

A Study on Use of Reclaimed Asphalt Pavement (RAP) Materials in Flexible Pavements

Brajesh Mishra

M. Tech., Assistant Engineer, U.P. Cane Development Department, Lucknow, India

ABSTRACT: A good road network is a key for rapid growth of economy of a country. It provides connectivity to remote areas for various transport activities. There is about 4.2 millions kilometre road network in India, which ranks second in the world only after United States. Most of the roads are bituminous surfaced pavements. These roads are periodically resurfaced as maintenance action. It is due to this periodic maintenance the roads have attained a higher raised level as compared to adjoining properties in urban locality. These roads can be lowered down up to required and feasible depth by milling process and can be resurfaced with suitable layer of bituminous mixes replacing all or part of the bituminous pavement. Reclaimed asphalt pavement (RAP) materials are resulted from milling process. In this study samples of Reclaimed asphalt pavement (RAP) materials were collected and analysed for suitability of their usage in flexible pavements. Their characteristics including gradation, California Bearing Ratio(C.B.R).Aggregate Impact value, Aggregate Crushing value, Specific gravity, Flakiness & Elongation Index, Loss Angles Abrasion value, Water absorption and soundness were determined and compared to the MORTH specifications. Form the study it was found that the RAP materials can be effectively used in the soil sub-grade, sub-base and base of the flexible pavements resulting in reduction of the construction cost.

KEYWORDS: Aggregate Impact value, Aggregate Crushing value, California Bearing Ratio(C.B.R), Flakiness & Elongation Index, Reclaimed asphalt pavement (RAP), Specific gravity, Water absorption.

I. INTRODUCTION

Large quantities of Reclaimed asphalt pavement (RAP) materials are produced during highway maintenance and construction. A part of this can be used in new hot mix asphalt concrete and rest is available for other uses. If these materials could be re-used in base and sub-base of the roads, resulting in minimization of environmental impact, reduce the waste stream and also transportation costs connected with road maintenance and construction activities. The properties of RAP materials can be improved by blending of aggregates and by addition of chemical stabilizers. In recent years there was a gradual increase in construction and demolition wastes. It has resulted in waste disposal problem due to shortage of available landfills. Reuse of these materials after proper recycling can be the right solution for the same. There will be a reduction in cost about 25 to 30% by reusing the recycled road aggregate generated at same site. Before using such materials the mechanical properties must be tested and suitable blending is done if required. The most used recycled materials are Reclaimed asphalt pavement (RAP) materials and recycled concrete aggregate (RCA). The generation of RAP and RCA result in an aggregate of high quality and grading. Due to coating of asphalt on the aggregate of RAP it reduces the water absorption in aggregates.

Production of Reclaimed asphalt pavement (RAP) materials: Removal and reuse of asphalt layer of existing pavement is termed as RAP. However full depth reclamation (FDR) is defined as removal and reuse of hot mix asphalt layer and entire base course. RAP can be reused immediately at sites, however it may be stockpiled as the case may be. The required gradation of RAP are achieved by pulverizing the material in a crusher.

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 12, December 2015



Fig:1 Demolished Asphalt Pavement

A condition of demolished flexible pavement is shown in Fig-1 which can be reused after proper processing and crushed to required size and grading as per requirements of site condition.

Properties of RAP: A Comparison can be made between RAP and crushed natural aggregates. RAP has a higher content of fines as a result of degradation of material during milling and crushing operations. Typical physical properties of RAP are tabled below-

Table:1 Typical Properties of RAP

S. No.	Parameters	Values
1	Unit Weight (Kg/m ³)	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/m ³)	1500- 1950
6	California Bearing Ratio (CBR)	100% RAP : 20-25%

Consumption of natural aggregate can be reduced by using Reclaimed asphalt pavement (RAP) materials. Amount of binder can also be reduced in asphalt paving mixes by using Reclaimed asphalt pavement (RAP) materials. Studies have revealed that performance of pavement by using up to 30% RAP material is similar to that of pavement constructed with natural aggregates without RAP materials. Increase demand of aggregates and binder supply can be meet out up to certain extent by using Reclaimed asphalt pavement (RAP) materials in hot mix asphalt (HMA) and other courses of the flexible pavements like sub-base and base. Last but not least recycling asphalt creates a cycle of reuse that optimizes the use of natural resources and sustains the asphalt industry. Economy, ecology and energy conservation are all achieved when the two main components i.e. asphalt and aggregate are reused as construction materials to provide a strengthened and improved pavement. The major advantages of use of RAP are listed below-

- Lower cost.
- Reduction in consumption and use of natural resources.
- Reduction in damages to other roads due to transportation of materials from quarry sites.
- No increase in pavement thickness, very important for urban roads and highways.
- As the transportation is minimized resulting in energy saving i.e. less consumption of diesel.

