

Coconut Shell as a Substitution in Mortar

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Abstract

Coconut shell Mortar is a well-known masonry unit to bind bricks stones and concrete units. Generally, the mortar paste consists cement as binding material, sand as fine aggregate and water in certain ratio. Currently, One of the wide expansion of construction industry by increasing the usage of sand from rivers for different purposes, which leading to over-exploitation of riverbeds and disrupted ecologies. Due to the excessive reclamation of sand resulted in river damage by less river steady and it can be threatening to environment due to its tough made tissues, the shell would not easily decompose and remains as solid waste for 100 to 120 years. The aims of this study are to evaluate the performance of mortar using coconut shell mortar in compressive strength and water absorption and To compare the performance between ordinary mortar and coconut shell mortar. To evaluate these objectives, we have conducted two tests which are, compressive strength test and water absorption test according to ASTM standard. The findings indicated that the addition of coconut shell gradually reduced the mortar's performance because the strength of the coconut shell is not as strong as a fine aggregate. It can be conclude that coconut shell can be a substitute for fine aggregate but it is less reliable than what an ordinary mortar does.

1. Introduction

It is well known that engineering has been developing in terms of the consumption of various natural elements. One of the wide expansions of construction industry by increasing the usage of sand from rivers for different purposes, which leading to over-exploitation of riverbeds and disrupted ecologies. Due to the excessive reclamation of sand resulted in river damage by less river steady. This predominantly causes many issues such, river depth, huge lowering of water levels, sea level arising and the riverbanks collapse [1]. Moreover, river sand utilization in the Indian construction sector has up risen around 630 to 1400 million tones and research proved that floods brought on changes in river flow from 2010 to 2020, which will critically affect the biodiversity [2]. Other than that, the coconut shell generally can be threatening to environment due to its tough made tissues, the shell would not easily decompose and remains as solid waste for 100-120 years [3]. The only ways to solve these problems by proper handling of this material and utilizing or reuse it as natural waste materials in engineering application. As the same time, the use of coconut in cooking in Malaysia is very high and has become the main ingredient for some people. This usage doubles during festivals especially Hari Raya and Deepavali. then, at this

moment coconut waste also increases [4]. As according to [5], coconut shells take approximately ten years to degrade in the environment which can leads to environmental pollution. In this case, an alternative should be research to reduce the over consumption done by construction that may disturb the biodiversity in the near future. For that a replaceable material such as coconut shell is an initiative that is researched in this paper to identify the capability of this material to substitute fine aggregate or sand in construction.

Mortar is a well-known masonry unit to bind bricks, stones and concrete units. Generally, the mortar paste consists cement as binding material, sand as fine aggregate and water in certain ratio. Usually, mortar will be in uses for both load bearing and non-load bearing structures. As per to engineering, Cementitious materials, such as concrete and mortar, are used in in large scale by the civil construction, mostly due to their compressive strength, In fact, concrete and mortar are composite materials and depending on the fraction of a phase incorporated they will present specific properties for each mixtures[6]. Testing a mortar is usually is related to its strength which gives the information of whether the mortar is suitable for non-bearing load which does need to be able to handle such force during construction. Studies have shown that among the tests that can be used on mortar, tensile test is the most vital in acknowledging the tensile strength of a mortar[7].

The goal of this study is outlined in three primary objectives that together provide a distinct and attainable study vision. This study has described it as ensuring our integrity in upholding each activity and choice that is necessary to achieve the goal. The aim for the study is to answer the three objectives which is to evaluate the performance of mortar using coconut shell mortar in compressive strength and water absorption and to compare the performance between ordinary mortar and coconut shell mortar. In order to find information for a specific standard that needs to be exceeded, which is by carrying out this study and comparing the product with the standard type of mortar, the performance evaluation of an ordinary mortar is essential to our research. This is also to recognize the shortcomings of regular mortar, despite its widespread use in construction. It can assess what to anticipate from coconut shell mortar by analysing how well regular mortar performs. However, more research is required to determine whether this mortar can perform tasks that ordinary mortar cannot. It is anticipated to function better than regular mortar. After assessing, those were compared to the specifications of the two mortars to determine what was lacking in each and what would be crucial for further research. The results of the experiments, the analysis, and additional references from the manufactured product are the basis for the comparison

2. Methodology

The primary objective of this study is to propose coconut shell (CS) as sand replacement in mortar paste that is use for non-bearing load structure. The evaluation for this hybrid mortar mixture begins with the sample preparation for CS as it needs to be macerate to 4.75 mm and smaller mimicking the sand size used for mortar mixture. The percentage of CS replacing sand is 2%, 4% and 6% that will be mix with 1:3. Three main tests are used to determine the strength of hybrid mortar mixture; compressive test, slump test and water adsorption test.

2.1 Materials

In contrast to concrete, mortar only requires three ingredients: cement, sand, and water. A common mortar ratio is 1:3. Sand is ranges in size from 4.75 mm and smaller. Although the type of cement used for mortar application differed depending on the locale, OPC is still widely utilized in building. In terms of the water ratio, it is lower than the 0.40-0.45. In this investigation, sand and cement are shown in Fig.1. When mixing mortar, fine aggregate is added in a 1:3 ratio to cement.



