

# Utilization of Waste Plastic in Flexible Pavement with Marble Chips as Aggregate

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**Abstract**— Solid waste management is the major threat to the environment in the current scenario. Of the various waste materials, plastic wastes are of great concern. Plastics are not eco-friendly as they are non-biodegradable. On the other side, the traffic intensity is increasing. The load bearing capacities of the road are to be increased. Marbles naturally possess high strength and resilience. This work presents partial replacement of bitumen by polypropylene reprocessed plastic waste in bituminous mixes with marble chips as aggregate and also to make a comparative study on the effect of plastic waste in bituminous layer of flexible pavement with the normal aggregates and also with the replacement of normal aggregates by marble chips. Various tests are performed on the aggregates, marble chips, bitumen and also on the bituminous mix to examine the strength of the materials and the pavement. The Marshall stability tests are conducted for the bituminous mix samples of various proportions of 5, 10 & 15 percentage plastic and is examined to determine various aspects such as the stability and voids content. The results obtained through these test give considerable stability in pavement.

**Keywords**—flexible pavement, resilience, polypropylene reprocessed plastic, Marshall Stability tests

## I. INTRODUCTION

Bitumen is a useful binder for flexible pavement. Different grades of bitumen like 30/40, 60/70, 80/100 are available on the basis of their penetration values. The steady increase in traffic intensity in terms of vehicles, and the significant variation in daily and seasonal temperature, demand improved characteristics in flexible pavement. Any improvement in the property of the binder is needed in the present scenario. Bituminous mixes are modified in order to improve the performance of bituminous mixtures. Various waste materials, plastic waste and municipal solid waste are of great concern. Today the availability of waste plastics is enormous. They either get mixed with municipal solid waste or thrown away over land area. If not recycled, their present disposal is either by land filling or by incineration. Both the processes have certain impact on the environment. Under this circumstance, an alternate use for the waste plastics is also needed. The waste polymer bitumen blend can be prepared and can be used for road laying. Also a major problem in flexible pavement is its stability. Marble chips are also a constructional waste that is left unused. In order to use it effectively, it is made use as

an alternative for aggregate in the bituminous mix in flexible pavement. Finally bitumen mixtures were prepared using modified and non-modified bitumen with plastic and the Marshall test was performed on them to compare the modified mix with the conventional bitumen mix. Plastic roads with marble chips would be a boon for India's hot and extremely humid climate, where the temperatures frequently cross 50°C and torrential rains create havoc, leaving most of the roads with big potholes.

## II. LITERATURE REVIEW

### A. *R.Vasudevan et al.(2015)*

Infers that addition of natural or synthetic polymers to bitumen is known to impart enhanced service properties. By adding small amounts of polymers to bitumen, the life span of the road pavement is considerably increased and the purpose is to achieve desired engineering properties such as increased shear modulus and reduced plastic flow at high temperatures and/or increased resistance to thermal fracture at low temperatures.

### B. *Saiyed Farhana et al.(2015)*

They conclude that the specific gravity of these aggregates ranges from 1.5 to 2.7 and the marble chips are extremely durable. They also reported that replacement of marble chips to aggregates had a beneficial effect on the mechanical properties such as crushing strength and stripping value.

### C. *M.S. Ranadive et al. (2015)*

An attempt has been made that the specimen of 8 percent waste polymer modified bitumen (WPMB) mix show 50 percent enhanced tensile strength compared to conventional mix and more resistance to water damage. The tests are conducted on the bituminous specimens to know the stability, flow value, bulk density, percent air voids, and per cent V.M.A. and presented. The Maximum density of compacted specimen is observed at 5.5% bitumen content for all the proportions of plastic. And there is a sudden increase in stability when the natural aggregates are coated with plastic which is water resistant and hence increasing stripping value.

D. P.K. Jain et al. (2012)

They observe that the Stability, rutting and retained stability of bituminous mixes and modulus values are better and also less susceptible to moisture. Waste plastic modified bituminous surfacing are more durable and offer improved performance. The optimum dose of plastic waste is 0.4% by weight of mixture and 8% by weight of bitumen.

III. MATERIALS

E. Bitumen: Bitumen of grade 80/100 was used

TABLE 1  
PHYSICAL PROPERTIES OF BITUMEN

Particulars	As per Code	Test Results Obtained
1) Penetration test	IS 1203-1978	87mm
2) Softening point	IS 1205-1978	57°C
3) Ductility test	IS 1208-1978	75cm
4) viscosity test	IS 1206 (PART II-1978))	1200poise.
5) specific gravity test	IS 1202-1978	1.36

F. Plastic : Polypropylene plastic

TABLE 2  
PROPERTIES OF POLYPROPYLENE PLASTIC

1) Density	0.855g/cm <sup>3</sup>
2) Impact strength	3 to 30 KJ/m <sup>2</sup>
3) SSS Thermal coefficient of expansion	100 to 150 x10 <sup>-6</sup>
4) Melting point	130-171°C

G. Coarse aggregates & marble chips

Coarse aggregates- Locally available natural coarse aggregate particles greater than 4.75mm. The coarse aggregates that are used for road laying are to be passed 12mm and retained on 4.75mm. The initial testing of aggregates are carried out in accordance to the IS 2386 (part III)-1963.

Marble chips-Marble chips are generated as a by-product during cutting and shaping of marble. The waste marble chips is approximately in the range of 20% of the total marble handled.

