UNIVERSITI PUTRA MALAYSIA

ASSESMENT OF CONCRETE STRENGTH BY COMBINED NONDESTRUCTIVE METHODS FOR NORMAL AND HIGH PERFORMANCE CONCRETE (UPV AND REBOUND HAMMER.)

BABANDEDE MOHAMMED ASHIRU

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By

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MS STRUCTURE -C

Submitted to the Department of Structural and Construction Engineering in partial fulfillment of the requirement of Master of Engineering

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DEDICATION

This work is dedicated to my family, my beloved wife Salamatu Mohammad and my kids Adnan and Ihsaan Mohammad.

Abstract of Masters Project Report presented to the Department of Civil Engineering of Universiti Putra Malaysia in partial fulfillment of the requirement for the degree of Master of Engineering.

ASSESMENT OF CONCRETE STRENGTH BY COMBINED NON DESTRUCTIVE METHODS FOR NORMAL AND HIGH PERFORMANCE CONCRETE

By

BABANDEDE MOHAMMED ASHIRU

April 2007

Supervisor: Associate Professor Ir Mohd Saleh Jafaar, PhD

Faculty: Engineering.

This Study deals with Non Destructive Testing (NDT) for both Normal and High Performance Concrete (HPC).

An experimental study was carried out, involving both destructive and non destructive methods applied to different concrete mixes, with compressive strength of 30, 40, 50, 60 and 70 MPa. The cubes use were 100mm x 100mm x 100mm. Model were choose from the literature and the strength Prediction Model for the HPC using UPV, Normal Concrete using UPV , generalized strength Prediction Model for Normal and HPC using Sclerometer and lastly combined generalized model were validated by the data obtained from the present study. Data were plotted in order to estimate the percentage of error that was given by the model. The results show Strength prediction model using Sclerometer test is a generalized model. **S**trength prediction model using UPV method could not be generalized and therefore, two different models were used for normal and high performance concrete. **T**he combined NDT model that is combined of Sclerometer and UPV method gave a power model and implied generalized.

PENILAIAN KEKUATAN KONKRIT DENGAN MENGGUNAKAN KAEDAH YANG TIDAK MEROSAKKAN UNTUK NORMAL KONKRIT DAN HPC

Oleh

BABANDEDE MOHAMMED ASHIRU

April 2007

Penyelia: Profesor Madya Ir Mohd Saleh Jafaar, PhD

Fakulti: Kejuruteraan

Kajian ini berkaitan dengan ujian tanpa musnah bagi kedua – dua normal dan konkrit prestasi tinggi (HPC)

Satu kajian eksperimen telah dijalankan , ia melibatkan kedua – dua cara musnah dan tanpa musnah dikenakan pada campuran konkrit berlainan campuran kekuatan dengan mampatan 30,40, 50, 60, dan 70MPa .kiub yang digunakan ádalah 100mm x 100mm x100mm . Model bagi HPC dengan menggunakan UPV,konkrit normal dengan UPV ringkasan ,kuasa jangkaan model bagi normal dan HPC manggunakan sclerometer dan akhiruya gabugan ringkasan model ádalah.validate dengan data diperolehi danpada kajian ini.

Data kemudian diplotken untuk mengira peratus ralat daripoda model.keputasan menunjukkan bahawa madel jangkaan kuasa menggunakan ujian sclerometer ádalah statu model ringkasan. Model jankaan kuasa menggunakan UPV tidak dap of dirinkasakan dan idu dua model berlainan digunakan untuk konkrit normal den prestosi tinggi- model kombinasi iaito cara sclerometer dan UPV memberi model kuasa dan menunjukkan ringkasan.

ACKNOWLEDGMENT

Alhamdulillah! Alhamdulillah!! Alhamdulillah!!! I give glory to Almighty Allah (SWT) for sparing my life to see the successful completion of my programme, it started like it will never finish, but by His special grace it has finally come to an end.

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Finally my special thanks goes to my Father Alhaji Mohammad Babandede and also my Brothers Mohammad Babandede Snr and jnr and their family, and the entire Babandede's Family, to my Mum for her support and prayers.

APPROVAL SHEET

This Project Report attached titled **"ASSESMENT OF CONCRETE STRENGTH BY COMBINED NON DESTRUCTIVE METHODS FOR NORMAL AND HIGH PERFORMANCE CONCRETE**
Submitted by **BABANDEDE MOHAMMED ASHIRU** in partial fulfillment of the requirements for the degree of Master of Science in Structural Engineering and Constructions is hereby accepted.

Approved by,

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Associate Professor, University Putra Malaysia

DECLARATION

I hereby declare that the thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it have not been previously or concurrently submitted for any other degree at UPM or other institutions.

