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Potential of RHA in Foamed Concrete Subjected to Dynamic Impact Loading

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Abstract. In relation to the conventional concrete then foamed concrete (FC) is weaker. Therefore FC was added by Rice Husk Ash (RHA) to alter the strength without eliminating its characteristic as aerated concrete. Actually function of RHA is substitute the sand partly. The strength of concrete affects to prevent the dynamic impact loading. However FC as aerated concrete can absorb energy impact by its porosity. Both of characteristics were presented in this investigation. SEM and EDS detected that pozzolanic reaction was done when FC was processing hydration of cement in admixture. The presence of RHA increased the strength of concrete owing to cement hydration process and pozzolanic reactivity of RHA. The result of impact loading on slab FC target displayed that FC with RHA was more shallow than without RHA. Beside of that local damage showed that FC with RHA denser and is not impression of fragments than FC without RHA.

1. Introduction

Constituent material of foamed concrete (noted by FC) basically is same with conventional concrete that used cement, aggregate and water. However only fine sand is used as fine aggregate and not required the coarse aggregate. Some time any light materials are added to increase the properties of FC such as fly ash or fibre. Properties of FC besides lightweight, very costly and easy in installation, it is exhibit excellent characteristics including high strength, energy saving, waste utilizing, heat preservation and noise insulation [1], even it is good absorb energy impact [2, 3].

Most investigations have been confined cement paste with replacement admixture of cement-sand mixes partially to obtain a specific purpose such as to increase density and strength, for example replacement of sand with fly ash resulted in higher strength which finer filler resulted in higher ratio of strength to density. The finer the filler caused an increasing strength of FC [4]. It does not exception for FC that can be added or replaced by another material to increase the strength without losing its constituent characteristic as aerated concrete [5, 6].

Rice Husk Ash (noted by RHA) is agro-waste which produced of agriculture industry, it can be used as filler or binder of concrete [7]. The characteristic of RHA as pozollan material has high pozzolanic activity index and it influence on improvement strength of conventional concrete [8]. In this investigations RHA was obtained from un-control burning below 700ºC precisely and pick up the expecting high pozzolanic activity index [8]. With the un-crontrol burnt of RHA that contained into FC affect on cratering local damaged when dynamic impact loading conducted on FC with RHA.

2. Cement Hydration and Pozzolanic Reactivity

The process of hydration of cement in concrete produce Calcium Hydroxide, that expressed as follow:

Cement hydration reaction:

$$2Ca_3SiO_5 + 7H_2O \quad 3C_{aO.}2SiO_2.4H_2O + 3Ca(OH)_2 \tag{1}$$

The presence of RHA as pozzolan material that rich of Silica into concrete admixture that brings about pozzolanic reaction as follow:

Pozzolanic reaction:

$$3Ca(OH)_2 + 2SiO_2 + H_2O \quad 3CaO.\ 2SiO_2.4H_2O \tag{2}$$

Calcium hydroxide and silicate hydrate that the major product of hydration and reaction process of RHA. Zang, et, al.[9], were reported that the cement paste incorporating with RHA had a lower Ca (OH) content than the control Portland cement paste without RHA. Further the pozzolanic reaction reduces width amount of interfacial zone between aggregate (sand) and cement paste. The process gives the FC increased its strength due to reduce of porosity and reduce amount of interfacial zone between the sand and cement also increased the density of the zone [5].

3. Influence of Strength of Concrete on Impact Loading

When structure of concrete loaded by impact loading, it different responses when they are given static loading. Concrete subjected by impact loading generate localized effect. It is characterised by penetration, perforation, cratering or scabbing and more widespread crack propagation. The concrete should be sufficient in compressive strength to prevent the impact loading, while a higher tensile strength of concrete could be reduce a crater size and impede the fracture [10]. This is contrary properties of concrete as a shield structure, according on Dancygier and Yankelevsky [11], they observed their experiment study of the response of high strength concrete to hard projectile impact that the higher compressive strength more resistance against dynamics punch, but the higher compressive strength also increase the brittleness of concrete and generate the wider crater size diameter and produce more fragments. Microstructure analysis of lightweight concrete specifically for porous or aerated concrete such as FC, define that the interfacial zone of lightweight concrete should be lesser dimension than that of normal-weight concrete [12]. The formation of interfacial zone of FC is partly due to the lack of wall effect (i.e. high porosity at the interfacial zone) and partly due to the interlocking of the cement paste onto rough surface pores of FC, it is likely that the large pores size at the interfacial zone of FC. It causes weaken the strength of FC. A compacted interfacial zone helps to realize a higher strength of lightweight concrete [13], such as FC.

