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Research article

PREDICTING THE PERFORMANCES RATE OF CALM SHELL ASH APPLICATION IN ASPHALT FOR FLEXIBLE PAVEMENT

[1]Nwaobakata C and [2]Eluozo, S. N.

[1]Department of Civil Engineering, University of Port Harcourt
E-Mail: makus20002000@yahoo.com
[2]Subaka Nigeria Limited, Port Harcourt, Rivers State of Nigeria
Director and Principal Consultant, Civil and Environmental Engineering,
Research and Development
E-mail:Soloeluozo2013@hotmail.com

Abstract

Design and construction of pavement has face lots of challenges on its durability, the study of calm shell as local material were carried out to monitor its level of strength in flexible pavements. Predicting the performance of calm shell was to evaluate the performances rate as filler in life expectances of flexible pavement, Fatigue cracking and permanent deformation is considered as most serious distresses associated with flexible pavements. These distresses reduce the service life of the pavement and increase the maintenance cost. Reductions of pavement distresses are in different solutions such as adopting new mix design or by using asphalt additives. Application of asphalt additives in highway construction is known to give the conventional bitumen better engineering properties as well as it is helpful to extend the life span of asphalt concrete pavement. The reduction in tensile strain was an indication that the fatigue life of pavement had been enhanced to carry increased numerous design of traffic loads within the design period before failure occurs. Furthermore, the inclusions of the local filler enhanced the stiffness (i.e. dynamic modulus) of the asphalt concrete. This means that the resistance of the pavement to design of traffic loads was increased thus extending fatigue life. Finally, predictive models to determine fatigue life from the modifier of asphalt concrete were developed for each frequency. The predicted values were generated from resolved developed model equation, these generated predicted values compared with other measured values, both parameter expressed best fits validating the model.

Keywords: predicting, performances calm shell and flexible pavement

1. Introduction

The increase in road traffic during the last two decades in combination with an insufficient degree maintenance due to shortage of fund has caused an accelerated and continuous deterioration in road network in major cities due to the effect of population e.g. in Nigeria as a case study; Lagos, Abuja, Port Harcourt, Kano etc. To alleviate this problem, several types of measure may be effective e.g. securing fund for maintenance, improved roadway design, use of better quality materials and the use of more effective methods of construction. The performance of flexible pavement as a kind of major road network in Nigeria can be influenced by many factors such as the properties of the components (binder, aggregate and additive) and the proportion of the components in the mix. Hence, adding different kinds of additives can modify bitumen, in the form of asphalt concrete. One of these additives is polymer. The addition of polymers typically improves the stiffness of the bitumen, thereby improving the rutting resistance of the mixture in hot climate and allows the use of relatively softer base bitumen, which in turn provides low temperature performance. Also, the modification of asphalt with polymer improves the temperature susceptibility. Furthermore, it shows improved adhesion and cohesion properties. However, it was observed that the limitations of bitumen as a road-paving material are associated with the problems of oxidation, which results in the cracking of the pavement and its stability with respect to local temperature variations. Due to these problems, various forms of modifications of the physical properties of bitumen have evolved over the years using different materials like natural rubber, recycled polyethylene from grocery bags; recycled plastics composed predominantly of polypropylene and low density polyethylene and processed plastic bags. This study is a further research into how to modify asphalt concrete in order to solve the problems of flexible pavement stated above by introducing high density polyethylene into it (Adekoye, 2010 Al-Ghanmam,1996; Al-Hadedy;2001 Al- Ddebe et al 1996,Vasundevan,2011).

