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Utilisation of RAP (Reclaimed Asphalt Pavement) Material Obtained By Milling Process: With Several Options in Urban Area at Surat, Gujarat, India.

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ABSTRACT
Some practical options to use the RAP material in urban areas and thereby achieving economy in the construction besides solving the raised level of roads, effective disposal of RAP and above all using the principles of environment friendly Green technology that is: Reduce, Reuse and Recycle.

Keyword –
1. RAP: Reclaimed Asphalt Pavement
2. GSB: Granular Sub Base
3. WMM: Wet Mix Macadam
4. DBM: Dense Bituminous Macadam
5. CBR: California Bearing Ratio
6. MoRTH: Ministry Of Road Transport and Highways (India)

I. INTRODUCTION

Having a long past of bituminous roads (flexible pavement) in India, due to repeated resurfacing as a periodic maintenance many pavements / roads have reached to higher raised level as compared to adjoining / abutting properties in old urban areas. The problem has reached to a saturated level and needs to be addressed effectively.

The raised level of the pavements can be lowered down up to desired and feasible depth with sophisticated milling machines and then after the same can be resurfaced with suitable wearing coat. The only objectionable part in the above method is that by introducing milling item, there is an addition of cost to the prevailing resurfacing methods and hence many authorities of urban areas are not adopting it.

Presently, working as an engineer of road department in local self government (Surat Municipal Corporation) of Surat city, author was / am facing the same in old city area where many roads are having higher elevated level as compared to adjoining properties and have become a serious problem. To overcome the above said problem, milling process was introduced in our municipal corporation and many roads were milled in different depths as per the requirement and feasibility and after milling the roads were resurfaced with adequate wearing coats. The problems of elevated road level as compared to adjoining properties were solved to a large extent but there was an addition of cost of milling to the existing / prevailing resurfacing method. Several options were tried to overcome / compensate this addition of milling cost and also to solve the problem of disposal of RAP material. In the course of trying the several options, beneficial results were obtained.

II. STUDY OBJECTIVES

The main / primary objective was to justify the cost of milling and to make it viable option so that the same can be used effectively.

To overcome the above problem, several options were tried and the results of some options were very much economical and effective and easy to use in urban areas.

Primarily the following options were decided to try.

1. To use the RAP material as filling material without doing any analysis and tests in low lying areas within the city.
2. To use the RAP material as GSB (Granular Sub Base) after analysing and adding the missing sieve size material.
3. To use the RAP material as WMM (Wet Mix Macadam) after analysing and adding the missing sieve size material.
4. To analyse the RAP material and after carrying out Marshal tests as per the guideline given in MS-2 of ASPHALT INSTITUTE and recycle the RAP material up to certain percentage of mixing with virgin aggregate and virgin bitumen.
5. To use the RAP material by way of certain percentage of mixing it with low CBR soil to improve the CBR of the existing soil and thereby

reducing the crust thickness and cost both as per IRC 37 method.

III. RESULTS AND ANALYSIS

Each option was tried as under and the analysis as well as the results and findings are as below. The tests were carried out in government recognised laboratory "Unique Engineering Testing and advisory Services".

A. As the material to be used as filling material of low lying area needs no such extra ordinary tests, the same was carried out in some of low lying areas which were having problem of stagnant water during monsoon and the problems were solved. In the outskirt of the city, RMC plant is established to produce the necessary concrete for the concrete road project which was having a large low lying area and it was almost impossible to run it during monsoon season and the same was solved by filling the low lying area with excess RAP material which was not well graded and had lot many lumps. The same was simply compacted with routine passes of roller and the plant was accessible throughout the monsoon season. The benefit achieved was elimination of filling material. Obviously it is worth to mention that there was a substantial saving by eliminating costly filling material and its transportation cost too.

B. The particle size analysis of RAP material of my city is shown in table no 1 as under.

Table 1: Particle size distribution of RAP material and corresponding code requirement for its use as GSB material.

