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Study of Addition of Waste Plastic in Dense Bituminous Macadam with Stone Dust and Bagasse Ash as Filler

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Abstract: Dense bituminous macadam (DBM) is composition of mineral aggregates and bitumen with proportion, the materials should resist the repeated traffic loads. The present situation availability of waste materials is increases due to increases in population and people life style, industrial growth etc. industrialization, it has creating the many wastes throwaway to society like waste plastic contains, plastic bags, wrappers covers, bottles, rubber and throwaway materials., also in sugar refining industry the bagasse ash is waste material. Because plastic is non bio degradable and disposal of waste plastic is creates the serious hygienic problems in environment. To avoid the impact in environment the alternate use of waste plastic needed. From the sugar refining industry the waste material obtain as bagasse ash. It will used as mineral filler, other side increasing in road traffic considerable changes in temperature and also increasing demand in highway construction, to enhance the road quality new techniques are using. The study presents the experiments conducted to find the behavior of DBM mix with plastic coated with thin layer of aluminum wrappers. The modified Waste plastic mix 5%, 7.5%, 10%, 12.5% and 15% with stone dust as filler material and 5%, 7.5%, 10% and 12.5% with bagasse ash filler. The results indicated with 12.5% of waste plastic with stone dust and 7.5% of waste plastic with bagasse ash as filler shows the more strength. Bagasse ash with waste plastic got less deformation 4.1 compared to stone dust and conventional mix.
Key Words: DBM, Waste plastic, Stone dust, Bagasse ash, Marshall Stability Test, Wheel Tracking Test

I. INTRODUCTION

Roads are refers to the mode of transportation. There are four modes of transportation. i.e. Road ways, Railways, air ways and water ways. Road ways are very commonly used for the transportation purpose, due to economical easily availability of vehicles to normal people for the transportation purpose. So that the roads should be resisting the repeated wheel loads and it should be maintained in good condition. To improve the road quality and to make the economical road construction new materials new techniques are being used. Generally pavements two types flexible Pavement and Rigid pavement. In Flexible pavements bitumen used for the surface course to make the pavements stable and even surface for the traffic. The rigid pavements are made up of RCC or PCC on the surface course. The rigid pavements are stiffer than flexible pavements. The pavements are constructed layer system, due to contact pressure on the top layer and high stress in top layer. The top layer made up from the bitumen which is acts like a binder material to improve the strength of roads, but it resistance towards water is poor. The most common roads use is flexible pavements due to their flexibility nature. Bitumen acts like a binder for the aggregates. Bitumen is a petroleum product obtained by the fractional distillation of crude petroleum. The different grades of bitumen were used for the road construction 30/40, 60/70, and 80/100 depends on their penetration value.

Disposal of plastics waste in municipal solid waste is carried out mainly by land filling and incineration method. There are two methods is not suitable for plastic disposal. The land filling is temporary process it will effect to water recharge, reduce the soil properties, clogging drainage problem in water line. While burning of polymers, it produces the gasses like CO, CO_2 which causes the air pollution. Plastics are non-bio degradable, if it is not recycled it will effect to the environment, to reduce the impact of environment and also to reduce the solid waste disposal problem.

II. LITERATURE REVIVE

Study was carried out by **Jain et.al (2011*)*** for the mitigation of rutting in bituminous roads by using the waste polymeric packaging materials (WPPM). The materials were used milk bags and other high density polyethylene (HDPE) like carry bags. The grade of bitumen was 60/70. Different size were used of WPPM is 5-10 mm × 3-6 mm. The WPPM varied from 0.1% to 0.6% (weight of bitumen). When the WPPM is modified with bitumen at the 0.2 to 0.3% the 30% stability increases. The Marshall quotient is 11.5% when addition of 0.3% WPPM. And increasing the WPPM at 0.4% the Marshall quotient is decreases. When adding of WPPM 0.3% the stiffness modulus increases. Rutting is depends on volumetric composition, shape of aggregates and characteristics of binder. For rutting test wheel tracking device used application of 20,000 cycles, by adding optimum quantity of 0.3% polyethylene in bituminous mix for road construction. Rutting values varies from 6.1mm and 16.2 mm to 3.6mm and 3.9mm with different temperature. It was observed that it ultimately improves pavement performance, reducing disposal problems of waste polymeric packaging material (WPPM) for clean and safe environment.

