TECHNICAL VIABILITY OF USING RECLAIMED ASPHALT PAVEMENT IN AHMEDABAD BRTS CORRIDOR FOR BASE COURSE

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***ABSTRACT** : The Ahmedabad BRTS started in October-2009 is among the most successful solutions to the problem of inefficient urban public transportation in India to provide mobility to people, reducing to distance and duration of travel. The Janmarg BRTS project plan consists of development of 217 km of BRTS corridors in three phases. In BRTS, dedicated corridor of 7.5m is provided, so for that they are constructing new roads by demolishing the existing road, up to granular sub base course and on that they are constructing new roads for BRTS route. In construction work of BRTS, no methodology for quantification was designed to calculate this waste. Due to this, the waste generated after demolishing the existing road is quite high in monetary terms, and they have not prepared any methodology to re-use or recycle this waste material. So in this research work we shall find out Technical viability of recycling construction waste as material for the base course of road.*

The main objective of this research was to evaluate characteristics of Recycled Asphalt Pavements (RAP) collected from selected BRTS corridor in Ahmedabad. The RAP was collected from Kalupur to Naroda patiya stretch of BRTS corridor. The aggregates were extracted from RAP, and tested for characteristics including gradation, Aggregate Impact Value, Flakiness and elongation index (F&E), specific gravity & Water Absorption test as per MoRTH and shall find out Technical Viability of using this material in base course layer.

KEYWORDS: Reclaimed Asphalt Pavement, W.M.M., Gradation test, Flakiness & Elongation Index Test, Aggregate Impact Value, Specific Gravity & Water Absorption test, B.R.T.S.

1. INTRODUCTION

Recycled Asphalt Pavement (RAP) refers to reclaimed and reprocessed pavement material containing asphalt binder and aggregates. These materials are produced when asphalt pavements are reclaimed for resurfacing, reconstruction or accessing buried materials. RAP contains useful materials, including asphalt binder and aggregate, when crushed and screened properly. RAP is obtained either by milling or by a full depth recovery method Recycling of asphalt pavements is a valuable approach for technical, economical, and environmental reasons.

2. OBJECTIVE:

The main Objective of this research is to find out technical viability of using this recycled waste of road material in base course of road in Ahmedabad BRTS.

3. STUDY AREA:

The primary data collected from the Kalupur to Naroda Patia stretch from the site, Contractor and Consultant office. This stretch is around 5.1 km in length and width of RoW varies along the corridor. The average RoW is about 30 m. This zone is divided as per land use in three parts i.e. Residential, Industrial & Commercial. Arvind mil, Gujarat Cancer Society Medical College, Hospital & Research centre, Divisional Railway Manager office and Naroda Mamco are located on this corridor. Due to the Industrial zone and Kalupur Railway station, there are heavy rush of truck and ST buses on this corridor. The project detail of this stretch is given below.

Name of Client:	Ahmedabad Municipal Corporation
Name of Design Consultant:	CEPT in association with LEA Associates South Asia Pvt. Ltd.
Name of PMC:	TÜV SÜD South Asia Pvt. Ltd.
Name of Contractor:	J. Kumar Infraprojects Limited

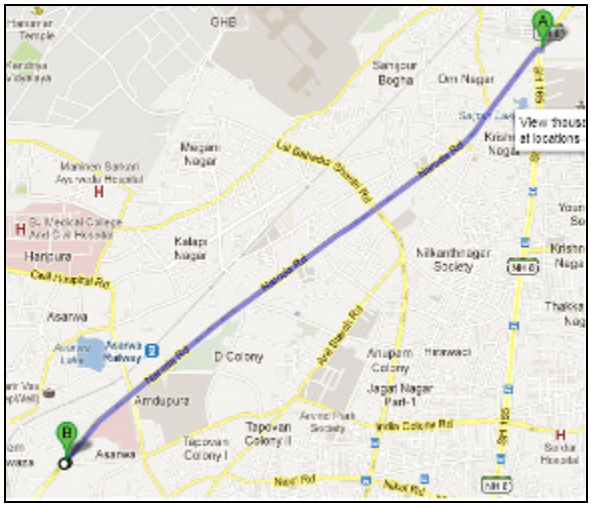

Fig.1 Kalupur to Naroda Patia Stretch

4. DETAILS OF EXISTING PAVEMENT

On the site, Asphalt layer are various from 100 mm to 130 mm in total length of 5190 mt road stretch, so average depth of asphalt layer is considered to be 115mm for whole stretch.

