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Preliminary Study on Properties of Oil Palm Shell Lightweight Concrete with Cockle Shell as Mixing Ingredient

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Abstract. Environmental pollution caused by the dumping of oil palm shell (OPS) from palm oil mill and cockle shell from cockle trade has initiated early exploration to discover the potential of these waste incorporated in concrete production. The present research investigates the effect of integrating crushed cockle shell as partial fine aggregate replacement on compressive strength and flexural strength of OPS lightweight aggregate concrete. A total of five mixes were prepared. OPS lightweight aggregate concrete containing 100% river sand was used as control specimen. Other mixes were produced by varying the percentage of crushed cockle shell by weight of sand. All specimens were water cured for 28 days before subjecting it to compressive strength and flexural strength. The finding shows the concrete exhibit strength increment when crushed cockle shell is added as partial fine aggregate replacement. Conclusively, crushed cockle shell has the potential to be used as mixing ingredient in OPS lightweight concrete production.

1. Introduction

Sand and gravel are two important ingredients required to make concrete in the building construction. As the amount of population is increasing, the needs for development and facilities also raises inducing growths in the construction industry. In Malaysia, most of the buildings and infrastructures are made from reinforced concrete as the materials are cheaper, easy to construct, stronger, durable and more sustainable. About 60-70% of the concrete components are made from fine and coarse aggregate, which are normally sand and granite, respectively. The aggregates are from natural resources obtained through mining the river and rock quarries. The consumption of these natural resources should be handled cautiously to avoid disruption on the environmental and topographical of river [1] and scarcity of the resources. Therefore, others alternative should be considered to overcome this situation. Using wastes as aggregates replacement is one of the potential solutions.

Malaysia is a country that have good soil for agricultural and plantation. Due to this, Malaysia becomes a major player in agricultural industries such as palm oil, paddy, and rubber. The agricultural industries also produce agricultural waste that can pollute the environment and requires significant amount of space for landfill disposal. Incorporating this waste into construction industry to replace natural resources will impact a win-win situation for both industries. The problem arises due to shortage of dumping areas can be eliminated if the waste can be recycled and reuse in the construction industries. Furthermore, the usage of natural resources such as sand and granite, or even cement can be replaced with this waste to produce sustainable concrete and minimize pollution. At the same time, the



environmental problems due to the river mining, waste disposal and even air pollution can be controlled. Thus, previous work has studied and tries to improve the performance of the concrete by using the continuously generated palm oil wastes such as oil palm shell [2-7], palm oil clinker [8-11] and palm oil fuel ash [12-17] which results in production of more environmental friendly concrete.

In the meantime, the expanding of fisheries industry such as cockle trade also poses environmental issue. Cockles that exist in muddy area is harvested, processed to remove the shell before the edible meat is sold. The shells are dumped at open area causing pollution to the environment [12] and emit unwelcomed stinking smell. The growing cockle industry generates larger amount of shell which dumped as waste. Turning this thrash into beneficial material would be rewarding both in terms of reduced land used for waste disposal and cleaner environment. The availability of free shells has inspired researchers [19-22] to utilize it as mixing ingredient partially replacing certain natural resource in construction material production. However, very limited research is available on the utilization of two types of wastes namely oil palm shell and cockle shell as mixing ingredient in concrete production. Thus, this research investigates the effect of crushed cockle shell content as partial fine aggregate replacement on the strength performance of oil palm shell lightweight aggregate concrete.

2. Experimental Details

2.1. Materials

Ordinary Portland cement (OPC) complying to ASTM C150 [23] was used as the binder. River sand from a single source was used as fine aggregate. Supplied tap water was used for concrete preparation and curing. Oil palm shells were collected from dumping area in the area of palm oil mill as illustrated in Fig. 1. The oil palm shells used is produced from palm oil tree of Dura species. Oil palm shells were cleaned to ensure it is free from debris. Then it is oven dried before kept in a closed container. Cockle shells shown in Fig. 2 were obtained from the dumping area nearby cockle processing location. Then, the shells were washed to remove the sands and dirt on its surface. Then it was dried before crushed into fine particles.



Figure 1. Oil palm shell disposal area.



Figure 2. Cockle shell.

2.2. Mix Proportion

Two types of oil palm shell lightweight aggregate concrete mixes were used in this experiment. A Grade 20, plain OPS lightweight aggregate concrete consisting 100% river sand was used as control specimen, CS0. The rest of the mixes CS5, CS10, CS15 and CS20 were prepared by varying the percentage of crushed cockle shell by weight of fine aggregate replacement. The quantities of crushed cockle shell used are 5%, 10%, 15% and 20% by weight of sand. Other mixing ingredients were kept constant. Table 1 presents the mix proportion of the mixes used.

Table 1. Mix proportion of concrete samples.