Another study was conducted by **Vidula et.al, (2012)** using the waste plastic like empty milk bags and plastic bags the size was 60µ of below for bitumen modification. The plastic were cut into pieces which were sieved through 4.75mm passing which is retained in 2.36mm. The bitumen were added in different percentage (4.5%, 5%, 5.5% and 6%) were the 10% of waste plastic was replaced for the bitumen the Marshall stability value ranges from 20.28 KN to 21.81 (4.5 to 6%) in the plain bitumen the Marshall value was 17.03 KN to 17.61 (4.5 to 6%). The flow value also increases from 4.57 to 5.15 mm, when increase th usage polymer decreased in the penetration value. The flash and fire point were increases when adding the polymer. The main reason for decreasing the ductility is interlocking of the polymer molecule in bitumen. The material cost of the project was reduced by 7.99%.. The optimum waste plastics were used (5-10%).

Malik Shoeb Ahmad (2014) test carried by using the low density polyethylene (LDPE), carry bags and soft drinks bottles in dense graded bituminous macadam and it is cut into sizes which is passes through 2-3 mm sieve in shredding machine. The filler materials are stone dust and cement. The total 5% of filler used (3% stone dust and 2% of cement). The LDPE was added with different percentage 0.2%, 4%, 6%, 8%, 10% and 12% (weight of bitumen). The stability, VFB, VMA increases and flow value, air voids decreases at the percentage of 8% and 12%. The stability increases 889 to 1012 KN with o and 12% of waste plastic added. The flow value is 3.46 to 2.30 with 0 and 12% of waste plastic. The optimum bitumen content is 4.5%.

Murana and Sani (2015)., were using the bagasse ash for a mineral filler in the road construction. The optimum bitumen content was 5.5%. The percentage of bagasse ash added as filler 10%, 20%, 30%, 40%, 50%. The tests were conducted and graphs plotted bitumen content v/s stability (KN), flow value (mm), air voids (%), voids mineral aggregate (VMA %), voids filled bitumen (VFB %). The stability increases when decreasing the bagasse ash and the flow value decreases when adding the 10% of bagasse ash. Percentage of voids, VFB increases with increasing bitumen content. The VMA values 16%. The optimum bagasse ash was 10%.

Kung's et.al.,(2014) studied that by using the waste sugar cane ash (WSCA) and plastic bags modification with bitumen. The grade of bitumen is 80/100. Modification was done by using the plastic, waste sugar cane ash and plastic and waste sugar cane ash (combined). The penetration value is decreased from 75mm to 51mm when the plastic is 1 to 5% and 1 to 3% WSCA added. The ductility, softening point decreased when adding the shredded waste plastic bags(SWPB) and waste sugar cane ash. The modification by using the 2%, 3% (SWPB) and 2%, 2.5% (WSCA), other modification was 2% SWPB +1.5% waste sugar cane ash, 1% WPB +2% waste sugar cane ash. The optimum binding content was 5.4%. Stability increases when 11450 N to 12600 N (2% and 2.5% WSCA) when compared to conventional bitumen (11300 N) and stability increases when adding the 2 to3% plastics and combined (2% SWPB +1.5% WSCA) the stability value 11600N and when increasing the WSCA with plastic stability will decreases 11500. The flow value, air voids, VFB and VMB decreases when adding the plastic separate and ash separate. WSCA can with stand high loading. When stability increases rutting and cracking will be reduced.

III. OBJECTIVE OF THE STUDY

The suitability of modified bitumen for the road construction with refers to the engineering properties.

