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Effect of Polyphosphoric Acid as Modifier on the Properties of Bitumen

Ahmad Saadiq

Assistant Professor, Department of Civil Engineering, BIT Meerut, U.P., India

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Abstract - *In this experimental work, an attempt has been made to study the properties of modified bitumen with Polyphosphoric Acid as modifier. The present investigation comprises of determining the properties of 60/70 penetration grade bitumen modified with Polyphosphoric Acid as Modifier. The results such as were compared. Basic properties like softening point, ductility, Penetration, specific gravity, flash and fire point of modified bitumen at various concentration of Polyphosphoric Acid were determined. These values were compared with plain bitumen. The study helps to ascertain the suitability of Polyphosphoric Acid as modifier.*

***Key Words*: Bituminous Concrete, Modified Bitumen, 60/70 Penetration Grade Bitumen, Polyphosphoric Acid**

1. INTRODUCTION

Bituminous binders are widely used by paving industry. In general pavements are categorized into 2 groups, i.e. flexible and rigid pavement. Flexible pavements are those, which on the whole have low flexural strength and are rather flexible in their structural action under loads. These types of pavement layers reflect the deformation of lower layers on-to the surface of the layer. If the surface course of a pavement is of Plain Cement Concrete then it is called as rigid pavement since the total pavement structure can't bend or deflect due to traffic loads. Pavement design and the mix design are two major considerations in case of pavement engineering. The present study is only related to the mix design of flexible pavement considerations. The design of asphalt paving mixtures is a multi-step process of selecting binders and aggregate materials and proportioning them to provide an appropriate compromise among several variables that affect mixture behaviour, considering external factors such as traffic loading and climate conditions.

1.1 Asphalt Additives

A conventional bituminous material does not have the performance requirements for the road construction, which are increasingly subjected to heavy loads, heavy traffic and several environmental conditions. When the produced asphalt does not meet climate, traffic, and pavement structure requirements, modification has been used as one of the attractive alternatives to improve its properties. Modification offers one solution to overcome the pavement distress deficiencies of bitumen and thereby improve the performance of asphalt concrete pavement. The main objective of the bitumen improvement is to produce ideal modified bitumen's materials with high resistance to permanent deformation, and fatigue cracking.

1.2 Need Of Asphalt Additives

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

- To obtain softer blends at low service temperatures and reduce cracking,
- To reach stiffer blends at high temperatures and reduce rutting,
- To increase the stability and the strength of mixtures,
- To improve fatigue resistance of blends,
- Lower susceptibility to daily and seasonal temperature variations
- Higher resistance to deformation at high pavement temperature
- Better age resistance properties
- Higher fatigue life for mixes
- Better adhesion between aggregates and binder
- Prevention of cracking
- To reduce structural thickness of pavements.

2. Materials Used

2.1 Binder

Bitumen of 60/70 penetration grade bitumen supplied by Mangalore Refinery Petroleum limited (MRPL) was used in the study.

2.2 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.

3. Test on Bitumen

The Specific gravity of bitumen was conducted as per IS: 1202 by using specific gravity bottle. The ductility test on bitumen was conducted as per the procedure laid down in IS: 120 by using Briquette mould. Sample was prepared by

