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Assessing the Performance of Agbabu Natural Plain Bitumen

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Abstract - The paper presents a preliminary evaluation of bituminous material obtained from Ondo State naturally occurring plain bitumen deposit situated in Agbabu, Odigbo Local Government Area of the state. It was aimed at assessing the binder qualities of the bitumen. The tests carried out on the bitumen were with the view of determining the binder properties in comparison with the standard specifications set by the Asphalt Institute and America Standards for Testing and Materials (ASTM). The tests involved solubility, loss of heating, specific gravity penetration and viscosity test. The results show that the bitumen sample contained 95% "percent bitumen" and approximately 28.8% loss in weight on heating during heating to temperature range of 160 -180ºC. It was also determined that the specific gravity and penetration value for the bitumen are 2.05 and 94 respectively.

Key words: Plain bitumen, bituminous, deposit, binder, qualities

1. Introduction

The importance of a good and adequate road system to the socio economic development of a developing nation, as in the case of Nigeria, cannot be overemphasized. "Unfortunately, the cost of highway construction in the country is galloping, a basic factor responsible for this ugly development being the continuous increase in the cost of construction materials. One of the means of taming costs is to make use of cheaper and readily available materials for the construction of roads". Such efforts can be geared towards assessing the various alternative sources of materials.

Nigeria is highly blessed with naturally occurring bitumen deposits which provide an alternative source of bitumen which is the most essential ingredients for the construction of flexible pavements. Such deposits occurred in large quantities in some countries like Canada, United States of America, Venezuela, Malagasy etc. however, it is worth noting that while concerted efforts are continuously made for the evaluation and exploration of the naturally occurring bitumen deposits of other nations, Nigeria pays significantly low attention to her vast deposit and continues to spend billions of naira of her limited foreign exchange to import raw materials in the form of asphalt yielding crude petroleum from other nations for the production of bitumen for pavement construction and other purposes.

Searching for oil and bitumen commenced in Nigeria even before her birth as a political entity (Onoh 1993; Nwaochei 1996). "According to Onoh (1993), a German company bagan bitumen exploration in Nigeria in the year 1908 along the coast region from Okitipupa in Ondo State to Lagos. The hydrocarbon discovered in 1909 was on the tar sand belt in the coastal area of the western part of the country (Etete, 2005)". Although very dense crude oil was manufactured from the well sunk on the deposit, the discovery of light to medium oil in commercial quantity at Olobiri in the NigerDelta area in 1956.

Based on the background, there arises a need to pay greater attention on the naturally occurring bitumen deposits in Nigeria such as the one located in the south western part of the country, Ondo State and eventual utilization can be expected to have a great impact on cost minimisation and foreign exchange preservation.

2. Materials and Methods

2.1 Sample collection

The sample of plain bitumen used for this work was obtained from the NBC-7 well situated in a compound directly opposite Community Primary School Agbabu at Odigbo Local Government area of Ondo State. The well is approximately 286 metres deep and is lined with a 250mm steel casing.

2.2 Laboratory work

2.2.1 Solubility test

The test was carried out on a portion of the raw sample. The mixing container was weighed and recorded. A small portion of the bituminous sample was later added and weighed. "A weighed volume of petrol was added into the container to dissolve the sample. After ensuring that it had totally dissolved, the sample was subsequently filtered through a weighed fine porosity filter. Insoluble material container in the filter was dried and cooled and the weight of the filter and residue retained was later determined". Then the percentage of soluble material would be calculated by the difference and is referred to as percent bitumen.

2.2.2 Loss of heating test

The test was equally performed on a portion of raw sample collected from the field. Weighted sample of the raw bitumen was put in a metal container and heated to the required temperature of 165^{o}C. Heating was continued for nest 15 minutes and removed from the hot plate. Later, it was allowed to cool to room temperature and weighed, there was loss of weight, which would be expressed as a percentage of the original weight.

