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Evaluating Pavement Strength by Partial Replacement of Aggregate with RAP

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Abstract **- A good road network is one of the important infrastructures in the development of country's economy like India. As India is a developing country so for developing of the road network to connect various places by bituminous road should be constructed because initial cost of construction is less. This study is carried out to use road construction material with reclaimed asphalt pavement obtained from old road pavement and dense bitumen macadam mix has been designed by the addition of different content of RAP by 0%, 5%, 10%, 15% in place of new aggregates. By doing all test on Marshall Mix design, we finally conclude that 10 percentage of RAP will give us the optimum value . The use of RAP material for constructing new pavement will considerably reduce the amount of aggregate and achieving the overall economy.**

I. INTRODUCTION

In developing countries like INDIA economical construction plays an important role for constructing country's infrastructure at reasonable price. Waste material like RAP (reclaimed asphalt pavement) is very important for road construction for making it economical. A good transport system i.e. road network plays an important role to improve country's economy. India having second largest road network in the world after USA.

Natural aggregates has taken out from various sources such as crushing rock aggregates and it is mostly used as road material. As construction of various infrastructural structure increases day by day for constructing the structure large amount of aggregate i.e. fine aggregate and coarse aggregate as an material is used. By which resources of aggregate are reduced, increase in the cost of aggregates. Here in this study use of RAP as an aggregate is used in place of fine and coarse aggregates. RAP is defined as removed material from the pavement containing asphalt and aggregate. The use of RAP material in the road construction is obtained from removal of old flexible pavement layer, demolition of pavement layer, reconstructing, resurfacing etc. A large amount of energy required for dumping it to another place and dumping of waste is also an environmental issue. Most of RAP material is recycled and reused which also reduce environment impact and reduce the use of other virgin material where RAP can be used.

To the same material used to build the original highway system can be reused to repair, reconstruct and maintain them. When appropriate recycling of aggregate and other highway reconstruction material may sound economic, environmental, and engineering sense.

A) Objective

Use of RAP material can be used for the construction of new pavement.

Reduce the consumption of natural resources.

Reduced the transportation cost by reducing the consumption of natural material which are used in construction.
The waste from surface course i.e RAP can be used for partial replacement which enhance the different properties in flexible pavement.

B) Scope

RAP material can be used as replacement of virgin aggregates

Reduced the efforts for dumping the RAP as a waste material

Lowers the cost of construction

Prevent depletion of the natural source

II. LITERATURE REVIEW

Ahmed Ebrahim Abu-El Maaty and Abdulla Ibrahim Elmohr (2015) [1] did research on "Characterization of recycled asphalt pavement for use in flexible pavement" in American Journal of engineering and Applied Sciences. They generally conclude that RAP is one of the most important type of green asphalt pavement that all world towards to use it where it reduces the environment impact through reduce the consumption of energy, improve mechanical properties, durability and stripping resistance of HMA. Niraj Patel and Prabhakar Kumar (2017) [3] in his research on "A laboratory study on the use of RAP in bituminous binder course" in International Journal of Emerging Trends in Science and Technology. Finally he concludes that the use of RAP material considerably reduce the amount of fresh aggregate during the construction and RAP also improve the water resistant capacity of pavement. Abhishek Verma, Rachit Sharma, Monil Shrivastava and Prashant (2017) [4] in World Journal of Engineering Research and Technology article on "Evaluation of Reclaimed Asphalt Pavement (RAP) in Flexible Pavement layers". They conclude that maximum dry density is achieved in the range of 6-7% water content for 0%, 3% and 5% cement dosages. T.Anil Pradyumna and Dr. P.K Jain (2016) [2] research on "use of RAP stabilized by hot mix recycling agents in bituminous road construction" in 11th Transportation Planning and Implementation Methodologies for developing countries. They conclude that use of recycling agent is essential for better performance of bituminous mixture containing higher RAP percentages. Panditharadhya B J, Reshma E K, Suhas R (2018) [5] research on "Utilization of RAP aggregate in Pavement Quality Concrete". They conclude that replacement of 25% RAP gives maximum compressive strength than other replacement percentage compared to the normal concrete mix.

