MODIFIED BITUMEN USING WASTE H.D.P.E AS ADMIXTURE

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Abstract: Rapid changes in temperature now a day's big problem to face worst situations, Durability point is a big factor which affects the life period of the pavement surface and its components, Nominal mixes which consists of inert material doesn't gives better Durability in severe traffic and climate conditions Today's flexible pavements are Required to perform better as they are facing increased volume of traffic, increased loads and increased variations in daily or seasonal temperature over what has been Challenged in the past. As these are non-biodegradable there is a major problem posed to the society with regard to the management of these solid wastes. Even, the reclaimed polyethylene originally made of **HDPE** has been observed to modify bitumen. In the present study, an attempt has been made to use HDPE as admixtures in nominal bitumen mix to overcome the problem of resistance to weathering actions and repetitive wheel loads.

The grade of bitumen produced in India without admixtures are not able to cope up with the extreme weather conditions across our country; there arise a need to reinforce bitumen mixes with proper admixtures. This waste materials can be operated and used successfully in the construction of roads thus avoiding the environmental problems and minimize the cost of construction of roads within the country Various studies are proposed to be conducted with varying the mix ratio of the admixtures with bitumen keeping the maximum level of admixtures to **10%** by volume.

Key words *– Modified Bitumen, Admixtures, Polyethylene, Marshall stability and flow, Dry mix, Gap graded mix*

I. INTRODUCTION

Flexible pavements generally with bituminous (or asphalt) materials. These can be either in the form of pavement surface treatments(such as a bituminous surface treatment generally found on lower volume roads) or, HMA surface courses. These types of pavements are called flexible since the total pavement structure bends or deflects due to Wheel loads. Pavement structure is generally composed of several layers of materials which can accommodate this flexing. Flexible pavements being economical are extensively used.

Construction of flexible pavement involves various layers that will be attached to each other in plastic nature, various case studies of road careful done and should be given to the amount and kind of traffic going over this road at present and also to the probable increase within the next few years. Proper study should be made of the condition of sub-soil and the old base.

If the present road has a good gravel or stone base that is holding up very well, a bituminous macadam top course is a very economical pavement to use. If it is a new grade there is a question whether some other types of pavement would not be as economical. One of the best higher cause for laying a bituminous macadam roads is the make the old base enough strong. A well compacted gravel or stone surface that has been laid down by heavy traffic for a period of years has appropriate value and that value may be sustained by laying a bituminous macadam top layer.

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The quality of a pavement that was constructed will be measured by its Durability, the word durability says that resistance to wear and tear and also against weathering agencies. So that the quality construction require high level of durability and resistance to wear and tear, Durability of pavement structure depends upon the material used in the construction and its quality and characteristics. Selection of a good suitable material for construction of pavement based on type of pavement and level of classification of that road.

MODIFIED BITUMEN:

Proper additives or blend of additives called as bitumen modifiers may improve properties of Binder and bituminous mixes. Bitumen treated with these modifiers is known as modified bitumen. **Polymer modified bitumen (PMB)/ crumb rubber**

modified bitumen (CRMB) should be used only in wearing course depending upon the requirements of extreme climatic variations. The detailed specifications for modified bitumen have been issued by IRC: SP: 53-1999. It must be noted that the performance of PMB and CRMB is dependent on strict control on temperature during construction. The advantages of using modified bitumen are as follows

- Lower susceptibility to daily and seasonal temperature variations Higher resistance to deformation at high pavement temperature Better age resistance properties.
- Resistance to Fatigue & Resistance to Repetitive loads

Admixures

Bitumen admixtures are mostly chemical in nature which temperature sensitive than bitumen. Bitumen will will induce health effects to the workers paving the surface be dissolved in petroleum oils where unlike tar with admixture added bitumen. With this perspective, in this study an attempt is made to utilize waste materials such as **High Density Polyethylene (HDPE)** and **Crumb rubber.**

High-densitypolyethylene (HDPE)or polyethylenehigh-density (PEHD)isa polyethylene thermoplastic made from petroleum. It is sometimes called "alkathene" or "polythene" when used for pipes. With a high strength-to-density ratio, HDPE is used in the production of plastic bottles, corrosion-resistant piping, geo-membranes, and plastic lumber. HDPE is commonly recycled, and has the number "2" as its resin identification code.