A. To evaluate the basic properties of aggregates, bitumen and filler material.
B. To obtain the Optimum Bitumen Content (OBC) for DBM based on the Marshall test properties.
C. To obtain the Optimum Plastic Content (OPC) for DBM based on volumetric properties when waste plastic is varied and stone dust is used as mineral filler.
D. To find OPC of DBM modified by different percentage of waste plastic and bagasse ash as filler material.
E. Comparing the characteristics of DBM modified by plastics with stone dust and bagasse ash as filler with control mix.
F. To study the rutting behavior of DBM with modified plastics and different filler materials.

IV. MATERILAS AND METHODOLOGY

A. Materials

1) *Aggregates:* Aggregates are the primary material and major portion for the road construction. These are influence to the high load bearing capacity in the roads. Aggregates should resist the wearing and abrasion action in the road surface due to loads and wheel contact pressure between road and wheels. So that before using aggregates test should be conducted and it should posses all the IS

limits. Aggregates size and shape influence the monolithic structure of pavements. Aggregates are naturally occurring or manufactured. Natural rocks extracted from larger rock from excavation. Manufactured aggregates are crushed in crusher machine required size. . The test results are given in Table 1

Table 1. Physical Properties of Aggregates

Tests	Test methods	Results	MORTH Specifications
Los Angeles Abrasion	IS:2386(III)	24.22%	35% maximum
Water Absorption	IS:2386(IV)	0.81%	2% maximum
Impact value	IS:2386(IV)	14.06%	27% maximum
Specific Gravity	IS:2386(III)	2.67%	-
Flakiness and elongation Index	IS:2386(I)	30.15%	35% maximum

2) Bitumen: Bitumen is a material which is byproduct petroleum refining. Bitumen is a complex material. It is highly viscous when temperature is high and when the load is intermediate and medium temperature it is viscous elastic. For the room temperature it is in solid form. The melting point of bitumen is 160^0C. Bitumen is fillers the voids and it will bind with aggregates. Due to the binding property and flexibility behavior with aggregates it used for the road construction. Bitumen was selected based on the site situation, temperature, type of roads and type of traffic, soil constitutions. The basic tests were carried out to know the properties of bitumen shown in table 2.. The grade of bitumen is 60/70 based on the penetration value.

Table 2. Physical properties of bitumen

Test	Test methods	Results
Penetration	IS 1203-1978	68mm
Ductility 27^0	IS 1208-1978	72mm
Specific Gravity	IS 1202-1978	0.96
Softening Point ^{o}C	IS 1205-1978	51^0C

3) Filler:

a) Stone dust: It is obtained by crushing of stones with crusher machines. The filler which means it passes from 0.075mm sieve size. It is industrial waste fillers in land area. It is used as filler materials in road construction. Fig 3.2 (a) shows the stone dust which is passes from 0.075mm.

b) Bagasse ash: It is fibrous waste materials obtained from sugar refining industry after extraction of sugar juice from sugar cane and burning of waste produce the ash. It is industrial waste product, it can be used in road construction as filler. It requires in different size, the filler should be passes from 0.075mm sieve so it will grain and sieved for use for construction. Due to chemical compositions it gains early strength

Fig 1 Stone dust

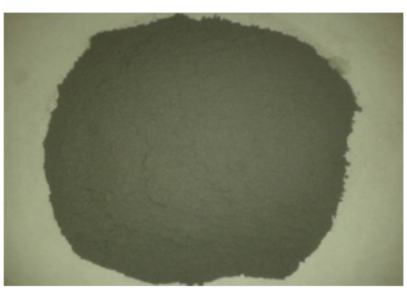

Fig 2 Bagasse ash

4) Waste Plastic: Polypropylene is used as a additive in present work. The additive aluminum coated plastic wrappers. Without

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cleaning plastic cannot be used in any work. It should be cleaned and shredded to a particular size and should be used. Polypropylene when added to bitumen as additive, the aggregates should be mixed in proper way, uniform mixing should be done. The size of plastic is shredded and which passes in 4.75mm and retained in 2.36 mm sieve size. In present work plastic are varied 5%, 7.5%, 10%, 12.5% and 15% weight of bitumen. The specific gravity of polypropylene is 0.905. Fig 3. shows the waste plastic.

