BEHAVIOUR OF HIGH STRENGTH REINFORCED CONCRETE BEAM WITH METAKAOLIN UNDER STATIC LOADING

AMER BIN YUSUFF @ MD YUSOFF

UNIVERSITI TEKNOLOGI MALAYSIA

BEHAVIOUR OF HIGH STRENGTH REINFORCED CONCRETE BEAM WITH METAKAOLIN UNDER STATIC LOADING

AMER B YUSUFF @ MD YUSOFF

A project report submitted in partial fulfilment of the
requirements for the award of the degree of
Master of Engineering (Civil-Structure)

Faculty of Civil Engineering
Universiti Teknologi Malaysia

APRIL 2005

To my mother Arison bt Haron and late father Yusuff @ Md Yusoff bin Puteh
for your companionship, understanding and
continuous encouragement over the years.

ACKNOWLEDGEMENT

The name of Allah, the most Gracious, the Dispenser of Grace, Salam to Nabi Muhammad SAW. His companion and friends as well to all the people who follow his path.

I would like to express my highest appreciation to my supervisor Assoc Prof Dr Abd Latif Saleh for his advice and guidance during the course of this project. His invaluable assistance and the constructive criticisms offered have resulted in the completion of this project.

Unforgettable, I would like to thank to Laboratory Technicians and research assistance of Civil Engineering Faculty, UiTM Penang for their kind help in assisting my project.

Last but not least, I would like to express special gratitude to my family, Khalilah Adibah Muhammad, Aiman Haziq, Aina Hazwani and Aimi Batrishiya for their persistent support in my studying at UTM. Also to my colleagues, your helps are really appreciated and will be remembered forever

ABSTRACT

The need of cement replacement material (CRM) in reinforced concrete has gained its popularity among the researchers to produce a high strength concrete (HSC) for structural engineering application. This paper presents the experimental results of the static loading effect on reinforced concrete beam with metakaolin (MK7003). Three different percentages, 5%, 10% and 15% of MK7003 were incorporated as CRM in reinforced concrete beam, and 0% of MK7003 as the control specimen. Eight no of beams, with dimension of 1400mm x 150mm x 125mm, were tested, two for each different percentages and two beams as control specimens. The beams were subjected to four point loading test until failure. The findings of the experiment been shown that the structural performance were improved with the inclusion of MK7003. The observation made suggested that MK7003 with 10% replacement gave the optimum performance of the reinforced concrete.

ABSTRAK

Keperluan bahan ganti simen dalam konkrit bertetulang semakin popular di kalangan penyelidik dalam menghasilkan konkrit berkekuatan tinggi untuk kegunaan kejuruteraan struktur. Laporan ini membentangkan keputusan ujikaji kesan beban statik ke atas rasuk konkrit bertetulang yang dicampur dengan Metakaolin (MK7003). Peratusan MK7003 yang digunakan dalam campuran konkrit bertetulang adalah 5%, 10% dan 15% sebagai bahan ganti kepada simen dan 0% MK7003 dijadikan sampel kawalan. Lapan rasuk bersaiz 1400mm panjang, 150mm dalam dan 125mm lebar telah diuji, setiap peratusan MK7003 mempunyai dua sample rasuk. Rasuk dikenakan ujian empat titik beban sehingga gagal. Hasil ujikaji menunjukkan keupayaan struktur rasuk telah meningkat dengan kehadiran MK 7003. Pemerhatian juga mendapati MK7003 dengan peratusan gantian sebanyak 10% telah memberikan keupayaan yang optimum kepada rasuk konkrit bertetulang.

TABLE OF CONTENTS

LIST OF TABLE

LIST OF FIGURES

LIST OF SYMBOLS

A_s	Cross section area for tension reinforcement
A_{sc}	Cross section area for compression reinforcement
A_c	Cross section area for concrete
b	Width of concrete section
h	Depth of concrete section
z	lever arm distance of concrete section
a_v	Shear span
I	Moment of inertia
E	Modulus of elasticity
V	Shear force
v	Shear stress
f_{cu}	Concrete compressive strength
f_y	Reinforcement tensile strength

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 General

The study of High Strength Concrete has become interesting, with the tendency of concrete building structure to become taller and larger. The importance has been shown by the Malaysian construction industry for the production of high strength concrete. An example of the use of HSC is in construction of the Petronas Twin Towers at the Kuala Kumpur City Centre which high early strength of about 15 N/mm^2 were achieved within 12 hours after casting (Zamin et al, 1995).

The usage of high strength concrete in structure application has been increasing worldwide and has begun to make an impact in Malaysia. A few years ago, a characteristic compressive strength of 40N/mm^2 would have been considered high in Malaysia, but now it was become normal phenomena. Nowadays, concrete with a 28 days curing and has characteristic cube strength of 60N/mm^2 and above will be considered as a high strength concrete. The achievement of such high strength concrete has been possible primarily through the introduction of materials such as Metakaolin.

Metakaolin is the most recent mineral to be commercially introduced to the concrete construction industry. A few report investigated the potential of local kaolin from several areas in Malaysia such Tapah, Perak and Johor. Metakaolin the product of processed heat treatment of natural kaolin is widely reported as a quality and effective pozzolanic material, particularly for the early strength development. In addition to pozzolanic reaction, the action of micro filler has been reported to partly improve strength development of cement-metakaolin mortar (Sabir et al, 2001).

There are several advantages of incorporating metakaolin to produce high strength for high rise building. These include reductions in member thickness resulting in reduced foundation loads, increased rentable areas and smaller structural element, as well as high early strength development of concrete which allows early stripping of formwork, thus speeding up concrete construction.

