INFLUENCE OF CEMENT ON COLD MIX ASPHALT

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Abstract

Asphalt is the combination of bitumen, aggregate and fillers in correct proportions. In this study, production of cold mix asphalt (CMA) was done using cold bitumen and modified with Portland cement. Asphalt produced with ordinary bitumen was used as control for the asphalt. The produced asphalt was then subjected to physical strength test in the laboratory. It was discovered that the stability and flow of asphalt produced with ordinary bitumen and that produced with modified bitumen was found to be 1,154.20 kg, 2.17 mm and 1,400 kg, 3.20 mm respectively it could be said that the modified bitumen asphalt and ordinary bitumen falls within the specification by the federal ministry of works and housing, roads and bridges (FMW&H) (1997) Code. The use of Portland cement resulted in strength increase of the cold mix asphalt.

Keywords: Cold mix asphalt, cement, modifier, stability.

1.0 INTRODUCTION

The Road is a thoroughfare, route, or way on land between two places, which has been paved or otherwise improved to allow travel by some conveyance including a horse, cart or motor vehicle (Ashworth, 1972). Pavements are floor like or tired structures constructed of either asphalt or concrete and ultimately rest on a natural soil (Devesh, 2014). Pavement is a structure consisting of superimposed layers of selected processed and unprocessed materials whose primary function is to distribute the applied traffic loads to the sub-grade (O'Flaherty, 1988). Pavement is the actual travel surface specially made durable and serviceable to withstand the traffic load coming upon it. Pavement provides friction for the vehicles thus providing comfort to the driver and passenger, and hence transfers the traffic load from the upper surface to the natural soil (Yoder, el ta; 1975). In earlier times before the vehicular traffic became most regular cobblestones, paths were much familiar for animals, carts and on foot traffic load. All hard roads pavement is normally categorized into two broad categories which are flexible and rigid pavement (Kadiyali, 1984).

Flexible pavements have its topmost layer as asphalt and reflect failure of sub-grade and the subsequent layers to the surface. The design of flexible pavement is based on load distributing characteristic of the component layers. While rigid pavement are pavements with a concrete surface, typically a concrete slab over underlying layers of stabilized or unstabilized base or sub-base materials. This type of pavement relies on the substantially higher stiffness of the concrete slab to distribute the traffic loads over a relatively wide area of underlying layers and the sub-grade. Some rigid concrete slabs have reinforcing steel to help resist cracking due to temperature changes and repeated loading on the pavement (O'Flaherty, 1988).

Pavement design is based on the premise that specified levels of quality are to be achieved for each layer in the pavement system. Each layer must, resist shearing within the layer, avoid excessive elastic deflections that would result in fatigue, cracking within the layer or in overlying layers and prevent excessive permanent deformation through densification (Yoder, 1975). As the quality of a soil layer is increased, the ability of that layer to distribute the load over a greater area is generally increased enough to permit a reduction in the required thickness of the soil and surface layers (Asworth, 1972).

Bituminous roads are road in which bitumen is used as a binder in its construction. It consists of appropriate mixture of aggregates, mineral filler and bitumen. The quality and durability of bituminous road is influenced by the type and amount of filler material in used (Kadeyali, 1997). The bitumen could come in different form and type. Bitumen when in cold form could also be used in the production of asphalt but the setting time or period will be longer than hot mix asphalt to reduce the setting time and improve its properties, that why an attempt was made to stabilizing the cold asphalt with cement with an attempt to improve the slow development of strength of emulsion treated mixes. The cement was added to the aggregate at the time the bitumen emulsion was incorporated.

2.0 METHODOLOGY

The materials used in this study were obtained from MSSR Carboncore Construction Company sokakahuta, Minna, Niger State. These materials include Cold bitumen, Aggregates, Stone dust and filler materials.

Material Properties Test

The following test which include, Sieve Analysis, Specific Gravity, Aggregate Impact Value, Crushing Value and Elongation Test were carried out in accordance to BS 812 Part 1 and the result obtained was compared to the General specification, Road and Bridges (1999) and it was found to be in conformity with the gradation requirement for aggregate to be used for asphaltic pavement.

Mix Design/Replacement Method

Mathematical method was used to determine the percentage requirement for each aggregate after it has been subjected to gradation test, this method in accordance AASHTO T27. The cold bitumen of 6% was added to already blend aggregates of 1,200g and compacted according to (FMW&H, 1999) this step was repeated for 15 other samples with bitumen increase of 0.5% to a total of 13%.