Fig 3. Waste plastic

B. Aggregate Gradation

The size aggregates were selected for the present work according to the IS code which is according with MORTH (V Revision) specifications. Selection of proper gradation is the important parameter. For the present work for dense bituminous macadam mix aggregate gradation grade II selected from MORTH (V Revision). DBM mix contains coarse aggregates, fine aggregates and filler based on the type of thickness, road construction the grading is adopted. The nominal aggregate size is 26.5mm as per MORTH. The total weight of aggregates is 1200 gm

C. Marshall mix design

Bruce marshal bitumen engineer with MINISTRY of state high formulated Marshall Method. It was modifier and improved by U.S crop engine. The test standards procedure was conducted based on the ASTMD. Specimens were prepared with standard procedure for proportioning of materials, heating, mixing, and compacting the aggregate- bitumen mixture. The main objective of Marshall Stability test is resist to flow of cylindrical specimen of aggregate- bitumen mixture load on the lateral surface of cylindrical specimen. It is the load carrying capacity at 60^0C± 1^0C, stability measured in kN. It also includes density, durability, flexibility resist to skidding, workability during the construction of pavements.

Fig. 4 Marshall Stability instrument

D. Wheel Tracking Test

Pavements are damaged by two types of loading. Mechanical loading and climatic loading. Mechanical loading is due to heavy traffic and climatic loading is due to variation in temperature. The failures is depends on aggregate proportioning aging of roads. Rutting is one of the distresses in pavements due to heavy traffic. The road surface will get damaged. It will affect the quality of roads. The permanent deformation occurs in the road surface due to repeated wheel loads. Pavement deformation occurs in pavement layers usually caused by lateral moments of materials due to traffic loads. 60% of rutting is occurs in the base course and 40% rutting occurs surface layers.

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E. Procedure for Wheel Tracking Test

1) The aggregates are proportioned and weighed as per the gradation. Total 21.24 kg of aggregates weighed from different size. The aggregates are heated to the temperature of 160^0C to 170^0C for pore of bitumen.
2) The bitumen is heated at 140^0C -170^0C and bitumen added in the (OBC) 5.4% of bitumen weight of aggregates. It should be mixed thoroughly uniform mixing should be done by maintaining desired temperature at 160^0C.
3) After mixing properly the mix should poured in to moulds which is 600X150X100mm slabs.
4) The specimen should compacted by compression machine by applying the load. After compaction specimen removed after 24 hours.
5) The slab specimen is placed into wheel tracking device before starting, the instrument should be set displacement, and number of passes should be zero.
6) Total 2000 cycles should be passes on the specimen surface. For each 200 passes the displacement should be recorded. Based on the displacement and number of passes the graphs are plotted.
7) The test was conducted for different specimen for Optimum bitumen content (OBC), optimum plastic content (OPC) with stone dust and bagasse ash filler.

