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Properties of concrete containing foamed concrete block waste as fine aggregate replacement

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Abstract. Environmental degradation due to excessive sand mining dumping at certain places and disposal of foamed concrete block waste from lightweight concrete producing industry are issues that should be resolved for a better and cleaner environment of the community. Thus, the main intention of this study is to investigate the potential of foamed concrete block waste as partial sand replacement in concrete production. The foamed concrete waste (FCW) used in this research that were supplied by a local lightweight concrete producing industry. The workability and compressive strength of concrete containing various percentage of foamed concrete waste as partial sand replacement has been investigated. Prior to the use, the foamed concrete waste were crushed to produce finer particles. Six concrete mixes containing various content of crushed foamed concrete waste that are 0%, 10%, 20%, 30%, 40% and 50% were used in this experimental work. Then the prepared specimens were placed in water curing until the testing age. Compressive strength test and flexural strength tests were conducted at 7, 14 and 28 days. The result shows that integration of crushed foamed concrete waste as partial sand replacement in concrete reduces the mix workability. It is interesting to note that both compressive strength and flexural strength of concrete improves when 30% crushed foamed concrete waste is added as partial sand replacement.

1. Introduction

Foamed concrete is manufactured by entraining relatively large volumes of air into the cement paste by the use of a chemical foaming agent [1]. Currently, foamed concrete which is classified as lightweight concrete are increasingly used in construction projects mainly due to its lightness, more economic structural design and also ease of handling at construction site. Foamed concrete is available in various form of product ranging from fresh foam concrete mix, precast wall panel and precast concrete block. Foamed concrete block is one of the lightweight concrete favoured by the contractors owing to its lower density and ease of handling in comparison to conventional concrete. Increase in demand for this product by local contractors has results in factories to manufacture this lightweight concrete product. The production of this blocks in huge quantity which then checked for is quality has caused some of the products are rejected due to defects resulting from mishandling or other factors. Those foamed concrete blocks are usually discarded as profitless waste near the factory. Being a



concrete material which does not degrade as organic plant, continuous disposal of these foamed concrete block waste consume larger dumping area as it piled up higher with the time. Utilizing this construction material waste in production of any products would be one of the solutions to turn the waste into profit making element. This would also lead to benefits in terms of reduction on cost, energy savings, promoting ecological balance and conservation of natural resources [2].

At the same time, sand that is one of the important mixing ingredients in concrete is used in increasing quantity for construction industries. The local sand used is mined from the rivers is also an income generating industry in the country. Excessive sand mining would cause negative impacts to the environment both to the river as well as water quality. This happens when the rate of extraction of sand, gravel and other minerals exceeds the rate at which natural processes generate these materials [3]. Sand mining activity cannot be stopped as it contributes to the development of other local industries. However, the quantity of sand harvested from the nature is possible to be controlled by introducing other waste materials that able to function as partial sand replacement material. Realization on the importance of managing the resources smartly for sustainable environment, has inspired local researchers [4-8] to investigate the potential existing waste materials as partial fine aggregate in concrete. So far, no literature review is available on the use of foamed concrete waste as partial sand replacement in concrete. Thus, the present research looks into the potential of the freely available foamed concrete block waste to be transformed into environmental friendly sand replacement material for the use in concrete production. The current research looks into the workability and mechanical properties of concrete containing crushed foamed concrete block waste as partial sand replacement.

2. Methodology

2.1. Materials

The materials used in this study were cement, fine aggregate, foamed concrete block waste, coarse aggregate and water. The type of cement used throughout this research was Portland Composite Cement (PCC) of Pheonix brand. Local river sand and granite aggregate has been used as fine aggregate and coarse aggregate respectively. Tap water is used for concrete mixing work and curing of the specimen. No superplasticizer is employed during the mixing work. The foamed concrete block chunks illustrated in figure 1 is obtained from Binaan Desjaya Sdn Bhd, Kuantan, Pahang. The foamed concrete wastes were collected from the factory and transported to laboratory. Then, the foamed concrete is crushed using jaw crusher shown in Figure 2 to produce fine size aggregate. The finely crushed foamed concrete block wastes which are ready to be used as partial fine aggregate replacement in this research were kept in closed container.



Figure 1. Foamed concrete block chunks.



Figure 2. Jaw crusher used to produce fine sand.

