Influence of Waste Materials on Mechanical Properties of Bituminous Mix Using Marshall Mix Method

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Abstract- *With the rapid economy growth and continuously increased consumption, large amount of waste materials is being generated. In this paper we studied the effect/influence of waste materials like glass powder and plastic on bituminous mix. In this paper crushed glass powder is used as a replacement material for fine aggregate in varied proportions of 5%, 10% and 15% ; plastic is used as an additional material for bituminous mix in varied proportions of 15%, 20% and 25% . The waste glass was sourced by over crushing glass from old bottles and broken glass from window frames, plastic was sourced from bottles, shopping bags . This paper aims to study the performance of asphalt pavement in which a fractional aggregate is replaced with crushed glass and plastic as additional material is added. In this paper, some important properties of asphalt mix, including stability, flow, specific gravity and air voids are investigated. The Marshall mix design is used to examine the mechanical properties. The result shows that by replacing 13% of fine aggregate with glass powder satisfactory results are obtained.*

Keywords- Glass powder, waste plastics, marshal stability test, stability & flow value, air voids, unit weight etc.

I. INTRODUCTION

Disposal of waste products in large quantities constitutes a real environmental problem. Hence, recycling waste into useful products is considered one of the most sustainable solutions to this crisis so that research into new and innovative uses of waste materials is continuously advancing. A wide range of alternative materials, including waste materials and industrial by-products, have been used successfully for many years as substitutes across the world.

In the current research, sand and natural coarse aggregate is partially replaced by glass powder and recycled coarse aggregates. The sheet glass powder is obtained from crushing the waste glass, which is disposed as landfill by the glass industries. Glass is widely used in our lives through manufactured products such as sheet glass, bottles, glassware, and vacuum tubing. Glass is an ideal material for recycling.

Plastic use in road construction is not new. Recent studies in this direction have shown some hope in terms of using plastic waste in road construction i.e. plastic roads. Plastic roads mainly use plastic carry bags, disposable cups and PET bottles that are collected from garbage dumps as an important ingredient of the construction material. When mixed with hot bitumen, plastics melt to form an oily coat over the aggregate and the mixture is laid on the road surface like a normal tar road.

II. OBJECTIVES

1. Use of glass powder to replace fine aggregates at 5%,10%and 15%.
2. Use of waste plastic as an additional material to the bituminous mix at 15%, 20% and 25%.
3. Determining variation in strength with respect to percentage variation of replacement.
4. Comparison of strength properties between pavements with and without replacement.

III. LITERATURE REVIEW

EHASANYAGHOUBI ET AL (2017): Stiffness properties of recycled concrete aggregate with polyethylene plastic granules in unbound pavement applications . The growing population in the modern world has resulted in increasing waste generation and stock piles .There have been increasing concerns on how to sustainably reuse waste in civil and geotechnical engineering applications .Two major municipal waste streams are plastic waste and recycled concrete aggregate(RCA) generated by demolition activities. Potential application for growing stock piles of plastic and RCA waste is in the construction of roads because pavement base and sub bases typically demand significant quantities of construction materials. In this research RCA was blended with low density polyethylene and high density polyethylene plastics . A range of geotechnical test such as CBR ,UCS and repeated load triaxial tests were conducted on RCA –HDPE and RCA-LDPE blends

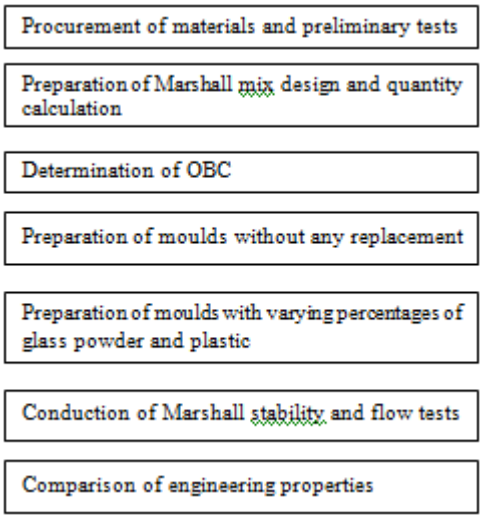
SANDEEPKARMARKAR ET AL (2016): Effect of waste plastic and waste tires ash on mechanical behavior of bitumen. This paper deals with the utilization of waste plastic and waste tire rubber with bitumen for construction of low budget roads instead of conventional polymer modified bitumen due to its high price value .Among polymeric waste only those containing high molecular, high density polyethylene polypropylene, LDPE and tire rubber ash are used in this investigation to modify the properties of conventional bitumen .the results of experiment indicated that addition of 1% by weight of mixed plastic to the hot 60/70 pen grade bitumen provides enhancement in temperature susceptibility resistance characteristic ,viscous properties and elastic recovery properties.

