Water transport properties and Life Cycle Assessment of low-grade fly ash based cementitious materials

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Abstract

In this study, fly ash is used as a replacement for cement in mortar to find its impact on durability indicators and the environment regarding greenhouse gas (GHG) emissions. This study focuses on GHG emissions from the construction materials, strength, and capillary transport of water which is a function of the w/cm ratio, pore size distribution, and curing period. The capillary sorption process showed a very complex time-dependent relationship. The sorptivity and absorption of mortar were found at different w/cm ratios and fly ash replacement. Fly ash replacement showed a negative impact on compressive strength as well as on water absorption due to its similar particle size compared to cement. The secondary absorption rate was lower than ~59 % to 88% compared to the initial absorption rate for all the mixtures. 35 % replacement of cement with fly ash resulted in a ~27% reduction of GHG emissions compared to control mortar mixtures.

Keywords: Compressive strength, Sorptivity, Capillary sorption, Greenhouse gas emissions, pore size distribution.

1 Introduction

Moisture transport in porous media plays a crucial role in the premature degradation of the material through the ingress of deleterious materials like chloride penetration. Cement-based materials are being used worldwide to construct dams, highways, buildings, and other infrastructures. In general, people thinks that cement-based materials have excellent durability, but their durability is a function of the properties of their constituent materials and their content in the mixture and the aggressiveness of the external environment. Also, strength is not only required to increase the concrete structure's service life, but durability is also equally important. The durability of any concrete structure largely depends upon its fluid transport properties through its pore structure which also decides its service life for its intended purpose [1]. Permeability and porosity are the two important properties that deal with the durability of any concrete structures. High-permeable concrete is more vulnerable to chloride and carbonation attack, leading to the corrosion of embedded steel bars in the concrete structure and premature deterioration.

Sorptivity is more general phenomenon as compared to permeability of the porous medium because it occurs when unsaturated paste, mortar and concrete are subjected to water or air moisture whereas permeability of the structure is the ability to transport fluids through its interconnected pore. Sorptivity is also known as capillary suction, is the transport of liquids in porous solids due the surface tension acting in capillaries of the mortar or concrete structure. The rate of absorption is dependent on various factors such as surface tension, viscosity, and density of the liquid in contact with the structure. It also depends on the pore structure i.e., tortuosity and continuity of the capillaries in the concrete structure. Sorptivity of the porous concrete structure provide an engineering measure of microstructure and properties important for the durability of the concrete subjected to various detrimental environment conditions. Various research is being conducted to make concrete more durable. Mineral admixtures also affect the absorption

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