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# PERFORMANCE OF BITUMINOUS MIXES USING MODIFIED BINDER

**Miss. Sonali P. Ghongade[1], Dr. M. R. Vyawahare[2], Mr. A. R. Bijwe[3]**

*[1]PG Student, M.E Transportation Engineering and Management, Dr. Rajendra Gode Institute of Technology and Research, (SGBAU) Amravati*
*[2]Professor and Head, Civil Engineering Department, Dr. Rajendra Gode Institute of Technology and Research, (SGBAU) Amravati*
*[3]Assistant Professor, Civil Engineering Department, Dr. Rajendra Gode Institute of Technology and Research, (SGBAU) Amravati*

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**ABSTRACT:-** In India, flexible pavements with bituminous surfaces are widely used. Due to increased traffic intensity of roads, overloading of commercial vehicles and temperature variation of pavements due to climatic changes leads to formation of various distresses like rutting, shoving, bleeding, cracking and potholing of bituminous surfacing. Due to high temperature, bitumen becomes very soft in summer and brittle in winter. Several Studies have revealed that properties of bitumen and bituminous mixes can be improved/modified with addition of certain additives and the bitumen premixed with these additives/modifiers is known as "modified bitumen". The present study aims for use of modified bitumen by using plastic waste for road construction. Modifiers applied for improving asphalt's viscoelasticity are : elastomers, plastomers, synthetic resins, crumb rubber, metal-organic compounds, sulfur, natural asphalts and paraffins. Also PolyPhosphoric acid (PPA)can be used for this purpose.

## I. INTRODUCTION -

Asphalt binders are often modified by the use of additives to improve properties and meet performance requirements. PPA is currently used in the air-blowing oxidation process, as an additive in reactive polymer applications, and as a direct binder modifier. PPA is classified as a chemical modifier because it reacts with some of the components of asphalt. Various types of polymers are used to change asphalt binders to achieve wider performance range. Many polymer modified asphalt binders tend to behave more as a polymer rather than bitumen.

### A. Modified Bitumen-

Certain additives or blend of additives called as bitumen modifiers can improve properties of Bitumen and bituminous mixes. Bitumen treated with these modifiers is known as modified bitumen.

### B. Need of Asphalt Additives for the Pavement Construction

There are many researchers looking for the reasons to modify bituminous materials. mentioned that the main reasons to modify bituminous materials with different type of additives could be summarized as follows:

1) To obtain softer blends at low service temperatures and reduce cracking,

2) To reach stiffer blends at high temperatures and reduce rutting,

3) To increase the stability and the strength of mixtures,

4) To improve fatigue resistance of blends,

5) Lower susceptibility to daily and seasonal temperature variations

6) Higher resistance to deformation at high pavement temperature

7) Better age resistance properties

8) Higher fatigue life for mixes

9) Better adhesion between aggregates and binder

10)Prevention of cracking

11)To reduce structural thickness of pavements.

**C. Object of the Study-**

The object of the present study is to determine the Marshall Test properties of Bituminous concrete mixes using 60/70 penetration bitumen modified using Poly Phosphoric Acid.

- To study the effect of Poly Phosphoric Acid as modifier in various proportions in bituminous mixes.
- To find out the optimum percentage of Poly Phosphoric Acid and binder used in the mix.
- It is proposed to investigate for the stability and flow values and other properties in design mix will be evaluated.

**2. LITERATURE REVIEW-**

P. De Filippis [127] (1995) There is a shift towards gel type of structure due to PPA modification exhibiting properties of air blown bitumen by way of stiffening. The PPA modification is a low cost alternative when compared to air blowing technique and the modification does not affect low temperature performance.

Orange et al [140](2004) PPA has the influence of neutralization of polar interactions between the stacked asphaltenes molecules, either by protonation of basic sites or by esterification.

