

Experimental Investigation on Bituminous Mixing Using Waste HDPE

Divya Bhavana Tadepalli¹, Srikanth Kandula², SaiVivek Reddy.K³&Sadgun Kumar.A⁴

Assistant Professor, Department of Civil Engineering, Aurora's Engineering College, Telangana, India¹

B. Tech Student, Department of Civil Engineering, Aurora's Engineering College, Telangana, India^{2,3,4}

ABSTRACT: Bitumen pavements or Flexible pavements are the most commonly used type of pavements in India .Because of high temperature roads that are laid, especially in water prone areas are highly getting damaged due to heavy traffic, lack of maintenance because of insufficient funds, and deteriorating before their life span. So to decrease these damages several measures such as, use of cost effective materials, quality materials, raising sufficient funds for the maintenance and improving the roadway design. The bitumen that is available in India is of cheap quality, not gives good strength and stability to the pavement. So providing the reinforcement using admixtures to this may give us desirable results. In this research an attempt is made to utilize High Density Poly Ethylene (HDPE) which is a waste material to enhance the quality of bitumen mix. This material can be successfully used in the construction of pavements thereby decreasing environmental problems and also cost. Experimental phase of this research starts with bitumen and aggregates quality tests. The optimum bitumen content is then worked out using Marshall Stability mix design process on control/conventional HMA samples. HDPE modified samples are then prepared by adding HDPE in the mix in the following proportions as 0%,6%,8%,10% by weight of optimum bitumen content and optimum HDPE content(i.e.,% by weight of optimum bitumen content)is then determined basing of Marshall stability criterion.

KEYWORDS: *High* Density Poly Ethylene(HDPE),Marshall Stability.

I. INTRODUCTION

Bituminous materials or asphalts are extensively used for road way construction, primarily because of their excellent binding characteristics and water proofing properties and relatively low cost. Bituminous material consists of bitumen which is a black or dark coloured solid or viscous cementitious substances consists chiefly high molecular weight hydrocarbons derived from distillation of petroleum or natural asphalt, has adhesive properties, and is soluble in carbon disulphide. Tars are residues from the destructive distillation of organic substances such as coal, wood, or petroleum and are temperature sensitive than bitumen. Bitumen will be dissolved in petroleum oils where unlike tar.

Road ways are the most important and widely used ways of transportation .So there is every need to improve the quality of the pavements .so here is an effort made to use an economically efficient material like High density Poly Ethylene. By this we can not only use the environmental hazardous material like polyethene but also increase the strength and stability of the roads.

II. RELATED WORK

K.Rajesh Kumar,Dr.N.Mahendran had investigated on Experimental Studies on Modified Bituminous Mixes Using Waste HDPE and Crump Rubberthis study an attempt is made to utilize waste materials such as High Density Polyethylene (HDPE) and crumb rubber enhance with flexible pavement quality bitumen. This waste materials can be handled and used successfully in the construction of roads thus mitigating 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.

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 4, April 2016

Sandhya Dixit (2013) concluded that From the Marshall test results, it is concluded that the Marshall stability value increases with an increase in bitumen content from 5% to 5.5% then it decreases. The optimum binder content was found to be 5.4 % .Also higher value of Marshall stability was found for a modified mix as compared to an unmodified one. From an environmental and economic standpoint, the use of waste plastic fibres, as a bitumen modifying agent may contribute to solving a waste disposal problem and to improving the quality of road pavements.

Dr. Muhammad Bilal Khurshid (RSETE 2013), stated that HDPE coating of aggregates increases abrasion and impact resistance of aggregates thus improving strength and wear resistance properties of the treated aggregates. Moreover polymer coating reduces its affinity for water and may improves tripping susceptibility. Mixture modification using 8% shredded HDPE improves the Marshall Stability of the mixture by 70% thus increasing its rutting resistance and load carrying capability. HWT test results also confirm that modified mixture has higher resistance to permanent deformation (rutting). Dry Process (polymer coating of aggregates) is more useful as compared to Wet Process (adding polymer in the binder) for manufacturing modified mixtures, as it can accommodate higher amount of waste plastic as modifier and results more stable mixtures.

Mohammad T (2007) experimentally proved that, the appropriate amount of polyethylene was determined to be (6-18%) by weight of the optimum asphalt percent (5.4%), which equates to (0.34-1.03%) by weight of total aggregate. However, the optimum modifier content was found to be 12%, which equals only 0.68% of the total aggregate weight. Overall, using the polyethylene in asphalt mixture reduces pavement deformation; increase fatigue resistance and provide better adhesion between the asphalt and the aggregate.