IVICA ANDROJIC and SANJA DIMTER(2014):
Properties of HMA with Substituted Waste Glass . This paper studies the properties of HMA with substituted waste glass, used for surface layers. Waste glass was sourced by over crushing glass from old bottles and broken glass from window frames. Increasing the glass fraction in asphalt mixture decreased the density, stability and void content of the mixture, as well as the proportion of voids filled with bitumen.

WARTMAN et al (2004): Select Engineering Characteristics of Crushed Glass. Crushed glass is readily available, environmentally friendly and relatively inexpensive performing equally or better than most natural aggregates. In road construction, glass waste can be used as a substitute for fine aggregates in stabilized bearing layers, as n additive in embankments and also in asphalt mixtures(glassphalt) and as a drainage material or substrate layer in the trenches below the lines. Numerous studies have the promise of using waste glass in asphalt mixes.

IV. METHODOLOGY

1. The coarse aggregates used in the present study are crushed hard rock passing 16mm, 12.5mm, 10mm and 6mm sieve sizes.
2. Waste glass is crushed so that it passes 2.36mm sieve to be used as a replacement for fine aggregates.
3. Waste plastic in the form of polythene bags has been used as additional material.
4. Granite powder from granite cuttings has been used as a filler instead of cement.
5. Various preliminary tests are conducted to determine basic properties of aggregates and bitumen according to Indian Standards.



V. EXPERIMENTAL STUDIES

Various lab tests were conducted on aggregates and bitumen. The test results are shown in Table below

1). COARSE AGGREGATES:

TESTS CONDUCTED	OBTAINED VALUES	IS STANDARDS
SPECIFIC GRAVITY	2.67	2.5-3.0 [IS 2386 (PART3)]
WATER ABSORPTION	0.75%	IS 2386 (PART3)
FLAKINESS TEST	4.21%	IS 2386 (PART1)
ELONGATION TEST	0%	IS 2386 (PART1)
IMPACT TEST	23.36%	30% [IS 2386(PART4)]
AGGREGATE CRUSHING TEST	34.33	IS 2386 (PART4)
ANGULARITY NUMBER	8	0-11
LOS ANGELES ABRASSION	17.06%	30% [IS 2386 (PART5)]

2). FINE AGGREGATES:

TESTS CONDUCTED	OBTAINED VALUES	IS STANDARDS
SPECIFIC GRAVITY	2.74	2.65-2.67 [IS 2386 (PART3)-1963]

3). BITUMEN:

TESTS CONDUCTED	OBTAINED VALUES	IS STANDARDS
SPECIFIC GRAVITY	1.008	0.9-1.1 [IS 1202-1978]
FLASH AND FIRE POINT	296° and 318° C respectively	Min. 175° C [IS 1209-1978]
DUCTILITY	63 cm	5-100 cm [IS 1208-1978]
SOFTENING POINT	52.5° C	[IS 1205-1978]
PENETRATION TEST	5.4 [50/60]	60/70 [IS 1203-1978]

Chemical Properties of Waste Glass Glass-formers are those elements that can be converted into glass when combined with oxygen. Silicon dioxide (SiO2), used in the form of sand, is by

Effect of Waste Glass.. Common glass contains about 70% SiO2. Soda ash (anhydrous sodium carbonate, Na2CO3) acts as a fluxing agent in the melt. It lowers the melting point and the viscosity of the formed glass, releases carbon dioxide and helps stir the melt. Other additives are also introduced into glass to achieve specific properties. These compositions interact with the asphalt mix to produce better properties and enhance the properties of the mix.