Fig.5 Wheel tracking specimens and instruments

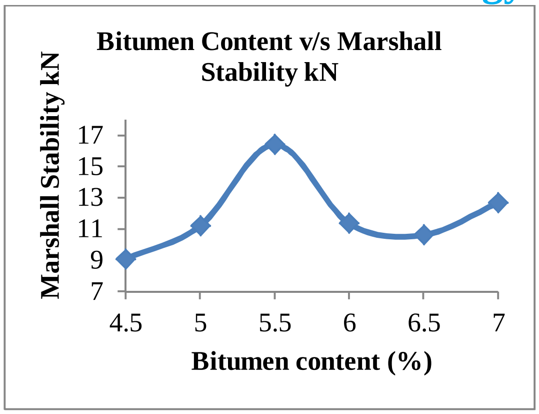
V. RESULTS AND DISCUSSION

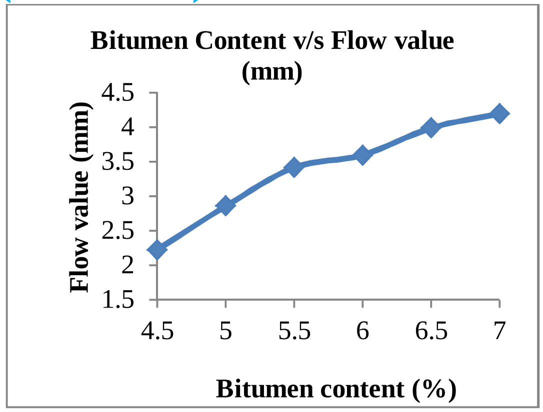
A. Marshall Properties Of Plain Bitumen Mix

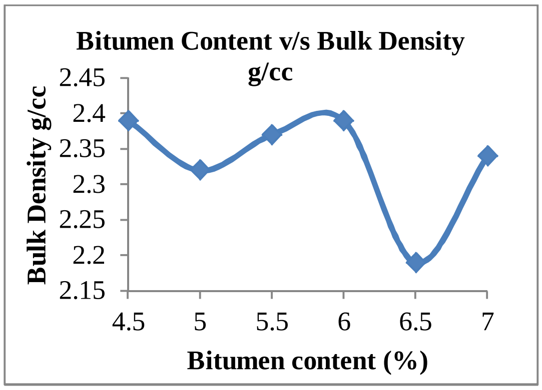
Marshall Property for optimum bitumen content is the capacity of a mix to fulfill stability, flow and volumetric properties. Using marshal method mix design and MORTH specification mix design is carried out by using, stone dust and bitumen to find the optimum bitumen content for the DBM mix. Results are tabulated in Table 3. In present work based on the test results on DBM mix the optimum bitumen content (OBC) is determined, based on the Marshall stability, 4% of air voids and maximum bulk density OBC is calculated. From the table 2 Maximum stability is obtained at 5.5% bitumen content. Bulk density is obtained at 6% of bitumen content. Air voids at the 4% at the 4.65% of bitumen content. Graphs are plotted for each characteristic. The OBC is 5.4% ((5.5+4.65+6)/3=5.4%) for DBM mix.

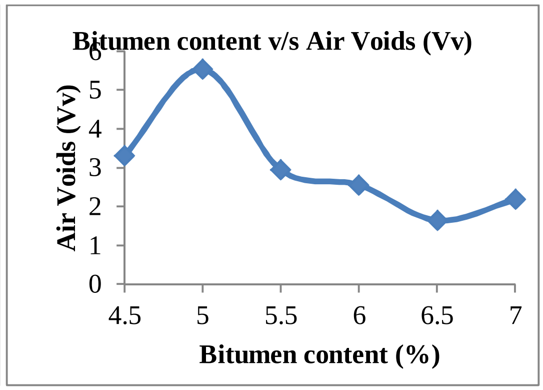
Table 3.Conventional Results for DBM Mix

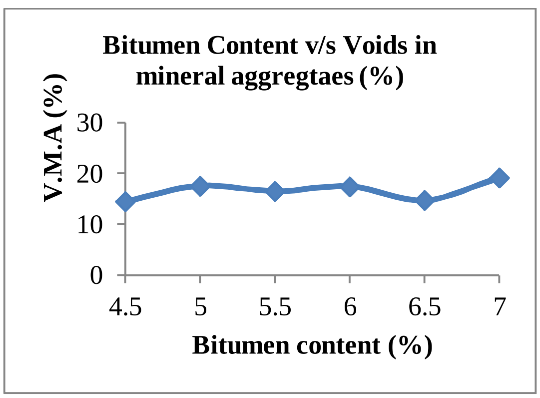
Property Tested	Bitumen content by Weight of aggregates					
	4.5%	5%	5.5%	6%	6.5%	7%
Marshall Stability (kN)	9.09	11.21	16.43	11.36	10.62	12.69
Flow Value (mm)	2.23	2.86	3.42	3.6	3.99	4.2
Bulk density (gm/cc)	2.38	2.32	2.37	2.39	2.19	2.34
Volume of voids V_v (%)	3.32	5.54	2.95	2.56	1.65	2.19
Voids in Mineral Aggregates (%)	14.55	17.63	16.57	17.49	14.75	19.22
Voids Filled with Bitumen (%)	77.93	69.04	81.34	85.71	88.84	88.83