The optimum bitumen content was determined through the Marshall Test analysis after which the optimum bitumen content was subjected to improvement with ordinary Portland cement in the range of 1% increase up to 15% according to FMW&H (1999)

The improvement method was an adopted style of this work to determine the optimum cement content to be added to the optimum bitumen content and determine the cement content which is best as addition to the asphalt. The cold asphalt was produced using cold bitumen and cold aggregates after the integrity test on the aggregates has been done and are in conformity with BS 812.

Marshal Stability Test for Cold – Mix Asphalt

The results were computed and the graph of density, void bitumen, Marshal Stability, void in total mix, flow was plotted against percentage of bitumen by weight and Portland cement by weight.
The trend in which the above outlined steps were in accordance to BS 812 achieved is as follows;

i. The mixture of binder (cold bitumen) and aggregate was put in the mould and was compacted with the specific number of blow of 4.54Kg compacted rammer falling through 457mm unto the top and bottom of each of the samples

ii. The bulk unit weight of each sample was next determined by weighing the sample in air and in water and was calculated as:

$$D = \frac{WA}{V} = \frac{WA}{WA - WW} \quad (1)$$

Where
d = bulk weight, g/cm^2.
W_A = weight of sample in air, g.
V = volume of sample, cm^3.
W_W = Weight of the sample in water, g

iii. The percentage of air void in each compacted sample is calculated by first of all determining the maximum theoretical unit weight and then expressing the difference between it and the actual unit weight as a percentage of total volume of the sample. The maximum theoretical unit weight can be visualized as the unit weight which could result if the sample had been compacted such that they were no void in aggregate binder mixture. Thus,

$$U = \frac{WA}{Vb+Vc+Vf+Vmf} \quad (2)$$

$$U = \frac{WA}{\frac{Wb}{Gb}+\frac{Wc}{Gc}+\frac{Wf}{Gf}+\frac{Wmf}{Gmf}} \quad (3)$$

Where;

W_A = weight of the sample, g
V_b = volume of binder in sample, m^3
V_c, vf and V_{mf} = volume of coarse, fine and mineral filler fractions, respectively of the aggregate in sample, cm^3
W_b = weight of binder in sample, g
W_c, W_f, W_{mf} = weight of coarse, fine and mineral fractions of the respective aggregate in sample, g
G_b = Specific gravity of the binder

G_c, G_f, G_{mf} = apparent specific gravities of coarse, fine and mineral filler fractions respectively of aggregate in sample

iv. The percentage of air void in the compacted sample is obtained by subtracting the actual from the theoretical unit weight and expressing the difference as a percentage of the theoretical unit weight. Thus,

% V.T.M = void total mixture, that is in the sample, %

U_t = theoretical maximum unit weight, g.cm^3

and d = bulk unit weight, g/cm^3

Also the percentage of void in compacted mineral aggregate frame work which is filled with binder is calculated by first determined the amount of void in aggregate framework (V.M.A) and then calculating the percentage filled with the binder material. The V.M.A is obtained by subtracting the volume occupied by the aggregate in the compacted sample from the bulk volume of the compacted sample that is the volume of the voids which in theory is available for filling with binder. Thus,

$$V.M.A = V - V_c - V_f - V_{mf} \quad (4)$$

$$\frac{W}{d} - \frac{Wc}{Gc} - \frac{Wf}{Gf} - \frac{Wmf}{Gmf} \quad (5)$$

Where V.M.A = Void in mineral aggregate framework, cm^3 and the training symbols are have been defined earlier.

$$\%V.M.A = V.M.A \times \frac{10}{V} \quad (6)$$

Where % V.M.A = Void in mineral framework, percentage of total mix.

V.M.A = void in mineral aggregate framework, cm^3 and

V = total volume of sample, cm^3

The percentage of void in aggregate framework which is filled with the binder is determined from;

$$\%\text{ voids filled with binder} = V_b \times \frac{100}{V.M.A} \quad (7)$$

Where V_b and V.M.A are described above.

The same percentage may also be calculated from the following equation:

$$\%\text{ voids filled with binder} = \frac{\%\,V.M.A - \%\,V.T.M}{\%V.M.A} \quad (8)$$

Where % V.M.A and %V.T.M are the percentage of void in mineral aggregate framework and in a compacted mixture respectively.

v. Determine the marshal stability and flow of each sample. The marshal stability of test sample is the maximum load, in Newton, required to produce failure when the sample is preheated to a prescribed temperature place in special testing and the load applied at a constant rate of strain of 50.8mm/min. While the stability test is in progress, a dial gauge is used to measure the vertical deformation of the sample; the deformation read at the load failure point is the flow value of the sample.

vi. The measured stability value is corrected using Stability Correlation Ratio Table.

