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Setting Time and Compressive Strength of Mortar Containing Cockle Shell Powder as Partial Cement Replacement

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Keywords: cockle shell; partial cement replacement; mortar; setting time; compressive strength.

Abstract. Environmental degradation caused by deforestation activities for harvesting of limestone from the hills and its calcination process at cement factory along with disposal of cockle shell waste from fisheries industries is in need of resolution. In view of sustainable green environment, approach of utilizing cockle shell waste as partial cement replacement in cement production would reduce pollution caused by both industries. Thus, this research investigates the effect of cockle shell powder as partial cement replacement on setting time and compressive strength of mortar. A total of five types of mortar mixes consisting different percentage of cockle shell powder as partial cement replacement from 0%, 10%, 20%, 30%, and 40% by weight of cement were prepared. Setting time test were conducted on fresh paste. All specimens were subjected to water curing until the testing age. Compressive strength test were conducted on hardened mortar cubes at 3, 7 and 28 days. Finding shows that integration of cockle shell powder as partial cement replacement influences the setting time and compressive strength of mortar. Suitable combination of 10% cockle shell powder successfully enhances the compressive strength of mortar. Conclusively, success in transforming the cockle shell waste to be used as partial cement replacement in mortar production able to reduce cement consumption, save landfill usage for trash dumping and promote cleaner environment for healthier lifestyle of community nearby.

Introduction

Concrete is considered one of the most important building materials around the world where it is a composite material composed of fine and coarse aggregate bonded together with cement that hardens over time. Cement as sole binder that is responsible in formation of strong concrete is produced using non-renewable resources obtained from the environment. Among the products used in cement production are limestone, shells and chalk or marl combined with shale, clay, slate, blast furnace slag, silica sand and iron ore [1]. Process to quarrying the limestone that requires deforestation activity destroys the house of various types of fauna and flora which their existence contributes to well-balanced ecosystem. Furthermore, the acquired limestone which must undergoes processing stages in the factory also cause the release of huge amount of greenhouse gas and environment polluting substances which unhealthy to living things. The destruction of environment due to cement production has been highlighted by many researchers. Around 8% of world carbon dioxide emission is from cement manufacturing industry [2]. Other than that, dust released during the industrial activities [3] affects the air quality. Air pollution caused by cement industry also can affect the natural life of vegetation and animal in that area [4]. Although, this material is the choice of many builders owing to its versatility and affordable price, but the unwelcome effect from its processing activites towards the living things need to be resolved. At present, option to totally avoid the use of cement in concrete production is not viable. However, discovering alternative material from industrial by-product to function as partial cement replacement is possible, as it can reduce the quantity of

cement utilized in concrete. In view of sustainable construction, utilization of waste in concrete production would limit the use of natural mineral from the earth and reduce quantity of thrash thrown at landfill.

Blood cockle, is an edible and cheap seafood which can be easily obtained at many wet markets in Malaysia. It can be found in huge quantity at certain states in West Malaysia and East Malaysia [5]. The process of preparing and supplying activities of cockle in form of fresh or processed food to other places which demand for this seafood has established cockle trade which contribute the economic prosperity of the locals. At the same time, the cockle industry also generates waste which need to managed. The disposal of cockle shells at dumping site pollutes the environment [6] and creates discomfort to the community living nearby the area. Disposing the shell into the sea has negative impact to the ecosystem in the sea [7]. Realization on the benefits of transforming waste to wealth, research has been conducted to explore the potential of cockle shell in product development. In terms of composition, the mineral content of cockle shell is almost like calcareous material [8]. The potential use cockle shell in various product development has been reported by some researchers [9-16]. Realizing the importance of preserving natural resources from being harvested excessively for cement production, the present research explores the effect of ground cockle shell as partial cement replacement towards setting time and compressive strength of mortar.

Experimental Details

Materials. Ordinary Portland cement, tap water, fine aggregate and powdered cockle shell were used to produce specimens for this research. River sand with the specific gravity of 2.65 were obtained from local supplier. Tap water was used for mortar preparation work. For this research, the cockle shells were collected from a dumpsite not far from fishing village as illustrated in Fig. 1. Cockle shells were washed thoroughly using flowing water to remove foreign particles such as mud and other debris before subjecting it to oven dry process for 24 hours. The raw cockle shell was grinded to be fine before used as a partial cement replacement material. Fig. 2 and 3 illustrates the OPC and finely cockle shell powder (CSP) which is ready to be used respectively. The percentage of cockle shell powder an OPC passing 45μm sieve during wet sieve test are 15% for cockle shell powder and 0.26% for cement.

