International Journal of Advanced Research in Engineering Technology & Science
ISSN: 2349-2819
Impact Factor: 7.10
(Peer-Reviewed, Open Access, Fully Refereed International Journal)
Email: editor@ijarets.org Volume-11 Issue-4 April-2024 www.ijarets.org

NONTRADITIONAL TECHNOLOGY - COCONUT SHELL CHARCOAL AS FILLER IN STONE MATRIX ASPHALT

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ABSTRACT

Within the range of 70 to 80 percent coarse aggregate, 5 to 7 percent binder, 8 to 12 percent filler, and 0.3 to 0.5 percent fiber, stone matrix asphalt (SMA) is found to be composed of. There is a gap grade in the combination. In this study, the engineering properties of SMA mixes that were created with and without fibers, namely coconut fibers, were compared one to the other. By ensuring that the mixture remains at a high temperature throughout the stages of development, manufacture, and transportation, these fibers prevent the bitumen binder from evaporating. The objective of this study is to establish whether or not the combination might be improved by the use of coconut fiber as a stabilizing agent. This will be accomplished by conducting an analysis of the combination's flow, mechanical properties, and stability in a laboratory environment that is under controlled conditions. According to the findings of the study, the filler material consisted of 5%, 5.5%, 6%, 6.5%, and 7% cement by weight of aggregates, while the binder component was VG-30 grade bitumen. The performance of SMA mixes with nominal maximum aggregate sizes (NMAS) of 19 mm is superior to that of mixes with NMAS of 13 mm. This is due to the fact that the incorporation of bigger aggregates into the mix causes improvements in stability, bulk specific gravity, and flow. When SMA is combined with coconut fiber, there are less air spaces than when coconut fiber is used alone. At a drain down rate of zero percent, the optimal fiber contents (OFC) for coconut fibers were 0.3% and 0.4%, respectively.

Keywords: - *flow, fiber, coconut, stone.*

INTRODUCTION

The SMA material exhibits remarkable resistance to rutting and distortion even when it is exposed to high temperatures and heavy traffic. When compared to dense graded mixes, SMA contains a lower proportion of medium-sized aggregate. Additionally, the proportion of coarse aggregate and mineral filler in SMA is larger. The formation of a structure similar to a skeleton occurs in SMA as a consequence of the large fraction of coarse particles present in the mixture. Because of this, the stone-on-stone contact is enhanced, which results in a robust resistance to rutting and greater durability over the long term. A combination of bitumen and filler is used in order to fill the structure that is similar to a skeleton. Chemicals that stabilize the mixture are added to the SMA mixture in order to reduce the amount of leak down. Stabilizing additives, which may include fibers, polymers, and waste materials, are used in order to prevent the binder from dropping. There is a significant role that stabilizing additives and mineral fillers play in increasing the quantity of binder that is employed, reducing the amount of binder that drains off, and improving the longevity of the material.

Goutham Sarang et al. researched the volumetric, stability, and flow properties of the SMA mix without using any stabilizing agent. This was done in order to determine the features of the SMA mix. By combining NMAS with dimensions of 16mm (SMA1) and 13mm (SMA2), the SMA mix was produced. When compared to SMA2 mix, the use of polymer modified binder (PMB) as a binder component in SMA1 mix results in coarse aggregate sizes that are bigger and a higher level of performance. When contrasted with the SMA2 combination, the SMA1 mixture demonstrated greater tensile strength, stability, fatigue life, and resistance to rutting. In this study, researchers studied the Marshall properties of SMA mix and analyzed bitumen grades CRMB 60 and VG 30. Mixtures that included CRMB60 performed better than those that contained VG30 grade bitumen in terms of the factors that govern flow and stability. In both grades of bitumen, the stability of the material improves with increasing fiber percentages up to a maximum of 0.5 percent, after which it begins to decrease. Researchers Aline and colleagues investigated the flow and stability properties of natural fibers, namely cellulose and coconut fibers by analyzing their flow and stability. The incorporation of fibers was found to improve the tensile strength ratio (TSR), and the results of the drain down test and air voids revealed that SMA with coconut fibers operates better than cellulose fibers. This was determined via the process of including fibers into the design of the material. By comparing the performance of VG 30 grade with coconut fibers to that of SMA mix, which is produced by combining PMB 70 with SBS (styrene-butadiene styrene) and coconut fibers, researcher conducted their research and found that the former was superior. Over a wide temperature range, SMA with PMB 70 and coconut fibers has improved rutting resistance, fatigue life, and static indirect tensile strength. This is in contrast to VG 30 grade and coconut fibers, which both display worse properties. Mr. Sangram and colleagues mixed bituminous mixes with fiber recovered from refrigerator door panels (FERD) and recycled plastic in order to construct roads. This was done for the aim of constructing roads. When compared to bituminous concrete, the stability value of SMA mixture is lower up to a fiber length of 6 mm, but it increases beyond that point. This is the case when comparing SMA mixture to bituminous concrete. A comparison was made by Mario et al. [21] between two SMA mixes that used the same grade but different kinds of binder. The binder was first formulated using elastomeric polymers, SBS, and PMB 45/80-65 as its initial ingredients. The PMB 45/80-65 R designation was assigned to the second compound after it underwent a reformulated process that included the use of SBS and rubber ELTs. When it comes to binder drainage and resistance to permanent deformation, the data indicate that SMA with PMB 45/80-65 R without fibers exceeds the performance of SMA with PMB 45/80-65 plus cellulose fibers.

