

Characterization of Indian reclaimed asphalt pavement (rap) on the basis of sources of rap and gradation characteristics of rap aggregates.

Anil Kumar Yadava, Syed Aqeel Ahmad

Abstract: A good road network is key for economic and social development of a country. There is about 4.2 million kilometer road network in India which ranks second in the world only after United States. It is necessary to maintain previously constructed roads along with new road construction. Both construction and maintenance of roads leading to over exploitation of resources of aggregates[1]. Most of Indian roads are bituminous surfaced pavements. Apart from depleting resources and Environmental issues, these roads are periodically resurfaced as maintenance action which intend to roads to attain a higher raised level as compared to initial level of road and adjoining properties and structures level[2]. Recycled or Reclaimed Asphalt Pavement (RAP) has increasingly been used to replace fresh or virgin materials for highway construction and maintenance as an Eco-friendly-Sustainable solution to overcome these problems. RAP can be used in different layers of Flexible and Rigid pavements[3]. In this research paper, an effort has been made to characterize the RAP on the basis of gradation characteristics of RAP aggregates and sources of RAP.

Keywords: Aggregates, Gradation, RAP, Recycling, Reclaimed, Asphalt, Pavement.

I. INTRODUCTION

Reclaimed Asphalt Pavement (RAP) is used as an alternative of fresh or virgin aggregates world-wide. UK, USA, Japan, Canada and other developed countries have well established procedure, guidelines and standards to classify and to reuse recycled asphalt materials. In India and other developing countries sufficient standards and guidelines as well efficient procedures are not available to characterize the reclaimed asphalt materials. Now it is highly required to classify the available RAP materials for further use in road construction. Reuse of these materials can reduce 25-30% cost of highway projects. Reclaimed Asphalt Pavement (RAP) materials can be characterize by different ways, such as sources of RAP, gradation characteristics of RAP, physical and chemical properties of RAP aggregates, recovered bitumen percentage and properties of recovered bitumen etc. This study was conducted to characterize the RAP material on the basis of its Origin or Source and Gradation Characteristics of RAP aggregate.

II. MATERIAL

The RAP is a deteriorated bituminous mix that contains aged bitumen and aggregates.

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Hence, its performance is poorer when compared to the fresh mix. The purpose of the bituminous recycling is to regain the properties of the RAP; such that it tends to perform as good as fresh mix. Thus, the process of bituminous recycling involves crushing, screening and stock piling and mixing with fresh aggregates. Use of RAP materials in road constructions will require characterized RAP, bitumen rejuvenators and virgin aggregates etc.

III. INITIAL CLASSIFICATION ON THE BASIS OF SOURCES OF RAP MATERIAL

Pavement Recycling (PR) classification could be base on the depth of the old pavement removed. If the top layers of pavement fail, then the upper layers are removed and laid again. This process is known as Surface Recycling (SR). If base failure occurs then the pavement layers up to base layer is removed and constructed again. This process is known as Full Depth Reclamation (FDR). This study was conducted to classify the RAP from Surface Recycling. RAP material obtained from different types of deteriorated bituminous pavement can be broadly classified as given in table No.1.

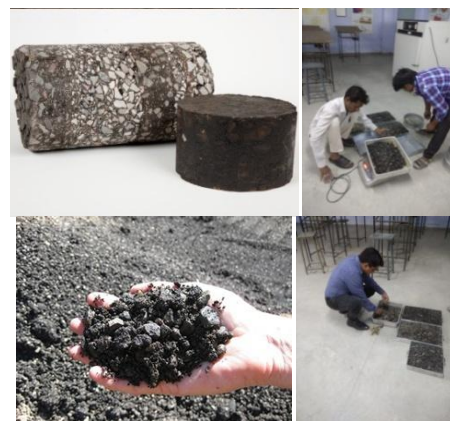


Fig 1: Core and Crushed Sample of Reclaimed Asphalt Pavement

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Table No. 1: Classification on the basis of Origin or Sources of RAP material

Sl No	Category	Recycled Course of Pavement	Sub-Category	Originally Material in Recycled Layer	Percentage of bitumen in Originally used Materials as per MORTH Specifications (%)	Minimum Thickness of Layer (mm)
1.	W	Wearing Course/Surface Course	W1	Premix Carpet & Seal Coat	3.5-4.0	20
			W2	SDBC	4.5-5.0	25-30
			W3	BC	5.3-5.5	30-50
2.	B	Binder Course/Bituminous Base Course.	B1	BM	3.3-3.5	50-100
			B2	DBM	4.0-4.5	50-100

At some places bituminous surface dressing (P1&P2) in village roads and few places mastic asphalt layers also available in city roads crossings, bridge approaches and on deck slab as wearing surfaces. But these are not available in significant quantity for recycling; hence not included in sampling and characterization or classification.