Crumb Rubber is a product obtained by crushing of waste tyres those can recycled, that tyres can be make into pieces and then to required size. Basically it is to be used after sieving it through 1.7mm sieve for most of all works.

II. LITERATURE REVIEW:

Sandhya Dixit (2013) concluded that using of waste recycled material which harms the environment leads to protection of environment against the pollution and environmental im- balance , it is mentioned that resistance to wear and tear from the repetitive loads can be challenged by adding such type polymer additives in the mix properly, it is said that increase in impact value of aggregates was found on increase in additive percentages is very crucial in certain levels of percentages of additives.

Dr. Muhammad Bilal Khurshid stated that adding of shredded plastics in various percentages may leads to change in marshal test results, most prominently upto 8% it is observed that high rise in the values of abrasion and impact values of aggregates that which in turn leads to increase in stability values of mixes and layers when the roads are paved. Dry process is eminent than Wet process that adding the polymers by after heating the aggregates to certain temperature , these modified mixtures are in turn proving greater resistance against the fatigue and drainage also as the results obtained from these modified bituminous mixes is greatly changing the parameters of both inert and binder material. Finally it was concluded that addition of polymers may leads to great change in the strength parameters of bituminous mix and also the surface resistance for the pavement.

Mohammad T(2007) experimentally proved that, the optimum content of additive is important, however the 5.4% of polymer content among total weight of aggregates results in good improvement in fatigue resistance and plastic deformation. Reducing the effect of pavement deformation is a better achievement in durability criteria of bituminous pavement construction. Increasing the additive content more than 12 % results in decreased mixing temperatures that are a eminent factor affecting on pavement mix preparation.

H.M.R.D. Silva (2011) concluded using varieties of plastic wastes in the nominal bituminous mix as partial replacement to the better results in concluding the emerging trends in one hand and environmental balance on the other hand. Commercial scenario of th e pavement construction can balance their outstanding results on using high quality additives as replacements but economical aspect cannot be balanced for them and for that scenario.

S.K.Palit, K. (2004) discussed that adding crumb rubber as an additive in binder can be profitable mix since the binder content is decreasing but the problem raised when these mixes are exposed to Higher temperature leads to failure of surface resistance and balance against variations of temperatures as warping effect of bituminous pavement is the major problem . It is observed that increased stability factor and tensile strength ratio by using the crumb rubber content as that consists of higher plastic value, stripping of characteristics is also one of the achievement in this with changing temperature differential.

Miss Apurva J Chavan(2013)concluded that , the stripping of characteristics results in inferior surface performance of any pavement as ravelling factor will increase as the bitumen is stripping off from the aggregate it looks very irregular surfacing even though the higher grades of materials has been used .The coating of polymer deceases the effect of ravelling in all temperature differentials and also the effect of rutting and pot holes formation consequently. As the heavy traffic leads to inferiority in surface

protection it is the better alternative by using the plastics waste in the mixes so that environmental balance is also happening. Better durability will be held with these modified bituminous mixes.

Rokade S (2012) concluded that, increase of strength properties of bituminous mix up to 8% to 10%Crumb Rubber then the value is going down as the deformation in mix is increasing consequently the deflection has been increasing the flow value rapidly with 8% to 12% of crumb rubber contents.

K.Rajesh kumar and Dr. N.Mahendran: Concluded that using of H.D.P.E granules which is obtained from recycling process of the waste H.D.P.E pipes and other materials is a better way of improving the mix quality and strength aspects, he considered that nominal mix which is prepared by using conventional material such as aggregate, binder with filler material may results in poor performance in exceptional drainage and exposure conditions and may cause to early deterioration.