Objective: -

1. A Critical Analysis of the Application of Coconut Fiber and Shell in the Construction of Roads
2. A Pavement that is Flexible and Made with Charcoal Powder from Coconuts in Place of Some Stone Dust

Research methodology

Using the Marshall stability testing equipment, several parameters including as stability, flow, bulk specific gravity, air voids, volumetric mass adsorption, volumetric fractional adsorption, and others were determined for the fiber-free mix design. From the results of the Marshall stability test, the OBC is derived by taking the median of the planned restrictions of 3 and 5, as well as the maximum stability, bulk specific gravity, and percentage of bitumen at 4% air voids. In addition, the marginal stability is also taken into consideration. In accordance with ASTM D 6390, which is titled "Determination of Drain down Characteristics in Uncompacted Asphalt mixtures" and is derived from IRC: SP:79-2008, these OBC are used in asphalt drain down experiments that make use of coconut fibers. It is assumed that there is no drain down when calculating the OFC for coconut fibers. For the purpose of determining the stability, flow, bulk specific gravity, air voids, VMA, VFB, and other characteristics of the coconut fibers that were included in the Marshall mix design, the Marshall stability testing equipment was used; this OFC was employed. The results of these Marshall stability tests are used to determine the OBC of coconut fibers.

Aggregate Gradation

According to IRC: SP: 79-2008, the composition of stone matrix asphalt is what should be used to establish the aggregate gradation for NMAS with a thickness of 13mm and 19mm. In Table 4, the total aggregate passing weight is shown as a percentage according to IS Sieve. This information is provided for both the 13mm and 19mm NMAS. By adding up the percentages that are passed by the weight of the entire aggregate, the upper and lower limit values may be computed. On the basis of the average gradations of 19mm, 13.2mm, and 4.75mm, as well as the filler (cement) in the combined gradation, the values that were computed were determined. The graph is given for both the upper and lower limits, as well as the middle value and the chosen value throughout the process.

Table 1.1 Aggregate Gradation for SMA using IRC: SP: 79-2008

IS Si (m	Cumulative % by weight of total aggregate			
	NMAS 13mm		NMAS 19mm	
	Range	Adopted	Range	Adopted
26.5	-		100	100
19	100	100	90-100	97.05
13.2	90-100	95.86	45-70	64.69
9.5	50-75	68.1	25-60	46.83
4.75	20-28	26.1	20-28	24.94
2.36	16-24	21.08	16-24	19.97
1.18	13-21	18.75	13-21	17.81
0.600	12-18	16.54	12-18	15.83
0.300	10-20	15.11	10-20	13.99
0.075	8-12	11.84	8-12	11.25

