# EXPERIMENTAL INVESTIGAION ON ROAD PAVEMENT WITH PARTIAL REPLACEMENT OF PLASTIC WASTES AS BITUMEN

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***ABSTRACT*: Bottles, containers and packing strips etc. is increasing day by day. As a result amount of waste plastic also increases. This leads to various environmental problems. Many of the wastes produced today will remain in the environment for many years leading to various environmental concerns. In present scenario, plastic wastes consisting of carry bags, cups and other utilized plastic can be used as a coating over aggregate and this coated stone can be used for road construction. The mix polymer coated aggregate and modified bitumen have shown higher strength. In our project , we can melt the PET wastes and mixed with bitumen act as modified bitumen.**

***Keywords*: PET wastes, Bitumen, Aggregates, Plastic road.**

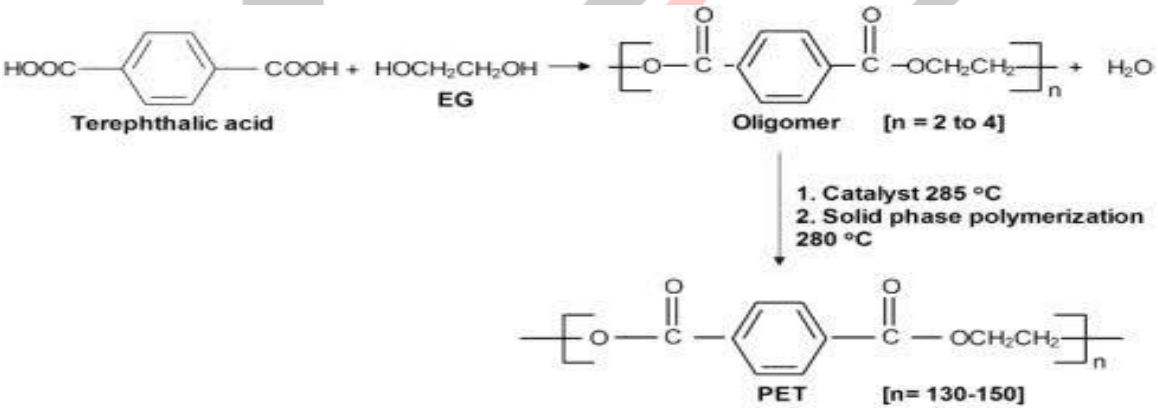
## 1. INTRODUCTION

The term "Plastics" includes materials composed of various elements such as carbon, hydrogen and oxygen. Plastics are macromolecules, formed by polymerization and having the ability to be shaped by application of reasonable amount of heatand pressure or another form of forces.Economic growth and changing consumption and production patterns are resulting into rapid increase in generation of waste plastics in the world.plastic waste due to:

- Plastic packaging,
- Plastic shopping bags,
- PET bottles
- Other goods/appliances using plastic as the major component.

### 1.1 WHAT IS PET?

PET is abbreviated as " POLYETHYLENE TEREPHTHALATE ".It is the most common thermoplastic polymer resin of polyester family. PET is commonly recycled and as a number "1" as it Resin Identification Code.Polyethylene terephthalate may exist both as amorphous and as semi crystalline polymer.




