Compressive Strength of Mortar Containing Cockle Shell Waste as Mixing Ingredient

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Abstract Undesirable pollution issue posed by disposal of shells from cockle trade and greenhouse gases release by cement industry requires solution. In view of cleaner environment, reducing waste dumped could be achieved through utilization of shell waste in cement production. In line with sustainable construction concept, production of construction material that contains lesser natural resources and combined with existing solid waste is more environmentally friendly. In relation to that, transforming the cockle shell waste into a value-added item such as partial cement replacement in construction material would reduce waste disposed to the environment. An experimental work was carried out to investigate the effect of cockle shell powder as a material for partial cement replacement on compressive strength and water absorption of mortar. Powdered cockle shell of 0%, 10%, 20%, 30% and 40% were integrated as partial cement replacement. Air curing method were used for all specimens. Specimen were subjected to compressive strength and water absorption test. The finding shows that incorporation of 10% cockle shell powder enhances compressive strength of mortar and reduces the percentage of water absorbed.

Keywords: cockle shell; partial cement replacement; mortar; compressive strength; water absorption.

1. Introduction

For national economic and social growth, the construction industry is crucial as it provides vital infrastructure and buildings for human activities [1] and it has seen remarkable growth in the last decade globally [2]. With growing demand for construction materials, shortage of supply of materials and rising environmental concern, resource efficient construction materials is highly debated globally [3]. The manufacturing of construction materials requires huge amounts of raw material after use [4]. As a result,

people in certain parts of the world are suffering from severe environmental pollution, especially air pollution [5]. The cement industry being ranked third among the world's most energy-consuming industries, representing approximately 7% of industrial energy consumption [6, 7]. The processing stage during cement production involves high energy consumption and release carbon dioxide to the environment [8]. Continuous release of this gas results in greenhouse gas effect which has influence on global climate change and well-being of human. Therefore, efforts need to be taken to reduce the harmful effect of the industrial processes [9].

At the same time, seafood trade generates seashell surplus which exceeds 100 Mil-lion pound annually [10]. Cockle is a type of seafood which harvested from muddy area and can be bought at affordable price. The cockle which protected with hard shell is removed before the edible meat can be eaten. Usually, the inedible hard shells are discarded [11]. Shells which thrown at dumping area creates unpleasant smells [12, 13] due to decomposing of leftover cockle flesh in the shell. Practice of discarding the shell in the sea also harms certain marine life [14] which is best to be avoided. In Peninsula Malaysia, a total of 57,544.40 tonnes of cockle were obtained from fisheries industry in year 2011 [15]. This also indicates abundance of shells was discarded as waste consuming space at dumpsite and attracts more pests. The quality of life for people in close proximity can be adversely affected by these problems and contribute to environmental pollution [16]. Option of recycling this waste for widely used construction material production would channel this waste from being thrown to the environment. Thus, the present research investigates the performance of mortar upon integration of cockle shell powder as partial cement replacement.

2. Experimental Work

2.1. Materials

Ordinary Portland Cement (OPC) with specific gravity of 2.86 were used as major binder in mortar preparation. Local river sand is used as fine aggregate. Tap water at the laboratory is used for fresh mortar mixing and curing purpose. Cockle shells were obtained from the dumping area nearby cockle processing location at Tanjung Karang, Selangor as shown in Figure 1. The shells were collected and packed in gunny before transported to the laboratory as illustrated in Figure 2. The CS was washed thoroughly to remove the dirt on its surface. Then it was dried in a drying oven at a temperature of 105 ± 5 °C for 24 hours. The CS crushed into small pieces before ground using Los Angeles machine to produce fine particles of cockle shell powder. Cockle shell powder (COSP) with specific gravity of 2.80 were also used as partial cement replacement material. The wet sieve result of OPC and COSP are 0.26% and 15% respectively. Figure 3 and Figure 4 show the SEM image of cement and cockle shell powder respectively.

Figure 1. Cockle shells at dumpsite ready for collection

Figure 2. Cockle shell collection process

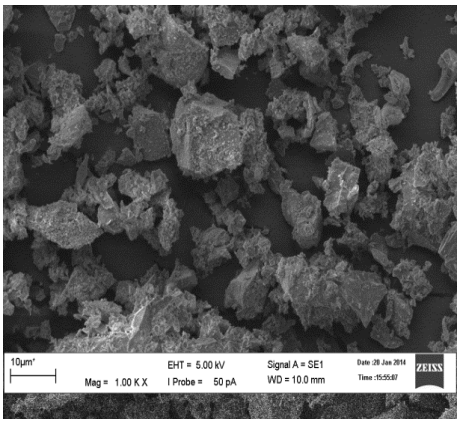

Figure 3. Ordinary Portland cement

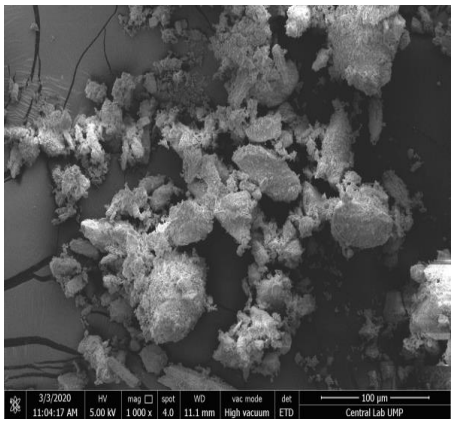

Figure 4. Cockle shell powder

2.2. Specimen Preparation and Testing

Five types of mixes were used for this experimental work. Mortar produced using ordinary Portland cement as sole binder were used as reference specimen. Other mix-es were prepared by using cockle shell powder content namely 10%, 20%, 30% and 40% as partial cement replacement. Mortar was mixed with a cement-sand ratio of 1:3. The mix proportions of the cockle shell powder used in this study are given in Table 1. Mixing of mortar was done by manually mixed and casting of samples was done in three layers. Specimens were compacted using a vibrating table in order to remove any entrapped air and attained maximum compaction. Each layer was vibrated for about 5 seconds. Samples were remoulded 24 hour after casting and subjected to air curing until the testing date. The compression strength testing were conducted at 3, 7, 14, 28 and 56 days. The compression strength test were conducted adhering to procedure in ASTM C109-07 [17]. The water absorption testing were carried out in accordance to BS 1881-122 [18] at 28 days.