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. A detailed laboratory investigation is required in order to use RAP in Hot mix asphalt (HMA) and Cold asphalt mix (CAM) to ensure that mixes have necessary minimum strength and durability. For better performance the following points should also be considered which are listed below-

- Quality control and additional processing
- Classifying RAP
- Changing the virgin binder grade

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 12, December 2015

- Preparing materials for mix design
- Blending the virgin and RAP binders
- Evaluation of performance

Sources of RAP: The various possible sources of RAP are as follows-

- Generation from milling of HMA layer
- Full depth pavement removal
- Waste from HMA generated at plant

Milling is the process of scraping and removing any distressed upper layers of existing pavement to a specified depth. The process includes grinding by machine and loading of RAP into a truck for transportation.



Fig: 2 Various Stockpiles of larger size RAP materials

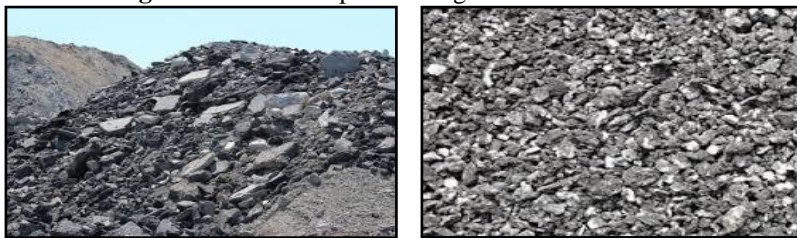


Fig: 3 Various Stockpiles of smaller size RAP materials

Stockpiles of RAP material of different sizes and shapes are shown in Fig-2&3. They can be reused as per requirements and their suitability in sub-base and base by conforming the grading and strength criteria.

II. OBJECTIVES

The main objective of the study is to find out suitability of Reclaimed asphalt pavement (RAP) materials to be used in construction of flexible pavements. To perform experimental investigations to assess the values of related parameters and their technical viability.

- To use untreated RAP materials as a stabilizing material to treat weak soil sub-grade to enhance CBR value and thereby reduction in the crust thickness and construction cost as well.
- To use RAP materials after blending in sub-base and base courses of flexible pavements.

III. MATERIALS AND METHOD

3.1. Collection of Samples: Samples of natural aggregate were obtained from Lalkuwan quarry near Haldwani district of Uttarakhand a State of India and sample of Reclaimed asphalt pavement (RAP) materials were collected from a stockpile near Lucknow district of Uttar Pradesh, a State of India.

The particle size distribution (PSD) of collected sample of RAP material and corresponding requirement of code to use it as granular sub-base (GSB) is shown below in table no.2.

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 12, December 2015

Table:2 The particle size distribution of RAP material and corresponding requirement of code to use as (GSB)

IS Sieve (mm)	Percentage passing by weight	Requirement for GSB grading II (table 400-2) of MORTH revision 4
53	100	100
26.5	92	50-80
19	80	-
10	66	-
4.75	38	15-35
2.36	22	-
0.60	11	-
0.075	2	<10

From table-2 above it is clear that certain sieve size material was missing in RAP to use as GSB material. To match the required grading the following modifications were done.

- 60% of 40mm down and 10% of stone dust as filler to satisfy the requirement as per MORTH 4th revision.
- The RAP material was used up to 30% to get the desired grading of GSB (coarse grade) as per MORTH 2013.

The table below shows the composition of mixed materials to get the desired grading of GSB material.

Table:3 Details of composite GSB with use of RAP

IS Sieve size (mm)	Material			Percent				Requirement for GSB grading II (table 400-2) of MORTH revision 4
	40 mm down	RAP	Stone dust	60% 40 mm down	30% RAP	10% Stone dust	Total	
53	100	100	100	60	30	10	100	100
26.5	60	92	100	36	27.6	10	73.6	50-80
4.75	11	38	97	6.6	11.4	9.7	27.7	15-35
0.075	0	2	8	0	0.6	0.8	1.4	<10

The RAP material was blended with suitable size of aggregates for required grading which was adopted to achieve maximum density.

