

Evaluation of Bituminous Concrete Mixture Using Reclaimed Asphalt Pavement

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Abstract— The huge amount of reclaimed asphalt pavement (RAP) obtained from damaged or abandoned pavement. Bituminous pavement is a mix of coarse aggregate, fine aggregates, mineral filler and bitumen. Due to repetition of wheel load and edging effect bituminous concrete tense to wear and tear. Using RAP in pavement construction has now become most common practice in many countries. These materials have been used not only proved to be economically but also environmentally sound. Mixing RAP in fresh materials has been favored over fresh material in the light of the increasing cost of asphalt, scarcity of quality aggregate, scarcity of asphalt and pressuring need to preserve the environment. An experimental investigation is carried out to evaluate the possible application of RAP in bituminous pavement design and to find out its design characteristics. Therefore, it is necessary to replace aggregates with RAP with the percentage of (30%, 50%, 60% and 70%) and carried out different test on bitumen & aggregate to finding out the difference between normal aggregates and RAP to increase the strength of road pavement. It is observed from test result that 60% of the RAP material replaced with natural aggregates mix shows good stability. Hence up to 60% of RAP material can be replaced to the BC grade.

Keywords: Bituminous Concrete Mixture, Reclaimed Asphalt Pavement

I. INTRODUCTION

A. General:

Natural aggregates have been carried out from a variety of rock sources and have been used as a road material. But the extraction of these virgin aggregate resources is increasingly being restrained by urbanization, increased costs and environmental concerns. The use of reclaimed asphalt pavement (RAP) materials in road construction could serve the purpose of reducing the amount of construction, land disposal, reducing environmental disturbance and the rate of natural resource depletion.

B. Need for Cycling:

Recycling of asphalt pavements is one of the effective and proven rehabilitation processes. It has been successfully used at many places world over and has shown satisfactory performance. Reasons to why recycling was not given importance in India during the first half of the 20th century are those of economic considerations and availability of suitable technology. Main factors in the recent year that make recycling viable are the economic factors considering the cost of bitumen and the non availability of quality aggregates against the process cost of recycling. Thus, recycling can help in reducing the cost, conserve scarce material and reduce the amount of energy required. The maximum limit of RAP content in conventional recycled hot mix produced in

conventional hot mix asphalt batch plants is widely considered up to 50 percent, limited by both heat capacity of the plants and gaseous hydrocarbon emissions. With increased demand and limited aggregate HMA producers have begun using reclaimed asphalt pavement (RAP) as a valuable component in HMA. As a result, there has been renewed interest in increasing the amount of RAP used in HMA. While several factors influence the use of RAP in asphalt pavement, the two primary factors are economic savings and environmental benefits. RAP is a useful alternative to virgin materials because it reduces the use of virgin aggregate and the amount of virgin asphalt binder required in the production of HMA. The use of RAP also conserves energy, lowers transportation costs required to obtain quality virgin aggregate, and preserves resources.

Additionally, using RAP decreases the amount of construction debris placed into landfills and does not deplete non-renewable natural resources such as virgin aggregate and asphalt binder. Ultimately, recycling asphalt creates a cycle that optimizes the use of natural resources and sustains the asphalt pavement industry. In order for it to be successful, recycled asphalt pavement must be cost effective, perform well, and be environmentally sound. To ensure that these requirements are met, Federal Highway Administration promotes the following:

- The use of recycled material in the construction of highways to the maximum economical and practical extent possible with equal or improved performance.
- The use of RAP in HMA because RAP can have a large economic, environmental, and engineering impact in pavement recycling. The use of RAP may grow by increasing the number of highway construction and rehabilitation projects that use RAP, as well as by increasing the amount of RAP used in specific projects. To meet these goals, the following tasks were identified:
 - Establish a public and industry working group.
 - Create funded and coordinated research and demonstrations projects.
 - Research deployment and technology transfer for information dissemination and education.

II. RECYCLING METHOD: -

Five broad categories have been defined by Asphalt recycled and Reclaiming association (ARRA) to describe the various asphalt recycling methods.

- 1) Hot in place recycling (HIR)
- 2) Cold recycling (CR)
 - Cold mining
 - Cold in place recycling (CIR)
- 3) Full Depth Reclamation
- 4) Hot mix recycling

III. OBJECTIVES: -

- To determine the physical properties of natural aggregates and RAP materials to know the strength conditions of materials.
- To work out the proportions of RAP materials used in the bituminous mix with the fresh aggregates.
- To determine the stability of different proportions of RAP materials replaced with virgin aggregates.
- To work out the cost analysis for the obtained proportions of RAP and natural aggregates.

A. Scope:

This study investigates the various physical properties of the virgin aggregates such as, aggregate impact test, aggregate crushing test, aggregate abrasion test, water absorption test and specific gravity tests. The physical properties of VG30 grade bitumen such as penetration, softening point, ductility and specific gravity have been determined. The solvent extraction test will be conducted on RAP material using benzene to determine percentage of bitumen and gradation of aggregate. Marshall Mix design of the BC Mixes have been carried out using the reclaimed bituminous to an extent and the results will be compared with virgin mix.