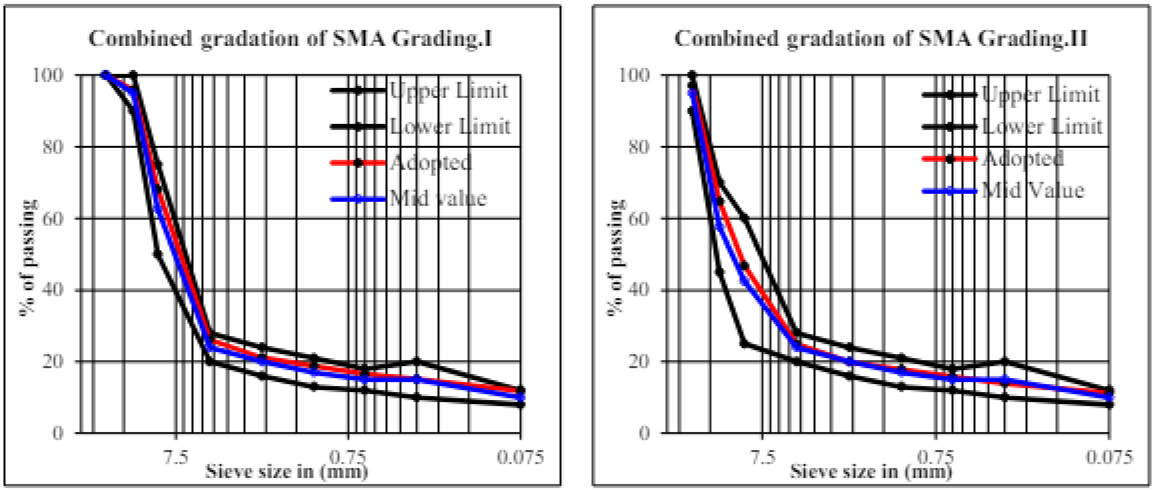

Figure 1.1 Gradation curve of SMA using IRC: SP: 79-2008 Figure 4 Gradation curve of SMA using IRC: SP: 79-2008

Marshall Stability Test Specimen Preparation

Creating the mix samples was accomplished via the use of the Marshall methodology, which is a method that is widely utilized and well-liked in India. The cement, coarse and fine aggregates, and the gradation that was selected were all combined after being heated to the appropriate temperature. A sufficient quantity of coconut fiber, which had been coarsely cut into pieces of about 6 to 8 millimeters in length, was included into the aggregate sample prior to the introduction of the binder. After bringing each component of the combination to the temperature that was required for combining (150 to 160 degrees Celsius), thoroughly mixing it, and then crushing it with 75 blows on each side, as indicated in Figure 5, the mixture was finally crushed. Adjustments were made to the concentrations in the range of 5% to 7% in order to ascertain the optimal amount of binder content. Figure 6 depicts the items that were checked by the Marshall stability testing system.

Figure 1.2 Marshall sample

Figure 1.3 Marshall stability testing machine

Drain Down Test Specimen Preparation

In line with ASTM D 6390, the drain down test was performed in a wire basket in the presence of standard 6.3 mm sieve cloth at temperatures ranging from 120 to 170 degrees Celsius. After the SMA mixture has been prepared to a certain weight, it is then placed in the basket and placed in an oven that has been adjusted to the temperature that will be used for the test, as shown in Figure 7. The procedure of collecting and weighing the material that drains during the course of the one-hour test period is shown in Figure 8. There is a ratio between the starting weight of the mixture and the weight of the material that is drained, and this ratio is referred to as the drain down ratio.

Figure 1.4 Drain down test sample

Figure 1.5 Asphalt drain down

RESULTS AND DISCUSSIONS

Stability and Flow

By examining Figure 2, we can observe how the incorporation of coconut shell into a porous asphalt mixture influences the combination's flow and stability. Over time, it became abundantly evident that the stability was very sensitive to variations in the composition of the CS. Increasing the percentage of CS has a detrimental effect on the stability of the mix. Its strength is diminished as a result of many factors, including its low specific gravity and considerable water absorption. An average stability of 10.9 kN is typical for a porous mix that is standard. There is a decrease in stability from 8.3 to 3.1 kN when the percentage of coconut shell replacement is increased from 10% to 50%. In terms of stability, a porous asphalt mix that had 10% CS demonstrated the greatest results when compared to mixtures that contained 30% and 50% CS separately. As a result, the optimal quantity of aggregate to substitute for CS is ten percent. There is also the differential movement between the starting loading and the maximum loading that is recorded as this flow. The results are shown in Figure 2, which demonstrates that the flow increases at a level that is proportional to the equal amount of coconut shell. A maximum flow of 3.6 millimeters is observed for a regular mix & it is discovered that a maximum flow of 16 millimeters is often specified for mix design and construction management. On the other hand, porous asphalt specimens that include coconut shell indicate a maximum flow of 5.9 millimeters when the percent of CS in the mixture is fifty percent.

