



Investigation Of The Use Of Recycled Asphalt Pavement (RAP) Material In Economical And Eco-Friendly Road Construction And Rehabilitation Projects

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Abstract: A robust road network plays a crucial role in accelerating economic growth by connecting remote regions, enhancing access to markets, schools, and healthcare services, and fostering trade and investment in less developed areas. Roads also enable efficient intermodal transportation by linking key infrastructure such as airports, railway stations, and seaports. However, conventional bituminous surfacing of flexible pavements is energy-intensive, involving the production of bituminous binder from crude oil, drying of aggregates, and manufacturing of the asphalt mix at a hot mix plant (HMP). Hot mix recycling offers an efficient alternative by blending reclaimed asphalt pavement (RAP) with new aggregates and, in some cases, recycling agents to produce hot mix asphalt. When properly designed, these recycled mixtures can match or even exceed the performance of conventional asphalt mixes. Recycling or rejuvenating agents—organic compounds selected for their chemical and physical properties—are used to restore the aged asphalt to its desired specifications.

Keyword: - Hot mix plant (HMP), Reclaimed asphalt pavement (RAP), Hot in-place recycling (HIR), Cold in-place recycling (CIR), Hot in-plant recycling (HIP), Cold in-plant recycling (CIP), Full depth reclamation (FDR)

INTRODUCTION

Reclaimed asphalt is combined with aggregates and existing asphalt in proportions similar to the original mix to produce new asphalt mixtures. When recycled asphalt material is used primarily as a base, filler, or binder source—rather than restoring it to its original full function—this practice is referred to as reuse in a reduced capacity. Modern asphalt pavements commonly utilize recycled materials in their base layers. Both urban and rural roadways employ hot-in-place or cold recycling techniques. Only minimal amounts of additives are typically introduced into the recycled asphalt.

Pavement construction, restoration, and repair have greatly benefited from prior well-designed and executed studies, which have shown that Reclaimed Asphalt Pavement (RAP) can deliver performance equal to or even better than that of virgin asphalt mixes. RAP mixtures offer two key advantages: enhanced compaction (density) and improved resistance to moisture. This study further reinforces the positive impact and effectiveness of using RAP in asphalt blends.

The traditional approach to bituminous surfacing of flexible pavements is highly energy-intensive, involving the production of bituminous binder, drying of aggregates, and preparation of the bituminous mix at Hot Mix Plants (HMP). For example, drying and heating just one ton of aggregates consumes roughly 6 liters of fuel. Considering the massive volume of aggregates required for road construction each year, this results in substantial fuel usage. Additionally, the process of heating both the binder and aggregates, along with the large-scale production of Hot Mix Asphalt (HMA), generates considerable greenhouse gas emissions and air pollutants. Emissions can double with every 10°C increase in production temperature, a common scenario when using modified binders in HMA.

Research Methodology

There are two primary methods for recycling asphalt materials: hot and cold processes. Hot-in-place recycling falls under the hot process category, whereas cold recycling includes all other methods, as outlined in IRC: SP:120-2015. In hot-in-place recycling, the existing pavement surface is heated, which softens, melts, or scarifies the bituminous layer, allowing the material to be reused on-site.

In contrast, cold recycling involves processing the pavement material without heating. The material is broken, cracked, or fractured while in a cooled state. Recycled materials from this process are often stored in large chunks after being compacted. Before storage, they may be screened and separated into different size fractions. Cold recycling methods may also involve the reconditioning of non-bituminous base or subbase layers through processes like ripening and sulfurizing, as specified in IRC: SP:120-2015.

Recycling technology can be categorized into two main types:

1. In- Place
2. In- Plant

The Following are the process of Reclaimed Asphalt process (RAP) Mixing.

1. Hot in-place recycling (HIR)
2. Cold in-place recycling (CIR)
3. Hot in-plant recycling (HIP)
4. Cold in-plant recycling (CIP)
5. Full depth reclamation (FDR)

Material used

Milling Material (RAP)

Stone Dust

Cement:

Bitumen Emulsion SS II:

Water:

Experimental Result and Discussion

Experimental investigation involves conducting various tests and systematic observations to examine the behavior, performance, or characteristics of materials, systems, or phenomena. This process includes designing experiments, gathering data, analyzing results, and drawing conclusions to either validate existing hypotheses or generate new insights.

Table No.1 Individual Gradation of Aggregate as tabulated below.