2.2.3 Specific gravity test

The specific gravity of a bituminous material is defined as the ratio of the weight of a given volume of the material at 25^{o}C to that of an equal volume of water at the same temperature. "The test was carried out on a portion of bitumen sample after it has been heated to drive off the water content. The pycnometer with stopper was cleaned and dried; and placed on an analytical balance. The weight was later recorded as W_o. The pycnometer was then completely filled with distilled water, after ensuring that the distilled water was at the standard temperature of 25^{o}C. The stopper inserted and the weight reading taken and recorded as W_w. A small portion of the bitumen was heated gently and poured into the pycnometer after the water had been removed. It was allowed to cool to the same temperature". The pycnometer with contents was placed on the balance and reading recorded as W_2. The pycnometer was then completely filled with water, the stopper inserted as before and the pycnometer weighed again and recorded as W_3. The procedure was carried out for two other bitumen samples.

2.2.4 Penetration test

The penetration of a bituminous substance is defined as the distance (in hundredths of a centimetre) to which a standard needle penetrates the material under known conditions of time, loading and temperature. A portion of the bitumen was heated and thoroughly stirred to ensure uniformity. "The heated bitumen was poured into an ointment tin to within 3.175mm of the tin. It was immediately flamed to remove air bubbles. The container was covered to prevent contamination by dust and allowed to cool at a room temperature for approximately one hour. The sample was later put in the transfer dish, which had been filled nearly full with water from the water bath. The sample was completely submerged during the test. The transfer dish containing the sample was then placed upon the stand of the penetration. The penetrometer apparatus was ensured that it had been levelled before conducting the test. The needle adjusted so that the point of the needle was just in contact with the surface of the sample. The penetrometer dial adjusted to zero. The needle was released for 5 seconds after which the penetrometer adjusted to obtain the distance penetrated". A total of three penetrations were made and it was ensured that no penetration spot was closer than 1 cm from the side of the container or from the previous penetration spot.

2.2.5 Viscosity test

Viscometer is used to perform the test at a temperature of 135oC. At this temperature the asphalt is sufficiently fluid to flow through the capillary tube under the gravitational forces and there is no need to apply any partial vacuum. This temperature was selected because it approximates the mixing and laydown temperatures used in the construction of HMA pavements.

Asphalt is poured into the large opening of viscometer until it reaches the filling line. "The viscometer is then placed in a clear oil bath medium to obtain the equilibrium temperature. A slight vacuum is applied for the small opening or a slight pressure is applied to the large opening to induce the flow of the bitumen over the siphon section just above the filling line. Then the gravitational forces cause the asphalt to flow downward in the vertical section of the capillary tube. A stopwatch is used to measure the time (in seconds) required for the asphalt cement to flow between the two timing marks". The kinematic viscosity in centistokes is obtained by multiplying this time by the calibration factor supplied with the viscometer tube.

3. Results and Discussion

3.1Solubility Test

The test was performed to determine the percentage of bitumen contained in the sample. The test was repeated three times in order to minimise the experimental error. The summary of the result was presented in Table 1. According to Table 1, the mean value was 94%. The results indicate that 94 % of the new bitumen sample is actually bitumen content which implies that percent bitumen of Agbabu natural plain bitumen is 94%.

Table 1: Centrifuge bitumen extraction test

Sample	1	2	3
Bitumen content (%) on the total weight in the mixture	93.9	93.9	94.2
Average		94.0%	

3.2 Loss of heating test

The test was carried out to determine percentage loss in weight of the raw bitumen sample on heating. The loss of heating result was presented in Table 2. From Table 2, the mean value was obtained as 27.8%, the result shows that percentage of water and volatile sub stances given off within the temperature range out of 100% raw sample is 27.8%. This shows that the percentage loss in weight of Agbabu natural plain bitumen on heating to temperature range of 160^{o}C – 180^{o}C is 27.8%.