IV. METHODOLOGY: -

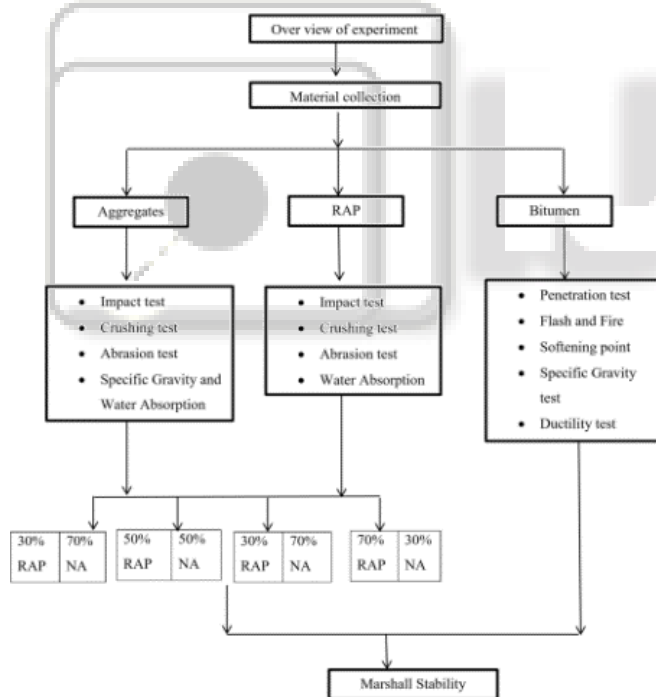


Table 1.1:

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 percentvoids filled with Bitumen in each Specimen.
- Select the optimum binder content from the data obtained.
- Evaluate the design with the design requirements.

TESTS ON AGGREGATES and BITUMEN

IMPACT TEST	20.73
CRUSHING TEST	23.02
LOS ABRASSION	23.40
SPECIFIC GRAVITY	2.61

PENETRATION TEST	63MM
FLASH AND FIRE TEST	230 -300° C
DUCTILITY	57.5 CM

Table 1.2:

A. Characteristics of Aggregates with Varying RAP Material

- Specific Gravity of RAP = 2.56
- Water Absorption = 0.51
- Los Angeles Abrasion Value of RAP for “C” Grade = 23.8%
- Bitumen Content in RAP = 6%

Physical Characteristics of aggregates with varying RAP proportions

TEST	50%RAP	60%RAP	70%RAP	100% RAP
Aggregate: Impact Value	19.37%	18.97%	17.67%	15.6%
Aggregate: Crushing Value	19.08%	21.05%	23.48%	16.39%

Table 1.3:

B. Grading of Materials

- The properties of a bituminous mix including the density and stability are very much dependent on the aggregates and their grain size distribution.
- Sieve the aggregates in IS sieves and note down the weight retained on each sieve. Then determine the percentage weight passing.
- The gradation of final mix after blending of aggregates and filler should be within the specified gradation of aggregates for bituminous concrete surface course as given in below table

Material A	20mm	20%
Material B	12.5mm	40%
Material C	4.75mm	40%

Sieve sizein (mm)	Aggregate A %Passing	Aggregate B %Passing	Aggregate C %Passing	Specified Gradation	Obtained Gradation
26.5	100	100	100	100	100
19	13.44	100	100	79-100	82.68
13.2	0.68	98	100	59-79	75.33
9.5	0.02	50.67	100	52-72	60.27
4.75	0	0.67	100	35-55	40.26
2.36	0	0.01	89.7	28-44	35.88
1.18	0	0	60.5	20-34	24.2
0.6	0	0	45	15-27	18.02
0.3	0	0	28	10-20	11.2
0.15	0	0	20.2	5-13	8.08
0.075	0	0	10.5	2-8	4.2

Table 1.5:

C. Marshal Stability Test



Fig. 1.1:

Marshall Properties of Bituminous Mix with varying RAP Proportions:-

% of Material		% Of Bitumen	Avg Height (mm)	Wt. of specimen		Gt	Vv (%)	Vb (%)	VM A (%)	VFB (%)	Correction factor	Proving Ring Reading (Kg)	Marshall Stability (KN)	Flow Value (mm)
RAP	NA	In Air	In Water											
30%	70%	5.2	67.0	1300	930	2.19	5.38	6.4	0.93	54.32	0.93	585	22.68	5.2
50%	50%	5.2	67.0	1290	960	2.19	5.38	6.4	0.93	54.32	0.93	600	23.26	5.0
60%	40%	5.2	65.0	1280	950	2.19	5.38	6.4	0.96	54.32	0.96	640	25.62	4.6
70%	30%	5.2	67.0	1320	860	2.19	5.38	6.4	0.93	54.32	0.93	580	19.58	4.8

Table 1.7

Graph of Marshall Stability with varying RAP proportions.