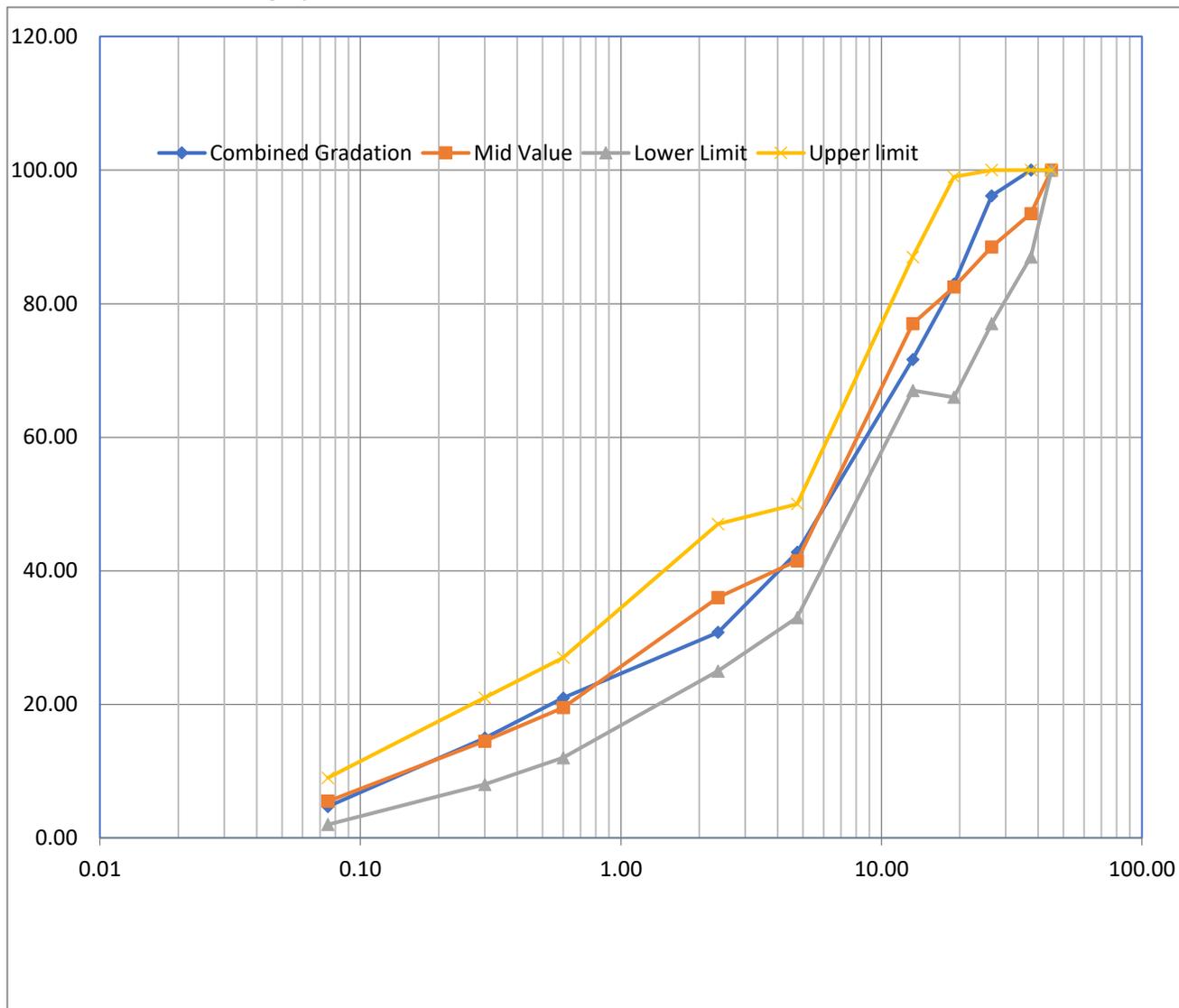
IS Sieve (mm)	% Passing of Individual Aggregates		
	Avg. of RAP	Avg. of Dust	Avg. of Filler
45	100.00	100.00	100.00
37.5	100.00	100.00	100.00
26.5	95.32	100.00	100.00
19	79.22	100.00	100.00
13.2	65.43	100.00	100.00
4.75	32.40	89.52	100.00
2.36	23.26	62.96	100.00
0.6	17.74	31.72	100.00
0.3	12.79	20.43	100.00
0.075	3.63	5.14	83.47

Table No.2 Combined Gradation as tabulated below.