IV. SAMPLING

Generally Reclaimed Asphalt Pavement (RAP) is available as mixture of material used in binder/bituminous base course and wearing/surface course. Hence they cannot separate from removed bituminous material. Thus sampling

of RAP done for further study is given in table no 2. Minimum four road sites selected for sampling of each group of reclaimed Asphalt pavement material; minimum four samples were tested from each road site at different chainages and results are summarizing for Characterization of RAP. As per existing guidelines and standards flexible pavements includes different bituminous layers (which can recycled) depending upon traffic count as CVPD of a particular road. If CVPD is up to 2.0 msa OGPC(Open Graded Premix Carpet) with seal coat used; if CVPD is 2.0-5.0 msa SDBC over BM or DBM layer used and If CVPD is more than 5.0 msa BC over DBM layer used.

Table No.2: Categorization of RAP in Different Groups

Sl. No.	Recycled Layers	Group of Sample	Description
1.	PC+SEAL	PS	Initially Open Graded Premix Carpet (OGPC) and Seal Coat exist at the road from where sample is collected.
2.	BM+SDBC	BS	Initially Semi Dense Bituminous Concrete Over layer of Bituminous Macadam exist at the road from where sample is collected.
3.	DBM+SDBC	DS	Initially Semi Dense Bituminous Concrete Over layer of Dense Bituminous Macadam exist at the road from where sample is collected.



4.	DBM+BC	DB	Initially Bituminous Concrete Over layer of Dense Bituminous Macadam exist at the road from where sample is collected.
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Different groups of RAP samples are collected from different roads of Lucknow and Barabanki district of Uttar Pradesh in India. Complete details of collected samples are given in Table No. 3.

Table No.3: Sampling of RAP of Different Groups

Sl. No.	Group of Sample	Coding of different Samples	Chainage	Name of Roads	Location	Category of Roads
1.	PS	PS1	0.400 Km	Para Link Road	Lucknow, Uttar Pradesh, India	Village Roads (VR)
		PS1'	1.500 Km			
		PS1''	2.600 Km			
		PS1'''	3.700 Km			
		PS2	0.800 Km			
PS2'	1.600 Km					
PS2''	2.500 Km					
PS2'''	3.800 Km					
PS3	3.200 Km	Lalpur Link Road	Lucknow, Uttar Pradesh, India	Village Roads (VR)		
PS3'	4.500 Km					
PS3''	5.400 Km					
PS3'''	6.200 Km					
PS4	2.300 Km				Nigoha Bazar to Meerak Nagar Link Road	Lucknow, Uttar Pradesh, India
PS4'	3.500 Km					
PS4''	4.600 Km					
PS4'''	5.800 Km					
2.	BS	BS1	36.400 Km	Haidergargh-Subeha-Shukul Bazar Road (ODR)		
		BS1'	37.500 Km			
		BS1''	38.600 Km			
		BS1'''	39.700 Km			
		BS2	10.100 Km	Bhanmau-Zaidpur-Safdarganj-Badosarai Road (ODR)	Barabanki, Uttar Pradesh, India	Other District Road (ODR)
		BS2'	11.500 Km			
		BS2''	12.300 Km			
		BS2'''	13.600 Km			
BS3	23.400 Km	Barabanki-Deviganj-Subeha Road (ODR)	Barabanki, Uttar Pradesh, India	Other District Road (ODR)		
BS3'	24.600 Km					
BS3''	25.600 Km					
BS3'''	26.800 Km					
BS4	09.400 Km	Mohammadpur-Siddhaur-Kaiserganj Road (ODR)	Barabanki, Uttar Pradesh, India	Other District Road (ODR)		
BS4'	10.200 Km					
BS4''	11.600 Km					
BS4'''	12.400 Km					
3.	DS	DS1	130.200Km	Barabanki-Haidergargh-Bachhrawan Road (SH-13)	Barabanki, Uttar Pradesh, India	State Highway (SH)
		DS1'	131.400Km			
		DS1''	132.600Km			
		DS1'''	133.800Km			



