Compressive Strength of Brick Containing Crushed Cockle Shell as Partial Sand Replacement

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Abstract—Negative impact to the environment posed by increase in the river sand mining and dumping of cockle shell waste by cockle processing factory has led to the development of brick containing this waste material. The present research investigates the strength performance of cement sand brick containing crushed cockle shell as partial sand replacement. At the first stage of the experimental work, mixes containing various percentage of crushed cockle shell as partial sand replacement were prepared in form of cubes and then water cured. Based on the compressive strength test conducted, only the best performing mix containing cockle shell were used to produce brick for the second stage of the work. The bricks were subjected to water curing until the testing age. The compressive strength test was carried out at 7 and 28 days. The findings show that the compressive strength of the mix increases when suitable content of crushed cockle shell is used. Addition of suitable content of crushed cockle shell up to 20% successfully enhances the compressive strength of the mortar mix. Crushed cockle shell brick exhibit better strength performance compared to control specimen throughout the curing age. Success in combining waste from fisheries industry in brick making able to reduce the use of natural river sand and decrease amount of cockle shell disposed at dumping site.

Keywords—river sand mining; cockle shell; environmental problem; partial sand replacement; compressive strength; brick

1. INTRODUCTION

River sand is a natural material which is used in production of concrete, brick and many other uses in construction industry. In Malaysia, sand is obtained from in-stream mining and the demand continues to rise [1]. The growing construction industry along with increasing population has also led towards mushrooming river sand mining activities. This has resulted in negative impact of environment including river bank erosion, river bed degradation, river buffer zone encroachment and river water quality drop [1]. According to [2], there are countries facing sand supply shortage. In order to protect the environment, one of the alternative approaches to reduce the high dependency of the construction industry on river sand supply is to discover other types of materials that can replace the use of sand totally or partially. From the sustainable environment approach, the best method is to use the freely available solid waste to function as sand that would bring more benefits in terms of reducing waste ending at landfill and also saving the river sand. At the same time, 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 [3]. The cockles trade which deals with processing of cockles either to be produced as canned food or sent to the fresh market, generates a large amount of cockle shell which dumped as waste. This fact has been highlighted by [4] that the active cockle trade has led towards the generation of abundant waste shell. Another researcher [5] reported that the shells that been dumped and left untreated may cause unpleasant smell and disturbing view to the surrounding. Looking at the increasing cockles’ production which the retail value of cockles alone increased by 33.53% by RM91.60 million in 2010 from 68.60 million the previous year [6], it is expected the availability of cockle shell as waste would be in larger amount as well which in turn will pose negative impact to the environment and also community. It is seen that utilizing the by-product as a raw in construction product would reduce amount of wastes ending at landfill and contributes towards cleaner environment. This awareness has led local researchers [3, 4, 7, 8, 9, 10] to investigate the potential of using this waste material for product making. The current research investigates

the possibility of using cockle shell as partial sand replacement in cement sand brick production. The paper discusses the effect of crushed cockle shell content as partial sand replacement towards strength performance of cement sand brick.

2. EXPERIMENTAL PROCEDURE

A. Materials

In this experimental work, Ordinary Portland cement (OPC) from a single source was used as a sole binder. Natural river sand was obtained from the nearby supplier. Supplied water at the concrete laboratory was used for the process of preparing the specimen and curing as well. The shell collected is from the species knows as Blood Cockle or Anadara Granosa that lives mainly in muddy and sandy shore. This suitable condition exists in West Coast Malaysia especially in Perak and Selangor area. For this experimental work, cockle shell was collected from a dumping area in the state of Perak, West Malaysia. Fig. 1 illustrated abundant cockle shells at dumping area which then collected and packed in gunny (Fig, 2) before transported to the concrete laboratory. At the laboratory, the cockles' shells were washed thoroughly using tap water to remove the dirt as shown in Fig. 2. Then, after drying process, it was crushed to reduce its size. Fig. 4 illustrates the physical appearance of cockle shell after processed ready to be used as fine aggregate replacement.

