

## Properties of Cement Sand Brick Containing Finely Crushed Cockle Shell as Partial Fine Aggregates Replacement

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### Abstract

Research towards producing environmental friendly cement sand brick stems out from the environmental problem caused by dumping of cockle shell by cockle trade and the increasing river sand mining. This paper discusses the effect of finely crushed cockle shell as partial fine aggregates replacement towards compressive strength, flexural strength and water absorption of cement sand brick. A total of six mixes have been used in this experimental work. Brick produced 100% river sand is considered as control specimen. Another type of mix was prepared by adding a range of crushed cockle shell that is 10%, 20%, 30%, 40% and 50% as partial fine aggregates replacement. All mixes were subjected to water curing until the testing age. Both compressive strength test and flexural strength were conducted at 7, 28 and 60 days. The findings shows that integration of 30% finely crushed cockle shell increase the compressive strength and flexural strength of brick. The same mix also exhibits the lowest water absorption value. Utilization of crushed cockle shell as partial fine aggregates replacement that acts as filler makes the internal structure of brick become denser and stronger. Success in incorporating cockle shell waste in brick production would assist in reducing quantity of shell disposed by cockle trade as solid waste and lower the consumption of natural river sand.

*Keywords: cement sand brick, finely crushed cockle shell, partial fine aggregates replacement, mechanical properties, water absorption.*

### 1. Introduction

Local river sand is one of the natural materials which widely used for many applications in construction project. Cement sand brick is one of the construction materials that produced using sand as one of the important mixing ingredient. In Malaysia, the raw sand and gravel produced is increasing from year 2014 which is about 34,341,300 tonnes to 29,862,000 tonnes on 2015 [1]. However, the active mining activity of river sand beyond the allowable limit poses negative impact to environment such as soil erosion, lower water quality, and destruction of

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aquatic that affects the life style of community surrounding. The effect of excessive sand mining to river environment has been discussed by past researchers [2, 3]. Realizing the importance of preserving the river environment, researchers [4-8] has taken initiative to explore the potential of available waste materials as fine aggregates replacement in production of construction materials. More discoveries made on identifying suitable industrial by-products to be used as partial fine aggregates replacement would contribute towards cleaner environment and reduce the quantity of sand mined from the river bed.

In relation to that, the availability of cockle shell which disposed as environmental polluting waste by cockle processing factory opens the door for its use in construction material production. Cockle grows along the mangrove swamps on the West Coast of Peninsular Malaysia. Being a cheap protein source, it is quite common to be prepared as local dishes. According to [9], the availability of cockles which is an important protein source in the South East Asian region is one of the factor that boost the cockle trade in Malaysia. In practice, the hard shell of cockles usually cracked open at the factory to acquire the edible meat to be processed as canned food or sent to fresh market. The shells are thrown as waste at dumping site. This creates discomforts to the community due to its stinky smell and unsightly view [10].

Success in integrating this waste material in production of materials would be one of the solutions to environmental problem posed by cockle shell dumping and able to offer alternative to save the use natural river sand. This has initiated researches that have been conducted to explore the potential of cockle shell as one of the materials for the purpose of bone repair, artificial reefs, concrete and other area. However, very little data is available on the performance of cement sand brick produced using crushed cockle shell as partial fine aggregates replacement. Thus, the present paper discusses the effect of finely crushed cockle shell as partial fine aggregates replacement towards mechanical properties and water absorption of cement sand brick.

## **2. Experimental Program**

### **2.1 Materials**

Ordinary Portland cement, river sand, supplied tap water and cockle shells are among the materials that were used in specimen preparation. River sand was obtained from the local supplier. Cockle shells were collected from cockle processing factory located in Kuala Sepetang, in the state of Perak, West Malaysia. At the laboratory, the cleaned cockle shells were crushed to be finer size. Then, the particles passing 1.18 mm sieve were used as partial fine aggregates replacement. Figures 1 and 2 illustrate the raw cockle shell and finely crushed cockle shell ready to be used.



Figure 1. Collected raw cockle shell.