The findings of behaviour of the sample during heating are thus recorded. Cracking sounds and foaming are indicative of the water presence (ASTM, 1978) in the sample were noted and these gradually become more pronounced with continued heating in the process of which water being evaporated. Volatile constituents evolved as vapours resembling slightly dark fume having an unpleasant choking smell. At the commencement of heating, it was characterized by increasing fluidity. As the temperature is increasing, its viscosity increases, it becomes more resistance to air the bowl contents as a result of increasing hardening coupled with the settling down of suspended matter.

Table 2: Loss of heating test result

Sample	A	B	C
Weight of container (g)	288.0	288.0	288.0
Weight of container before heating + sample (g)	488.0	488.0	488.0
Weight of container after heating + sample (g)	432.4	432.0	432.6
Weight loss (g)	55.6	56.0	55.4
% of loss in weight (%)	27.8	28.0	27.7
Average % loss in weight (%)		27.8	

3.3 Specific gravity

The result of specific gravity was presented in Table 3. It can be ascertain from Table 3 that the specific gravity of the bitumen sample was 2.47 which falls within the normal range of refinery penetration grade bitumen which lies in the range of 1,00 – 1.05 (O'Flaherty, 1974). From the specific gravity result of the bitumen, it clearly shows that the bitumen of a given volume is 1.04 times denser than water of equal volume at the same temperature.

Table 3: Specific gravity test

Sample	A	B	C
Weight of pycnometer (g) = W_1	288.0	288.0	288.0
Weight of pycnometer + bitumen only (g) = W_2	488.0	488.0	488.0
Weight of pycnometer filled of water only (g) = W_3	432.4	432.0	432.6
Weight of pycnometer + bitumen + water (g) = W_4	55.6	56.0	55.4
Weight of bitumen = $W_2 - W_1$	27.8	28.0	27.7
Specific gravity of bitumen = $\frac{W1-W2}{(W3-W1)-(W4-W2)}$	2.48	2.42	2.51
Average of specific gravity of bitumen		2.47	

3.4 Penetration test

The test was carried out to determine the penetration grade of the bitumen sample. The test was repeated five times so as to reduce the experimental error. The penetration test result was presented in Table 4. From Table 4, the average penetration was obtained as 91. The penetration result implies that the plain bitumen falls into the category of 80/100 class of bitumen as classified by Shell for bitumen grades requirement (NNPC1990). The result of the penetration test shows that the Agbabu bitumen is soft, which could make it to deform under a very high temperature and reduce its durability when used as asphaltic cement.

Table 4: Penetration test result

Sample	A	B	C	D	E
Initial reading	0	0	0	0	0
Final reading	89	92	91	90	93
Penetration value	89	92	91	90	93
Average penetration value			91.0		

3.5 Binder viscosity

Viscosity grading of bitumen binders is based on viscosity measurement at 60^{o}C and 135^{o}C as suggested by the Strategic Highway Research Program (SHRP) (Read and Whiteoak, 2003). To obtain a viscosity value at 60 ^{o}C, the test was initially performed at 90^{o}C since the spindle of the Viscometer cannot rotate effectively when used at 60^{o}C. The value of viscosity at 60^{o}C was later obtained by using a linear interpolation of viscosity at temperatures of 90^{o}C and 135^{o}C. The line is linear because viscosity is the ratio between shear stress and shear rate.

According to the SHRP, the shear rate is determined as a constant variable, i.e. 6.8/s and remains constant for all test temperatures. The linear relationship between viscosity values was used by Rusbintardjo (2011) to determine the proper mixing and compaction temperatures of the HMA. The linear relationship between viscosity values is illustrated in Figure 1. The detailed viscosity test results are summarised in Table 5. As noted from Table 5, the average viscosity at 60^{o}C and 135^{o}C is 22700 and 358 respectively.