Baumgardner et al [126] (2005) Studied the influence of PPA modification on two asphalts he performance grade of both asphalts was raised by PPA. In one of the asphalt, PPA affected the dispersed phase; in the other, it affected the matrix. The stiffening effect of PPA was asphalt dependent. Several mechanisms were proposed to explain the stiffening from the PPA modification of asphalt binders: formation of PPA adducts; alkylation of aromatics; cross-linking of neighboring asphalt segments; the formation of ionic clusters; and the cyclization of alkyl aromatics. Detailed physico-chemical analysis of PPA-modified asphalt binders will be required to determine which mechanism(s) prevail.

Baumgardner et al [135] (2005) Proposed various bitumen dependent mechanism of PPA which also affected the lower weight components of the bitumen: co-polymerization of the saturates, alkyl aromatization of the saturates, cross-linking of neighboring bitumen segments, the formation of ionic clusters and the cyclization of alkyl-aromatics.

Masson [151] (2008) The mechanism of reaction between the PPA and Bitumen is unknown. PPA has high dielectric constant and whereas the bitumen has low. It is postulated that PPA can only dissociate and react with bitumen in enclaves of high dielectric constants.

**3. MATERIALS USED -**

**A. Binder -**

Bitumen of VG 30(60/70) penetration grade bitumen was used in the study.

**B. Modifier -**

The modifier selected for the present study is Polyphosphoric acid. The chemical formula is H(n+2)P(n)O(3n+1). Generally it is used as strong drying and dehydrating agent, reaction medium and solvent. It is also used in metal treatment and as an additive in asphalt.

**C. Sample Preparation-**

One of the objectives of the study is to examine the efficacy of PPA modified binders and hence, the paving grade bitumen VG 30 was modified with varying dosages of PPA to establish the optimum PPA dosage. Bitumen is heated at the trial dosage of laboratory grade PPA with 105% concentration of H3PO4 (ranging from 0.5% to 2.0% with incremental dosages of 0.5%) and subjected to the respective testing protocols under controlled conditions prescribed for the testing.

- VG 30 paving grade bitumen
- VG 30 + PPA (3%) modified sample
- VG 30 + PPA (6%) modified sample
- VG 30 + PPA (9%) modified sample
- VG 30 + PPA (12%) modified sample

**D. LABORATORY TESTING**

**A.Test on aggregates:**

**1. Specific gravity of coarse aggregate:-** Coarse aggregate shall be crushed material retained on 2.36mm sieve and shall be crushed stone, crushed slag or crushed gravel. Three trials have been conducted for determining the specific gravity of the sample using Pycnometer.

**2. Specific gravity of fine aggregate**:- Fine aggregate shall be the fraction passing 2.36mm sieve and retained on 75um sieve, consisting of crusher run screenings, natural sand or a mixture of both. Three trials have been conducted for determining the specific gravity of the sample using Pycnometer .

**3. Specific gravity of mineral filler:-** The mineral filler fills the voids, stiffens the binder and offers permeability. In the present project, a mineral filler of 2um is used. Three trials have been performed for determining the specific gravity of the sample using specific gravity bottle.

**4. Los angeles abrasion test**:- The principle of Los Angeles abrasion test is to produce abrasive action by use of standard steel balls which when mixed with aggregates and rotated in a drum for specific number of revolutions also causes impact on aggregates.

The percentage wear of the aggregates due to rubbing with steel balls is determined and is known as Los Angeles Abrasion Value. The Los Angeles abrasion test on aggregates are done for following purposes:

•To determine the Los Angeles abrasion value.

•To find the suitability of aggregates for use in road construction.

Los Angeles test is commonly used to evaluate the hardness of aggregates**.**

**5. Impact test:-** The property of a material to resist impact is known as toughness. Due to movement of vehicles on the road the aggregates are subjected to impact resulting in their breaking down into smaller pieces. The aggregates should therefore have sufficient toughness to resist their disintegration due to impact. This characteristic is measured by impact value test. The aggregate impact value is a measure of resistance to sudden impact or shock, which may differ from its resistance to gradually applied compressive load.

**6. Shape test:-** Recommended Values of Flakiness Index and Elongation Index-The shape tests give only a rough idea of the relative shapes of aggregates. Flaky and elongated particles should be avoided in pavement construction, particularly in surface course.

