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# Modification of Bituminous Concrete Mix Using Rubber and Plastic Waste Materials

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**Abstract** *: Disposal of huge amount of discarded waste materials like plastic, polythene bags, bottles, rubber tyres etc, which are generated in huge quantity and causes environmental hazards after their disposal. Present study attempts to utilize these waste materials as partial replacement of bitumen to develop a modified binder, for making bituminous concrete mix. To simulate with the field conditions, 'Marshall Stability Analysis' was performed on the samples prepared by partially replacing 'Optimum Bitumen Content' with waste plastic (4%, 6%, 8% and 10%) and crumb rubber (5%, 10% and 15%). Experimental results demonstrate that partial substitution of bitumen with waste plastic results up to 16% increment in strength whereas with rubber material, about 50% increment in strength was observed as compared to the conventional mix (CM). Laboratory testing results indicate that by using waste materials, bituminous concrete of required strength and density can be obtained and an environment friendly green pavement can be prepared with less material cost.*

**Key Words : Bituminous concrete , Plastic Waste , Rubber tires , Marshall Stability method.**

## INTRODUCTION

Today, for most of the advance countries, flexible pavements are one of the important types of road construction. In recent times, it is been observed that due to raise in axel cargo and traffic intensity the efficiency of the bituminous binder is been reduced causing bleeding in hot circumstance, cracks in low temperature, rutting and pot holes. Disposal of a diverseness of plastic & pencil eraser wastes in an eco-friendly way is the substance area of today's research. The waste plastic and the crumb rubber for the twist of flexible pavement material which would give a better solidity, resistance and strong, suit to the road as compared to the conventional rubber. As they are remarkably non-biodegradable thus can be used as a modifier in bitumen and aggregates to increase their strength.

## MATERIALS

**Aggregates**: The natural totality again are classified as coarse aggregates lie of crushed rock aggregates or gravel and fine aggregates or sand.

**Bitumen:** Bitumen is used as binders in Pavements constructions. Optimum bitumen content considers by Marshall tests.

**Plastic :**A plastic material is any of a wide range of synthetic or semi-synthetic organic solids that are malleable. And they are usually synthetic. Most commonly derived from petrochemicals. Plastic waste (bags, cups, bottles) made out of PE, PP and PS cut in to a size between 2.36mm and 4.75mm using shredding machine.

| TYPES | SOURCES |
|---|---|
| Low density Polyethylene (LDPE) | Bags, sacks, bin lining and squeezable detergent bottles etc. |
| High Density Polyethylene (HDPE) | Bottles of pharmaceuticals, disinfectants, milk, fruit juices, bottle caps etc. |
| Polypropylene (PP) | Bottle cap and closures, film wrapping for biscuits, microwave trays for ready-made meals etc. |
| Polystyrene (PS) | Yoghurt pots, clear egg packs, bottle caps. |
| Foamed Polystyrene | Food trays, egg boxes, disposable cups, protective packaging etc. |

**Table no. 1: Different types and sources of waste plastic**

**Crumb rubber :** Crumb rubber is obtained from truck or automobile tires. Whole truck tires contain 18% natural rubber compared to 9% in automobile tyre. And the scrap tyre is shredded into small pieces by the help of mechanical blades up to sizes of 1mm-75µm.

**Purpose of Bitumen modification:**

- To obtain softer blends at low temperature for reducing cracks.
- To increase the stability and strength of mixtures.
- To improve the asphalt cohesive strength in pavements.
- To improve oxidation and resist aging.
- To reduce costs of pavement.

**Need and Necessity:**

- Disposal of waste plastic and rubber tyre is a major problem.
- It is non-biodegradable.
- To find its utility in bituminous mixes for road construction.
- Burning of these waste plastics and tires causes environmental pollution.
- Laboratory performance studies were conducted on bituminous mixes.
- Improvement in properties of bituminous mix provides the solution for disposal in an useful way.

## Objectives of the project:

- To determine the engineering properties of plastic waste, rubber tires and compare them with conventional bitumen.
- To study the effect of plastic waste & crumb rubber on strength of BC mix.

- To select the optimum percentage of plastic waste and rubber to be blended with commonly used bitumen to produce maximum compressive strength.
- To study the Marshall properties of the bitumen concrete mixes with plastic and crumb rubber.

