The Use Of Palm Oil Clinker In Self-Compacting Lightweight Concrete

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Abstract

This paper presents result of a study on the effectiveness of palm oil clinker (POC) as an alternative to gravel in self–compacting lightweight concrete. Specimens were prepared by using ordinary Portland cement, Kahang sand, palm oil clinker, timber industry ash (TIA), tap water and superplasticizer named Rheobuild 1100. The quality of the mix, especially the strength is monitor for age 7-days, 28-days and 90-days. The results shows that by utilizing palm oil clinker as the lightweight aggregate and the superplasticizer as the admixture, a low water cement ratio in the range of 0.39 – 0.42 self-compacting lightweight concrete with high workability and the strength that meets the minimum requirements can be produced.

Introduction

Malaysia is well known for its palm oil industry. However, the palm oil industry also produces a kind of waste, known as clinker. POC can be obtained from the boiler of every palm oil mill. POC was found to be suitable to replace normal gravel aggregate in concrete mixture (1). Concrete mixture containing POC as an aggregate can be classified as lightweight aggregate concrete due to its low density. The British Standard, BS 8110: Part 2: 1985 classified lightweight concrete as concrete having densities of 2000 kg/m^3 or less.

In recent decade lightweight concrete is widely used due to the economic factor. However, the most obvious characteristic is that for the same crushing strength, the density of the lightweight aggregate concrete can be as much as 35 per cent lower than the normal weight concrete (2). For concrete structures, reduction of dead weight makes the construction less expensive.

There is also an extensive use of self-compacting concrete (SCC) in concrete structure buildings such as Macao Tower in China, and Akashi-Straits Bridge in Japan. SCC has proven its usefulness in filling up voids, especially in heavily reinforced section where the immersion vibrator cannot reach.

Since lightweight concrete can be very economical, a research is carried out to study the performance of POC concrete mixture towards SCC. This paper reports the result of experimental study on the full replacement of POC as coarse aggregate in producing self-compacting lightweight concrete in the presence of superplasticizer as the admixture.

Experimental Work

Preparation of Material

(i) Cement and aggregate

The cement used was ordinary Portland cement while TIA was used to replace 10 percent of the total cement required. Kahang sand was used as fine aggregate and palm oil clinker as coarse aggregate. Concrete was design accordance to the *Performance Data Sheet* of Rheobuild 1100 dosage [3].

The clinker was taken from a local palm oil mill, Kian Hoe Plantation Berhad, situated in Kluang, Johor. All the clinkers taken out from the boiler need to be crushed into smaller size (Figure 1). The clinkers were crushed manually by using hammer so that it can fit to a size average of 20 mm. The clinker aggregates were then sieved using BS 410 sieve sizes in order to segregate the aggregate to require to nominal size of 20 mm, which will be used as coarse aggregate replacing gravel (Figure 2). For those aggregate larger than 20 mm will be crushed again until it is 20 mm or smaller than that while those smaller than 5 mm will be discard. Figure 3 shows the grading curve for coarse aggregate.

Figure 1. Clinker in original size

Figure 2. Clinker after process

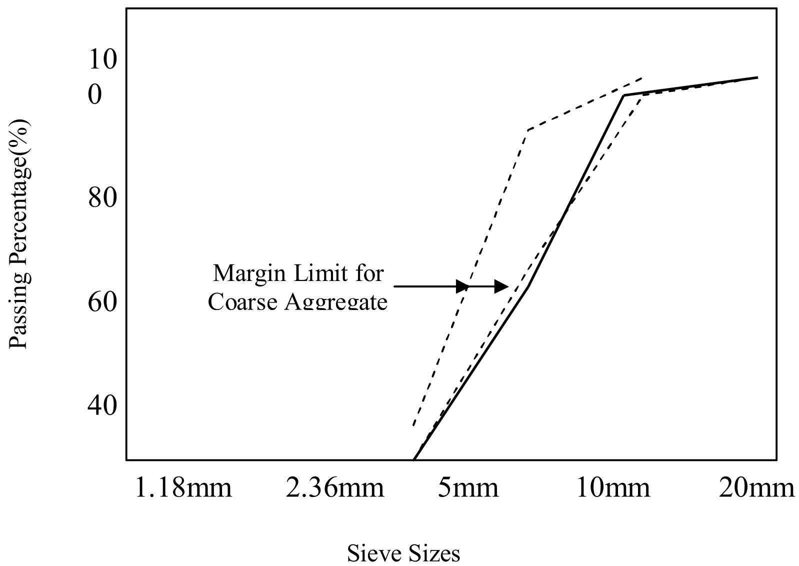

Figure 3. Grading curve for coarse aggregate

Before the POC were mixed into concrete mix, required amount of clinker had to be saturated in the water. The POC was immersed in water for 24 hour and later surface-dried.