Correction Factors for Marshall Stability Values

Volume of Specimen, in m3	Volume of Specimen, in m3	Volume of Specimen, in m3
457-470	57.2	1.19
471-482	58.7	1.14
483-495	60.3	1.09
496-508	61.9	1.04
509-522	63.5	1.00
523-535	65.1	0.96
536-546	66.7	0.93
547-559	68.3	0.89
560-573	69.8	0.86

Table 1.6:

Specific gravity values of aggregates, filler and bitumen are to be determined as follows.

$$G_t = \frac{W_1 + W_2 + W_3 + W_4}{G_1 + G_2 + G_3 + G_4}$$

W1 = % weight of coarse aggregate,

W2 = % weight of fine aggregate

W3 = % weight of filler,

W4 = % weight of bitumen in total mix

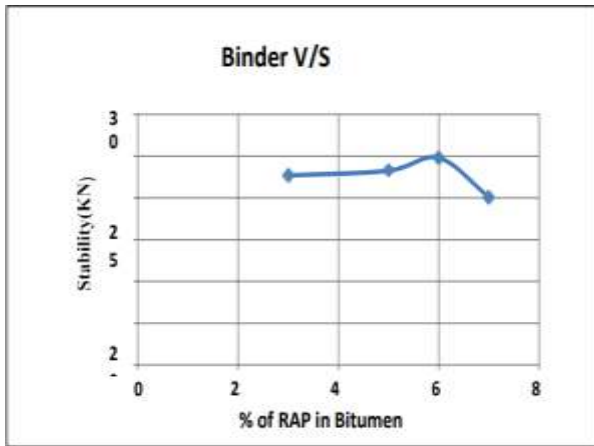
G1, G2, G3 and G4 are apparent specific gravity values of coarse aggregate, fine aggregate and bitumen.

Density and void analysis:

$$V_v, \% = \frac{100(G_t - G_b)}{G_t}$$

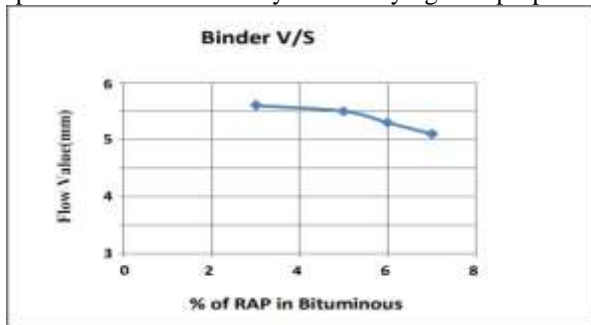
$$V_b, \% = \frac{(G_b \cdot W_4)}{G_4}$$

$$VMA, \% = V_v + V_b$$



Graph 1.1

Graph of Marshall Stability with varying RAP proportions.



Graph 1.2

COST ANALYSIS OF AGGREGATES FOR 1km ROAD

Length = 1km Width = 7m Thickness = 100mm

Volume = $1000 * 7 * 0.1 = 700 \text{ m}^3$

Quantity of Aggregates = Volume * Density of aggregates
= $700 * 2400$

$1680000 \text{ kg} = 1680 \text{ tons}$

Cost of Aggregates = Quantity of aggregates * Rate
= $1680 * 700 = ₹11,76,000$

From the test result we can use 60% of RAP with natural aggregates and can reduce the cost of aggregates upto ₹7,05,600 for 1km road. The cost reduction also depends on the method of refining of RAP material.

V. DISCUSSION

- The physical properties of natural aggregates, RAP materials and bitumen are satisfying the standard values.
- In table gradation of aggregates are matched with BC Grade -1 as per MORT&H2001 and obtained percentages for aggregate sizes of 20mm, 12.5mm and 4.75mm as 20%, 40% and 40% respectively.
- In table 4.13 when we use 30% of RAP and 70% NA stability is 22.68KN and flow value 5.2mm. For 50% RAP and 50% NA stability is 23.26KN and flow value 5.0mm. For 60% RAP and 40% NA stability is 25.62KN and flow value 4.6mm. For 70% RAP and 30% NA stability is 19.58KN and flow value 4.2mm.
- In graph 4.11, A graph of percentage of RAP in bituminous mix V/S Stability as the percentage of RAP increases stability increases upto 60% later decreases.

- In graph 4.12, A graph of percentage of RAP in bituminous mix V/S Flow Value as the percentage of RAP material increases flow value decreases.

CONCLUSION

- As per the test result all the physical properties of both natural aggregates and RAP materials are within the limit in which the RAP material physical properties are almost equivalent to the natural aggregates.
- The obtained gradation is 20%, 40% and 40% for 20mm, 12.5mm and 4.75mm aggregate sizes by the gradation of aggregates for BC Grade-1. When we are adding different percentages of RAP material to the natural aggregates we observed from the test result that 60% of RAP replacement with natural aggregates (60% RAP + 40% NA) achieved maximum stability for the mix, later the stability value get decreases and flow value increases.
- Hence we can use 60% of RAP material for the construction of an BC Grade-1 with natural aggregates as per test results.
- We can reduce 60% of total amount of aggregates by replacing 60% of RAP material with natural aggregates.

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