Modified Andreason & Andersen Particle Packing Optimization method to develop low cement high performance concrete with partial cement replacement by fly ash and silica fume

Abstract

With the groom in construction industry with rapid urbanization, need for high-performance concrete is increasing exponentially because of its high mechanical and durability properties. CO_2 emissions related to production of cement is proving to be a big threat for environment because of which sustainability is a big challenge for concrete industry. High-Performance concrete with minimization of cement is must. So, for address this particle packing approach with partial replacement of cement with SCMs is major objective of this work. Mix designs have been developed using Design of Experiment (DOE) for Modified Andreason & Andersen Particle packing model and results were compared to ACI control mixes. Five-factor two level central composite design DOE was with the maximum and minimum Silica Fume and Fly Ash replacements being 15 kg/m^3 & 66 kg/m^3 and 0 kg/m^3 & 83 kg/m^3 respectively. The comparison for strength and durability was done by five tests i.e., Slump, compressive strength, rapid chloride penetration, abrasion resistance and absorption. The concrete mixes were also analyzed for sustainability in terms of cement consumption and CO_2 emissions per MPa of concrete. Testing for the 28-day and 56-day properties the mix with 73% Portland cement, 13% silica fume and 14% fly ash was most efficient one. For the mixes the average reduction in CO_2 emissions per MPa was about 30-40%. In addition to this the concrete developed had good workability with average slump of 189.56mm and very high durability (average RCPT & abrasion resistance value being 898.596 Columb & 0.285%). The conclusion drawn can be used to develop efficient and ecological high-performance concrete. This will contribute to significant reduction of CO_2 emissions.

Key Words: - High-Performance Concrete, CO_2 emissions, Modified Andreason & Andersen Particle Packing Model, Design of Experiment, Sustainability, Supplementary Cementitious Materials