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The durability properties of polypropylene fiber reinforced fly ash concrete

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ABSTRACT

This paper reports of a comprehensive study on the durability properties of concrete containing polypropylene fiber and fly ash. Properties studied include unit weight and workability of fresh concrete, and compressive strength, modulus of elasticity, porosity, water absorption, sorptivity coefficient, drying shrinkage and freeze–thaw resistance of hardened concrete. Fly ash content used in concrete mixture was 0%, 15% and 30% in mass basis, and fiber volume fraction was 0%, 0.05%, 0.10% and 0.20% in volume basis.

The laboratory results showed that inclusion of fly ash improves; however, polypropylene fiber decreases the workability of concrete. Moreover, polypropylene fiber addition, either into Portland cement concrete or fly ash concrete, did not improve the compressive strength and elastic modulus. The positive interactions between polypropylene fibers and fly ash lead to the lowest drying shrinkage of fibrous concrete with fly ash. Freeze–thaw resistance of polypropylene fiber concrete was found to slightly increase when compared to concrete without fibers. Moreover, fly ash increased the freeze–thaw resistance more than the polypropylene fibers did.

1. Introduction

Concrete is a tension-weak building materials, which is often crack ridden connected to plastic and hardened states, drying shrinkage, and the like [1]. When the water, present in concrete, freezes then its volume increases approximately 9%. This expansion results in concrete with a tensile stress and strain; thus, if tensile strength and strain capacity of concrete is exceeded then the concrete disintegrates [2].

It is known that the tensile strength of concrete is relatively much lower than its compressive strength, therefore, crack propagation can be developed more quickly [3]. The tensile strength of concrete is only about 10% of its compressive strength, and concrete cracks when subjected to tensile stresses [4]. Crack control plays a crucial role in the performance life of concrete in construction. This is because the settlement and plastic shrinkage cracks may pass through fresh concrete, thus forming planes of weakness and lowering the integrity of the structure of concrete [5]. Polypropylene fibers mitigate plastic and early drying shrinkage by increasing the tensile property of concrete and bridging the forming cracks [6]. The polypropylene fiber has a low Young's modulus so they cannot prevent the formation and propagation of cracks at high stress level but they can bridge large cracks [7]. Shrinkage especially the drying shrinkage influences the performance of structural concrete which could induce cracking and thus reduces the durability [8].

Polypropylene fiber is introduced in the mix to minimize brittleness of the matrix thereby reducing the susceptibility to cracking of a concrete [9]. It is also reported that polypropylene fiber was effective in resisting the development of cracks caused by drying shrinkage [10,11].

It is known that inclusion of polypropylene fiber in concrete shows excellent durability on exposure to freeze–thaw cycling [12]. Although, it is expected that fibers to be effective in reducing frost damage because of their crack-arresting properties [13], contrary conclusion was also reported by Allan and Kukacka [14] stating that polypropylene fibers did not significantly change the residual compressive strength of air entrained grouts subjected to freeze–thaw cycles.

The environmental protection and cost-effective considerations bring about the era of using the industrial by-products such as fly ash and slag in concrete [15]. There are many advantages of using fly ash in concrete. The addition of fly ash can increase workability [16], increase long-term strength [17] and increase durability and reduce the heat of hydration of concrete [18,19].

An area that has not been much examined previously is the influence of polypropylene fiber on the shrinkage and frost resistance of not only for Portland cement concrete but also fly ash concrete. Therefore, the aim of this research is to study the effects of polypropylene fibers on drying shrinkage and freeze–thaw resistance of concrete made with and without fly ash. This is achieved by measuring the unit weight, workability, and compressive strength, modulus of elasticity, porosity, water absorption, sorptivity coefficient, drying shrinkage and freeze–thaw resistance of con-

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