If such particles are present in appreciable proportions, the strength of pavement layer would be adversely affected due to possibility of breaking under loads. Workability is reduced for cement concrete. The shape test was conducted to determine the flakiness index and elongation index of the aggregate

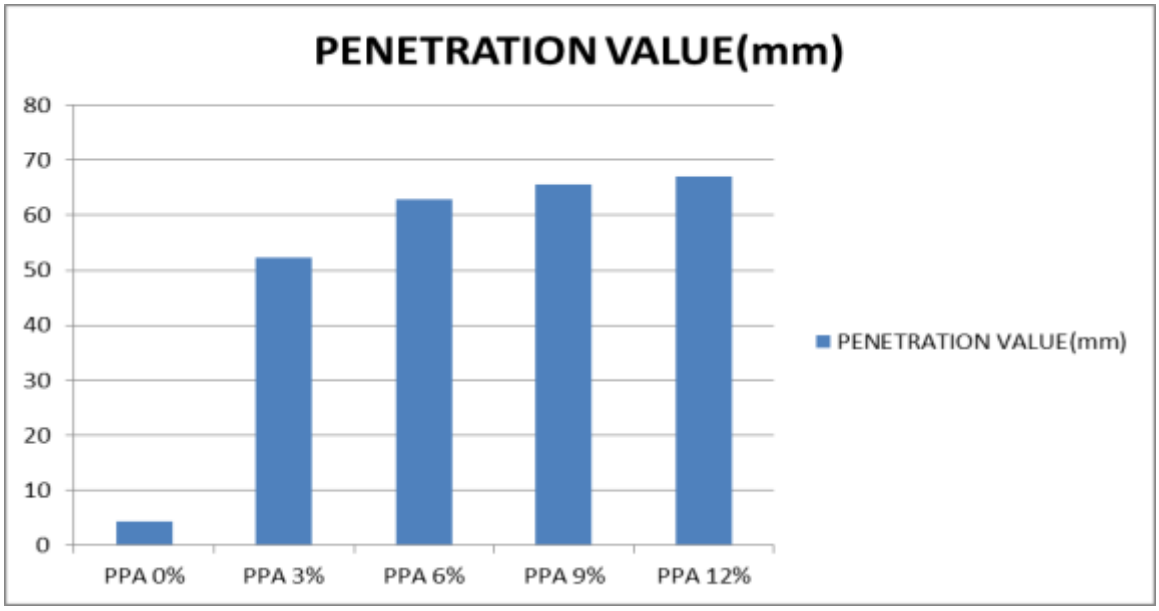
**B. Test on Bitumen:-**

**1. Bitumen penetration test:-**This test conducted for determining the penetration value of normal bitumen and modified samples. By conducting this test we found the hardness of sample. This test conducted by using Penetrometer. Following results were observed after conducting penetration test. Penetration value is the vertical distance traversed or penetrated by the point of a standard needle into the bituminous material under specific conditions of load, time and temperature. This distance is measured in one tenths of a millimeter.Penetration test is used for evaluating consistency of bitumen. 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.