3.0 RESULTS AND DISCUSSION

Material properties

The test result on aggregates used, showed that the properties such as the specific gravity value, water absorption, impact and crushing value are within the recommended value for aggregates to be used for asphalt production as such they were certify good for the asphalt production as can be seen in Table 1.

Table 1. Obtained and Standard Properties of Aggregates

S/No.	Properties	Obtained Result	Specified Standard
1	Impact Value	17.70%	< 30 %
2	Crushing Value	15.98%	< 30 %
3	Specific Gravity	2.65%	2.4 – 2.9 %
4	Water Absorption	0.25%	0.2 – 1.5 %

Figure 1 shows the result of aggregates blending for all the aggregates materials used. It's also shows the upper and lower limit for the aggregates. It was observed that the materials lie perfectly within the envelop in Figure 1

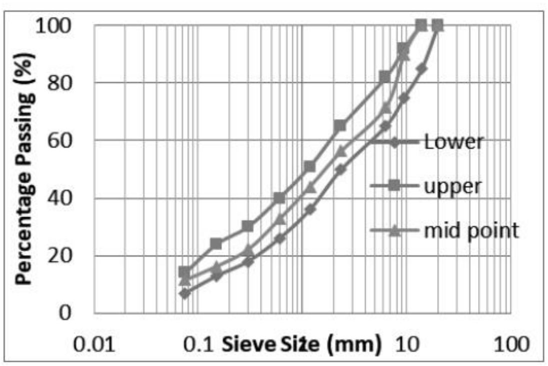

Figure 1. Aggregates gradation chart

Optimum Bitumen Content and Marshall Stability Test

Shown in Figure 2 to Figure 6 are the Marshall test result for the cold asphalt before the addition of cement. The maximum unit weight (density), stability, void in total mix, void filled with bitumen and optimum bitumen content were obtained. The optimum binder/bitumen content (OBC) was selected as the average binder content for maximum density, maximum stability and specified percentage air voids in the total mix and was obtained to be 9.33%.

Figure 2, shows the Marshall stability result for un-stabilized cold asphalt, at 9.33 % the stability was obtained to be 1,152.4 Kg

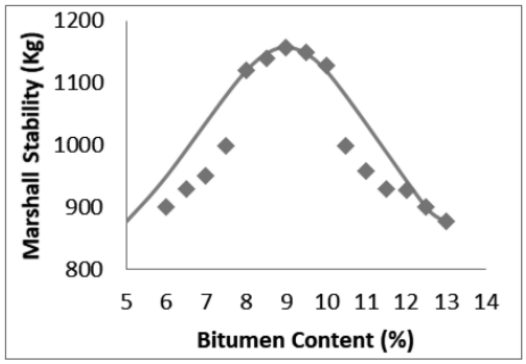

Figure 2. Marshal Stability against Bitumen Content

Figure 3, shows void in total mix, at 9.33 % void in total mix is 4.5 %. The maximum density as indicated in Figure 4 at 9.33 % was 2.3 which was far from the maximum theoretical of 2.45. The flow for the Marshall test foe the un-stabilized asphalt at 9.33 % OBC is 2.5 mm, which is within the recommended value 0f 2mm – 4mm for hot mix asphalt to be use on the highway.