Materials	kg/m ³				
	CS0	CS5	CS10	CS15	CS20
Cement	550	550	550	550	550
Oil palm shell	360	360	360	360	360
Fine aggregate	870	826	783	739	696
Crushed cockle shell	0	44	87	131	174
Superplasticizer	5	5	5	5	5
Water	225	225	225	225	225

2.3. Specimens preparation and testing

Mixes were prepared in form of cubes and beams. All the specimens were cured up to 28 days using water curing method in the laboratory. Then, the specimens were subjected to mechanical properties testing at 7, 14 and 28 days. The cubes compressive strength test was conducted following the procedure in BS EN 12390-3 [24]. The flexural strength of the beam specimens was measured in accordance with BS EN 12390-5: [25].

3. Results and Discussion

The Figure 3 and 4 illustrate the effect of crushed cockle shell content as partial sand replacement on compressive strength and flexural strength of oil palm shell lightweight concrete. All specimens exhibit strength increment throughout the curing age. Leaving the specimens immersed in water at all time, ensures undisturbed hydration process. Presence of moisture allows chemical reaction by cement that generates larger amount of binding gel known as calcium silicate hydrate gel. These gels fill in the voids of internal structure making the hardened concrete denser. The formation of compact structure increases the capacity of concrete to sustain larger load. Calcium silicate hydrate gel plays significant role in increasing concrete strength through densification of the microstructure [26]. Therefore,

providing a suitable environment for uninterrupted hydration process is vital for strength development of concrete containing cement as a sole binder.

Looking at the effect of adding crushed cockle shell, this preliminary study shows that inclusion of crushed cockle shell waste up to 20% contributes positively in enhancing the compressive strength and flexural strength of concrete. It is believed that role of fine crushed particle acts as filler creates a more compacted concrete internal structure. This assists the concrete to carry higher load. The encouraging contribution of other waste material when used as fine aggregate replacement at suitable amount in enhancing concrete strength has been reported in past studies [27-29]. Further study needs to be carried out to determine the optimum percentage of crushed cockle shell which contains high calcium oxide that can be used without detrimental effect to the oil palm shell lightweight aggregate concrete strength and durability aspect. The role of crushed cockle shell in improving oil palm shell lightweight aggregate concrete performance remains to be ventured. Conclusively, the success in combining both agricultural wastes for production of construction material saves the use of the precious natural resources, ensures environmental sustainability and reduces amount of waste thrown as landfill.

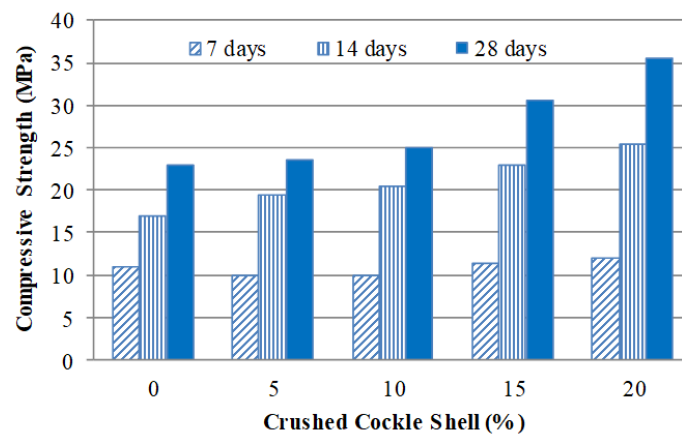


Figure 3. Compressive strength of specimens containing various percentages of crushed cockle shell

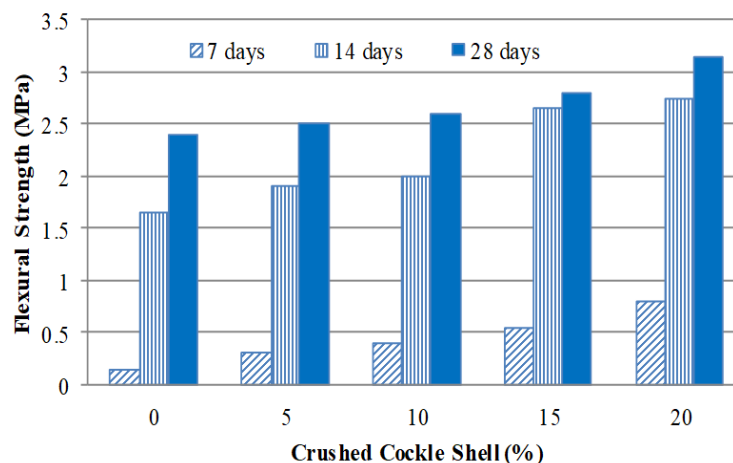


Figure 4. Flexural strength of specimens containing various percentages of crushed cockle shell.

4. Conclusion

This investigation finds that integration up to 20% of crushed cockle shell contributes towards strength enhancement of oil palm shell lightweight aggregate concrete. Further investigation on the effect of integrating crushed cockle shell as partial fine aggregate replacement towards the long term

mechanical, durability and thermal conductivity properties of oil palm shell lightweight aggregate concrete is among the area that remains to be ventured.

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