The HSC fracture behaviour is being studied with great seriousness. High strength concrete is nearer to linear theories of fracture and is relatively more brittle. The challenge is whether one can make high strength concrete relatively more ductile by improving the cohesiveness of cracks.

1.2 Objectives and Scope of Study

The objective of this study is to determine the structural behaviour of high strength concrete beam grade 60 N/mm^2 with replacement of 5%, 10% and 15% MK7003 to weight of ordinary Portland cement due to static load. The water binder ratio is fixed at 0.35 and cured in room temperature. Parameters to be investigated include cracking, deflection, moment resistance and modulus of elasticity due to bending.

Laboratory experiment will be conducted in the Civil Engineering Laboratory, UiTM Pulau Pinang, using 1000 kN Universal Testing Machine. The result will identify the following responses:

i) Mid span deflection
ii) Initial crack occur

iii) Location of crack and type of crack failure
iv) Moment resistance of the beam
v) Modulus of elasticity due to bending.

1.3 Problem Statement

This chapter will discuss the justification and the requirement of the study. The three main aspects such as high strength concrete, cement replacement material ie. MK 7003 and structure behaviour will be explain detail to support the justification in this study.

1.3.1 High Strength Concrete

The tendency of concrete building structures to become taller and simpler has led to the:

i) Increased the member size dimension and heavily loaded columns in high rise building structure.
ii) The need to design flat slabs economically, constrain of the punching effect would lead to undesirably thick slabs.

The necessity of using higher strength concrete to obtain columns of reduced section and floor systems without internal beams, for heavy loaded structure is obvious sometimes without any beam. In the case of columns, the increase of concrete strength often result in more economical sections, while allowing increased usable floor space.

For flat slabs, the main reason to use higher strength is to obtain minimum slab height with sufficient punching shear resistance.

1.3.2 Cement Replacement Material (CRM)

The construction industry has taken considerable strides forward over the last two or three decades with regard to many materials, in particular – High Strength Concrete and generally High Performance Concrete.

The development of new technology in the material sciences is progressing rapidly. Advanced composite construction material and HSC/HPC are gaining wide acceptance in the construction industry of today, and are well positioned for increasing proliferation in use in the future. HSC and HPC will continue to make important contributions to the enhanced quality and efficiency in the construction of infrastructure and our communities in the next century.

The utilization of high strength and high performance concrete has been increasing throughout the world. Amongst the various methods used to improved the strength and performance of concrete, the use of CRM like MK7003 is a relatively new approach.

1.3.3 Structure Behaviour

Visual behaviour is very important in assessing the reason for deterioration of concrete structures. The first stage in an evaluation of concrete structure is to study the condition of the concrete, to note any defect in the concrete. Among of the important are the presence of cracking, the crack propagation and deflection of the structure. Visual assessment determine whether or not to proceed with detailed investigation.

The understanding of fracture mechanism of RC structure is important and under this study its focusing to crack and deflection behaviour for RC beam under static loading.

REFERENCES

Amerogen C.V. (1971). *Reinforced Concrete*; An International Mannual; The Butterworth Group.

Amer Y. (1999). *Behaviour of Reinforced Concrete Beam With Silica Fumes Under Static Loading*; University Technology of Mara : Degree Thesis (unpublished).

British Standard Institution (1990). *Code of Practice For Design and Construction*, London BS 8110.

British Standard Institution (1970). *Method of Testing Concrete.* London BS 1881, Part 5.

Caldarone M.A, Gruber K.A., Burg R.G. (1994). *High Reactivity Metakaolin: A New Generation Mineral Admixture.* Concrete Institute : 37 – 40.

Chong Y. S. et al (1994). *Deflection and Cracking Controlled RC Beam Under Repeated Loading and Fatique*; University Malaya: Master Thesis

Jirawat, S., Jaroenwut P.(2001). *Impact of Low Sulfate Metakaolin on Strength and Chloride Resistance of Cement Mortar and High Strength Concrete.* Department of Civil Engineering Kasetsart University; Elsevier.

Johnson R.P. (1975). *Composite Structure of Steel and Concrete*, Volume 1; Granada Publishing Limited

Kong, F. K., Evans, R. H. (1987). *Reinforced and Prestresses Concrete 3rd edition.* London: Chapman and Hall.

Lydon, F. D. (1982), *Concrete Mix Design*; University of Wales Cardiff.

Megat J. et al (2000). *Effect of admixture on Setting Times of High Strength Concrete*; Cement & Concrete Composite; Elsevier

Naville,A.M.(1987). *Properties of Concrete*; Longman

Regan P.E., Al Hussaini (1993). *Behaviour of High Strength Concrete*; Proceeding of the International Conferences; Scotland, UK

Sabir, B. B., Wild, S. and Bai, J. (2001). *Metakaolin and Calcined Clays as Pozzolans for Concrete: A review*; Cement & Concrete Composite: Elsevier

Sih, G.C. and Ryan, N.E. (1983), *Fracture Mechanic Technology Applied to Material Evaluation and Structure Design*; Martinus Nijhof Publisher.

Wild S., Khatib J.M. and Jones A. (1996), *Relative Strength, Pozzolanic Activity and Cement Hydration in Superplasticised Metakaolin Concrete.* Cement Concrete Res. 26: 1537 – 1544.

Zamin M. J. et al (1995); *Initial Study on Behaviour of High Strength Concrete Beam Under Static and Dynamic Loading*, Fourth International Conference on Concrete Engineering & Technology (CONCET 95).