III. MATERIALS

The major materials in constructing the road surface course are:

a) Aggregates
b) Bitumen

Along with these materials the material is used Reclaimed asphalt pavement (RAP) which considerable reduced the amount of new material used.

A. Aggregates:

These are the materials such as gravel, sand and crushed stone that are used as a binding medium to form composite materials such as bituminous concrete, Portland cement concrete etc. Aggregate will withstand under the load and further transmit that load into successive layers. The different size of aggregates are used in different pavement layers and the gradation for the particular pavement is under MORTH specification.

B. Reclaimed Asphalt Pavement:

The material was collected from the Mahal road near Akshaypatra, Jagatpura (Jaipur). After the test results the material i.e. RAP be used for the DBM Gr-2 layer.The average bitumen content of RAP material which collected from the site was 4.71%.

C. Bitumen:

Bituminous material is derived from destructive distillation of petroleum which is broadly used in construction and maintenance work of road. It is used as cohesive material which is used in the constructing pavement by binding aggregates together. VG-30 Bitumen was used.

D. Marshall Mix Design:

It was adopted for the design of DBM Gr-2 layer with different trial content of bitumen was adopted for design 4.5%, 5%, 5.5%, 6% with the different content of RAP used i.e. 5%, 10%, 15% of aggregate mix.

Table I

Test on Aggregates

S.NO.	TESTS	RESULTS
1.	Aggregate Impact Value	16%
2.	Aggregate Crushing Value	26.08%
3.	Aggregate Abrasion Value	34.01%
4.	Flakiness and Elongation Index	19.39%
5.	Specific Gravity	2.595
6.	Water Absorption	0.845%

Table II

Test Results on Aggregates with Different % of RAP

Tests	Results			
	0% RAP	5% RAP	10% RAP	15% RAP
Aggregate Impact Value	16%	15.70%	15.50%	14.50%
Aggregate Crushing Value	26.08%	24.95%	24.685%	23.465%
Aggregate Abrasion Value	34.01%	29.85%	26.47%	22.225%

Table III

Tests Results on Bitumen

S.No.	Tests	Results
1.	Penetration Test	67 mm
2.	Ductility Test	94 mm

Table IV

Final Proportion of Mix

Sieve size (mm)	Proportion of mix
20-10 (A)	40%
10-6.3 (B)	6%
6.3-.075 (C)	47%
Sand dust (D)	4%
Filler (E)	3%

Table V

Combined Gradation of Sample

IS SIEVE (mm)	**Combined Gradation for DBM Gr-2**										**%Passing**
	% Passing of Individual Aggregate					**Mix Proportion**					
	A	B	C	D	E	A	B	C	D	E	
37.5	100	100	100	100	100	40	6	47	4	3	100
26.5	100	100	100	100	100	40	6	47	4	3	100
19	82.6	100	100	100	100	33	6	47	4	3	93
13.2	46.6	100	100	100	100	19	6	47	4	3	78.7
4.75	0	0	68.9	100	100	0	0	32.4	4	3	39.4
2.36	0	0	47.8	96	100	0	0	22.5	3.8	3	29.3
0.3	0	0	10.7	26.2	100	0	0	5	1.1	3	9.06
0.075	0	0	2.57	0.95	100	0	0	1.2	0.03	3	4.24

Table VI

Combined Gradation of Sample with RAP

IS Sieve (mm)	% Passing of RAP	5% RAP	95% Fresh	Combined (5% +95%)	10% RAP	90% Fresh	Combined (10%+ 90%)	15% RAP	85% Fresh	Combined (15%+ 85%)
37.5	100	5	95	100	10	90	100	15	85	100
26.5	100	5	95	100	10	90	100	15	85	100