4. Experiment

4.1. Material and Mix Proportion

Pre-foaming as one of produce foamed concrete was applied in this research. To pursue the target density 1800 Kg/m^3, firstly base mix of concrete contained cement [14], sand [15]and water were blended. The ratio of cement-water was 0.60 and ratio cement-sand was 0.25 [5] in the mean time stable preformed aqueous foam made separately. The density of foam 50 Kg/m^3 that prepared aqueous surfactant solution was diluted by water 1:5 [16, 17]. Afterwards the stable foam blended gently into the base mix until reach target density. Base on chemical composition RHA and original fly ash is similar with each other [18]. So that the investigation of RHA was treated as originally fly ash [19]. The RHA obtained from rice manufacturer and uncontrolled burning under 700ºC during ± 6 hours. The composition of cement-sand-RHA was 1:3:1 with 1.25 ratio of RHA-water. The RHA was mixed into concrete admixture before foam blended into admixture.

4.2. Experimental and Test Procedures

The uni-axial load was conducted on the foamed concrete to carry out compressive strength test [20]. The FC specimens both of with and without RHA were moulded and maintained at temperature 23 ± 2°C for 24 hours. After casting, they were removed from the mould and treated with the same temperature. Some specimens limited for 28 curing days, the other specimens continued for 60 and 90 days of curing. It was done with the same manner to slab target for impact loading. The dimension of each slab was 600mm of width and 600mm of length and 160mm of thickness. The surface area and thickness of slab was conforming to some prediction formulas [21-25].

SEM and EDS was applied to determine the microstructure and composition of FC containing RHA. Impact test were conducted using an instrumented falling-weight impact tower. The rigid non-deformable impactor was released with various elevations 5m, 4m and 3m or various velocities 10 m/s, 8.9 m/s and 7.7m/s respectively. Actually the impactor is a ball shape and non-deformable impact on concrete and ceramic. It is represent the model of a non-deformable projectile with blunt nose. In present experiment the impactor is made of urethane and polymer composite with 6 kg by weight, 218mm of diameter and 1094 kg/m^3 of density.

5. Result and Discussion

5.1. Compressive Strength of foamed concrete with RHA with different curring days

Table 1 presents the compressive strength of 1800 kg/m^3 both of FC with and without RHA in various densities 1400 kg/m^3, 1600 kg/m^3 and 1800 kg/m^3.

Table 1. Compressive strength of 1800 kg/m^3 density, both of FC with and without RHA.

Curing Days	Compressive Strength (N/mm^2)	
	FC	FC + RHA
28	6.190	10.495
60	6.611	11.749
90	7.122	14.914

The compressive strength of FC is accordance with causal of incorporation between cement and silica in hydration process and pozzolanic reactivity. Therefore the presence of RHA gives contribution on compressive strength, which its reactivity is additive for cement in concrete [5, 8]. Table 1 shows significantly the increasing compressive strength with different curing days for FC with RHA has proven the reaction hydration of cement and pozzolanic reaction into matrix FC.

5.2. Microstructure of Foamed Concrete Contains RHA

Figure 1, the SEM image shows the RHA fusible into solid part (circle) in cement paste. It is agree with figure 2 which the EDS test has detected Calcium hydroxide and Silicate Hydrate that the major product of hydration and reaction process of RHA [8].

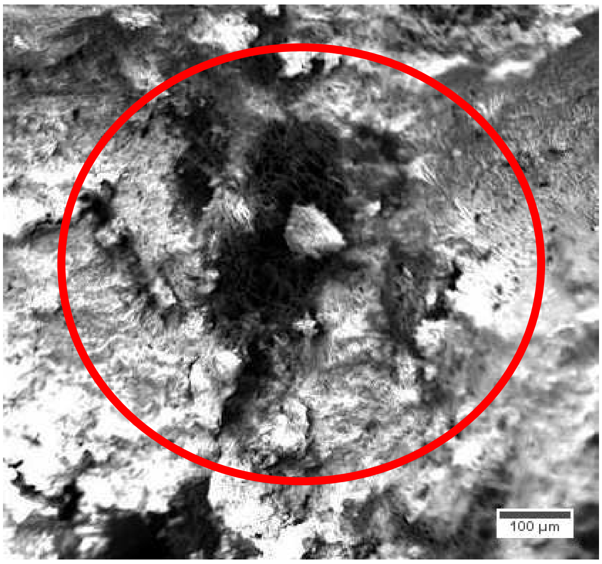


Fig. 1 Microstructure of FC contains RHA.