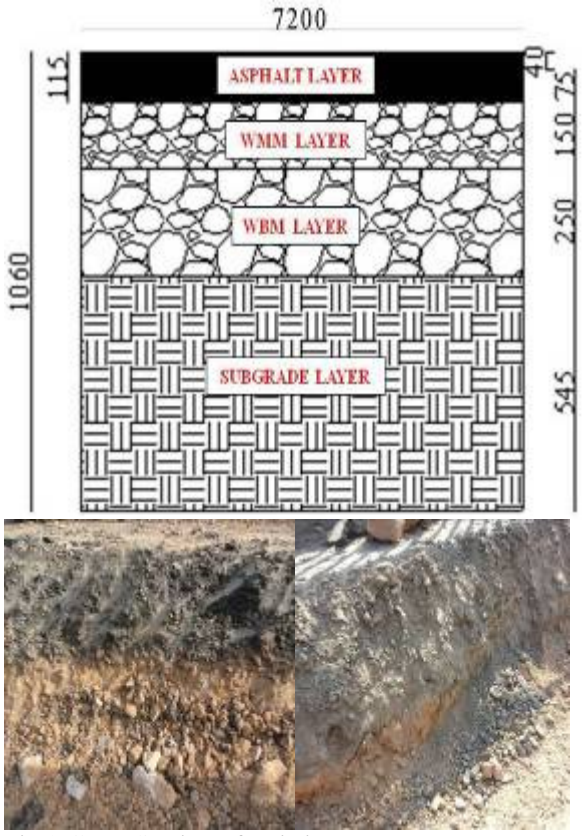

Fig.2 Cross Section of Existing Pavement

As shown in this fig, subgrade layer having thickness of 545mm contains brickbats, Rubber Soling & debris, however there is no continuity found in the materials. Above subgrade 250 mm WBM & 150mm WMM found respectively & Asphalt layer which is approximately 115mm thick, contains 40mm BC and 75mm BM. Total crust thickness of existing pavement is found around 1060mm.

5. CROSS SECTION OF NEW PAVEMENT REQUIRED AS PER BRTS DESIGN

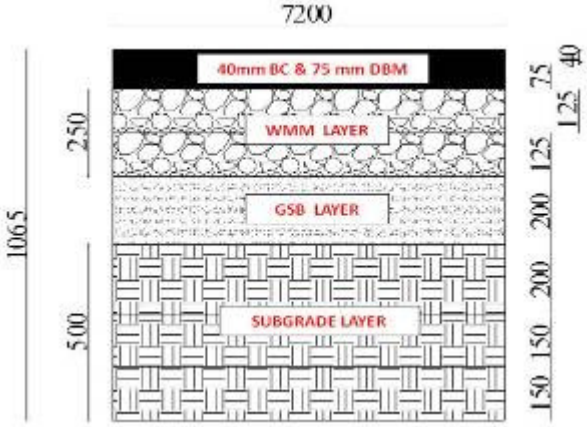

Fig.3 Cross Section of New Pavement

6. COLLECTION OF SAMPLE:

The material was collected from the Kalupur to Naroda Patia stretch. The scarification of BRTS corridor is carried out by the help of JCB machine. At the time of excavation material was collected form of chunk from the site as layer wise differently. As per availability of material, Asphalt layer, WMM layer & WBM layer were collected from site to find technical viability of using this layer into WMM layer in the new pavement.

Fig.4 collection of samples from site

7. LABORATORY INVESTIGATION:

The study is basically on a lab study and the practical of the aggregates have been done in contractor laboratory at charodi hot mix plant in Ahmedabad. As very less research work has been done for recycled material and the behavior of recycled material is unknown hence all the experiment for testing the suitability of recycled material needs to be done. Thus the study involved the laboratory test for aggregate specification to confirm whether the recycled material complies with the established standards or not.

The Physical Requirements of coarse aggregates for WMM for base courses is given below as per MoRTH.

Coarse aggregate shall be crushed stone. If crushed gravel/shingle is used, not less than 90 per cent by weight of the gravel/shingle pieces retained on 4.75 mm sieve shall have at least two fractured faces. The aggregate shall confirm to the physical requirements set forth in table.

Table: 1 Physical requirement of coarse aggregates for WMM for Sub-base/base courses.

Sr.No.	Test	Test Method	Requirements
1.	*Los Angeles Abrasion value or	IS:2386 (Part-4)	40 percent (Max.)
	*Aggregate Impact value	IS:2386 (Part-4) or IS:5640	30 percent (Max.)
2.	Combined Flakiness and Elongation indices (Total)	IS:2386 (Part-1)	30 percent (Max.)**

(Source: "Specification For Road & Bridge Works" (Fourth Revision) (MOSR&TH), Published By "Indian Road Congress", New Delhi – 2001.)

