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doi:10.4028/www.scientific.net/KEM.594-595.93

Contribution of RHA Granules as Filler to Improve the Impact Resistance of Foamed Concrete

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Keywords: foamed concrete, rice husk ash, impact, penetration depth

Abstract. Foamed concrete as aerated concrete widely used in range of constructions application, no exception to structure shield. As structure shield is important to resist on impact loading. Whilst, Rice Husk Ash (RHA) as agro-waste potentials as filler for foamed concrete. RHA that is produced by uncontrolled burning under 700ºC during ± 6 hours obtain the granules contain the carbon and porous. The granules of RHA may fill the porous in matrix foamed concrete without remove the characteristic the foamed concrete its self as aerated concrete. This investigation RHA has been used as a replacement for fine aggregate. Target density 1800 kg/m^3 of foamed concrete both of with and without RHA have been produced to compare their strength and characteristic of impact resistance. SEM and EDS test has been conducted to determine microstructure and chemical composition of foamed concrete with RHA. The results showed that granules of RHA filled the porous and bonded with the denser part into matrix. The presence of granules of RHA has been changing the role of the air cell of porous in foamed concrete when it was subjected to impact loading. Also the granules of RHA give the foamed concrete denser without losing its characteristic of porous entirely.

1. Introduction

The Rice Husk Ash (noted by RHA) can be used as filler or binder for sustainable material base on cement such as concrete [1]. It is owing to the characteristic of RHA as pozollan material which has high pozzolanic activity index and it can be improved strength of concrete [2]. Moreover RHA as agro-waste is not difficult to obtain, especially in developing country where almost over 100 million tons of rice husk produced every years [1]. When the RHA was burned in un-control burning ± 700°C and obtain expecting high pozzolanic activity index [2, 3]. This combustion process produced the partly not burned. It is identified by the high carbon into RHA [3] and this part is porous. This condition can be utilized as filler for foamed concrete (noted by FC) as resistance of impact structure due to ability to absorb energy impact [4, 5]. Beside of that influence of RHA into admixture improves the strength of concrete [3]. The resistance of impact loading identified with penetration depth of the local damaged phenomena is called cratering [6, 7].

2. Foamed Concrete Subjected to Impact loading

If impact loading conducted on foamed concrete slab as a target, afterwards impactor start to touch the surface of target then compressive elastic wave initiate the linear elastic region in stress-strain curve. The elastic wave has been produced by compressive elastic stress, it will be refflected from the surface, when the surface free then the reflection to be tensile wave. If the concrete is brittle and low tension then the reflection tensile wave will produce the fracture and fargments that separated and fly

away or spalling. Along with that, when compressive stress wave reflected propagate through to rear surface of target or transverse direction then the walls of porous are stretching, furthermore opposing walls of porous will close each other until almost collapse. This condition causes altering strain walls of porous and create plateau region in stress-strain curve. The collapse of walls of porous is called brittle crushing. Afterwards the strain decrease and target surface compresses the solid itself [8].

In cases where foamed cocnrete contains a lot of the air cavities so may absorb much energy impact. Effect stress wave propagation relates on energy absorption and densification [4]. The present of granulated of RHA into foamed concrete may fill the air porous in matrix and changing the role of the air cell of porous in foamed concrete, which the elasticity of garnulated more higher then walls porous of foamed concrete.

3. Experimental

3.1. Materials and Mix Proportions

The experiment was conducting pre-foaming method to produce the slab target. First step was to produce base mix of concrete contained cement [9], sand [10] and water, whilst stable preformed aqueous foam made separately. Afterwards the foam placed into of concrete admixture gently until reach the target density. The RHA obtained from rice manufacturer at Muar-Johor Malaysia which uncontrolled burning under 700ºC during ± 6 hours. the investigation of RHA was treated as originally fly ash [3, 11]. The density of foam 50 kg/m^3 that prepared aqueous surfactant solution was diluted by water 1:5 [3] in a dry system generator which ordinary used by industry. The target denisty of foamed concrete both of with and without RHA as slab target was 1800 Kg/m^3 that were produced by 0.60 of water-cement ratio, 0.25 of cement-sand ratio, 1:3:1 of cement-sand-RHA ratio and 1.25 RHA-water ratio.