III. SCOPE AND OBJECTIVES OF WORK:

- The present study aimed at preparation of Gap –graded mix of bitumen and modified with crumb rubber and to find the variation of conventional properties.
- Study the effect of adding polyethylene on the hot mix asphalt.
- To identify the best mechanism of adding the polyethylene (dry or wet process) to the asphalt mixture to achieve better mixture properties.
- To find out the optimum percentage of HDPE and asphalt to be used in the mix.

OUTLINE OF THE PROJECT:

The work has been started with various gradations of aggregates and binder contents The optimum binder content and aggregate content is then worked out using Marshall Stability mix design process on control/conventional HMA samples. Crumb rubber modified bitumen and aggregates quality tests are then performed to explore the effects of variation of polymer (HDPE) content (i.e. % by weight of optimum asphalt content) on the performance of these materials. HDPE modified samples are then prepared by adding HDPE in the mix in different percentages by weight of optimum asphalt content and optimum HDPE content (i.e. % by weight of optimum asphalt content) is then determined basing of Marshall Stability criterion.

a) Wet Process: : In the wet process, shredded HDPE was added to bitumen at 160° C. This process did not yield a homogenous bituminous mix with prominent separated solid deposits/pieces of mix. Therefore wet process was not adopted for this study. Hence another waste material (crumb rubber) has been selected to add it to the bitumen. The proportion of crumb rubber has been selected as 10% by weight of binder contents.

b). Dry Process : In this process aggregates are heated to 170°C and then above mentioned percentages of shredded HDPE are added and mixed to coat the aggregates. These coated aggregates have been used for the preparation of the bituminous mixes.

Table 1 : Details of materials per sample

Coarse aggregate content in mix (%)	40.625%
Fine aggregate content in mix (%)	53.29%
Filler content in mix(%)	6%
Binder content	5%, 6% and 7% (of total aggregate content)

IV. EXPERIMENTAL WORK:

The work has been started with various gradations of aggregates and binder contents The optimum binder content and aggregate content is then worked out using Marshall Stability mix design process on control/conventional HMA samples. Crumb rubber modified bitumen and aggregates quality tests are then performed to explore the effects of variation of polymer (HDPE) content (i.e. % by weight of optimum asphalt content) on the performance of these materials. HDPE modified samples are then prepared by adding HDPE in the mix in different percentages by weight of optimum asphalt content and optimum HDPE content (i.e. % by weight of optimum asphalt content) is then determined basing of Marshall Stability criterion.

Figure.1: Aggregate sample coated with H.D.P.E

Table no 3: Summary of test results on aggregates

S.NO	Test	Maximum permissible value	Normal aggregates	6% HDPE coated aggregates	8% HDPE coated aggregates	10% HDPE coated aggregates
1.	Specific gravity	2.75	2.6	2.44	2.44	2.44
2.	Water absorption	2	1.9%	0.4%	0.4%	0.4%
3.	Impact value	30	24.09%	12.4%	10.98%	9.87%
4.	Crushing value	45	26.29%	18.68%	16.48%	15.18%
5.	Abrasion value	35	30%	14.2%	12.6%	9.2%

Table No. 8: Summary of test results on bitumen

PROPERTIES	SPECIFIED VALUES	NORMALBITUMEN	MODIFIED BITUMEN
Specific gravity at 27°C	0.97 to1.02	1.02	1.05
Flash point	175	220	250
Softening Point. °C	35°C to 70°C	47	48
Penetration at 25°C 100gm, 5 sec.	80 to 100	91	89
Ductility (cm) 100	54	80	