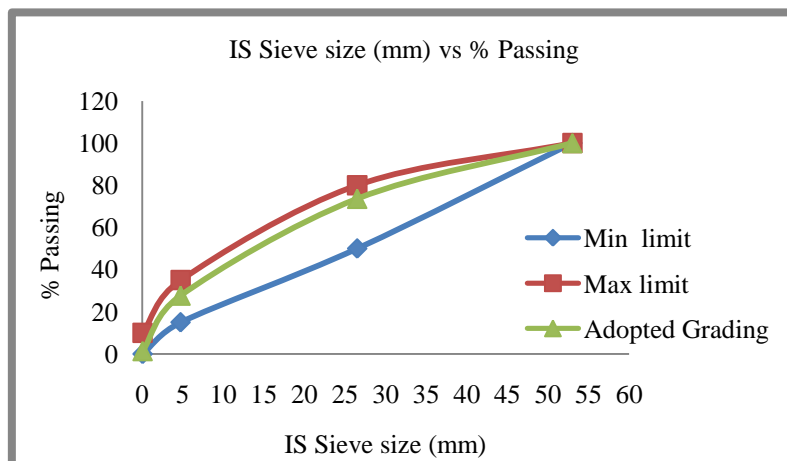


Fig:4 Showing limits and adopted Grading details for composite GSB

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 12, December 2015

The Fig-4 shows the minimum, maximum limits and adopted grading for GSB after blending of aggregates with composition of RAP as mentioned in table 3.

Table:4 Details of composite WMM with use of RAP

IS Sieve size (mm)	Material				Percent					Requirement for WMM grading (table 400-II) of MORTH revision 4
	45 mm down	RAP	11.2 mm down	Stone dust	32% 45 mm down	35% RAP	13% 11.2 mm down	20% Stone dust	Total	
53	100	100	100	100	32	35	13	20	100	100
45	100	100	100	100	32	35	13	20	100	95-100
22.4	28	92	100	100	8.96	32.2	13	20	74.16	60-80
11.2	0	70	98	100	0	24.5	12.74	20	57.24	40-60
4.75	0	38	8	97	0	13.3	1.04	19.4	33.74	25-40
2.36	0	22	0	75	0	7.7	0	15	22.7	15-30
0.6	0	11	0	40	0	3.85	0	8	11.85	8&22
0.075	0	2	0	8	0	0.7	0	1.6	2.3	<10

For use of RAP in base course of flexible pavement the modification was done to achieve the required grading as per details mentioned in table no-4.

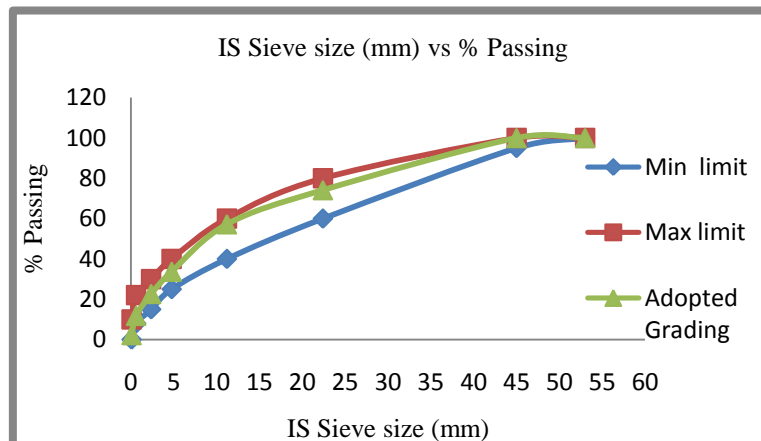


Fig:5 Showing limits and adopted Grading details for composite WMM

The Fig-5 shows the minimum, maximum limits and adopted grading for WMM after blending of aggregates with composition of RAP as mentioned in table no- 4.

3.2.Method: Both natural and RAP samples were brought to required size and suitable grading required for sub-base, base and surface course as per MORTH specifications. Samples of different compositions were prepared by adding different percentage of RAP materials (0% RAP, 10%RAP,20%RAP, 30%RAP, 40%RAP and 100% RAP) as shown below-

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 12, December 2015

Table: 6 Samples of different compositions

Sample No.	Details of Composition
C1	RAP 0% + 100% Natural Aggregate
C2	RAP 10% + 90% Natural Aggregate
C3	RAP 20%+ 80% Natural Aggregate
C4	RAP30% + 70% Natural Aggregate
C5	RAP40% + 60% Natural Aggregate
C6	RAP 100% + 0% Natural Aggregate

