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INFLUENCE OF BANANA FIBERS ON ASPHALT BINDER

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Abstract- The application of natural fibers as a modifier in the asphalt binder has been extensively increased due to their environment and economic friendly extraction. In this study, banana fibers of 6mm length have been used to prepare modified asphalt binder with three different dosages of 2, 4 and 6% by weight of binder. The effect of banana fibers on various binder properties was investigated by conducting a combination of conventional and rheological testing which includes penetration, softening point, ductility, performance grading and frequency sweep tests. The study concludes that penetration and ductility of modified asphalt binder decreases but the softening point increases with the increase in the percent dosages of banana fibers. The shear modulus improved significantly with an increased dose of fibers which concludes that banana fibers made the asphalt binder harder, stiffer and improved its resistance to high temperature performance.

Keywords- Banana fibers, asphalt binder, performance grading, dynamic shear rheometer.

1 INTRODUCTION:

Bitumen is used as an asphalt binder in the flexible pavements. It is a viscoelastic material and its behavior is very sensitive to the temperature. The unmodified bitumen which is supplied from the refineries does not perform well in the extreme temperatures [1]. In summer, especially in the areas of high temperature, it becomes too soft to be used for paving and fails prematurely because of rutting [2]. To tackle this problem one way is binder modification.

There are different modifiers have been used in the bitumen which includes polymers, waste materials, hydrocarbons, extenders and fibers [3]. Fibers can be extracted from natural or can be made artificially. Naturally, the origin of the fiber may be an animal, mineral or a plant. It can be extracted from the different seeds, stem or leaves of the plant. Natural fibers are environment friendly and cheaper.

It has been concluded that each type of fiber enhance some of properties of asphalt binder depending upon the mixture properties [4]. The study showed that the penetration value of fiber modified bitumen binder gets decreased and at the same time the softening point becomes increased with the inclusion of fiber in the bitumen binder [5]. The shear modulus and resistance to flow of bitumen binder also enhanced [6]. The behaviour of asphalt in term of cracking and rutting become enhanced. The resilient modulus has been improved after the inclusion of fiber modification of asphalt binder [7]. The fatigue properties of asphalt mixture were significantly improved [8]. The mechanical properties of the asphalt mixture were improved by the addition of fiber as a modifier [9]. Fiber reinforcement improved the resistance to flow and rutting of asphalt mixture [5]. Ceramic fiber increases the viscosity and decreases the workability of asphalt binder [10]. The glass fiber modified asphalt showed more resistance to crack initiation comparative to the unmodified asphalt [11]. Natural fiber modified asphalt showed improved high temperature performance [12]. [13] Bamboo modified asphalt showed enhance behavior in low temperature cracking and also in term of rutting.[14][15]. In this study Banana fibers, which have been extracted from the stem of the banana plant used as a modifier in the bitumen

Previously, banana fiber used in SMA in different lengths and fixed content of 0.3% by weight of asphalt binder [15]. In this study the influence different dosages of banana fiber on asphalt binder in length 6mm has been studied.

The objective of this study is to evaluate the effect of banana fiber on the asphalt binder considering conventional and rheological properties.

2 MATERIALS AND METHODS

2.1 Materials

The base bitumen of PG58 used in this study has been supplied by the Attack refinery limited (ARL). Banana fibers were supplied and cut into a length of 6mm by a local manufacturer. To ensure that fiber is moisture was first placed in the oven at the temperature of 105 ±10ºC and then the weight difference after every 2 hours until the become insignificant. The mixing of banana fiber with bitumen binder was done through a shear mixer of 1500 rpm [9].

3 TEST METHODS

3.1 Conventional Testing

Conventional techniques which include penetration test, softening point test and ductility test have been used with base bitumen and fiber modified bitumen. Penetration test was performed according to the ASTM D5 . The softening point test was performed using the ring and ball apparatus according to ASTM D36. The ductility test which represents the length of elongation shown by the bitumen samples when the tensile pull is applied was carried out in accordance with ASTM D13.