3.2. Experimental and Test Procedures

The compressive strength was carried out by uni-axial load test [12]. Casting the specimens were moulded from mixture and were maintained at temperature 23 ± 2°C. After 24 hours the specimens removed from mould and they were treated with the same temperature limited for 28 curing days. It was the same way to produce 600 mm x 600 mm x 160 mm the slab target, which the thickness of slab conforming to some prediction formulas [7, 13-16] to predict the slab thickness subjected to impact loading using dimensionless prediction. SEM and EDS was applied to determine the microstructure and composition of foamed concrete 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.

4. Result and Discussion

4.1. Compressive Strength of Foamed Concrete containing RHA

Table 1 shows the result of compressive strength with 1800 kg/m^3. The compressive strength on foamed concrete is accordance with causal of incorporation between cement and silica. The strength of concrete is contributed by pozolanic characteristic of RHA which its reactivity is additive for cement in concrete. During process of the cement hydration is liberating the pozzolanic reaction between silica and calcium hydroxide, that the RHA is which contain high amount of silicon dioxide (SiO_2). Further, calcium silicate hydrate that produce during reaction make into microstructure of

concrete denser than without RHA [2, 3]. In addition, the presence of granules may fill the porosity increase the strength of foamed concrete and affected the penetration depth. It will be discussed later.

Table 1 Compressive strength of FC and FC with RHA

Material	Density (Kg/m^3)	Compressive Strength (N/mm^2)
FC	1800	6.190
FC + RHA	1800	10.490

4.2. Microstructure of Foamed Concrete with RHA as Sand Replacement

RHA was observed with 100 times magnification of SEM. Figure 1 shows RHA that has not all burnt which is defined by granule (circle) bonded into solid part, and the cement hydration process occurs [17]. Figure 2 shows the EDS result test detect amount of carbon as RHA which has not all burnt. It is depict that the granulated carbon of RHA can be filled the porosity of foamed concrete.

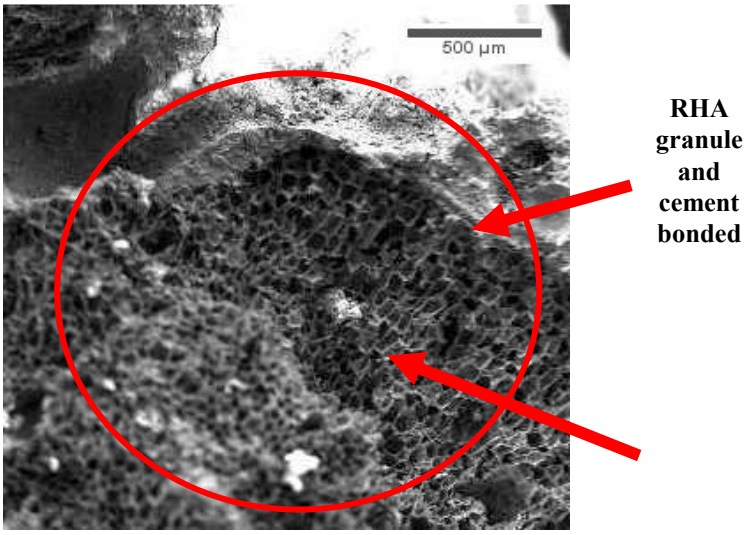


Fig. 1 SEM has detected granules of RHA in matrix foamed concrete which filled the porous.