III. MATERIALS USED

Bitumen

Bitumen is an oil based substance. It is a semi-solid hydrocarbon product produced by removing the lighter fractions (such as liquid petroleum gas, petrol and diesel) from heavy crude oil during the refining process. As such, it is correctly known as refined bitumen. This material is extensively used for road ways construction, primarily because of their excellent binding character and water proofing properties and relatively low.

The Paving Grades of bitumen are 30/40, 60/70 and 80/100. The grade 80/100 is commonly used in India

Table 1: Bitumen physical properties

Test	Normal bitumen	IS Code
Specific gravity	1.052	IS :1202 -1978
Penetration	90.67mm	IS: 1203 –1978
Softening point	49 °C	1205 – 1978
Ductility	70cm	IS:1208 -1978
Flash point	110 °C	IS:1209- 1978
Fire point	204 °C	IS:1209 -1978

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 4, April 2016

Coarse Aggregate:

Ordinary granite broken stone of size greater than 12mm are used conforming to IS 383-1987 having a specific gravity of 2.67.

High density polyethylene (HDPE)

HDPE are been used before in experimental works related to flexible pavements showing positive results related to use of plastic waste in flexible pavements. The polymer coated aggregate bitumen mix perform better for flexible pavements. The results for both dry and wet specimen of different percent waste polymer modified bitumen (WPMB) mix show 50 percent enhanced tensile strength compared to conventional mix and more resistance to water damage.

Table 2: Summary of Test Results of Aggregates

Test	IS Code	Normal aggregates	6% HDPE coated aggregates	8% HDPE coated aggregates	10% HDPE coated aggregates
Specific gravity	IS 2386 PartIII1963.	2.67	2.8	2.79	2.79
Water absorption	IS 2386 PartIII1963.	1.62	0	0	0
Impact value	IS 2386 PartIV1963	16.94	13.33	11.23	9.6
Crushing value	IS 2386 PartIV1963	28.3	24.56	22.27	19.46
Abrasion	IS 2386 PartIV1963	38.3	35.2	30.8	27.2
Flakiness index	IS 2386 Part I 1963	6.9	6.9	6.9	6.9

IV. METHOD OF MIXES

Marshall Mix Design

The Marshall Stability and flow test provides the performance prediction measure for the Marshall mix design method. The stability portion of the test measures the maximum load supported by the test specimen at a loading rate of 50.8 mm/minute. Load is applied to the specimen till failure, and the maximum load is designated as stability. During the loading, an attached dial gauge measures the specimen's plastic flow (deformation) as a result of the loading. The flow value is recorded in 0.25 mm (0.01 inch) increments at the same time when the maximum load is recorded.

Types Of Mix

a) Well-graded mix:- Dense mix, bituminous concrete has good proportion of all constituents and are called dense bituminous macadam, offers good compressive strength and some tensile strength

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 4, April 2016

- b) Gap-graded mix:- Some large coarse aggregates are missing and has good fatigue and tensile strength. In this study Gap –graded Mix were prepared.
- c) Open-graded mix:- Fine aggregate and filler are missing, it is porous and offers good friction, low strength and for high speed.
- d) Unbounded:- Binder is absent and behaves under loads as if its components were not linked together, though good interlocking exists. Very low tensile strength and needs kerb protection.

Specimen Preparation

In this project gap-graded mix has been chosen. Approximately 1200g of aggregates is heated to a temperature of 175°C to 190°C.

Bitumen is heated to a temperature of 121°C to 125°C with the first trial percentage of bitumen (5.5% by weight of them aggregates) to the heated aggregates and thoroughly mixed at temperature of 154°C to 160°C. The mix is placed in a preheated mould and compacted by a rammer with 75 blows on either side at temperature of 138°C to 149°C. The weight of mixed aggregates taken for the preparation of the specimen may be suitably altered to obtain a compacted thickness of 63.5+/-3 mm. Vary the bitumen content in the next trial by +0.5% upto 6.5% and repeat the above procedure. The prepared mould is loaded in the Marshall test setup.

Table 3: Samples of Various Proportion Mix

Mix name	Bitumen	Aggregates	Binder contents	No.of Sampels
A	Normal	Normal	5.5%, 6%, 6.5%	9
MB-A6	Normal	6% HDPE coated aggregates	5.5%, 6%, 6.5%	9
MB-A8	Normal	8% HDPE coated aggregates	5.5%, 6%, 6.5%	9
MB-A10	Normal	10% HDPE coated aggregates	5.5%, 6%, 6.5%	9

V. RESULTS AND DISCUSSIONS

Marshall Stability Test

Marshall Stability of a test specimen is the maximum load required to produce failure when the specimen is preheated to a prescribed temperature placed in a special test head and the load is applied at a constant strain (5 cm per minute). While the stability test is in progress dial gauge is used to measure the vertical deformation of the specimen. The deformation at the failure point expressed in units of 0.25 mm is called the Marshall Flow value of the specimen.