Plastics: Plastics are typically organic polymers of high molecular mass and often contain other substances. They are usually synthetic, most commonly derived from petrochemicals, however, an array of variants are made from renewable materials such as polylactic acid from corn or cellulosic from cotton linters. Most plastics contain organic polymers. The vast majority of these polymers are formed from chains of carbon atoms, 'pure' or with the addition of: oxygen, nitrogen, or sulfur. The chains comprise many repeat units, formed from monomers. Each polymer chain will have several thousand repeating units.

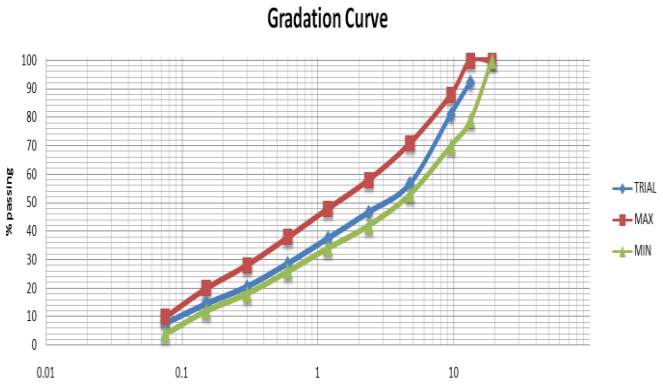
VI. MIX DESIGN

Asphalt mixes were designed using standard laboratory procedures. Conventional fine hot mix aggregate gradations, as specified in MOST (Ministry of Surface transport) were used.

The original sample is prepared without any replacement or additional material for 4.5%, 5%, 5.5% and 6% bitumen. Procedure is as follows

By trial and error method the aggregate proportioning has been obtained which is in the limits as specified by MORTH. The obtained proportions are:

MATERIALS	PERCENTAGE (%)
CA (20-12.5)	40
CA (12.5-4.75)	35
FA (4.75 down size)	23
FILLER (granite powder)	2



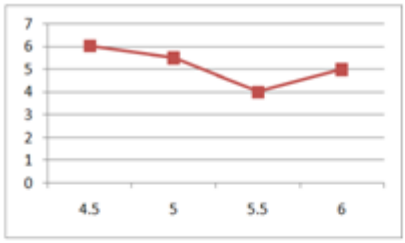
Curve showing the obtained proportions are within the values as specified by MORTH

Using these aggregate proportions the optimum bitumen content for the mix is found out. The procedure for calculations of optimum bitumen content is as follows.

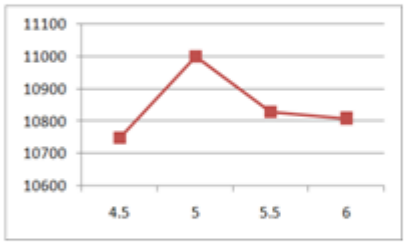
1. Aggregates along with filler(granite powder) is pre-heated at the temperature of 140°C in a oven.
2. The aggregates are then transferred to a pan and respective bitumen percentage is added when the temperature reaches around 140 to 160°C.
3. The mix is then transferred to pre heated Marshall mix mould and manually compacted with 75 blows on each side.
4. Compacted specimens are cooled to room temperature and removed from moulds using specimen extractor.
5. The mean height of the specimen are measured and weight of each specimen in air and suspended in water is determined.
6. The specimens are kept immersed in a thermostatically controlled water bath at a temperature of 60 °C for 40 minutes.
7. Specimens are taken out one by one and placed in marshal test head.
8. It is tested to determine the Marshall stability value and flow value.
9. The graphs are plotted with percentage bitumen content on X axis and stability value, unit weight and air voids on Y axis.
10. The OBC is thus determined by taking the average values of the 3 bitumen contents from the graphs of unit weight, air voids and stability and it is found to be 5.3%

