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Evaluation of Entrained Air Void Structure in Fly Ash Concrete Using Foam Index Test and 4D X-ray Micro-CT

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Coal combustion ash (CCA), specifically fly ash, is a supplementary cementitious material (SCM) used in the construction industry to lower the carbon footprint and the cost-efficiency of concrete production. However, the inclusion of CCA introduces challenges to achieving adequate air void (i.e., large pore) structure because of the adsorption of the air entraining admixtures (AEAs) by the excess unburned carbon in CCA and the high fineness (i.e., high specific surface area) of ash particles. In this study, we investigate the relationship between the results of the Foam Index (FI)test and the resulting air void structure in hardened fly ash concrete. The FI test (ASTM C1827-20) is the standard method used to determine the optimal AEA dosage required to attain the target air void content in slurry form. Cylindrical concrete samples were then generated using the results from the FI test and X-ray micro-computed tomography (CT) scanned (Figure 2a) to obtain high-resolution 3D visualizations as a function of the curing time of the internal air void structure in both the transition to and final hardened concrete. Advanced image processing techniques were then employed to calculate the 3D spacing factor among the air voids, a critical parameter for assessing freeze-thaw durability. The analysis offers detailed insights into pore distribution, and the influence of fly ash properties on air void content and concrete performance. By integrating experimental methods like foam index testing with computational analysis using X-ray CT imaging, this research provides a comprehensive approach to optimizing air entrainment in fly ash concrete. The findings contribute to the development of more durable construction materials and offer practical guidance for incorporating supplementary cementitious materials into concrete design.

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References

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