Fig. 1 Mortar mixture material (a) sand, (b) cement

2.2 Compressive Test

Using a compressive testing machine, the samples were put through a compressive strength test. For each batch of mix, three cubic specimens measuring 100 mm by 100 mm by 100 mm were evaluated, and the average values of the readings were determined. The compressive strength was ascertained by recording the greatest load obtained. Cube compressive strength for each mortar mix was then determined by taking the mean value of compressive strength derived from three cubes.

2.3 Water Absorption Test

A technique for determining how much water is absorbed by various materials under given circumstances is the water absorption test. The specimens are dried in an oven for twenty-four hours, cooled in a desiccator prior to the final weighing (W_2), and finally submerged in water at a specific temperature and duration, or until they reach equilibrium. The water tightness or waterproofness of the mortar mixes determines how much water they absorb. After a 28-day wet curing period, a water absorption test will be conducted on 12 cubes. For the test, they were removed from the curing tank and oven dried for 24 hours at $100 \pm 5^\circ$ until a consistent mass was reached. After that, each sample will be weighed. After 24 hours, the samples will be removed from the tank, shake to remove bulk of water, and dried with a cloth as fast as possible to remove all free water on the surface. They then weighed again.

$$\text{Percentage of Water Absorption} = \frac{W_2 - W_1}{W_1} \times 100\% \quad (1)$$

Where, W_1 is the oven dry weight of samples (kg), and W_2 is the wet weight of samples (kg).

3. Results

The test's objectives are to determine the workability, compressive strength, and water absorption. A conclusion can be drawn by carrying out these tests and examining, evaluating, and observing the data collected. Important information on the functionality of coconut shell mortar is gathered by extensive testing, which includes assessments of compressive strength, workability, and water absorption. The results of these tests yield quantifiable information that can be used to assess whether coconut shell mortar is appropriate for use in different construction applications.

3.1 Compressive Test

In order to ascertain the coconut shell mortar's compressive strength, the ASTM C109 test protocol is followed, which predicts that the mortar will yield a higher compressive strength than regular mortar. To make sure mortar can withstand the maximum force applied by the machine, a test is also conducted to determine the precise value of mortar that can be substituted. Our test indicates that the mold with 0 (%) coconut shell has the highest load for compressive strength; these molds are regarded as control samples. High compressive strength guarantees the fabrication of high-quality, dimensionally correct parts by indicating that the mould material can withstand large stress and pressure without deforming or breaking. Moreover, it has been proved that more of coconut shell caused lack of compressive strength. Hence, the expected result also has changed vice versa.

3.2 Water Absorption Test

The weight of the cube should be measured once it has been dried in the oven. It is expected that the weight of the mortar will be higher than that of the ordinary mortar because the coconut shell may reduce the pores and voids in the mortar. The dry density also is expected to be above 2000 kg/m_3 as the average of the common mortar under these figures. The measurement of the weight of the cube after drying in the oven allows for the calculation of the dry density of the coconut shell mortar. It is possible to obtain knowledge about the possible structural advantages of using coconut shell as an aggregate substitute by comparing this dry density with that of regular mortar.

3.3 Data and Analysis

After the cube has dried in the oven, its weight needs to be determined. Because the coconut shell may minimize the mortar's pores and voids, it is anticipated that the weight of the mortar will be more than that of regular mortar. According to these data, the dry density is also anticipated to be greater than 2000 kg/m_3 , which is the average for common mortar. The dry density of the coconut shell mortar can be determined by

weighing the cube after it has dried in the oven. By contrasting this dry density with that of conventional mortar, one can learn more about the potential structural benefits of employing coconut shell as an aggregate alternative. The result for both compressive strength and water absorption test are tabulated as in Table 1.

Table 1 Compressive strength and water absorption according to sample percentage

Sample Percentage, %	Test	
	Compressive Strength, N/mm ²	Water Absorption, %
0	S1	54.40
	S2	55.20
	S3	62.60
2	S1	44.90
	S2	37.10
	S3	41.5
4	S1	41.00
	S2	36.70
	S3	27.80
6	S1	33.30
	S2	23.40
	S3	27.60

It is clear from the statistics that coconut shell is no longer useful for increasing mortar strength in terms of compression. Even though the mortar was exposed to non-bearing load structures, it is still not advised for construction because of this significant strength drop. In addition, the value that was acquired differs from mortar type O. The average proportion of coconut shell samples is slightly less than that of typical type O mortar, which is 52. Additionally, the mortar cubes that included coconut shells performed less well when compared to the control samples as shown in Fig. 2.

