Recent Trends in Civil Engineering and Built Environment Vol. 3 No. 1 (2022) 049-056
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RTCEBE

Homepage: http://publisher.uthm.edu.my/periodicals/index.php/rtcebe
e-ISSN :2773-5184

Study on a Coconut Shell as an Additive in a Concrete Mix

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DOI: https://doi.org/10.30880/rtcebe.2022.03.01.006
Received 4 July 2021; Accepted 13 December 2021; Available online 15 July 2022

Abstract: Many researches have now been performed on the use of natural waste as an additive in concrete mixtures. The coconut shell is one of the solid wastes from agricultural disposal operation. The focus of this study is to evaluate the effectiveness of the coconut shell as an additive in the concrete mixture and to observe the influence of the coconut shell inclusion in concrete on the microstructural characteristics. By critical review from previous research, from the analysis, it shows that 20 percent are the most suitable percentage to added the coconut shell as an additive. The compressive strength along with the tensile strength by given 24.22 MPa and 2.77 MPa respectively. It also influences the water absorption results. In microstructural testing, performed a Scanning Electron Microscope (SEM), X-ray Diffractometer (XRD) and Fourier Transform Infra-red (FTIR). SEM shows the coconut shell soaked with water has a high in water absorption and XRD results shows the sample is not containing a radioactive material. From FTIR testing, the sample shows that it contains quartz, carbon and vitreous phase. To conclude coconut shell is suitable to be added as an additive in the concrete.

Keywords: Coconut Shell, Additive, Microstructural Characteristics

1. Introduction

Concrete is one of the most commonly used civil engineering materials as a binding material for maintaining the world's rapidly increasing population and for rapid urban growth, especially in developing countries [1]. Due to the increasing demand for buildings and other infrastructure, huge amounts of cement are used and then disposed of in landfills with insufficient space, resulting in massive emissions of greenhouse gases [2]. In recent years, the world has been battling with the problem of solid waste disposal, with industrial waste being one of them. Agricultural waste has also affected this problem [3]. Limited supplies and environmental degradation are pushing scientists to look for new and

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reliable substitutes made from vast quantities of natural resources to use as additives in the partial substitution of cement [4]. The coconut shell is one of the solid wastes from agricultural disposal operation [5]. Due to their high strength and modulus properties, coconut shells are possible candidates for the production of new composites [6].

The aim of the study is to identify the suitable percentage of coconut shell as an additive in concrete mixing. Therefore, to ensure the purpose of the study is fulfilled, the objectives are to investigate the effectiveness of coconut shell as an additive on engineering properties based on compressive strength test, tensile strength test and water absorption test parameters through a critical review from previous research. In addition, to observe the influence of the coconut shell inclusion in concrete on the microstructural characteristics. This study is being carried out after a thorough examination of prior studies.

2. Methodology

For this research, the data collected based on specific parameter. The selected parameter for this research is compressive strength, tensile strength and the water absorption. Besides, the data testing on a microstructural particle such as Scanning Electron Microscope (SEM), Energy Dispersive X-ray Spectroscopy (EDS), X-ray Defractometer (XRD) and Fourier Transform Infra-red (FTIR) were collected from the previous research. The data that had been obtained before was analyzed through a table and interpreted in the form of a graph in this critical evaluation. From these results it shows the percentage from range of 0 percent to 60 percent of coconut shell added to the concrete mix.

3. Results and Discussion

3.1 Compressive Strength Test

Table 1 shows the data of compressive strength test which have been collected from the previous research. The collected data were interpreted in a form of graph for better understanding on which percentage achieved the best results of compressive strength test.

Figure 1 shows, the sample with 0 percent in this testing which also represent the concrete without the strength addition of the coconut shell as an additive. The lowest data of compressive test are from Ruben (2013) [7] which is only 5.458 MPa. While the highest data of compressive strength in 0 percent of coconut shell as an additive in concrete is from Ali (2011) [8] which the data stated 22.18 MPa of compressive strength. The greatest compressive strength test data was acquired by researcher Dhana (2019) [9] in the percentage of 1.5, and the results showed 27.91 MPa as the highest strength. In Ali (2011) [8] found that at 20 percent of additional of coconut shell as an additive have the highest compressive strength among the rest. The highest compressive data which is in percentage of 10 percent in Aniza's (2010) [10] and the highest compressive strength in Ruben (2013) [7] is in the percentage of 30 percent. When compared to ordinary concrete, the impact resistance of concrete with coconut shell addition is higher because the coconut shell produces a "paste"-like component that reinforces the cement, resulting in a stronger connection inside the concrete [7].