Figure:2: Sample preparation

Figure 3: Bitumen heated

Figure 4: Samples prepared

Figure 5: Samples in water bath

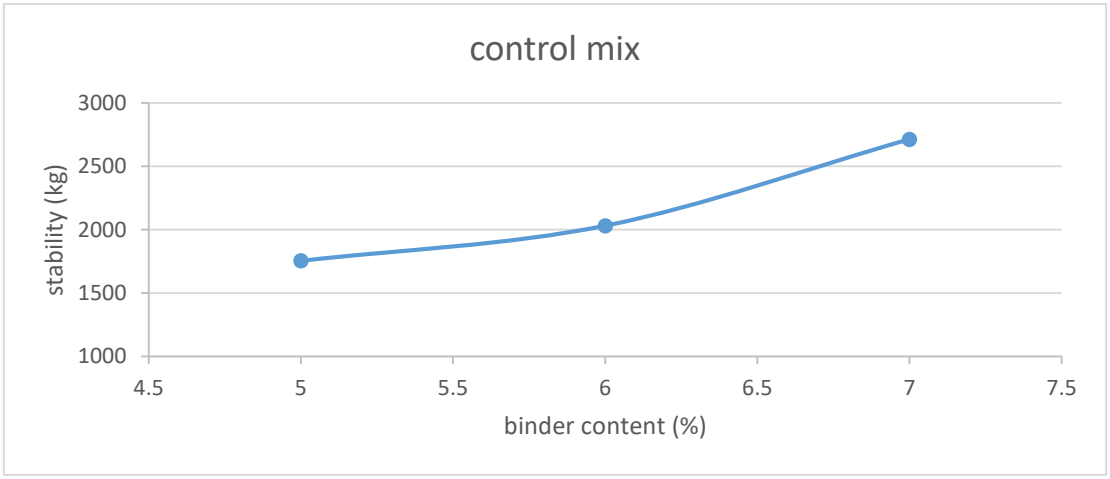
V. RESULTS AND DISCUSSIONS:

Mix	Bitumen content (%)	Sample no.	Stability (kg)	Flow value in 0.25 mm units
Control mix	5	1	1677.4	17.22
		2	1755	18.56
		3	1832.6	14.62
	6	1	2178.75	14.60
		2	1999.15	15.21
		3	1919.75	18.19
	7	1	2893.32	19.28
		2	2217.80	17.11
		3	2378.25	17.61
MB-A6	5	1	2630.27	8.7
		2	2378.22	8.1
		3	2504.89	12.6
	6	1	256932	11.2
		2	2218.78	11.1
		3	2242.25	11.3
	7	1	2465.65	15
		2	2716.10	18.1
		3	3015.55	20.9
MB-A8	5	1	2181.58	14.10
		2	2462.16	16.28
		3	1818.33	15.22
	6	1	1930.57	17

