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RESEARCH ARTICLE

Mechanical and Durability Properties of Medium Strength Self-Compacting Concrete with High-Volume Fly Ash and Blended Aggregates

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Abstract

This research investigates the fresh state properties and hardened state properties of medium strength, self-compacting concrete incorporating a high volume of class F fly ash as a partial replacement to cement and blended fine aggregates while maintaining satisfactory properties of SCC. The properties of self-compaction investigated are: slump flow, J-ring, L-box, V-funnel, sieve stability and Visual Stability Index tests. Those of hardened concrete include compressive strength, splitting tensile strength, complete immersion water absorption, apparent volume of permeable voids, sorptivity, and rapid chloride ion penetration tests. The experiments on fresh state properties investigate the filling ability, the passing ability and the segregation resistance of concrete. The results show that fly ash improves workability and decreases the compressive strength as well as splitting tensile strength. Fly ash based SCC shows better resistance to water absorption, apparent volume of permeable voids, sorptivity, and chloride penetration than the control mix.

Keywords

Self-compacting concrete (SCC) · low calcium fly ash · fresh state properties · hardened state properties · blended fine aggregate

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1 Introduction

Self-compacting concrete is a concrete that can be placed and compacted under its own weight without resorting to any compaction process while maintaining its homogeneity. This type of concrete can flow through and fill reinforcement gaps and formwork corners during placement. The elimination of compaction not only improves productivity (reduces the required labour by more than 50% and increases the construction speed) but is also a more sustainable approach [1]. It is used in the precast concrete industry and also in situ application. The main hypothesis for SCC is the reduction of coarse aggregate volume, incorporating a viscosity-enhancing admixture, or by reducing the water-to-cement ratio (w/c). This provides excellent deformability and adequate viscosity of the materials [2].

According to Sambasivan and Soon [3], one of the most obvious causes for delays in the Malaysian construction is low productivity and a shortage of skilled workers. A significant portion of the labour force in the construction industry comes from neighbouring countries and the majority of these labourers are unskilled. With the introduction of medium strength SCC the number of skilled workers required can be substantially reduced.

Under the current situation in the Malaysian construction industry, the application of SCC would be an essential change in the industry. Some of the obvious advantages of using SCC in Malaysia would include the reduced number of skilled workers required, improved concrete performance, a reduction in the overall construction cost and higher productivity. There are also many environmental benefits from the application of SCC. These include reduced noise pollution, greater energy savings and a reduction of dust in the air due to the absence of vibration.

Today, SCC is being researched worldwide, with papers being presented at almost every concrete related conference. However, most of the research done is based on High Strength Concrete. Vilanova et al. [4] developed a database from 138 references belonging to publications between the years 1997 to 2008. There was a total of 627 mix proportions obtained, but median of compressive strengths, for different mix proportions of SCC, is around 50 - 60 MPa. In a number of practical applications the concrete strength is higher than actually necessary. This has cost