19	91.83	4.592	88.36	92.95	9.183	83.72	92.90	13.77	79.06	92.83
13.2	74.3	3.72	74.71	78.43	7.43	70.79	78.22	11.15	66.85	78
4.75	51.91	2.59	37.43	40.02	5.19	35.47	40.66	7.79	33.49	41.28
2.36	29.17	1.458	27.85	29.31	2.917	26.38	29.23	4.375	24.91	29.28
0.3	9.11	0.45	8.61	9.06	0.91	8.154	9.06	1.366	7.701	9.067
0.075	0.04	0.002	4.03	4.032	0.004	3.81	3.814	0.006	3.60	3.606

IV. RESULTS

Table VII

Results of Mix for DBM Gr-2

Bitumen	Corrected stability	Flow value	Bulk density	%Air voids	V_b	VFB	VMA
4.5%	17.31	2.4	2.34	5.77	9.16	61.35	14.93
5%	18.57	2.86	2.37	4.51	10.25	69.45	14.758
5.5%	21.36	3.3	2.42	3.81	11.47	75.05	15.28
6%	16.93	3.67	2.35	3.78	12.09	76.18	16.94

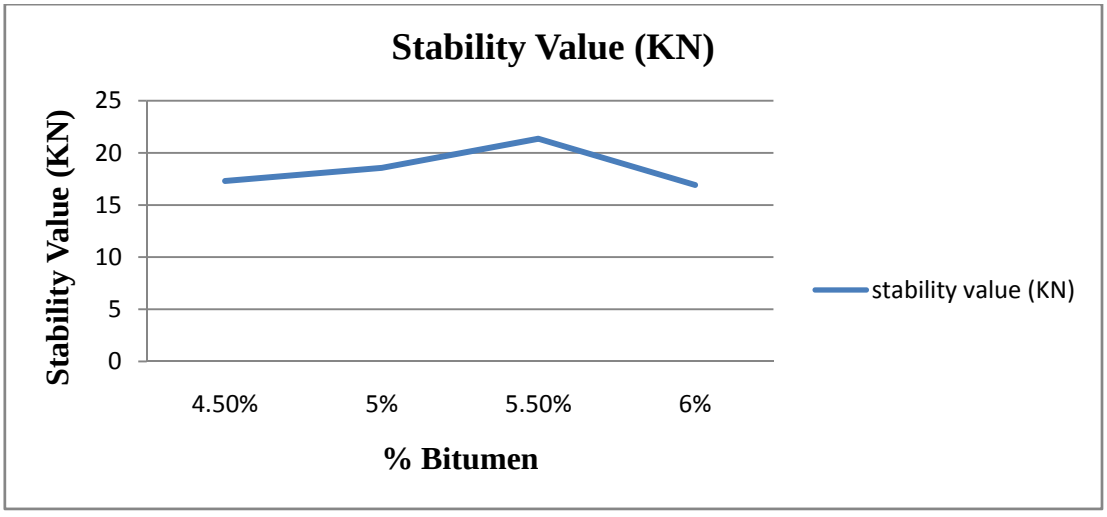

Fig. 1 Graph between Stability Value V/S %Bitumen

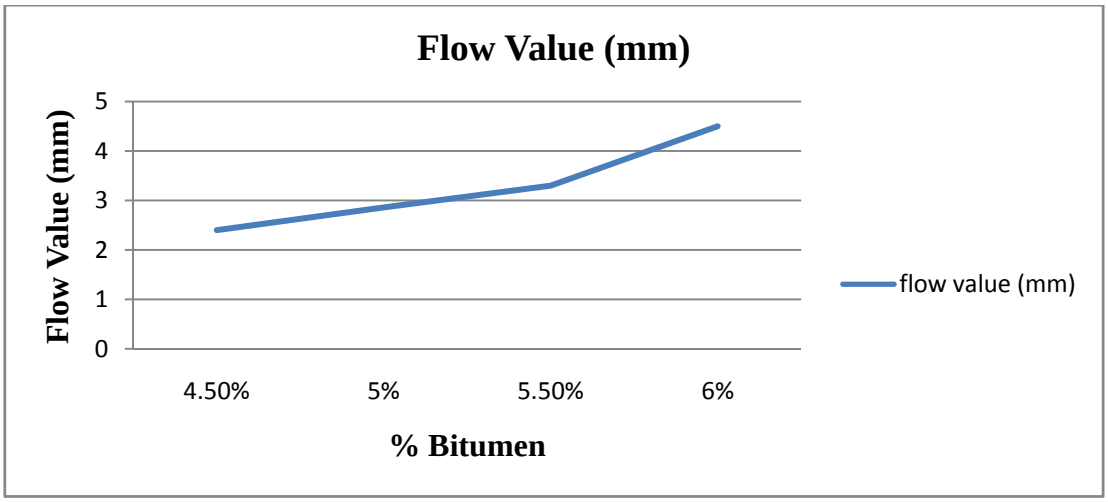

Fig. 2 Graph between Flow Value V/S %Bitumen

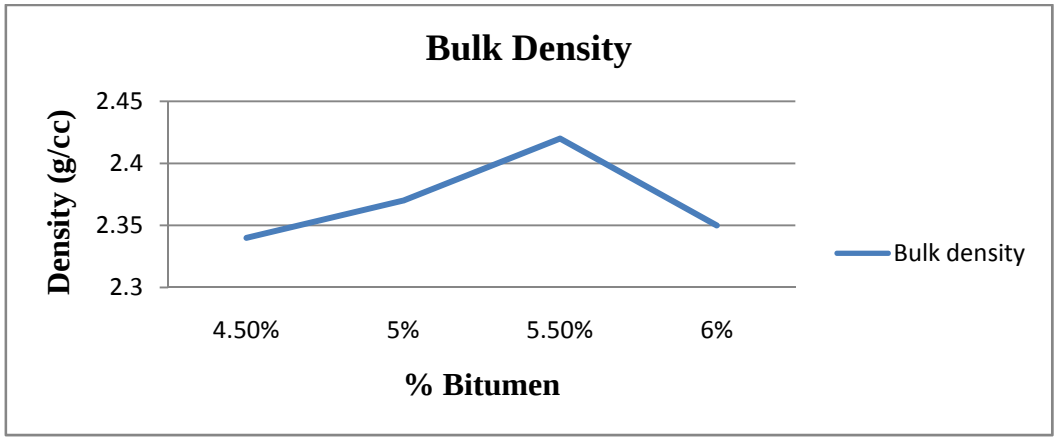