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		DS2 DS2' DS2'' DS2'''	10.400 Km 11.200 Km 12.400 Km 13.200 Km	Haidergargh- Ramsnehigha t Road (MDR-3)	Barabanki, Uttar Pradesh, India	Major District Road (MDR)
		DS3 DS3' DS3'' DS3'''	16.400 Km 17.500 Km 18.600 Km 19.700 Km	Intauja- Mahona- Kumhrawan- Kursi-Deva- Chinhat Road (MDR-88)	Barabanki, Uttar Pradesh, India	Major District Road (MDR)
		DS4 DS4' DS4'' DS4'''	1.400 Km 2.500 Km 3.600 Km 4.700 Km	Haidergargh- Maharajganj Road (SH- 13A)	Barabanki, Uttar Pradesh, India	State Highway (SH)
4.	DB	DB1 DB1' DB1'' DB1'''	260.400 Km 261.500 Km 262.600 Km 263.700 Km	Palia- Shahjanpur- Hardoi Road (SH-25)	Lucknow, Uttar Pradesh, India	State Highway (SH)
		DB2 DB2' DB2'' DB2'''	59.400 Km 60.400 Km 61.600 Km 62.300 Km	Lucknow- Sultnpur Road (NH- 56)	Barabanki, Uttar Pradesh, India	National Highway (NH)
		DB3 DB3' DB3'' DB3'''	22.400 Km 23.500 Km 24.600 Km 25.700 Km	Lucknow- Faizabad- Gorakhpur- Mokama Road (NH28)	Barabanki, Uttar Pradesh, India	National Highway (NH) City Portion.
		DB4 DB4' DB4'' DB4'''	2.400 Km 3.500 Km 4.600 Km 5.700 Km	Barabanki- Bahraich- Nanpara- Rupaidiha road (NH-28 C)	Barabanki, Uttar Pradesh, India	National Highway (NH)

V. METHODOLOGY AND EXPERIMENTAL PROGRAM

Experimental work done with different set of RAP samples and results can be used to characterize the RAP materials. First of all RAP collected from different Areas and different roads for this study. Samples were oven dried and crushed so that lumps were break to a level so that each and every bitumen coated coarse aggregates separated to each other. Bitumen from RAP sample washed out by using Benzene Solution and extracting with Bitumen Extractor. These samples were oven dried again and sieved on IS designated Sieves and results were summaries for further study of performance of Reclaimed Asphalt Pavement (RAP) aggregates in different layers of pavements. Methodology Developed for characterization of Indian Reclaimed Asphalt Pavement will include steps listed below:

- Step1: Identify the road for collection of Reclaimed Asphalt Pavement (RAP).
- Step2: Collection of core and disturbed samples from identified road sites.
- Step3: Drying samples in oven for 24 hours at 1000 C.
- Step4: Crushing of oven dried collected samples.

- Step5: Washing of crushed samples with Benzene solution.
- Step6: Extracting the washed samples with bitumen extractor.
- Step7: Oven drying samples again.
- Step8: Sieve analysis of washed, extracted and oven dried samples.
- Step9: Tabulation of result of sieve analysis.
- Step 10: Averaging the result for predicting gradation pattern.

VI. RESULTS:

Sieving of graded, crushed and oven dried RAP aggregate samples were done in four lots. Each lot has at least four sample of different group of samples collected from different site of different roads. Average percentage passing by weight of aggregated is given in tables. **A. Group PS:** This group of sample collected from sites where roads are having OGPC and Seal Coat over Granular Base and Sub Base. These sites are mostly on Village Roads in different districts. On these roads CVPD is up to 2.0 msa during initial construction of the road.





