Modification of bitumen using Reclaimed Tire Rubber

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Abstract

Bangladesh being a developing country is undergoing a lot of the roads and highways construction. Due to the heavy traffic volume, the pavements break down owing to high axial loads & weather condition. Bitumen, the main constructing ingredient of flexible pavements is modified in these recent experiments by using the crumbed tire rubbers. Now these crumb rubbers are easily found from the discarded tire rubbers every year. These reclaimed rubbers are synthetic in nature making it non-biodegradable and also non-oxy-degradable. So, the use of these tire rubbers is a part of green use whereas the process significantly reduces the Carbon emission. Now these crumb rubbers were mixed with the 60/70 grade bitumen by the dry method where the crumb rubbers were mixed at different proportions viz 10%, 15%, 20%. Several tests were performed. From the Marshal Stability and other several tests result it was found that the use of rubberized bitumen is much effective than the ordinary bitumen.

Keywords: *Crumbed Rubber; Bitumen; Modification; Rheological parameters; Kinematic Viscosity*

1. Introduction

Communication which is a part of development of a country and it is also the main theme of Globalization. Since the communication is becoming more fluid more day by day, it indicates that there is a requirement of lot of roads. The number of commercial vehicles and public transportation with increased axle loads has taken our roads and it is clear that this process will continue in the future. The civil engineers specialized of highway and transportation are thinking about the alternative solutions to cope up with the upcoming challenges. In this regard the addition of different polymers has been implemented to enhance the physical properties of road pavements which was considered a long time ago and nowadays has become a real alternative for the developed countries. A number of different additives are used in order to get the better properties within a wide range of temperature. Good number of research works have been done in many countries which have confirmed that the use of polymer addition to bitumen is quite much beneficial (Hossain, 2006).

But the recent experiments which we have been conducting in our research is basically a modification which has been done using the used crumbed tire rubber as modifier used with the bitumen. It is seen that the tire rubbers are non-biodegradable and produces toxic fumes on burning them. It is quite much significant that this type of tires rubbers cannot be disposed in the open place or inside the soil. It is used in the ordinary bitumen as a modifier which is a kind

of organic modifier and performing different kinds of experiments it was found that different types of physical properties show better performance in case of the rubberized bitumen than that of ordinary 60/70 grade bitumen.
Conducting different types of rheological property testing experiments it is also found the thermal property of the modified bitumen has a better performance and high range of deformation temperature. This takes us to the point that bitumen can be modified using the rubber scraps we get from the waste tires which gives better longevity of the traditional pavements compared to that of the ordinary bitumen.

2. Significance of our study

We use the bitumen as the binding material in making the flexible pavements in Bangladesh. But from the analysis it is found that this kind of road do not last long and due to the adverse weather condition of our country the use of the ordinary bitumen in not much economically feasible. The modification of this bitumen is very important which is done by using the tire rubbers. To know the properties and compatibility of rubber with bitumen, we need to know a lot. So, this study is very important because nothing comes out without test results and by this study we had come up with the very interesting and very effective test results which show the better deforming temperature range, better durability, better viscosity and better strength capacity.

3. Methodology

The main goal in this study is to investigate and correlate the results of ultrasound measurements with performance properties of rubber modified asphalt mixture. On the other hand, it is necessary to determine performance properties of each sample to be able to compare them with the ultrasound test results. Considering to the fact that there is no investigation in Nevada about best combination of rubber content with local asphalt binder, determining best rubber percent for modifying asphalt binder was also added to this research. In order to achieve its aforementioned goals, the study is divided into three sections.

3.1 Processing of Tire

The crumb rubber is produced through a process of grinding rubber tires into very small particles. Among the two process of grinding namely ambient grinding and cryogenic grinding, we have used the ambient grinding process.

3.1.1 Ambient Mechanical Grinding

In ambient mechanical grinding process, the breaking up of a scrap tire happens at or above normal room temperature. Ambient grinding is a multi-step technology and uses whole or pre-treated car or truck tires in the form of shred or chips, or sidewalls or treads. The rubbers, metals and textiles are sequentially separated out. Tires are passed through a shredder, which breaks the tires into chips. The chips are fed into a granulator that breaks them into small pieces while removing steel and fiber in the process. Any remaining steel is removed magnetically and fiber through a combination of shaking screens and wind sifters.

The machines most commonly used for fine grinding in ambient plants are:

- Secondary granulators

- High speed rotary mills
- Extruders or screw presses
- Cracker mills

3.2 Method of Blending

There are mainly two methods of blending polymer with bitumen, the dry blending method and wet blending method. In the dry method rubber is mixed with heated aggregate whereas in the wet blending method, polymer is added to the hot bitumen prior to adding the resulting binder to the aggregate. The wet method is termed as "Cooking Method" (Hossain, 2006).
Blending can be performed in three ways by using:
• Commercial automated blending system
• Laboratory milling machine
• Manual cooking device

3.2.1 Manual Cooking Device

It is a manual method of blending crumb rubber with bitumen; it works in the same principle as that of a commercial blending system. In this device the required shear force is produced by means of manual stirring.
Advantages of manual cooking method:
• Low cost
• Easy to manufacture
• Easy to operate
This technique was used in order to conduct our experiment.

4. Procedure

Nine conventional tests are performed on the four samples of binder (one pure and three modified) in order to analyze the effects of crumbed rubber in the bitumen. All of the tests are performed following the AASHTO/ASTM designation. In order to obtain representative results, all the tests are carried out as preciously as possible following the standards test procedures. In spite of this, due to some instrumental constraint or problems a few tests may have shown some inconsistent results.

4.1 Penetration

Test Method: AASHTO DESIGNATION T 49-93 (ASTM DESIGNATION D5-86).

