Preliminary study on Mechanical Properties of Concrete added with Fine Palm Oil Clinker

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ABSTRACT The problem on environmental and sustainability has guide to the innovations of new material using by-product or waste material in concrete mix. Palm oil clinker (POC) a by-product produce from palm oil industry normally produced abundantly, being dumped and treated as disposal waste. This paper is part of the experimental results of an on-going research project of concrete mix using by-product waste, POC as fine aggregate in concrete mix. As preliminary study the research has been conducted by replacing 5% and 10% of POC by weight of fine aggregate (sand). Different mechanical properties were studied including compressive and flexural strength test. Concrete with POC replacement then were compared with plain concrete (control specimen). The results complied so far showed that the compressive and flexural strength increases as the POC content increased. From the result it is indicate significant improvement in the strength properties of concrete by inclusion of POC as partially replacement of fine aggregate.

INTRODUCTION

Malaysia currently accounts for 39% of world palm oil production and 44% of world export. Proof profits in 2010 shows Malaysian palm oil recorded a higher export volume, generating a total of RM59.77 billion. The palm oil comes from the flesh of the fruit and also from the seed or kernel through several processing operations. For every 10 tonnes of palm oil, about 1 tonne of palm kernel oil is also obtained (Anon. 2011). Becoming the largest producer in palm oil industry, Malaysia also facing a problem of waste by-product generated from the processing of palm oil. Palm oil clinker (Figure 1) considered as a by-product waste produced from burning of palm oil fibre and oil palm shell inside the boiler under high temperature in order to generating steam engine for extracting palm oil. Sometimes this waste used as materials of heaping up to cover puddle, muddy yards or roads in rural roads but mostly this waste being dumped near the palm oil plant. According to Siddique 2008, solid waste management contributes one of the major environmental in the world. With the increasing awareness about the environment, lack of land-fill space and due to its ever increasing cost, waste materials and by-products utilization has become an attractive alternative to disposal. No doubt the way of POC being disposed all this while will create an environmental problem in future too. Therefore alternative approach to solve this problem perhaps by substitutes this waste as aggregate replacement in concrete mixture.

Figure 1 Palm oil clinker produced after burning the palm oil fibre and oil palm shell with high temperature.

Concrete is a material used in construction industry globally until today. Basically, normal concrete consists of cement, water, coarse aggregate and fine aggregate. Fine aggregate is an important component of concrete. Most of fine aggregate is natural river or pit sand. The demand for natural sand is quite high in developing countries such as Malaysia and Thailand. Therefore, it is required to identify alternative materials to lessen or replace the demand of natural sand (Saifuddin 2007). Several researchers (Khalifa 2010; Evangelista & Brito 2007; Siddique 2003) have used manufactured fine aggregate as a partial replacement of natural sand, and investigated its effect on major concrete properties. For example, fly ash, slag, and limestone and siliceous stone powder were used in concrete mixtures as a partial replacement of natural sand. Also, the rock dust was used as an alternative to natural sand and its effects on the strength and workability of the concretes were investigated. Studied done by researchers (Basri et al. 1999; Mannan & Ganapathy 2002; Teo et al. 2007 and Alengaram et al. 2011) using palm oil industry waste product, namely oil palm shell in concrete; proved the strength of concrete added with oil palm shell as aggregate can be accepted for the production of structural lightweight concrete.

This paper focuses on using palm oil clinker which having different properties with oil palm shell but both are waste from oil palm mill. The aim of this study is to investigate the compressive and flexural strength of concrete added with POC by partially replace the fine aggregate with 5% and 10% of POC in normal concrete mix. The experimental results were compared with plain concrete strength as control specimen.

EXPERIMENTAL PROGRAMME

Materials

The raw material used in this investigation was taken from nearby palm oil mill located in Gambang, Pahang, Malaysia. The POC were taken out from the furnace and left to cold after being burned for 4 hours at 400°C. Everyday about 10 tonnes of POC were generated from the mill and dumped into the wastelands behind the mill. The POC obtained from the mill in a form of big chunks look alike a porous stone in gray colour then crushed into fine using jaw crusher. Sieve analysis was carried out on representative sample after crushing process. Besides substituting fine POC, river sand also was used as the fine aggregate with size below 4.75 mm. Crushed granite stone with nominal size of 20 mm was used as coarse aggregate. The idea to use POC as fine aggregate in this preliminary study because POC found failed to pass the test for coarse aggregate properties. No admixture used in the concrete mix.

Preparation of concrete specimen

Design mix for this research based on DOE standard to produce concrete grade 30. Research has been conducted by replacing fine POC by weight of fine aggregate as stated in Table 1.

Table 1 Proportion of aggregate in mix

Mix	Description	No of specimen	
		7 day	28 day
A	Control mix (plain concrete)	3	3
B	100% Coarse aggregate + 95% fine aggregate (sand) + 5% fine POC	3	3
C	100% Coarse aggregate + 90% fine aggregate (sand) + 10% fine POC	3	3

Mixing of the concrete mix was carried out in a rotating drum mixer. All dry materials were added into the mixer in the following sequence of coarse aggregates, cement and fine aggregate to get a homogenous mix. While the drum mixer still rotates, one-third from total mixing water was added to the mix and this was followed by the addition of fine POC. Afterwards the remaining mixing water was added to complete the whole mixing process. Subsequently workability test were performed on the mix. The concrete mix then is ready to cast into the respective cube and prism steel mould. After left for 24 hrs in the laboratory the specimen were cured in water tank and left for 7 and 28 days.

