# MECHANICAL PROPERTIES OF HIGH STRENGTH CONCRETE AT HIGH TEMPERATURE LOADING

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To my beloved wife, children and all family

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# ABSTRACT

The research effort aim characterized the mechanical behavior of high strength concrete at high temperature loading. Mechanical behaviors of two different type of concrete were measured after heated to $200^0$C, $400^0$C, $800^0$C and $1000^0$C. The average compressive strength of these two types of concrete before being too exposed to the high temperature is 30MPa and 60MPa.

The following physical behaviors were measured for each concrete specimen prior to high temperature exposure: physical dimension, mass (initial mass, heated mass and total mass loss) and longitudinal resonance frequency (before and after heating). Before heating specimens until the selected temperature, a baseline data or control data set was generated for each type of concrete after exposure to a nominal room temperature ($25^0$C).

The selected temperatures were accomplished by placing the specimens into a low temperature electrical furnace for temperature below than $300^0$C and used high temperature electrical furnace for temperature greater than $300^0$C. Then the specimens will heat with rate of heating $200^0$C per hour or $5^0$C per minute until reached steady state condition at one of selected temperature. Specimen will heat with a total heating period of 7 hours before cooled to room temperature for 24 hours. The specimens were weighed and resonance frequency was measured again (after heating). The compressive strength of each specimen was measured. Result from this research may be useful for assessing post fire behavior properties of high strength concrete.

# ABSTRAK

Penyelidikan ini adalah bertujuan untuk mengkaji sifat-sifat mekanikal konkrit berkekuatan tinggi apabila dibakar pada suhu yang tinggi. Sifat mekanikal konkrit hanya bertumpu pada suhu $200^0$C, $400^0$C, $800^0$C dan $1000^0$C. Dua jenis konkrit akan digunakan didalam penyelidikan ini iaitu kunkrit grad 30 MPa dan konkrit grad 60 MPa.

Sifat fizikal konkrithanya bertumpu kepada ukuran dimensi fizikal, berat (erat permulaan, berat selepas di baker dan jumlah kehilangan berat) dan perintangan frekunsi resonan (sebelum dan selepas di baker). Sebelum specimen dibakar, data ujuan di perolehi akan digunakan sebagai data kawalan bagi kedua-dua jenis konkrit. Pembakaran specimen akan menggunakan dua jenis oven relau iaitu relau bersuhu rendah (kurang dari $300^0$C) dan relau bersuhu tinggi (lebih dari $300^0$C). specimen akan di baker pada kadar $200^0$C sejam atau $5^0$C seminit. Pembakaran anak dijalankan selama tujuh jam sebelum di biarkan menyejuk pada suhu bilik selama 24 jam. Berat dan frekunsi resonan disukat sekali lagi (sesudah dipanaskan). Setelah itu ujian mampatan dijalankan. Data dan keputusan penyelidikan ini boleh digubakan untuk melihat kesan konkrit berkekuatan tinggi setelah dibakar pada suhu yang tinggi.

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# CHAPTER 1

# INTRODUCTION

## 1.0 Introduction

Fire induced collapsed of the world trade centre (WTC), New York on 9th September 2001was highlighted that the important of performance construction materials at high temperature loading especially for the high rise building.

The high strength concrete (HSC) is a materials often used in high rise building structure design. HSC can be manufactured by most concrete plane using the state of additives such as silica fume and super plasticizer or water reducing admixture. In the high rise building structure, the HSC offer significant economical and achievement advantages over ordinary concrete or normal strength concrete (NSC).

However, results of many recent fire tests have shown that there are much different this of two types of concrete HSC and NSC during the high temperature exposure. These include the different in mechanical behavior properties such as compressive strength retained by HSC and NSC at high temperature. HSC specimen show fail by explosive spalling when subjected to rapid heating.

*"Malhotra (1956), Zoldners (1960), Davis (1967), Abrams (1971), Faiyadh (1989),Khoury (1992) and Noumowe et. Al (1994) has reported the effect of high temperature exposure on the properties of concrete. Several mechanism have identified for the deterioration of concrete due to high temperatures. These include decomposition of the calcium hydroxide into lime and water, expansion of lime on re-hydration, destruction of gel structure, phase transformation in some types of aggregate and development of micro cracks due to thermal incompatibility between cement paste matrix and aggregate phase"*

The type of aggregate also influenced the response of concrete to high temperature. On this research, assumes that all the aggregate and other materials used follow the British Standard, ASTM or equivalent.

At the end of this research, the mechanical behavior of HSC exposure in high temperature will know and it will assist in the development of new standard for used the HSC. These data produced may be being able to assist in the development of new formulation of HSC that are less prone to explosive spalling.

