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COCKLE SHELL: A POTENTIAL PARTIAL COARSE AGGREGATE REPLACEMENT IN CONCRETE

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Abstract. Effort towards preserving natural coarse aggregate for future generation and reducing cockle shell waste originating from the fisheries industry has initiated studies on possibility of integrating this waste in concrete production. This paper presents the result on the workability and compressive strength of concrete containing various percentage of cockle shell content as partial coarse aggregate replacement. Concrete mixes containing 0%, 5%, 10%, 15%, 20%, 25% and 30% cockle shell replacement level were cast before subjected to water curing for 28 days. Workability test and compressive strength test were conducted in accordance to BSEN 12350 and BSEN 12390 respectively. Results show that replacement of appropriate cockle shell content able to produce workable concrete with satisfactory strength. Integration of 20% cockle shell enhanced the strength of concrete making it to be the highest as compared to any other replacement level.
Keywords: cockle shell, partial coarse aggregate replacement, concrete, workability, compressive strength.

Introduction

Research towards producing a new concrete material stems out from two factors presented by two different industries in Malaysia that is the growing need of construction trade and by-product of cockle shell trade. The continuously growing construction industry has posed the possibility on depletion of natural aggregates in the future that would increase the cost of concrete material. This fact has been addressed Alshahwany [1] who highlighted that the natural resource decrease while the demand for aggregate to be used in concrete production is still high. Anticipating this issue, various types of waste materials have been investigated their potential to be used as partial coarse aggregate replacement material in concrete production such as oil palm shell [2], periwinkle shell [3], recycled coarse aggregate [4] and others. However, to the best of author's knowledge no work has been reported on the use of cockle shells as partial coarse aggregate replacement in concrete .

The availability of cockles a marine bivalve mollusks which is an important protein source in the South East Asian region [5] is one of the factor that boost the cockle trade in Malaysia. It has been highlighted by Boey et al [6] that the active cockle trade has lead towards the generation of abundant waste shell. The shells that been dumped and left untreated may cause unpleasant smell and disturbing view to the surrounding [7]. 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 [8], 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 nearby area.

This has lead towards the effort of integrating this waste cockle shell as one of the mixing ingredient in concrete production thus opening a new horizon in agro concrete research and at the same time offering alternatives to preserve natural coarse aggregate for the use of future generation. Success in incorporating this material as partial coarse aggregate replacement in concrete making would contribute towards reduction in the quantities of cockle shell ending up as waste. The present paper investigates the performance of concrete mix in terms of workability and compressive strength upon addition of this waste cockle shell as partial coarse aggregate replacement material.

Experimental Programme

A single batch of Ordinary Portland Cement (OPC) complies with the Type 1 Portland Cement as in ASTM C150 [9] was used in this experiment. Local river sand with fineness modulus of 1.64 was used as fine aggregate and the coarse aggregate integrated in the mix consist of single sized 10 mm crushed granite. Cockle shell illustrated in Fig. 1 was collected from the food stalls, washed with tap water to remove dirt before dried. The particle sizes range from 10 to 14mm. Tap water was used during the study in mixing, curing, and other processes.

Six mixture proportions were made to achieve the objectives of this experimental work. All the mixes prepared had a water cement ratio of 0.5. All the way through the study, the total cementitious material content has been kept constant in all the mixes except for the variation in the percentage of natural coarse aggregate used. A control specimen was formed consisting 100% natural coarse aggregate and the other six mixes containing cockle shell as partial coarse aggregate replacement from the range of 5% to 30%. The cockle

shells was integrated into concrete mix as a direct replacement for coarse aggregate on weight basis.

At the early stage, the influence of cockle shell content upon workability of the mix was investigated by conducting slump test following the procedures outlined in BSEN 12350-2[10]. All the mixes were cast in cubes (100 x 100 x 100 mm) and then demoulded after 24 hrs of the casting before placed in a water curing tank until the age of testing. The compressive strength test was conducted in accordance to the BSEN 12390-3[11].

Fig. 1 : Cockle shell

Workability. Illustration in Fig. 2 shows that the concrete workability reduces as the percentage of cockle shell added as partial coarse aggregate replacement become higher. At the replacement of 30% of cockle shell, the concrete mixture which consistency is very low and difficult to be mixed exhibit very low slump. As the amount of cockle shell added is increased, this rough textured material causes the mix become harsher, more difficult to be mixed thus exhibit lower slump value. This is probably credited to the variation in the texture of cockle shell which is rougher than natural aggregate due the symmetrically radial ribs running on the outer shell as can. The rougher surface creates more friction thus decrease the fluidity of the mix containing higher percentage of cockle shell. The influence of surface texture of coarse aggregate towards concrete workability has been discussed by Mindess, Young and Darwin [12] who highlighted that the use of smooth particles for concrete mixing would produce more workable than the one consisting rougher particles.

