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# Effect on Stability and Swell Characteristics of Asphalt Concrete Mixtures Blended With Egg Shell Ash.

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***ABSTRACT***
*Flexible pavements constructed with conventional asphalt concrete mix, are susceptible to deterioration in the presence of moisture due to loss of strength of the various aggregates that make up the mix. Organic and inorganic materials such as plastics, polymers, glass, fibre, oils periwinkle shell, etc. have been used as additives to improve the stability while decreasing the flow of these flexible pavements and these have shown a curtailment of pavement distress. This work investigated the use of blended egg-shell as void filler for improving the stability and moisture resistance in terms of swell of Hot Mixture Asphalt (HMA) concrete as well as its effects on Swelling Index of Asphalt concrete, this work was carried out using an optimum binder content of 4.92% alongside with varying percentages of eggshell ash ranging from 0% to 5%. Findings from this research revealed that the performances of the modified asphalt concrete using blended eggshell were better as compared to conventional asphalt concrete in terms of Mix Design Properties Marshal Stability and Swelling Index. Eggshell can serve as void filler for flexible pavements especially for gap-graded mixes and in areas susceptible to flooding. Therefore, this work describes egg shell ash as an agro-waste void filler material in HMA concrete.*

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## I. Introduction

Mineral fillers have a significant role in the improvement of both the workability and stability of asphalt mixtures (Kuity, 2014 *et al.*, Shukry, 2018). The composition of different types of fillers has varying eff ects on the performance characteristics of asphalt concrete mixtures (Zemichael, 2007; Al-Suhaibani, 1992). More recently, the partial replacement of mineral powder by industrial waste has gained considerable research attention, considering the long-term performance of asphalt pavements (Chen, *et al.*, 2015; Tuncan, *et al.*, 2006; Do Mun, 2008; Hu, 2017).

In tropical regions, sudden temperature increases can result in binder bleeding or flowing of the wearing course.Some researchers claim that the situation affects their strength characteristics, particularly stability and density.In terms of fatigue life during the pavement's design life, these factors govern the pavement's stiffness, stresses, reactivity, and behavior whether it is exposed to extreme moisture conditions or not (Igwe *et al* 2016; Igwe *et al* 2016;Igwe *et al* 2016; Igwe & Ottos 2016; Igwe & Ottos 2017; Otto & Akpila 2020; and Otto *et al* 2020).

It is estimated that roughly 100 million tons of hen egg shell is generated throughout the world every year without realizing that it has many uses in other areas, eggshell is fit on mineral salts such as calcium, phosphorus, manganese, molybdenum, iron, copper, chromium, fluorine, zinc. The researchers chose this material in order to investigate its effect on bitumen as long as it's having an effect on the chemically cement material. These egg-shells waste are non-biodegradable and the majority of eggshell waste is deposited as landfills. Egg-shell waste in landfills attracts vermin due to the attached membrane in landfills and causes problems associated with human health and environment. So, this egg-shell waste is useless as a landfill material (Dexit, *et al.*, 2016).However, this present study seeks to exploit the use of egg shell ash as an effective mineral filler on the durability and moisture resistance performance of asphalt concrete mixtures.

## II. Material and Method

### 2.1 Material Sampling

Different materials were gathered for this study from different sources. The materials were aggregates (sand and gravel), waste egg shell (filler) and asphalt binder. The bitumen, also known as asphalt cement, was gotten from Setraco, in Port Harcourt, Rivers State, Nigeria.The materials (gravel and sand) that were used, on

the other hand, were purchased directly from market vendors at Mile 3 Diobu Port Harcourt, Rivers State, Nigeria. While the waste egg shell was gotten from homes.

**2.2 Preliminary Test for Asphalt, Aggregates and Void fillers:**

The materials used in the study (AsphaltBinder, Waste Egg Shell and Aggregates) were first categorized in order to achieve the study's goal.That is, the asphalt cement and aggregates' specific gravities were determined as stated in standards below.To establish the penetration, viscosity, and softening point of the bitumen employed, a classification test of the substance was also conducted; the results are in section 3.

- Specific gravity test – ILLINOIS TEST PROCEDURE – ITP-84 & 85 (2015)
- Sieve analysis - ILLINOIS TEST PROCEDURE – ITP-27 (2015)

**2.3 Sample Preparation**

In this investigation, samples were prepared using the Bruce Marshall method, which was described in Asphalt Institute (1997).In order for test data curves to show clearly defined optimal values, a number of test samples were prepared for various asphalt contents.There were at least three tests above and below the ideal concentration in additions of asphalt binder of 0.5 percent.For each asphalt content, three test samples were prepared in order to offer sufficient information.Five minutes were spent heating both the fine and coarse aggregates.In order to properly absorb into the particles during the preparation of the pure and modified asphalt concrete samples, binder was subsequently applied.Then, using a 6.5 kg rammer, the material was put into a mould and a load was applied on both faces of 75 blows for compaction.According to the AASHTO Design Guide(2002), compacted specimens were evaluated for bulk specific gravity, stability and flow, density, and voids at temperatures of 60 degrees Celsius.The calculated optimal asphalt content for pure asphalt concrete was based on the results.The samples were then modified using the same Marshal Design Procedures as before to produce modified concretes with varying mix design properties, particularly air voids content. The waste egg shell was added to the samples at the optimal asphalt content in varying amounts (1 to 5 percent of the total mix).