Fig. 1. Cockle shell collection process

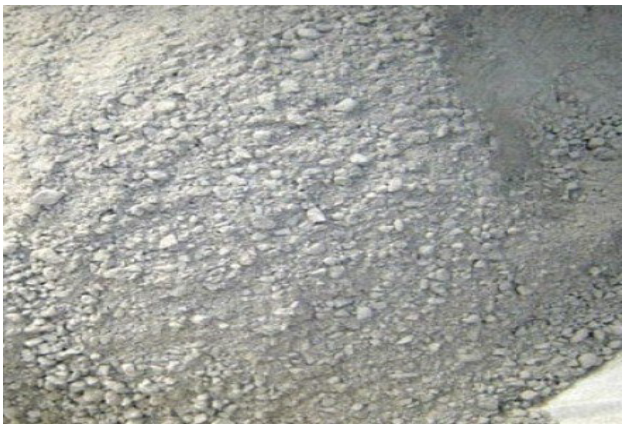

Fig. 2. Greyish ordinary Portland cement

Fig. 3. Whitish cockle shell powder

Specimen Preparation and Testings. A total of 5 mortar mixes were prepared. Control mix which prepared using 100% OPC is designated as CSP-0. Other mixes containing diverse cockle shell powder content is known as CSP-10, CSP-20, CSP-30 and CSP-40. The detail of mix proportion used is tabulated in Table 2. Before the preparation of specimen, all the required raw materials were weighed accurately. The specimens were prepared by mixing the materials using hand mixer. The mixture is filled in three layers into a cube mould of size 50x50x50 mm which has been cleaned and greased. The specimens of cubes were removed from the mould 24 hours after casting and subjected to water curing until the time of testing. Setting time tests were performed by referring to ASTM C191-08 [17]. Compressive strength test were conducted on hardened mortar cubes adhering to ASTM C109-99 [18].

Table 2. Mix proportion of mortar mixes (kg/m^3)

Mixes	Cement	Sand	Cockle shell powder	Water
CSP-0	600	3375	-	675
CSP-10	540	3375	60	675
CSP-20	480	3375	120	675
CSP-30	420	3375	180	675
CSP-40	360	3375	240	675

Results and Discussion

Setting Time. Fig. 4 illustrates the effect of powdered cockle shell on the initial and final setting times of cement. Inclusion of powdered cockle shell as partial cement influences the setting time of cement. The use of 10% powdered cockle shell increases the setting time. Upon the inclusion of 10% powdered concrete shell, the setting time of plain cement which is 120 min rise to be 135 min. Similarly, final setting time also become longer whereby the setting time changed from 210 min for 100% cement paste to 225 min for the cement paste containing 10% powdered cockle shell. However, beyond that replacement which is 20% to 40% powdered concrete shell, the setting time of cement shortened. This probably due presence of $CaCO_3$ which in cockle shell powder. The high content of $CaCO_3$ in cockle shell which is more than 90% has been reported by Hazurina et al. [13]. It has been noted by Neville [19], alkalis carbonate in cement which formed during storing period react with calcium hydroxide forming $CaCO_3$ tend to precipitate and causes rigidity of the paste. In this experimental work, integration of higher quantity of cockle shell powder increases the quantity of $CaCO_3$ which causes the paste become rigid in a shorter time. Generally, it can be concluded that the use of cockle shell powder affects the setting time.