IV. EXPERIMENTAL RESULTS

To The results of experimental investigations are listed in tables as shown below-

Table: 7 Results on Samples of 100% RAP and 100% Natural Aggregates

Characteristics	100% RAP Aggregates	100% Natural Aggregates	MORTH Limits (Max.)	Remarks
Aggregate Crushing Value	22.52%	20.10%	30%	Satisfactory
Aggregate Impact Value	22.80%	19.60%	30%	Satisfactory
Flakiness & Elongation Index (Combined)	20.62%	20.32%	35%	Satisfactory
Loss Angeles Abrasion Test Value	21.80%	19.55%	30%	Satisfactory
Specific Gravity	2.63	2.65	2.6 - 3.0	> 2.60 Satisfactory
Water Absorption	1.42%	0.38%	2%	Satisfactory
Soundness Test (with Na ₂ SO ₄)	8%	4%	12 %	Satisfactory

From the test results as shown in table no-7above, it was observed that the RAP material can be easily used in granular sub base as it satisfies the norms as prescribed by MORTH. All the parameters are with in the prescribed specifications by MORTH.

Table: 8 Results on Samples of different compositions of RAP and Natural Aggregates combinations

Sample Composition	Aggregate Crushing Value	Aggregate Impact Value	Flakiness & Elongation Index (Combined)	Loss Angeles Abrasion Test Value	Specific Gravity	Water Absorption	Soundness Test
RAP 10% + 90% Natural Aggregate	22.42%	21.80%	20.60%	21.10%	2.65	1.32%	7.2%
RAP 20%+ 80% Natural Aggregate	22.10%	21.12%	20.55%	20.12%	2.65	1.10%	7.10%
RAP30% + 70% Natural Aggregate	20.15%	19.52%	20.42%	19.80%	2.66	0.98%	6.56%
RAP40% + 60% Natural Aggregate	20.20%	19.56%	20.42%	19.82%	2.65	1.12%	5.20%

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 12, December 2015

The test results of various combinations of proportions of RAP and natural aggregates are shown in table 8 above. The various parameters like Aggregate Crushing Value, Aggregate Impact Value, Flakiness & Elongation Index (Combined), Loss Angeles Abrasion Test Value, Specific Gravity, Water Absorption, Soundness Test value and California Bearing Ratio (CBR) values are with in the norms prescribed by MORTH and it can also be used in base of in flexible pavements. The best result was obtained on combination of 30% RAP along with 70% Natural Aggregates.

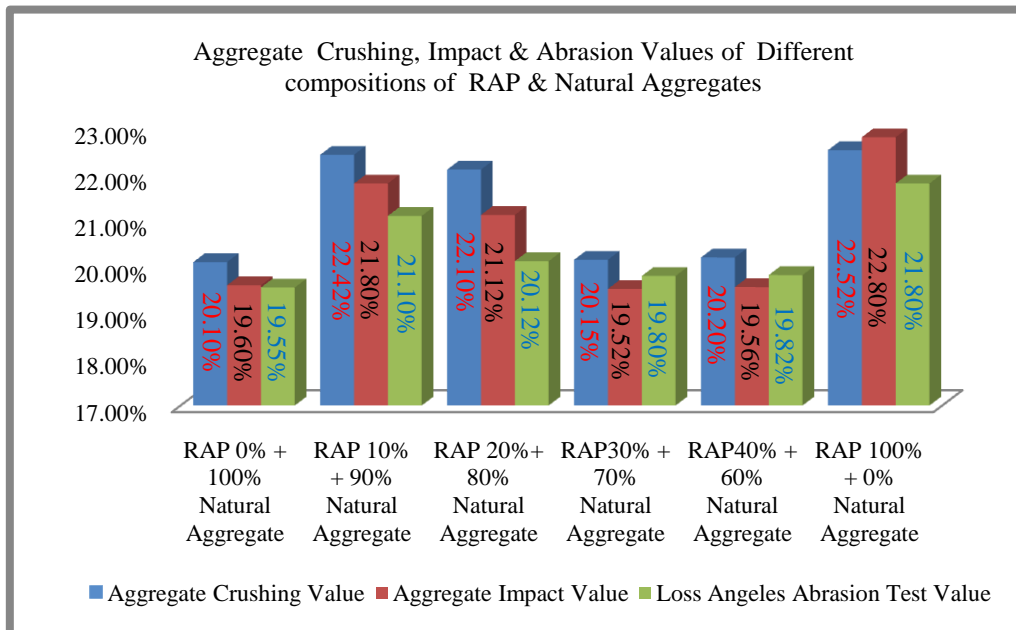


Fig:5 Values of Different parameters at various compositions of RAP & Natural Aggregates

The aggregate crushing, Los Angeles abrasion and Impact values are represented in figure no:5 above. The low values shows that the fraction of aggregate crushed is low and hence stronger and more tougher the aggregate is and it can capable of withstanding on higher wheel loads. The best result was observed on combination of 30% RAP along with 70% Natural Aggregates.

