

A Study Review of Coconut Shells as Replacement for Coarse Aggregate

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Abstract: Nowadays concrete which is material is the most widely used building material in the construction industry. The increase of concrete used also contributes to the massive demand for coarse aggregate. The massive demand for natural aggregate raises major concerns regarding natural aggregate source preservation. Other alternative materials are utilized to replace coarse aggregates such as coconut shells. The usage of coconut shells is a suitable concept to follow the sustainable development of society. The objectives of this study are to review the effectiveness of coconut shell as a coarse aggregate replacement on engineering properties such as strength, water absorption, and workability on concrete based on previous research and to review the influence of the coconut shell inclusion in concrete on the microstructural characteristics. By critical review, this study found that concrete with coconut shell shows a positive impact on the workability of concrete and water absorption but on compressive strength. The percentage of replacement of 0% - 30% influence an improvement of the workability and water absorption but has a negative effect on compressive strength. The microstructural characteristic of coconut shell in concrete also gives positive influence in concrete and make coconut shell appropriate to use coconut shell as coarse aggregate in concrete. After considering all factors based on analysis, about 20% to 25% of replacements are suitable to replace coarse aggregate.

Keywords: Coconut Shells, Coarse Aggregate Replacement, Microstructural Characteristics

1. Introduction

Concrete is the most widely used building material for the construction industry. The components include cement, fine and coarse aggregates, water, and admixtures [1]. When cement and water are combined, a paste is formed in a concrete mix, where fine and coarse aggregate are bound together. According to Mathew [2], without concrete, no construction activity can be considered in the current era. Concrete is the most often used construction material and the world's second most consumed substance. As stated by Rajasekhar [3], the massive demand for natural aggregate raises major concerns regarding natural aggregate source preservation for long-term development.

Using agricultural waste materials as aggregates replacements have become common in the construction industry. The utilization of waste materials conserves natural resources and waste material while also assisting in the preservation of a clean environment [4]. In this study, the use of coconut shell as a coarse aggregate are emphasized. Using concrete made from coconut shells would offer more advantages than the coarse aggregate. The concrete using coconut shell aggregates achieves the concrete basic conditions. Coconut Shell has higher moisture retention and water absorption ability than conventional aggregate [5].

Due to its economical price and availability of waste materials, using coconut shells in concrete can help lower the cost of construction materials and is also known as lightweight structural concrete. Coconut shells have been discovered to be a better lightweight low resistant aggregate [4]. According to Sonawane [5], it can be used as a concrete aggregate or as a partial substitute, and it has both engineering and economic benefits, and it has both engineering and economical advantages. Agricultural waste has unique physical and chemical properties that may make it suitable for use in concrete. Coconut shells produce better coarse aggregate for concrete because of their high strength and modulus, as well as their high lignin content, which makes composites more moisture resistant, which means they absorb less moisture than other agricultural waste [7]. At this point, remarkable coconut shell properties like water absorption and specific gravity are reestablished for the benefit of the community [8].

To achieve the main purpose of this study, there are two main objectives have been outline to review coconut shell as replacement for coarse aggregate. Those objectives were to review the effectiveness of coconut shell as a coarse aggregate replacement on engineering properties such as strength, water absorption and workability on concrete based on previous research and to review the influence of the coconut shell inclusion in concrete on the microstructural characteristics.

In research conducted by Hasbullah [9] containing coconut shell in following ratios: 0%, 5%, 10%, 15%, and 20%. The result showed that the workability of the concrete found decrease as the increment percentage of replacement. Meanwhile, the compressive strength of concrete result showed a steady fall of compressive strength with the increasing of replacement. The compression strength in all ages, is consistently smaller than that of the control specimen.

Further research by Leman [10] with 0%, 5%, and 10% of percentage. Concrete workability found decreases with increasing percentage. Same as the compressive strength of concrete, the result showed the compressive strength drastically decrease with 10% of replacement. The decrement in concrete compressive strength as the amount of percentage that has been added to concrete increased could be in relation to each concrete mix workability. [10].