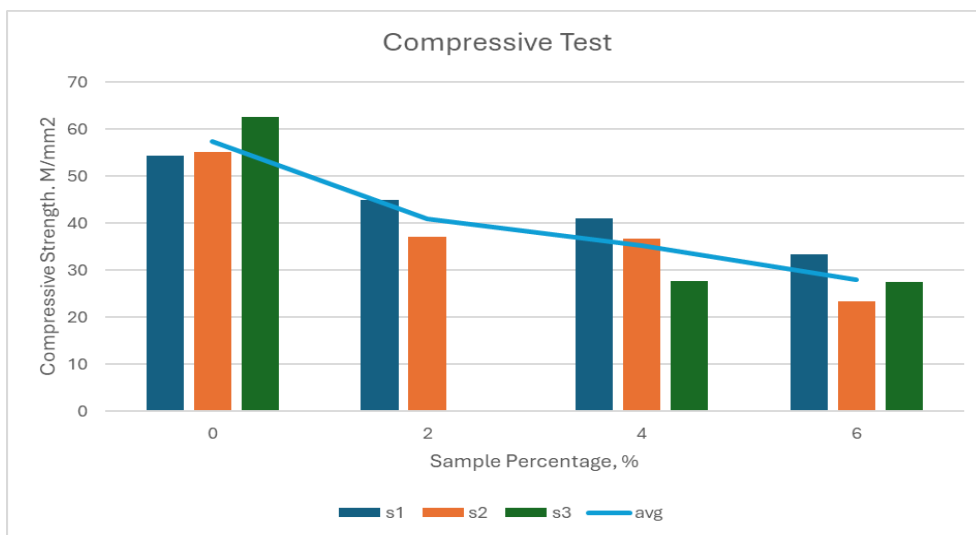


Fig. 2 Compressive strength test result

Furthermore, coconut shell performed no better than regular mortar in the water absorption test. For this test, the anticipated outcome was also the opposite: the stronger the mortar, the lower the water absorption rate. The test's lowest average value, which was also noted for the control mortar cubes, was 0%. Thus, it is most definitely not advised to use this for building. An excessive amount of water absorption can result in structural flaws. The table and figure following provide more details regarding the findings.

As shown in Fig. 3, the average percentage of water absorption has been rising in relation to coconut shell, meaning that the coconut shell with the lowest water absorption capacity is also the one with the lowest amount. Therefore, it is not advised to use coconut shell in civil building when it comes to water absorption. In contrast to unreinforced alloys, coconut shell is classified as a Metal matrix composite (MMC) along with fly ash and rich hush. MMCs have excellent properties such as good precise strength, precise modulus, good weather resistance, and great damping capacity.



Fig. 3 Water absorption test result

4. Conclusion

Two goals and two problem statements for this project flow have already been specified in Chapter 1, Introduction. Based on the findings and analysis, this project has achieved its two initial goals: comparing the efficacy of regular mortar with coconut shell mortar and assessing the performance of mortar in terms of compressive strength and water absorption. The first objective (I), achieved by conducted compressive strength and water absorption test in 'Bengkel Teknologi Konkrit' in UTHM, Pagoh. The following result also has been analyzed in previous chapter, which is result and analysis. For the second objective (II), those tests that have been done successfully compared the performance between ordinary mortar and coconut shell mortar. As the result, the performance of ordinary mortar is higher than coconut shell infused mortar. Thus, this project successfully managed to fulfill both of the objectives.

In the case of problem statement, the primary issue is excessive reclamation of sand in river resulted in crucial river damage and predominantly causing many issues such, river depth, huge lowering of water levels, sea level arising and the riverbanks collapse. Through this project, it was believed that coconut shell can be an alternative as partial sand replacement, but the tests result didn't favor on this issue, thus the coconut shell cannot be a partial replacement for mortar. So that, there is no effective way in reducing usage of sand from river. The second issue is all about the coconut shell generally can be threatening to environment due to its tough made tissues, the shell would not easily decompose and remains as solid waste for 100-120 years. As the same time, the use of coconut in cooking in Malaysia is very high and has become the main ingredient for some people. This usage doubles during festivals especially Hari Raya and Deepavali. then, at this moment coconut waste also increases. For this issue, the coconut shell would be chosen for this project by made an attempt implementing in Civil Engineering. As the result, the coconut shell was not suitable for mortar as the fine aggregate. Therefore, other effective ways yet to find out to reduce the excessive waste of coconut shell in Malaysia to avoid critical bad effects towards environment.

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Conflict of Interest

Authors declare that there is no conflict of interests regarding the publication of the paper.

Author Contribution

The authors confirm contribution to the paper as follows: **study conception and design:** Thevaraj A/L Arasan, Adi Radhi Fadzilah, Elvin Meringgai, Nor Farah Atiqah Ahmad; **data collection:** Thevaraj A/L Arasan, Adi Radhi Fadzilah, Elvin Meringgai, Nor Farah Atiqah Ahmad; **analysis and interpretation of results:** Thevaraj A/L Arasan, Adi Radhi Fadzilah, Elvin Meringgai, Nor Farah Atiqah Ahmad; **draft manuscript preparation:** Thevaraj A/L Arasan, Adi Radhi Fadzilah, Elvin Meringgai, Nor Farah Atiqah Ahmad. All authors reviewed the results and approved the final version of the manuscript.

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