3.2 Rheological testing

Performance grading of base and modified asphalt binder were studied through Dynamic shear rheometer according to AASHTO T15 with 25 mm geometry under strain controlled at 10HZ. Frequency sweep test was also carried to investigate the rheological characteristics of base and modified asphalt binder under temperature ranges (58°C, 64°C, 70°C and 82°C) under strain controlled condition. The data obtained from the test was used as input in a sigmoidal function to create a master curve at a reference temperature of 58ºC [16].

4 RESULTS

4.1 Conventional test results:

The result of penetration, softening point and ductility test results of base and modified asphalt binder has been shown in figure 1 which concludes that with banana fiber modification the penetration and ductility of asphalt binder decreases while at the same time increase in the softening point has been observed. The decrease in the penetration and ductility values indicates that asphalt binder becomes hard and stiff with the fiber modification. Moreover, the elevation in softening point shows that temperature susceptibility gets reduced. These results reflect that high temperature performance of asphalt binder has been improved by the inclusion of banana fiber.

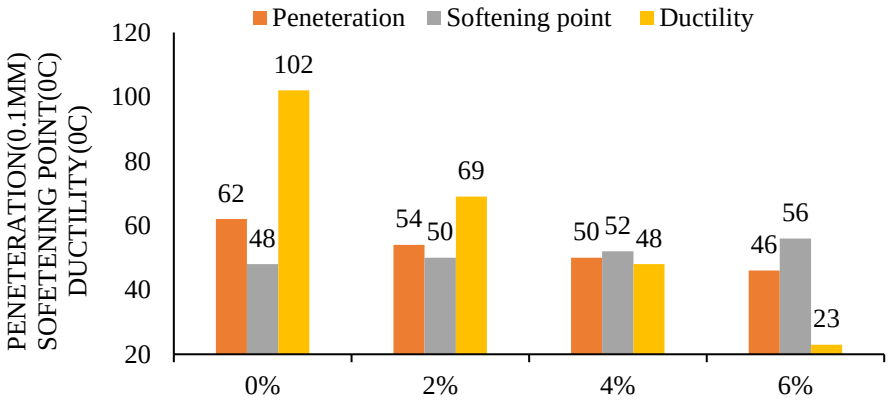

Figure 1 Conventional Test results

4.2 Rheological testing

4.2.1 Performance Grading:

The effect of banana fiber on the performance grading of asphalt binder has been studied through dynamic shear rheometer. The test results presented in figure 2 reveals that with the inclusion of banana fiber the PG of asphalt binder significantly improved.

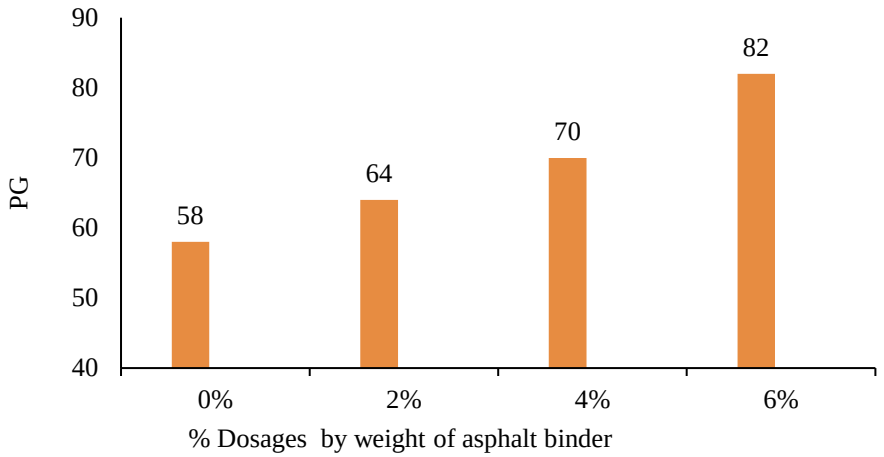

Figure 2 Performance Grading

4.2.2 Frequency sweep test:

The effect of banana fiber on rheological properties of asphalt binder was also studied through the frequency sweep test which concludes that modified asphalt binder has greater G^* values as comparative to the bases asphalt binder. The test result has been shown in figure 3 which indicates that with the modification the asphalt binder becomes stiffer and as a result, the capability the resistance to the permanent deformation has increased.

