Effect of unground oil palm ash as mixing ingredient towards properties of concrete

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Abstract. Malaysia being one of the world largest palm oil producers generates palm oil fuel ash (POFA), a by-product in increasing quantity. This material which usually disposed as solid waste causes pollution to the environment. Success in converting this waste material into benefitting product would reduce amount of waste disposed and contributes towards cleaner environment. This research explores the potential of unground oil palm ash being used as partial sand replacement in normal concrete production. Experimental work has been conducted to determine the workability, compressive strength and flexural strength of concrete when unground oil palm ash is added as partial sand replacement. A total of five mixes containing various percentage of oil palm ash, which are 0%, 5%, 10%, 15% and 20% have been prepared. All specimens were water cured until the testing date. The slump test, compressive strength test and flexural strength test was conducted. The findings show that mix produced using 10% of palm oil fuel ash exhibit higher compressive strength and flexural strength as compared to control specimen. Utilization of unground oil palm ash as partial sand replacement would be able to reduce dependency of construction industry on natural sand supply and also as one of the solution to reuse palm oil industry waste.

1. Introduction

Concrete is one of the widely used construction material in the world owing to its strength and durability. The growing construction industry causes the demand for concrete supply increases. In relation to that, larger amount of non-renewable resources namely coarse and fine aggregates are also needed for its production. Fine aggregates which is one of the important material in producing a compact concrete is usually obtained from mining activity at river. Excessive sand river mining poses threat to the fauna and flora in river environment. In addition, mining activity that been carried without any control also affect the water quality and river bed. The environmental degradation due to sand mining has been well elaborated by [1]. Looking at the long term impact, these environmental problems finally would pose negative impact on healthy life of the community surrounding and also future generation. In view of this problem, success in identifying other materials to reduce the high dependency on river sand for concrete production would ensure the sustainability of river environment.

At the same time, Malaysia being the world second largest palm oil production produces a huge quantity of by-products which disposed as waste. Approximately 4kg of dry biomass is produced for each kg of palm oil produced [2]. The solid wastes are in different forms such as kernels, fibers, empty fruit bunches, shell and palm oil fuel ash (POFA). POFA or also known as oil palm ash is an end product generated from incineration process of palm oil fibers and palm oil kernel to generate electricity to the mill. In practice, this light greyish is dumped behind the mill as waste. As the palm oil production is increasing annually, larger amount of ash is generated resulting in higher waste management expenses. In addition, the increase in the quantity of ash disposed also larger space consumption at dumping site. The ash which carried by the wind also creates discomfort to the people surrounding [3].

Realizing that success in discovering the potential use of this waste material in producing products would reduce amount of waste disposed, many researchers has attempted to integrate this material in concrete production. As a result, this waste material which contains high silica content enabling it to be classified as pozzolanic material has been ground to be fine and used as partial cement replacement in concrete. Ground POFA classified as pozzolanic material when used as mineral admixture enhances the concrete performance [4, 5, 6, 7, 8]. However, the ash which undergone improper combustion at the factory has very low silica content, making it unsuitable to be used as partial cement replacement for strength and durability enhancement of concrete normally discarded as waste. Thus, the present research investigates the possibility of utilizing unground oil palm ash generated at any palm oil mill as partial sand replacement in concrete. The experimental work has been conducted to determine the mechanical properties of concrete containing various percentage of oil palm ash as partial sand replacement.

2. Methodology

The experimental work was conducted at the concrete laboratory in Faculty of Civil Engineering and Earth Resources, Universiti Malaysia Pahang. The overall work comprises of three stages that is material preparation, casting of specimens and testing.

2.1. Materials

Cement, coarse aggregate, river sand, water, and oil palm ash are among the materials that were used for specimen preparations in this preparation. Cement from a single source was used throughout the experimental work. Local river sand is used as fine aggregates. The tap water supplied at laboratory was used for concrete mixing and curing process. Unground oil palm ash was collected from a palm oil mill located in the state of Pahang, West Malaysia. At the laboratory, the raw POFA were processed before ready to be used for concrete production. The ash is oven dried and then cleaned to remove foreign material. Unground oil palm ash that is ready to be used is shown in Figure 1.