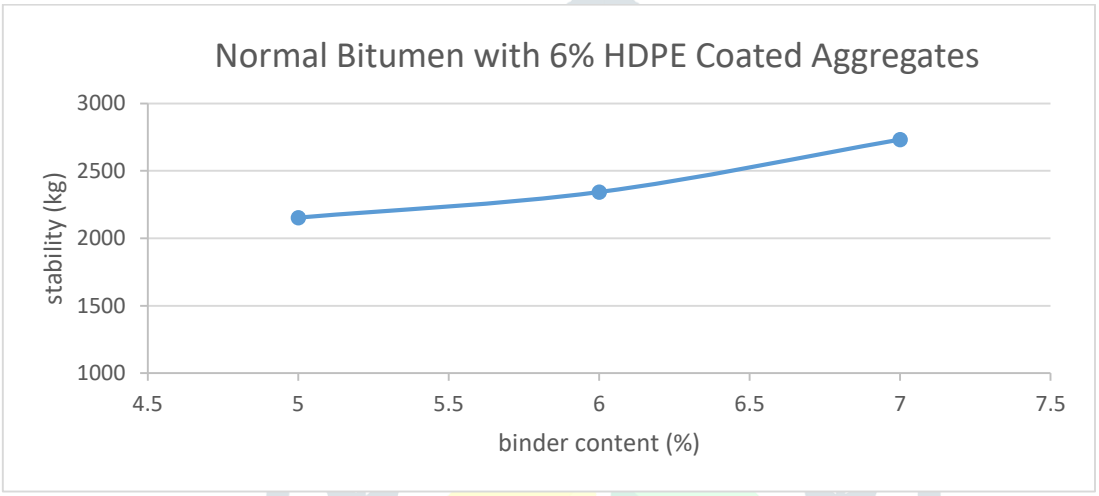
MB-A8	6	2	3105.28	14.86
		3	2881.37	18.54
	7	1	2715.66	16.88
		2	2922.41	16.98
		3	2950.93	17.62
MB-A10	5	1	2565.14	15.6
		2	2017.14	16.28
		3	2683.72	17.32
	6	1	2504.66	18.32
		2	2563.22	14.28
		3	2368.12	20.2
	7	1	2676.20	16.72
		2	2786.58	18
		3	2538.22	18.08
CRMB-A6	5	1	4230.28	14
		2	4652.34	17.6
		3	4441.19	18.2
	6	1	4132.04	17.43
		2	3840.49	19.21
		3	3986.31	19.76
	7	1	4356.21	20.23
		2	4326.57	17.8
		3	4589.79	19.57
CRMB-A8	5	1	4424.65	16.02
		2	4685.55	18
		3	3867.82	18.78
CRMB-A8	6	1	3995.25	17.2
		2	4326.22	18.56
		3	4656.53	20.64
	7	1	4624.82	19
		2	4758.32	18.62
		3	4671.86	19.98
CRMB-A10	5	1	3324.09	18.02
		2	3562.89	16.88
		3	3463.11	17.90
	6	1	3686.52	19.12
		2	3456.28	20.92
		3	3957.20	22.36
	7	1	4122.62	17.2
		2	4288.32	18.40
		3	4471.06	18.80
CRMB	5	1	1593.07	17.54
		2	1785.36	18.28
		3	1689.2	19.36
	6	1	1391.97	21.60
		2	1119.3	18.69
		3	1147.29	18.51
	7	1	911.07	19.6
		2	867.46	22.32
		3	1124.51	22.88

NOTE:- CONTOL MIX: Mix without Admixtures
MB A6 : Modified bitumen with 6% H.D.P.E content coated to aggregate
MB A8 : Modified bitumen with 8% H.D.P.E content coated to aggregate
MB A10 : Modified bitumen with 6% H.D.P.E content coated to aggregate
CRMB A6 : Modified bitumen with 6% H.D.P.E coated to aggregate and Crumb rubber content 10% of total binder content.
CRMB A8 : Modified bitumen with 8% H.D.P.E coated to aggregate and Crumb rubber content 10% of total binder content.
CRMB A10 : Modified bitumen with 10% H.D.P.E coated to aggregate and Crumb rubber content 10% of total binder content.
CRMB : Modified bitumen Crumb rubber content 10% of total binder content and normal aggregate.
GRAPHS FOR TEST RESULTS

