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Engineering Properties of Alkali Activated Fly Ash Foams

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Abstract: Inorganic foams were prepared from alkali activated fly ash and aluminum powder blowing agent. Curing process was accelerated by thermal treatment at 80 °C for 12 hours. Bulk densities ranged between 420 and 800 kg/m^3, depending on batch proportions. Compressive strength was found in the range 3.7-9.0 MPa, Young's modulus 0.6-1.1 GPa, thermal conductivity 0.14-0.16 W/m/K. Young's modulus was reproduced using 2D numerical simulations and analytical homogenizations.

Introduction

The cement-based autoclaved aerated concrete (AAC) is a lightweight inorganic construction material, in Europe well known since 1920's. A Swedish architect Johann Erikksson patented the AAC in 1923. Fly ash-based foam was first mentioned in Costopoulos' patent in 1987 [1, 2, 3].

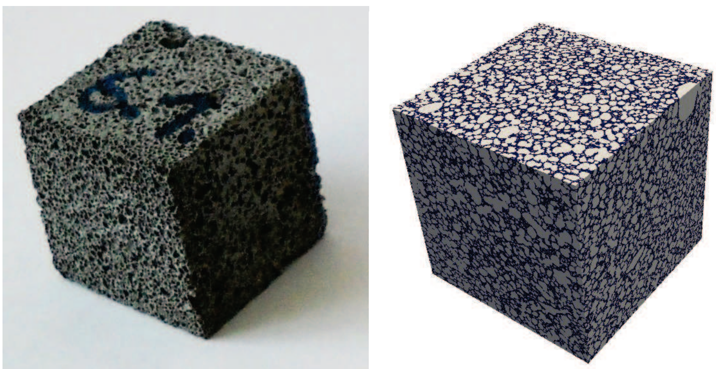

Fig. 1: Left, typical specimen of alkali activated fly ash foam, bulk density 600 kg/m^3, porosity 75%. Right, visualization of CT-scanned foam microstructure.

This work aims at reproduction of measured Young's modulus of alkali-activated fly ash foam (FAF). The FAF is Portland cement-free inorganic foam synthesized at temperatures below 80°C from alkali-activated fly ash and aluminum powder as a blowing agent [4]. Hydrogen liberation during the activation process leads to a closed-pore network. Figure 1 shows a typical FAF specimen.

Results

Finite element simulations on 2D representations and analytical homogenizations aimed at reproducing the FAF elasticity. The intrinsic Young's modulus of alkali-activated paste is of 35.35 GPa and the Poisson's ratio is set at 0.2 [4]. The numerical simulations were done on 2D regular mesh with 500x500 elements with an element size 40 μm. The horizontal edges are loaded by prescribed displacement, while the vertical edges are kept free; averaged vertical stress and strain provide the effective Young's modulus. Mori-Tanaka method and self-consistent scheme [5] were used in the analytical homogenizations.

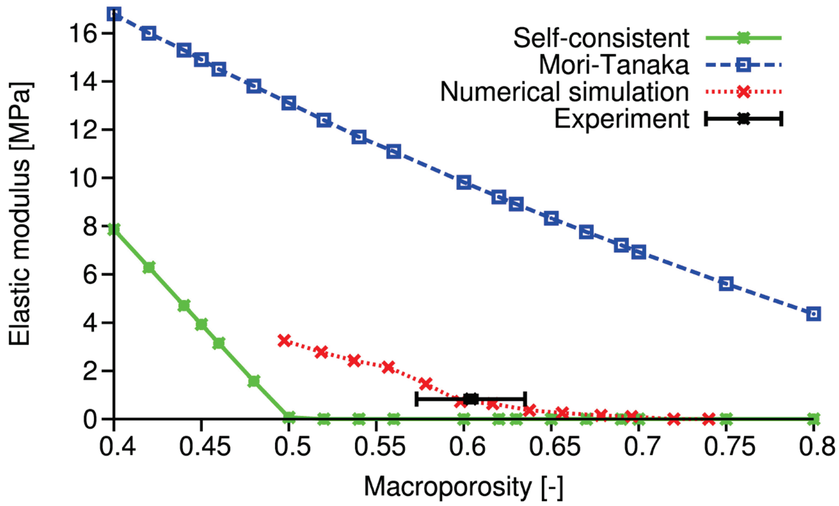

Fig. 2: Comparison of analytical homogenizations of effective Young's modulus of fly ash foam with numerical prediction and measured data.

Additionally, thermal conductivity was reproduced using FFT-based Galerkin method by Jaroslav Vondřejc, CTU in Prague [6].

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