Summary of the Method: The sample is melted and cooled under controlled condition. The penetration is measured with a Penetrometer by means of which a standard needle is applied to the sample under the specified condition.

4.2 Fire Point

Test Method: AASHTO DESIGNATION T 48-91 (ASTM DESIGNATION D92-85) (Cleveland Open Cup Method)

Summary of the Method: After reaching flash point the sample is more heated pin an open cup and at intervals when fire is applied near its surface. The fire point is recorded very carefully.

4.3 Softening Point

Test Method: AASHTO DESIGNATION T 53-92 (ASTM DESIGNATION D36-89) (Ring and Ball method).

Summary of the Method: The sample is melted and thoroughly stirred to avoid incorporation of air bubbles and to ensure homogeneity in case of modified binder. Then the sample is poured into the ring which was rested on an amalgamated brass plate.

4.6 Specific Gravity

Test method: AASHTO DESIGNATION T 228-93 (ASTM DESIGNATION D70-76).

Summary of the Method: The sample is heated and stirred to be sufficiently fluid to pour. Then sample is poured into a clean, dry and warmed Pycnometer to the three fourth of its capacity. The Pycnometer with its contents is allowed to cool to ambient temperature for a period not less than 40 minutes and is weighted.

4.7 Marshal Stability

Test method: ASTM DESIGNATION D6927-06

Summary of Method: In this test the mix design is computed first i.e., an empirical formula is derived. Then the test specimen is prepared where **t**he "expected design" binder content can be determined from experiences, computational formula or by performing the centrifuge kerosene equivalency and oil soak tests in the Hveem procedure.

5. Results & Discussion

5.1 Penetration Test

Table 1. Result of Penetration test

Test Method	Sample Name	Penetration Test Result	Unit
ASTM D5	60/70 Grade Bitumen	71	0.1 mm
	Mix 5% Tire rubber with Bitumen	69	
	Mix 10% Tire rubber with bitumen	65	
	Mix 15% Tire rubber with bitumen	65	

From the test results, we can see that the more the amount of crumbed rubber is mixed with the virgin bitumen, the more the penetration result decreases. It is to be record that less the penetration is better the pavement quality is for sustainability and longevity.

Table 2. Result of Fire Point

Test Method	Sample Name	Fire Point	Unit
ASTM D92	60/70 Grade Bitumen	346	^{0}C
	Mix 5% Tire rubber with Bitumen	351	
	Mix 10% Tire rubber with bitumen	355	
	Mix 15% Tire rubber with bitumen	360	

5.3 Fire Point

From the test results, we can see that the more the amount of crumbed rubber is mixed with the virgin bitumen, the more the fire point result increases. It is to be record that more the flash point is better the rheological property of the pavement for better sustainability and longevity.

Table 3. Result of Softening Point

Test Method	Sample Name	Softening Point	Unit
ASTM D36	60/70 Grade Virgin Bitumen	47	^{0}C
	Mix 5% Tire rubber with Bitumen	53	
	Mix 10% Tire rubber with bitumen	56	
	Mix 15% Tire rubber with bitumen	58	

5.4 Softening Point

From the test results, we can see that the more the amount of crumbed rubber is mixed with the virgin bitumen, the more the softening point result increases. It is to be record that more the flash point is better the rheological property of the pavement for better sustainability and longevity.

5.8 Marshal Stability

Table 4. Result of Marshal Test

Percent of 60/70 grade Bitumen	15% Mixed Crumb Rubber	5% Mixed Crumb Rubber	10% Mixed Crumb Rubber	15% Mixed Crumb Rubber
4%	19.1	17.19	20.01	19.1
4.50%	21.44	19.11	21.22	21.44
5%	24.9	21.42	24.1	24.9
5.50%	21.19	20.34	22.18	21.19
6%	19.9	19.14	19.1	19.9

From the experiment we can see that after adding different proportions of crumbed rubber for different proportions of virgin bitumen, the pavement sample showing several results which have been plotted in the graph below all together. It is evident after the analysis that for a 15% mixture of crumbed rubber with 5% virgin bitumen gave a very considerable good result compared to other proportions and remarkably from the virgin bitumen alone.

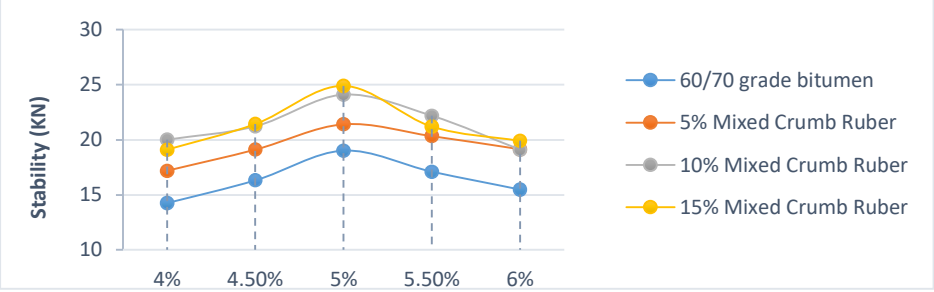

Figure 1 Marshal Stability Curve

6. Conclusion

This after conducting several physical and chemical testes for both ordinary 60/70 grade bitumen and crumbed rubber modified bitumen it is so far evident that in all the parameters, the modification has shown significant amount of better quality which is very important. So far, the crumbed rubber will be available for the usage of the car tires are increasing as a part of growing population in our country. That is the demand for the crumbed rubber for modification can be mitigated from domestic source. Thus, for a climate and population challenging country like ours where the roadways is a part of everyday development can be made more sustainable by using the above mentioned crumbed rubber modified bitumen.

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