Fig. 3 Graph between Density V/S % Bitumen

Table VIII

Result of Mix with 5% RAP Material

Bitumen	Correct stability	Flow value	Bulk density	Air voids	V_b	VMA	VFB
4.5%	18.80	2.3	2.42	5.14	9.47	14.61	64.82
5%	20.45	2.80	2.46	4.2	10.65	14.85	71.71
5.5%	22.40	3.10	2.52	3.78	11.94	15.72	75.95
6%	19.83	3.70	2.48	3.66	12.76	16.32	78.18

Table IX

Result of Mix with 10% RAP Material

Bitumen	Correct stability	Flow value	Bulk density	Air voids	V_b	VMA	VFB
4.5%	20.73	2.7	2.408	4.08	9.42	13.5	69.78
5%	21.84	2.90	2.45	3.92	10.6	14.52	73
5.5%	23.66	3.20	2.46	3.65	11.65	15.30	76.14
6%	22	3.60	2.39	3.20	12.29	15.50	79.29

Table X

Result of Mix with 15% RAP Material

Bitumen	Corrected Stability	Flow Value	Bulk Density	Air Voids	V_b	VMA	VFB
4.5%	19.26	2.4	2.43	6.12	9.51	15.63	60.85
5%	20.30	2.70	2.45	4.95	10.60	15.55	68.17
5.5%	21.36	3.30	2.48	4.38	11.75	16.13	72.84
6%	21.10	3.95	2.44	3.96	12.56	16.52	76.03