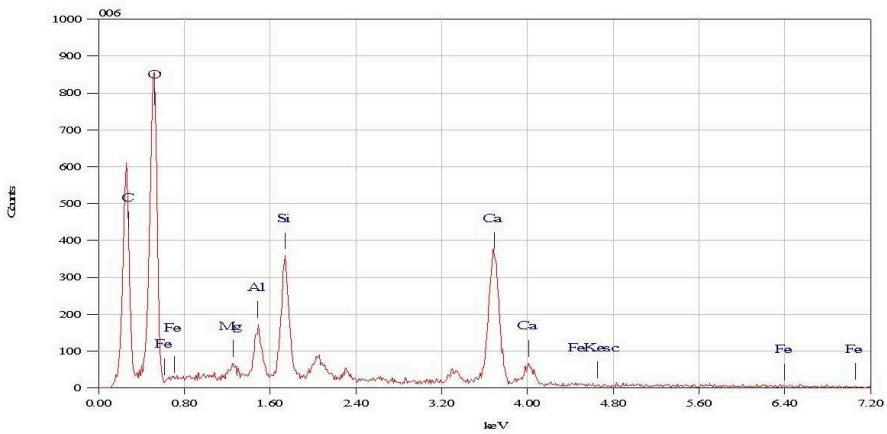


Fig. 2 EDS has detected the circle in figure 1defined as carbon

4.3. Penetration Depth of FC with RHA

After impactor stroke the surface target then the foamed concrete gives the response by the wall of porous in matrix [8]. In the case of foamed concrete without RHA then the response produce bigger strain in material. Afterwards the increasing strain formed the plateau-region in stress-strain curve. It is larger than the compressive plastic stress. This condition goes on until plastic stress increase and the strain decrease rapidly. It is defined with collapsing the wall of porous and the air in the porous release out and the material denser or densification [4, 8].

In the case when the porous was filled by granulate of RHA then the collapse would be delayed due to alter of strain walls of porous [8], which the elasticity of walls porous increased by presence of granule. However the present of granules of RHA in porous give foamed concrete denser than foamed concrete without RHA. It is so increase the strength of foamed concrete beside influence of pozzolanic reaction of RHA into cement paste [1, 18]. So, that why the walls of porous more plastic and less of fragments, Jones and Zhang [19], they reported that reducing of porosity of foamed concrete would be reduced indentation and less fragments when foamed concrete impacted by low velocity. It is agree with the figure 3 that foamed concrete with RHA is more shallow than without RHA. Figure 4 depicts that foamed concrete with RHA after hit by impactor denser (fig. 4-b) than without RHA (fig. 4-a).

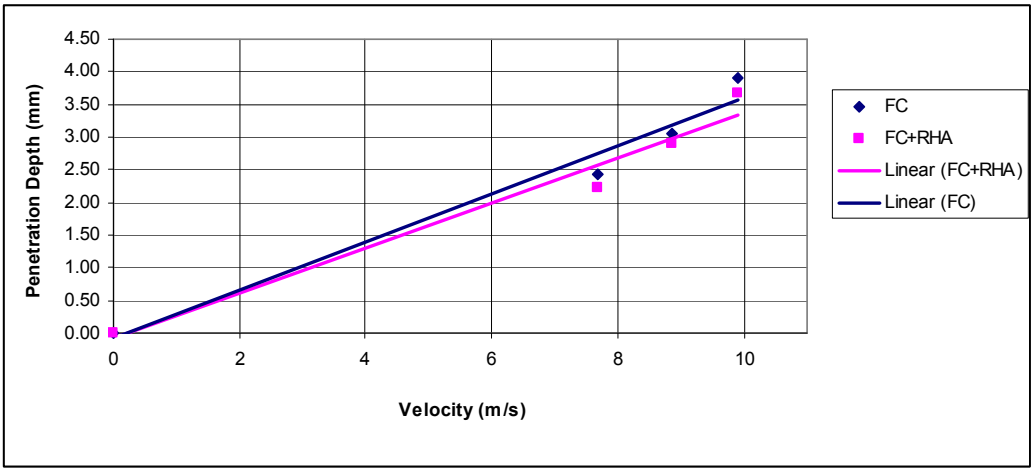
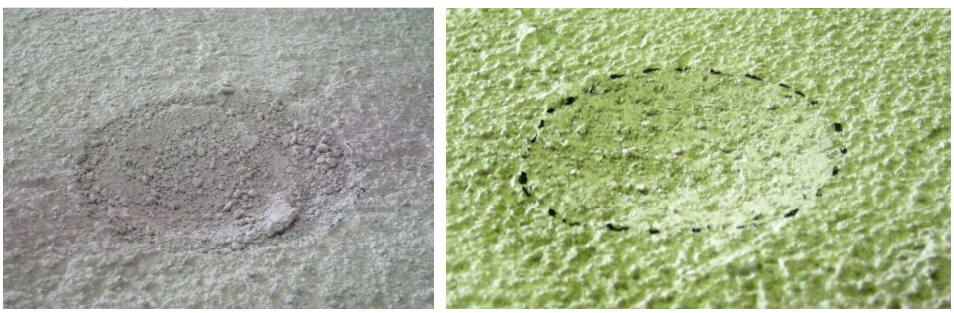


