DEVELOPMENT OF AXIOMATIC DESIGN-BASED HIGH STRENGTH CONCRETE FRAMEWORK

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ABSTRACT

High strength concrete (HSC) is a highly complex type of concrete that is characterized by a superior level of performance and properties that cannot be achieved using normal ingredients of water, cement and aggregates and conventional design procedures. The concrete industry is generally very competitive and many concrete companies have invested enormously in the development of concrete mix design. In the laboratory, technical personnel would try numerous mix proportions to design concrete with the desired strength and properties. This trial-and-error procedure to obtain the optimal and economical combination of the constituents is time consuming and one of the contributing factors to material wastage and high cost of concrete production. The aim of this research is to present a systematic methodology for designing HSC with the desired strength and suitable workability for practical applications using locally available materials in Malaysia. The design framework was developed based on axiomatic design (AD) theory, which was pioneered by Suh at the Massachusetts Institute of Technology (MIT) in the 1970s as a general design framework to all design activities. Several HSC mixtures were prepared and tested in the laboratory to illustrate how to apply the conceptual AD approach based on the proposed design framework.

CHAPTER 1

INTRODUCTION

1.0 Background of Study

High strength concrete (HSC) has gained popularity in construction projects worldwide because of the advantages provided in terms of cost saving (Naik et al., 2012). A major difference between normal concrete (NC) and HSC is the superior level of performance and properties of the latter, which can be achieved using chemical admixtures such as superplasticizer (SP) and supplementary cementitious materials like silica fume (SF), fly ash (FA) and ground-granular blast-furnace slag (GGBFS). SP is used as a water reducer in order to reduce porosity within hydrated cement paste, thereby enhances durability of HSC (Uzal and Turanli, 2012). On the other hand, SF, FA and GGBFS, which are industrial waste by-products, are added to partially replace cement for economic and environmental benefits (Megat et al., 2011). From various studies (e.g. Gardner et al., 2005; Beshr et al., 2003; Brooks et al., 2000; Ozturan and Cengizhan, 1997), these materials are known to be pozzolanic and with their finer particle sizes than the cement, a denser and stronger microstructure of the hardened cement matrix can be produced.

Therefore, HSC is a highly complex material that is designed to meet the target level of performance, which cannot be achieved using normal ingredients of water, cement and fine and coarse aggregates and conventional design procedures. In general, using compressive strength determined from cube or cylindrical test as the main parameter for quality control, concrete with strength more than 40 MPa (cylindrical test) can be defined as HSC (Mehta and Monteiro, 2006).

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

The use of high strength concrete (HSC) is expected to increase as we move into next century for all over the world. In recent years, there has been a rapid growth of interest in HSC. HSC offers many advantages over normal concrete (NC). NC is the lay term for concrete that is produced by mixing the normal ingredients of concrete of cement, aggregate and water. The proportion of these ingredients in any particular mix depends on the target strength to be achieved. NC can typically withstand a pressure from about 10 N/mm^2 to 40 N/mm^2 (Gibson et al, 1999). Typically, a batch of concrete can be made by using weight and volume.

HSC can be advantageously used in compression members like columns and piles. The higher strength results in reduction of column size and increases available floor space. HSC can also be effectively used in structures such as domes, folded plates, shells and arches where large in-plane compressive stresses exist. The relatively higher compressive strength per unit volume, per unit weight will also reduce the overall dead load on foundation of a structure with HSC. Also, the natural techniques of producing HSC generate a dense microstructure making ingress of deleterious chemicals from the environment into the concrete core difficult, thus enhancing the long-term durability and performance of the structure (Rashid and Mansur, 2009).