A. FOR CONTROL MIX

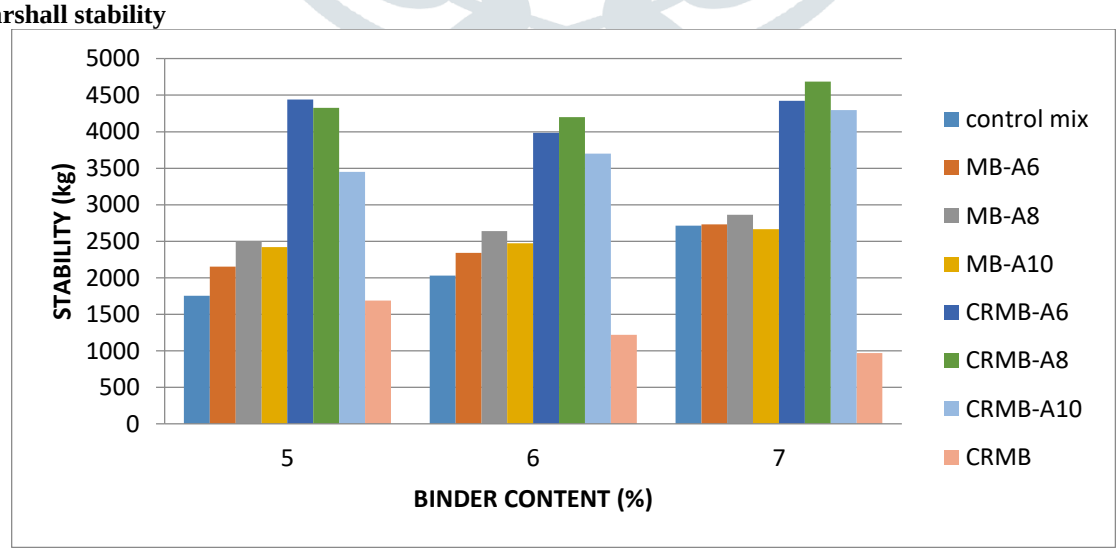


A. FOR MIX MB-A6

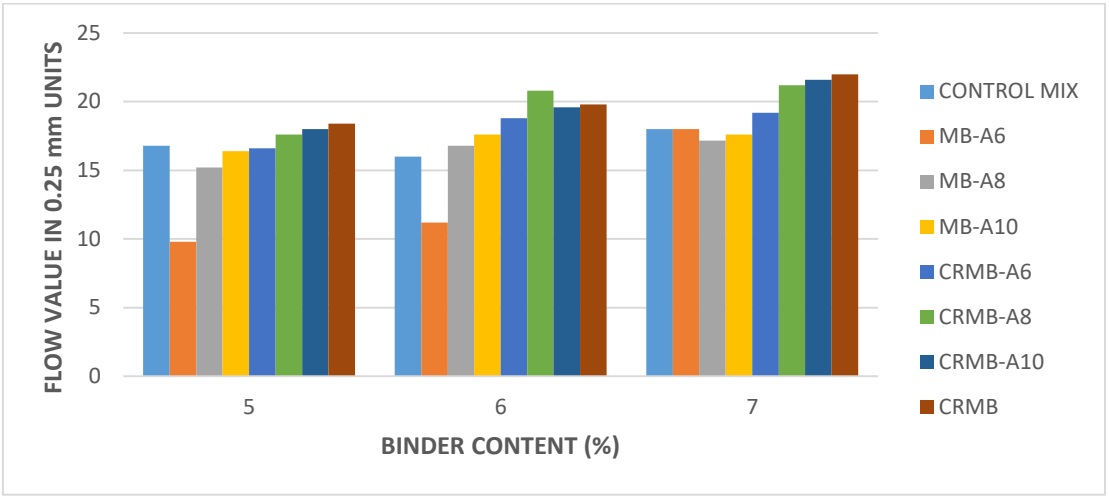


COMPARISION OF PROPERTIES OF BITUMINOUS MIXES

