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Experimental Study on Bituminous Mix using LDPE, Crumb Rubber and Mild Steel Chips in the Construction of Flexible Pavement

Teerthananda Sagar C S
Assistant Professor, Civil Engineering
Dr. T. Thimmaiah Institute of Technology,
KGF, Karnataka, India.

Yashashwini M S, Ravichandra N,
Architha N, Nikil V
UG Students, Civil Engineering
Dr. T. Thimmaiah Institute of Technology,
KGF, Karnataka, India.

***Abstract* — In recent years, the use of plastic (LDPE), rubber from squandering to modify the mechanical possessions of bituminous fusions has become progressively important in highway engineering. There is presently much research devoted to the influence of this waste substantial on mix performance. This paper presents a study of the incorporation of plastic and crumb rubber. The results obtained show that plastic and crumb rubber improved the stiffness and stability of mixes. A part from the evident environmental benefits, adding this waste to asphalt mixes improves the long-term performance of road surfaces because it reduces the effect of traffic loads on the pavement. In this paper we are improving bitumen possessions and diminish cost of construction and mainly plastic and rubber disposal so that environment expansion can attain and its eco-friendly and also here we are profitable to diverge LDPE and crumb rubber content from 10% to 50%to increase the Marshall stability strength of the road and we have utilized mild steel as an admixture to increase the Marshall stability in rubber replacement. By the experimental analysis we got 20% and 20% optimum values for LDPE and Crumb Rubber respectively.**

Keywords:- (Urbanization, Bituminous Mix, Eco-Friendly, Non-Biodegradable, Deformation)

I. INTRODUCTION

India is a blooming country where conveyance shows a significant role. In India conveyance chiefly depends on the road network which as a road length of 5.6 million kilometers and stands as the second largest road network in the world. Discarded valorization has turn out to be crucial to a more efficient and sustainable development in the world in the present day. The reuse and reinsertion of waste substantial in the production chain reduces the consumption of basic commodities and, in many cases, even prevents the depletion of valuable natural resources. Moreover, it also alleviates the accumulation of waste at landfills, which is now a serious problem. Consequently, great efforts are currently being made to reuse waste material in production systems. As they are non-biodegradable, positioning them is a serious issue. Improper discarding of these waste plastic and tires causes harmful effects on the environment and human life. One of the temporary methods of disposing the waste plastic and tires is burning which releases the toxic harmful gases such as carbon di-oxide and carbon monoxide which results in the air pollution. Therefore, by partially replacing the bitumen with waste plastic and crumb rubber to certain extend the properties of flexible pavement like durability, solidity and strength can be increased. When crumb rubber is added to the hot bituminous mix, it adequately increases the viscosity, lowers the penetration and increases the softening point of the bitumen. Carbon which is present in the rubber acts as an anti-oxidant and prevents the bitumen from aging and oxidation. The main objective of this study is to find the optimum percentage of waste plastic, crumb rubber and mild steel chips that can be partially replaced for bitumen to strengthen the surface course and reduce the cost of construction and also to provide an alternative solution for the disposal problem of waste plastic and crumb rubber.

II. OBJECTIVES

1. To reduce the bitumen content by the addition of waste plastic and crumb rubber in the hot bituminous mix.
2. To know the stability of the modified bituminous pavement by conducting Marshall Stability test.
3. To minimize the cost of construction of the flexible pavement.
4. To reduce the environmental impacts, that arises during the disposal of waste tires.

III. MATERIALS USED

A. BITUMEN:

In the construction of flexible pavement, bitumen plays an important role in binding the aggregates together. Various grades of bitumen are 30/40, 50/60, 60/70, 80/100.

Desirable properties are,

- Bitumen provides a good resistance to surface wear.
- Reduces the surface water infiltration.
- Provides smooth and readable finish.
- Also provides structural support to the wheel loads.

B. COARSE AGGREGATES:

The aggregates bind together with the help of binding materials such as bitumen. Aggregate are the major constituents of the pavement that should have high strength, durability, toughness, hardness etc. Aggregates used are of sieve size 16mm, 12mm, 12.5mm, 10mm, 4.75mm, 2.36mm and stone dust.

C. LOW DENSITY POLYETHYLENE [LDPE]:

Low density polyethylene is a thermoplastic made from the monomer ethylene. It was the first grade of polyethylene.

