Neutron Imaging of Moisture Transport, Water Absorption Characteristics and Strength Properties for Fly Ash/Slag Blended Geopolymer Mortars: Effect of Drying Temperature

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Geopolymers are considered an alternative binder to Portland cement (PC), for achieving efficient waste recycling and reducing emissions of carbon dioxide. Fly ash -based geopolymer mortar containing 0, 10,20,30,40 and 50% slag were prepared and cured at room temperature. Mechanical strengths were determined at curing times 7 and 28 days. Sorptivity was determined by the gravimetric method at low (45^0C) and high (100^0C) drying temperatures. Water absorption (%) (W_1), water absorption after immersion and boiling % (W_2), the volume of permeable voids % (VBV), and dry bulk density (D) were determined. Neutron radiography was used for the first time to study both the effect of slag addition to fly ash-based geopolymer mortars and the impact of low and high drying temperatures on water absorption processes into the samples investigated. The compressive, flexural and splitting tensile strengths of the geopolymer mortars obtained in this study increased with the slag addition at all curing ages. The mortars showed early age strength development. As the percentage of slag increased, sorptivity decreased. Drying the samples accelerate the water absorption process. The values of sorptivity for the samples dried at 100^0C are higher than those for the samples dried at 45^0C. W_1, W_2, and VBV, decreased and dry bulk density (D) increased as the % slag in the fly ash/slag mortars increased. In addition, as the values of W_1, W_2, and VBV decreased, sorptivity decreased, however, mechanical strengths increased. The neutron radiography results revealed that as the absorption time elapsed, the samples absorbed water with different rates. The water profiles, $\theta(x,t)$ at the highest water content are characterized with steep gradients along the water flow direction. The water absorption processes for the samples dried at 100 ^{0}C are mainly faster than those dried at 45^0C. The waterfront positions and the cumulative water absorption followed approximately $t^{1/2}$ -scaling. As the slag content in the geopolymer mortar samples increased, both the values of the capillary penetration coefficients k and sorptivities S for the samples dried at 100^0C are mainly higher than the corresponding values at 45^0C. The k and S-values followed the same trend as the values of sorptivity, water absorption, water absorption after immersion and boiling, and volume of permeable voids for fly ash/slag mortars. All these parameters decreased and increased as the slag content in the samples investigated and drying temperature increased, respectively. There are good agreements between the values of sorptivities determined by the gravimetric and NR methods for the fly ash-based mortar samples dried at 45^0C. The present results could be used to provide recommendations and simplified procedures for the drying conditions for fly ash/slag based- geopolymer mortars for the measurement of sorptivity. The $\theta-\phi$ profiles collapsed well at the high absorption times. The second Fick's law of diffusion can be used for modeling the results at the high absorption times. Water diffusivities were determined analytically and via differentiation and integration of the smoothed results. As the slag content and drying temperature increased in the mortars, diffusivity decreased and increased, respectively. The diffusivity results showed that as the content of slag in the fly ash based-geopolymer mortars increased, the water absorption behavior changed from D(θ)- dependent on water content to D(θ)- independent for most of the water absorbed, except at the highest water content, D(θ) decreased abruptly. The NR results are new results can be used in durability and service life models and the performance evaluation of geopolymer mortars.