Furthermore, the difference in physical characteristic of the denser granite aggregate compared to the curved and roughly parabolic shape of the textured cockle shell is also one of the factors lowering concrete workability. Since the solid granite is heavier and the replacement is by weight, the specific surface area increases with the increment of cockle shell content in the mix. This condition creates the needs for larger quantity of cement paste than the amount available in the mix to coat the cockle shell particles and this leads to lesser workability for concrete mix containing larger percentage of cockle shell replacement. The influence of cement quantity towards concrete workability has been highlighted by Daneshmand and Saadatian [13] who stated that insufficient cement content in the mix for lubrication of the aggregate would reduce the workability of the mix. Similarly, Kosmatka et al [14] and Adewuyi and Adegoke [15] have mentioned that the shape of coarse aggregate is one of the factors that influence workability of concrete. On overall, this study indicates the optimum replacement of cockle shell is possible to produce a workable mix for concrete work.

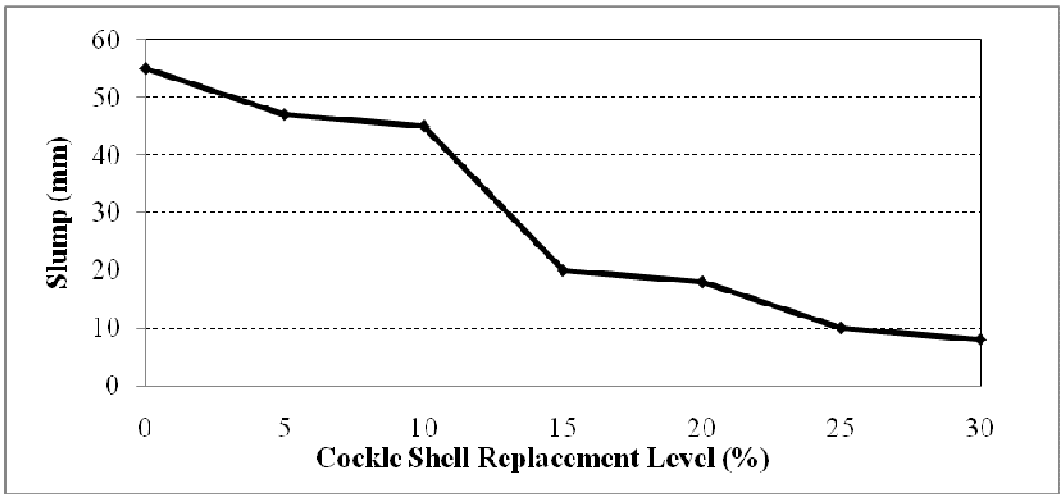

Fig. 2 : Effect of cockle shell content on slump value of concrete mix

Compressive Strength. Fig. 3 and 4 demonstrates that replacement of natural coarse aggregate partially with cockle shell enhances the strength performance of concrete when a right mix proportion is formulated. It can be noticed that mix consisting replacement of 20% cockle shell exhibit the highest value of compressive strength which outshine other mixes including plain concrete. The surface texture of

cockle shell which is rougher than granite aggregate improves bonding and increases inter particle friction which is turn enhances the compressive strength of the concrete. Mindess, Young and Darwin [12] has highlighted that aggregate with rough textured surfaces will improve the mechanical component of the bond. However, it is apparent that too much of cockle shell tend to decrease the compressive strength of concrete as can be seen in the performance of concrete mix consisting 30% of cockle shell. It is justified since too much of cockle shell which means higher effective surface area, would lead to insufficient proportion of cement paste thus leading to poor bonding properties of the matrix with aggregates. In addition, the reduction in concrete workability with increase of cockle shell makes the mix difficult to be compacted resulting in hardened concrete with higher porosity thus exhibit lower strength.

On overall, the proportion and characteristic of cockle shell used as partial coarse aggregate replacement influence the strength performance of concrete. The effect of coarse aggregate properties and proportion of constituent materials towards concrete properties has been highlighted by Abdullahi [16] and Nawy [17] respectively. This study has indicated that, only a certain percentage of cockle shell could be integrated as partial coarse aggregate replacement material so that an exclusive environmental friendly composite material could be produced creating a win-win situation between the two industries, fisheries and construction, finally producing an end product having better properties than the existing one and possess the potential to be used as building material. Formulation of a right mix proportion consisting cockle shell as partial coarse aggregate replacement would result in concrete with enhanced strength. This exploratory study attempting to discover the potential of this free locally available waste in concrete production intended for building work requires further in depth research in both long term engineering properties studies and durability aspect.