Table 1: Compressive test data from previous research.

	Percentage Of Coconut Shell (%)	Compressive Strength (Mpa)
(Aniza, 2010)	0	20.897
	5	17.527
	10	21.767
(Ali, 2011)	0	22.18
	20	24.22
	40	20.60
	60	15.22
(Ruben M. Ruiz et al., 2013)	0	5.458
	15	6.216
	30	13.169

(Dhana et al., 2019)	0	17.37
	0.5	21.93
	1	22.22
	1.5	27.91

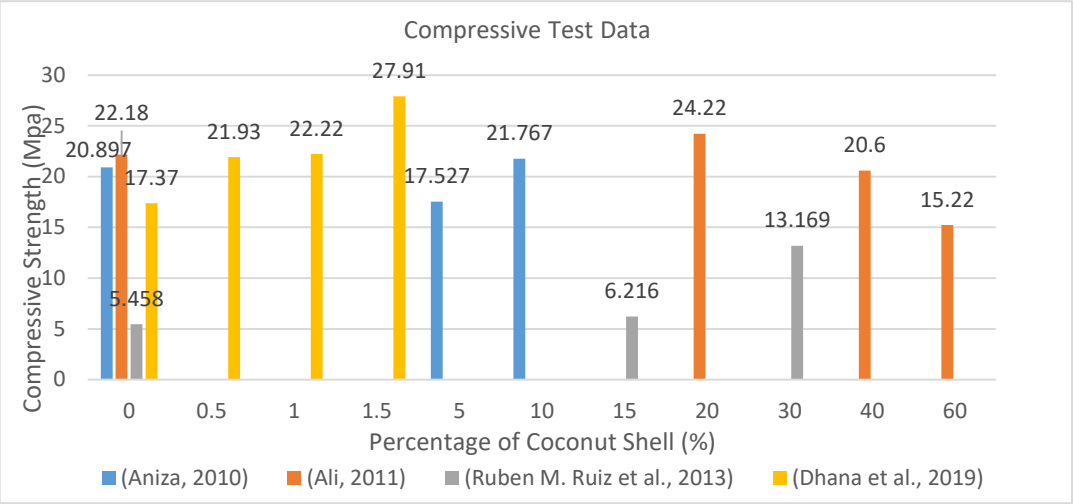

Figure 1: Compressive test data comparison obtained between previous researchers.

3.2 Tensile Strength Test

Table 2 shows the data of tensile strength test which collected from previous research. From the figure 2, Ali (2011) [8] obtained tensile strength at 0 percent of coconut added which means there is conventional concrete stated 2.48 MPa of tensile strength. In which his tensile strength is the highest in 0 percent of coconut shell added to the concrete. While at 20 percent of coconut shell added to the concrete as an additive stated the highest tensile strength which is 2.77 MPa in Ali (2011) [8] research. While the highest tensile strength above all of the percentage is 30 percent in the research from Ruben (2013) [7]. Ali (2011) [8] stated that the addition of the coconut shell might give effects to its workability and both compressive strength and the tensile strength.

Table 2: Tensile test data from previous research.

	Percentage Of Coconut Shell (%)	**Tensile Strength (MPa)**
(Ali, 2011)	0	2.48
	20	2.77
	40	1.79
	60	1.23
(Ruben M. Ruiz et al., 2013)	0	1.89
	15	2.94
	30	3.34
(Dhana et al., 2019)	0	1.92
	0.5	2.29
	1	2.49
	1.5	3.16