The limitations of bitumen as a road-paving material are associated with the problems of oxidation, which results in the cracking of the pavement and its instability with respect to local temperature variation' (Othmer, 1963). The properties of asphalt concrete could be improved, making it more durable, safer an even quieter by adding polymers or plastics to the cold-mix process as experimented by a University of Wisconsin - Madisons civil engineering professor-Hussain Bahia. Also, various forms of modifications of the physical properties of bitumen have evolved over the years using different materials like natural rubber, as worked on by (Mummah and Muktar,2001), and (Igwe *et al.* 2008,) via Modifying the voids properties of a trafficked pavement using rubber latex. Lina Shbeeb (2007), concluded that the modified mixture has a higher stability and VMA (Void in Mix Aggregate) percentage compared to the non-modified mixtures. This, in returns, would positively influence the rutting resistance of these mixtures. The air void contents of the modified mixtures are not far from that of the non-modified one. Air void proportion around 4% is not enough to provide room for the expansion of asphalt binder to prevent bleeding or flushing that would reduce the skid resistance of the pavement and increase rutting susceptibility. In summary, using the poly-ethylene in asphalt mixtures reduces pavement deformation; increase fatigue resistance and provide better adhesion between the asphalt and the aggregates. Abiola (2006), carrying out a research on using glass as filler in asphalt concrete analyzed that there was a statistical significance in stability when crushed glass was increased from 5 - 6 % for 30% stone content with measured at 95% while there was no significant difference when the stone content was increased. Hussein Bahia (2008), explained that asphalt is made workable in South Africa, by shearing it into fine particles and then mixing it with water and soap-like chemical that harden after the stuff is laid down(sangita,2011,Zoorob and Surparma,2000).Generally binders are selected based on some simple tests and other site-specific requirements. These tests could be different depending of the type of binder viz. penetration grade, cutback, emulsion, modified binder etc. For most of these tests, the test conditions are pre-fixed in the specifications. Temperature is an important parameter which affects the modulus as well as the aging of binder. Superpave specifications

[Superpave 1997, 2001] suggest that these acceptability tests are to be carried out at the prevalent field temperatures, not in a laboratory specified temperature. This is an important consideration because, binder from two different sources may show same physical properties at a particular temperature, but their performances may vary drastically at other temperatures. In Superpave specifications, therefore, only the acceptable test values are recommended, and not the test temperatures. The temperature values are found out from the most prevalent maximum and minimum temperatures at the field at a given probability level. Theoretically, it is difficult [Senov 1987, Aberg 1996] to predict the aggregate volumetric parameters, even the resultant void ratio, when the gradation curve is known. The Fuller's experimental study for minimum void distribution [Fuller and Thompson 1907] still forms the basis of these exercises. Strategic Highway Research Program (SHRP), USA formed a 14 member Expert Task Group for evolution of appropriate aggregate gradation to be used for Superpave. The group, after several rounds of discussions decided to use 0.45 power Fuller's gradation as the reference gradation, with certain restricted zones and control points (Lidelo and Lagerkvist, 2007, Verina, 2008).

2. Materials and Method

The materials used in this research study include 40/50 penetration grade bitumen, river sand free from deleterious materials and crushed granite purchased from a quarry site at mile 3 area of Port Harcourt and Calm shells were obtained in sufficient quantities from mile 3 market, they were dumped after the removal of the edible portion. Impurities such as soils and other dirt were removed and the shells were sun dried and oven dry at a temperature of 400c and crushed, and sieved with sieve No 200. Table 1 gives a summary of the result of some of the test performed on the bitumen. Also Table 2 gives some properties of coarse and fine aggregates.

3. Results and Discussion

Tables and figure in Graphical Representation of calm shell are shown below:

Table: 1 Predicted and measured values at various percentage of calm shell

% calm Shell Ash	Measure Values on Number of circle	Predicted Values on Number of circle
0	7.496704689	7.510014
1	7.527691046	7.51761
2	7.540873747	7.525451
3	7.548508067	7.552191
4	7.550843596	7.559322
5	7.568141081	7.567095

Table: 2 Predicted and measured values at various percentage of calm shell

% calm Shell Ash	Measure Values on Number of circle	Predicted Values on Number of circle
0	7.477492914	7.490452
1	7.508479264	7.49795

