Use of RAP Materials on Bituminous Pavement and Sustainable Development

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Abstract – *This paper presents the use of RAP (Reclaimed Asphalt Pavement) materials on bituminous pavement and looks for sustainable environment which is the major concern of the day. RAP is a new concept and method of construction. Modern planning of roads construction extended to create of variety of environmentally sustainable options i.e. resource challenges and to be resilient to the environment problems like different types of problems.*

Recycling of Asphalt pavement is fruitful in terms of economy and also ensures from results that RAP mixes are either similar or better than virgin mixtures. The use of RAP also reduce CO_2,SO_2 emission to the environment .This paper presents the co-relation between the road construction by using RAP and the protection of environment by reducing pollution. Both are important for sustainable development, sustainable environment and sustainable assessment.

Key word: *RAP, Asphalt, sustainability, virgin aggregate, pavement.*

1. INTRODUCTION

This paper intends to enhance the better understanding between the use of fresh mixtures and RAP mixtures in bituminous pavement through Hot-Mixing Process and the sustainable development and sustainable environment. Owing to rapid population growth and their habitation throughout India, compelled us for rapid and extensive road construction, in order to provide communication each corner of the state .It naturally enhanced the demands of developing new roads and highways, at the same time, betterment of existing old roads and highways are needed to be reconstructed and improving or widening lanes to meet the pressure of traffic volumes like heavy commercial trucks and passenger vehicles. But all these depends on the provision of funds from the government or authority. No need to say that funds are limited whereas construction of new roads and highways are unavoidable. To solve this problems, Civil Engineers are to think the alternative ways by which construction and maintenance cost of roadways, could be reduced and new constructional works can be carried on.

To solve the aforesaid problems, the application of RAP materials on bituminous pavement can be undertaken. Through recycling process the aggregate materials can be collected from dilapidated and deteriorated pavement, known as Reclaimed Asphalt Pavement which can be partly or fully reutilised in the new road construction. The result of RAP mixing is , more or less similar or better than new or virgin mixing. It reduces the cost of construction, maintenance, energy and fuel consumption and having excellent durability. It also reduces CO2 emission which is related to sustainable development and sustainable environment.

This paper stresses on this point which was not mentioned earlier that mixing process of RAP materials for bituminous pavement could be viable for sustainable development and sustainable environment. So the application of RAP is justified. This paper attempted to experiment various parameters of Marshall Stability Test to achieve the desired result. Use of fresh mix 30%RAP and 40% RAP etc. and 5.8% bitumen content for each mixtures in this process. Among these fresh or virgin gives the best result and 30% RAP is better than 40% RAP and it is environmentally having good impacts on human health, eco-system, climate change etc. Use of RAP materials provide safe and smooth journey ,less friction with tyres along with conservation of non-renewable resources for future generation.

1.1 Objective Of The Study:

1. To review critically the different methods of conducting a pavement sustainability, assessment and then recommended approach.

2. To find out the possibility of using RAP as a substitute of conventional road materials or aggregates.

3. To stop the misuse of RAP materials only in the worksor purpose of land-filling without being tested or analyzed.

4. To know how far the use of RAP can save the non- renewable natural resources, cost of construction and to provide sustainable environment.

2. Literature Review:

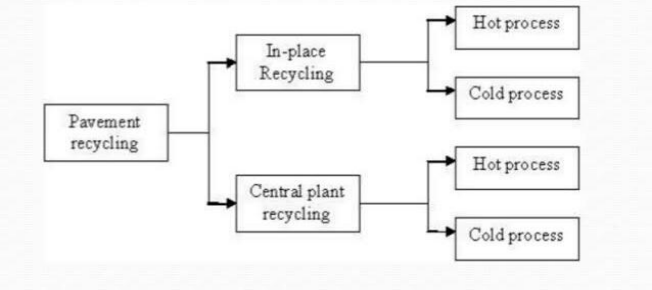
1.HOVERTH et.el. studied the environmental impacts of the pavement made of asphalt and steel-reinforced concrete by a life-cycle inventory analysis based on publically data. They found that asphalt pavement to have high energy input, lower are and fertilizer input requirement, and lower toxic emission but generates higher amount hazardous waste in comparison with steel reinforced concrete pavement.

2.KIM et.el. conducted a series of studies on GHG from road construction based on the data for a pavement project at the planning phase. The framework was applied to 23 typical highways construction projects in the Republic of Korea. The project also studied the emission of GHG from on site equipment's usage during road construction and summarized the eight major GHG –producing activities during construction.

3. Methodology:

In order to recycle the bituminous mix, there are two possible ways. One is that central plant recycling and the other is in- situ recycling. If recycling process is done in central plant which is away from the site and need to transport from one place to another that is Central Plant Recycling. In –situ recycling process is done on that very site where RAP is used for road construction.