2.2. Mix proportions

Six mixes were used in this experimental work. The control mix used is grade 30. The control mix consist 100% river sand as fine aggregate. The rest of the mixes contain various percentage of crushed foamed concrete waste (FCW) that is 10%, 20%, 30%, 40% and 50% as partial sand replacement. The mix proportion used to produce specimens presented in Table 1.

Table 1. Mix proportion of concrete mixes.

Mix Design	Cement (kg/m ³)	Sand (kg/m ³)	Coarse Aggregate	Foamed Concrete Waste (kg/m ³)	Water (kg/m ³)
FCW 0	330	1020	905	0	190
FCW-10	330	918	905	102	190
FCW-20	330	816	905	204	190
FCW-30	330	714	905	306	190
RFC-40	330	612	905	408	190
RFC-50	330	510	905	510	190

2.3. Specimen preparation and testing method

All the mixes were prepared in form of cubes (100x100x100mm) and beam (100x100x500) for determination of compressive strength and flexural strength respectively. Specimens were subjected to water curing until the hardened properties testing date. The effect of crushed foamed concrete waste (FCW) content when used as partial sand replacement on concrete mix workability were determined through slump test. Slump test was carried out adhering to the steps stated in BS EN 12350:2 [9]. Compressive strength test conducted following the procedures in BS EN 12390:3 [10]. Flexural strength test was conducted by referring to BS 1881 – 118 [11] to determine the flexural strength for concrete specimens. Both types of destructive test were conducted when the specimens reach the curing age of 7, 14 and 28 days.

3. Result and discussion

3.1. Workability

Figure 3 illustrates the effect of foamed concrete waste content on the slump of concrete. Generally, inclusion of crushed foamed concrete waste as partial fine aggregate replacement effects the concrete mix workability. The slump reading of the concrete increases as the percentage of foamed concrete waste used as partial sand replacement increased. All slump readings are classified as medium workability. The highest slump value recorded at 50% replacement level, which still considered medium value. The concrete slump value at 10%, 20% and 30% of RFC replacement had given low workability with 58mm, 63mm and 66mm respectively, which are higher as compared to control specimen with value of 53mm.

The highest slump value observed at 50% of sand replacement that is 72mm. Increment in the workability of mixture when FCW replacement increasing is may be due to the fineness of FCW as compare to normal sand. The increase in slump value is due to high porosity of FCW particles, which cause the absorption of more water. This is due to large voids in the foamed concrete. In addition, the high demand of water as the FCW content increases could cause slump to collapse due to loss of adhesion between the mixing ingredients. This is an additional function of water in the mixture to

prevent the slump from collapse. That means, more water is required in addition to water required during hydration of cement [12].

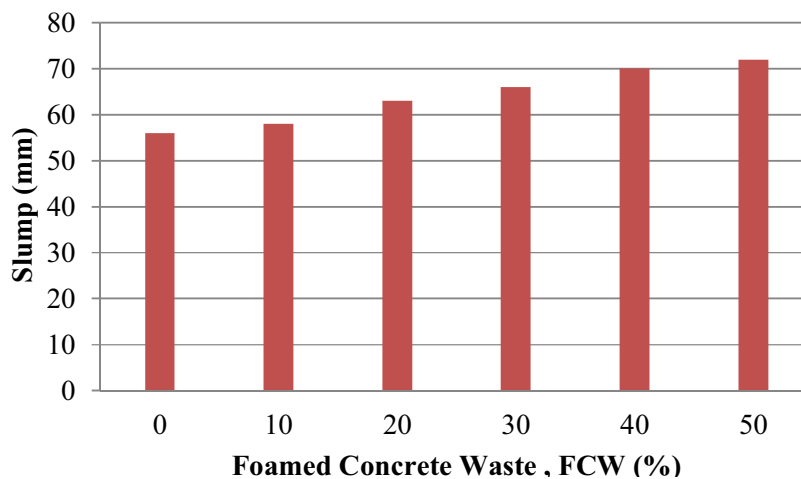


Figure 3. Effect of foamed concrete waste content on concrete workability.

3.2. Compressive strength and flexural strength

Figure 4 and 5 illustrates the compressive strength and flexural strength development of the concrete containing various percentage of foamed concrete waste as partial sand replacement. On overall, all mixes exhibit increment in the strength value as the curing age increases from 7 to 14 and 28 days. Application of water curing ensures continuous hydration process, which is vital for production of larger amount of calcium silicate hydrate that is responsible for compressive strength development. Looking at the effect of crushed foamed concrete waste on concrete strength, it is evident that integration of this waste material at suitable percentage able to increase the strength of concrete.