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 4, April 2016



Fig 1: Bituminous mix

Table4: Density and voids analysis

Mix Name	Sample No.	Bitumen content (%)	Weight (g)	Avg. Gravity of compacted mix (Gmb)	Sp. of	Max.Theoretica l Sp.Gr.of mix (Gmm)	Air voids percent (Vv)	Voids in mineral aggregate (VMA)	Voids filled with bitumen (VFB)
Mix A	1	5	1272	2.29		2.51	8.68	17.13	49.32
	2	5.5	1279.53	2.34		2.47	5.27	15.98	67
	3	6	1237.33	2.25		2.515	10.53	19.6	46.2
Mix-A6	1	5	1220	2.4		2.54	5.5	13.41	59.1
	2	5.5	1254.6	2.38		2.44	1.652	14.14	88.3
	3	6	1256.67	2.38		2.46	3.25	14.95	77.03
Mix-A8	1	5	1237	2.41		2.51	3.98	13.05	69.5
	2	5.5	1227	2.4		2.45	2.04	13.83	85.24
	3	6	1236	2.45		2.49	1.660	12.44	87.09
Mix-A10	1	5	1218	2.41		2.49	3.21	13.05	75.43
	2	5.5	1235	2.34		2.49	6.02	15.09	60.10
	3	6	1230	2.39		2.43	1.64	14.95	88.75

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 4, April 2016



Fig 2:Bituminous moulds

Table 5: Stability and Flow Values

Mix Name	Sample No.	Bitumen content (%)	Stability value (KN)	Flow value
Mix A	1	5	19.50	3.4
	2	5.5	23.50	3.1
	3	6	21.20	3.2
Mix-A6	1	5	22.00	2.9
	2	5.5	46.90	2.1
	3	6	33.90	2.4
Mix-A8	1	5	26.20	2.7
	2	5.5	39.98	2.6
	3	6	42.23	4.6
Mix-A10	1	5	27.70	5.7
	2	5.5	23.50	4.1
	3	6	44.23	4.5