Further the RAP could be heated to condition it, then the process is known as "Hot Mixing Recycling (HMR)".On the other hand ,in "Cold Mix Recycling " old materials are conditioned using recycling agent (like low viscosity emulsion , small amount of cement or lime)without using heat. This classification is presented below schematically in Diagram.



Test on RAP Materials:

1. Marshall StabilityTest

2. Aggregate ImpactTest

3. Specific Gravity & Water Absorption Test on Aggregate

4. Penetration Test

5. Softening Point Test

6. Ductility Test

7. Specific Gravity Test on Bitumen

4. Result:

Sources of Materials:

For this paper RAP materials, aggregates, bitumen etc. are all materials were collected from the Hot Mix Plant located near Sainthia, Birbhum (W.B).

According to the laboratory tests were managed to determine the physical properties of virgin aggregates and RAP aggregates essential values as per MORTH 5th Edition.

- **Results on Virgin Aggregate and RAP Aggregate:**

Table-1

Test Name	Results of Virgin Aggregates	Results of RAP Aggregates	Requirements as per MORTH 5th Edition
1. Impact Value (%)	12.70	16.2	Maxm 24%
2.Specific Gravity	2.69	2.76	Maxm 2.6-2.8
3.Water Absorption (%)	1.35	1.5	Maxm 2%

- Test Results on bitumen physical properties:

- Physical properties of used virgin bitumen and RAP bitumen and VG-30 bitumen binder used in this purpose are as follows:

Table-2

Test Name	Result of Virgin Bitumen	Result of RAP Bitumen	Required Value	Method of Test as per specification of Indian Standard
1. Penetration	56	35	50-70	IS:1203:1978
2.Softening Point (°C))	49°C)	52°C)	47°C)	IS:1205:1978
3.Ductility	77cm	20cm	75cm	IS:1208:1978
4.Specific Gravity	1.02	1.08	0.99	IS:1202:1978

Job Mix Formula: As per MORTH 5TH Edition- Recommended mixture of aggregate and bituminous asphalt type binder in an appropriate form , especially for Dense Bituminous Macadam (DBM)Road construction. The thickness of the single layer of this type road thickness shall be within 50-100mm, 40mm, 25mm,etc may also be used.

Mixing gradation of fresh bituminous mix materials with 30%, 40% RAP materials.

Table-3

IS Sieve size	Percentage of requirement value for passing	Grading of virgin mix (fresh)	Grading of 30% RAP mix	Grading of 40% RAP mix
19mm	100	99.90	97.09	95.99
13.2mm	79-100	92.10	82.11	79.89
9.5mm	70-88	88.88	76.54	74.04
4.75mm	53-71	56.30	56.90	57.00
2.36mm	42-58	45.70	47.26	47.50
1.18mm	34-48	35.70	37.02	38.58

600µ	26-38	27.50	28.52	29.54
300µ	18-28	20.19	21.51	21.79
150µ	12-20	12.20	13.22	13.50
75µ	4-10	7.99	8.50	8.68

values for the gradation of coarse aggregate, fine aggregate, filler used for both virgin and RAP mixing materials for this purpose followed by the table 500-11 in "SPECIFICATION FOR ROAD AND BRIDGE WORKS", MORTH 5TH REVISION, published by Indian Road Congress.

Ratio of mixing materials:

Table-4

The mean value (in %) results of various limitations of

The mix proportion suggests and conforms to reach the final results of tested materials. The required materials

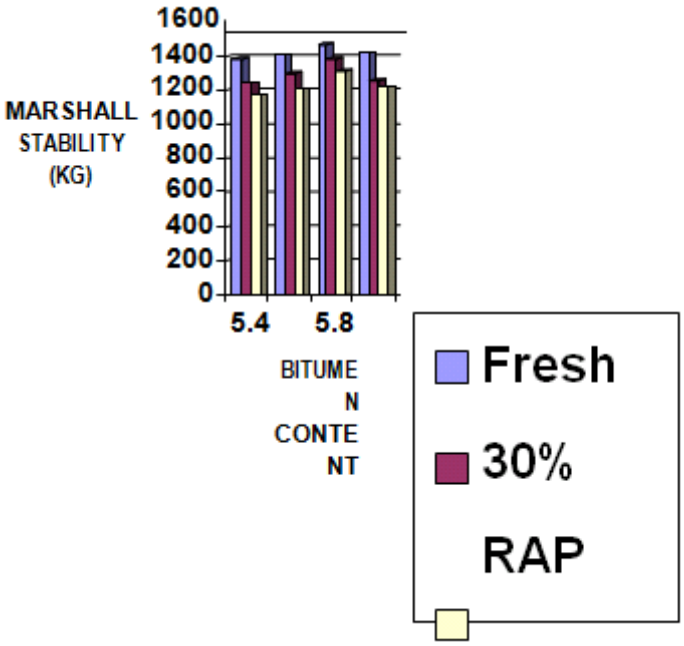
	Fresh mix (%)	30% Fresh mix RAP	40% RAP
1. Coarse Aggregate (20mm,12mm,6.7 mm)	14%,15%, 23%	6%,7%,15%	3%,4%,11%
2. Fine Aggregate (stone dust)	45%	38%	39%
3. Filler (cement)	3%	3%	3%
4. RAP percentage	---------	30%	40%

