THE RELATIONSHIP OF MIX PROPORTIONS AND MECHANICAL PROPERTIES OF HIGH STRENGTH CONCRETE

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To my beloved mother and father

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ABSTRACT

High strength concrete is commonly used in the construction of high rise buildings. However, many engineers are sceptical about using high strength concrete partly due to the lack of understanding of its mechanical properties and mix proportions. This research presents the investigation of the relationship of mechanical properties and mix proportion of high strength concrete. The findings can help local engineers and contractors to equip themselves with sufficient knowledge on the mix proportions and properties of high strength concrete. The data of mix proportions and mechanical properties of high strength concrete were collected from the existing literature and experimental test. The data is presented graphically. The relationships of mechanical properties of high strength concrete with water-cementitious ratio, cement content and fine-coarse aggregate ratio were studied. The analysis indicates that the mechanical properties, which are compressive strength, splitting tensile strength, elastic modulus and modulus of rupture of high strength concrete decrease with an increase of water-cementitious ratio. It is also found that the mechanical properties of high strength concrete increase with an increase in cement content but decrease with an increase in fine-coarse aggregate ratio. For the experimental data, generally it shows the same relationship of mechanical properties and mix proportions with data obtained from available literature. In addition, there are expressions proposed in literature and standards which are suitable for prediction of the values of mechanical properties of high strength concrete.

ABSTRAK

Konkrit kekuatan tinggi yang biasa digunakan dalam pembinaan bangunan tinggi. Walau bagaimanapun, ramai jurutera meragui tentang penggunaan konkrit kekuatan tinggi yang sebahagiannya disebabkan oleh kekurangan pemahaman tentang sifat-sifat mekanikal dan kadar campuran. Kajian ini membentangkan penyiasatan hubungan sifat-sifat mekanikal dan kadar campuran konkrit kekuatan tinggi. Hasil kajian boleh membantu jurutera dan kontraktor tempatan untuk melengkapkan diri mereka dengan pengetahuan yang mencukupi tentang kadar campuran dan sifat-sifat mekanikal konkrit kekuatan tinggi. Data kadar campuran dan sifat-sifat mekanikal konkrit kekuatan tinggi yang dikumpulkan dari literatur yang sedia ada dan uji kaji. Data ini dipersembahkan secara grafik. Hubungan sifat-sifat mekanikal konkrit kekuatan tinggi dengan nisbah air simen, kandungan simen dan nisbah batu baur halus kasar dikaji.Analisis menunjukkan bahawa sifat-sifat mekanikal konkrit kekuatan tinggi, iaitu kekuatan mampatan, kekuatan tegangan, modulus elastik dan modulus keanjalan, menurun dengan peningkatan nisbah air simen. Ia juga mendapati bahawa sifat-sifat mekanikal konkrit kekuatan tinggi meningkat dengan pertambahan kandungan simen tetapi menurun dengan perningkatan nisbah batu baur halus kasar. Bagi data uji kaji, secara amnya ia menunjukkan hubungan yang sama sifat-sifat mekanikal dan kadar campuran dengan data yang dikumpulkan dari literatur yang sedia ada. Di samping itu, terdapat persamaan yang dicadangkan dalam literatur dan standard yang sesuai untuk ramalan nilai-nilai sifat-sifat mekanikal konkrit kekuatan tinggi.

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d	-	Size of specimen
f'_c	-	Compressive strength of 150 mm x 300 mm cylinder
f_{ck}	-	Compressive strength of cylinder
f_{cm}	-	Mean value of concrete cylinder compressive strength
$f_{cu}(d)$	-	Compressive strength of cube
$f_{ct,sp}$	-	Splitting tensile strength
f_{ctm}	-	Mean value of axial tensile strength of concrete
$f_{cy}(d)$	-	Compressive strength of cylinder
f_r	-	Modulus of rupture
f_{sp}	-	Splitting tensile strength
E_c	-	Modulus of elastic
$E_{c,100}$	-	Modulus of elastic of cylinder with diameter of 100 mm
$E_{c,150}$	-	Modulus of elastic of cylinder with diameter of 150 mm

CHAPTER 1

INTRODUCTION

1.1 Background of Study

Concrete is the most common material in the construction industry. It is a strong and economical material. The common compressive strength of concrete used in construction is from 25 N/mm^2 to 35 N/mm^2. The compressive strength of concrete is affected by the mix proportion and the quality of the raw material. In recent years, the utilization of high strength concrete has been increased in the construction industry. The increase of utilization of high strength concrete is due to its good rheological, mechanical and durability properties (Shannag, 2000).

