Failure Mechanism of Foamed Concrete Made with/without Additives and Lightweight Aggregate

Prof. Dr. Ameer A. Hilal

College of Engineering / University of Anbar

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It has been reported that owing to a densification of the internal structure of concrete, adding mineral admixtures leads to a more brittle behaviour. Therefore, with the intention of modifying (increasing the strength of) foamed concrete to make it suitable for structural purposes by means of admixtures and lightweight aggregate addition, the effect of these additions on the failure mechanism under compressive and tensile loading using different techniques is evaluated and discussed in this paper. Eight different mixes, made using a pre-formed foam, were investigated with varying density (different foam volumes), nominally 1300, 1600 and 1900 kg/m3, without/with admixtures (silica fume, fly ash and su perplasticizer) and lightweight aggregate. The Digital Image Correlation (DIC) technique was adopted to measure the deformations and strains on the surface of a specimen under uniaxial compressive load. Meanwhile, a Video Gauge technique was used to measure the horizontal deformation of discs during a splitting tensile test. From elasticity, fracture and fractal points of view, it was found that, for the same density, brittleness increases with many of the additives while it reduces with inclusion of lightweight aggregate. However, for all mixes, the lower the density (higher added foam volume), the higher the ductility.

Materials

To produce conventional foamed concrete (FC), the following constituent materials were used in this study:

- Portland cement, CEM I-52,5 N (3.15 S.G.) con- forming to BS EN 197-1(2011).
- Natural sand (2.65 S.G.) conforming to BS 882 (1992) with additional sieving to remove particles greater than 2.36 mm.
- Fresh, clean and drinkable water.

- Foam (45 kg/m3) was produced by blending the foaming agent, EABASSOC (1.05 S.G.), water and compressed air in predetermined proportions (45 g water to 0.8 ml foaming agent) in a foam generator, STONEFOAM-4.

  The relevant mixtures are termed FC3, FC6 and FC9 being nominally 1300, 1600 and 1900 kg/m3 in density, respectively. Then, to produce modified foamed concrete mixes suitable for structural purposes (FCx3 / FCx6 / FCx9), the following additives (the 'x' being a letter representing the additive type) were used depend- ing on the desired mixes:
- Silica fume: Elkem Micro silica (2.2 S.G., 92% SiO 2, mean particle size 0.15 μm and specific surface 20 m2 /g) [x= 's'].
- Fly Ash: CEMEX fly ash-class S (2.09 S.G.) con- forming to BS EN 405-1 (2005) [x= 'f'] Super plasticizer: MIGHTY 21 EG made by Kao Chemical GmbH of density 1.1 g/cm3, compatible with the EABASSOC foaming agent [x= 'p']. In addition, lightweight aggregate (LYTAG LWA) conforming to BS EN 13055-1 (2002) with a saturated surface dry specific gravity of 1.64 in its coarse (4- 10mm) size was used in two mixes [x= 'y'] to examine its effect on the failure mechanism of foamed concrete.

In this study, eight different foamed concrete mixes, made using a preformed foam, with varying density (different foam volumes), nominally 1300, 1600 and 1900 kg/m3 , without/with admixtures (silica fume, fly ash and superplasticizer) and lightweight aggregate were investigated. Their failure mechanism under compressive and tensile loading using different techniques is evaluated and discussed in this paper. Based on the results and discussion, the following conclusions are made:

From a brittleness point of view:

- Mixes without silica fume, fly ash and superplasti- cizer (FC) are more ductile compared to those with these additives having a similar density.
- Compared to mixes without LWA, for a given density, inclusion of LWA leads to improved ductility of mix with and without the other additives.

From a fracture point of view:

- During a splitting tensile test, the stronger the concrete (increased density or silica fume, fly ash and superplasticizer additives used) the larger the lateral deformation (crack width) before failure.
- The percentage of critical stress increases with increased density (reduced added foam) and for a given density it increases with inclusion of silica fume, fly ash and superplasticizer additives in combination showing a tendency to a more brittle.

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