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ANALYSIS OF EFFECT OF USE OF RAP IN BITUMINOUS CONCRETE

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Abstract - *Present study was carried out in order to ascertain strength of bituminous mix in surface course using different percentages of RAP and to find optimal percentage of RAP for bituminous concrete. For this purpose, RAP samples were collected from the road in the vicinity of Chandigarh. In order to evaluate the strength and other engineering characteristics of RAP, for example age, grading, residual binder content etc, various laboratory tests were conducted. Then, samples of bituminous mix for BC (Bituminous concrete) were prepared using fresh material by Marshall Method by using different proportions of RAP i.e. 25, 30, 35 and 40%. Overall from this study it was concluded that RAP 35% showed results similar to that of virgin bituminous mix and best performance amongst other RAP percentages. Also with the use of RAP 35 the cost of project was reduced by 50%*

Keywords: Reclaimed Asphalt Pavement, Bituminous concrete.

1. Introduction

HMA (Hot Mix Asphalt) pavements are flexible pavements are so named because the total pavement structure deflect or flexes under any loading. A flexible pavement structure is a typically composed of several layers of material each of which receives the loads from the above layer, spreads them out and then passes them on to the layer below. Thus the lower layers in the pavement structure bear fewer loads (in terms of force per unit area). Flexible pavements support loads through bearing rather than flexural action. The design ensures the load transmitted to each successive layer does not exceed the layer's load bearing capacity.

RAP is a technique of reusing the pavement materials for the construction of a new pavement. Since it is based on the principles of recycling therefore by using this technique much benefits can be achieved. If done efficiently even the contractor may increase his profits. RAP is an emerging technique in India which requires more attention and testing. RAP materials for the construction of fresh pavements are being successfully used all over the world especially United States. No optimal percentage of RAP has been defined yet by any standards. RAP materials are being used at very different percentages ranging between 10-50%. An effort has been made in this research to find an optimum percentage of RAP in Bituminous Concrete.

2. Objectives of the Study

The objectives of this study are:

1. To ascertain strength of bituminous mix in surface course using different percentages of RAP.
2. To find optimal percentage of RAP for bituminous concrete.
3. To evaluate the strength and other engineering characteristics of RAP, for example age, grading, residual binder content etc.
4. To make an attempt for the classification of RAP on the basis of age, strength.
5. To evaluate or to make a cost comparison study between RAP and fresh bituminous mix.

2. Methodology

The following gives the step by step process of the tests that will be performed at the laboratory.

1. RAP sample is collected from the road in the vicinity Sec 48, Chandigarh.
2. Samples of bituminous mix for BC (Bituminous concrete) shall be prepared using fresh material by Marshall Method.
3. Properties of RAP shall be ascertained: e.g. grading, residual bitumen etc.

The tests which are going to be performed in this thesis are written below:

1. Residual binder content
2. Characterization of binder:
   a. Ductility test of binder content
   b. Softening test of bitumen
   c. Penetration test
3. Grading of reclaimed aggregate
4. Marshall Stability Test: Samples shall be prepared by adding different %age of RAP and detailed analysis shall be carried out to ascertain variations in stability. Flow value and other parameters at different %ages of RAP.
5. An attempt will be made to reuse the RAP content in the laying of BC (Bituminous concrete) as Surface course.
6. Percentages of RAP selected for this thesis are 25, 30, 35 and 40%.
7. Changes in binder content requirement, if any shall be ascertained with respect to normal mixes.

4. Results and Discussion

The aggregates were tested for different proporties and test results were shown in the table below:

Table: 1. Physical properties of Aggregates.

Physical Properties of Aggregates	20mm	10mm	Required Values as per MORTH 5th revision
Sp. Gravity	2.60	2.71	**2.6-2.8**
Elongation Index, %	15.68	14.82	**Combined Elongation and Flakiness Max 30%**
Flakiness index, %	14.28	16.34	
Impact Value, %	16.1	16.3	**24% Max**
Water absorption	.24%	.32%	**2% Max**
Stripping	<2%	<2%	**<5%**

The binder were tested for different proporties and test results were shown in the table below:

Table: 2. Properites of Binder.