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 12, December 2015

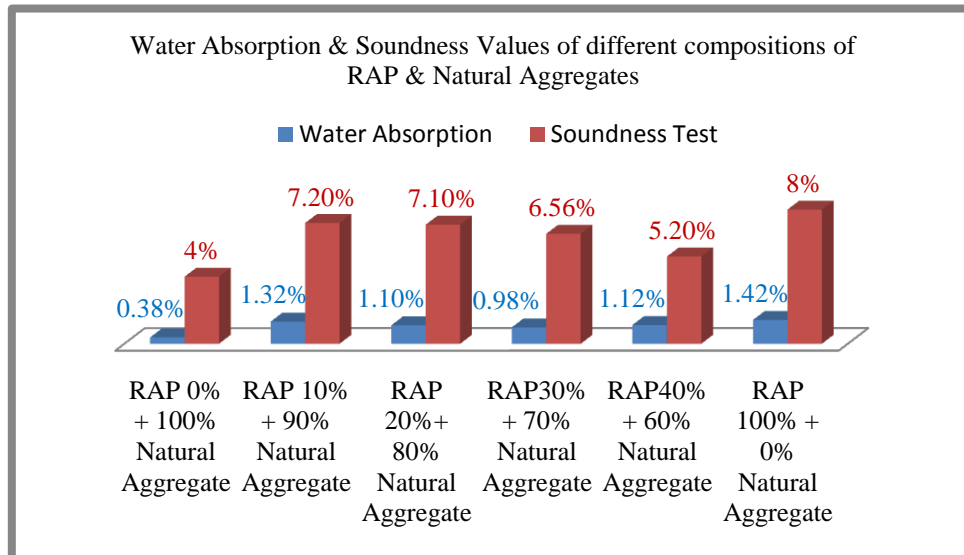


Fig:6 Water Absorption & Soundness Values of different compositions of RAP & Natural Aggregates

The Water Absorption & Soundness Values of different compositions are plotted in figure no:6 above. The water absorption value and soundness value for 30% RAP along with 70% Natural Aggregates combination was found to be 0.98% and 6.56% respectively.

V. CONCLUSION

On the basis of study and experimental investigations following conclusions were drawn-

1. It was observed that the RAP materials can be successfully used in granular sub base layer of flexible pavements after blending to match the required grading as per MORTH specifications for sub base material.
2. It was also observed that the RAP materials in combination to natural aggregate in various proportions can be easily used after blending to match the required grading as per MORTH specifications in the base courses of flexible pavements.
3. It is clear from the above investigation results that 30% replacement of natural aggregate can be successfully done in base course of flexible pavements, resulting in a savings of around 25- 30% in construction cost.
4. It was observed that RAP has a higher content of fines as a result of degradation of material during milling and crushing operations it can be easily used for soil stabilization purpose to increase the CBR value of sub-grade and hence the crust thickness of road will be reduced resulting in reduction of cost of construction.
5. Above all the problem of disposal of RAP wastes can be easily solved and adverse effect on environment may be avoided by using the RAP materials in flexible pavement construction.

REFERENCES

- [1] SP 20-2002: IRC Rural Road Manual.
- [2] Specification of Road & Bridge Work, Ministry of Shipping, Road Transport & Highway, Revision 4.
- [3] IS Codes: 2386, 2720.
- [4] IRC-37:2012, Tentative Guidelines for The Design of Flexible Pavement , Indian Road Congress, New Delhi .
- [5] Sunil S, K M Mallesh and T Chnadra Sekharaiah, Experimental Investigations on the performance of Bituminous Mixes with Reclaimed Asphalt Pavement Material, International Journal of Research in Engineering and Technology, Volume 3, 2004.
- [6] Dr. B. B. Pandey, Cold Mix Recycling and Mix Design, Workshop on Recycling and other Pavements Rehabilitation Methods, 2005, 7-11, IIT Kanpur
- [7] S.K. Khanna and C.E.G. Justo, highway material testing manual.