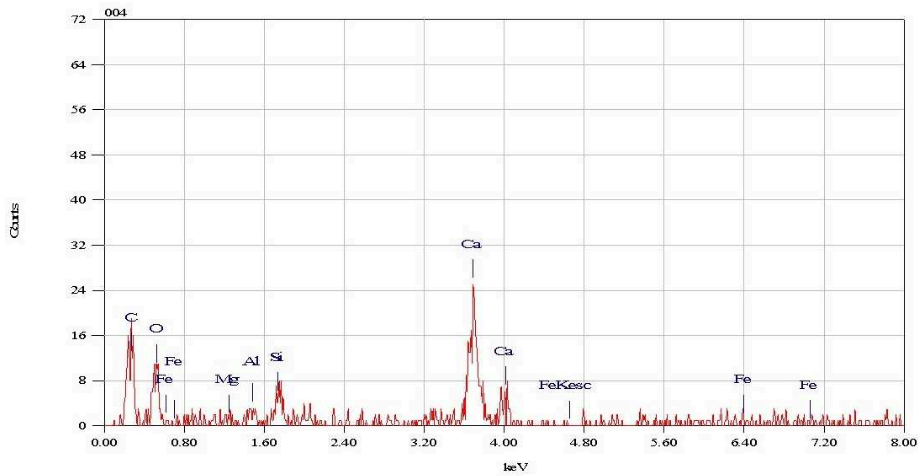


Fig. 2 The composition of circle area in figure 1 is presented by EDS

5.3. Local damage of foamed concrete contains RHA Subjected to Impact Loading

Figure 3 shows that penetration depth both of FC with and without RHA. The penetration depth trend of the FC with RHA is more shallow than FC without RHA. The presence of RHA in matrix increase strain walls of porous due to granules of RHA [5] and alter the resistance of shock impact. Beside of that influence of RHA as pozzolan materials has given the FC increased its strength due to reduced amount of interfacial zone between the sand and cement, therefore reduce the porosity and increase density of the zone. It is agree with Zang, et., al. [10] concluded that the impact resistance concrete to prevent penetrate the projectile then the concrete should be higher compressive strength. However presence the RHA does not reduce overall characteristic of FC especially as aerated concrete. Figure 4 displays results of local damage due to impact loading, which the FC contain RHA denser and no fragments than FC without RHA. However both of them do not find spalling or scabbing [26].

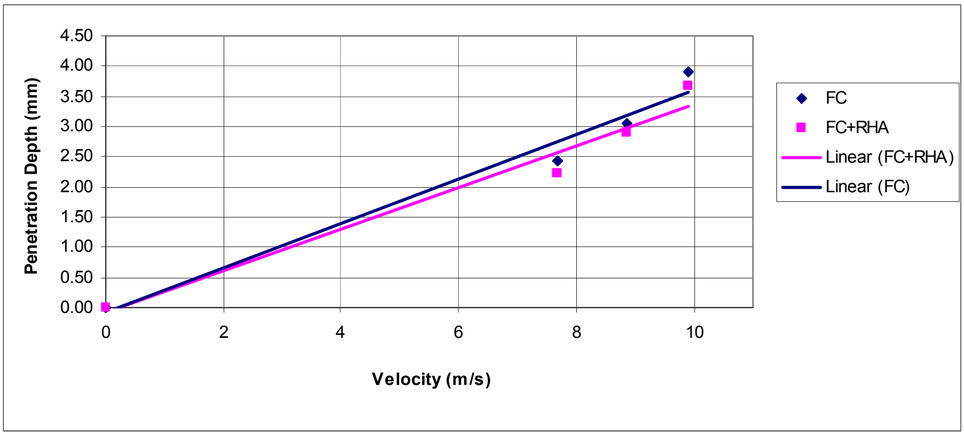
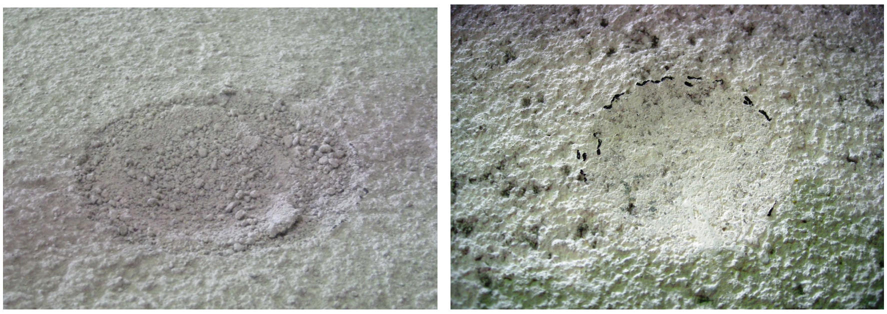


Fig. 3 Penetration depth of foamed concrete with various impact velocities.



(a) (b)

Fig . 4 Local effects due to impact loading with 10 m/s of impact velocity (a) FC without RHA and (b) FC with RHA

6. Conclusion

Usage RHA as partly sand replacement in this investigation was from uncontrolled burning process which expected chemical composition such as Silicon Oxide of that contained in RHA was required. The Silicon Oxide was used in reaction pozzolan with Calcium Hydroxide that was liberated from cement hydration. The pozolannic reactivity contributes to alter the strength of foamed concrete. The strength of foamed concrete was important role on impact resistance of foamed concrete. The results presented that local damage due to impact loading showed crater without fragments and obtained neither spalling nor scabbing. It is depict that foamed concrete can absorb energy due to porous although it was modified with added the RHA. The presence RHA did not reduce overall characteristic of foamed concrete especially as aerated concrete.

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