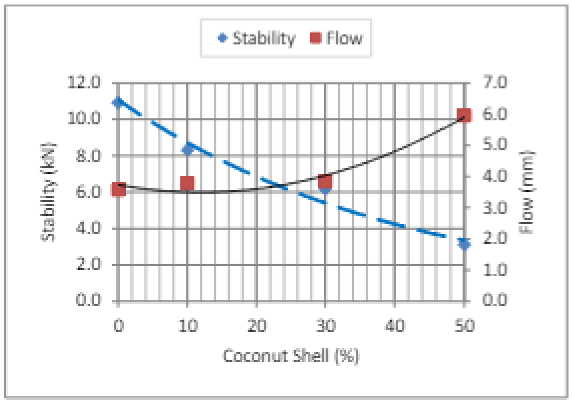

Figure 1.6 Relationship between stability and flow at different percentage coconut shell

VFB and VTM

The quantity of bitumen that is present in relation to the total volume of the VMA is what the Voids Filled Bitumen (VFB) takes into account. In terms of the air voids, the VFB has a connection that is in the other direction. Because the proportion of air gaps is becoming closer and closer to zero, the VFB is getting closer and closer to 100 [25]. Within the context of VFB, Figure 3 illustrates the total effect that a porous asphalt mix that contains coconut shell has. The value of the VFB decreases as the quantity of coconut shells increases. As the amount of coconut shell increases from 0% to 50%, the volatile fiber content decreases from 62.1% to 45.2% during the same time period. According to the JKR standard, the VFB should be anywhere between 75% and 85% all the time. On the other hand, the standard does not offer any specific limit values for porous asphalt, especially when it comes to materials that are combined with waste from agricultural production. Figure 3 illustrates the findings of the inquiry into Voids in Total Mix (VTM) that was conducted for the study. When it comes to the majority of mixes, the trend is obviously somewhat inconsistent. After the control sample, which is the 0% CS mix, the VTM is highest in the CS-10 and CS30 samples, in that order. The control sample is the one with the highest VTM. In spite of this, the VTM value goes up when CS is blended in at a ratio of fifty percent. According to Yi and Wan et al, the aging process of asphalt cement films that are contained inside aggregate mass is slowed down when the air void contents are reduced. In addition to this, they lessen the possibility of moisture penetrating the thin coating and dissolving asphalt cement from aggregates. According to the findings of this investigation, the VTM values on porous asphalt mixtures that included 10% and 30% coconut shells were the lowest.

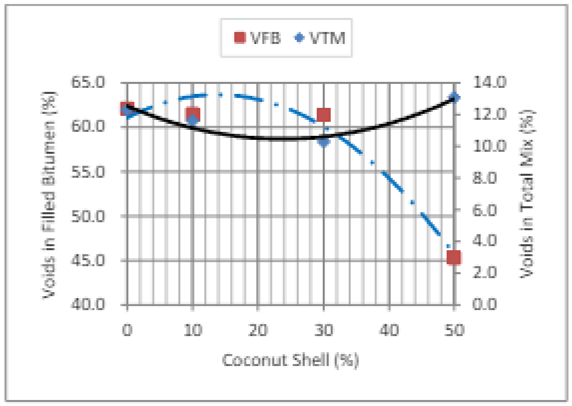

Figure 1.7 Relationship between VFB and VTM at different percentage coconut shell

Loss of Abrasion

Through the use of Cantabrian testing, the ability of coconut shells composed of compacted porous mixes to sustain abrasion loss is evaluated. In the context of abrasion loss, the unit of measurement is the mass loss expressed as a percentage of the starting mass. Figure 4 depicts the association between abrasion loss and coconut shell at different percentages of replacement based on the value of the replacement %. When it comes to the porous mixes that were examined, the degree of abrasion loss demonstrates the loss of inter-aggregate particle cohesion. In many cases, porous asphalt mixtures that include coconut shell exhibit a lower level of abrasion resistance when compared to mixtures that contain precisely zero percent CS. A good illustration of this would be the abrasion loss of the mixture, which is 7.6% when there is no CS present and 13.1% when 10% CS is introduced. Therefore, increasing the quantity of CS does not result in an improvement in the mix's resistance to abrasion or capacity to withstand wear and tear. The ideal way to obtain abrasion resistance, on the other hand, is to begin with a 10% CS mix, then go on to 30% CS, and eventually finish with 50% CS. An abrasion loss that is lower than average suggests that the combinations have a lower probability of disintegrating.