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LDPE is sometime recycled and tends to be both durable and flexible. It can withstand temperature of 80°C continuously and 95°C for short time. The use of LDPE will not only strengthen the pavement but also increases its durability.

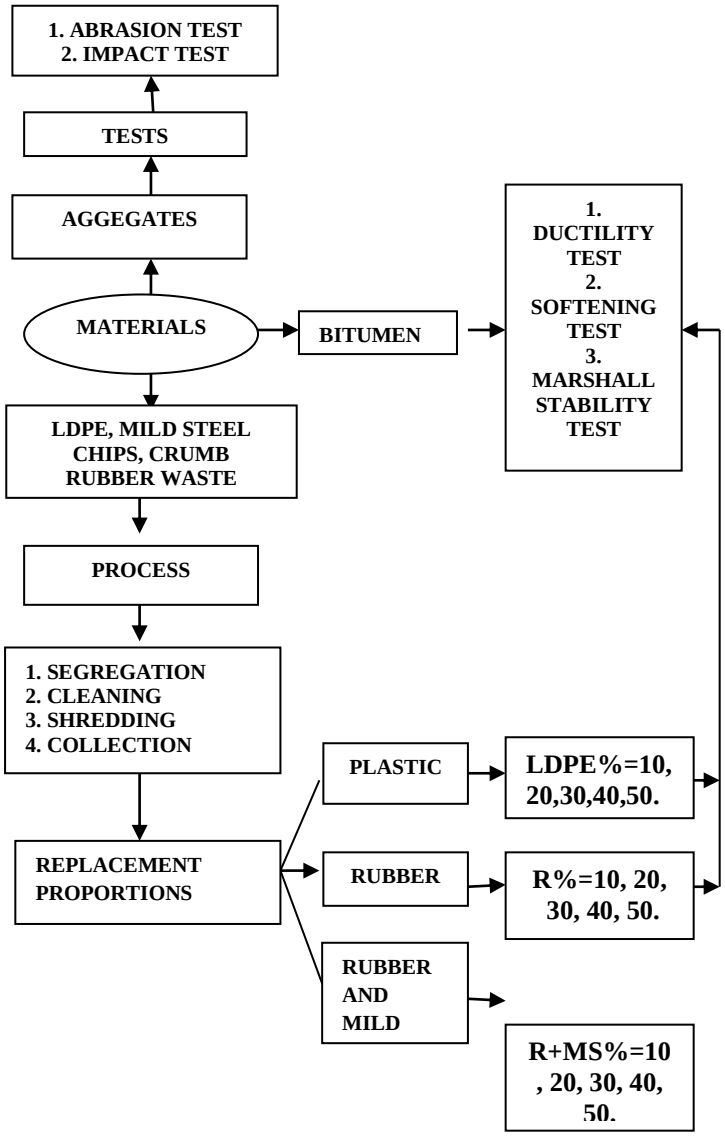
D. CRUMB RUBBER:

Crumb rubber is the shredded form of waste tires which is obtained from the truck and automobiles tires (or) crumb rubber are the recycled rubber obtained by grinding up whole scarp tires and other waste products.

E. MILD STEEL CHIPS:

Mild steel chips are obtained from the process of cutting the mild steel (turning, filing) by mechanical means using the tools such as, lathes, saws and milling cutters. These chips are the debris or waste that is obtained from the machining or material removing process. Mild steel chips contains approximately 0.05-0.2% of carbon which makes it malleable and ductile. Also it has relatively low tensile strength. By using the waste mild steel chips in the construction of flexible pavements, the stability can be relatively increased.

IV. METHODOLOGY



V. EXPERIMENTAL RESULTS AND DISCUSSION

1. TESTS ON AGGREGATES

Aggregates are tested according to IRC codes and examined it with standard acceptable values

TABLE I: *SHOWS TEST ON AGGREGATE*

Sl.No	*Experiments*	*Results obtained*	*Acceptable Range*
1	Impact Value (%)	25	10-20(Strong) 20-30(Good)
2	Los-Angeles Abrasion Test (%)	26	<30%
3	Flakiness(%)	10.3	<35%
4	Elongation (%)	33.60	<35%
5	Specific Gravity	2.6	2.5-3

2. TESTS ON BITUMEN

Bitumen is tested according to IRC codes and examined it with standard acceptable values.