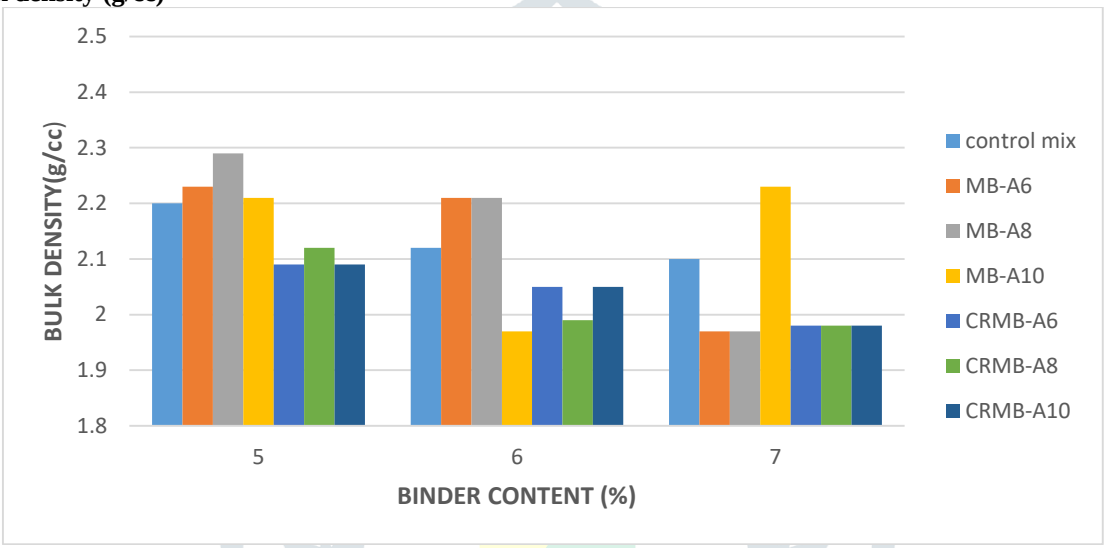
1. Marshall stability



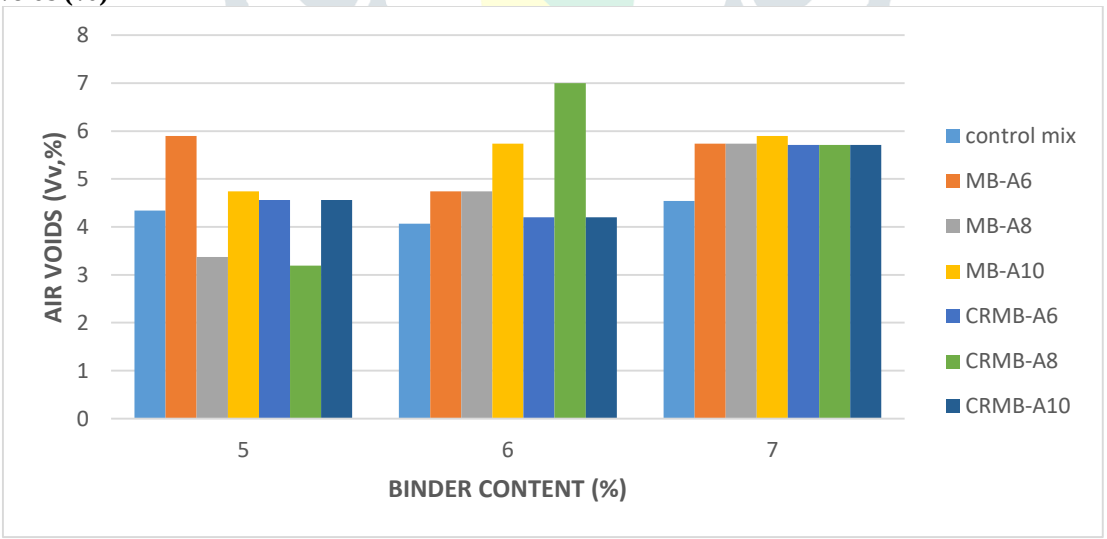
2. Flow value



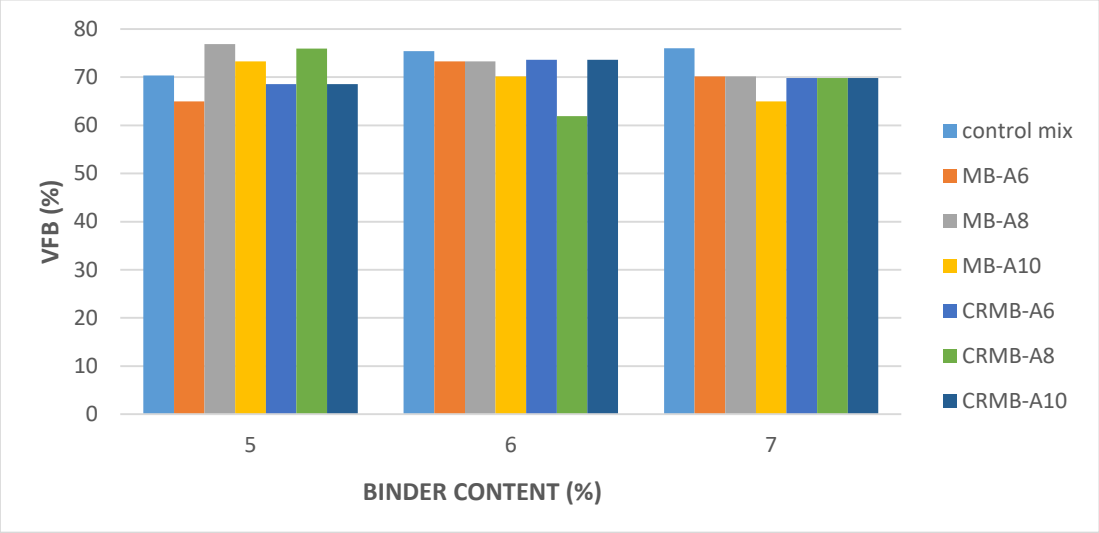
3. Bulk density (g/cc)



