ADVANCES IN CONCRETE TECHNOLOGY: A STATE OF ART REPORT ON HIGH PERFORMANCE CONCRETE

YUSUF BIN HAJI MORTADHA

Universiti Malaysia Sarawak
2000

Advances In Concrete Technology:

A State of Art Report on High Performance Concrete

By

Yusuf Bin Mortadha

A literature review report submitted in partial fulfillment of the requirement for the

Degree of Bachelor of Engineering (Hons) Civil Engineering

in Faculty of Engineering Universiti Malaysia Sarawak 94300 Kota Samarahan,

Sarawak

May 2000

Universiti Malaysia Sarawak
Kota Samarahan

fk

BORANG PENYERAHAN TESIS

Judul: ADVANCES IN CONCRETE TECHNOLOGY : A STATE OF ART REPORT ON HIGH PERFORMANCE CONCRETE

SESI PENGAJIAN: 1997 – 2000

Saya YUSUF B. HJ. MORTADHA
(HURUF BESAR)

mengaku membenarkan tesis ini disimpan di Pusat Khidmat Maklumat Akademik, Universiti Malaysia Sarawak dengan syarat-syarat kegunaan seperti berikut:

1. Hakmilik kertas projek adalah di bawah nama penulis melainkan penulisan sebagai projek bersama dan dibiayai oleh UNIMAS, hakmiliknya adalah kepunyaan UNIMAS.
2. Naskhah salinan di dalam bentuk kertas atau mikro hanya boleh dibuat dengan kebenaran bertulis daripada penulis.
3. Pusat Khidmat Maklumat Akademik, UNIMAS dibenarkan membuat salinan untuk pengajian mereka.
4. Kertas projek hanya boleh diterbitkan dengan kebenaran penulis. Bayaran royalti adalah mengikut kadar yang dipersetujui kelak.
5. * Saya membenarkan/tidak membenarkan Perpustakaan membuat salinan kertas projek ini sebagai bahan pertukaran di antara institusi pengajian tinggi.
6. ** Sila tandakan (✓)

☐	SULIT	(Mengandungi maklumat yang berdarjah keselamatan atau kepentingan Malaysia seperti yang termaktub di dalam AKTA RAHSIA RASMI 1972).
☐	TERHAD	(Mengandungi maklumat TERHAD yang telah ditentukan oleh organisasi/ badan di mana penyelidikan dijalankan).
☑	TIDAK TERHAD	

Disahkan oleh

(TANDATANGAN PENULIS)

(TANDATANGAN PENYELIA)

Alamat tetap: P.O.Box 94, Satok Post Office,

93860 Kuching, SARAWAK.

(082 – 258 579)

EN. MOHAMMAD IBRAHIM
SAFAWI B. HJ. MOHAMMAD ZAIN
(Nama Penyelia)

Tarikh: 22 Mei 2000

Tarikh: 23-5-00

CATATAN * **Potong yang tidak berkenaan.**
** **Jika Kertas Projek ini SULIT atau TERHAD, sila lampirkan surat daripada pihak berkuasa/ organisasi berkenaan dengan menyertakan sekali tempoh kertas projek. Ini perlu dikelaskan sebagai SULIT atau TERHAD.**

Pkt/2000

ACKNOWLEDGEMENTS

Many people have been extremely generous with their time and expertise while I have been writing this final year project. In particular, I would like to thank my supervisor, Mr. Mohd Ibrahim Safawi B. Hj. Mohammad Zain for his encouragement, advises and aspiring guidance throughout the duration of this work. He was also of immense help in checking the grammar and relevance of the text. Without him, the work would undoubtedly be poorer. Of course, as author I accept full responsibility for the final content of this project.

I would like to thank Miss Cheam C. L. for her enthusiasm and commitment in supporting and motivating me throughout the writing of this final year project. In the absence of her, it seemed that the project would never reach to the end.

Finally, I would like to thank my friends and family who have supported and encouraged me during the completion of this project. I am extremely grateful to my father for his support and to my mother, without whom the whole project have been impossible. They have my wholehearted thanks.

Yusuf B.Hj. Mortadha, May 2000

CONTENTS

List of Figures

List of Tables

ABSTRACT

This project reviews the concrete properties, which are related to the following works such as concrete problems and advancements. Problems with the use of concrete mainly on quality, workability and economic bring up more advances concrete technology to provide more alternate solutions in the construction industry. The most popular advancement in the past decade would be the High Performance Concrete (HPC). There are too many types of HPC in the engineering industry, High Strength Concrete and Self-Compacting Concrete are just the two examples mentioned here. The approaches that have been done to come up with this special concrete are the achieving of low water-cement ratio (W/C) and the contributions or effects that are brought by four types of admixture. They are air entraining, set-controlling, high-range water reducing and mineral admixtures. This special concrete really has obvious advantages over the conventional concrete, which cover the strength, durability, workability and economic aspect. There are a few disadvantages of HPC but this would not stop the development of the HPC. It would be interesting to know where it is applied. Applications are widely found in bridges and pavements from the United States, Canada, European countries and Japan.