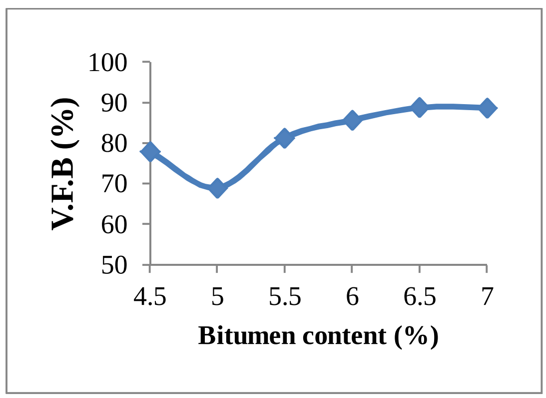


Table 4.Marshall test results modified DBM mix

Property tested	Plastic content with stone dust					Plastic content with Bagasse ash			
	5%	7.5%	10%	12.5%	15%	5%	7.5%	10%	12.5%
Marshall Stability (kN)	11.53	14.5	16.61	21.75	15.73	15.38	22.44	16.39	15.09
Flow Value (mm)	2.2	3.5	4.3	4.7	5.6	2.8	3.6	4.7	5.2
Bulk density (g/cc)	2.27	2.272	2.285	2.9	2.272	2.285	2.265	2.225	2.222
Air voidsV_v (%)	6.95	6.68	5.76	4.45	5.7	2.84	3.53	5.54	5.07
VMA(%)	19.70	19.46	18.66	17.30	18.49	15.79	16.36	18.06	17.5
VFB (%)	64.81	65.93	69.40	74.36	69.21	81.86	78.48	69.73	73.34

The additive is thin aluminum coated waste plastic wraps added to bitumen is stone as filler. Increase in plastic content variation in bulk density. The air voids is gradually decreasing, when increasing the plastic content up to 12.5% and it satisfies the MORTH speciation (3-5). VMA is satisfied MORTH (minimum14) and VFB is within in the specified range (65-75). The Marshall stability is increased at 12.5% plastic content. Based on the volumetric properties and Marshall Stability value the optimum plastic content is 12.5% with stone dust as filler. The volumetric properties results are tabulated in table 4 The additive is added to bitumen in thin aluminum coated waste plastic wraps bagasse ash as filler. Increase in plastic content slight variation in bulk density. The air voids is gradually increasing, when increasing the plastic content up to 7.5% and it satisfies the MORTH speciation's (3-5). VMA is satisfied MORTH (minimum14) and VFB is not in specified range in the specified range (65-75). The Marshall stability is increased at 7.5% plastic content. Based on the volumetric properties and Marshall Stability value the optimum plastic content is 7.5% with bagasse ash as filler. The volumetric properties results are tabulated in table 4.