IS Sieve Size (mm)	Percentage Passing	Requirement for GSB grading II (table 400-2) of MoRTH revision 4.
53	100	100
26.5	100	50-80
19	82	-
10	68	-
4.75	36	15-35
2.36	22	-
0.6	11	-
0.075	2	<10

From the above table 1 it is clearly found that certain sieve size material was missing in RAP to use it as GSB material and hence the same were added and it was used in ongoing Cement Concrete Pavement project.

To match the above requirement the following modifications were done.

65 % of 40 mm down and 10 % of stone dust as filler material were added to meet the requirement as per MoRTH 4th revision.

The RAP material was used up to 25 % to get the desired GSB grade II (coarse grade) as per the MoRTH 2013.

The Table 2 shows the composition of mixed material to get the desired GSB material.

The economic saving achieved was almost in the range of 25 %.

C. The similar tests were carried out for the use of RAP material as WMM (Wet Mix Macadam) and the study shows that RAP can be utilised up to 35 % to get the desired WMM as per the MoRTH 2013 which are shown in table no 3.

D. To recycle the RAP material and use it as DBM (Dense Bituminous Macadam) grade II as per the MoRTH 2013 the design approach was adopted as per MS-2 sixth Edition of asphalt institute by "modified Marshall Method". The results and findings are as shown in table no 4 and Table No 5.

Table 2: 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	65 % 40 mm Down	25 % RAP	10 % Stone Dust	Total	
53	100	100	100	65.00	25.00	10.00	100.00	100
26.5	62	100	100	40.30	25.00	10.00	75.30	50-80
4.75	12	36	97	7.80	9.00	9.70	26.50	15-35
0.075	0	2	8	0.00	0.50	0.80	1.30	< 10

Table 3: Result summary for various percentages RAP used in WMM

IS Sieve Size (mm)	Material				PERCENT					Requirement for WMM (table 400-11) of MoRTH revision 4.
	45 mm Down	RAP	11.2 mm Down	Stone Dust	32.5 % 45 mm Down	35 % RAP	12.5 % 11.2 mm down	20 % stone Dust	Total	
53	100	100	100	100	32.50	35.00	12.50	20.00	100.00	100
45	100	100	100	100	32.50	35.00	12.50	20.00	100.00	95-100
22.4	26	95	100	100	8.45	33.25	12.50	20.00	74.20	60-80
11.2	0	71	99	100	0.00	24.85	12.38	20.00	57.23	40-60
4.75	0	36	9	90	0.00	12.60	1.13	18.00	31.73	25-40
2.36	0	22	0	75	0.00	7.70	0.00	15.00	22.70	15-30
0.6	0	11	0	40	0.00	3.85	0.00	8.00	11.85	8-22
0.075	0	2	0	10	0.00	0.70	0.00	2.00	2.70	0-8

Table 4: Result summary for various percentages RAP used in DBM Grade - II

Asphalt Content by wt. of total mix in %	4.00	4.25	4.50	4.75	5
Unit Wt. in g/cc	2.433	2.438	2.445	2.433	2.427
Voids in mineral aggregate (VMA) in %	17.01	16.84	16.59	17.01	17.21
Percent air voids in compacted mix (Vv)	6.07	5.14	4.49	4.22	3.70
Void Filled with Bitumen (VFB) in %	64.31	69.47	72.95	75.18	78.51
Corrected Stability in KN	8.40	8.70	10.70	10.00	8.40
Flow in mm	2.81	3.06	3.37	3.72	4.00

Table 5: Change in mix properties with various percentages RAP used in DBM Grade - II

% RAP	0.00	10.00	20.00	30.00
Virgin Binder in %	4.50	4.20	3.90	3.60
Unit Wt. in g/cc	2.445	2.446	2.450	2.455
Voids in mineral aggregate (VMA) in %	16.59	16.80	16.43	16.08
Percent air voids in compacted mix (Vv)	4.49	4.47	4.28	4.09
Void Filled with Bitumen (VFB) in %	72.95	73.42	73.96	74.57
Corrected Stability in KN	10.70	10.10	10.20	10.30
Flow in mm	3.37	3.43	3.49	3.58

It is worth to mention here that for the hot mixing processes any suitable plants which are having special arrangements to introduce the RAP material can be used but the same is a costly initial investment if not available. Unfortunately I had to face the same and the option was kept limited up to laboratory tests and analysis only.