Blending of Material			Combined Gradation	Specific Limits as per MoRTH Table 500-44		
RAP	Dust	Cement		Mid Value	Lower Limit	Upper limit
82%	17%	1.00%				
82.00	17.00	1.00	100.00	100.00	100	100
82.00	17.00	1.00	100.00	93.50	87	100
78.17	17.00	1.00	96.17	88.50	77	100
64.96	17.00	1.00	82.96	82.50	66	99
53.65	17.00	1.00	71.65	77.00	67	87
26.57	15.22	1.00	42.78	41.50	33	50
19.07	10.70	1.00	30.78	36.00	25	47
14.55	5.39	1.00	20.94	19.50	12	27
10.49	3.47	1.00	14.96	14.50	8	21
2.98	0.87	0.83	4.69	5.50	2	9



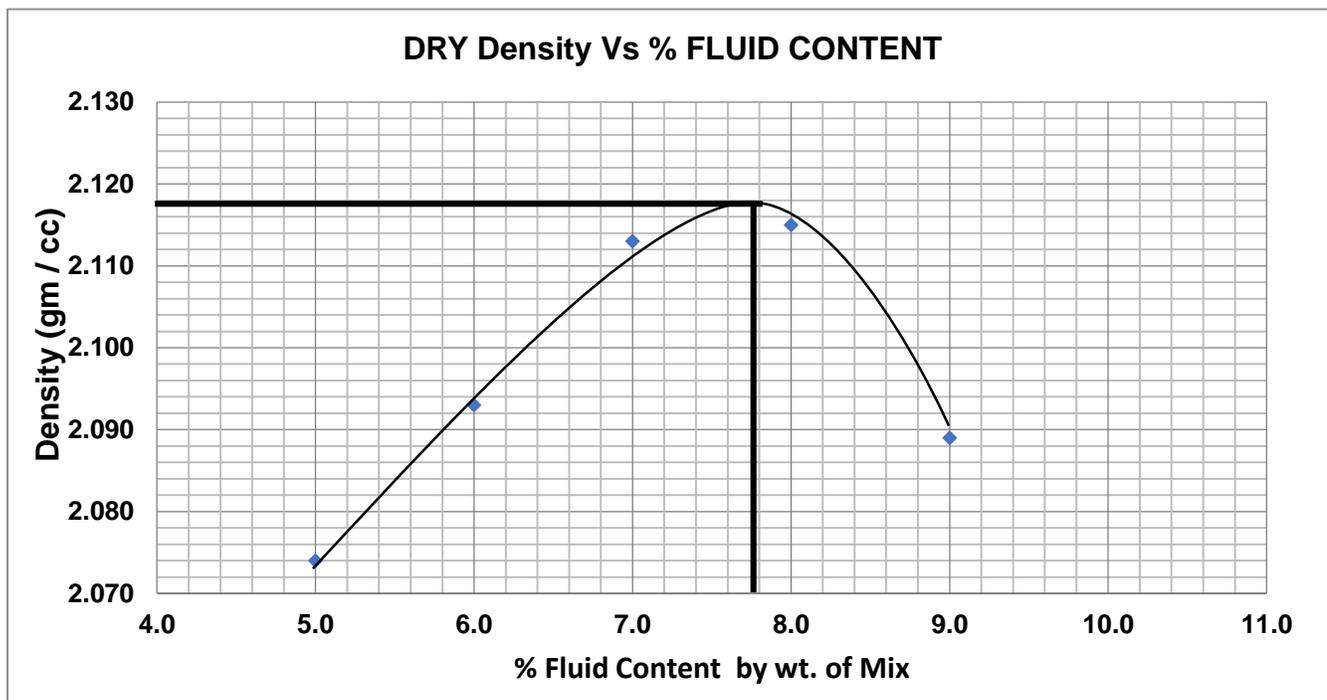
Combined Gradation graph



Sr. No	Moisture Content in RAP in %	Water added in %	Emulsion Content added in %	Total Fluid %	Wt of Specimen in Air (gms)	Wt of Specimen in Water (gms)	SSD Wt of Specimen (gms)	Volume if Replaced Water (cc)	Bulk density D bulk	Avg Bulk density bulk	Wt of Dry Specimen	Moisture Content %	Average Moisture Content	Avg Dry Density Ddd
1	0.30	1.7	3.00	5.00	1227.0	663.00	1244.50	581.50	2.110	2.107	1208.50	1.53	1.61	2.074
	0.30	1.7	3.00		1224.5	671.50	1252.50	581.00	2.108		1205.00	1.62		
	0.30	1.7	3.00		1236.0	673.50	1261.00	587.50	2.104		1215.50	1.69		
2	0.30	2.7	3.00	6.00	1238.0	681.50	1260.00	578.50	2.140	2.142	1211.00	2.23	2.35	2.093
	0.30	2.7	3.00		1237.0	684.50	1261.50	577.00	2.144		1209.50	2.27		
	0.30	2.7	3.00		1234.5	685.00	1261.50	576.50	2.141		1204.00	2.53		
3	0.30	3.7	3.00	7.00	1244.0	696.50	1269.50	573.00	2.171	2.168	1211.50	2.68	2.74	2.110
	0.30	3.7	3.00		1246.5	698.50	1273.50	575.00	2.168		1213.50	2.72		
	0.30	3.7	3.00		1253.0	701.00	1279.50	578.50	2.166		1218.50	2.83		
4	0.30	4.7	3.00	8.00	1245.0	695.50	1264.00	568.50	2.190	2.185	1208.50	3.02	3.18	2.118
	0.30	4.7	3.00		1249.0	695.00	1266.50	571.50	2.185		1211.00	3.14		
	0.30	4.7	3.00		1251.5	696.00	1270.00	574.00	2.180		1210.50	3.39		
5	0.30	5.7	3.00	9.00	1254.0	690.50	1272.00	581.50	2.156	2.169	1209.50	3.68	3.79	2.089
	0.30	5.7	3.00		1258.0	693.50	1274.50	581.00	2.165		1210.00	3.97		
	0.30	5.7	3.00		1251.5	696.00	1269.00	573.00	2.184		1206.50	3.73		

ANALYSIS OF DRY DENSITY Vs OPTIMUM FLUID CONTENT FOR COLD MIX

SUMMARY OF DENSITY TEST FOR OPTIMUM FLUID CONTENT



Maximum Dry Density = 2.118 g/cc

Optimum Fluid Content = 7.8%

PROPORTION OF MATERIAL (RAP)