## Advantages:

- Reduce the need of bitumen by around 10%.
- Develop a technology which is eco-friendly.
- Improvements in fatigue life of roads.
- Due to presence of pores, the air accumulates in the pores thereby oxidizing bitumen resulting in loss of its visco-elastic property. Due to the addition of polymers, porosity is reduced to less than 2%, resulting in very less stripping of bitumen thereby improving the aggregate quality.
- The ability of the aggregate to resist weather conditions is improved.
- As plastics are added to the aggregates, the moisture absorption ability of the aggregates decreases, resulting in better resistance to rain.
- Rebound deflection is minimized.
- Higher resistance to rain and water logging.
- Load withstanding property of the road is improved and caters to the increasing road transport
- Increase the strength and better performance of the road.

**Methodology:**

- **Test on aggregates :**
  1. Aggregate crushing test
  2. Los Angeles abrasion test
  3. Impact test

## 1. Aggregate Crushing Test :

One of the model in which pavement material can fail is by crushing under compressive stress. A test is standardized by **IS: 2386 part-IV** and used to determine the crushing strength of aggregates. The aggregate crushing value provides a relative measure of resistance to crushing under gradually applied crushing load.

## 2. Los Angeles Abrasion Test :

Abrasion test is carried out to test the hardness property of aggregates and to decide whether they are suitable for different pavement construction works. Los Angeles abrasion test is a preferred one for carrying out the hardness property and has been standardized in India (**IS: 2386 part-IV**). The principle of Los Angeles abrasion test is to find the percentage wear due to relative rubbing action between the aggregate and steel balls used as abrasive charge.

## 3. Impact test :

The aggregate impact test is carried out to evaluate the resistance to impact of aggregates. Aggregates passing 12.5 mm sieve and retained on 10 mm sieve is filled in a cylindrical steel cup of internal dia 10.2 mm and depth 5 cm which is attached to a metal base of impact testing machine. The material is filled in 3 layers where each layer is tamped for 25 numbers of blows. Metal hammer of weight 13.5 to 14 Kg is arranged to drop with a free fall of 38.0 cm by vertical guides and the test specimen is subjected to 15 numbers of blows. The crushed aggregate is allowed to pass through 2.36 mm IS sieve.

- **Test on Bitumen :**
  1. Penetration test
  2. Softening point test
  3. Ductility test
  4. Specific Gravity test
  5. Viscosity test
  6. Marshall Stability test

## 1. Penetration Test :

Penetration is a measurement of hardness or consistency of bituminous material. It is the vertical distance travelled or penetrated by the point of a standard needle in to the bituminous material under specific condition of load, time and temperature. This distance is measured in one tenth of a millimeter. This test is used for evaluating consistency of bituminous materials. It is not regarded as suitable for use in connection with the testing of road tar because of the high surface tension exhibited by these materials and the fact that they contain relatively large amount of free carbon.

## 2. Softening Point Test :

The softening point of bitumen or tar is the temperature at which the substance attains a particular degree of softening. As per IS:334-1982, it is the temperature at which a standard ball passes through a sample of bitumen in a mould and falls through a height of 2.5 cm, when heated under water of glycerin at specified conditions of test.

## 3. Ductility Test:

The property of bitumen which allows it to undergo deformation or elongation is called ductility of bitumen. The ductility of bitumen is measured by the distance in Cm (centimeter), to which the bitumen sample will elongate before breaking when it is pulled by standard specimen at specified speed and temperature.

### 4. Specific Gravity Test :

Specific gravity of a material is defined as the ratio of the density of a substance to the density of a standard, usually water for a liquid or solid, and air for a gas.

## 5. Viscosity Test :

Viscosity is defined as the increase of fluidity. The degree of fluidity at the application temperature greatly influences the ability of bituminous material to spread, penetrate in to void and also coat the aggregates and hence affects the strength characteristics of the resulting paving mixes. There is an optimum value of fluidity or viscosity for mixing and compacting for each aggregate gradation of the mix and bitumen grade. At high fluidity or low viscosity, the bitumen binder simply "Lubricates" the aggregate particles instead of providing a uniform film thickness for binding action. Similarly, low fluidity or high viscosity does not enable the bitumen to coat the entire surface of aggregates.