The obtained results are tabulated below. Graphical representation has been done with **bitumen content in X axis and flow, stability, air voids and unit weight in Y axis**

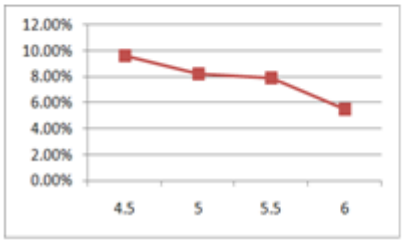
Properties	4.5%	5%	5.5%	6%
W_a	1.250kg	1.241kg	1.238kg	1.241kg
W_w	0.721kg	0.715kg	0.712kg	0.720kg
G_b	2.282	2.292	2.294	2.32
G_t	2.55	2.510	2.490	2.442
V_a	9.6%	8.2%	7.88%	5.5%
V_v	9.9%	10%	12.10%	13.20%
VMA	19.5%	18.2%	19.98%	18.7%
VFB	50.76%	54.94%	60.56%	70.58%



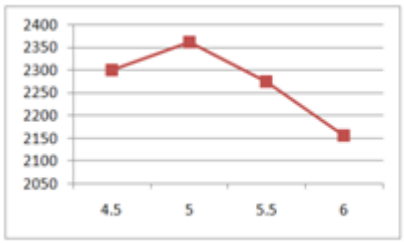
Flow (mm)



Stability (N)



Air voids (%)



Unit weight 10^{-3} (KG/CM^3)

By taking the OBC as 5.3% further moulds were prepared by replacing fine aggregate with glass powder in 5%, 10%, 15% and plastic is added as an additional material in 15%, 20% and 25%

Constant parameters:
OBC : 5.3%
Size of specimen:
Height: 63.5 mm
Dia: 101.6 mm
Weight of hammer: 4.54 kg
Falling height: 45.7cm

Variable parameters:

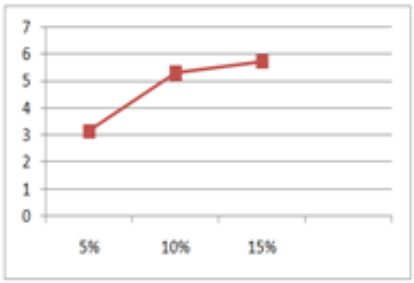
Glass powder: Replacing fine aggregate in 5%, 10% and 15%
Plastics: Additional material to the mix in 15%, 20% and 25%

Above procedure is followed for further moulds with glass powder as replacement material and plastic as an additional material in varied percentages and the results are tabulated below

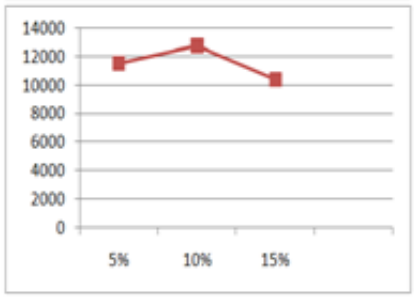
1. RESULTS FOR GLASS POWDER AS A REPLACEMENT MATERIAL FOR FINE AGGREGATE

Graphs for the same are plotted with **% glass powder on X axis and flow, stability, air voids and unit weight in Y axis**

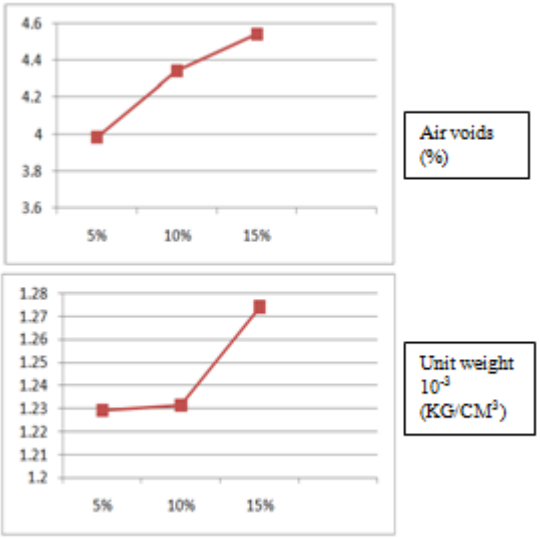
Properties	5%	10%	15%
W_a	1.229kg	1.231kg	1.247kg
W_w	0.717kg	0.717kg	0.724kg
G_b	2.40	2.392	2.38
G_t	2.50	2.498	2.197
V_a	3.98%	4.34%	4.54%
V_v	11.7%	11.97%	11.57%
VMA	15.68%	16.32%	16.11%
VFB	74.82%	73.36%	71.72%