* Aggregate may satisfy requirements of either of the two tests.

** To determine this combined proportion, the flaky stone from a representative sample should first be separated out. Flakiness index is weight of flaky stone metal divided by weight of stone sample. Only the elongated particles are separated out from the remaining (non-flaky) stone metal. Elongation index is weight of elongated particles divided by total non-flaky particles. The values of flakiness index and elongation index so found are added up.

If the water absorption value of the coarse aggregate is greater than 2 percent, the soundness test shall be carried out on the material delivered to site as per IS 2386 (part-5).

7.1 CRUSHING OF AGGREGATES:

As the material was collected as the form of chunk from the kalupur to naroda patia stretch, it was broken by the help of hammer to convert it in aggregate form.

Fig.5 Breaking of RAP aggregates with the help of hammer

7.2 BITUMEN EXTRACTION:

This test is done to determine the bitumen content as per ASTM 2172. The apparatus needed to determine bitumen content are -

i) Centrifuge extractor

ii) Miscellaneous – bowl, filter paper, balance and commercial benzene.

- To know the bitumen content in RAP, sample of 500g is taken.

Fig.6 Sample taken after heating of RAP mix

- The mixture is not soft enough to separate with a trowel, place 1000g of it in a large pan and warm up to 100o C to separate the particles of the mixture uniformly.

Fig.7 Procedure of Bitumen Extraction

- Place the sample (Weight 'A') in the centrifuge extractor. Cover the sample with benzene, put the filter paper on it with the cover plate tightly fitted on the bowl.
- Start the centrifuge extractor, revolving slowly and gradually increase the speed until the solvent ceases to flow from the outlet.

Fig.8 RAP Aggregates after bitumen extraction

- Allow the centrifuge extractor to stop. Add 200ml benzene and repeat the procedure.
- Repeat the procedure at least thrice, so that the extract is clear and not darker than the light straw colour and record the volume of total extract in the graduated vessel.
- Remove the filter paper from the bowl and dry in the oven at 110 + 5o C. After 24hours, take the weight of the extracted sample (Weight 'B').

Reporting of results:
Bitumen content = [(A-B)/B]×100 %
Wt of total sample (A) = 500gm
Wt of extracted sample (B) = 483.18

$$\text{Bitumen content} = \frac{500 - 483.18}{483.18} X\ 100$$

= 3.48%

- The existing binder content (bitumen) in RAP as per result is 3.48%

As per above method the all aggregates were extracted from RAP is carried out for further laboratory test to find out suitability for WMM as per Specification for Road and Bridge works under MoRTH (Ministry of Shipping, Road Transport & Highways), Section: 400 Sub bases, bases (Non Bituminous) and shoulders.

7.3 GRADATION TEST:
The material obtained from milling varied greatly in size, therefore it is necessary to establish uniform sizing of material to comply with specified gradation limits for WMM & GSB layers. Therefore the first step in the study after the collection of the material is to determine its gradation.
Here, as per IS 2386 (Part-1), the samples were taken to fix the percentage of passing for each sieves size. The material with various sizes like 40 mm, stone dust and recycled material were taken for making the proportion of W.M.M. There were four samples taken for each size material and the average was taken from the four individual gradation tests. The J.M.F. (Job Mix Formula) was developed on the basis of percentage passing limit for the each sieve sizes as per MoRTH specification.
Table.2 JMF for WMM Mix in Proportion (RAP: 40mm: Stone dust)

Proportion WMM	**RAP**	**40mm**	**Stone dust**	**Mix**
	0.60	**0.30**	**0.10**	**1.00**

IS Sieve Size mm	**RAP**	**40mm**	**Stone Dust**	**Achieved Result**	**Specified Limit**
53.00	100.00	100.00	100.00	100.00	100.00
45.00	100.00	100.00	100.00	100.00	95-100
22.40	95.44	24.28	100.00	74.55	60-80
11.20	71.33	3.83	100.00	53.95	40-60
4.75	36.89	0.00	100.00	32.13	25-40
2.36	21.84	0.00	82.59	21.36	15-30
0.600	10.74	0.00	52.48	11.69	8-22
0.075	1.75	0.00	5.09	1.56	0-8
Pan	0.00	0.00	0.00	0.00	0.00

From the gradation of RAP aggregates, we observed that the large size of aggregates were deficient in RAP mix due to the action of crushing & aging. So to set RAP mix in specific limits, by adding 60% of RAP mix, 30% of 40mm size of aggregates & 10 of % stone dust, we can achieve the passing limits of each sieve size of aggregates as per MoRTH.