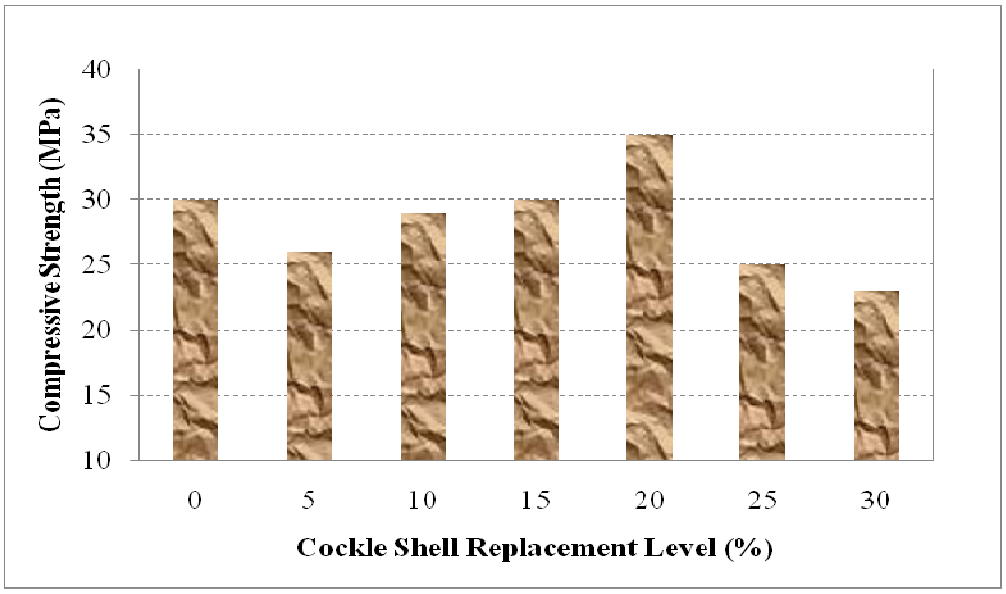

Fig. 3 : Compressive strength of concrete containing various content of cockle shell at 28 days

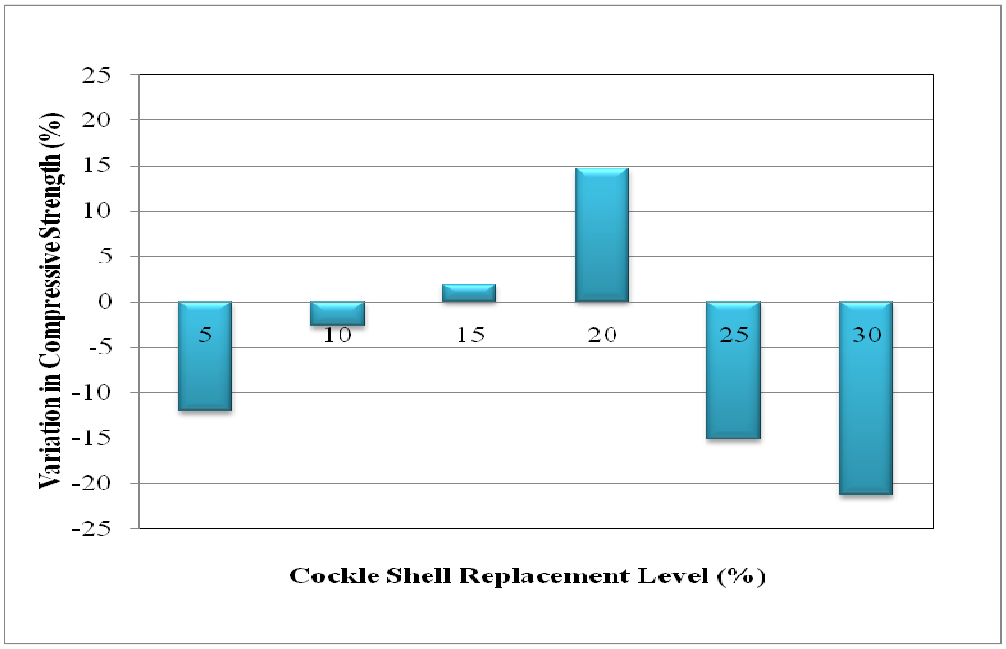

Fig. 4 : Variation in compressive strength of concrete containing various content of cockle shell at 28 days

Conclusion

This early study found that addition of cockle shell as partial coarse aggregate replacement reduces the concrete workability owing to its shape and rougher texture. However, it is interesting to note that replacement of natural coarse aggregate by cockle shell at a level of 20 % resulted in the increase of compressive strength compared to control specimen. Nevertheless, integration of too much of cockle shell produces harsher mix which causes difficulties to produce dense concrete thus disrupt the strength performance.

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