## 1.1 Objective

Generally the main objective of this research is to study the mechanical properties of high strength concrete after heated in high temperature. In detail the objective of this research as a following:

- To find out the mechanical behavior of High Strength Concrete at temperature $200^0$C to $1000^0$C
- Determine the percentage of HSC strength reduction by increasing temperature loading from $200^0$C to $1000^0$C with rating $200^0$C per hour.
- Determine a systematic comparison of result of high temperature test on Normal Strength Concrete (NSC – grade 30 MPa) and High Strength Concrete (HSC – grade 60 MPa) specimen to examine the effect of high temperature exposure to the mechanical properties of concrete with different original compressive strength.

## 1.2 Scope of Research

The mechanical properties of high strength concrete at high temperature influenced by type of aggregate properties, water content, admixture content and etc. in this research, the scope will covered following:

- Concrete design mix for both type of concrete is used BS 8110. The types of concrete to be used, 30MPa & 60Mpa. The entire test involved before heated in high temperature will be conduct and the result of testing will be used as a controlled data.

- Only the ***unstressed residual property test*** will be done which mean the specimens allowed to cool down within 24 hours after heated on the target temperature.

Value of the compressive strength will be recorded and analyzed for the temperature $200^0$C, $400^0$C, $800^0$C and $1000^0$C or until specimens explode which reached first

## 1.3 Research Methodology

The research methodology started from find the problem and then to resolved the problem. All stage to get the result as shown in the following Figure 1.

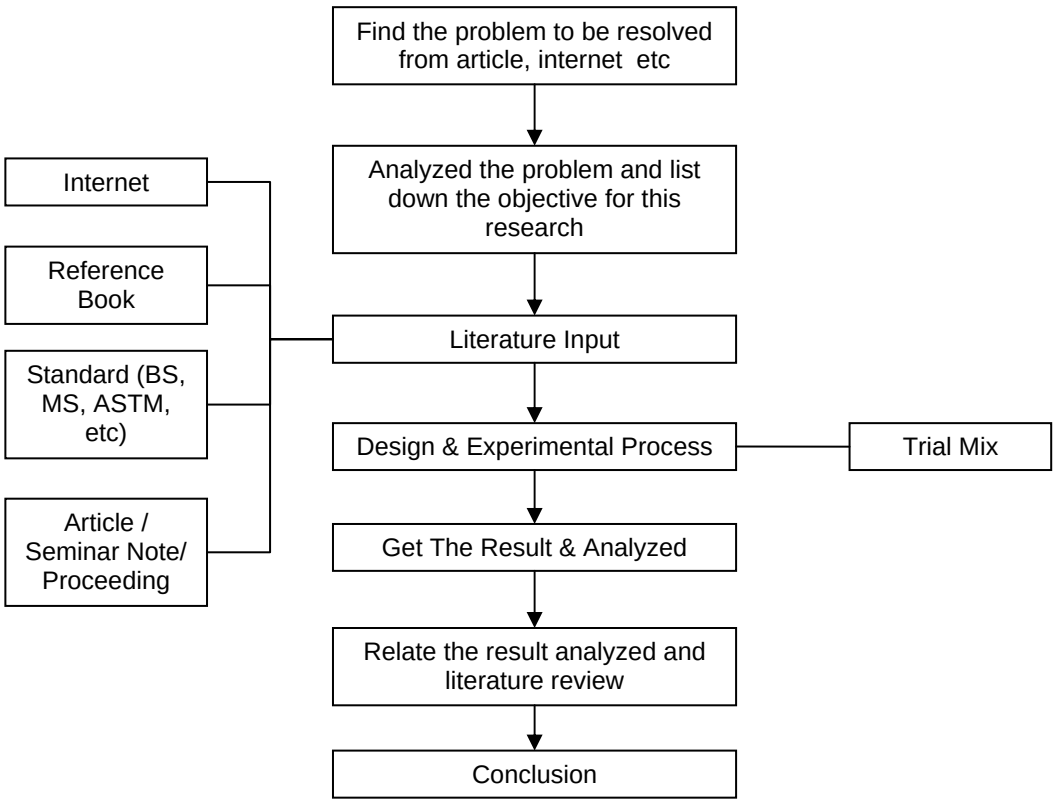


Figure 1: Research Methodology Flow Chart

environment without spalling could also reduced the residual strength of concrete members. Further research is needed to find out the actual maximum temperature of high strength concrete and normal concrete can resist and also the reinforced concrete structural behaviors after exposed to high temperature.

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