There are many advantages of using high strength concrete in the construction. One of the advantages is the reduction of sizes of beam and. This can reduce the dead load of a building, especially for high rise building. For prestressed concrete construction, longer span can be achieved by using high strength concrete.

The mechanical properties of high strength concrete are affected by the mix proportion. Generally, low water-cementitious ratio is used in producing high strength concrete. Existing publication also agrees that high strength concrete made with low water-cementitious ratio (ACI Committee 363, 1992; Price, 2003; Mazloom et al., 2004). Low water-cementitious can reduce the porosity of concrete. The types and the quality of the aggregate also affected the mechanical properties of high strength concrete. Good quality of aggregate increases the bonding between aggregate and cement. The ratio of coarse and fine aggregate also contributes to the difference of mechanical properties of high strength concrete. It is because the ratio can affect the homogeneity of the concrete.

High cement content is required to produce concrete with high strength. However, thermal cracking may occur in the concrete if the cement content is too high. This is due to the high heat of hydration. The highest strength of high strength concrete cannot be achieved if the cement content used is beyond the optimum cement content (ACI Committee 363, 1992). Therefore, by knowing the optimum mix proportions, high strength concrete can be produced with better mechanical properties.

1.2 Statement of Problem

The properties of high strength concrete are very dependent on the mix proportion of the concrete. Aspects of mix proportioning includes cement content, water-cement ratio, ratio of fine aggregate to coarse aggregate, content of chemical admixture and mineral admixture. Variations in the mix proportion can produce high strength concrete with different mechanical properties. Compare with normal strength concrete, mix proportioning of high strength concrete is more critical.

In recent years, the utilisation of high strength concrete has been increased in the construction industry. Although the utilization of high strength concrete has been increased, there are many engineers from contractors and consultancy firms still lack the knowledge of the mechanical properties and mix proportions of high strength concrete. This knowledge can help the engineers to check on mix proportions provided by the ready mix contractor. By doing so, the engineers can ensure that the concrete mix supplied has meet the requirement. Structural failure may occur if the concrete mixture supplied does not meet the requirement such as compressive strength.

Besides that, there are also doubts on the optimum values of mix proportion. The optimum values include optimum cement content and optimum fine-coarse aggregate ratio. The values of mechanical properties may decrease when the cement content or fine-coarse aggregate ratio are beyond the optimum values. By knowing the optimum values of mix proportion, high strength concrete with better properties can be produced.

1.3 Objectives

The aim of this study is to investigate the relationship of mix proportions and mechanical properties of high strength concrete. The objectives of this study are as follow:

(a) To study the relationship of the mechanical properties of high strength concrete and aspects of mix proportion, such as water-cementitious ratio, cement content and fine-coarse aggregate ratio

(b) To determine the optimum range of mix proportions for different range of compressive strength of high strength concrete

(c) To compare the relationship of mechanical properties and mix proportions for experimental data and data obtained from literature.

(d) To compare the data obtained from literature with the expressions proposed in various literature and standards for prediction of mechanical properties of HSC

1.4 Scopes

In this research, the mechanical properties of high strength concrete that will be studied includes compressive strength, splitting tensile strength, flexural strength and elasticity of modulus. The aspects of mix proportions involved were water-cementitious ratio, cement content and fine-coarse aggregate ratio. The compressive strength of concrete is higher than 40 MPa.

1.5 Research Significance

There are significances in this study. The results, which are the optimum mix proportions, can be used as reference for those who are interested in this field of study. By knowing the optimum mix proportions, such as optimum cement content and fine-coarse aggregate ratio, the researches or manufacturers can produce high strength concrete with better properties. Besides, the findings can help local engineers and contractors to equip themselves with sufficient knowledge on the mix proportions and properties of high strength concrete.

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