Properties of Binder	VG-30		Test Method
	Calculated	Required	
Penetration	55	50-70	**IS:1203:1978**

Softening Point	48.3	47 Min	**IS:1205:1978**
Ductility	78	40 Min	**IS:1208:1978**
Specific Gravity	1.00	0.99	**IS:1202:1978**

Binder was used at 5.4%, 5.6%, 5.8% and 6%. Their respective quantities were shown in the table below:

Table: 3. Quantities of Bitumen Binder.

Percentage of Bitumen (%)	Weight of Bitumen (g)
5.4%	68g
5.6%	71g
5.8%	74g
6.0%	77g

JOB MIX FORMULA

Sieve Size	% passing (required)	% passing IS 19mm	% passing 13.2mm	% passing 6.7mm	% passing Stone dust	Cement	Grading of mix
19mm	100	98.6	100	100	100	100	99.86
13.2mm	79-100	10.2	100	100	100	100	91.02
9.5mm	70-88	1	87	99.4	100	100	86.87
4.75mm	53-71	0	1	42.4	99.3	100	55.55
2.36mm	42-58	0	0	6.4	90.3	100	44.78
1.18mm	34-48	0	0	2.2	68.9	100	34.30
600	26-38	0	0	2.2	51.3	100	26.48
300	18-28	0	0	2.2	37.1	100	20.09
150	12-20	0	0	1.7	19.6	100	12.12
75	4-10	0	0	1.7	10.5	100	8.03
Ratio		0.1	0.24	0.18	0.45	0.03	

Therefore, according to job mix formula, quantities of aggregates used as follows:

- 20MM = 120G
- 10MM = 288G
- 6.7MM = 216G
- STONE DUST = 540G
- CEMENT = 36G

MARSHALL STABILITY TEST RESULTS OF NORMAL MIX

Table: 4. Marshall Stability Test results for Normal mix.

Bitumen %	5.4	5.6	5.8	6.0
Density (g/cc)	2.365	2.366	2.369	2.368

Volume of Bitumen, V_b %	12.77	13.25	13.74	14.21
Volume of aggregates $V_{a\%}$	82.19	81.99	81.86	81.59
Voids in mineral aggregate (VMA)%	16.45	16.23	16.27	16.45
Voids filled with bitumen (VFB)%	77.63	81.65	84.47	86.39
Measured stability, (N)	13.81	1402	1461	1416
Flow Value (mm)	3.2	3.0	2.9	3.1
Marshall quotient (Stability/Flow)	4.31	4.67	5.03	4.56
S.G of mix, S_t	2.722	2.724	2.726	2.728

MARSHALL STABILITY TEST RESULTS OF RAP 25%

Table: 5. Marshall Stability Test results for mix containing RAP 25%.

Bitumen %	**5.4%**	**5.6%**	**5.8%**	**6.0%**
Density (g/cc)	2.353	2.354	2.357	2.355
Volume of bitumen, $V_{b\%}$	12.706	13.182	13.671	14.130
Volume of Aggregates, $V_{a\%}$	82.952	82.750	82.619	82.312
Voids in mineral aggregate (VMA)%	70.31	17.07	17.11	17.32
Voids filled with bitumen (VFB)%	73.40	77.19	79.90	81.58
Measured stability(N)	1007	1081	1189	1114
Flow Value (mm)	4.3	4.1	3.8	4.0
Marshall quotient (Stability/Flow)	2.34	2.63	3.12	2.78
S.G of mix, S_T	2.683	2.685	2.687	2.689

MARSHALL STABILITY TEST RESULTS OF RAP 30 %

Table: 6. Marshall Stability Test results for mix containing RAP 30%.

Bitumen %	**5.4%**	**5.6%**	**5.8%**	**6.0%**
Density (Gm) g/cc	2.357	2.358	2.361	2.358
Flow Value(mm)	3.6	3.4	3.1	3.5
Voids in mineral aggregate (VMA)%	17.302	17.066	17.099	17.344
Voids filled with bitumen(VFB)%	73.562	77.374	80.086	81.575

Volume of aggregates, $V_{a\%}$	83.289	83.086	82.953	82.610
Measured stability(N)	1226	1289	1376	1247
Marshall quotient (Stability/ Flow)	3.4	3.79	4.43	3.56
Volume of bitumen, $V_{b\%}$	12.728	13.205	13.694	14.148
S.G of mix, S_T	2.677	2.679	2.681	2.683

MARSHALL STABILITY TEST RESULTS OF RAP 35%

Table: 7. Marshall Stability Test results for mix containing RAP 35%.