## III. Results and Discussions

The stability results obtained are presented below in Table 1 and Figure 1. While the swelling index results are presented in Table 2 and Figure 2 respectively.

**Table 1: Stability of Asphalt Concrete for Different Waste Egg Shell Content.**

| Stability Values (N) | | | | | | |
|---|---|---|---|---|---|---|
| Soaking Days | % Modification of Waste Egg Shell | | | | | |
| | 0% | 1% | 2% | 3% | 4% | 5% |
| 0 | 17210 | 18130 | 19050 | 20350 | 21410 | 21970 |
| 1 | 16400 | 17320 | 18240 | 19540 | 20600 | 21160 |
| 2 | 15590 | 16510 | 17430 | 18730 | 19790 | 20350 |
| 3 | 14780 | 15700 | 16620 | 17920 | 18980 | 19540 |
| 4 | 13970 | 14890 | 15810 | 17110 | 18170 | 18730 |
| 5 | 13160 | 14080 | 15000 | 16300 | 17360 | 17920 |

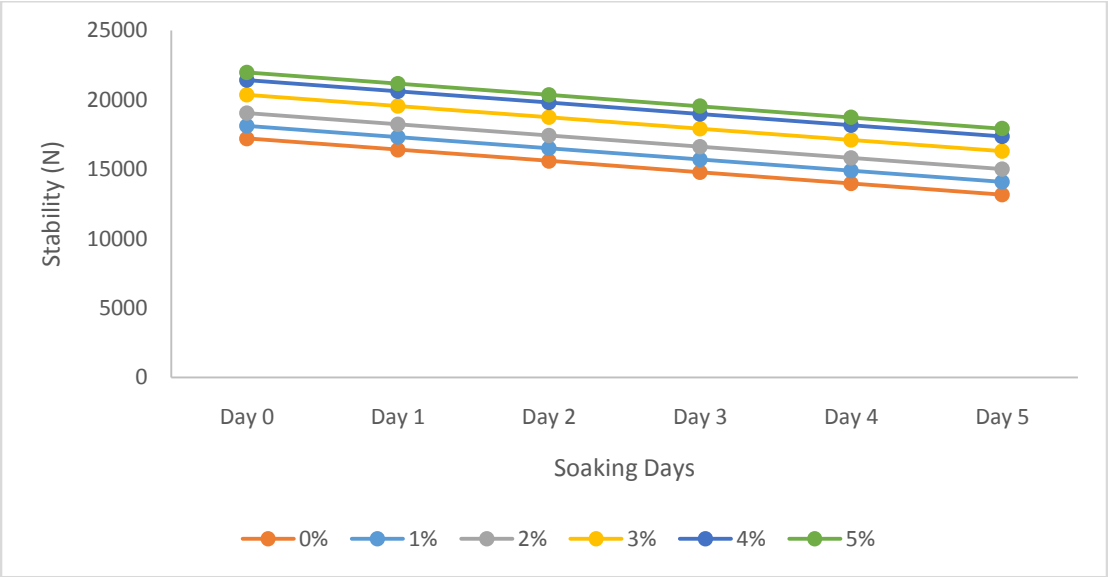


**Figure 1: Stability against Soaking days for Different contents of Waste Egg Shell**

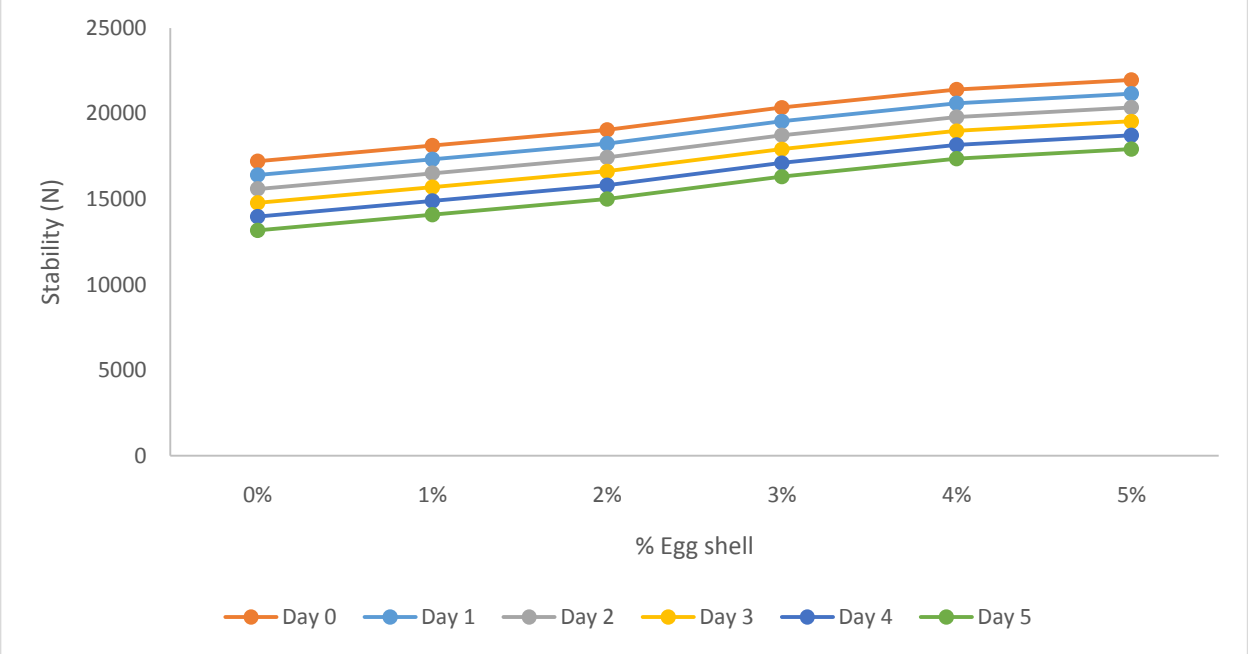


**Figure 2: Stability against% Waste Egg-Shell for Different Soaking Days**

The stability results as shown in Table 1,and Figure 2, shows clearly that the addition of waste egg shell as filler material improved stability. This improvement is at an average rate of 5.02%. However, in Figure 1, as the number of soaking days increases, the value of stability reduces. This reduction is at an average rate of 5.22%.

**Table 2: Swelling Index of Asphalt Concrete for Different Waste Egg Shell Content.**

| Swelling Index values for Waste Egg Shell Modified Asphalt | | | | | | |
|---|---|---|---|---|---|---|
| Soaking Days | % Modification of Waste Egg Shell | | | | | |
| | 0 | 1 | 2 | 3 | 4 | 5 |
| 1 | 0.66 | 0.55 | 0.44 | 0.33 | 0.26 | 0.02 |
| 2 | 1.3 | 1.2 | 0.88 | 0.66 | 0.46 | 0.13 |
| 3 | 1.71 | 1.29 | 1.08 | 0.94 | 0.81 | 0.22 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 4 | 1.89 | 1.49 | 1.29 | 1.08 | 0.87 | 0.31 |
| 5 | 2.07 | 1.68 | 1.48 | 1.28 | 1.07 | 0.44 |