Figure 2. Finely crushed cockle shell.

## 2.2 Mix proportion

Six batches of mixes containing various percentage of crushed cockle shell as partial fine aggregates were used in this experimental work. All specimens were prepared in form of brick with the dimension of 210mm long, 100mm wide and 65 mm thick. Plain cement sand brick produced using 100% river sand was used as reference specimen. The rest of the mixes contain various dosages of crushed cockle shell from 10% up to 50% as partial fine aggregates replacement. The amount of finely crushed cockle added was by weight of sand.

## 2.3 Specimens Preparation and Testing Methods

The mixing process was done by using an electrically powered mixer to ensure all the materials thoroughly mixed. Then, the fresh mix were placed in brick mould and compacted. Then, it was covered with wet gunny overnight. The next day, the bricks were demoulded and immediately immersed in the water until the testing date. Both compressive strength test and flexural strength were conducted at 7, 28 and 60 days. Water absorption test were conducted at 28 days. All tests were conducted in accordance to ASTM C55 [11].

## 3. Results and discussion

### 3.1 Mechanical Properties

The compressive strength and flexural strength of brick are shown in Figures 3 and 4, respectively. All specimens exhibit strength increment as the curing age become longer. The application of continuous water curing ensures better hydration process resulting in formation of more calcium silicate hydrate (C-S-H) gel that is vital for strength performance of concrete.

The graphs show that both compressive strength and flexural strength of brick is affected by finely crushed cockle shell replacement. Inclusion of finely crushed cockle shell at 10%, 20% and 30% results in strength increment of brick. The reason can be attributed to the fineness of the crushed cockle shells particles used. The SEM image illustrates the finer features of crushed cockle shell (Figure 5) in comparison to the river sand (Figure 6) used. The fine

particles act as filler by filling in the existing voids making the internal structure of mortar more compact and contribute towards strength increment.

In a related research, Shettima et al. [7] observed similar trend when iron ore tailing were used as partial fine aggregates replacement. They reported that when finer particles of waste materials are used as partial fine aggregates replacement at suitable content, the concrete strength increases owing to the role of finer particles that fills in the pore and optimized the pore structure. However, the use of the crushed cockle shell needs to be limited. As it can be observed in the graph, bricks begin to experience strength reduction when 40% and 50% finely crushed cockle shell is added. Generally, integration of suitable content of crushed cockle shell would contribute towards positive strength increment of the concrete. Similar trend has been reported by other researchers [12, 13] who used waste materials such as bagasse ash and saw dust ash as partial fine aggregates replacement in concrete.

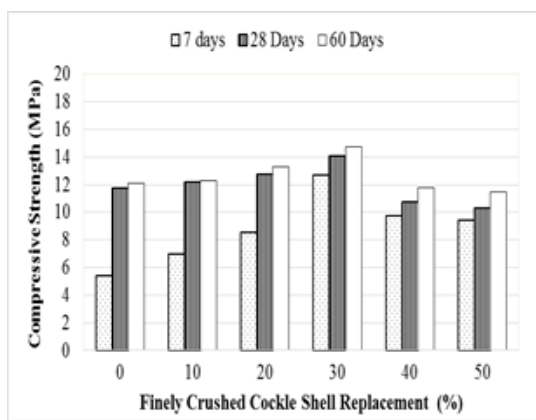


Figure 3. Compressive strength result of 60 days.

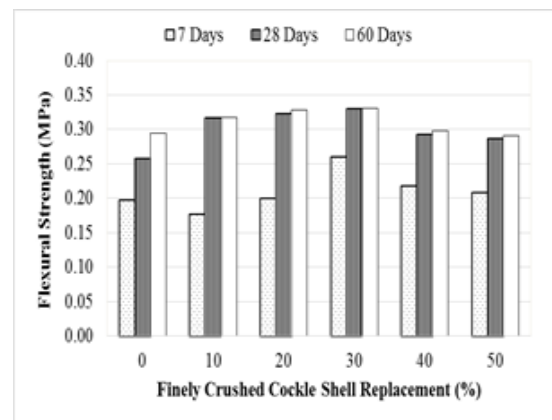


Figure 4. Flexural strength result of 60 days.

