-5 %
3	Asphalt Content	5-6 %
4	Asphalt penetration (%) at 25° C	10-80
5	Compacted Unit weight(Kg/m3)	1500-1950

FILLER MATERIAL

Filler material consists of finely powdered mineral matter for filling the voids in the mix specimen. These should normally have selected as material passing through 0.075 mm sieve (85- 100 % passing). Hydrated lime, Portland cement, or rock dust mix or suitable combination of any material can be used as filler material.



Fig -1: Reclaimed Asphalt Sample (RAP)

3.2. Objectives of Mix Design

The objective of the mix design is to produce a bituminous mix by proportionating various components so as to have:

1. Sufficient bitumen to ensure durable pavement
2. Sufficient strength to resist shear deformation under traffic at high temperature
3. Sufficient air voids in the compacted bitumen to allow for additional compaction by traffic
4. Sufficient workability to permit easy placement without segregation
5. Sufficient flexibility to avoid premature cracking due to repeated bending by traffic
6. Sufficient flexibility at low temperature to prevent shrinkage cracks.

Constituent of Mix

- Coarse aggregates: offers compressive and shear strength and shows good interlocking properties. E.g. Granite.
- Fine aggregates: Fills the voids in the coarse aggregate and stiffens the binder. E.g. Sand, Rock dust
- Filler: Fills the voids, stiffens the binder and offers permeability. E.g. Rock dust, cement, lime
- Binder: Fills the voids, cause particle adhesion and gluing and offers impermeability. E.g. Bitumen, Asphalt, Tar.

Desirable properties

From Above discussion, desirable properties of a bituminous mix can be summarized as follows:

- Stability to meet traffic demand
- Bitumen content to ensure proper binding and water proofing
- Voids to accommodate compaction due to traffic
- Flexibility to meet traffic loads especially in cold season
- Sufficient workability for construction
- Economical mix

3.3. MARSHALL MIX DESIGN

Table No.3: Gradation of Aggregates to be used for Marshall Mix Specimen

Nominal Aggregate size	37.5 mm	26.5 mm
Layer Thickness	75-100 mm	50-75 mm
Sieve Size, (mm)	Percentage Passing by Weight	
	Grade 1	Grade 2
45	100	-
37.5	95-100	100
26.5	63-93	90-100
19	-	71-95
13.2	55-75	56-80
9.5	-	-
4.75	38-54	38-54
2.36	28-42	28-42
1.18	-	-
0.6	-	-

0.3	7-21	7-21
0.15	-	-
0.075	2-8	2-8
Bitumen Content, % by Weight of total mix	Min. 4	Min. 4.5

Marshall stability test is conducted on compacted cylindrical specimens of bituminous mix of diameter 101.6 mm and thickness 63.5 mm. The load is applied perpendicular to axis of the cylindrical specimen through a testing head consisting of a pair of cylindrical segments at a constant rate of deformation 51 mm per minute at a standard test temperature of 60°C.

Marshall stability of mix specimens is maximum load carried in kg. at a standard temperature of 60°C when load is applied under specified conditions. Flow Value is the total deformation that marshal test specimen under goes at the maximum load expressed in mm.

The type of aggregates to be used, the type of bitumen binder and range of binder to be used are given in the relevant standard specification (Indian Road Congress IRC and Ministry of Road Transport and Highways).



Fig -2: Marshal Asphalt Sample



Fig -3: Marshal Asphalt Sample Preparation

4. Result Analysis

Table No. 4: Gradation of aggregates for 15% RAP Mix

Sieve size(mm)	20 mm	10 mm	6 mm	Filler	RAP	15% RAP	85% Fresh	Combined	DBM Grade-2
26.5	100	100	100	100	100	15	85	100	90-100
19	5	100	100	100	92.28	13.842	64.81	78.652	71-95
13.2	0	96.5	100	100	85.35	12.8025	62.7	75.5025	56-80
4.75	0	0	18.6	100	60.2	9.03	32.61	41.64	38-54
2.36	0	0	3.6	100	72.2	10.83	32.36	43.19	28-42
0.3	0	0	0	29	17.08	2.562	9.36	11.922	7-21
0.075	0	0	0	11	0	0	3.55	3.55	2-8

Table No. 5: Gradation of aggregates for 25% RAP Mix

Sieve size(mm)	20 mm	10 mm	6 mm	Filler	RAP	25% RAP	75% Fresh	Combined	DBM Grade-2
26.5	100	100	100	100	100	25	75	100	90-100
19	5	100	100	100	92.28	23.07	57.1875	80.2575	71-95
13.2	0	96.5	100	100	85.35	21.3375	55.33125	76.66875	56-80
4.75	0	0	18.6	100	60.2	15.05	28.779	43.829	38-54
2.36	0	0	3.6	100	72.2	18.05	24.554	42.604	28-42
0.3	0	0	0	29	17.08	4.27	8.265	12.535	7-21
0.075	0	0	0	11	0	0	3.135	3.135	2-8

5. CONCLUSIONS

The use of RAP (Reclaimed Asphalt Pavement) material in the construction of new Pavement (Dense Bituminous Macadam Grade – II) will considerably reduce the use of fresh aggregate in the construction. Use of RAP satisfies the design requirement as per Marshall mix method.

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