Table 1. Mix proportion for mortar mixes in kg/m^3

Mixes	**Cement**	**Sand**	**Cockle Shell Powder**	**Water**
COSP-0	600	3375	-	675
COSP-10	540	3375	60	675
COSP-20	480	3375	120	675
COSP-30	420	3375	180	675
COSP-40	360	3375	240	675

3. Results and Discussion

3.1. Compressive Strength

The results of compressive strength test for mortar subjected to air cured are shown in Figure 5. Generally, the compressive strength of mortar increases along with curing age. Incorporation of cockle shell powder content affects the compressive strength performance of mortar. The use of suitable content of cockle shell powder able to improve the strength of mortar. It appears that the mortar produced using 10% replacement of cockle shell showed the best compressive strength. This finding is partly due to the fact that cockle shell particles serve as a filler material inside the mortar mix forming a better packed and denser structure. The tiny particles of the cockle shell therefore serve as a filler material and fill the gaps between the cement particles [19]. The strength decreases when the percentage replacement of cockle shell content is in-creased at 20%, 30% and 40%. Similar trend has been reported by previous researcher, Andas and Anuar [20].

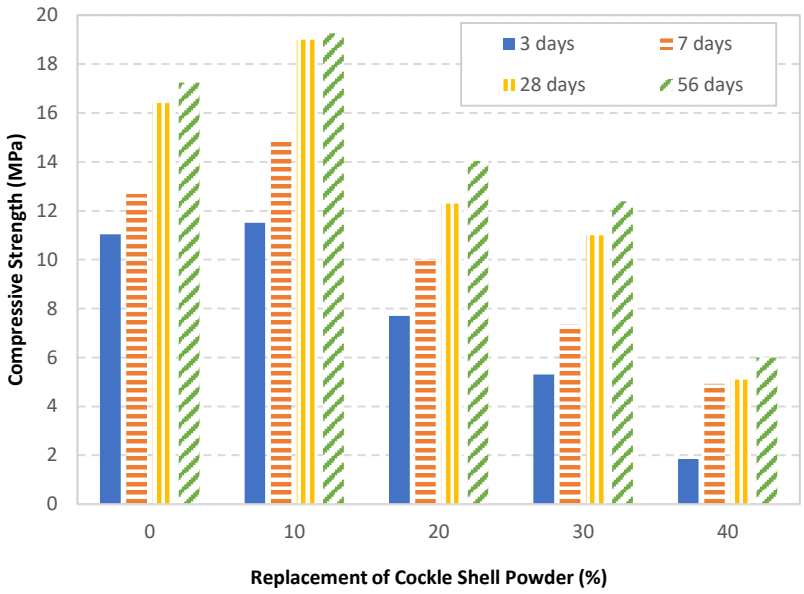

Figure 5. Compressive strength test result

3.2. Water Absorption

Figure 6 illustrates the absorption results of mortar produced with various cockle shell powder replacements. The quantity of cockle shell powder used influence the water absorption of mortar. Mortar mix blended with 10% cockle shell powder exhibit the lowest water absorption value. However, starting at 20% replacement and onwards, the mortar absorbs larger percentage of water. Mortar mix recorded increment in percentage of water absorbed as larger quantity of cockle shell powder is integrated in the mix. It seems that, excessive use of cockle shell powder as partial cement re-placement causes formation of more voids which rises the water absorption of mortar. Similar pattern was reported in past publication by Tayeh et al., [21].

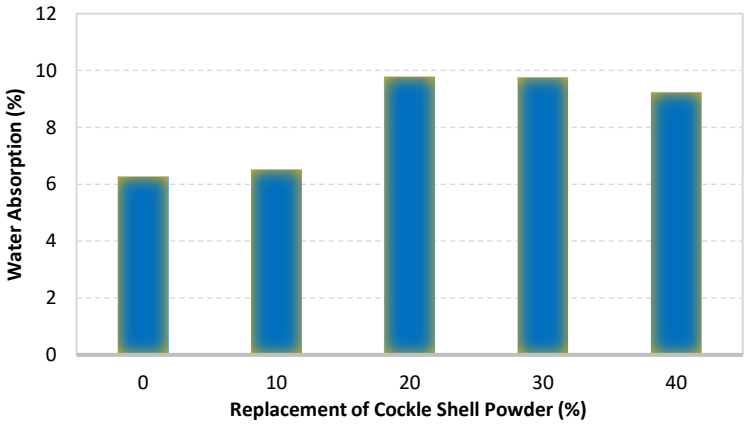

Figure 6. Water absorption result

4. Conclusion

The use of 10% cockle shell powder successfully improves the properties of mortar by enhancing its compressive strength and reducing its water absorption properties. Excessive use of cockle shell powder need to avoided as it lowers the compressive strength of mortar. Success in utilizing cockle shell powder as partial cement re-placement in mortar would be able reduce high consumption of cement for construction material production and diverts cockle shell waste from being thrown up at the dumpsite.

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