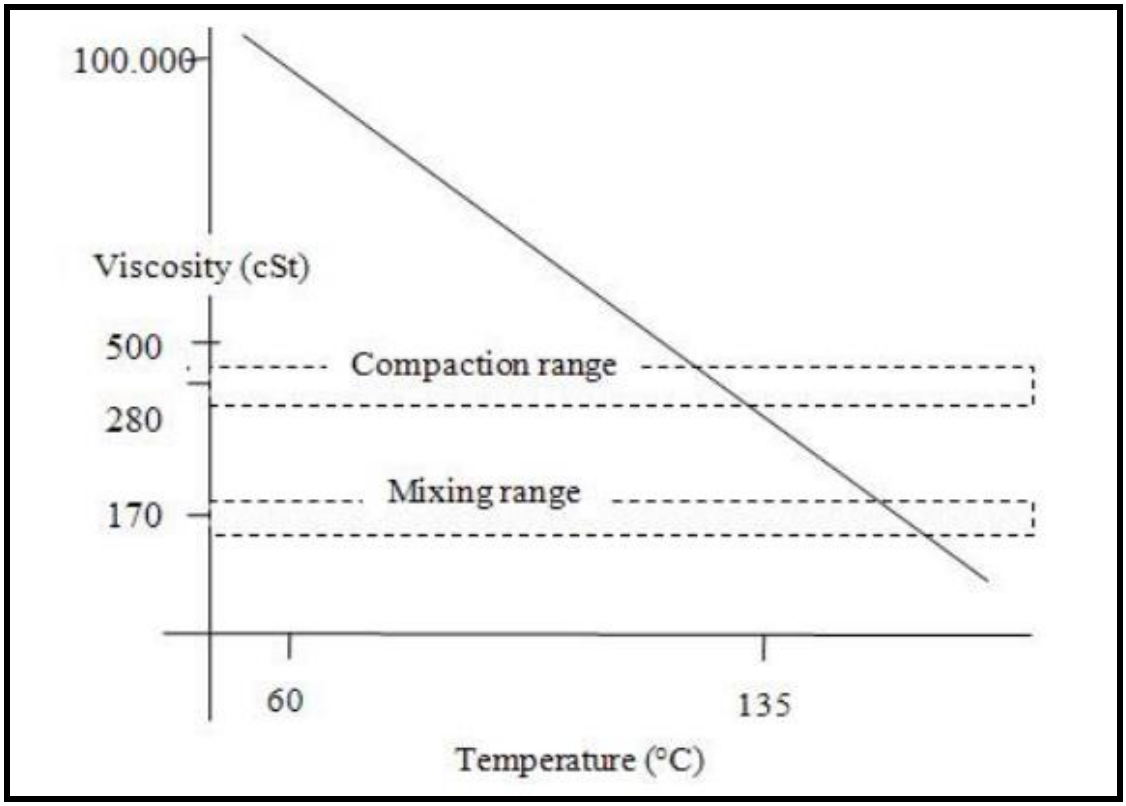

Figure 1: Temperature-Viscousity relationship (Lavin, 2003)

Table 5: Viscosity test result of the binder

Sample	Viscosity values (cP)	
	60 °C	135 °C
A	23200	400
B	22400	380
C	22700	330
D	22500	320
Average	22700	358

4. Conclusion

The binder properties of Agbabu bitumen have been evaluated based on the limited tests, loss on heating, specific gravity, penetration and solubility test. This has led to better understanding of the behaviour of the plain bitumen hence the following conclusion can be drawn from the research work carried out. The plain bitumen was foaming on heating because of the presence of sizeable quantity of water. The unpleasant odour noticed during heating may be as a result of decaying organic matter, which the plain bitumen might contain during formation under the ground. The plain bitumen was soft and can be easily deformed when used in road pavement construction based on the penetration test. The plain bitumen cannot be used directly for road asphaltic concrete based on the findings of Adedimila and Olagoke 1990. Suitable modification can be applied to the plain bitumen as reported to be done for natural bitumen in Trinidad Lake asphalt (Knebs and Walter, 1991)

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