applying grease on the glass plate by arranging the end pieces and side pieces of the briquette mould on a glass plate so that grease is applied on inside of the side pieces. The given bitumen sample was heated to a pouring consistency and carefully pour into the mould and it was allowed to cool in air for about for about 30-40 minutes. Later the mould with the plate was immersed in a water bath maintained at 27º C for 30 minutes. Later the mould was taken out and excess of bitumen, if any, was cut off with a sharp hot knife. Later again the mould was replaced back in water for 85 to 90 minutes, at 27º C. With the help of hot knife, the side pieces of the mould were removed and the sample from the plate was separated. The sample was placed carefully in the ductility machine on the plate provided by fixing the ends of the mould to the plate. The temperature of water in the ductility machine was measured. It should be 27º C. The initial reading on the scale provided on the machine was noted. Machine was started and the sample was stretched and a thread is formed in the middle. The sample stretches at a uniform rate of 50 ± 2.5mm per minute. The thread formed at the middle breaks at a certain distance. The distance up to which the sample stretches before the thread breaks, is recorded as the ductility value expressed in terms of centimeters. The softening point test on bitumen was conducted as per IS: 1205 by using Ring and Ball apparatus. The flash and fire point test on bitumen was conducted as per IS: 1209 by using Pensky Martin Closed Cup Apparatus. The viscosity test on bitumen was conducted as per IS: 1203 by using Penetrometer. The bitumen is first soften to a paving consistency between 75º C and 100º C above the approximate temperature at which bitumen is soften. Then the sample was thoroughly stirred to make it homogenous and free from air bubbles and water, the sample containers was cooled in atmosphere to a temperature not lower than 13º C for one hour then they are placed in temperature controlled bath at temperature of 25º C for period of one hour. The weight of needle, shaft and additional weights are checked the total weight of this assembly should not be more than 100gms. Using adjusting screw, the needle assembly was lowered and tip of needle was made to just touch the top surface of the sample. The needle assembly was clamped in this position, the contact of the tip of the needle is checked using the mirror placed on the rear of the needle. The initial reading of penetrometer dail is either adjusted to zero or the initial reading is noted. Then the needle was released by pressing a button and stop watch is started, the needle is released exactly for a period of 5 seconds. Similarly three measurements were made on each sample by testing at distance of not less than 100mm apart. The difference between the initial and final penetration readings are taken as penetration value. All the above basic tests was conducted for plain and modified bitumen at 3, 6, 9 and 12% modifier content by percent weight of bitumen.

4. Results

The experimental results on basic properties of 60/70 grade bitumen modified with Polyphosphoric acid as modifier is represented in the Table 3.

Table -3 : Properties of Bitumen modified with polyphosphoric acid.

Tests	Percentage of Polyphosphoric acid added				
	0%	3%	6%	9%	12%
Softening point, °C	54	56	87	96.5	100
Ductility, cm	76	3	3	4.6	3.5
Specific gravity	1	0.96	1	1	1.03
Flash point, °C	285	290	298	310	315
Fire point, °C	305	305	317	310	325
Penetration, mm	43.67	52.33	63	65.5	67

Graph is plotted taking basic properties obtained values on Y-axis and tests on X-axis, modified with Polyphosphoric acid at various concentrations is as shown in Figure 1.

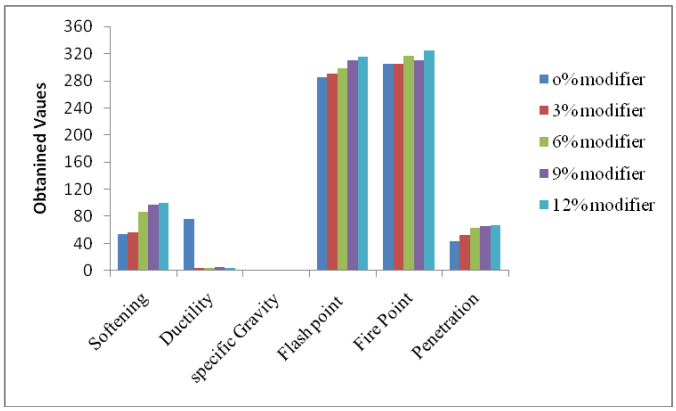

Fig -1: Variation of Basic Properties with Polyphosphoric Acid modified bitumen

3. CONCLUSIONS

The test results obtained from the bitumen 60/70 modified with Polyphosphoric acid was analyzed. All these parameters are indicators of the performance of bituminous concrete mix in the field. It is seen that all basic properties are improved as modifier content increases. Modified bitumen shows better results compared to plain bitumen except ductility value.

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BIOGRAPHY

Ahmad Saadiq is an Assistant Professor in the Department of Civil Engineering in Bharat Institute Of Technology, Meerut, India. He has done his Bachelor of Civil Engineering from Visvesvaraya Technological University, Karnataka, India in the year 2014 and Master Of Technology from the National Institute Of Technology, Silchar, India in 2016.