### 6. Marshall Stability Test :

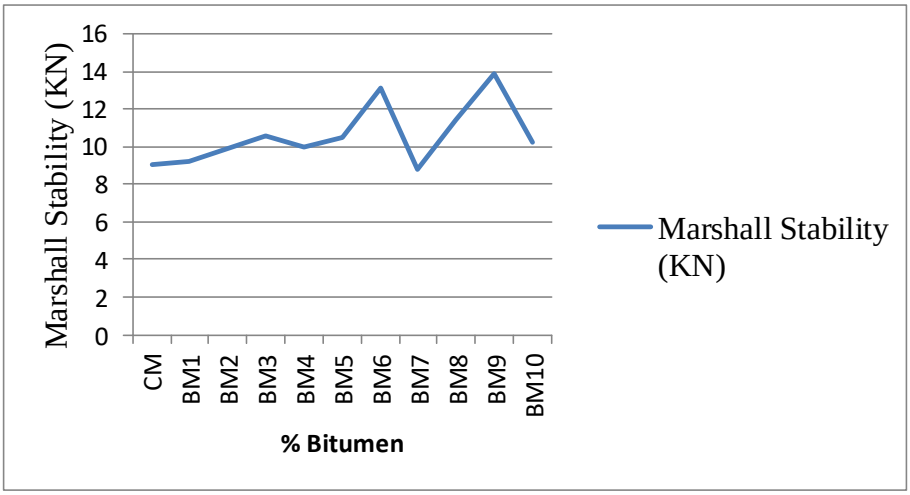
The stability of the mix is defined as a maximum load carried by a compacted specimen at a standard test temperature of $60^0$C. The flow is measured as the deformation in units of 0.25 mm between no load and maximum load carried by the specimen during stability test (flow value may also be measured by deformation units of 0.1 mm). This test attempts to get the optimum binder content for the aggregate mix type and traffic intensity. This is the test which helps us to draw Marshall Stability vs. % bitumen.

Marshall Stability plays a very important role in the testing of road materials. Hence the values obtained by the Marshall Stability test shows the actual strength and load carrying capacity of the road material.

Discarded waste materials like crushed plastic bottles, thrown away polythene bags and used rubber tires were the minor constituents of the binder along with bitumen as major constituent. All binders were divided into three series namely A, B and C. Series A and B represent the binary mixes i.e., Bitumen (B) + Plastic (P) and Bitumen (B) + Rubber (R) respectively while Series C is the tertiary mix with varying proportion of plastic and rubber both in bitumen. All the mixes having varying percentages of binder constituents are represented as Bitumen Mix (BM).