TABLE II*: TESTS ON BITUMEN*

Sl.No	Experiments	Results obtained	Acceptance Range
1.	Ductility	58	40cm(Min)
2.	Ring & Ball Test	54	47°C(Min)

3. TESTS ON WASTE COATED AGGREGATES

Aggregates are coated with plastic at 100◦C as acts anti stripping agent on aggregate

TABLE III: *TESTS ON WASTE COATED AGGREGATES*

Test on Aggregates	Natural Aggregate	LDPE Aggregate	Rubber Aggregate
Los Angeles Abrasion test	26	24	23.4
Impact test	25	14.75	16.94

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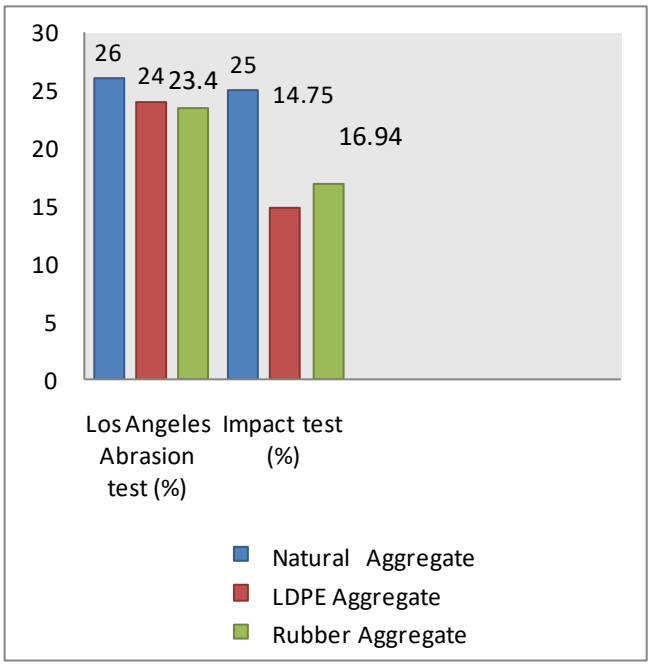

Chart 1: Tests on Coated Aggregates

4. *TESTS ON REPLACED BITUMEN*

The bitumen test is lead and the analyses were tabularized. For the evaluations gained the following graphs are strategized compared to Bitumen and various parameters

a) *LDPE REPLACEMENT*

LDPE is switched with bitumen in innumerable magnitudes like 10%-50%. Marshall Stability test where conceded out for every single replacement of plastic magnitudes and annotation down the readings correspondingly.

TABLE IV*: MARSHAL STABILITY TEST FOR LDPE REPLACEMENT*

LDPE (%)	Stability (kN)	Flow value (mm)
Bitumen	35.5	4.5
10	73.39	3
20	100.30	2.5
30	51.36	3.5
40	45.93	4
50	39.2	4.5

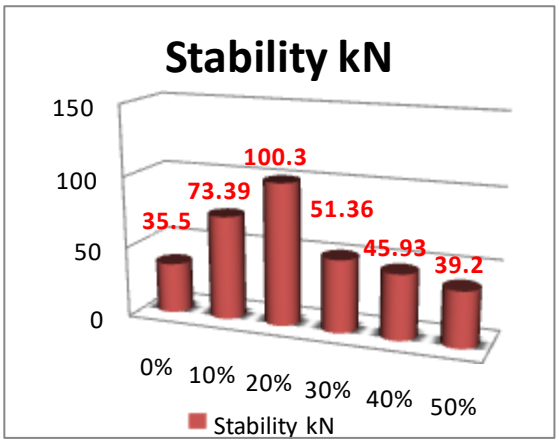

Chart -2: Stability Graph for LDPE replacement

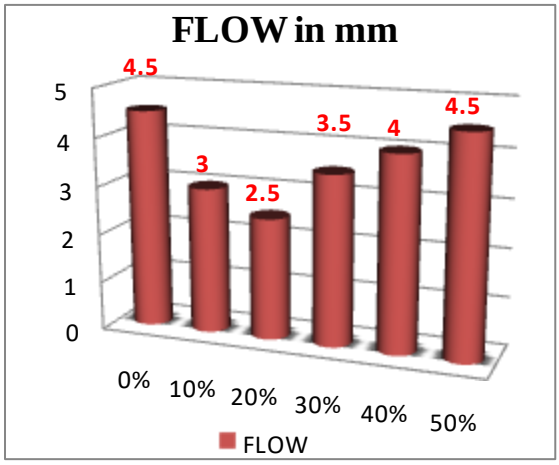

Chart -3: Flow Graph for LDPE replacement

b) *CRUMB RUBBER REPLACEMENT*

CRUMB RUBBER is switched with bitumen in innumerable magnitudes like 10%-50% Marshall Stability test where conceded out for every single replacement of plastic magnitudes and annotation down the readings correspondingly.

