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Preliminary Investigation On the Effect of Crumb Rubber (From Waste Tyre) On Nigerian Tar Sand Bitumen and Conventional 60/70

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***Abstract*— In this study, standard laboratory tests such as: Penetration, Viscosity, Softening Point, Specific gravity and Flash/Fire Point tests, were conducted on samples of crumb rubber-modified Tar sand bitumen and crumb rubber-modified conventional 60/70 bitumen, using crumb rubber replacement percentages of 0%, 2.5%, 5%, 10%, 12.5% and 15%.**

***Index Terms*— Bitumen, Crumb rubber (CR), Marshall Stability & Flow, Tar Sand**

I. INTRODUCTION

Nigeria's road network of about 200,000km is largely in a bad state despite the fact that Nigeria is reputed for having the second largest deposit of bitumen in the world, spanning approximately 120 kilometers across Ogun, Ondo, Lagos and Edo State [1]. The estimated probable reserve of bitumen in Ondo state alone is 16 billion barrels, while that of Tar Sands and Heavy Oils is estimated at 42 billion barrels. Its primary use (70%) is in road construction as a binder mixed with aggregate particles to form Asphalt Concrete [2]. About 80% of Asphaltic materials used for road construction in the country is still being imported despite our vast bitumen deposit. The high cost of pavement construction makes it imperative to seek for alternatives to conventional bitumen. A rheological weakness of conventional bitumen has generated an increasing interest in the use of polymer-modified binders to enhance conventional bitumen properties [3]. To modify the natural bitumen obtained from tar sand, it is important to employ readily available and abundant waste material such as scrap tyre rubber.

Crumbed rubber tyre, CR, is usually defined as rubber having a particle size of 9.5mm (3/8 inch) or less [4].

Tar sand, also known as Bituminous Sand or Oil Sands are naturally occurring deposits containing loose sands or particularly consolidated sandstones that are saturated with highly viscous bitumen [5].

II. MATERIALS AND METHODOLOGY

The materials used in this research work include: Tar sand, Crumb rubber, and Conventional 60/70 Bitumen.

2.1 Tar Sand

Tar sand used for the purpose of this research was collected at Imeri village, Ijebu Mushin, Ijebu East Local Government area of Ogun state which lies between latitude 06^0 46'N and 06^0 47'N and longitudes 003^0 59'E and $003^0$59'E [8]. Its properties are highlighted in TABLES 1 and 2 below.

Table 1: Properties of Tar Sand Sample

Bitumen Saturation		
Samples	A	B
Weight of Tar Sand (g)	2474.7	2468.2
Weight of Sand (g)	2008.5	2002.0
Weight of fillers (g)	283.4	278.2
Weight of bitumen (g)	182.8	177.6
% of weight of Bitumen	7.4	7.2
Average % weight of bitumen	7.3	

Table 2: Gradation Analysis of Tar Sand

Sieve sizes	**Cumulative weight**	**% Cumulative retained**	**% Cumulative passing**
25mm	-	-	-
19.5mm	-	-	-
12.5mm	-	-	-
9.5mm	9.00	0.44	99.56
4.75mm	58.90	2.94	97.06
2.36mm	115.70	5.76	94.24
1.18mm	184.50	9.18	90.82
600mm	292.30	14.55	85.45
300mm	657.60	32.74	67.26
150mm	1684.50	83.86	16.14
75mm	2002.10	99.68	0.32
Pan	2005.00		

2.2 Crumb Rubber (CR)

Crumb rubber (from Scrap tyres) used for this research was obtained from Tensquare Engineering Services Ltd, Lagos. Its properties are shown in TABLE 3.

Table 3: Properties of Crumb Rubber sample

S/N	**Properties**	**Test Result**
1	Size	Passing 600-micron sieve
2	Specific gravity	1.104
3	Moisture content	0.84%

Figure 1: Crumb rubber sample

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2.3 Conventional 60/70 Bitumen Sampling

The 60/70 conventional bitumen used was collected from JB Euro65 lab supplied by ASCA Bitumen Ltd, Sapele, Nigeria.

2.4 Methodology

The series of laboratory tests conducted are listed in TABLE 4.