ABSTRAK

Projek ini mengulas tentang sifat-sifat konkrit di mana kerja-kerja seterusnya seperti masalah dan kemajuan konkrit adalah berkait-rapat. Masalah penggunaan konkrit merangkumi kualiti, kebolehkerjaan dan ekonomi telah mewujudkan lebih banyak kemajuan dalam teknologi konkrit untul memberi lebih penyelesaian dalam industri pembinaan. Kemajuan yang paling popular dalam masa sedekad ini adalah "Konkrit Prestasi Tinggi" (KPT). Ada banyak jenis KPT dalam industri kejuruteraan, "Konkrit Kekuatan Tinggi" dan "Konkrit Kompak Sendiri" adalah dua contoh yang diberi di sini. Pendekatan yang telah dibuat dalam menyediakan konkrit istemewa ini adalah pencapaian nisbah air kepada simen yang rendah dan sumbangan ataupun kesan yang dibawa oleh empat jenis *admixture*. Mereka adalah *air entraining, set-controlling, high-range water reducing* dan *mineral admixtures*. Konkrit istimewa ini mempunyai kelebihan yang sungguh jelas daripada konkrit konvensional, yang meliputi aspek kekuatan, ketahan-lamaan, kebolehkerjaan dan ekonomi. Ada beberapa kelemahan juga namun ini tidak membantutkan perkembangan KPT. Dengan kelebihan pada KPT, adalah menarik sekiranya dapat tahu di mana ia digunakan. Pengunaanya boleh dijumpai secara meluas pada jambatan dan jalan berturap dari Amerika Syarikat dan Jepun.

Chapter 1: Introduction

Concrete, steel and wood are the common materials used in the construction industry. These materials can be found in structures like highways, bridges, dams and buildings generally. However, concrete should be the most widely used material due to the massive volume involved in constructions.

The biggest problem faced by the concrete is deterioration. The decreasing of concrete durability can lead to structure failure. Deterioration in concrete generally is caused by abrasion, erosion, freezing and thawing cycle and chemical attacks or reaction such as sulphate attack and alkali-aggregate reaction. Major signs of this problem are cracks, spalling, deflection, corrosion, erosion and stains. To solve this problem, repair services are needed so that the service life of the concrete can be extended. On the other hand, effective protection and maintenance are the keys in preserving the concrete structures, thus lowering the chance of concrete deterioration.

As the use of concrete keep increasing, more and more concrete structures would be found anywhere in the urban regions. This factor may rise the demand of repair or maintenance services. An alternate approach has been adopted. This alternate approach is to develop and implement special concretes that can perform beyond than the ordinary concrete. High Strength Concrete should be the earliest special concrete developed, where strength became the major concern in constructing high-rise buildings for the past few decades. Following on, special new materials that can enhance the properties of concrete were found. Adding these special ingredients

such as fibres or special cements, the performance of concrete achieving is reaching beyond the imagination.

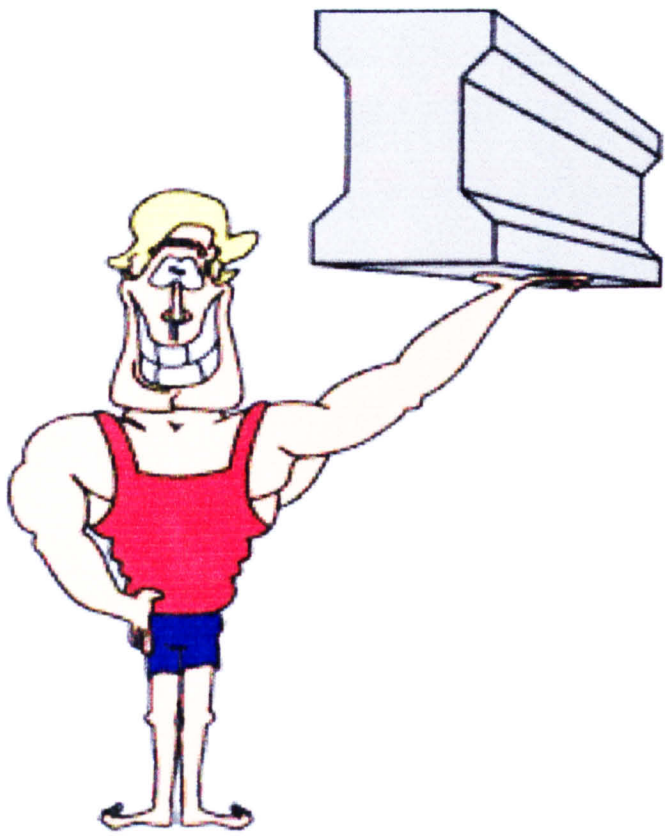
Due to the increasing of special concretes in the construction industry, a term was introduced to represent all special concretes. High Performance Concrete (HPC) was the name given, where it can be defined as any concrete other than ordinary concrete that is produced with new methods and the capabilities of the final product would be better than the conventional one.