7.4 AGGREGATE IMPACT VALUE:
Toughness is the property of a material to resist impact. Due to traffic loads, the road stones are subjected to the pounding action or impact and there is possibility of stones breaking into smaller pieces. The road stones should therefore be tough enough to resist fracture under impact. A test designed to evaluate the toughness of stones.
As per I.S. 2386 (Part – 4) the methodology was adopted for the test and calculation is done here in Table.3
Table.3 A.I.V. observation for WMM

Sr. No.	**Description**	**1**	**2**	**3**	**4**
1	Total Weight of aggregate taken W1 (gm)	345	342	340	346
2	Weight of Aggregate retained on 2.36 mm I.S. Sieve W2 (gm)	292	287	295	289
3	Weight of Aggregate passing through 2.36 mm I.S. Sieve W3= W1-W2 (gm)	53	55	45	57
4	Aggregate Impact Value (W3/W1) * 100 in %	15.36	16.08	13.23	16.47
Average Impact Value			15.285%		

Reporting of Results:-
The mean of the three results is reported as the Aggregate Impact Value of the specimen to the nearest whole number. The result was 14.89% which is less than the 30 % maximum permissible limits as per MoRTH for WMM. Hence the material is satisfied.

7.5 FLAKINESS & ELONGATION INDEX TEST:
The particle shape of aggregates is determined by the percentages of flaky and elongated particles contained in it. For base course the presence of flaky and elongated particles are considered undesirable as they may cause inherent weakness with possibilities of breaking down under heavy loads.

As per I.S. 2386 (Part – 4) the methodology was adopted for the test and calculation is done here in Table.

Table.4 F.I.&E.I. observation for WMM

Sr. No.	IS Sieves (mm)		Weight retained (gm)	Weight of Flakiness materials (gm)	Weight of non Flakiness materials (gm)	Weight of Elongated materials (gm)
	Upper	Lower				
1	63	50				
2	50	40				
3	40	31.5	12140	1872	10268	1244
4	31.5	25	6495	990	5505	689
5	25	20	3704	565	3139	390
6	20	16	2025	312	1713	209
7	16	12.5	865	133	732	92
8	12.5	10	390	60	330	41
9	10	6.3	255	39	216	27
10	6.3	PAN				
			W: 25874	W_1: 3971	W_2: 21903	W_3: 2692
			(W_1/W) X100: 15.35 %		(W_3/W_2)X100: 12.29 %	

Combined F.I+E.I = 15.35+12.29
= 27.64 %

Reporting of Results:-

The obtained result was 27.64% which is less than the 30 % maximum permissible limits as per MoRTH for WMM. Hence the material is satisfied.

7.6 SPECIFIC GRAVITY & WATER ABSORPTION TEST:

The specific gravity of an aggregate is considered to be a measure of strength or quality of the material. The specific gravity test helps in the identification of stone.

Water absorption gives an idea of strength of aggregate. Aggregates having more water absorption are more porous in nature and are generally considered unsuitable unless they are found to be acceptable based on strength, impact and hardness tests.

The Specific gravity & Water absorption of each size of aggregates like RAP aggregates, 40 mm size aggregates & stone dust were found out individually by taking four samples and the average was taken from the four individual tests.

Table.5 Specific Gravity & Water Absorption of RAP aggregates for W.M.M.

Sr. No	Description	1	2	3	4	Avg. value
1	Weight of saturated aggregate suspended in water with the basket, W1 (gm)	2654	2659	2658	2640	
2	Weight of basket suspended in water, W2 (gm)	723	723	723	723	
3	Weight of saturated aggregate in water, (W1-W2) WS (gm)	1931	1936	1935	1917	
4	Weight of saturated surface dry aggregate in air, W3 (gm)	2954	2974	2976	2950	
5	Weight of oven dried aggregate in air, W4 (gm)	2931	2949	2955	2928	
6	Specific Gravity $\frac{W_4}{W_3-(W_1-W_2)}$	2.865	2.841	2.839	2.834	2.845
7	Apparent Specific Gravity $\frac{W_4}{W_4-(W_1-W_2)}$	2.931	2.911	2.897	2.896	2.909
8	Water Absorption (%) $\left(\frac{W_3-W_4}{W_4}\right)\times 100$	0.780	0.848	0.711	0.751	0.773

Table.6 Specific Gravity & Water Absorption of 40mm size Aggregates for W.M.M.