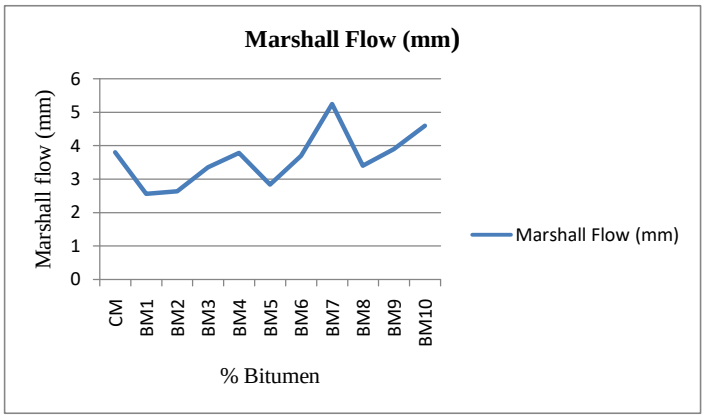
**RESULT:**

1. **Marshall Stability Value:**



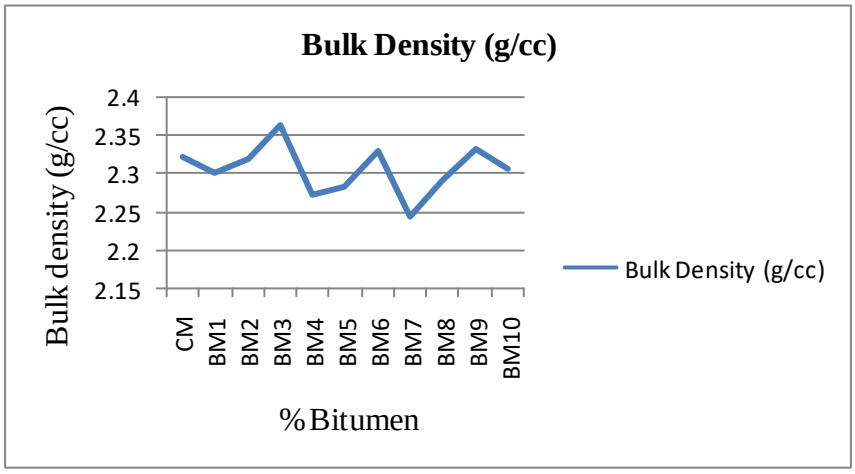

**Grapgh No.1: % Bitumen Vs Marshall Stability Value**

**2.Marshall Stability Flow :**



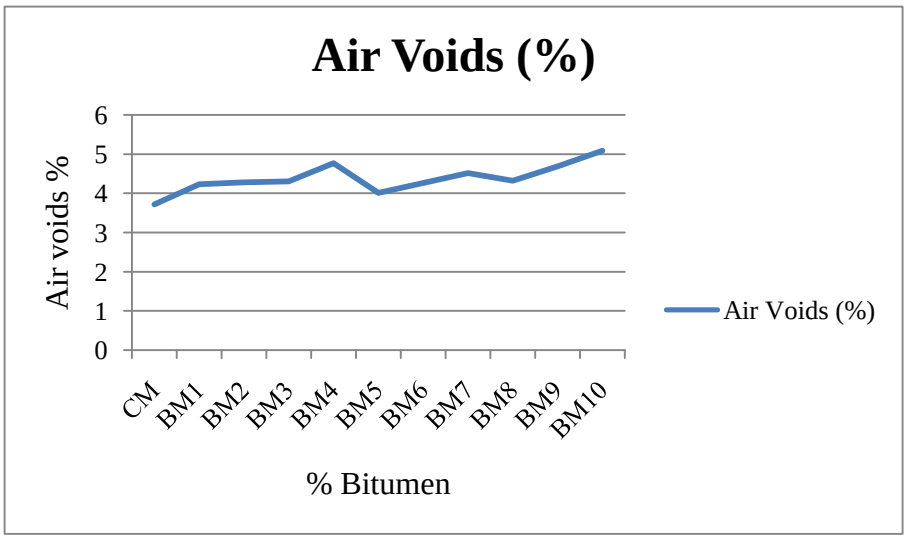

**Graph No.2 : % Bitumen Vs Marshall flow**

**3.Bulk Density :**



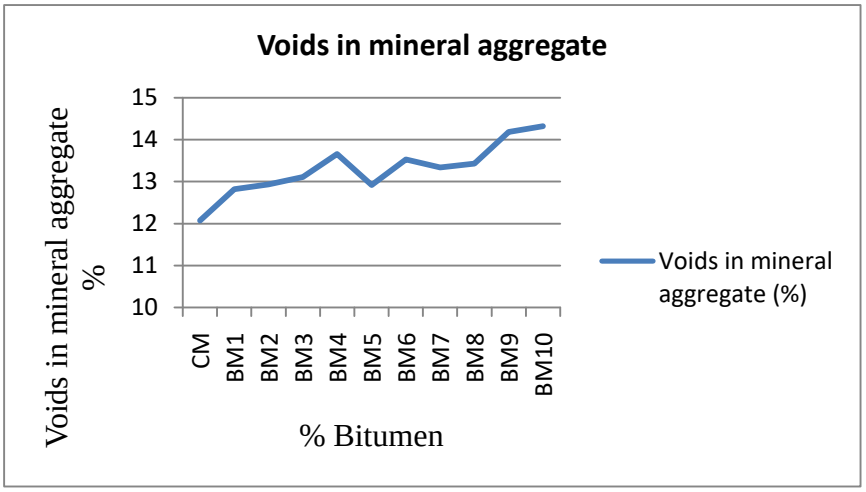

**Graph No.3 : % Bitumen Vs Bulk Density**

**4.Air Voids :**




**Graph No. 4: % Bitumen Vs Air Voids**

**5.Voids in mineral aggregate :**




**Graph No 5 : % Bitumen Vs Voids in mineral aggregate**

**CONCLUSION :**

- The stability value of tertiary mix BM9, binary mix BM6 and BM3 is significantly higher than the non-modified mix.

- For road construction, from tertiary mix BM9, binary mix BM6 and BM3 should be used.
- Research findings of the study indicate that use of rubber tires and waste plastic bottles improves the strength and overall durability of the BC mix by increasing its overall performance manifold. Therefore, with application of these waste materials in the fixed proportions, targeted characteristics of BC can be achieved.

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