In HPC, the most significant difference between itself and ordinary is its water-cement ratio (W/C). In HPC, the W/C can be as low as 0.30 while it is impossible for ordinary concrete. To achieve this, superplasticizer, which is a type of admixture, is used. With the combination with other type admixture such as air-entraining, set-controlling agents and mineral admixture, the results obtained by the end of production will be much better than the use of one type of admixture.

Occasionally, there would be doubts sensed when bringing up the use of HPC issue in construction projects. So proper explanations on the benefits of HPC have to be implemented. The strength and durability advantages should be brought up first. With HPC, higher compressive strength can be achieved while providing better durability to meet challenges in the unfavourable environments. Following on should be the economic consideration advantage. The cost reduction of a project can be achieved by reduction in column size and numbers of beams due to higher strength. With more durable concrete, preservation services can be decreased thus reducing expenses after construction completion period.

There are three objectives in this work or study. First, this work would like to introduce the advances in concrete technology particularly the advancement so-called High Performance Concrete. Secondly, this study hopefully would give readers clearer picture on the concept and production of HPC. Lastly, the author wanted to do literature review of the HPC applications around the globe.

This report contains six chapters. Following this introductory chapter, a discussion on the concrete technology mainly on the properties, problems and advances is presented in Chapter 2. Chapter 3 describes the concept of HPC, followed by the HPC production. Applications of HPC are described in Chapter 5 and finally, conclusions and recommendations by the author would be drawn in Chapter 6.



Chapter 2: Concrete Technology

2.1 Introduction

Concrete in the broadest sense is any product or mass made by the use of a cementing medium. To produce this medium, a reaction between hydraulic cement and water has to be created. Nowadays, this definition can describe a wide range of products. To be specific, concrete is made with several types of cement and also containing pozzolan, fly ash, blasting furnace slag, a 'regulated set' additive, sulphur, admixtures, polymers, fibres and so on; and these concretes can be heated, steam-cured, autoclaved, vacuum-treated, hydraulically pressured, shock-vibrated, extruded and sprayed [1]. In this project, consideration of concrete is taken as not more than a mixture of cement, water, aggregate and admixtures.

In construction, a structure can be fully made of concrete or steel, or even a combination between them. Steel is manufactured under carefully controlled conditions, thus it makes life easier in designing a steel structure where a designer just has to specify the correct steel that should be used with the help of a relevant standard. The case is different when constructing a concrete structure. It is easy to obtain concrete of specified quality from a ready-mix supplier. However, transporting, placing and compacting will create a great impact to the final product. Besides that, unlike steel, concrete can has an infinite choice of mixes. To obtain quality concrete, a great knowledge of concrete technology should be possessed.

2.2 Types of Concrete

There are three types of concrete. The terms ***lightweight***, ***normal*** and ***heavyweight*** are used to describe it. Different terms are used above because of the different amount and distribution of each concrete component. The concrete component that derives the term will be the density of the aggregates. Compressive strength always has been used to differentiate the concrete. Table 2.1 below shows the types of concrete with its compressive strength [2]:

Type	Compressive Strength (MPa)
Lightweight	< 20
Normal	20 – 40
Heavyweight	> 40

Table 2.1 Concrete category with respect to compressive strength

However, the above compressive strength is becoming unpopular nowadays. Compressive strength as high as 80 MPa can be achieved with High Performance Concrete (HPC). In Ajdukiewicz's writing (1999) [3], he reported Very High Performance Concrete (VHPC) with strength resistance of 100 – 150 MPa and so called Ultra-High Performance Concrete (UHPC) with over 150 MPa compressive strength are the fields development most intensively. This shows that strength at 40 MPa is very common and easily achieved.