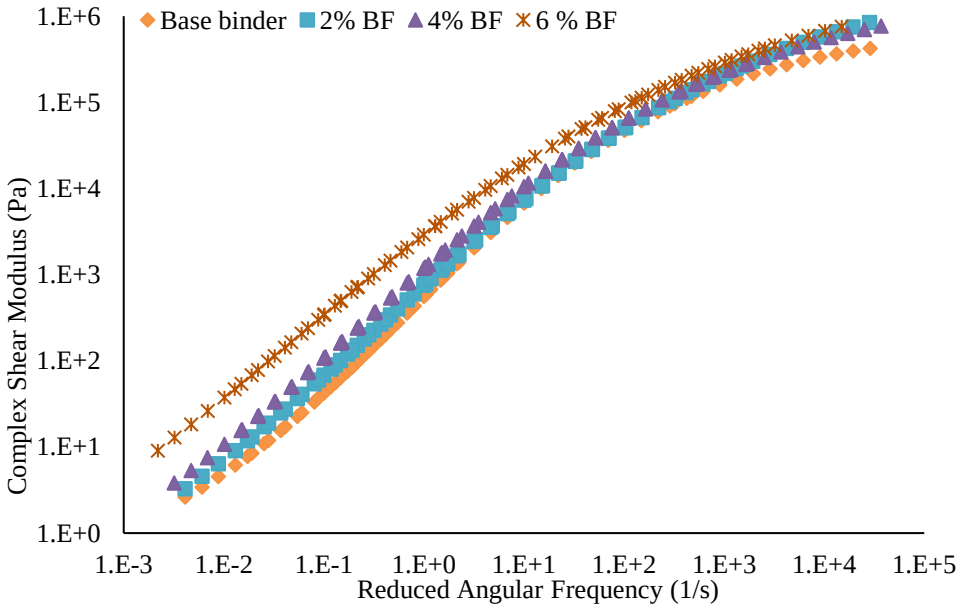

Figure 3 Result of Frequency Sweep Test

Recommended Fiber content:

The fiber content of 4% has been recommended based on test results. With the increase in the percentage of fiber content, the stiffness of asphalt binder increases and 6% dosage of banana fiber content makes the asphalt binder significantly stiff which may cause the abrupt failure of asphalt binder. Moreover, the modified binder prepared with 4% dosage has a PG 70 grade which is considered suitable considering climatic conditions of Pakistan where average temperature lies between 0°C and 50°C [17].

5 CONCLUSION

In this study fiber extracted from the banana plant has been used as a modifier in asphalt binder. The effect of banana fiber modification in asphalt binder was investigated by a combination of conventional and rheological test techniques. The test results reflects that asphalt binder become stiffer and improvement in the complex shear modulus with the increase of percent dosage of BF this concludes that the modified asphalt binder can perform well in the high temperature area and can enhance the distresses in the pavement. Moreover, BF has been obtained from the natural source so it is an economic and environment friendly modifier.[15]The conclusion which can be drawn based on the test results from this study are as follows:

- Asphalt binder modification with the banana fiber decreases the penetration and ductility values. This shows that asphalt binder has become harder and stiffer with this modification.
- With the increase in the dosage of banana fibers in asphalt binder, its softening point also increases which reveals that temperature susceptibility of asphalt binder decreases.
- A significant improvement in the complex shear modulus was observed in the asphalt binder modified with fibers in comparison to the base binder.
- Fiber content of 4% has been recommended based on test results and local conditions.

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