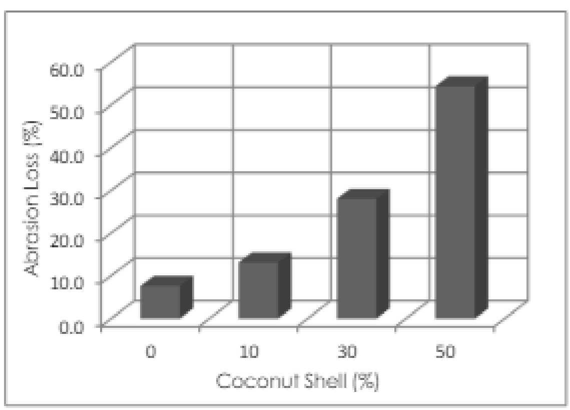

Figure 1.8 Loss of abrasion porous asphalt mixture incorporating coconut shell

Binder Drainage

Figure 5 illustrates that the binder drain-down increases as the percentage of coconut shells in the mixture increases. The data reveal a considerable drop of 0.02 in binder drain-down at 10% CS in compared to conventional porous asphalt, which rises from 0.15% to 0.25% at 30% CS and from 0.12% to 0.15% at 50% CS. In other words, the binder drain-down at 10% CS becomes much lower. You should use 10% CS if you are seeking for a solution to lessen the problem of binder drainage in compared to the usual mix. This is the way to go.

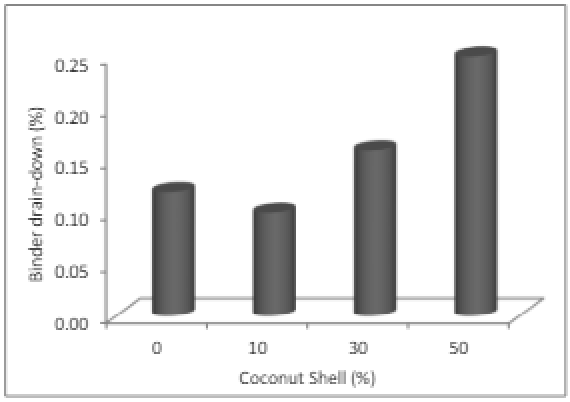

Figure 1.9 Binder drain-down of porous asphalt mixture incorporating coconut shell

Sound Absorption Coefficient

In this study, porous asphalt mixtures that included coconut shell were investigated, and the impedance tube method was used to determine the normal incidence sound absorption coefficient. During the course of the laboratory measurements of the acoustic spectrum, the porous asphalt was repeatedly inserted into and extracted from the container that contained the sample. During the course of the measurements, there were completely no adjustments made to the orientation of the specimens in relation to the sound source. As can be shown in Figure 6, the coconut shell is a significant coarse aggregate compound that is used in porous asphalt. In the comparison of the conventional specimens with the modified specimens, the pattern is the same for all of the mixes. The peak frequencies reveal slight variations within a range of ±100 Hz for each and every single porous asphalt mixture. The sensitivity of the peak frequency, which is within a range of ± 100 Hz, and the greatest acoustic absorption coefficient, which is within a range of ± 0.1, are not regarded to be serious difficulties [27]. It is common practice to use the porous asphalt that was used in this study as pavement in order to reduce the amount of reflected traffic noise and tyre-road interaction noise that occurs in the frequency range of 0–1600 Hz. Additionally, the curve of the specimen often had a peak at three distinct frequencies, as seen in Figure 6. The sound absorption coefficient (α) was found to be within the range of 0.05 to 0.06, and the first frequency peak was recognised as occurring between 100 and 700 Hz. The second group of frequencies reaches its highest point between 700 and 1000 Hz, with an absorption value of 0.89 and a maximum peak at 850 Hz to illustrate its range. Last but not least, the coefficient of absorption is somewhere in the range of 0.62 to 0.18, and the third frequency peak is somewhere between 1000 and 1600. In the event that there is an increase in the amount of air voids, it is predicted that there will be a significant reduction in the amount of noise that occurs between 700 and 1000 Hz (Figure 7). It should not come as a surprise that a greater percentage of air voids ultimately leads in improved absorption performance. In conclusion, it is possible to assert that a larger absorption coefficient was accomplished by adding an average percentage of thirty percent of coconut shell. The capacity of porous surfaces to absorb sound makes them a popular option for the purpose of lowering the amount of noise that is produced by roads. It was discovered in a research that they had the ability to reduce pass-by noise by 1–9 decibels (A) when compared to a typical layer.