Flow (mm)



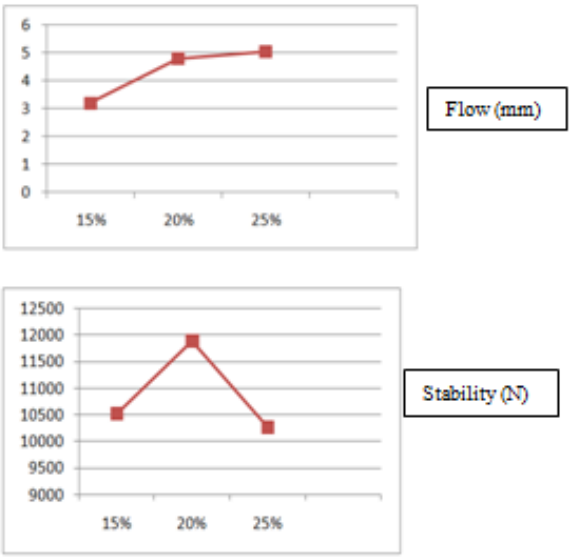
Stability (N)

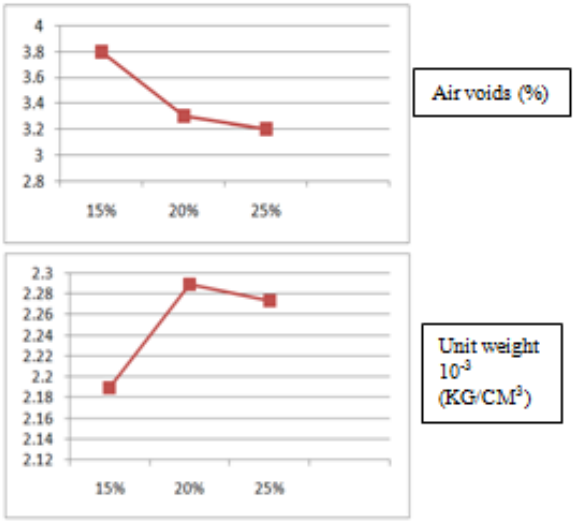


2. RESULTS FOR PLASTIC AS AN ADDITIONAL MATERIAL TO THE BITUMINOUS MIX

Properties	15%	20%	25%
W_a	1.29kg	1.226kg	1.248kg
W_w	0.717kg	0.717kg	0.724kg
G_b	2.38	2.38	2.38
G_t	2.49	2.50	2.496
V_a	3.8%	3.3%	3.2%
V_v	11.57%	11.77%	11.87%
VMA	15.8%	15.47%	15.332%
VFB	72.96%	73.12%	73.18%

Graphs for the same are plotted with **% plastic on X axis and flow, stability, air voids and unit weight in Y axis**





VII. CONCLUSION

The main objective of this paper was to study the change in asphalt mixture properties after adding crushed glass and waste plastic . The tests were conducted using the standard Marshall Apparatus. Stability, flow, specific gravity and air voids of the prepared samples were recorded.

1. Taking the average of %Glass Powder from 3 graphs (Stability, Unit Weight, Air Voids) , it is inferred that glass is best replaced at 13% of fine aggregates.
2. Taking the average of %Plastic from 3graphs (Stability, Unit Weight, Air voids), it is evident that plastic can be optimally used at 18% as an additional material.
3. Hence, it is concluded that Glass Powder enhances the Stability of bituminous mix than Plastic when used at an optimum value of 13% as a replacement of fine aggregates.

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