TABLE V: *MARSHAL STABILITY TEST FOR CRUMB RUBBER REPLACEMENT*

Crumb Rubber (%)	Stability (kN)	Flow value (mm)
Bitumen	35.5	4.5
10	58.9	4.0
20	69.5	3.5
30	77.3	3.0
40	59.6	3.5
50	52.2	4.0

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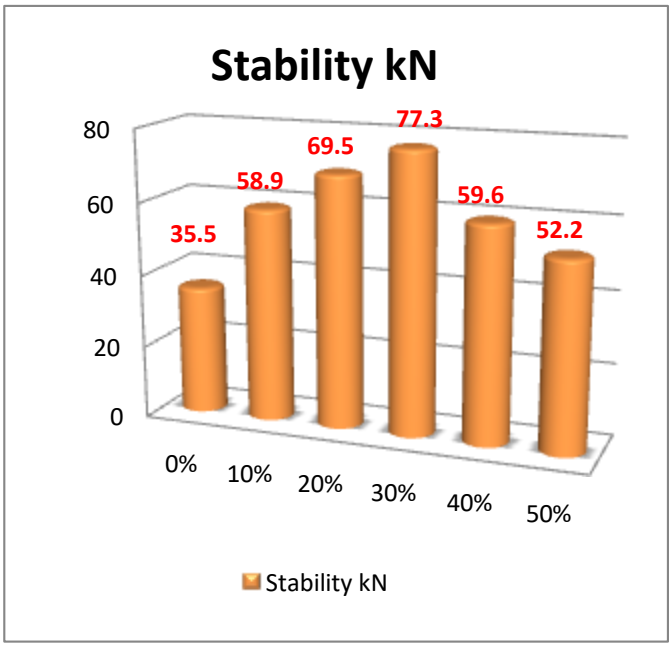

Chart -4: Stability Graph for crumb rubber replacement

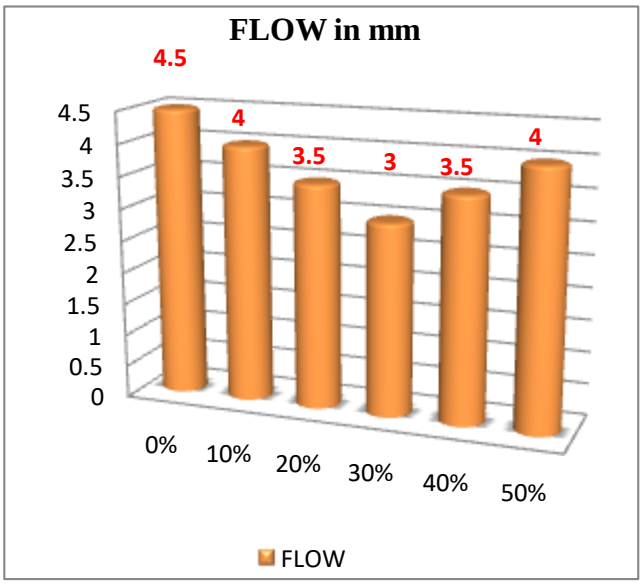

Chart -5: Flow Graph for CRUMB RUBBER replacement

c) CRUMB RUBBER REPLACEMENT WITH MILD STEEL AS ADMIXTURE

Crumb rubber is switched with bitumen in innumerable magnitudes like 10%-50%. We got the 30% as optimum value, on this result we have added mild steel to increase the strength. Marshall Stability test where conceded out for every single replacement of crumb rubber magnitudes and annotation down the readings correspondingly.