Penetration test on bitumen is carried to determine:-

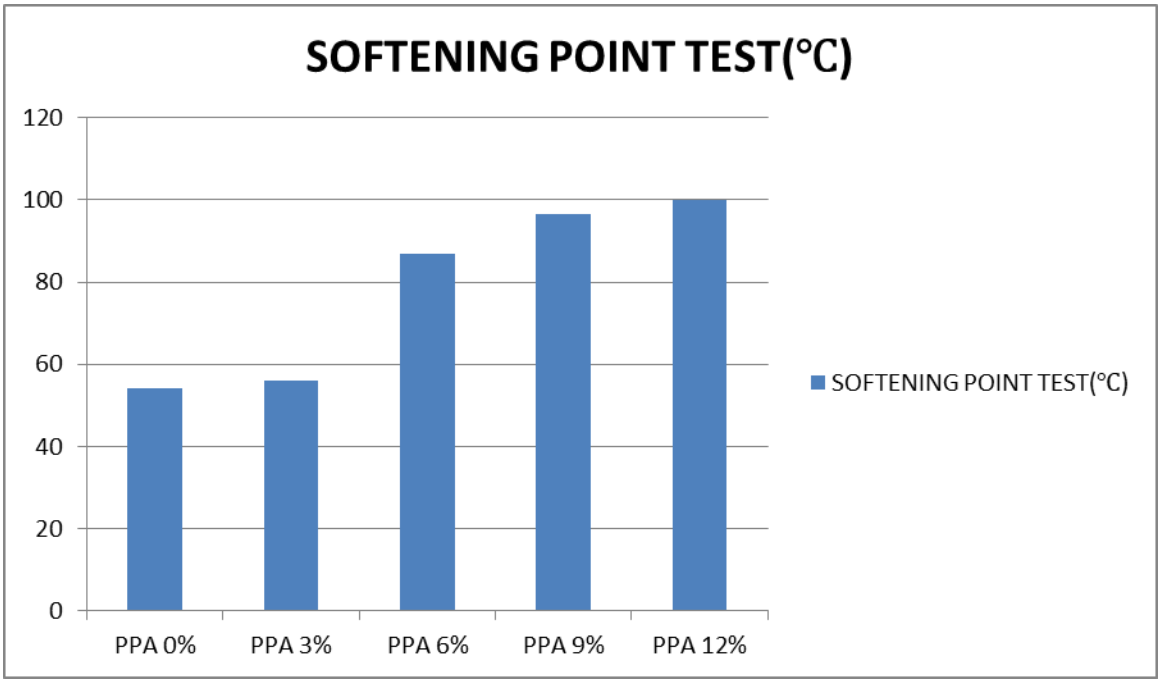
•Consistency of bituminous material

•Suitability of bitumen for use under different climatic conditions and various types of construction.




**2. Softening point test:-** Softening point is defined as the temperature where the bitumen becomes soft. By conducting this test the softening temperature of modified samples were found.

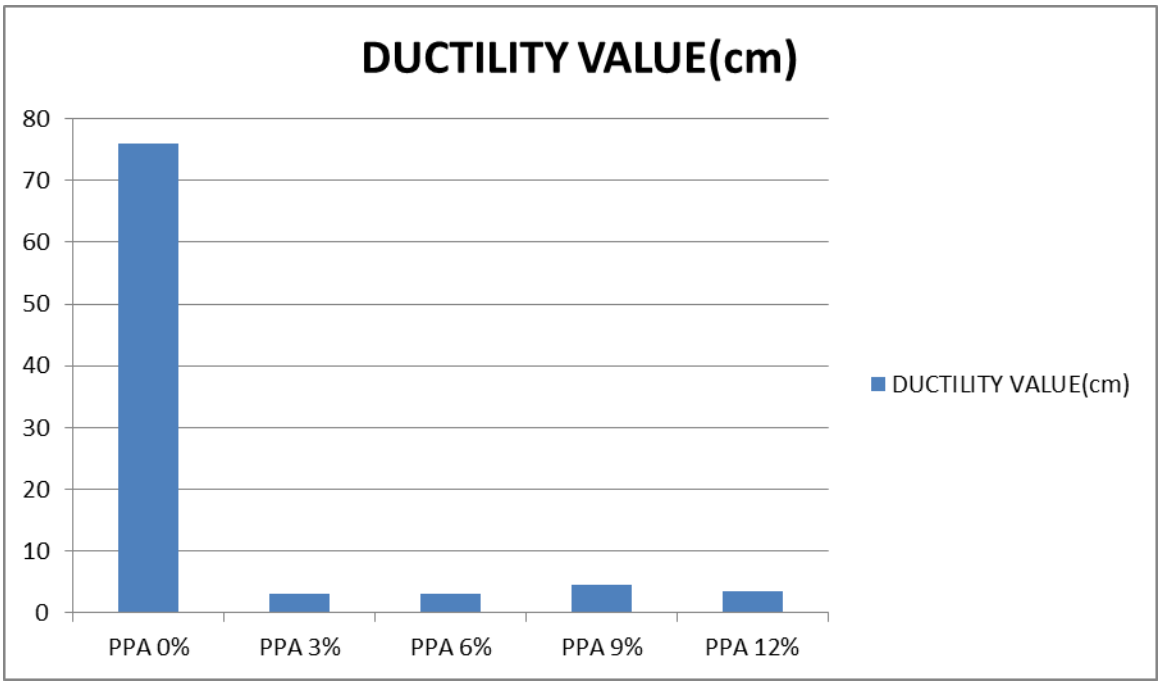
This test was conducted by using ring and ball apparatus. A brass ring containing test sample of bitumen is suspended in liquid like water or glycerin at a given temperature. Temperature is noted when the softened bitumen touches the metal plate which is at a specified distance below. Generally, higher softening point indicates lower temperature susceptibility and is preferred in hot climates. After conducting this test following results were obtained.