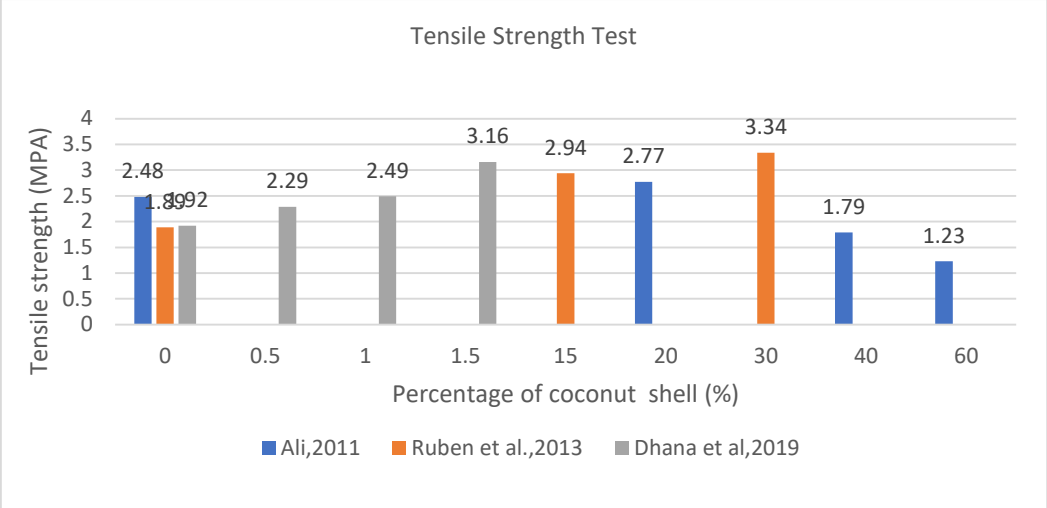

Figure 2: Tensile test data comparison obtained between previous researchers.

3.3 Water Absorption Test

Table 3 shows the data of the water absorption conducted by Ruben (2013) [7]. The figure 3 shows a graph of water absorption data. From Ruben (2013) research concrete sample with coconut shell added as an additive gives a high value of water absorption which is 0.73. This value is high from the normal concrete which stated only 0.2 value of water absorption in the concrete. Water-cement ratios were evaluated in this study is 1:2:4 [7]. Due to too much water, it might impair the concrete's strength. As a result, Ruben (2013) [7] gradually added water to avoid affecting the concrete sample's strength. The shell's moisture absorption was also observed since it was resistant to water absorption. Because fewer voids were produced, water absorption in the concrete had no effect on its strength [7].

Table 3: Water absorption test data from previous research

Author	Concrete without coconut shell	Concrete with coconut shell
(Ruben M. Ruiz et al., 2013)	0.20	0.73

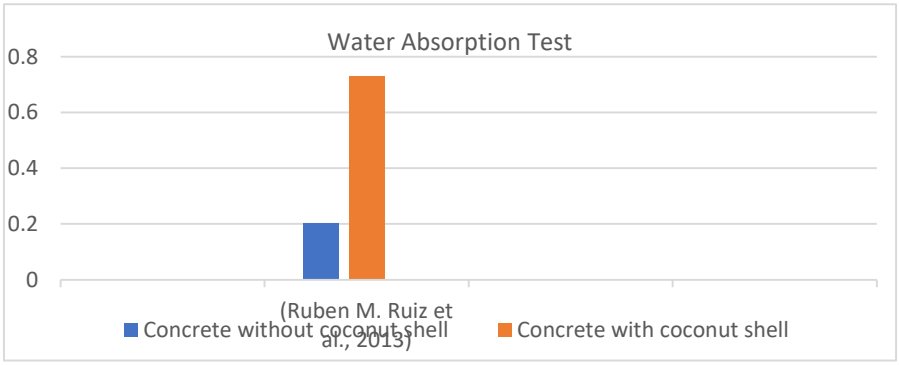

Figure 3: Water absorption test data comparison obtained between previous researchers.

3.4 Microstructural Testing

From figure 4 (a) and figure 4 (b) show the results of Gunasekaran (2012) [11] for coconut shell samples without and with soaking. Figure 4 (b) illustrates that coconut shell has a high-water absorption capacity because it absorbs water and stores it as a reservoir in a pore structure inside coconut shell. While in Figure 4 (c) shows the coconut shell ash's SEM investigation, which revealed that its structure is solid

yet uneven in size [12]. The purpose of this testing is to observe the influence of the coconut shell inclusion in concrete on the microstructural characteristics.

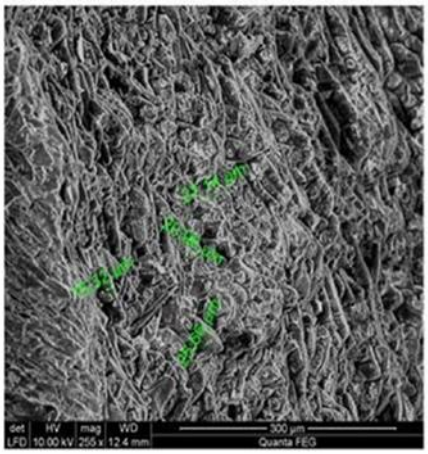

Figure 4 (a): Coconut shell without soaking [11]

