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Study of Effect of Nano-Silica on Strength and Durability Characteristics of High Volume Fly Ash Concrete for Pavement Construction

Bimal Kumar [a], Sanjeev Sinha [a*], Hillol Chakravarty [a]

[a] *National Institute of Technology Patna, Mahendru, Patna-800005, Biha, India.*

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Abstract

Increasing demands of cement concrete for construction of rigid pavements motivates for the utilization of other sustainable waste cementitious materials. High volume fly-ash concrete (HVFAC) which is composed of more than 50% fly-ash fulfils the aspiration of large volume of fly-ash which are produced world over. The disadvantage which the HVFAC has is its delayed gain of strength. Contemporary literature identifies nano-silica as the material which when added in small percentages in HVFAC has the potential to improve its strength and durability characteristics at an early age. The objective of the study is to investigate the strength and durability characteristics of HVFAC modified with addition of different percentages of nano-silica so that it can be used for construction of rigid pavements. The methodology of the study involves mix proportioning of HVFAC and introducing nano-silica powder in aqueous medium after mixing it thoroughly at 2500 rpm. Various tests related to strength and durability was carried out after 28, 56 and 90 days age of concrete. The tests related to strength namely flexural strength, compressive strength and split tensile strength tests were carried out. Durability characteristics were evaluated by permeability, sorptivity and rapid chloride penetration tests and were confirmed by density and ultrasonic pulse velocity test. The test results show that the utilization of 2% nano-silica in HVFAC enhances the strength and durability characteristics to a level that are comparable to that of normal concrete after 28 days and thus, can be sustainably utilized for rigid pavement construction.

Keywords: Concrete; High Volume Fly-ash Concrete (HVFAC); Nano-silica; Strength; Durability.

1. Introduction

Concrete is the most widely used man made material in the world and is second only to water as the most utilized substance on the planet [1]. It is produced by mixing water, aggregates along with cementing material and at times admixtures in the required proportions. With the increase of population, economic development and quality of life of people, the consumption of concrete is bound to increase in future. It is estimated that about 25 billion tons of concrete are manufactured all over the world. The principal binding material for cement concrete is cement but its production is an energy intensive process. It is estimated that cement production contributes about 7% of the total carbon dioxide emission, leading to its detrimental effect on environment and human health [2]. China, India and USA are among the three largest cement producing countries [3]. Presently, with its inherent qualities, cement concrete is being used in large quantities for construction of rigid pavements and is generically called as pavement quality concrete (PQC).

Lately, large quantities of fly ash are being produced in coal based thermal power plants where it is arrested mostly in the electrostatic precipitators (ESP). It has been established that the fly ash possesses pozzolanic properties meaning

* Corresponding author: sanjeev@nitp.ac.in

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