Instead of hot mixing process the cold process was used in which a mix was prepared with addition of 1.5, 2.0, 2.5 and 3.0 % emulsion and the same was tried in less important work like pothole filling and some patchwork during the monsoon. Surprisingly many of the potholes repaired with the above mentioned randomly mixed material, are intact even after the passage of one whole year and that too at a very less cost as compared to other available routine options.

E. The most portion of Surat city is having “black cotton soil” which is highly vulnerable to seasonal environmental changes because of its high compressibility in nature due to alteration in moisture content. As a part of improvement in existing soil having very low CBR, the soil samples were mixed with RAP in 20, 40 and 60 % proportions and the CBR improvement was excellent. (The initial CBR of 0.85 was brought to 2, 3.8 and 6.8 respectively by 20, 40 and 60 % RAP mixing). By mixing RAP material in low

CBR soil the CBR has improved to a large extent and thereby reducing in crust thickness and cost both. The below figure no 1 is self explanatory.

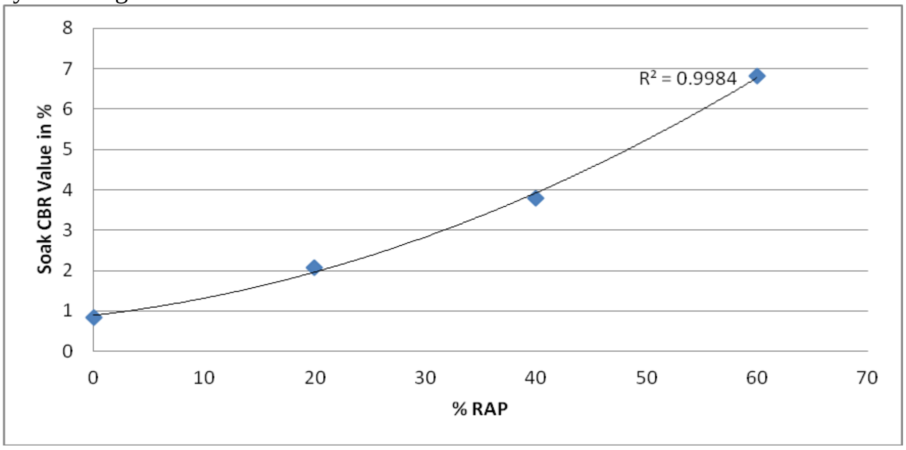

Fig. 1: CBR improvement of black cotton soil with various percentage RAP additions.

IV. CONCLUSION

The above practical study shows the definite impact on replacement of virgin material for various road constructions. The CBR values increasing to 2, 3.8 and 6.8 % respectively by 20, 40 and 60 % RAP mixing in black cotton soil surely work for improved sub-grade.

Also the study shows the saving of 25 % virgin material for GSB grade – II and 35 % for WMM by utilising RAP.

The laboratory test for Dense Bituminous Macadam shows the overall reduction in pavement cost with saving of bitumen and aggregates. Also without any complicated analysis and testing the random mixing of emulsion in RAP material and utilising it in pothole repairing material also proved to be an economical and effective option.

The above shown options can be effectively, economically and advantageously used in urban areas which will not only solve the raised road level problems but also the use of RAP obtained by milling process will enhance the poor soil condition and economy can be obtained in GSB, WMM and DBM.

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