(ii) Superplasticizer

The superplasticizer used for this research to produce self-compacting lightweight concrete is Rheobuild 1100 produced by Master Builders Technologies Sdn. Bhd. According to the user manual, the dosage of Rheobuild 1100 required is 1.2 litres to 100 kg of cement. Required dosage of Rheobuild 1100 is mixed with water equally before it is poured into the material mixture.

Figure 4. Materials ready to be mixed

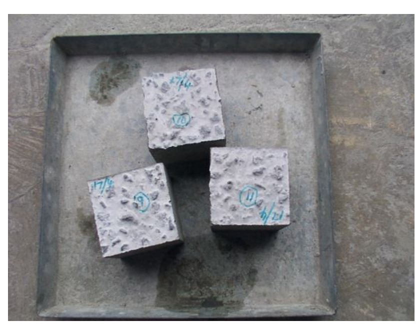

Figure 5. Cubes cured at room temperature

Mix Design

The lightweight concrete mix was designed by referring to *Performance Data Sheet* of Rheobuild 1100 dosage. The ratio of material compositions are given in Table 1.

Table 1: Ratio of Material Compositions

Batching	Cement (+10% TIA)	Water	Fine Aggregate	POC
01	1	0.42	1.51	2.01
02	1	0.39	1.6	1.92
03	1	0.40	1.55	2.33

Specimens Casting and Curing

The specimens were placing in the mould with dimensions 100 mm x 100 mm x 100 mm. After casting, all specimens were left to be cured at room temperature (Figure 5).

Result And Discussion

The results of slump, density and the compressive strength for three different mix designs are shown in Table 2. As the concrete mix is designed as self-compacting lightweight concrete, the result shows that the workability of the fresh concrete is very high (170 mm – 190 mm slump) although the water-to-cement ratio is quite low (w/c: 0.39 – 0.42). The high workability of the concrete is due to the reaction of the admixture in the concrete.

From the testing results, it is found that the density of the concrete is around 13% lower than the normal dense concrete thus it can be classified as the lightweight concrete. Since the palm oil clinker is used as the lightweight aggregate, the concrete produced can be categorized as lightweight aggregate concrete.

The compressive strength for the self-compacting lightweight concrete is found to be adequate although it is made of palm oil clinker having lower strength than the normal aggregate. If the samples are cured in water, it estimated that the mean compressive strength will be higher than air-cured. The result also shows that the compressive strength is higher for the concrete with higher density.

As the compressive strength of the self-compacting lightweight concrete has met the minimum strength requirements for reinforced concrete with lightweight aggregate which is 15 MPa or 2200 psi according to the British Code CP110: 1972, this concrete is suitable to be used as the reinforced lightweight concrete.

Table 2: Slump, Density and Compressive strength

Batching no.	Slump (mm)	Mean Density (kg/m^3)	Mean 28 days compressive strength (N/mm^2)
1	170	2006.5	31.6
2	180	2106.8	36.5
3	190	2121.5	47.6

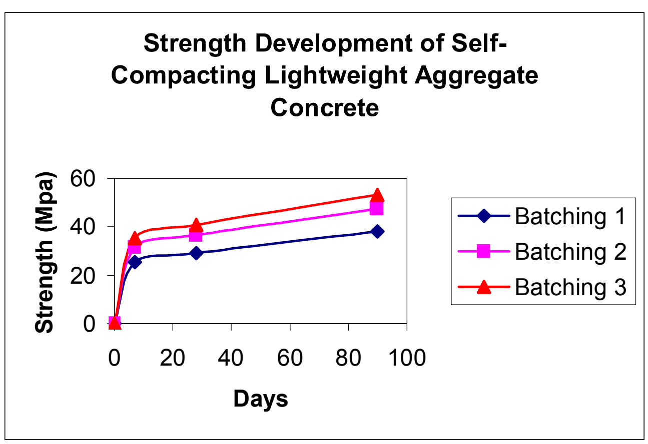

Figure 6. Strength development of SCC concrete

The graph in Figure 6 shows the compressive strength development for the self-compacting lightweight concrete. The strength development was similar to the normal concrete where almost 80% of the 28-days strength could be achieved at 7 days age.

Conclusion

Based on the results of the research, the following conclusions could be made:

(i) Since the aggregate was not fully replaced by the palm oil clinkers for both fine and coarse aggregate, the density achieved is higher than the required. The reduction of weight can be done by replacing both fine and coarse aggregate with palm oil clinker.

(ii) The coarse aggregate used in the concrete mix does not fit in the margin limit due to the method of crushing aggregate. The sizes of the clinker could not be controlled because it was crushed manually by using hammer.

(iii) As the conclusion, utilizing palm oil clinker as the lightweight aggregate and the super-plasticizer as the admixture can produce self-compacting lightweight concrete with high workability and the strength that meets the minimum requirements.

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