4. Air voids (%)



5. **Void filled with bitumen (%)**



VI Conclusions:

- HDPE coating of aggregates increases abrasion, crushing value and impact resistance of aggregates thus improving strength and wear resistance properties of the treated aggregates.
- Modified bitumen with crumb rubber as admixture improves ductility and softening point thus increasing ability of sustaining under high temperatures and plastic deformation.
- Optimum binder content obtained is 7% which is common for both control mix (without admixtures) and modified bituminous mixes (with admixtures).
- Mixture modification using 8% shredded HDPE improves the Marshall Stability of the mixture and thus increasing its rutting resistance and load carrying capability.
- Stability of bituminous mix is increasing on proportional to increasing of HDPE up to 10%
- Greater stability is obtained at lower binder content (ie..5%) for the mix with crumb rubber modified bitumen and normal aggregate.
- The flow values of bituminous mix is remaining constant for the mixes with crumb rubber modified bitumen.
- It is found that maximum stability value obtained for the mixes with 8% HDPE coated aggregate.
- It is observed on adding crumb rubber with HDPE coated aggregates, stability as well as the flow has been improved when compared to crumb rubber added bitumen with normal aggregate.
- Using crumb rubber in mix results higher ductility and increasing the plastic nature of binder.
- Used Rubber tires may cause solid waste or harm when they burn in out lands instead of that using those tires in construction work is better alternative to waste.
- At whole this can be said as the combination of Rubberized and Plastic roads,if the combination of Crumb rubber and H.D.P.E is taken.
- L.D.P.E (low density polyethylene) may cause more harmful emissions as the L.D.P.E is from waste plastics and low quality polymers.
- The use of waste plastics as asphalt mixture modifier ensures its safe, useful and environmental friendly disposal.
- It is observed that using such polymer admixtures emits harmful gases that may cause un healthy environment in surroundings, But taking preventive measure is possible in hot mix plant.
- Use of waste polyethylene in HMA (hot mix asphalt) is expected to yield better and enhanced waste management and better city hygiene and environment.
- The proposed mixes are economical since we are attaining greater strength at very little investment. (HDPE 80/- kg & Crumb rubber 18/- kg)
- By adding proposed admixtures the initial cost of the mix may be high, but overall cost on using them in construction will be economical.

SCOPE FOR FURTHER STUDY

- Modified bitumen with various varieties of polymers or some other materials which gives better mix properties.
- In this study we have been used the Re cycled H.D.P.E and Crumb rubber as additives which was completely going waste, There are another waste materials such as Plastic waste (Plastic roads) which is causing environmental pollution can be used extensively and can extend this study .
- We can also compare the mix properties achieved by the H.D.P.E and Plastic waste (Domestic).
- We can use Zycosil as a proper additive in the bituminous mix which gives better Plastic properties for the mix and increase Durability of pavements.

- In this study we concentrated on only the mix grades and proportions regarding to the surface course , Bituminous concrete mixes only , But we can extend this study for the mixes used for the base courses also.

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