Figure 1 : Unground oil palm ash to be used

2.2 Specimen Preparation and Testing

Five types of mixes were used to prepare specimens for the experiments. A plain concrete and another four types of concrete mixes were produced by partially replacing the river sand with unground oil palm ash. The percentages of ash used to substitute the sand are 5%, 10%, 15% and 20% by the weight of sand. All the mixes were mixed carefully, placed in moulds and compacted. Then, the specimens were covered with wet gunny sack and left overnight. The next day, it was demoulded and immersed in water tank until the testing date as shown in Figure 2. The slump test (Figure 3) to measure workability of concrete has been conducted following the procedure in BS EN 12350: Part 2 [9]. The compressive strength of the concrete was determined by testing cubes specimens (100x100x100mm) as per BS 1881: Part 116 [10]. The flexural strength of the concrete was carried out on prism (100x100x500mm) according to BS 1881: Part 118 [11]. The mechanical properties testing were conducted at 7 and 28 days.

Figure 2 : Concrete specimens are water cured

Figure 3 : Slump test in progress

3. Results and Analysis

3.1 Workability

As can be observed Table 1, all mixes containing unground oil palm ash can be categorized as high workability. There is slight variation in the slump value when unground POFA is added as partial sand replacement at various percentages. Integration from 5% to 20% of ash causes changes in slump value. The slump value remains constant at 15% and 20% replacement. It can be observed that incorporation of unground oil palm ash as partial sand replacement influences the concrete workability. This is due to the differences in the characteristic of ash which is porous unlike the solid river sand. Past researcher [12] also noted changes in workability of lightweight concrete mix when palm oil fuel ash is added as mixing ingredient.

Table 1. Slump test result

Sample	Slump Value	Slump Classification
Control	100	High
5%	110	High
10%	115	High
15%	120	High
20%	120	High

3.2. Compressive Strength and Flexural Strength

Figure 4 and 5 presents the compressive strength test and flexural strength result of specimens containing various content of unground oil palm ash as partial sand replacement. All specimens exhibit strength increment as curing age prolonged. The continuous curing water method applied promotes undisturbed hydration process resulting in generation of larger amount of calcium silicate hydrate gel making the concrete internal structure become more compact and stronger. The findings also indicate the integration of unground oil palm ash as partial sand replacement has effect on the strength of concrete. Looking at the effect of unground oil palm ash as partial sand substitute, it can be deduced that the concrete strength increases when suitable amount of unground oil palm ash is added in the mix. However, inclusion of the ash beyond certain limit has adverse effect on the concrete strength performance.

The strength gain of the concrete with unground oil palm ash was superior to that of the control mix as the percentage of POFA replacement was increased to up to 15%. The highest compressive strength was obtained by the 10% sand replacement by ash that appears to be 16% higher than the control specimen with is 39.45 MPa. This encouraging result is attributed to the function of unground oil palm ash as filler making the concrete internal structure denser and more compact resulting in higher compressive strength. A decrease in compressive strength was observed as the percentage of sand replacement was more than 10%. The compressive strength of the 20% unground oil palm ash specimens are lower than that of the control specimen. Based on the experimental work conducted, it can be concluded that utilization of unground oil palm ash at certain amount would contribute towards the better strength achievement of concrete.