Chemical Composition for PET

**1.2 TYPES OF PLASTIC AND ITS CODE**

| THE PLASTIC IDENTIFICATION CODE | | | | |
|---|---|---|---|---|
| **Symbol** | **Type of Plastic** | **Properties** | **Common Uses** | **Recycled in:** |
| 1 PET | **PET** Polyethylene Terephthalate | Clear, tough, solvent resistant, barrier to gas and moisture, softens at 80˚ | Soft drink and water bottles, salad domes, biscuit trays, salad dressing and containers | Pillow and sleeping bag filling, clothing, soft drink bottles, carpeting, building insulation |
| 2 HDPE | **HDPE** High Density Polyethylene | Hard to semi-flexible, resistant to chemicals and moisture, waxy surface, opaque, softens at 75˚C, easily coloured, processed and formed | Shopping bags, freezer bags, milk bottles, ice cream containers, juice bottles, shampoo, chemical and detergent bottles, buckets, rigid agricultural pipe, crates | Recycling bins, compost bins, buckets, detergent containers, posts, fencing, pipes, plastic timber |
| 3 PVC | **PVC** Unplasticised Polyvinyl Chloride PVC-U | Strong, tough, can be clear, can be solvent welded, softens at 80˚C | Cosmetic containers, electrical conduit, plumbing pipes and fittings, blister packs, wall cladding, roof sheeting, bottles | Flooring, film and sheets, cables, speed bumps, packaging, binders, mud flaps and mats, new gumboots and shoes |
| | Plasticised Polyvinyl Chloride PVC-P | Flexible, clear, elastic, can be solvent welded | Garden hose, shoe soles, cable sheathing, blood bags and tubing | |
| 4 LDPE | **LDPE** Low density Polyethylene | Soft, flexible, waxy surface, translucent, softens at 70˚C, scratches easily | Cling wrap, garbage bags, squeeze bottles, irrigation tubing, mulch film, refuse bags | Bin liners, pallet sheets |
| 5 PP | **PP** Polypropylene | Hard but still flexible, waxy surface, softens at 140˚C, translucent, withstands solvents, versatile | Bottles and ice cream tubs, potato chip bags, straws, microwave dishes, kettles, garden furniture, lunch boxes, packaging tape | Pegs, bins, pipes, pallet sheets, oil funnels, car battery cases, trays |
| 6 PS | **PS** Polystyrene | Clear, glassy, rigid, opaque, semi-tough, softens at 95˚C. Affected by fat, acids and solvents, but resistant to alkalis, salt solutions. Low water absorption, when not pigmented is clear, is odour and taste free. Special types of PS are available for special applications. | CD cases, plastic cutlery, imitation glassware, low cost brittle toys, video cases\ | Coat hangers, coasters, white ware components, stationery trays and accessories, picture frames, seed trays, building products |
| 6 PS-E | **PS-E** Expanded polystyrene | | Foamed polystyrene cups, takeaway clamshells, foamed meat trays, protective packaging and building and food insulation | |
| 7 OTHER | **OTHER** Letter below indicate ISO code for plastic type e.g. SAN, ABS, PC, Nylon | Includes all resins and multi-materials (e.g. laminates). Properties dependent on plastic or combination of plastics. | Automotive and appliance components, computers, electronics, cooler bottles, packaging | Automotive components, plastic timber |

## 2.LITERATURE REVIEW

[1] " USE OF WASTE PLASTIC IN ROAD CONSTRUCTION "., 

**Mr. Ahmed Trimbakwala (APRIL 2017)**

It shows that the waste plastic such as PVC or HDPE are made into the form of powder; 3 to 4 % is used to increase the durability of the road. The plastic can be used as an additive with hot bitumen in different proportion varying from 0to 12 % by weight. It was observed that the penetration and ductility values can be decreased with increase in proportion of plastic additive upto 12 % by weight. The softening point is increased in proportion of plastic additive upto 8 % by weight. It also indicated worthy increase in fatigue life under repeated application of loads.

[2] " USE OF PLASTIC WASTE IN ROAD CONSTRUCTION "., 

**Mr. AzmatShaikh, Mr. Nabeel Khan, Mr. Faisal Shah, Mr.DevendraShukla, Mr. Gaurav Kale (2017)**

It shows that the plastic waste such as polythenes are used for polymer coating on the aggregate used for bituminous mix.From the study of the behavior of plastic waste modified BC, we can conclude that the modified mix possesses improved Marshall Characteristics. It is observed that Marshall Stability value increases with plastic content and we observed that the Marshall Flow value decreases upon addition of polythene.

[3] "PARTIAL REPLACEMENT OF BITUMEN BY USING PLASTIC WASTE IN BITUMEN CONCRETE"., 

**Mr. Rupesh Kumar, Mr. Shad Ahmad, Mr. Jitendra Kumar Dhawan, Mr. PremchandYadav (JULY 2016)**

It shows that the waste plastics of particle size which are are passed on 4.75mm sieve and retained on 2.36mm sieve are replaced by 5%, 7.5%, 10% and 12.5% was mixed. The result shows that with increase of waste plastic inbitumen increases the properties of aggregate and bitumen. The optimum use of plastic can be 7.5% and 6% of bitumen based on Marshal Stability test.

[4] "APPLICATION OF WASTE PLASTIC MATERALS IN ROAD CONSTRUCTION"., 

**Mr. Amit Kumar Sahu, Mr. R.K. Singh (MARCH 2016)**

Our studies on the performance of plastic tar road conclusively proves that it is good for heavy traffic due to better binding, increased strength and better surface condition for a prolonged period of exposure to variation in climatic changes Above all, the process helps to dispose waste plastics usefully and easily. Use of higher percentage of plastic waste reduces the need of bitumen by 10%. It also increases the strength and performance of the road. In compliance with the expected results we can ignore the cavities, unsoundness and water accumulation on the roads and make the roads durable and of higher compressive strength along with abrasion resistant in an affordable and cost-effective manner.