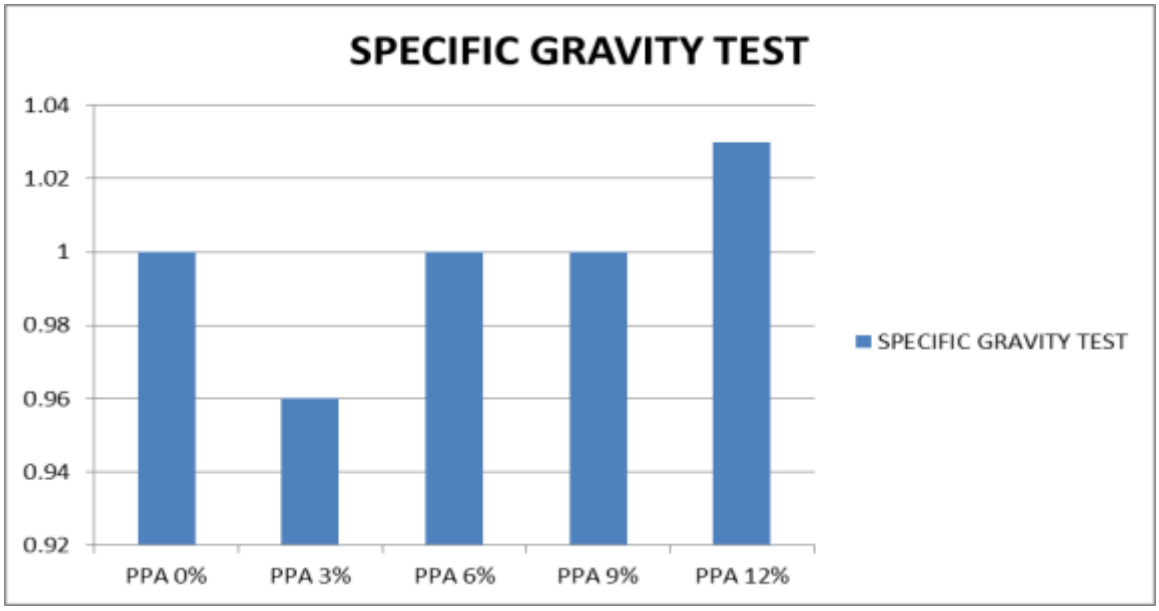
**3. Ductility test:-** The ductility test gives a measure of adhesive property of bitumen and its ability to stretch. In flexible pavement design, it is necessary that binder should form a thin ductile film around aggregates so that physical interlocking of the aggregates is improved. Binder material having insufficient ductility gets cracked when subjected to repeated traffic loads and it provides pervious pavement surface.

Ductility of a bituminous material is measured by the distance in centimeters to which it will elongate before breaking when two ends of standard briquette specimen of material are pulled apart at a specified speed and specified temperature.

This test was conducted for determining the ductility value of modified samples. Ductility values were noted where the bitumen will sag or break. The test was conducted at room temperature. This test was conducted by using briquette mould and ductility machine. New mould was prepared for ductility test with 8mm neck dimension because by using 10mm neck dimension of briquette mould gave values beyond the calibrated values of the ductility machine. The test was conducted at the speed of 1cm/min and 5cm/min. after conducting this test following result were obtained.