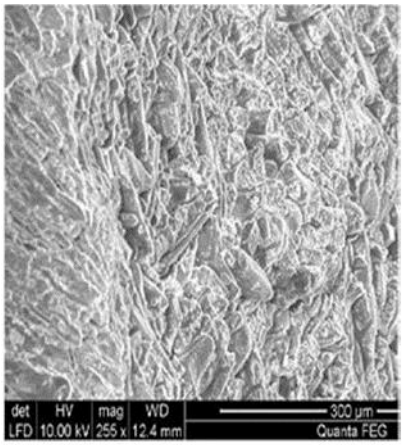

Figure 4 (b): Coconut shell with soaking [11]

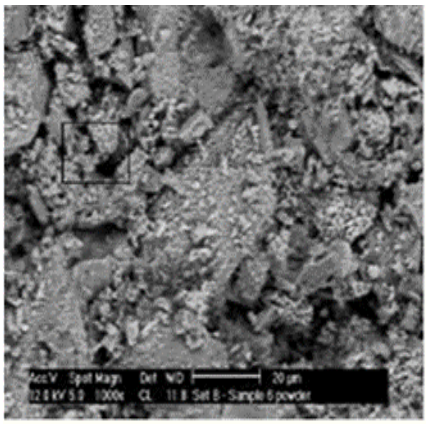

Figure 4 (c): Coconut shell ash's SEM investigation [12]

Figure 5 (a) shows Energy Dispersive X-ray Spectroscopy EDS spectrum of Coconut shell ash. As demonstrated in the EDS scan, the chemical analysis of the coconut shell ash morphology comprises mostly of Si, C, O, Mg, Al, and minor quantities of Fe [13]. From Figure 5 (b), A Philips X-ray diffractometer was used to identify the chemical composition of the phase-in coconut shell ash [12]. And lastly for figure 7 shows that an infrared spectrophotometer with Fourier transform was used to look for functional groups in coconut shell ash [12]. In figure 5 (c) also Mullite is visible in a series of bands ranging from 3797 cm-1 to 4091.15-14617.74 cm-1, while carbon groups are seen in a series of bands ranging from 4091.15 to 14617.74 cm-1. Because of the bands of multiphase ash, glassy, and quartz phase cross between 1220 cm-1 and 1434.12 cm-1, it was verified that the mullite phase, quartz phase, carbon phase, and vitreous phase exist [12]. Quartz powder is a frequent ingredient in the production of high-performance and ultra-high-performance concrete (UHPC). At typical ambient temperatures, quartz powder is chemically inert, although it is not entirely inert at high temperatures and pH values [14].

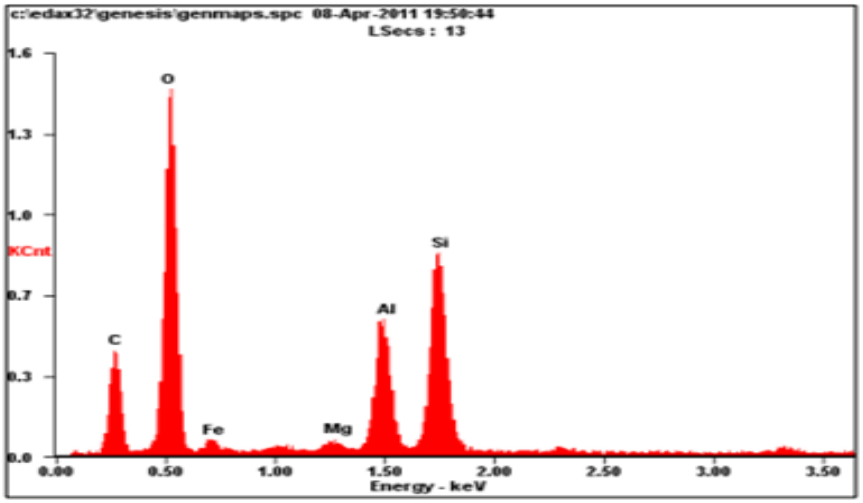

Figure 5 (a): EDS spectrum of Coconut shell ash [12]