Bitumen %	**5.4%**	**5.6%**	**5.8%**	**6.0%**
Density (g/cc)	2.361	2.362	2.364	2.363
Volume of Bitumen, $V_{b\%}$	83.627	83.423	83.254	82.980
Volume of aggregates, $V_{a\%}$	12.749	13.227	13.711	14.178
Voids in mineral aggregate(VMA)%	17.300	17.062	17.129	17.302
Voids filled with bitumen (VFB)%	73.694	77.525	80.048	81.943
Measured stability(N)	1303	1344	1431	1284
Flow value (mm)	3.5	3.2	3	3.4
Marshall quotient (Stability/Flow)	3.72	4.20	4.77	3.78
S.G of mix, S_T	2.671	2.673	2.675	2.677

MARSHALL STABILITY TEST RESULTS OF RAP 40%

Table: 8. Marshall Stability Test results for mix containing RAP 40%.

Bitumen %	**5.4%**	**5.6%**	**5.8%**	**6.0%**
Density (Gm) g/cc	2.356	2.357	2.358	2.356
Volume of bitumen, $V_{B\%}$	12.722	13.199	13.676	14.136
Volume of aggregates, $V_{A\%}$	83.682	83.477	83.273	82.964
Voids in mineral aggregate,(VMA)%	17.581	17.341	17.442	17.649
Voids filled with bitumen(VFB)%	72.363	76.115	78.413	80.097
Measured stability (N)	1156	1198	1308	1216
Flow value (mm)	3.9	3.7	3.5	3.7
Marshall quotient	2.96	3.23	3.73	3.28

(Stability/Flow)				
S.G of mix, S_T	2.663	2.665	2.667	2.669

4. Conclusions

Following are the outcomes of experiment conducted for the comparison of RAP mixes and Virgin bituminous mix:

- By comparing specifications which are specified in table 500-1 in "SPECIFICATIONS FOR ROAD AND BRIDGE WORKS",MORTH(fifth revision) it is found that the optimum binder content for virgin mix was at 5.8% bitumen percent. It is also observed that the optimum binder content for RAP mixes was same as that of virgin samples. This clearly indicates that there is no change in optimum binder content for RAP mixes.
- The fact that Optimum Binder Content remained unchanged even after adding RAP materials indicates that the old binder perfectly blended with fresh binder.
- Densities of virgin mix were slightly higher than that of RAP 35 %(2.364 g/cc) by 0.21% followed by RAP 30% (2.361 g/cc) , RAP 40% (2.358g/cc) and RAP 25% (2.357g/cc).
- The Marshall Stability values of virgin mixes were found to be greater than RAP 35% (1431 kg) followed by RAP30%(1376KG), RAP 40%(1308 KG) and RAP 25% (1189 kg).
- At optimum binder content it is observed that RAP 25% (3.8 mm) had the maximum flow values followed by RAP 40%(3.5mm), RAP 30%(3.1mm), RAP 35%(3 mm) and fresh bituminous mix. Fresh bituminous mix had minimum values out of all mixes.
- VMA values of RAP mixes were higher than those of virgin mix. VMA values were observed maximum for RAP 40% (17.44%) followed by RAP 30% (17.09%), RAP 25% (17.11%) and RAP 35% (17.12%).
- VFB values of virgin bituminous mix were greater than those of RAP mixes. RAP 25% (79.90%) showed maximum FB values of RAP 35% (80.04%) were highest amongst other RAP mixes followed by RAP 30% (80.08 %) , RAP 40% (78.41%) and RAP 25%.
- Volume of bitumen Vb was observed more for virgin mix than RAP mixes. In RAP mixes RAP 35% (13.71%) had greater values than RAP 30% (13.69%) followed by RAP 40% (13.67%) and lastly RAP 25% (13. 17%).
- It is observed that by using 35% RAP the project cost was reduced by 50%.
- An attempt was made to classify RAP on the bases of age and strength. This was unsuccessful as the age and strength of RAP vary from pavement to pavement.
- Time period for mixing was similar in all the cases.
- An attempt was made to reuse the binder from RAP. Though it was unsuccessful so fresh binder was added to RAP mixes.

Overall from this study it was concluded that RAP 35% showed results similar to that of virgin bituminous mix and best performance amongst other RAP percentages. Al so with the use of RAP 35 the cost of project was reduced by 50%

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