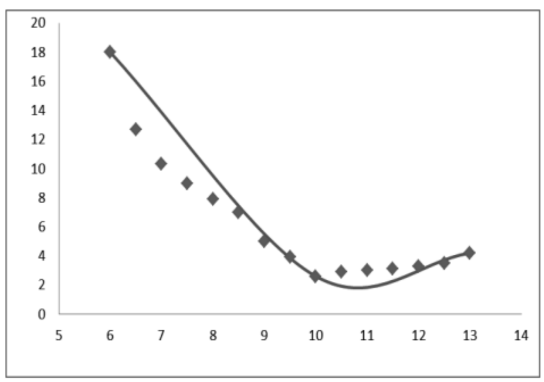

Figure 3. Void in Total Mix against Bitumen Content

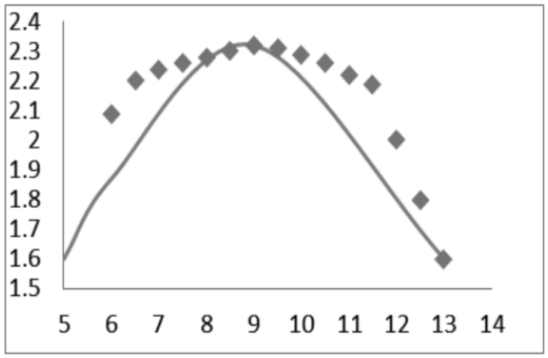

Figure 4. Unit Weight against Bitumen Content

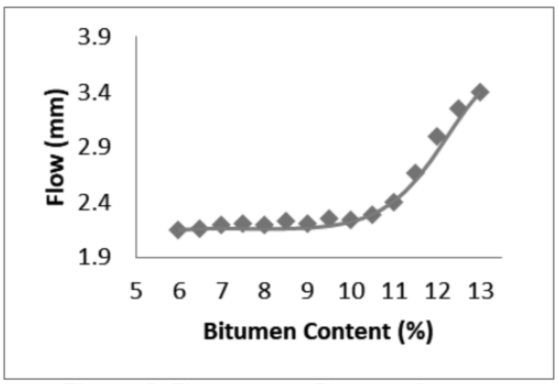

Figure 5. Flow against Bitumen Content

Addition of Portland Cement in Percentage Proportion

After the Optimum binder content has been obtained to be 9.33% cold bitumen by weight of the total mix, the value was then used to produce the modified cold asphalt with Portland cement as the modifier. The percentage of Portland cement addition was 1 to 14% at percentage increment of 1% up to 14%.

Table 2. Marshall Stability Results for Modified Asphalt

Cement Addition (%)	**Stability (kg)**	**Flow (mm)**	**Density g/m^3)**	**Void in Total Mix (%)**
0	1,152.4	3.32	2.18	5.22
1	1,292.4	3.15	2.17	5.65
2	1,305.1	2.96	2.18	5.21
3	1,312.7	3.00	2.23	3.04
4	1,348.1	3.22	2.19	4.78
5	1,426.9	3.20	2.22	3.47
6	1,415.1	3.42	2.17	5.65
7	1,406.7	3.40	2.26	1.74
8	1,343.2	2.95	2.27	1.30
9	1,342.9	3.10	2.19	4.78
10	1,285.4	3.12	2.22	3.48

11	1,299.6	3.00	2.21	3.91
12	1,286.7	3.33	2.28	1.43
13	1,181.9	2.96	2.17	5.65
14	1,196.5	3.16	2.27	1.30

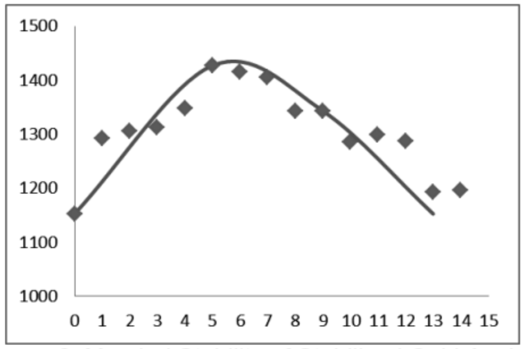

Figure 6. Marshal Stability of Stabilized Cold Asphalt

Figure 6, shows the Variations in Stability of Bitumen with Increase in Percentage of Portland cement. From the Figure 6, it was observed that the point at which the maximum stability occurs was at 5.88% addition of cement.

4. 0 CONCLUSION AND REMARKS

The following conclusions were drawn;

- The optimum bitumen content for the cold bitumen was obtained to be 9.33% this was found to be in conformity with Kolo and Jimoh (2008) finding of bitumen content for various cold asphalt mixes
- The stability of cold asphalt before stabilizing was 1,154.2 kg and after stabilizing its improved to 1,400 Kg, which shows a significant improvement in the stability and durability. Addition of 1% produced an increase in stability of 112% over that of untreated specimens. Specimens without cement immersed in the water after stability tests disintegrated after 24hours, whereas cement treated specimens indicate no deterioration, this was able to prove the work carried out by Head (1974) and Dardak, (1993) where cement was added to sand emulsion mixtures.
- The cement content at which the stability was at its best was 5.9 %
- The asphalt was discovered to have set faster after the addition of stabilizing agent i.e cement.
- It was concluded that mixes treated in this way cured faster, developed a high modulus of resilience (M_r) more rapidly, and were more resistant to water damage. The rate of development of M_r in emulsion treated mixes is greatly accelerated by the addition of cement. (Schmidt, et al 1973).
- Addition of cement had a very significant effect on mix stability and its shows that cement is a good stabilizing agent when durability and stability properties are to be tested.
- Other properties such as density, void in total mix and flow also exhibited improvement in their properties.

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