[5] "Use of Plastic Waste in Pavement Construction: An Example of Creative Waste management"., 

**Mr.Anzar Hamid Mir (FEBURARY 2015)**

In construction of Asphalt pavement, hot bitumen is coated over stone aggregates mixed, laid and rolled.Bituminous mix with recycled plastics mainly LDPE replacing 30% of 2.36 - 5mm aggregates showed 250% increase in Marshall stability and the mix density reduced to 16% and in addition to it the Indirect Tensile Strength (ITS) was also improved.Waste plastic is ground and made into powder; 3 to 4 % plastics mixed with the bitumen.

[6] "Use of Plastic Waste in Road Construction"., 

**Ms. Shweta N. Rokdey, Ms. P. L. Naktode**
**Mr. M. R. Nikhar (2015)**

Plastic will increase the melting point of the bitumen.This innovative technology not only strengthened the road construction but also increased the road life.Strength of the road increased, Better resistanceto water & water stagnation. No stripping & have no potholes. Increased binding & better bonding of the mix. Better soundness property. Maintenance cost of the road is almost nil. No effect of radiation like UVrays.

## 3.EXPERIMENTAL PROGRAM

Experiments were conducted on cylindrical mold prepared by partial replacement of bitumen by using of PET wastes.plastics are replaced by 1%, 2% and 2.75% of total weight of aggregate and hot mix bitumen concrete design was prepared . the optimum bitumen content can be taken as 5.5% of total weight of aggregate.

### 3.1PHYSICAL PROPERTIES OF AGGREGATE

Water Absorption - 0.1 % (0 – 1%)
Specific Gravity - 2.72 (2.5 – 3)
Crushing Strength - 12.18 % (< 35%)
Impact Value - 13.88 % (< 30%)
Flakiness Index - 25.94 % (5 – 25%)

Elongation Index - 19.95 % (15 – 25%)

**3.2PHYSICAL PROPERTIES OF BITUMEN**

Specific Gravity - 1.001 (0.97 – 1.02)
SofteningPoint -56.4◦C (35 - 70◦C)
Ductility - 81cm (> 75 cm)
Viscosity - 2765 secs (2400-3600 secs)
Penetration - 35mm (mini. 35mm)

**3.3 MARSHALL STABILITY & FLOW TEST**

The coarse aggregate, fine aggregate and mineral fillermaterial should be proportioned and mixed.Take 1200gms of aggregates and filler are taken and heated to a temperature of 175$^{o}$C - 195$^{o}$C.The bitumen is heated and required quantity of bitumen is added to the heated aggregate and mixed using mechanical mixer or hand mixing.The mix is transferred into the pre heated mould and compacted by 75blows on each side by rammer.Then the mould is remould by the hydraulic jack.Then the air weight, water weight, SSD can be calculated.After that the mould is kept on water bath for 20 minutes at a temperature of 60$^{o}$C.The specimen is taken out and placed in the marshall test equipment and the stability and flow are noted.