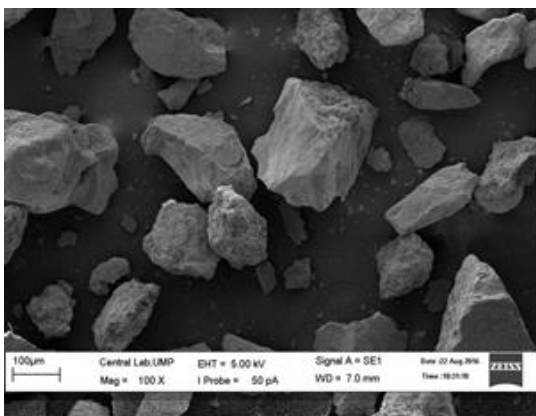


Figure 5. SEM Image of river sand.

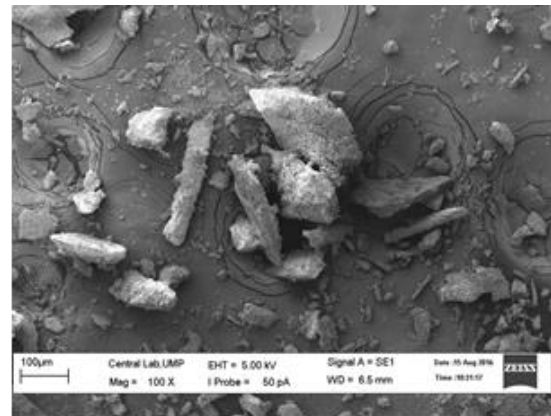


Figure 6. SEM Image of finely crushed cockle shell.

### 3.2. Water Absorption

The water absorption results are presented in Figure 7. Evidently, the water absorption value becomes lower when crushed cockle shell is added up to 30% replacement by weight of sand. This likely due to role of fine particles of crushed cockle shell that fill in the existing

voids making it denser resulting lower water absorption. The positive contribution of waste material such as fly ash when used as partial fine aggregates replacement that results in lowering the water absorption has been reported by [14]. On overall, the content of crushed cockle shell used and its fineness is one of the factors that influence the compactness of mortar structure which determine the water absorption of the material.

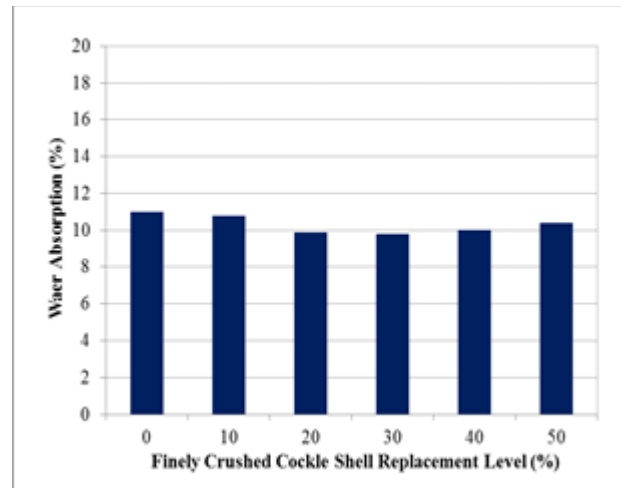


Figure 7. Water absorption test result.

#### 4. Conclusions

Finely crushed cockle shell seems to have good potential as partial fine aggregates replacement in cement sand brick production. Utilization of finely crushed cockle shell up to 30% successfully increases the strength performance of brick. In addition, the use of cockle shell in production of environmental friendly brick is a smart approach of converting the waste to wealth. Pollution resulting from dumping of cockle shell also can be reduced and river sand can be saved from excessive mining activity. Long term experimental work need to be conducted to observe the performance of mortar or cement sand brick containing finely crushed cockle shell both in terms of mechanical and durability properties.

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