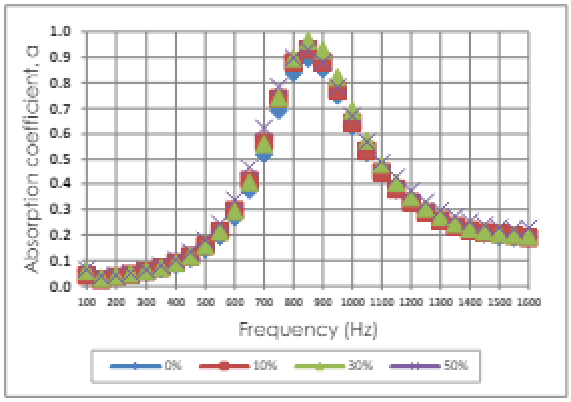

Figure1.10 Sound absorption coefficients at varying coconut shell replacement

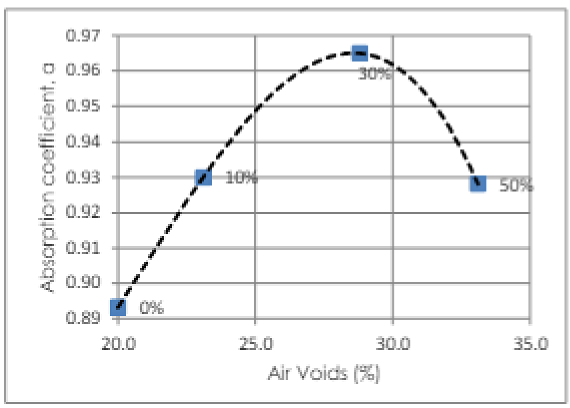

Figure 1.11 Correlation between sound absorption vs. air voids

Permeability, Porosity and Coconut Shell

Demonstrates the typical relationship that exists between the porosity and permeability of a porous asphalt mix that is produced using varying proportions of coconut shell. The percentage of coconut shell is shown along the X-axis, while the porosity and permeability of the material are represented along the two Y-axes. With each point on the graph, the average of two measurements is calculated. It can be seen in the figure that the proportion of coconut shells increases, which results in an increase in both porosity and permeability. It was found that the coefficient of permeability (k) of specimens that did not include any CS replacement was lower than that of samples that had 50% CS, 30% CS, and 10% CS, in that order specifically. The ability of porous asphalt mixes to allow more air and water to move through them is often greater than that of ordinary asphalt. The permeability of mixtures that include coconut shells advances in a linear fashion from 0% to 50%, beginning with a permeability coefficient of 0.24 cm/s and reaching a value of 0.83 cm/s from there. When coconut shell is replaced, the porosity data show a pattern that is consistent on this occasion. The use of coconut shell as a replacement for porous materials has the potential to improve the permeability and porosity of the materials. The increasing sealing of pores by the replacement coconut shell is not a plausible explanation for the higher permeability coefficient. This notion is not supported by the available evidence.

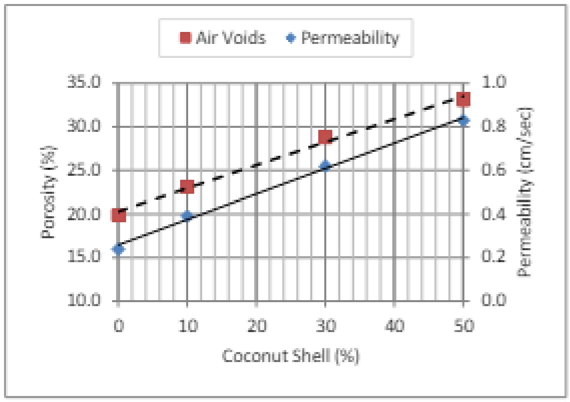

Figure 1.12 Correlation between porosity and permeability at different level coconut shell

CONCLUSION

Researchers conducted an investigation into the incorporation of coconut shell into a porous asphalt mixture in order to study the ways in which the attributes may be altered. The purpose of the investigation was to uncover the potential for change. The use of coconut shell as a replacement material for aggregate has been demonstrated to be incapable of improving the technical properties of porous asphalt mixes, according to the findings of a research. However, when compared to other replacement levels, combinations that incorporated 10% CS performed very well. This was the case. In addition to its many other advantages, the use of coconut shell has the capability of efficiently reducing the sound absorption coefficient. The fact that it only requires thirty percent replacement is yet another benefit of utilizing coconut shell, which is only one of the numerous advantages of using coconut shell.

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