**3.4 Bulk Density Calculation**

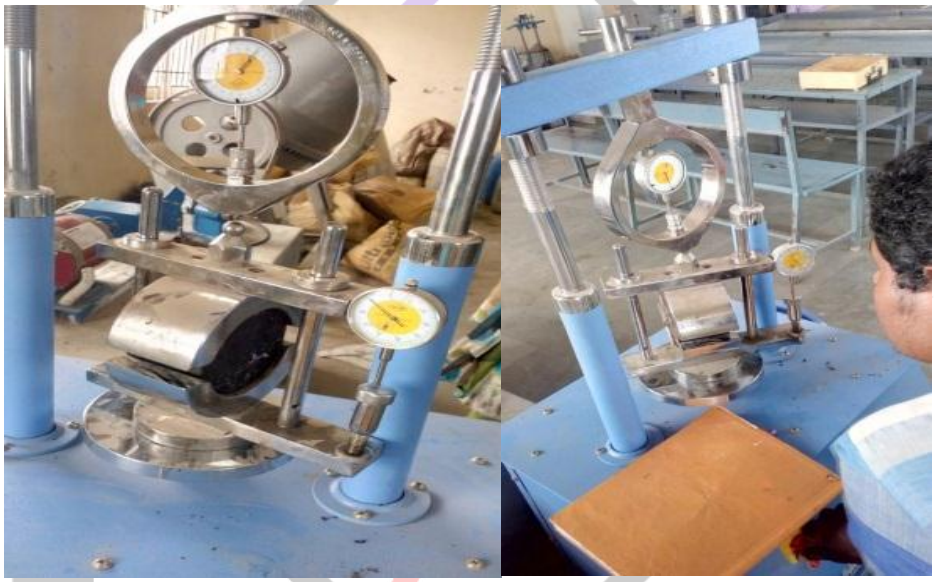
| MOULD | BITUMEN | PLASTIC | AIR WEIGHT g | WATER WEIGHTg | SSD g | BULK DENSITY |
|---|---|---|---|---|---|---|
| 1 | 5.5% | - | 1267 | 723 | 1272 | 2.31 |
| | | | 1265 | 724 | 1266 | 2.33 |
| 2 | 4.5% | 1% | 1259 | 687 | 1261 | 2.19 |
| | | | 1261 | 729 | 1267 | 2.34 |
| 3 | 3.5% | 2% | 1258 | 708 | 1260 | 2.28 |
| | | | 1269 | 722 | 1273 | 2.30 |
| 4 | 2.75% | 2.75% | 1273 | 706 | 1276 | 2.23 |
| | | | 1272 | 702 | 1275 | 2.22 |

**Table 3.4 for Bulk Density Test**

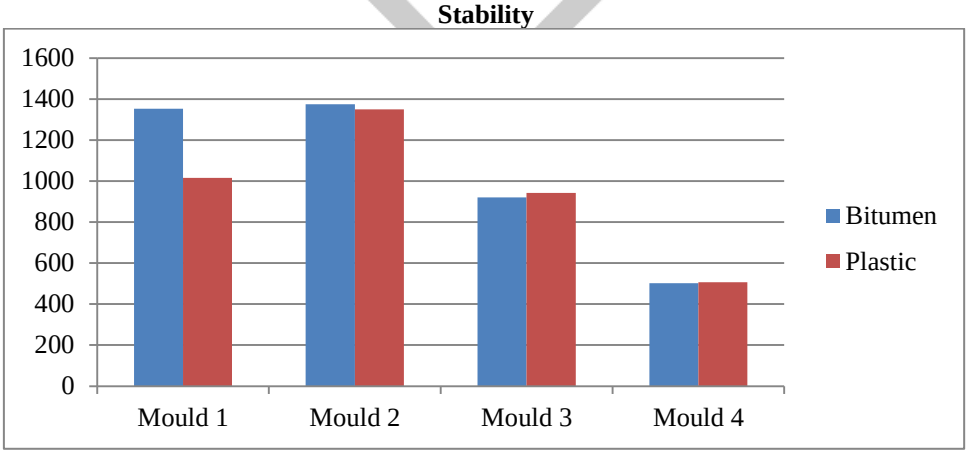
**3.5 Stability and Flow test**

| MOULD | BITUMEN | PLASTIC | STABILITYkg | FLOWmm |
|---|---|---|---|---|
| 1 | 5.5% | - | 1353.41 | 4.15 |
| | | | 1061.14 | 3.89 |
| 2 | 4.5% | 1% | 1375.03 | 3.90 |
| | | | 1349.09 | 4.10 |
| 3 | 3.5% | 2% | 921.01 | 3.70 |
| | | | 942.63 | 3.35 |
| 4 | 2.75% | 2.75% | 501.58 | 1.60 |
| | | | 505.91 | 1.40 |