Fig 2: Washing, Extracting and Gradation Experiment of RAP

Table No.4: Gradation of “Group PS” RAP

Sl. No.	IS Sieve Designation(mm)	Percentage passing by weight (Average)
1	53	-
2	45	-
3	37.5	-
4	26.5	-
5	19	-
6	13.2	100
7	9.5	100
8	4.75	-
9	2.36	20
10	1.18	-
11	0.6	-
12	0.3	-
13	0.150	-
14	.075	5

B. Group BS: This group of sample collected from sites where roads are having SDBC over layer of BM supported by Granular Base and Sub Base. These sites are mostly on ODR and MDR in different districts. On these roads CVPD is 2.0-5.0 msa during initial construction of the road.

Table No.5: Gradation of “Group BS” RAP

Sl. No.	IS Sieve Designation(mm)	Percentage passing by weight (Average)
1	53	-
2	45	-
3	37.5	100
4	26.5	100
5	19	100
6	13.2	90
7	9.5	85
8	4.75	40
9	2.36	25
10	1.18	23
11	0.6	-
12	0.3	13
13	0.150	-
14	.075	10

C. Group DS: This group of samples collected from sites where roads are having SDBC over layer of DBM supported by Granular Base and Sub Base. These sites are

mostly on ODR and MDR in different districts. On these roads CVPD is 2.0-5.0 msa during initial construction of the road.

Table No.6: Gradation of “Group DS” RAP

Sl. No.	IS Sieve Designation(mm)	Percentage passing by weight (Average)
1	53	-
2	45	-
3	37.5	100
4	26.5	98
5	19	85
6	13.2	80
7	9.5	-
8	4.75	55
9	2.36	48
10	1.18	23
11	0.6	-
12	0.3	15
13	0.150	-
14	0.075	8

D. Group DB: This group of samples collected from sites where roads are having BC over layer of DBM supported by Granular Base and Sub Base. These sites are mostly on SH and NH in different districts. On these roads CVPD is more than 5.0 msa during initial construction of the road.

Table No.7: Gradation of “Group DB” RAP

Sl. No.	IS Sieve Designation(mm)	Percentage passing by weight (Average)
1	53	-
2	45	-
3	37.5	100
4	26.5	97
5	19	93
6	13.2	84
7	9.5	80
8	4.75	60
9	2.36	58
10	1.18	45
11	0.6	35
12	0.3	19
13	0.150	-
14	0.075	7

VII. CONCLUSION

On the basis of study and experimental investigations following conclusion were drawn:

- (a). In India variety of Reclaimed Asphalt Pavement (RAP) Materials are available. Depending on Sources of RAP i.e. deteriorated asphalt pavement and type of bituminous mixes used in these pavements during construction and cyclic renewal or resurfacing of road. Indian RAP can be categorized in different categories or groups.
- (b). Indian Reclaimed Asphalt Pavement (RAP) can be initially classified in four different categories or groups namely PS, BS, DS and DB.
- (c). Characterization of Indian Reclaimed Asphalt Pavement (RAP) in PS, BS, DS and DB groups are based on the type of bituminous mixes used during construction and resurfacing of road.



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If initially Open Graded Premix Carpet (OGPC) and Seal Coat used then recovered RAP material termed as “PS category/group”. If initially Semi Dense Bituminous Concrete (SDBC) over layer of Bituminous Macadam (BM) used then recovered RAP material categorized as “BS category/group”. Similarly If initially Semi Dense Bituminous Concrete (SDBC) Over layer of Dense Bituminous Macadam (DBM) used then recovered RAP material categorized as “DS category/group”. Last one is if initially Bituminous Concrete (BC) over layer of Dense Bituminous Macadam (DBM) used then recovered RAP material categorized as “DB category/group”.

(d). Observing gradation results it can be concluded that RAP is a graded material and can be used in different layer of pavements; by filling the gap in gradation with fresh/virgin materials as per grading requirement of the concerning layers according to MORTH specifications and IRC guidelines.

(e). Using gradation tables blend of Classified RAP material with virgin aggregates can be prepare to use in Granular Sub Base course, Granular or Stabilized Base course, Bituminous Base Course or Binder Course and also in Wearing or Surface course.

(f). Gradation pattern of RAP indicates that during removal, milling and crushing lot of fines generated. RAP is having sufficient quantity of fines which is inert material and can be blended to sub grade to improve its CBR and MDD, therefore reducing crust thickness of road pavement, but further detail study regarding this purpose required.

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