Marshall Stability Test reports for the construction of DBM road with virgin mix, 30% RAP and 40% RAP materials at optimum bitumen content in Table 5:

Table-5

RAP (%)	Virgin Mix	RAP (30%)	RAP (40%)
1. Density (g/cc)	2.366	2.358	2.355
2. Volume of Bitumen (V_B %)	13.77	13.67	13.60
3. Volume of Aggregates (V_A%)	80.60	82.45	84.40
4. Voids in Mineral Aggregate (VMA %)	16.18	17.20	17.49
5. Voids filled with Bitumen (VFB%)	85.20	83.88	79.51
6. Marshall Stability (KN)	1467	1383	1315
7. Flow Value (mm).	2.7	2.3	3.0

Marshal Stability Graph



Datasheet of Graph:

Table-6

A		B	C	D
	5.4	5.6	5.8	6.0
1. Fresh	1385	1407	1467	1420
2. 30% RAP	1233	1296	1383	1254
3. 40% RAP	1163	1205	1315	1223

5. Discussion:

Marshall Stability v/s Bitumen Content

1. Density between Fresh, 30% RAP and 40% RAP, fresh mix gives best result and 30% RAP density better than 40% RAP mix materials.

2. 5.8% bitumen binder content are taken identical for fresh, 30% RAP, 40% RAP.

3. Flow value among the RAP 30%, 40% both are better than fresh mixture as per required range (2mm-4mm).

4. V.M.A value of RAP 40% gives best results rather than the fresh and 30% RAP materials.

5. Fresh or virgin mix materials gives the best V.F.B value.

6. 40% RAP has the highest volume of aggregate and virgin mix has the lowest volume of aggregate and 30% has more value than fresh mix.

7. It is determined that the volume of bitumen 'V_B' in fresh mixture has the highest value and virgin mix has the lowest value(13.77%) and then 30% RAP (13.67%) and next 40% RAP (13.60%).

In the view of the above discussion , this paper present that RAP 30% gives better result than RAP 40% and RAP 30% showed good results as compare to 40% and also giving similar result as new or fresh mixture. Mixing 30% RAP with virgin materials saving aggregates, bitumen, filler etc. and also reduce CO_2 emissions by using already burnt bitumen

in RAP directly. It is known that direct burning of bitumen increase CO_2 global factor. So, it is an ideal for sustainable development and environment.

6. CONCLUSIONS:

This paper presents that in order to replace the old, distressed pavements, severely cracked or rutted layers, along with possible low-cost road construction, at the same time to keep away from harmful effect on environment and a sustainable development, an extensive study carried on. Use of RAP materials on bituminous pavement helps to reuse the existing materials mixing with virgin materials, results a standard road construction as good as new. For its' several benefits, advanced countries are interested to follow this process but in India it is gaining popularity slowly but steadly. It reduces emission of harmful air pollutants like SO2, Co2. In the surface layer standard use of 30% RAP with virgin materials proved a standard mixture for road construction to provide a long span 0f road life, smooth surface finishing, strong capacity to the load of heavy commercial trucks. Today road construction is a vital sector where steps to be taken to reduce costing and expenditure, energy demands and specially to protect the environment. Any project of road and highway construction should contribute to the sustainable development. Road construction with RAP materials and about the sustainable sense on environment are ensured more or less by the using of RAP materials in pavement design. As India has set a target to extend the roads throughout the country, for achieving the goal, only solution is avoiding the cost-burden and by using RAP materials in the work. So the use of RAP materials is unavoidable to keep the sustainable development and sustainable environment in fact.

Future scope:

No research work may be final and last words to say. Every research work opens new idea, innovative concept and further improvement. So, when new coming generations of Civil Engineers will think to find out the new methods and techniques, addition and alteration of new ingredients of aggregates and binding materials for construction of roads and highways, then they will be more careful about the process of highways construction by which they can save green world i.e. human, animals, trees and aquatic animals world from different pollutants gases like CO_2, SO_2 causing global warming. This paper supports and confirms the use of RAP materials the use of RAP materials on bituminous pavement is beneficial from different point of view. Like that use of rubber crumble, glass, polymer, chemical ingredients, wooden dust, plastic and other disposal materials also can be utilized for road construction as well as stand for conservation of valuable, non-renewable resources in order to provide sustainable development and environment. In fine, a good wishes to the new researchers in the field of roads and highways constructional process, new techniques, use of materials etc. Their investigation will be in such a novel way by there our world will be safe and green for future generation.

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BIOGRAPHIES

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