B. Mix Proportioning and Testing Procedure

This experimental work is divided into two stages. Two types of mixes that is plain cement sand brick and cement sand brick containing crushed cockle shell content as partial sand replacement were used in this study. At the first stage, testing was conducted to select the best percentage of cockle shell for strength enhancement of mortar mix. Plain cement sand brick containing 100% river sand was used as reference specimen. The amount of crushed cockle shell used is varied that is 0%, 10%, 20%, 30 %, 40% and 50% by the weight of total sand. All the mixes were prepared in form of mortar cube and water cured for 7 days before subjected to compressive strength test. Then, the best mix which is identified based on the highest strength value, were used in the second stage of experimental work. During this stage, mix containing 100% river sand and the containing cockle shell were prepared in form of bricks using the timber mould illustrated in Fig. 5. The mixing and casting process of the brick is shown in Fig. 6 and 7. The fresh mixes in the mould were covered with wet gunny sack overnight. After 24 hours, the specimens were removed from the mould and immersed in tank filled with tap water (Fig. 8) until the testing age. The compressive strength test is conducted on the bricks adhering to the procedure in [10] at 7 and 28 days.

3. RESULTS

The compressive strength result of the mortar specimens containing various percentage of crushed cockle shell is presented in Fig. 9. Generally, quantity of crushed cockle shell does influence the compressive strength performance of the mix. The highest compressive strength value is achieved at the addition of 20% of crushed cockle shell with only 80% of fine aggregate is natural river sand. This positive contribution is probably due to the filling effect of this fine waste material which makes the concrete denser and stronger. Although inclusion of more crushed cockle shell would be able to reduce larger amount of natural river sand used which makes the material more environmental friendly, the utilization of this waste material in the mix need to be limited. This is because; too much of crushed cockle shell integrated in the mix causes the compressive strength of the mix to drop. It was observed, beyond 20% replacement of crushed cockle shell the strength of mortar continue to decrease as the amount of cockle shell integrated become larger.

Figure 1: cockle shells at dumping site

Figure 2: Cockles shell packed in the gunny

Figure 3: Cockle shell were washed to remove the dirt

Figure 4: Finely crushed cockle shell

Figure 5: Formwork for brick making

Figure 6: Cement sand brick mixing process

Figure 7: Cement sand brick casting process

Figure 8: Cement sand brick curing process

Looking at the strength performance of brick produced using 100% natural river sand and the one containing 20% cockle shell as illustrated in Fig. 10, both specimens exhibit continues strength increment throughout the curing period. Application of water curing has ensured continuous hydration process resulting production of larger amount of Calcium-Silicate-Hydrate (C-S-H) gel. When more C-S-H gel fills in the voids of the matrix, the ability of the specimens to sustain load also increase. This is in line with the idea of [12] who highlighted the role of calcium silicate hydrate as a major strength-providing reaction product of cement hydration, which also act as a porosity reducer resulting in a dense microstructure in concrete. Comparing the compressive strength result between these two mixes, brick containing 20% cockle shell performs better in all curing age. This finding encourage the use of cockle shell as partial sand replacement in cement sand brick production which consume lower quantity of river sand. Most importantly, pollution issue related to disposal of cockle shell as dumping site can be reduced as lesser amount of shell would end up as waste. Conclusively, another locally made environmental friendly cement sand brick is possible to be produced for the use in construction industry.