Test method

The test conducted on the hardened POCC include compressive and flexural strength test. Compressive strength test for compression cube were determined according to BS 1881: Part116:1983 with cube size of 150 mm x 150 mm x 150 mm and for flexural strength the specimens was determined according to the BS 1881: Part 118:1983 with using prism specimens of 100 mm x 100 mm x 500 mm in dimensions. Results were obtained on specimen at 7 and 28 days curing age.

RESULTS AND DISCUSSION

Compressive strength test

Generally Figure 2 indicates the results of compressive strength test for 7 and 28 days. As shown in the figure, the strength of concrete with fine POC increase as level of percentage replacement increased. For early 7 days strength shows considerably increment about 19% for 5% fine POC inclusion and 23% for 10% fine POC compared to control specimen. It can be observed at 28 days the inclusion of 10% fine POC produced 6.7% and 17.6% higher than 5% fine POC added and control specimen respectively. The results for both inclusions meet the strength requirements of concrete grade 30.

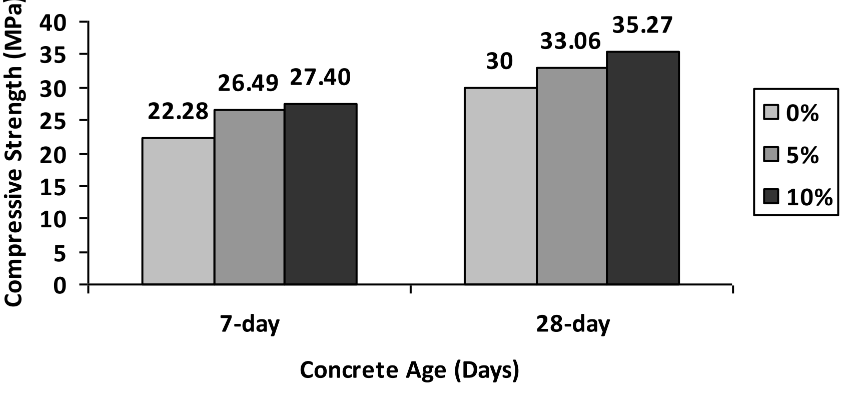

Figure 2 Compressive strength of POC concrete and conventional concrete

Investigation on the crack failure during compressive test shows the concrete with POC inclusion having a moderate brittle crack failure but still capable retaining the load till failure. Comparison in crack shows 10% fine POC inclusion having more cracks compared to 5% fine POC inclusion

Flexural strength test

The flexural test method measures behaviour of materials subjected to simple beam loading. The increment on flexural strength for both inclusion mixes also expected. As shown in Figure 3, illustrates that the inclusion of 10% of fine POC approximately 33% higher compared to control concrete and 4% higher than 5% inclusion at 28 days. Concrete with fine POC replacement shows higher flexural strength at early ages because inclusion of fine POC as partial replacement of sand starts pozzolanic reaction and densification of the concrete matrix and improved interfacial bond between paste and aggregates.due to this reason the strength of POC concrete is higher than the strength of control specimen even at early ages. This study also confirmed that rougher particles of fine aggregate produce lower void in mineral aggregate and also contributes to the higher density which increased the stability of the concrete mixture.

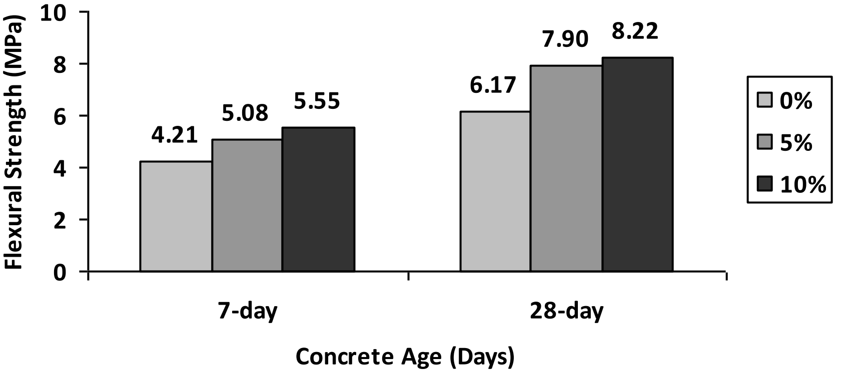

Figure 3 Flexural strength result of POC concrete and conventional concrete

CONCLUSION

The test results from this preliminary study provide the understanding on the basic engineering properties of fine POC added in concrete.

1. Compressive strength and flexural strength for both 5% and 10% percentage replacement of fine POC concrete were higher than the plain concrete (control specimen) specimens at both 7 and 28 days.
2. The compressive strength of 10% inclusion of fine POC higher 17.6% (35.27 MPa) compared to plain concrete (30 MPa) at 28 days.
3. The flexural strength of 10% inclusion of fine POC also gives result 33% higher (8.22 MPa) compared to plain concrete (6.17 Mpa) at 28 days.
4. Results of this investigation suggest that fine POC could be used in structural concrete.

Utilization of by-products materials is a partial solution to environmental problems and it may helps in reducing the cost of concrete manufacturing.

ACKNOWLEDGEMENT

The author expressed gratitude to Nur Amalina Mohammad Yuden and Lee Chooi Ying for their help on the experimental throughout this study.

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