TABLE V: *MARSHAL STABILITY TEST FOR CRUMB RUBBER AND MILD STEEL REPLACEMENT*

Sl. No	% Of Bitumen	% Of Crumb Rubber + Mild Steel Chips		Stability Value (kN)	Flow Value (mm)
1	70	30 + 0		77.3	3.0
2	70	27	3	86.07	2.5
3	70	24	6	88	2.5
4	70	21	9	104.49	2.0
5	70	18	12	93.71	3.0
6	70	15	15	80.2	3.5

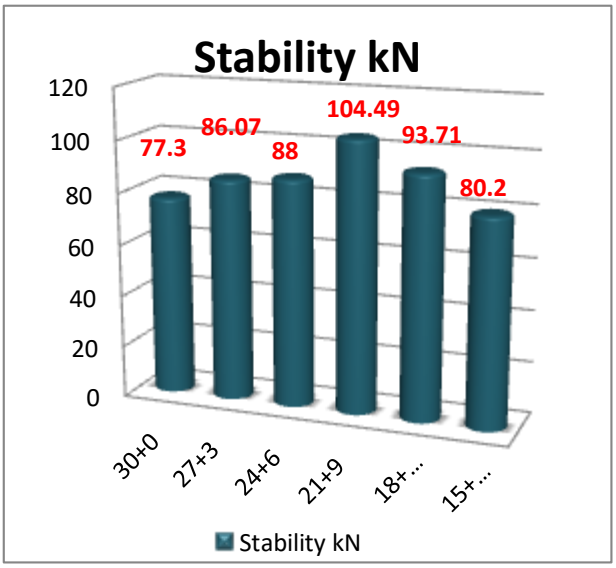

Chart -6: Stability Graph for crumb rubber and mild steel replacement.

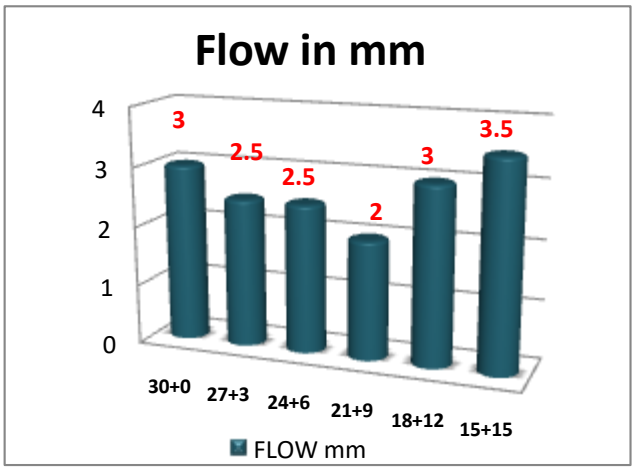

Chart -7: Flow graph for crumb rubber replacement

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TABLE VII: *ESTIMATION AND COMPARISION*

MATERIAL NEEDED	PLAIN BITUMEN PROCESS	LDPE-BITUMEN ROAD	RUBBER-BITUMEN ROAD	RUBBER-MILD STEEL CHIPS – BITUMEN ROAD
60/70 BITUMEN	15.4 tonnes	12.32 tonnes	10.78 tonnes	10.78 tonnes
WASTE	----------	3.08 tonnes	4.62 tonnes	4.61 tonnes
COST RS.	1494000	948700	908660	914100
COST REDUCED	NIL	545300	585340	579900
COST REDUCTION	**0%**	**36.49%**	**39.17%**	**38.81%**
STABILITY KN	35.50	100.30	77.3	104.49
STABILITY INCREASED BY	4.5	2.5	3	2
FLOW VALUE DECREASED BY	0 times	2.82 times	2.17 times	3 times

CONCLUSION

1. The graph illustrate about assorted content of bitumen and properties of behavior of Marshall stability moulds shown positive outcome at 20% of waste LDPE and 30% of crumb rubber. Hence we can conclude that among 10% -50%, 20% and 30% is optimum value for waste LDPE and crumb rubber respectively.
2. Due to reduction in ductility value water penetration, stripping and rutting are nullified.
3. The bitumen modifier increases the stability and density of mix which is suggested for surface course.
4. The thickness of pavement may decreases to half of normal thickness which results in economy of cost by reducing quantity of materials and by achieving the work in less duration of time with better quality.
5. From the optimum values obtained, 20% and 30% of bitumen can reduces for waste LDPE and crumb rubber. Hence total cost of bitumen can be reduced and reduces same quantity of waste LDPE and crumb rubber from environment in useful way and protects nature from harmful effects.
6. Due to use of waste materials the cost reduction is up to 36.5% (Rs.545300), 40%(Rs.585340) and 38.81% (plastic, rubber, rubber and mild steel chips respectively) when compare to ordinary bitumen.

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