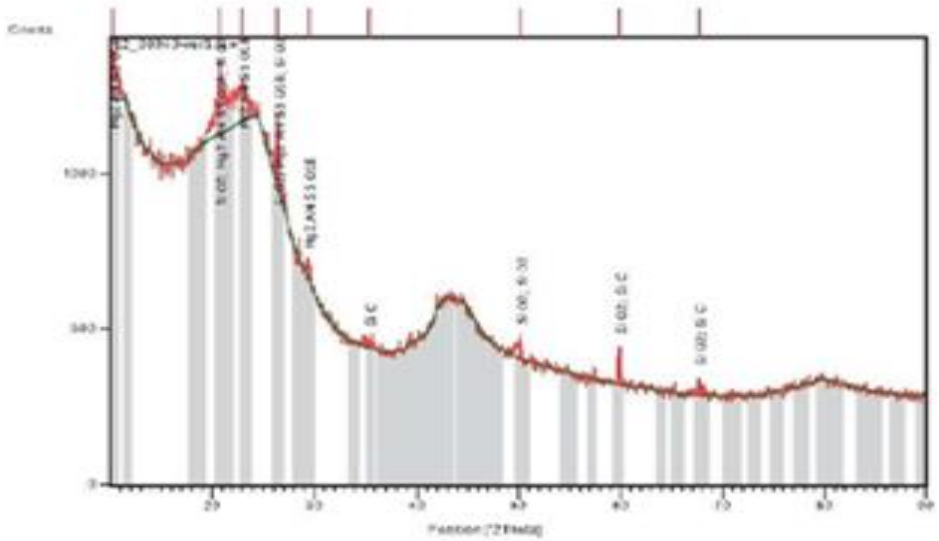

Figure 5 (b): Coconut shell ash XRD pattern [12]

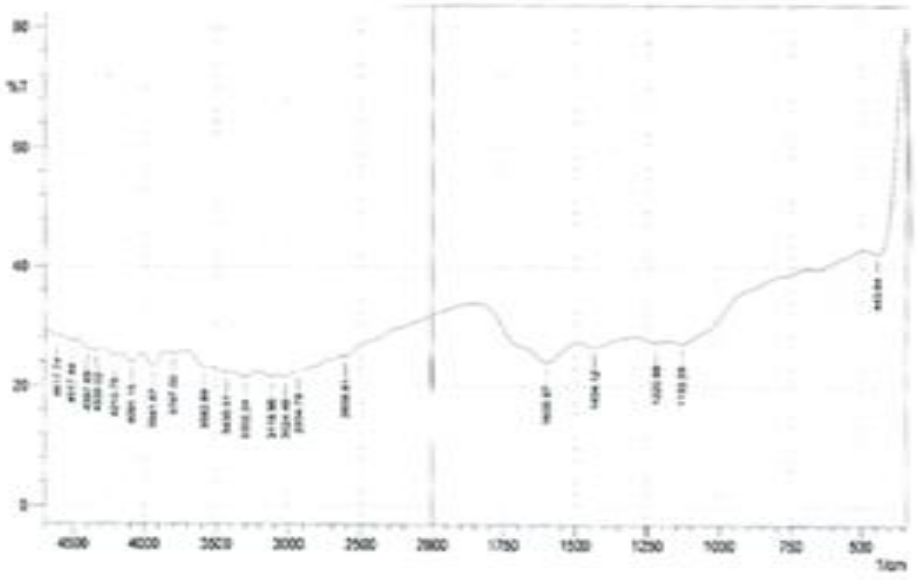

Figure 5 (c): Coconut shell ash FTIR pattern. [12]

4. Conclusion

Based on the critical review, it shows that the percentage from Ali (2011) which is 20 percent have the suitable percentage of coconut shell added to the concrete as an additive. Due to this, it shows an impressive result on compressive strength test and tensile strength test. It has the suitable compressive strength along with the tensile strength. This can be proving the data of compressive strength of 20 percent have 24.22 MPa while the tensile strength data of 20 percent stated 2.77 MPa. While different from the other percentage, the other percentage might have the highest compressive strength but it may have not a quite good value of tensile strength. From the critical review of water absorption test, the concrete with the addition of coconut shell as an additive have the highest water absorption value compare to the concrete without the addition of coconut shell as an additive in the concrete. In this microstructural testing Ting (2016) performed a Scanning Electron Microscope (SEM), X-ray Diffractometer (XRD) and Fourier Transform Infra-red (FTIR). Ting's (2016) research of SEM at the coconut shell soaked with water shows that it has a high in water absorption. For an investigation un XRD shows that the sample is not containing a radioactive material. Lastly under FTIR testing, the sample shows that it contains quartz, carbon and vitreous phase. To conclude coconut shell is suitable to be added as an additive in the concrete. From the graph from figure 1 and figure 2 shows that concrete which contain coconut shell as an additive reached higher compressive strength and tensile strength compare to conventional concrete.

Acknowledgement

The authors would like to thanks the Faculty of Civil Engineering and Built Environment, Universiti Tun Hussein Onn Malaysia for its support.

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