From the research by George [11] with 0%, 25%, 50% and 100% of replacement. The results found concrete with coconut shell workability increases with increases of replacement. However, the compressive strength result found decreases with increases of replacement. For 25% replacement mix of coconut shell, the average of compressive strength are 22.62, which is the strength of replacement mix almost same as strength of normal concrete [11].

Another study was conducted by Rao [12] with 0% 10% and 20% of replacement. The results showed the compressive strength at 7 days are increases with increases of replacement, while 28 days decreases steadily with increase of replacement but still high in strength. The water absorption result showed as the percentage increases, water absorption of coconut shell also increases.

2. Methodology

For this research, the implementation of an appropriate set of parameters for the selection of secondary data to be used in the analysis therefore plays an important role in improving the level of validity and reliability of the research. The parameter selected for this research are workability test, compressive strength, and the water absorption. From the collected data on previous research, 0%, 20% and 25% replacement of coconut shell that will be selected for this study. Another data testing on microstructural to evaluate the composite material of coconut shell were collected from the previous research, such as Scanning Electron Microscope (SEM), and X-ray Diffractometer (XRD). The previous collected data was analyzed using a table and interpreted in the form of a graph based on testing which are workability test, compressive strength test and water absorption test in critical review. Based on analysis, about 20% to 25% of replacement are suitable to replace coarse aggregate.

3. Result

3.1 The workability test of concrete containing coconut shell

Figure 1 shows the slump test of concrete with coconut shell. From figure 1, there are four researchers that conducted the same experiment but with different percentage of coconut shell.