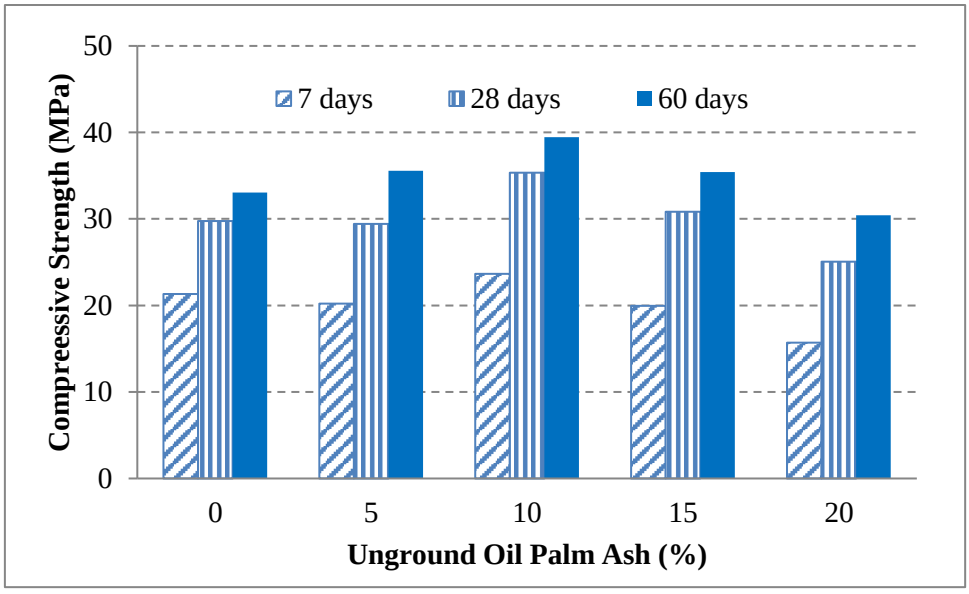

Figure 4. Effect of unground oil palm ash content on compressive strength of concrete up to 60 days

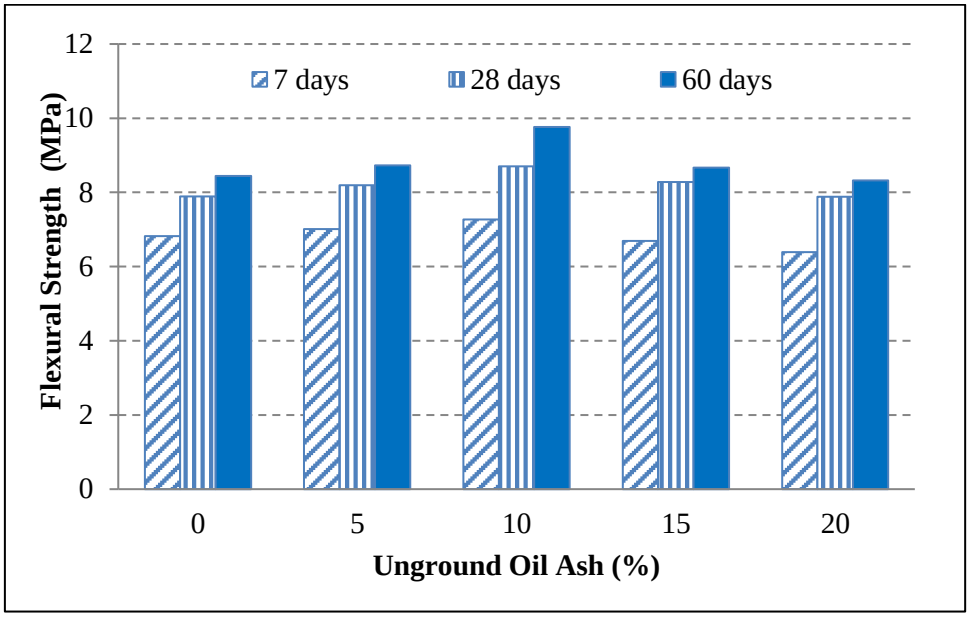

Figure 5. Effect of unground oil palm ash content on flexural strength of concrete up to 60 days

4. Conclusion

Conclusively, this study shows that integration of 10% unground oil palm ash as partial sand replacement able to produce concrete with better performance in terms of compressive strength and flexural strength, as compared to plain concrete. Another locally made environmental friendly concrete containing lesser natural river sand is possible to be produced for the use in construction industry. Success in integrating this palm oil industry waste generally helps the industry to be more environmental friendly as the pollution issue related to disposal of oil palm ash at dumping site can be reduced.

5. Acknowledgement

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