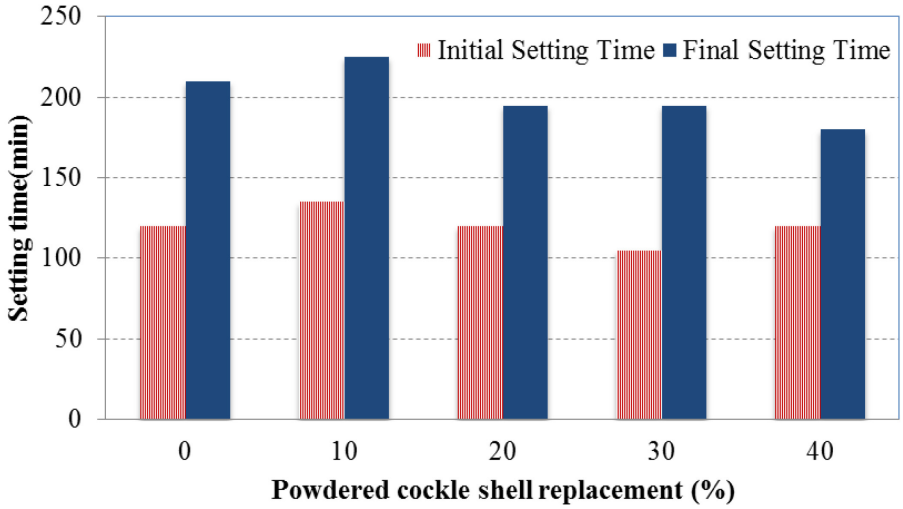

Fig. 4. Setting time test result

Compressive Strength. Fig. 5 shows the effect of cockle shell as partial cement replacement on compressive strength of mortar. On overall, all specimens exhibit strength increment as curing age increase. Longer immersion time in the water, facilitates cement hydration process which promotes larger quantity of binding gel generation thus increasing the ability of mortar to sustain load. It is known that the hydration is a reaction between water and cement which enables the Portland cement to become bonding agent [19]. The concrete strength rises as the hydration of cement progress [19]. Utilization of suitable amount of powdered cockle shell which is 10% as partial cement replacement increases the mortar compressive strength. Further, incorporation of 20, 30 and 40% of powdered cockle shell results in strength declination. The positive strength enhancement of mortar mix upon the use of certain percentage of cockle shell in powder form has been reported by [12] [13] and [20].

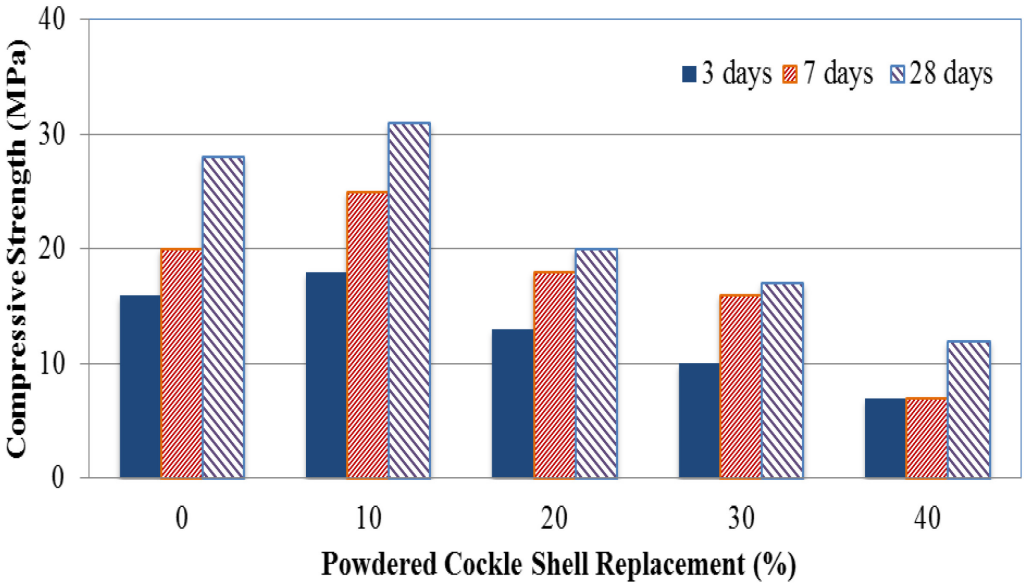

Fig. 5. Compressive strength test result

Conclusion

From the findings it can be concluded the use of cockle shell as partial cement replacement affects the setting time of cement. Integration of 10% of cockle shell powder enhances the compressive strength of mortar. However, excessive use of this waste causes strength declination. Success in using cockle shell for building material production is an advantageous way for recycling this waste instead of directing it to dumpsite which causes pollution and uncomfortable environment for residents nearby.

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