The result indicates that utilization of 30% crushed foamed concrete waste as partial fine aggregate replacement able to produce concrete with the highest strength as compared to all mixes. The compressive strength of concrete mix containing 30% of sand is almost 4.8 % higher than control specimens. This positive contribution is possibly due to the role of this fine waste material as filler that tend to occupy existing voids in the concrete making it denser and stronger. Similar observation has been made by [13-15] who reported that when solid waste in form of fine particles were integrated as partial fine aggregate replacement in concrete at suitable proportion the concrete exhibit strength increment. However, decrease in both compressive strength and flexural strength of concrete was observed as the percentage of sand is replaced with by foamed concrete waste 40% and 50%. That could be explained as the content of FCW increased above 30%, the water content became insufficient for the hydration process to take place. This causes the concrete to experience loss of adhesion between the aggregates owing lower amount of C-S-H gel generated finally resulting in drop of strength.

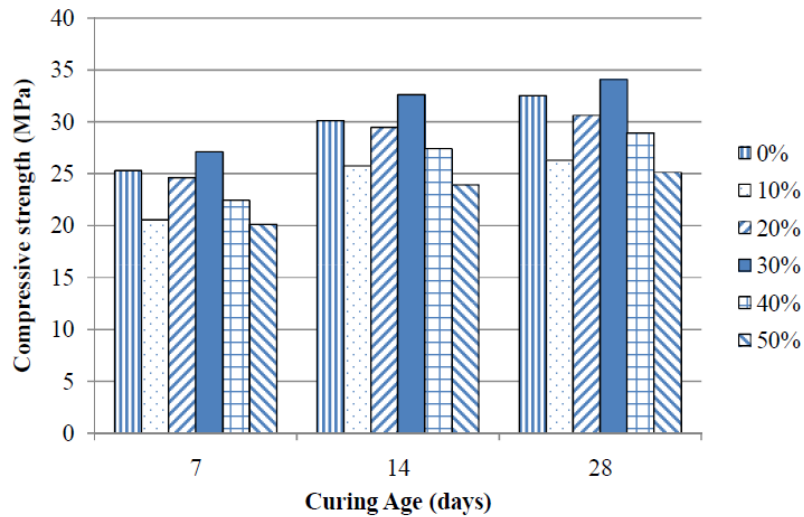


Figure 4. Effect of foamed concrete waste content on compressive strength of concrete.

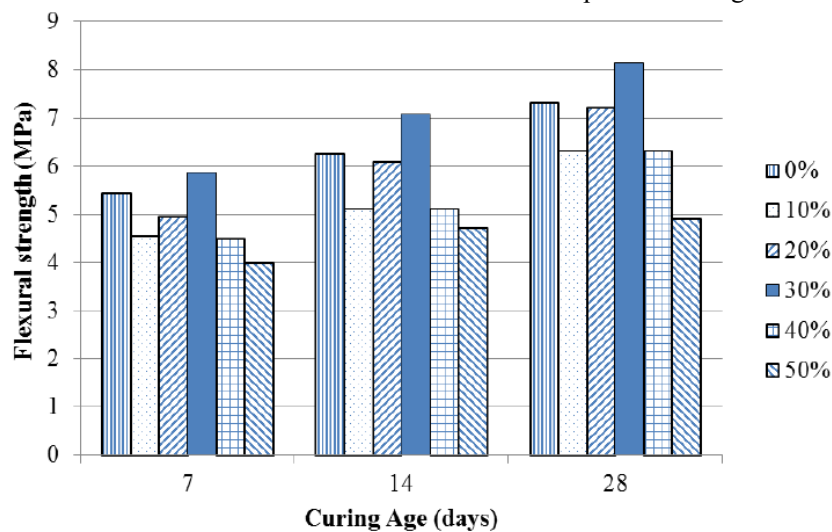


Figure 5. Effect of foamed concrete waste content on flexural strength of concrete.

4. Conclusion

Compressive strength of concrete reaches its optimum at 30% replacement level of foamed concrete waste (FCW) with the sand. However, integration of FCBW beyond 30% decreases the compressive strength of concrete gradually. Success in integrating crushed foamed concrete block waste as partial fine aggregate in concrete able to reduce amount of waste disposed by foamed concrete block manufacturing industry and save the use of natural river sand resulting in cleaner environment.

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