2	**7.52166182**	**7.50598**
3	**7.529296071**	**7.532621**
4	**7.531631829**	**7.539725**
5	**7.548929256**	**7.547527**

Table: 3 Predicted and measured values at various percentage of calm shell

% calm Shell Ash	Measure Values on Number of circle	Predicted Values on Number of circle
0	**7.44123432**	**7.443711**
1	**7.472220741**	**7.461729**
2	**7.485403206**	**7.476061**
3	**7.49303767**	**7.51466**
4	**7.49537325**	**7.4954**
5	**7.512670733**	**7.5727**

Table: 4 Predicted and measured values at various percentage of calm shell

% calm Shell Ash	Measure Values on Number of circle	Predicted Values on Number of circle
0	**7.411376047**	**7.434765**
1	**7.442362326**	**7.433158**
2	**7.455545008**	**7.435553**
3	**7.463179273**	**7.450909**
4	**7.46551489**	**7.45494**
5	**7.482812407**	**7.456356**

Table: 5 Predicted and measured values at various percentage of calm shell

% calm Shell Ash	Measure Values on Number of circle	Predicted Values on Number of circle
0	**7.337238551**	**7.462032**
1	**7.36822495**	**7.460415**
2	**7.381407508**	**7.46273**
3	**7.389041737**	**7.477706**
4	**7.391377556**	**7.481637**
5	**7.408674938**	**7.482974**