TABLE 3  
PROPERTIES OF COARSE AGGREGATES & MARBLECHIPS

S.No	Properties	Results obtained for Coarse aggregate	Results obtained for marbles
1	specific gravity test	2.82	2.74
2	Impact value	28.8%	22.8%
3	water absorption test	0.26%	0.43%.

4	Fineness modulus	1.207	1.87
5	los Angeles abrasion test	34.50%	36.08%

IV. COMPARATIVE STUDY

The plastic recyclables are shredded into fragments which then undergo processes to eliminate impurities and it is melted and often extruded into the form of pellets. In this there are several kinds of plastic among these polypropylene waste plastic is used in this work. These plastic is mixed with bitumen with different proportions as 5,10 and 15 percentage of the quantity of bitumen to arrive the optimum usage of plastic in bituminous mixture. For finding this penetration test, softening test, ductility test, viscous test and specific gravity test are selected.



Fig 1 Reprocessed waste plastic granules

TABLE 4  
COMPARATIVE RESULTS OF ADDITION OF PLASTIC IN BITUMEN : PENETRATION TEST (AS PER IS 1203-1978)

Bitumen	Bitumen + 5% plastic	Bitumen + 10% plastic	Bitumen + 15% plastic
87mm	78mm	72mm	89mm

TABLE 5  
COMPARATIVE RESULTS OF BITUMEN BASED ON THEIR SOFTENING POINT (AS PER IS 1205-1978)

Bitumen	Bitumen + 5% plastic	Bitumen + 10% plastic	Bitumen + 15% plastic
57 °C	62 °C	78 °C	73°C

TABLE 6  
COMPARATIVE RESULTS OF BITUMEN BASED ON THEIR DUCTILITY VALUES (AS PER IS 1205-1978)

Bitumen	Bitumen + 5% plastic	Bitumen + 10% plastic	Bitumen + 15% plastic
75cm	76cm	79cm	68cm

**TABLE 7**  
COMPARATIVE RESULTS OF BITUMEN ON THEIR VISCOSITY VALUES (AS PER IS 1206 (PART II)- 1978)

Bitumen	Bitumen + 5% plastic	Bitumen + 10% plastic	Bitumen + 15% plastic
1200 poise	1500 poise	1600poise	1500poise

**TABLE 8**  
COMPARATIVE RESULTS OF BITUMEN ON THEIR SPECIFIC GRAVITY VALUES (AS PER IS 1202-1978)

Bitumen	Bitumen + 5% plastic	Bitumen + 10% plastic	Bitumen + 15% plastic
1.36	1.38	1.40	1.39

**V. ANALYSIS**

Partial replacement of plastic with bitumen was made to form bituminous mix with marble chips and natural aggregates to get the optimum usage of reprocessed polypropylene plastic waste for flexible pavement.

*H. Marshall stability test for bituminous mix (as per MORTH specification)*

1) Flow: Marshall flow is a measure of deformation of the asphalt mix determined during the stability test. In both types of failure, the Marshall flow is the total sample deformation from the point where the projected tangent of the linear part of the curve intersects the x-axis (deformation) to the point where the curve starts to become horizontal.

2) Voids content: Voids content is the percent of air voids by volume in the specimen and is given by,

$$V_v = (G_t - G_m)100/ G_t$$

Where,  $G_t$  - Theoretical specific gravity of the mix  
 $G_m$  - Bulk or actual specific gravity of the mix



**Fig 2 Marshall Stability mould**

**TABLE 9**  
COMPARATIVE RESULTS OF MARSHALL STABILITY PARAMETERS OF AGGREGATE POLYMER BITUMEN.

Description	Bitumen + CA	Bitumen + CA + 5% plastic	Bitumen + CA + 10% plastic	Bitumen + CA + 15% plastic
Stability (Kg)	840	870	900	1000
Flow (mm)	3.01	3.00	2.91	2.90
Voids content (%)	3.64	3.50	3.32	3.24
Bitumen content (%)	5.3	5.3	5.3	5.3

**TABLE 10**  
MARSHALL STABILITY OF MARBLE CHIPS POLYMER BITUMEN

Description	Bitumen + marble chips	Bitumen + marble chips + 5% plastic	bitumen + marble chips + 10% plastic	bitumen + marble chips + 15% plastic
stability (kg)	890	950	980	910
flow (mm)	2.91	2.90	2.90	3.00
voids content (%)	3.1	3.15	3.25	3.31
bitumen content (%)	5.3	5.3	5.3	5.3

**VI. COMPARISON OF RESULTS**

On adding plastic to the bituminous mix of aggregates, the load carrying capacity of the sample increases at a gradual rate. Therefore the flexible polymer pavement withstands load on even increasing the plastic content. Whereas, on adding plastic to the bituminous mix of marble chips, the load carrying capacity increases up to the addition of plastics up to 10% and decreases on further addition of plastic. Therefore the marble chips polymer flexible pavement fails on increasing the plastic content above 10% of the weight of the bitumen.

**VII. CONCLUSION**

Comparing the behavior of marble chips and normal aggregates in flexible pavement with polymer bitumen in various proportions, the stability of marble chips plastic pavement gives considerably good result than conventional plastic pavement up to addition of 10% plastic. After that conventional plastic pavement gives better stability than marble aggregate plastic pavement. Therefore marble aggregate plastic bitumen can be used up to 10% for providing better stability and provides good anti stripping. Apart from this marble chips can be used effectively up to 10% in plastic roads which is a trend setter in present and also in the near future.

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