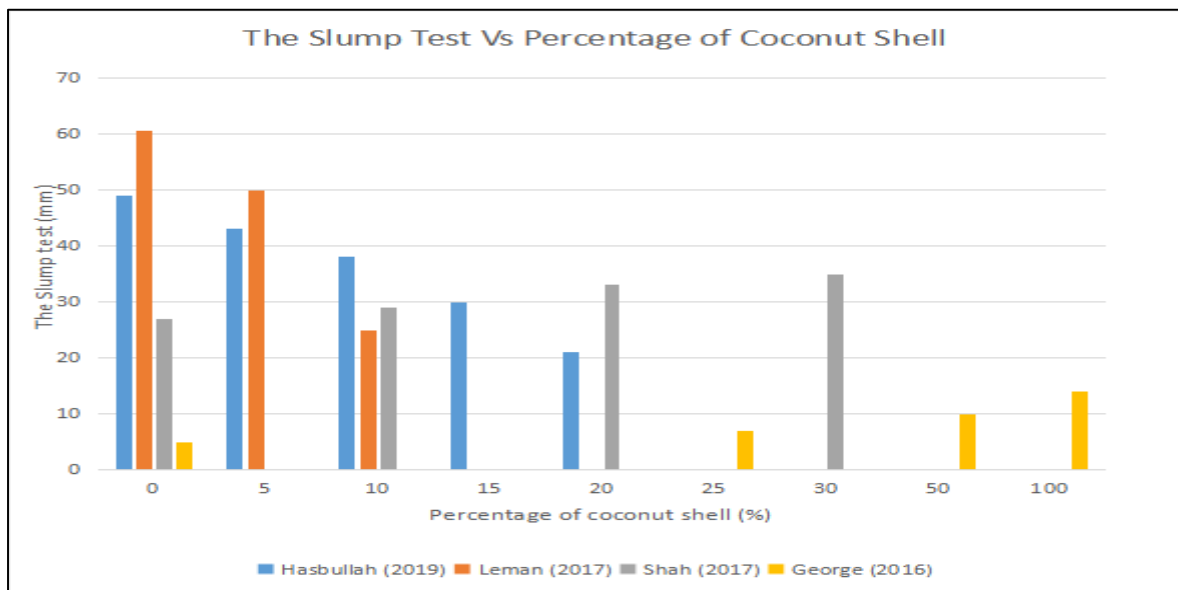


Figure 1: The Slump Test of Concrete with Coconut Shell

Based on the figure 1, found out that the studies from Shah [13] and George [11], concrete workability when mixed with coconut shell are increase due to the increment of percentage, while the studies from Hasbullah [9] and Leman [10], concrete workability are decrease due to the percentage of coconut shell increase. The study from Shah [13] show an improvement on the workability of concrete. The slump test increase with increase replacement of coconut shell. Same as George [11], the workability of concrete increase slowly with the increment of percentage. In addition, shaped and flakiness particles of coconut can reduce the aggregate overall movement and reduced workability. However, for Leman [10], the workability of concrete drop drastically at 20% of replacement. High water absorption of coconut shell in concrete influence the workability of concrete. Meanwhile, the study from Hasbullah [9], concrete workability tends to decrease if the percentage of replacement increases.

3.2 The compressive strength of concrete

Figure 2 shows the compressive strength test for concrete with coconut shell for 28 days of curing. Based on the figure 2, every researcher found out that using coconut shell as coarse aggregate in concrete decrease the compressive strength.