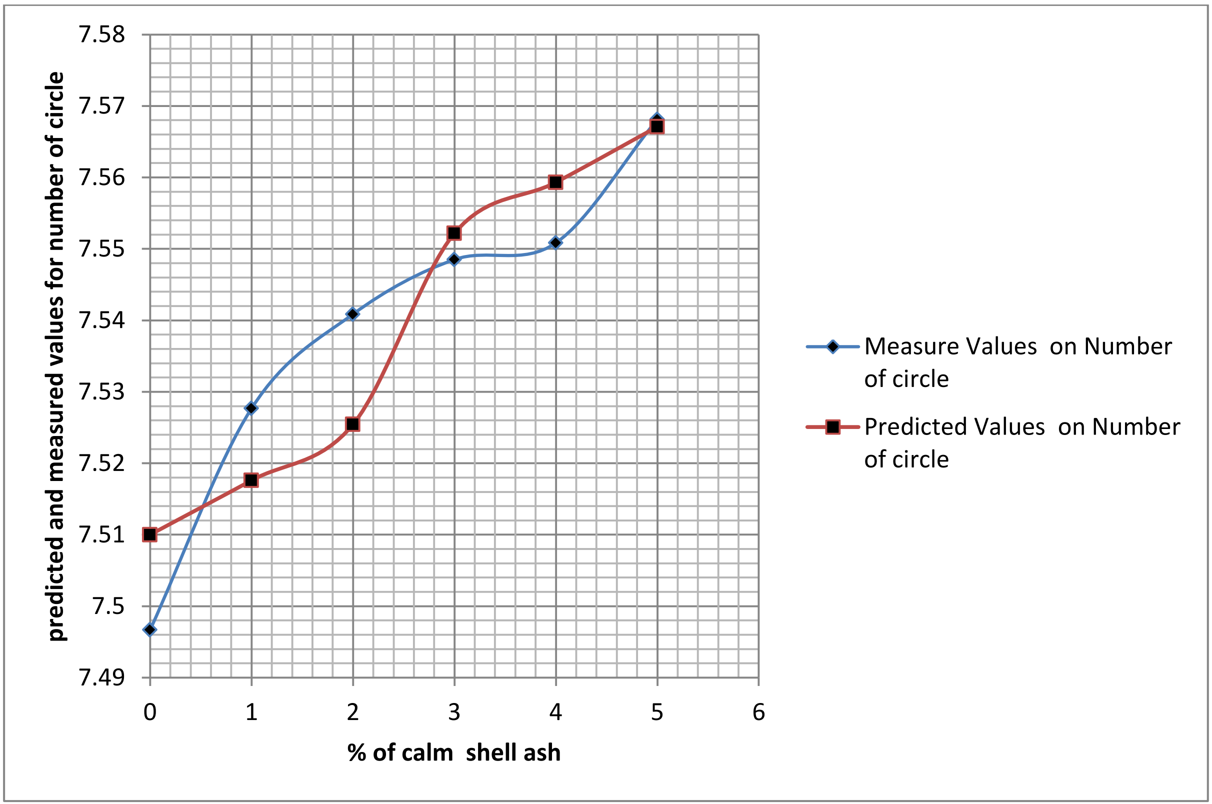

Figure: 1 Predicted and measured values at various percentage of calm shell

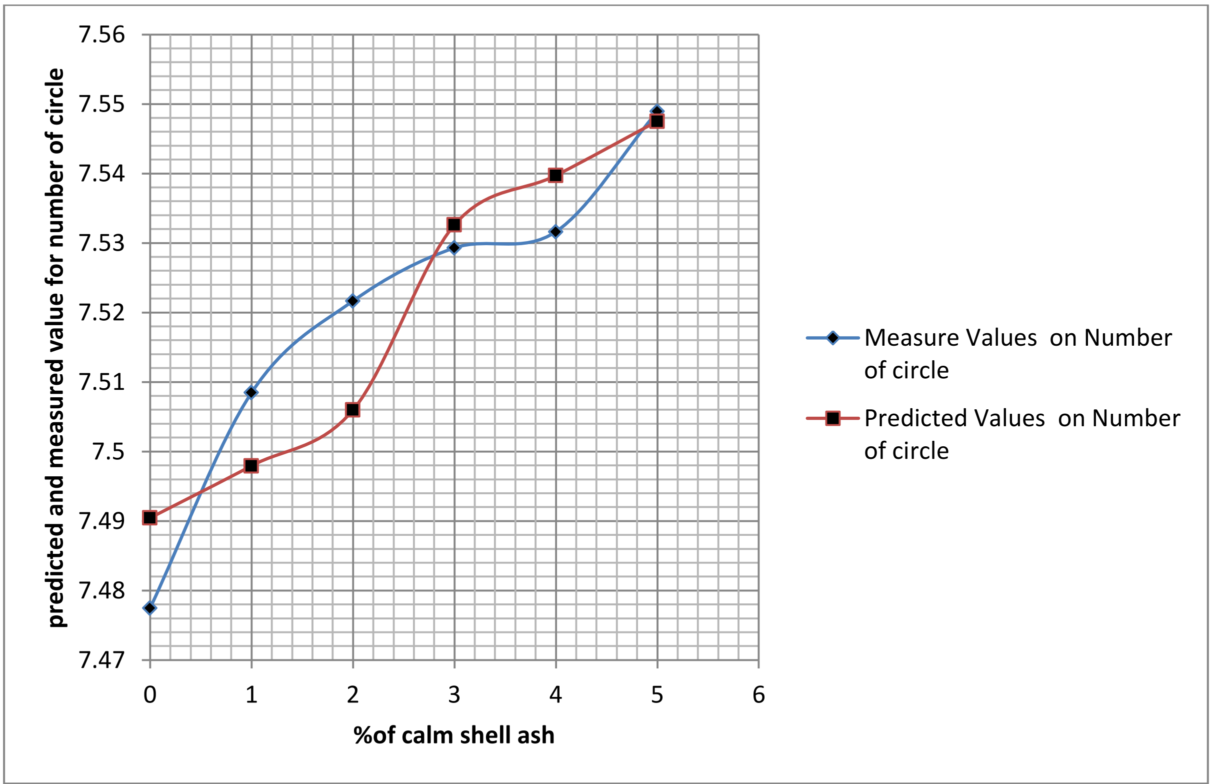

Figure: 2 Predicted and measured values at various percentage of calm shell

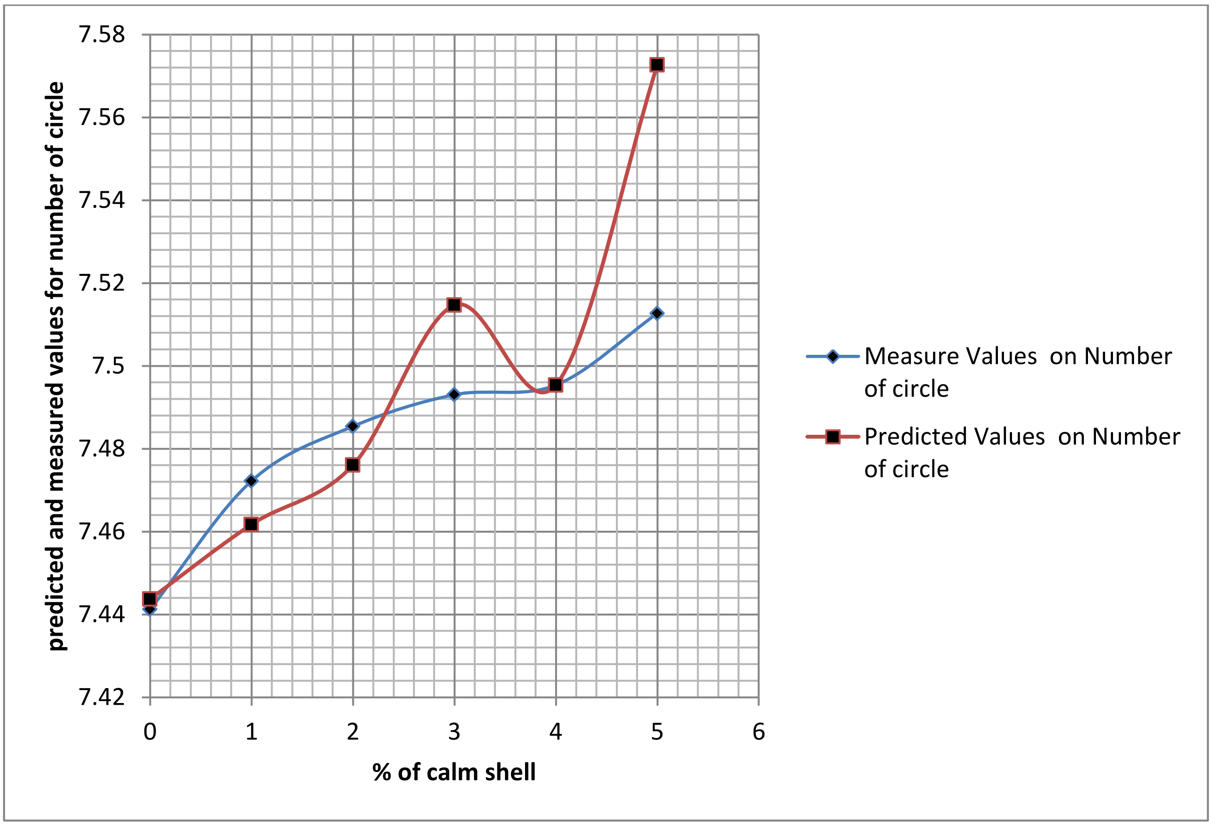

Figure: 3 Predicted and measured values at various percentage of calm shell

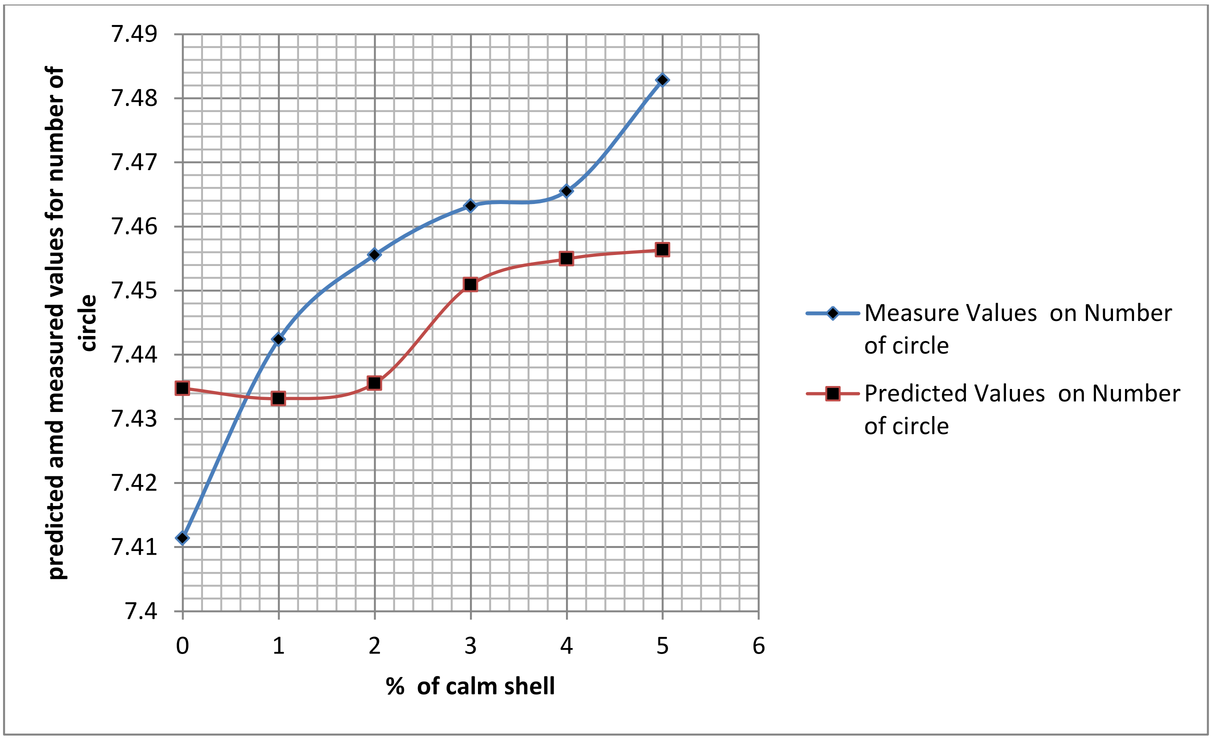

Figure: 4 Predicted and measured values at various percentage of calm shell

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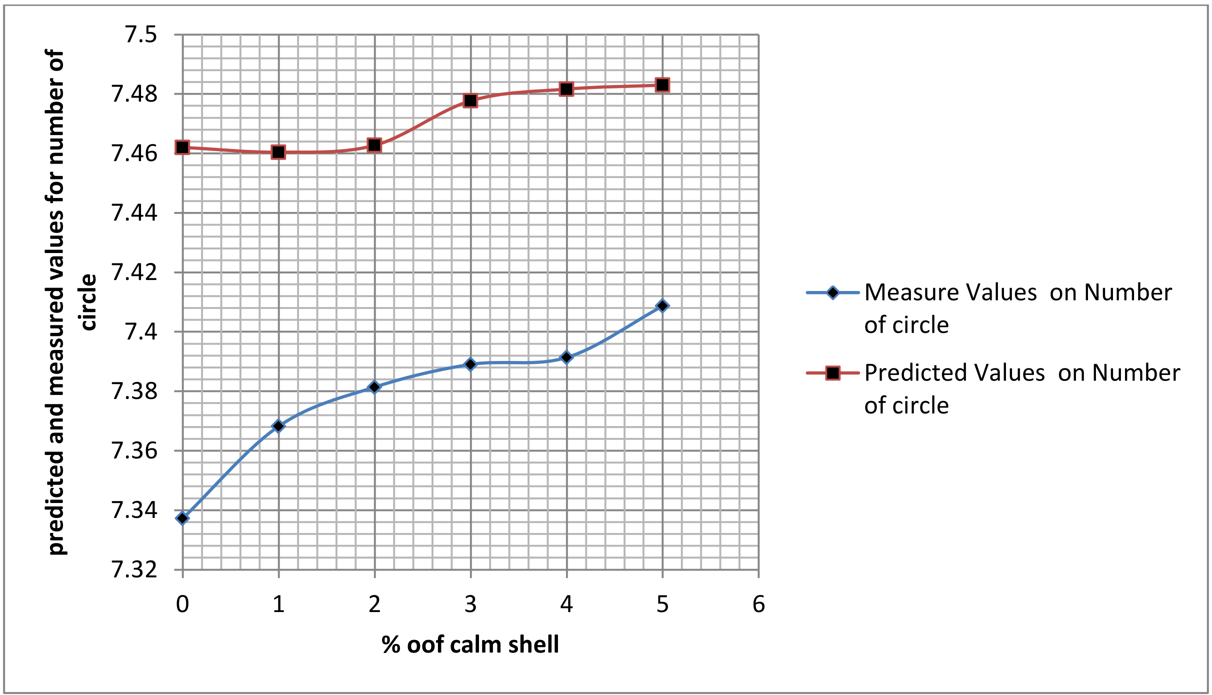

Figure: 5 Predicted and measured values at various percentage of calm shell

From the graphical representation shows that in Figure one shows that the predicted express vacillation in gradual increase to the point where an optimum values was obtained , similar condition was experienced in the trend for the measured values, fluctuation were also