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A experimental study of natural admixture effect on conventional concrete and high volume class F flyash blended concrete

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ABSTRACT

The present investigation is focused to introduce broiler hen egg as Natural Admixture (NAD) in concrete and study the effect of NAD on conventional concrete (CC) and class F fly ash (FA) blended concrete. Cement is replaced by FA at various levels (0%–55%) to its weight. Chemical composition of broiler hen egg ingredients was determined by energy dispersive X-ray analysis (EDAX) after lyophilization. Broiler egg was added to concrete at various replacement dosages (0%–0.75%) in water by maintaining the constant liquid to binder ratio at 0.5. The compressive strength and spitting tensile strength of concrete was determined to optimize NAD dosage in FA blended concrete to get the desired strength of M 25 grade of CC. Studies revealed that 0.25% NAD dosage has very much significant effect on compressive strength and splitting tensile strength of all concrete mixes at all curing periods. Based on experimental results a new expression was developed and compared with CEB-FIP and ACI 363R predicted models for STS. The measured MOE was compared with ACI 363R, AASHTO LRFD/ACI318 predicted models. The C-65_FA-35 with 0.25% NAD dosage is concluded as optimum mix. As per cost analysis, C-45_FA-55 with 0.25% NAD was concluded as economical mix and can be recommended to use broiler hen egg as natural admixture.

1. Introduction

In ancient period, the structures were constructed by using materials like lime, clay, mud, surkhi, wood, egg, jaggery, sugar, burnt coconut shells etc. Oral traditional sources tell us egg whites were used as ingredients of mortar, which were used to bind building materials for the ancient constructions. Egg whites were generally used as adhesive which is a compound that adheres or bonds two items. Historically, they were also used to produce paint binder [1]. Among the ancient admixtures, jaggery and egg were widely used. Michelle had a research on existing historical buildings by collecting mortar samples and proved that egg was used in building constructions [1]. After invention of cement by Joseph Aspdin in 1824, cement has been widely used in construction. The major drawback of cement usage is liberation of huge amount of green house gas (CO_2) emissions into environment which causes global warming. Recently, various supplementary cementitious materials such as fly ash, ground granulated blast furnace slag, rice husk ash etc., are being used as partial replacement of

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cement to reduce green house gas emissions. Several investigations are being done on historical constructions and concluded that lime, mud and surkhi were used as binders and starch, jaggery and egg were used as admixtures.

Jaya Sankar et al. used egg shell powder as partial replacement of cement in concrete and designed for M 20, M 25 & M 30 grade of concrete [2]. They concluded that the compressive strength and split tensile strength were decreased with the increasing replacement level of egg shell powder. Dhanalakshmi et al. also concluded that the compressive strength, workability and density of concrete were decreased with the increasing replacement of egg shell powder [3]. Hanifi Binici et al. concluded that replacement of egg shell powder in sand, the compressive strength and flexural strength of cement mortar were decreased. But it has higher resistance to radiation effect [4]. Ferhat and Ilhan concluded that class F fly ash can be replaced up to 55% to cement [5]. Siddique concluded that splitting tensile strength (STS) depends on compressive strength of concrete and age of concrete [6]. Guru Jawahar et al. concluded that the compressive strength of Class F fly ash blended concrete was increased due to pozzolanic reaction of class Fly ash [7].

Ramesh Babu and Neeraja [8] have concluded that the Natural Admixture (NAD) acts as accelerator to enhance the hydration of binder, when it added to binder. They were explained that the fresh properties of binder with and without NAD with standard consistency and initial setting time. At 0.25% NAD dosage the initial setting time of binder is less than that of without NAD and they were concluded that at this dosage the setting takes places very faster. The fresh properties of concrete were explained with workability of Conventional Concrete (CC) and Class C fly ash blended (FA) concrete was explained by slump cone test. They were concluded that, at 0.25% NAD the slump of concrete mixes were very less, because due to high viscosity of NAD the mix becomes homogenous and high bonding nature.

The mechanical properties of CC and FA blended concrete were explained and they were reported that 0.25% of NAD is concluded as optimum dosage [9]. And 25% Class C fly ash can be replaced with addition of 0.25% NAD to get designed strength.

Though various chemical admixtures are available for several purposes in concrete construction industry, the present study is mainly focused, to promote the usage of egg as admixture and determine the effect of egg on mechanical properties of concrete. Keeping in view of the importance of egg in respect to mechanical and durability properties of concrete, the main aim of research work is to use egg as natural admixture (NAD) and study the effect of NAD on compressive strength, Splitting Tensile Strength (STS) and Modulus of Elasticity (MOE) of conventional concrete (CC) and Class F fly ash blended (FA) concrete at different curing periods.

1.1. Lyophilization

Lyophilization or freeze drying is a drying process of solvent or suspended medium in which liquid will crystallize at low temperature. Drying of solvent can be done by air drying process. Chirife and Buera [10] concluded that air drying offers physical changes, chemical reactions and biochemical effects. In physical changes which include increasing or decreasing porosity and decreases bind water and microscopic structure damage. George and Datta, 2002 [11], Dincer 2003 [12] and Liu et al. [13] are concluded that lyophilization is widely used in food preservation, pharmaceuticals, medicine preservation, cosmetics and special chemicals and pigment preservations etc.

Lyophilization mainly consists of two phases; freezing and drying. During the freezing phase the products are freeze, so that the water is turned into ice. In drying phase the intracellular water is sublimated, so this water evaporates, it is caught up and resolidify on cold condenser plates at $-60\,^{\circ}C$ to $-70\,^{\circ}C$. The resultant product will be used for energy dispersive X-ray analysis (EDAX) to determine the chemical composition of NAD.

2. Experimental study

2.1. Experimental program

The main intension of the research work is to study the effect of natural admixture (NAD) on compressive strength, Splitting Tensile Strength (STS) and Modulus of Elasticity (MOE) of Conventional concrete (CC) and Class F fly ash (FA) blended concrete. The cement was replaced with Class F fly ash levels of 0%, 25%, 35%, 45% and 55% by its weight. Broiler hen egg was added to CC and FA mixes by mixing with water at various dosages of 0%, 0.25%, 0.5% and 0.75% to the weight of binder. The Binder (cement + fly ash) and liquid (water + NAD) ratio is kept constant at 0.5.

2.2. Material properties

2.2.1. Cement

Ultratech 53 grade Ordinary Portland cement was used confirming to IS 12269:1987 [14]. The physical and chemical properties of cement are showed in Tables 1 and 2.

2.2.2. Natural admixtures

Broiler hen eggs which were collected from local poultry forms nearby Chittoor, A.P, India used as natural admixture in this research work. White albumen and yellow yolk of broiler egg was thoroughly mixed and added to concrete.