Table 4: List of Laboratory Tests Conducted

Mixture	Test Conducted
First Set of Tests (Preliminary Tests)	
Bitumen sample only (60/70 ASCA, Tarsand Bitumen)	Penetration
	Viscosity
	Specific Gravity
	Flash and Fire Point
	Softening Point
	Solubility
Second Set of Tests	
Bitumen Samples (60/70 ASCA) + Crumb Rubber (2.5% -15%)	Penetration
	Viscosity
	Specific Gravity
	Flash and Fire Point
	Softening Point
Bitumen Samples (Tar Sand Bitumen) + Crumb Rubber (2.5% -15%)	Penetration
	Viscosity
	Specific Gravity
	Flash and Fire Point
	Softening Point

The laboratory tests were conducted according to ASTM D2172- Standard Test Method for bitumen extraction, ASTM D5/D5M - Standard Test Method for Penetration, ASTM D36 / D36M – Standard Test for Softening Point, , ASTM C136/ IS: 1206-1978-Standard Test for Viscosity by Tar Viscometer and ASTM C136- Sieve Analysis of aggregates.

III. Results, Analyses and Discussions

3.1 Effect of Crumb Rubber (CR) on Penetration value, Softening Point, Viscosity, Flash and Fire Point Values of Tar Sand Bitumen and 60/70 Conventional Bitumen

From the results obtained and listed in TABLES 5 and 6, it was observed that penetration values decreased linearly for both tar sand bitumen and conventional 60/70 bitumen as crumb rubber content was varied. However, the values of softening point, viscosity, flash and fire point increased linearly. The results are shown diagrammatically in Fig 5, 6, 7, 8 and 9.

Table 5: Effect of Crumb Rubber on Properties of Conventional 60/70 ASCA Bitumen

LABORATORY TESTS	BASE BITUMEN PROPERTIES (Unmodified)	CRUMB RUBBER REPLACEMENT (%)						
		2.5	5.0	7.5	10.0	12.5	15	20
Penetration	62.6	43.9	41.2	40.5	37.5	31.2	25.4	-
Softening Point	50.6	53.2	57.6	59.6	65.8	66.6	71.2	-
Viscosity	22.5	-	23.5	-	25.5	-	27	28
Flash point	150	185	210	210	220	221	225	-
Fire point	235	240	243	250	255	260	265	-

Table 6: Effect of Crumb Rubber on Properties of Tar Sand Bitumen

TEST	BASE BITUMEN PROPERTIES (Unmodified)	CRUMB RUBBER REPLACEMENT						
		2.5%	5.0%	7.5%	10.0%	12.5%	15%	20%
Penetration	82	77.3	70.3	65.1	59.3	48.1	45.0	-
Softening Point	50	60.2	62.5	67.4	69.8	73.0	75.8	-
Viscosity	16	-	16.7	-	17.5	-	18	21
Flash point	165	165	190	220	230	235	250	-
Fire point	245	260	265	265	265	270	280	-