Sr. No	Description	1	2	3	4	Avg Val
1	Weight of saturated aggregate suspended in water with the basket, W1 (gm)	2536	2422	2590	2750	
2	Weight of basket suspended in water, W2 (gm)	723	723	723	723	
3	Weight of saturated aggregate in water, (W1-W2) WS (gm)	1813	1699	1867	2027	
4	Weight of saturated surface dry aggregate in air, W3 (gm)	2770	2600	2860	3098	
5	Weight of oven dried aggregate in air,W4 (gm)	2757	2589	2850	3085	
6	Specific Gravity $\frac{W_4}{W_3-(W_1-W_2)}$	2.881	2.873	2.870	2.880	2.876
7	Apparent Specific gravity $\frac{W_4}{W_4-(W_1-W_2)}$	2.921	2.909	2.899	2.916	2.911
8	Water Absorption (%) $\left(\frac{W_3-W_4}{W_4}\right)\times 100$	0.472	0.425	0.351	0.421	0.417

Table.7 Specific Gravity & Water Absorption of Stone dust for W.M.M.

Sr. No	Description	1	2	3	4	Avg Value
1	Weight of saturated surface dry aggregate in air(A) (gm)	736	800	750	760	
2	Weight of Pycnometer filled with Sample And filled with Water(B)	1961	2000	1970	1975	
3	Weight of Pycnometer filled with Water (C)	1508	1508	1508	1508	
4	Weight of oven dried Sample (D) (gm)	725	787	738	748	
5	Specific Gravity on oven Dried Basis D/A-(B-C)	2.562	2.555	2.563	2.553	2.558
6	Specific Gravity on SSD Basis A/A-(B-C)	2.601	2.597	2.604	2.594	2.599
7	Apparent Specific Gravity D/D-(B-C)	2.665	2.668	2.674	2.662	2.667
8	Water Absorption (%) (A-D)/D*100	1.517	1.652	1.626	1.604	1.6

Limits:

The specific gravity of aggregates ranges from 2.5 to 3.0

The water absorption of aggregates ranges from 0.1 to 2.0 %.

Reporting of Results:-

The obtained result which was laying in the permissible limits so material is satisfied.

8. CONCLUSION

Major findings from the laboratory investigation were given below.

- The RAP aggregates did not meet the required gradation as per MoRTH. We observed that the large size of aggregates were deficient in RAP mix due to the action of crushing & aging. So, to meet the required gradation numbers of trials are made with natural aggregate and by adding 60% of RAP mix, 30% of 40mm size of aggregates & 10 of % stone dust, we can achieve the passing limits of each sieve size of aggregates.
- Aggregate Impact Value was 14.89% which is less than the 30 % maximum permissible limits as per MoRTH for WMM. Hence the material is satisfied.
- The Combined Flakiness & Elongation index was 27.64% which is less than the 30 % maximum permissible limits as per MoRTH for WMM. Hence the material is satisfied.
- The specific gravity of aggregates was lying from 2.8 to 3.0 and the water absorption of aggregates ranges from 0.3 to 2.0 % which was between specifying limit so material is satisfied.

From the study analysis it was found that recycled aggregates confirmed to the standards specified in MoRTH specification, and can be used as base course of pavement materials.

9. REFERENCES

[1] Audrey Copeland (2011), "Reclaimed Asphalt Pavement in Asphalt Mixtures: State of the Practice", Turner-Fairbank Highway Research Centre, Federal Highway Administration, FHWA-HRT-11-021, pp.1-40.

[2] Ahmedabad Bus Rapid Transit System, Urban Transport Initiatives in India: Best Practices in PPP, National Institute of Urban Affairs.

[3] Bhavin S. Gamit, (2011) "Reappraisal of Asphalt Concrete Recycling as a Coarse aggregate used in base of Flexible Pavement" Gujarat Technological University, 1-78.

[4] Eric J. McGarrah, (2007) "Evaluation of Current Practices of Reclaimed Asphalt Pavement/Virgin Aggregate as Base Course Material", Washington State Department of Transportation, WA-RD 713.1 , pp. 1-30

[4] Jie Han, Subhash C. Thakur, Oswald Chong, Robert L. Parsons (2011) "laboratory evaluation of characteristics of recycled asphalt pavement in kansas" University of Kansas, K-TRAN: KU-09-2, pg no.16 -25.

[5] "Specification for Road & Bridge Works" (Fourth Revision), Ministry of Shipping, Road Transport & Highways (MOSR&TH), Section: 400 Sub bases, bases (Non Bituminous) and shoulders. Published By "Indian Road Congress", New Delhi – 2001.