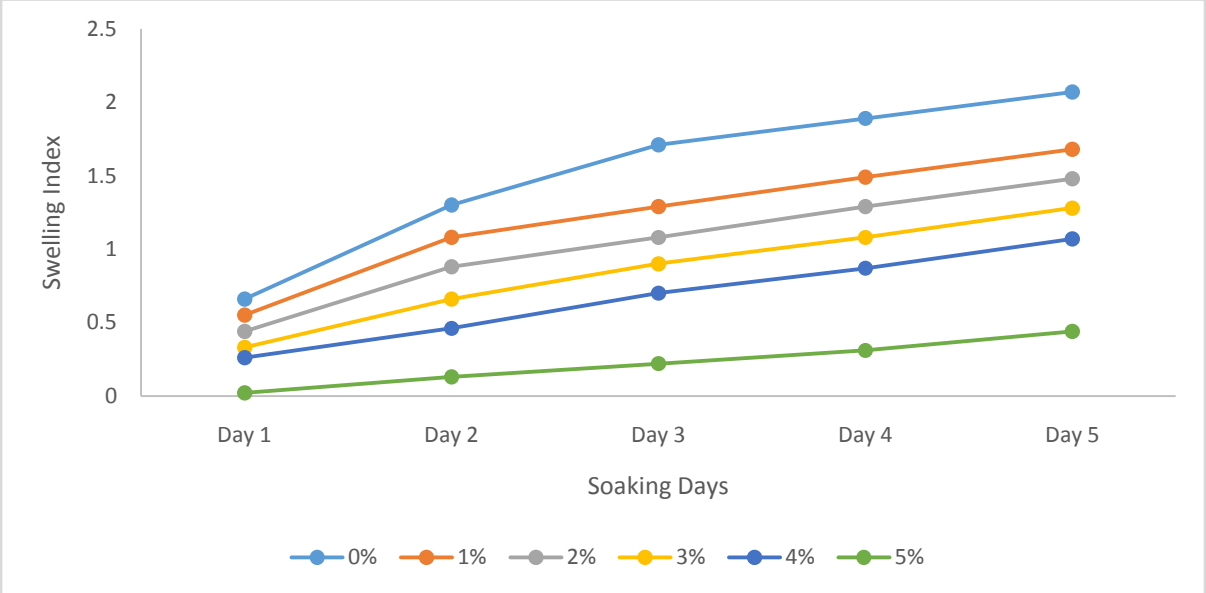


**Figure 3: Swell Index against Soaking days for Different contents of Waste Egg Shell**

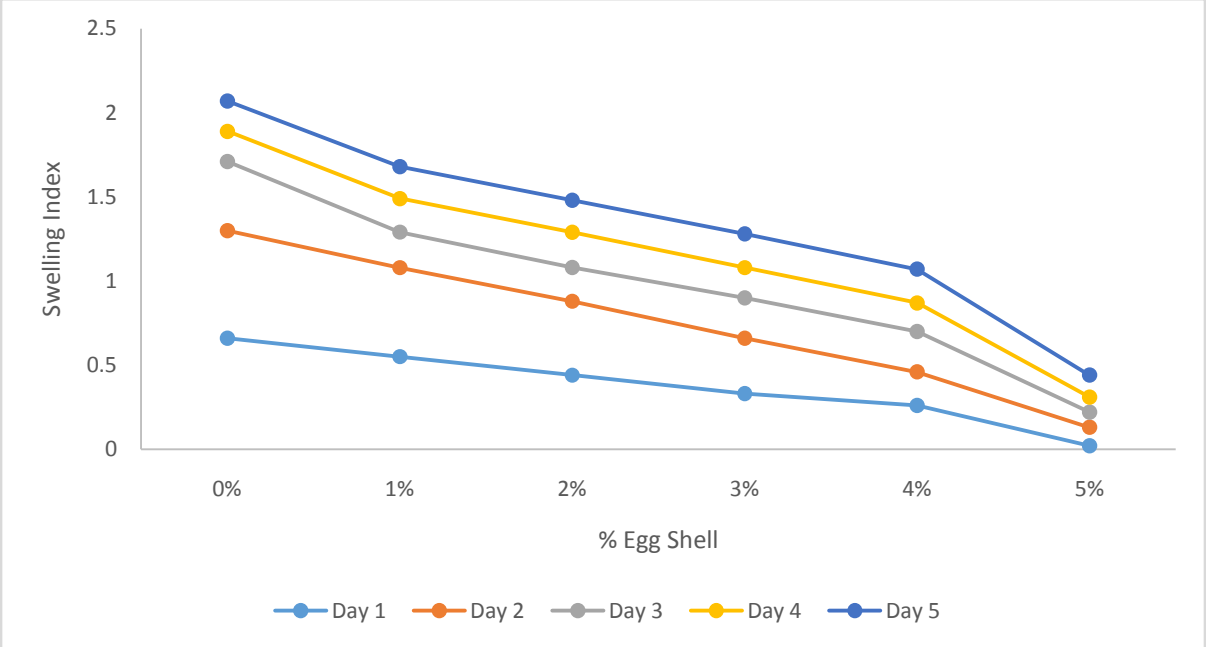


**Figure 4: Swell Index against % Waste Egg-Shell for Different Soaking Days**

In Table 2, Figure 3 and Figure 4 above, the effect of egg shell ash modified asphalt on swelling index (SI) was presented. The soaking of the pavement sample up to 5days of the egg shell ash modified sample resulted in continuous swell due to moisture absorption which eventually resulted to the disintegration of the binder from the aggregate, which led to pavement deterioration and untimely failure.However, the effects of egg-shell in asphalt concrete mixtures as void filler have resistance to moisture as it decreased continuously throughout the soaking days as shown in Figure 4. This is to illustrate the importance of agro-waste in asphalt concrete when blended. However, it can be noticed that the increase in percentage modifier content led to a decrease in the level of swell at day 5 to 97%.

## IV. Conclusion:

Based on the set objectives of this study and the results obtained, the following conclusions were made.

1) Egg-Shell can be added to asphalt concrete as a filler material.
2) That in using Egg-Shell, it should be limited to 5% by weight of total aggregates.
3) Stability and Swellof the concrete blended with Egg-Shell improved in stiffness up to 5%.
4) Egg-Shell should be adopted during the mix of asphalt concrete as it improves stability and reduce water absorption.

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