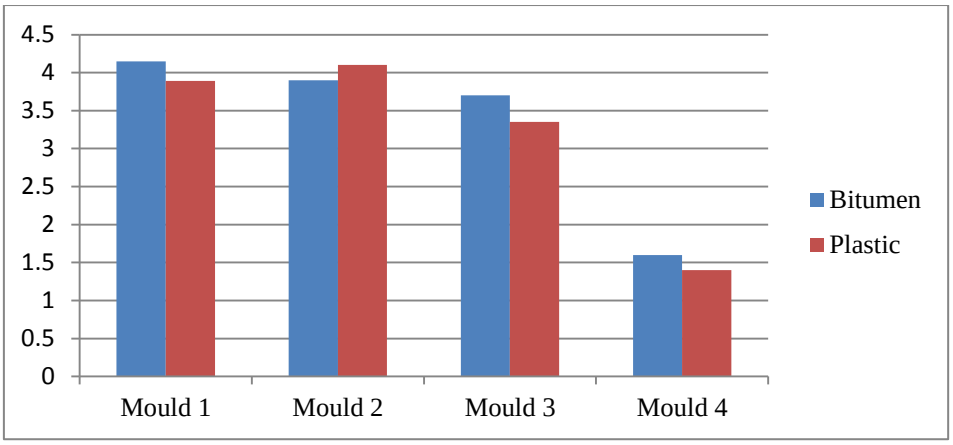
**Table 3.5 for Stability and Flow**



**Stability**




**Graphical Representation for Stability Test**
**Flow**

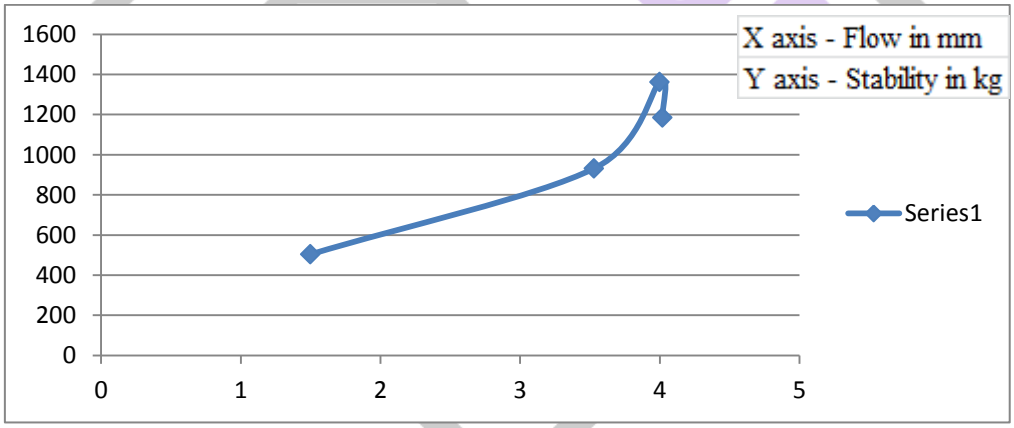



**Graphical Representation for Flow Test**

### 3.6 Average Value of Stability and Flow

| MOULD | STABILITY kg | FLOWmm |
|---|---|---|
| 1 | 1184.76 | 4.02 |
| 2 | 1362.06 | 4 |
| 3 | 931.82 | 3.53 |
| 4 | 503.75 | 1.5 |

**Table 3.6 for average stability and flow value**




**Graphical Repesentation for Stability and Flow**

**Fig. i. Road Laid To Our Project**

## 4. CONCLUSION

- The use of waste plastic in construction of roads brings out a better performance. Since there is better binding of bitumen with plastic.so that the frequency of voids is also reduced due to increased bonding and area of contact between polymers and bitumen.
- The roads can withstand heavy traffic, thereby making them more durable.
- The use of the innovative technology not only strengthened the road construction but also increased the road life as well as will help to improve the environment.
- Using of waste plastic in flexible pavements shows good result when compared with conventional flexible pavements.
- In our project the partial replacement of plastic waste in bitumen such as 1% , 2% and 2.75% by the weight of metals.
- Based on marshall stability and flow test, the stability can be increased than the conventional mix in the replacement of 1% of PET wastes and than the flowvalue remains same for conventional and partial mix.
- Increasing the percentage of replacement of PET waste of 2% the stability and flow can be decreased.

## REFERENCES

[1] **S.K. Khanna and C.E.G Justo** "Highway Engineering" 2008

[2] IRC : 111 – 2009

[3] IRC : 37 – 2001

[4] **RAJASEKARAN .S ,VASUDEVAN .R , SAND PAULRAJ .S (2013) "**Reuse ofwaste plastics coated aggregates-bitumen mix composite for road application-green method**".** American Journalof Engineering and Research, 2, 1-13.

[5] **MORT&H Specifications for Roads and Bridge Works, (2009)**

[6] **Amol S. Bale** "Potential reuse of plastic waste in road construction" IJAET/Vol. II/ Issue III/July-September, 2011/233-236 .

[7] IS : 73 : 2013

[8] IS 1203, IS 1205, IS 1206 (Part 2), IS 1208