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 4, April 2016

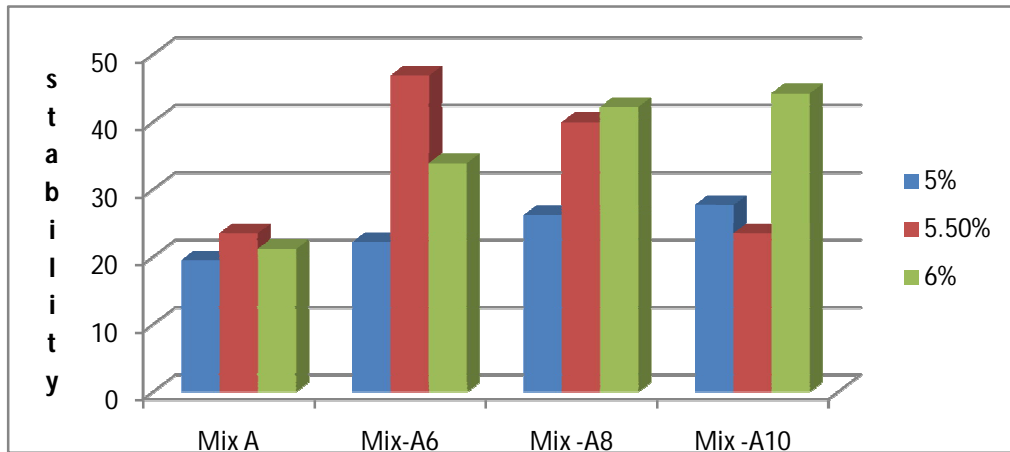


Fig 3: Binder Content Vs Stability for Mix

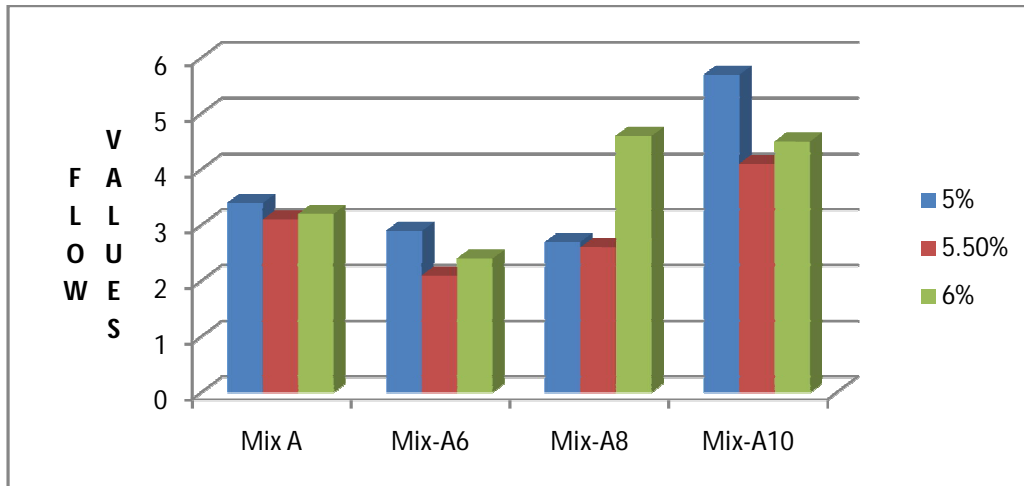


Fig 4: Binder Content Vs Flow values for Mix

From the above table 5 and fig 2,3 it is observed that the Mix-A6 at 5.5% has achieved an increase in stability and flow decreases when compared to conventional mix. The results of the study indicated that the modified mixture has a higher stability and VMA percentage compared to the non-modified mixtures. This would positively influence the rutting resistance of these mixtures.

VI. CONCLUSION

Based on the experimental investigations the following conclusions are drawn:

- HDPE coating of aggregates increases abrasion and impact resistance of aggregates thus improving strength and wear resistance properties of the treated aggregates. Moreover polymer coating reduces its affinity for water and may improve stripping susceptibility.

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 4, April 2016

- Mixture modification using 6% shredded HDPE improves the Marshall Stability of the mixture and thus increasing its rutting resistance and load carrying capability.
- Dry Process (polymer coating of aggregates) is more useful as compared to Wet Process (adding polymer in the binder) for manufacturing modified mixtures, as it can accommodate higher amount of waste plastic as modifier and results more stable mixtures.
- Direct addition of HDPE into heated bitumen (wet process) did not yield a homogeneous bituminous mix with prominent separated solid deposits/pieces of mix. Therefore, wet process was found to be unsuitable for use in preparation of HDPE modified asphalt mix, unless some other chemicals/additives are also used in wet process, which may be explored in future research.
- The use of waste plastics as asphalt mixture modifier ensures its safe, useful and environmental friendly disposal.
- Use of waste polyethylene in HMA is expected to yield better and enhanced waste management and better city hygiene and environment.

ACKNOWLEDGMENT

The authors wish to thank T.Swapna ,Asst.Professor BSIT College, T.Divya Bhavana, Assistant professor for internal guidance ,and Syed Eashan Adil ,HOD of civil department and Aurora Engineering College for their kind support, valuable guidance and providing all facilities for conducting this experiment.

REFERENCES

- [1] Ministry of Road Transport and High Ways, Manual for construction and supervision of Bituminous works, New Delhi, November 2001.
- [2] Vasudevan, R., Utilization of waste plastics for flexible pavement, Indian High Ways (Indian RoadCongress), Vol. 34, No.7. (July 2006).
- [3] Justo C.E.G., Veeraragavan. A "Utilization of Waste Plastic Bags in Bituminous Mix for Improved Performance ofRoads", Centre for Transportation Engineering, Bangalore University, Bangalore, India, 2002.
- [4] AslamShahan-ur-Rahman "Use of Waste Plastic in Construction of Flexible Pavement", New Building Materials & Construction World, 2009.
- [5] Sandhya dixit "Studies on the improvement of characteristics of bitumen with use of waste plastic" International Journal of Emerging Technology and Advanced Engineering (ISSN 2250-2459, ISO 9001:2008 Certified Journal, Volume 3, Issue 3, March 2013).
- [6] Mohammad T. Awwad and LinaShbeeb "The use of polyethylene in hot asphalt mixtures", American Journal of Applied Sciences 4 (6): 390-396, 2007. ISSN 1546-9239© 2007
- [7] Md.NobinurRahman, M.A.Sobhan, T.U. Ahmed and Mohammad Ahmeduzzaman, "Performance Evaluation Of Waste Polyethylene And PVC On Hot Asphalt Mixtures" in American Journal of Civil Engineering and Architecture, 2013, Vol. 1, No. 5, 97-102.