observed with similar increased in trend. The optimum values expressing similarity in fitness. These conditions could be seen in a similar condition on that of figure two, the predicted values observed gradual increase in oscillation to where the optimum was experienced, while that of the measured values express in a similar condition, but meet at the same trend, while figure three observed fluctuation with rapid increase between four and five percent were optimum values were recorded, while that of the measured values experienced gradual increase with slight fluctuation but were not at the same trend with that predicted values thus predicted value were higher. This shows that at a frequency of Hz of the predicted values will be low. From figure four it is observed that the measured values where higher than predicted value. This shows that at a frequency of 10Hz the predicted values will be low. The measured values linear increase while the predicted showed oscillation in trend from figure five, it is observed that the predicted values where higher than measured value. This shows that at a frequency of 25Hz the predicted values will be high. While they both show similar trend of increase.

4. Conclusion

For the purpose of these present research work, fatigue cracking of the asphalt concrete samples was expresses in terms of the number of traffic load repetitions that will occur before failure of the asphalt concrete as cracking commences. The results of fatigue cracking were obtained by the derived generated equation for the different modifiers at varying frequencies under heavy traffic. However, for convenience the log number of load repetitions were also determined and used in place of the actual load repetitions. The performance of calm shell shows the relationship between the Dynamic Modulus and the loading frequencies for the five tested groups (0, 1, 2, 3, 4 and 5% CSA). The 5% CSA mixes showed the best performance, followed by the 4%, 3%, 2% and 1% CSA mixes, respectively. The addition of CSA improved the performance of the modified asphaltic concrete and increased resistance to permanent deformation. The dynamic modulus showed a proportional correlation with the horizontal tensile strain properties of the mixes, in simple words an increase in dynamic modulus properties of the sample is followed by a decrease in horizontal tensile strain, and this is expected and understood. The performances of calm shell as filler has definitely establish the durability from it level of performances in hot mix asphalt pavement, the study has express the level of stability on the application of these local content in flexible pavement for heavy traffic.

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