B. Rutting Properties

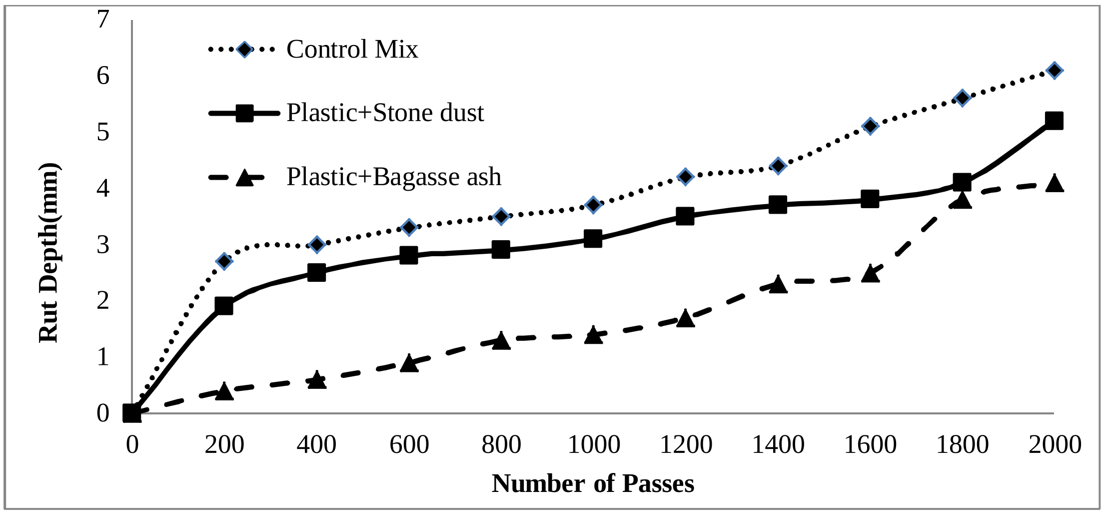


Fig 6. Deformation of rutting DBM mix

From Fig 6 shows rutting characteristics of control mix, Plastic with Stone dust bagasse ash as filler. Deformation is less in waste plastic with bagasse ash filler when compared to the control and plastic with stone dust as filler. Less deformation shows the durability of pavements surface. When compared to plastic with stone dust and plastic with bagasse ash in control mix has got more deformation i.e. for 2000 passes deformation is 6.1mm, it shows the early failure of road surface. Compare with plastic with stone dust as filler, the plastic with bagasse ash got less deformation, control mix got more deformation.

VI. CONCLUSION

The study was carried out on the waste plastic coated with aluminum layer with stone dust and bagasse ash as fillers. The waste plastic was added 5% to 15% with increment of 2.5% by weight of bitumen. Following conclusions are derived based on the Marshall stability of conventional mix, modification of waste plastic with stone dust and bagasse ash in DBM mix.

A. The basic tests were conducted for aggregates and bitumen satisfies the IS codes, so it used for the study.

B. Based on the Marshall Stability, air voids and bulk density the Optimum Bitumen Content (OBC) in DBM mix is 5.4%.

C. The Optimum Plastic Content (OPC) in DBM mix with stone dust as filler is 12.5%. The Marshall stability with the addition of waste plastic and stone dust filler, the maximum stability is obtained at 12.5% of plastic content is 21.75kN.

D. The 7.5% of waste plastic with bagasse ash as filler in DBM shows maximum stability as 22.44 kN. Based on the Marshall Stability, air voids and bulk density, the Optimum Plastic Content (OPC) in DBM with waste plastic and bagasse ash as filler is considered as 7.5%.

E. The maximum stability of DBM mix with waste plastic and the bagasse ash as filler is (22.44kN) more compared to DBM mix with waste plastic and the stone dust as filler (21.75kN). DBM with bagasse ash gains higher strength with lesser OPC, when compared to the stone dust as filler. Addition of waste plastic by weight of bitumen to DBM gives better stability compared

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conventional mix.

F. Rutting characteristics of DBM with bagasse ash filler shows the lesser deformation compared to the stone dust filler with plastic. DBM with plastic and bagasse ash filler shows the better resistance to wearing and abrasion action. DBM mixes with waste plastic gives better resistance to deformation than the conventional mixes.

G. Addition of waste plastic improves the strength of DBM mix, hence recommended to use waste plastics in construction which reduces the disposal and the environmental problems.

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