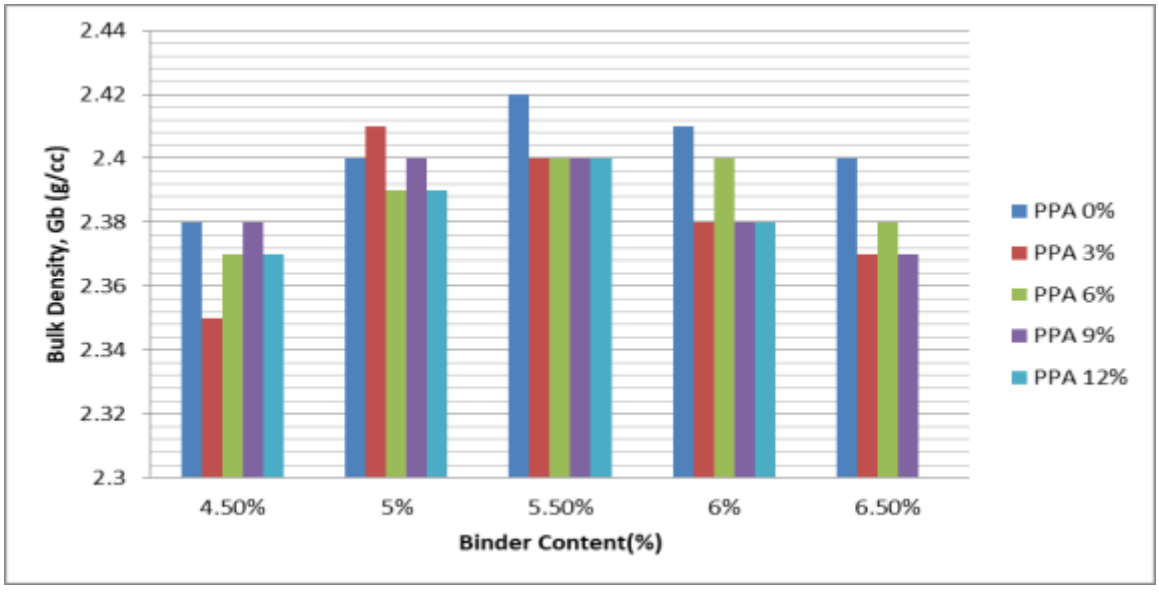

**4. Specific Gravity test:-** Specific gravity of a material is defined as the ratio of the density of a substance to the density of a standard, usually water for a liquid or solid, and air for a gas.




**5. Marshall stability test:-**

Mississippi State Highway Department formulated Marshall stability test – flow test on bitumen and is applicable to hot mix design of bitumen and aggregates of maximum size 2.5 cm. Bituminous concrete mix is commonly designed by Marshall Method.

The stability of the mix is defined as a maximum load carried by a compacted specimen at a standard test temperature of 600C. 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.



**4. CONCLUSIONS:-**

In this section the properties such as bulk density, Volume of air voids, volume of bitumen, VMA, VFB, Marshall Stability and flow values were analyzed for Poly Phosphoric Acid modified bitumen in varying proportion 3%, 6%, 9% and 12% for 4.5%, 5%, 5.5%, 6% and 6.5% bitumen content, are presented.

All these properties play a vital role in the performance of BC mix in the field. In the sight of the usefulness of the addition of modifiers, the following discussions are presented. From the above results, it is observed when the percentage of Poly Phosphoric Acid (modifier) increases the Marshall stability values and bulk density values are increased and decreases, where stability is found maximum at 26.69Kn for 6% Poly Phosphoric Acid at 5% bitumen content and density of 2.41 g/cc for 3% Poly Phosphoric Acid at 5% bitumen content respectively. It is also observed that that; volume of air voids, VMA decreases where as Volume of bitumen, VFB and flow value increases.

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