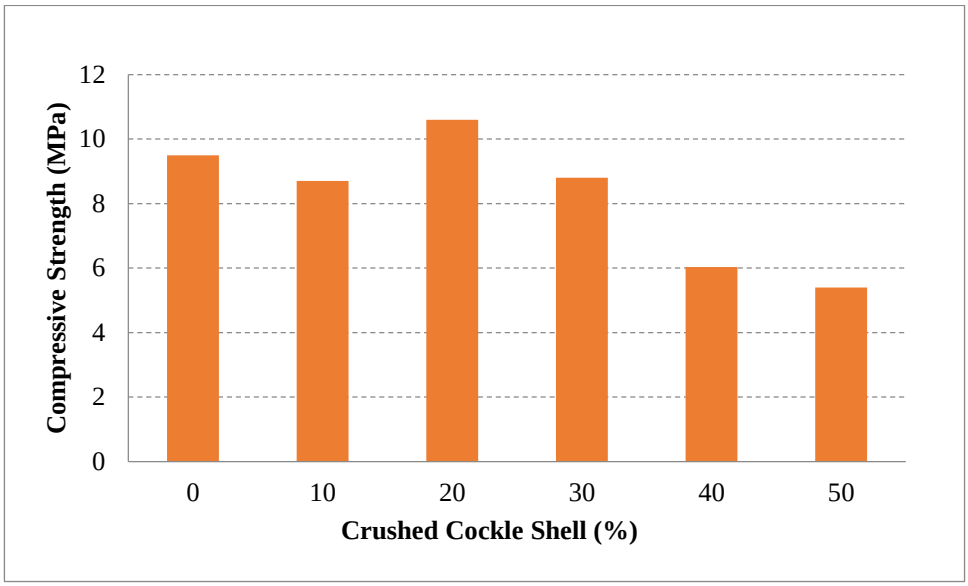

Figure 9: Compressive strength of mortar cube with various percentage of crushed cockle shell as partial sand replacement

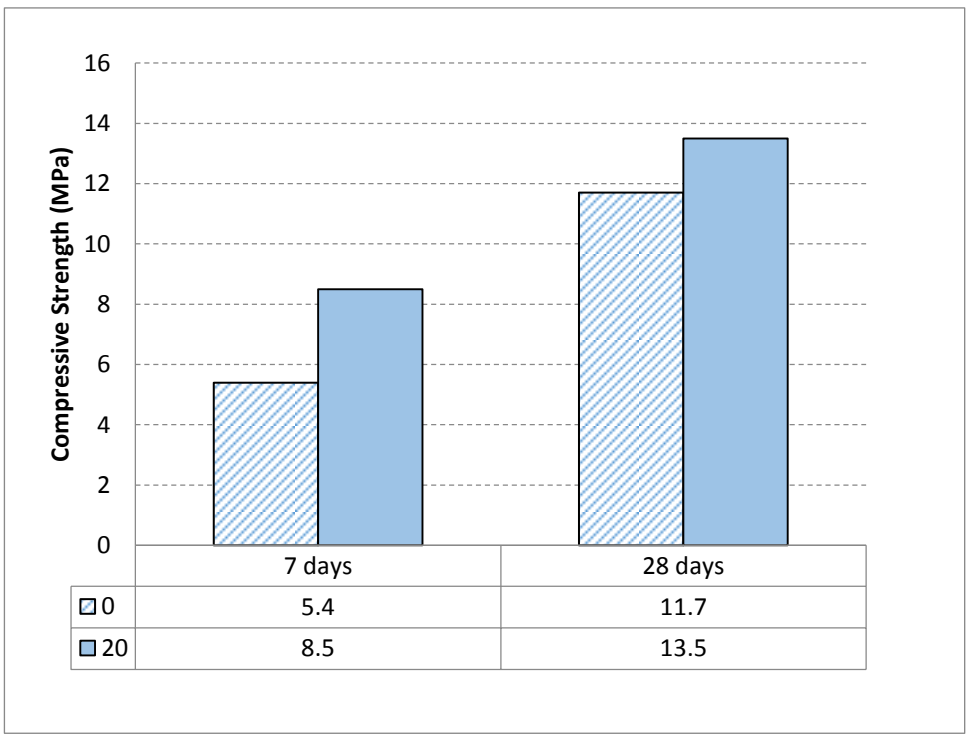

Figure 10: Compressive strength of cement sand brick with and without 20% crushed cockle shell at 7 days and 28 days of curing age

4. CONCLUSION

The freely available cockle shell waste can be utilized as partial sand replacement to produce a more environmental friendly cement sand brick. Incorporation of suitable content of cockle shell as partial sand replacement of 20% successfully increases the compressive strength of cement sand brick. More research can be conducted to investigate the long term mechanical properties performance of the brick containing cockle shell and also other properties such as fire resistance.

ACKNOWLEDGMENT

The authors would like to express their gratitude to the staffs of concrete laboratory for their contribution in this research. The financial provided by Universiti Malaysia Pahang through RDU is also acknowledged.

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