Table No.4

Material	% Weight of Mix	Batch Weight (gms.)
(RAP) Material	75.60 %	907.2
Stone Dust	15.67 %	188.04
Cement	0.93 %	11.16
Emulsion SS II	3.5 %	42
Water	4 %	48
Moisture In RAP	0.30 %	3.6
Total	100%	1200

Table No. 5 Cold Mix as Per IRC 37-2017 And MoRTH Vth

S.NO	Test Parameter	Test Method	Result	Specified Limit As per IRC 37 and MoRTH
1	Fluid Content %	MS 14	7.8	-
2	Emulsion Content %	IRC 37	3.5	3 - 4
3	Dry Density gm/cc	ASTM D 2726	2.119	-
4	Unsoaked stability @ 22 0C	IS 6927	4.97	Min 2.2 KN
5	Flow Value	IS 6927	3.83	Min 2 mm
6	Soaked stability @ 22 0C	IS 6927	3.39	-
7	Stability Loss	MS 14	31.79	Max 50 %
8	ITS Dry 25 0C	ASTM D 6931	265.10	> 225 kPa
9	ITS Wet 25 0C	ASTM D 6931	157.10	> 100 kPa

Conclusion

- Using the specified ingredients and different emulsion percentages—3.0% to 4.5% —the RAP Cold mix design was completed. The optimal Fluid content (OFC) was found to be 7.8 % with density of 2.119 g/cc, Soaked stability value of 3.39, Unsoaked stability value 4.97 and flow value of 3.83 mm.
- Acceptable-quality bituminous mixes incorporating RAP can be designed to meet the necessary volumetric and mechanical properties while achieving the desired performance criteria. However, to assess the actual field performance of RAP mixes, evaluation through the Accelerated Pavement Testing Facility (APTF) is essential.
- The incorporation of RAP significantly enhanced the indirect tensile strength.
- Reclaimed Asphalt Pavement (RAP) is recognized as one of the most significant advancements in sustainable asphalt paving, increasingly adopted worldwide.
- Its use helps reduce environmental impact by lowering energy consumption while enhancing mechanical properties, durability, and stripping resistance in Hot Mix Asphalt (HMA).
- Utilizing RAP materials in light paving construction effectively addresses the issue of waste disposal while mitigating adverse environmental impacts, ensuring a more sustainable approach to asphalt recycling.
- The growing adoption of RAP materials has resulted in substantial cost reductions and resource savings, effectively preserving both financial investments and natural resources.

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