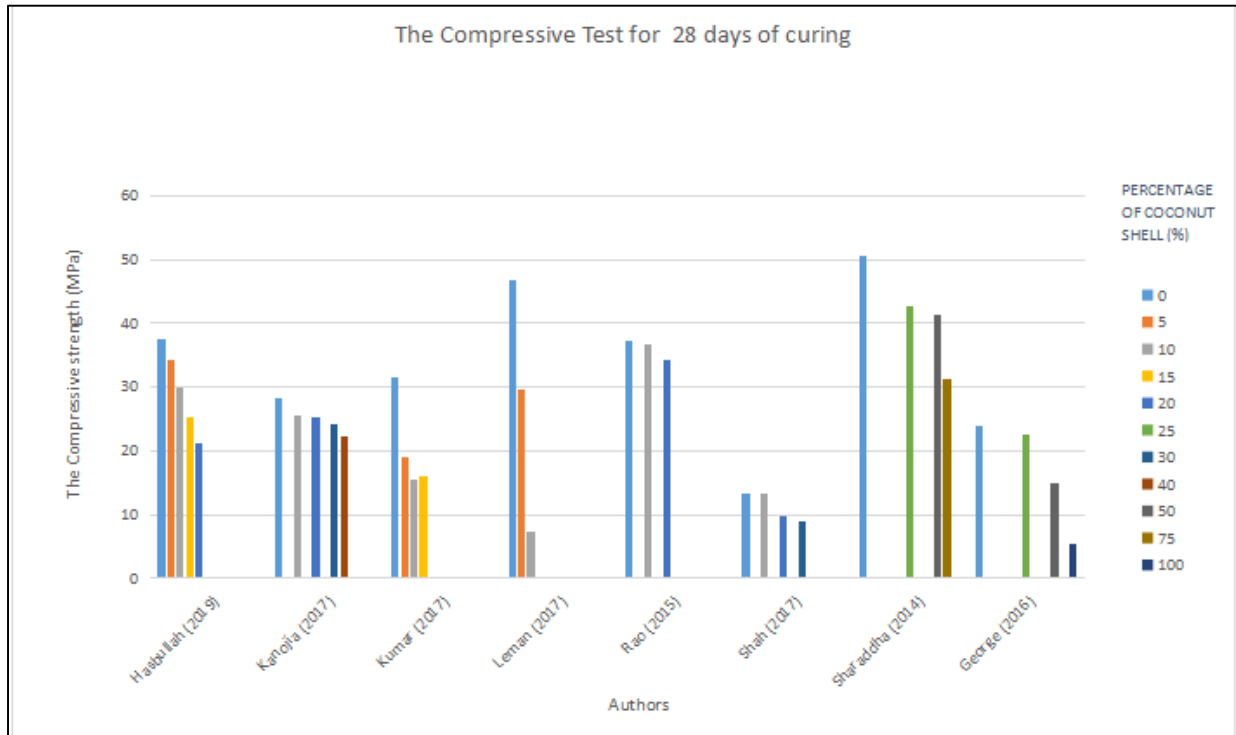


Figure 2: The compressive test result for 7 and 28 days

From figure 2, found out that there are low strength in compressive strength for 28 days of curing such as Kumar [14] and Leman [10], which the percentage drop drastically with the increment of percentage. Even though the compressive strength decrease with the increment of coconut shell, the compressive strength for 28 days of curing for Hasbullah [9], Kanojia [7], Rao [12] and Sharadha [15] are still high in terms of strength and can be used in low strength application such as and can be used in normal strength concrete application. As the higher workability, the compressive will decrease. The decreasing of compressive strength test occur when the bond failure between cement mortar and coconut shell aggregate. Moreover, the workability of coconut shell also influences the decreasing of compressive strength of concrete.

3.3 The water absorption test of concrete

Figure 3 shows the percentage of water absorption for coconut shell concrete. Both researchers found the percentage of amount water absorbed increase with the increase of replacement.

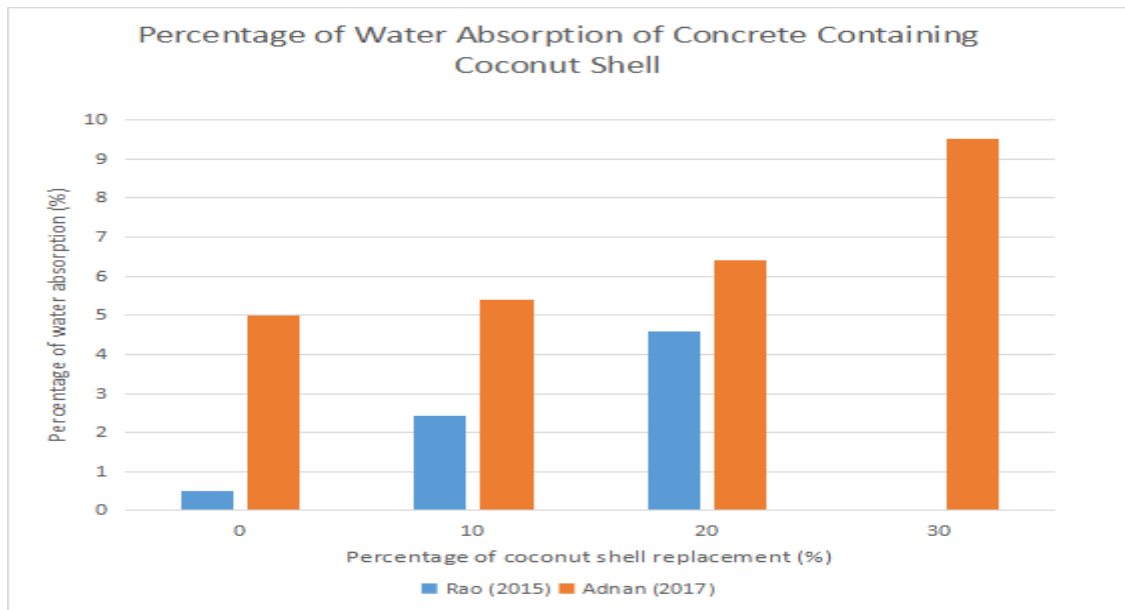


Figure 3: The percentage of water absorption for coconut shell concrete

Based on figure 3, for Rao [12], the water absorption seems low compared to Adnan [16]. From Rao [12], even in initial amount of water absorbed was little, the concrete with 20% of coconut shell absorption were nearly same. According to Adnan [16], the amount of coconut shell in the mixture impacted the rate at which water is absorbed. The rate of water absorption increased as the percentage of coconut shell increased. The pore structure of the concrete determines strength and water absorption in both studies, which are inversely proportional, meaning that as increasing of porosity, strength will decrease while absorption will increases.