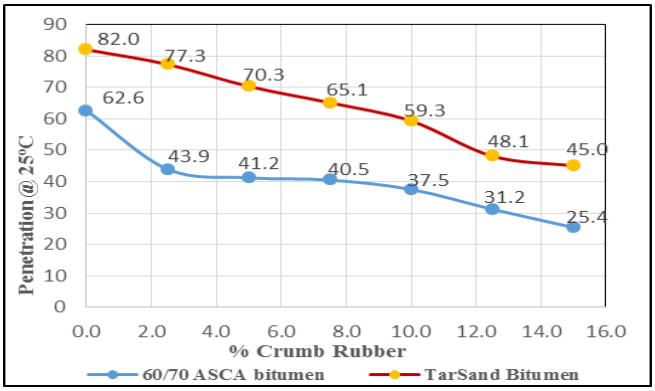

Figure 5: Variation of Penetration with Crumb rubber (CR) content

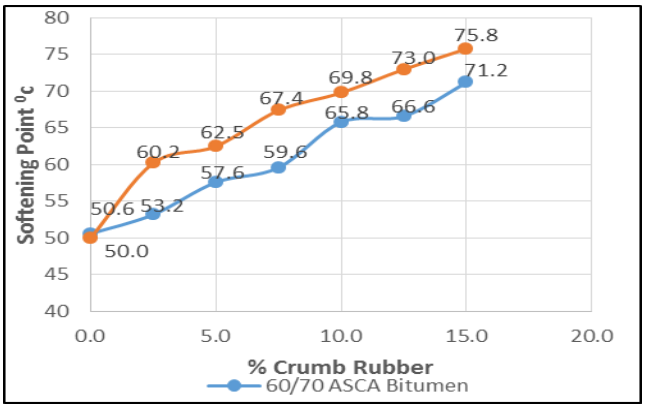

Figure 6: Variation of Softening Point values with Crumb rubber (CR) content

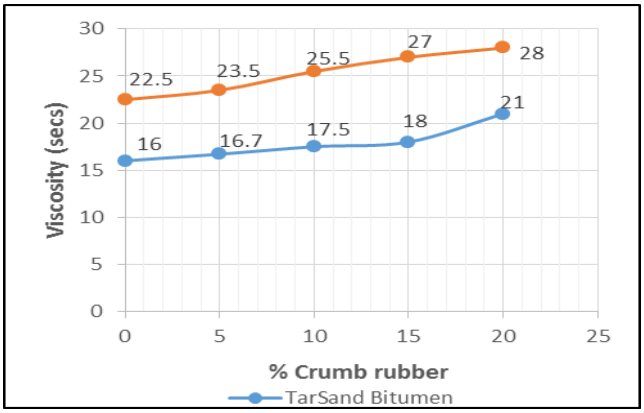

Figure 7: Graph of Viscosity against % Crumb Rubber

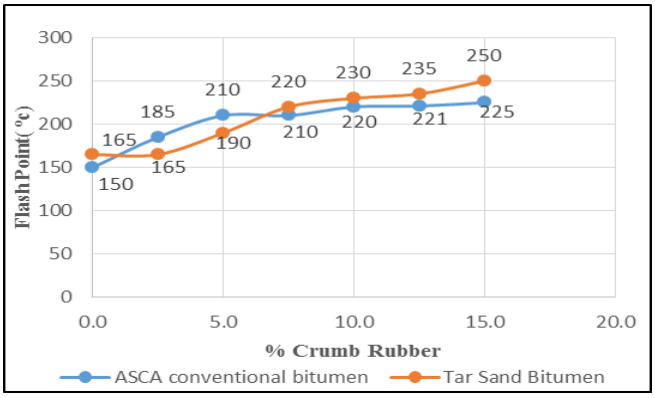

Figure 8: Graph of Flash Point against % Crumb Rubber

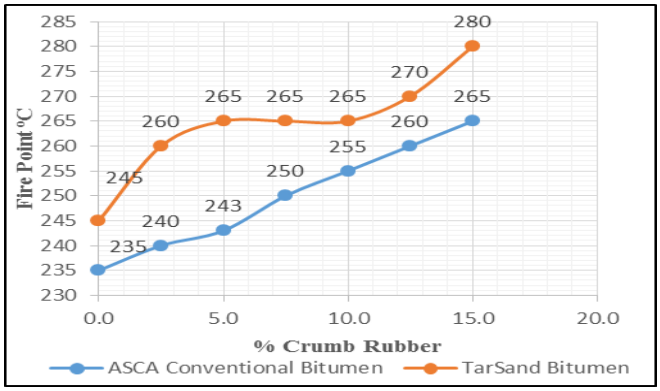

Figure 9: Graph of Fire Point against % Crumb Rubber

IV. CONCLUSIONS

From the results of the investigation carried out within the scope of the study, the following conclusions can be drawn:

- Tar Sand collected contained an average of 7.3% bitumen content. The gradation shows more than 90% of the sand retained on the 75mm sieve. Tar sand bitumen had an average penetration value 82 pen (Grade 80/100) and Softening Point of 50°C.
- The use of crumb rubber decreases the penetration value of both Bitumen types (Tarsand bitumen and 60/70 conventional bitumen) and increased the Softening point, Viscosity, Flash and Fire point, and Specific gravity values of Tarsand bitumen and conventional 60/70 bitumen.
- Asphalt modification by crumb rubber provides benefit through improvement of rutting resistance and reduction of fatigue/reflection cracking due to higher viscosity and softening point; thus, improving the service life of pavement and lowering pavement maintenance costs.

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