Fig. 3 Penetration depth between FC and FC with RHA



(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

5. Conclusion

Characteristic of foamed concrete as aerated concrete is important, especially as the resistance material on impact loading. However, foamed concrete is required the appropriate strength to prevent the shock compressive wave. The present of RHA as substitution of fine aggregate gives the concrete more light in weight and more strength than foamed concrete without RHA. The test impact results were obtained that the local damage was cratering and was not found spalling also less fragments. The granules of RHA give the foamed concrete denser without losing its characteristic of porous.

References

[1] M. N. AI-Khalaf, H. A. Yousif, The International Journal of Cement Composites and Lightweight Concrete. Vol. 6 (1984), p. 241-248.
[2] A. A. Ramezaniapour, M. Mahdi Khani, G. Ahmadibeni, International Journal of Civil Engineering. Vol. 7 (2009), p. 83-91.
[3] J. Hadipramana, A. A. A. Samad, A. M. A. Zaidi, N. Mohamad, F. V. Riza, Advanced Materials Research. Vol. 626 (2013), p. 769-775.
[4] A. Z. A. Mujahid, Q.M.Li, Structure and Building. Vol. 162 (2009), p. 77-85.
[5] J. H. Pramana, A. A. A. Samad, A. M. A. Zaidi, F. V. Riza, European Journal Scientific Research. Vol. 44 (2010), p. 285-299.
[6] R. P. Kennedy, Nuclear Engineering and Design. Vol. 37 (1976), p. 183-203.
[7] Q. M. Li, S. R. Reid, H. M. Wen, A. R. Telford, International Journal of Impact Engineering. Vol. 32 (2005), p. 224-284.
[8] L. J. Gibson, M. F. Ashby, Cellular Solids Structure and Properties, Cambridge University Press, (1997), in press.
[9] BSEN-197-1, (2000).
[10] BSEN-882, (1992).
[11] BSEN-450-1, (2005).
[12] BS1881, (1983).
[13] G. Hughes, Nuclear Engineering and Design. Vol. 77 (1984), p. 23-35.
[14] J. D. Riera, Nuclear Engineering and Design. Vol. 115 (1989), p. 121-131.
[15] D. J. Frew, M. J. Forrestal, J. D. Cargile, International Journal of Impact Engineering. Vol. 32 (2006), p. 1584-1594.
[16] Q. M. Li, S. R. Reid, A. M. Ahmad-Zaidi, Nuclear Engineering and Design. Vol. 236 (2006), p. 1140-1148.
[17] J. Hadipramana, A. A. A. Samad, A. M. A. Zaidi, N. Mohamad, F. V. Riza, Advanced Materials Research. Vol. 626 (2013), p. 769-775.
[18] M. S. Ismail, A. M. Waliuddin, Construction and Building Materials. Vol. 10 (1996), p. 521-526.
[19] M. R. Jones, L. Zheng, ICE Publishing. Vol. 65 (2012), p. 209 –219.