3.4 The microstructure characteristic of concrete

Figure 4(a) and Figure 4(b) shows the scanning electron microscopy (SEM) images on coconut shell without soaking and with soaking.

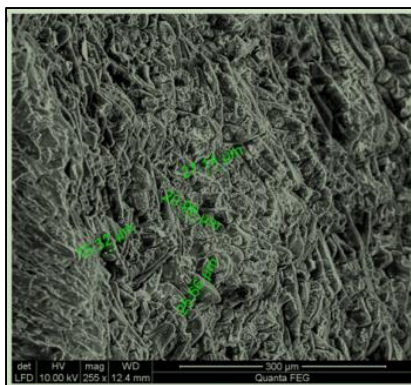


Figure 4(a): Without Soaking [17]

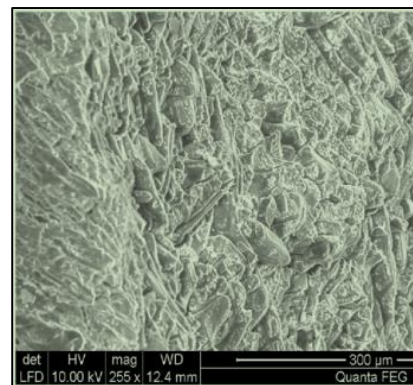


Figure 4(b) : With Soaking [17]

From the scanning electron microscopy (SEM) images on coconut shell without soaking and with soaking by Gunasekaran [17], the water absorbed during soaking is high, that is because the pore within the shell during soaking acts as a storage space. This shows that the coconut shell and cement paste appear to have a stronger bond [17].

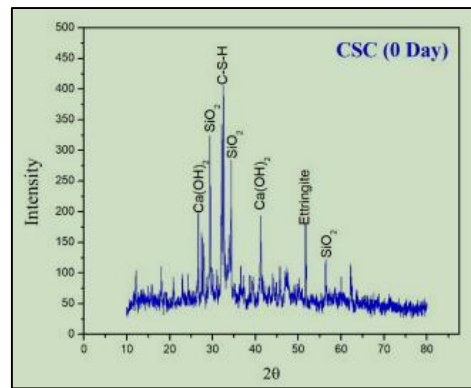


Figure 5: XFD analysis at zero day [18]

Besides that, the study by [18], on coconut shell specimen X-ray diffraction (XFD) analysis. The results showed the main chemicals compound discovered by XFD are C-S-H, Ca (OH)₂ and CH, the intensity of C-S-H increase while the other compounds are decreases. With intensity of C-S-H compound are high, that showed a significant positive influence to the strength of concrete [18].

4. Discussion

The result shows that most of the study found that concrete with coconut shell shows a positive impact on the workability of concrete and water absorption. However, that is not same case for the compressive strength. Most of the past research is using 0% - 30% replacement in concrete mix. The percentage replacement improves the workability and water absorption of concrete but has a negative impact on compressive strength. The microstructural characteristic of coconut shell in concrete also gives positive influence in concrete and make coconut shell appropriate to use coconut shell as coarse aggregate in concrete. After considering all factor based on analysis, about 20% to 25% of replacement are suitable to replace coarse aggregate.

5. Conclusion

The data from previous research that carried out shows that, about 20% to 25% of replacement of coconut shell which is in the compression strength are the same as the strength of regular concrete and it suitable in high strength applications. Around 20% to 25% replacement of coconut shell as coarse aggregate also made great concrete workability. Meanwhile, from the water absorption test, the amount of water absorption is found higher with the concrete with coconut shell than the normal concrete. So that, we that the quantity of water penetrating into concrete with coconut shell as replacement is high. Previous research using scanning electron microscopy (SEM) and X-ray diffraction (XFD), the pore structure within the coconut shell acts as a storage, implying that the coconut shell and cement bond are stronger, and that the compounds of coconut shell in concrete have a significant positive impact on the concrete strength.

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