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Effect of steel fiber on the mechanical properties of oil palm shell lightweight concrete

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This paper reports the results of a study conducted to investigate the effect of low volume content of steel fiber on the slump, density, compressive strength under different curing conditions, splitting tensile strength, flexural strength and modulus of elasticity of a grade 35 oil palm shell (OPS) lightweight concrete mixture. The results indicate that an increase in steel fiber decreased the workability and increased the density. All the mechanical properties except the modulus of elasticity (E) improved significantly. The 28 day compressive strength of steel fiber OPS lightweight concrete in continuously moist curing was in the range of 41–45 MPa. The splitting tensile/compressive and the flexural/compressive strength ratio for plain OPS concrete are comparable with artificial lightweight aggregate. The (E) value measured in this study was about 15.5 GPa on average for all mixes, which is higher than previous studies and is in the range of normal weight concrete. Steel fiber can be used as an alternative material to reduce the sensitivity of OPS concrete in poor curing environments.

1. Introduction

Lightweight concretes (LWCs) have many advantages, thereby making them an attractive topic for researchers to identify new techniques and materials to use it. These advantages include savings of reinforcement, foundation cost, transport cost, saving on formwork and scaffolding, better thermal insulation and sound absorption than ordinary concrete, lower tendency to warp or buckle due to differential temperature gradients, superior anti-condensation properties, better fire resistance, durability, heat isolation and frost resistance [1–3]. However, the disadvantages of this type of concrete include lower mechanical properties, more cement is required than in normal weight concrete for the same strength, greater shrinkage, creep and prestressing loss, need for more shear reinforcement and higher material costs. Such disadvantages justify the efforts to resolve the problems with existing LWC.

The most popular method of LWC production is through the use of lightweight aggregates (LWA) [4], which may be either natural or manufactured. Common natural LWAs include diatomite, pumice, scoria, volcanic cinders and tuff [1]. Another type of natural LWA is an agricultural resource oil palm shell (OPS). In countries where the oil palm industry is important, such as Malaysia, Indonesia and Nigeria, there are large amounts of agricultural residue. Malaysia is one of the world leaders in the production and export of palm oil [5] and it has been estimated that over 4 million tonnes of OPS is produced annually in this country alone [6]. The densities of the OPS are within the range of most typical LWAs [7,8]. However, the mechanical properties of OPS concrete are lower than other types of LWAC [9]. Generally, the mechanical properties of LWAC are lower than ordinary concrete [4]. One way to enhance the mechanical properties of LWC is through the use of steel fiber. For most structural and non-structural purposes, steel fiber is the most commonly used of all the fiber [10]. The addition of steel fibers improves all the mechanical properties of concrete, especially the tensile strength, impact strength and toughness [11]. In addition, it also transforms concrete from a brittle to a more ductile material [3]. Steel fiber concretes have much higher fracture energy than plain concrete [12].

Most research on OPS lightweight concrete has focused on the investigation of its engineering properties as there is inadequate information concerning the enhancement of its low mechanical properties. Furthermore, no studies have been conducted or reported concerning the properties of OPS concrete including steel fibers. Therefore, this study investigates the effect of different low volume contents of steel fiber on the compressive strength under different curing conditions, as well as the splitting tensile strength, flexural strength and the modulus of elasticity.

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