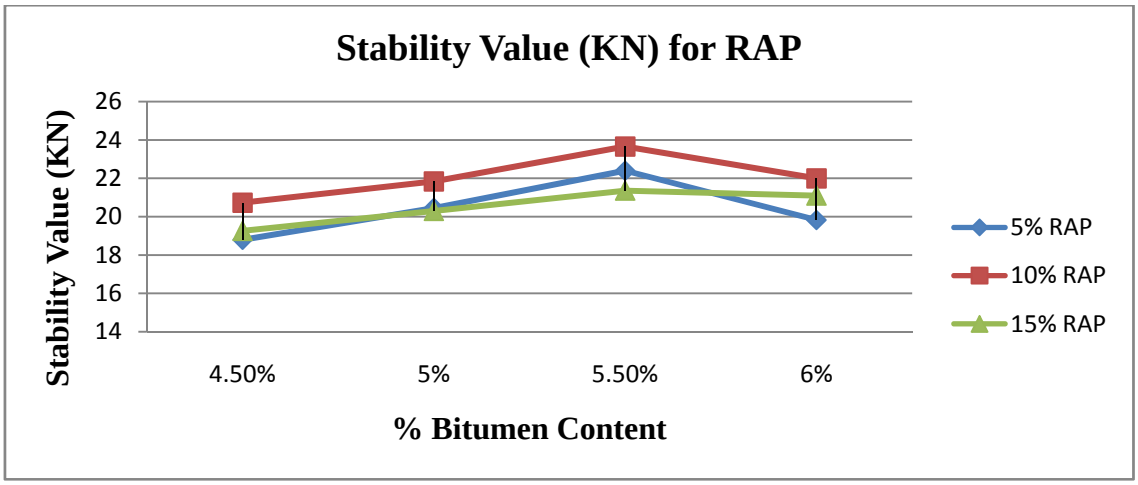

Fig. 4 Graph Between Stability Value V/S %Bitumen

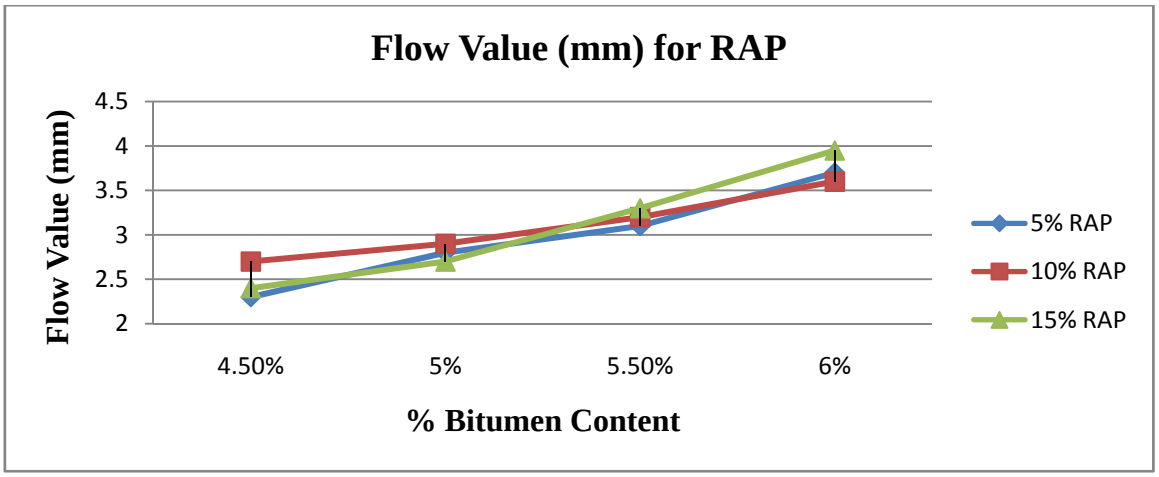

Fig. 5 Graph between Flow Value V/S % Bitumen

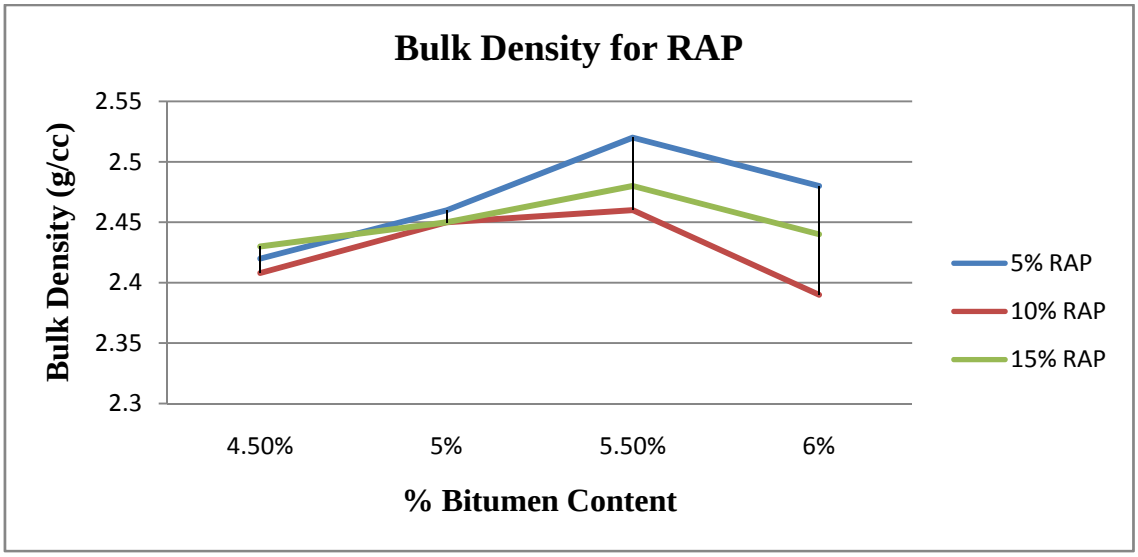

Fig. 6 Graph between Bulk Density V/S % Bitumen

V. CONCLUSIONS

The objective of this study is to analyses the effect of RAP material as an aggregates in the DBM Gr-2 layer with different proportions i.e. 0%, 5%, 10%, 15% and finally some conclusions comes out as following:

- By the use of the RAP material in the impact value test the value continuously decrease which indicates that as the content of RAP material increases the mix will have more ability to resist impact loading.
- As the RAP proportion increased in the crushing testing machine the crushing resistance of the mix. Increase as increase in the percentage of the RAP material.
- In the abrasion test done with the Los Angeles apparatus the value decreases as increase the RAP

proportion which indicates that the resistance against the abrasion will increase.

- The specific gravity of the RAP material is slightly more than the fresh aggregate sample.
- With the increase in the value of the RAP in Marshall mix method the stability value will be increased slightly which means that by mixing of the RAP material the strength of the pavement layer is increased.
- The bulk density is also increased in Marshall test such that the more dense structure is formed.
- The optimum bitumen content with 10% RAP in the mix is 5.25% at that percentage content of RAP the optimum bitumen content comes out least with respect of virgin aggregates and different proportions of the material used.
- Replacing virgin aggregates with RAP material till 15% at 5% interval from this result shows that more increase of RAP material % it will decrease the strength of mix.
- Results shows the increase in flow value as RAP content increases by which flow value increases more flexibility in the pavement but value of flow within permissible limit so that it can be used in the construction work.
- Use of RAP satisfy the design requirements as per Marshall mix method and use of RAP material we achieve overall economy be replacing with natural aggregates upto 10% as per result comes from experimental work.

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