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BABANDEDE M. ASHIRU

Date:

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LIST OF SYMBOLS AND ABBREVIATIONS

ACI	American Concrete Institute
BS	British Standard
C-S-H	Calcium Silicate Hydrates
C3A	Tricalcium Aluminates
COV	Coefficient of variation
D, D’	Depth of reinforcement below the concrete surface
Expo	Exponential
F_C	Compressive strength from correlation relationship
F_{cu}	characteristic strength
F_{mean}	Sample mean strength
FKA	Fakulti Kejuruteraan Awam
HPC	High Performance Concrete
ICRI	International Concrete Repair Institute
JKR	Jabatan Kerja Raya
k -	Tolerance factor
Khz -	Kilohertz
Km -	Kilometer
KN -	KiloNewton
Ln	Lognormal
Log -	Logarithmic

LS -	Least square
MS	Malaysian Standard
mm	millimeter
MPa -	MegaPascal
N/mm2	Newton per millimetres square
NDT -	Nondestructive testing
OPC -	Ordinary Portland Cement
PCHPC	Portland cement High Performance Concrete
Q -	Sum of squared deviation
R -	Rebound number
r -	Correlation coefficient
R^2 -	Coefficient of determination
s' -	Sample standard deviation
SF	Silica Fume
SP	Superplasticizer
sec -	Seconde

UPM - Universiti Putra Malaysia

V - Pulse velocity

W/c - water/cement

ε - Random error

CHAPTER 1

INTRODUCTION

1.1 General

The assessment of concrete strength by NDT is of considerable interest to engineers. Several national and international standards recognize the various NDT methods as suitable.

The non-destructive testing (NDT) of concrete is of great scientific and practical importance. The subject has received growing attention during recent years, especially the need for quality characterization of damaged constructions made of concrete, using NDT methods.

Nondestructive tests (NDT) provide indirect data that can be empirically related to compressive strength by calibration with strength measurements from a number of cast specimens. NDT measurement technique has been used for more than two decades for quality evaluation and assessing concrete compressive strength.

The direct determination of the strength of concrete implies that concrete specimens must be loaded to failure; it becomes abundantly clear that non destructive method of testing concrete cannot be expected to yield absolute value of strength.

The currently available method can be broadly classified into two categories.

The first category consists of those methods which attempt to measure some property of concrete from which an estimate of its strength, its durability, and its elastic property are obtained.

Some such properties of concrete are its hardness, its resistance to penetration or projectiles, rebound values, resonance frequency, and ability to allow ultrasonic pulses to propagate through concrete.

Interest in testing of hardened concrete has increased considerably over these recent years. In the UK this has mainly been due to the number of concrete structures, especially those of relatively recent origin, that have showing signs of deterioration. Similar problems have also emerged in other part of the world. Changes in cement manufacture, the use of cement replacements and admixtures, and decline in standards of workmanship and construction control, have all been held responsible. There is also an increasing awareness of the shortcomings of control or compliance tests that require a 28 days wait before the results are available. Even then, such tests reflect only the adequacy of the material supplied rather than overall construction standards.

In each case the need for concrete strength measurement is clear but to many engineers the features, and especially the limitations, of a variable test methods are unknown and consequently left to “expert” .Whilst it is essential that the test should be performed and interpreted by experienced specialist, many difficulty arise both at the planning and interpretation stage because of lack of common understanding. A great deal of time,

effort and money can be wasted on unsuitable or badly planned testing, leading to inconclusive results which then become the subject of the heated debate.

1.2 Problem Statement

Researches on normal strength concrete using non-destructive test techniques have been established. But these researches are progressing for high performance concrete. Estimation of strength for normal concrete using Sclerometer test and UPV test has been quite discussed and different researchers recommended different correlation models. But correlations for the high performance concrete are yet to be established. Several researchers made attempt to generalize strength prediction models using those NDT techniques. The generalized strength prediction regression model means; a model that can estimate concrete strength for normal as well as for high performance concrete. The reliability of those strength prediction models are yet to be verified in order to ascertain whether they are suitable for their own mix or can be used for other mix as well. Therefore, validations of those regression models are sought.

1.3 Objectives of the Study

The aim of the present study work is to produced a range of concrete mix from normal to high performance concrete in the laboratory and test them in non-destructive and destructive manner. The followings objectives are set forth in the investigations:

i) To validate generalized strength prediction regression model using Sclerometer test.

ii) To validate generalized strength prediction regression model using UPV method.

iii) To validate generalized strength prediction regression model using combined NDT method (Sclerometer and UPV test).

1.4 Scope and Limitations of the Study

The study covers five different mix of normal and high performance concrete (HPC), which are mainly designed to achieve 28days characteristic strength of 30 MPa, 40 MPa, 50 MPa 60 MPa and 70 MPa. The locally sourced coarse aggregates (Sandstone) of 10mm maximum sizes were used in the mix. The 7 and 28 days strength in the normal and HPC mix is investigated using Sclerometer test and UPV method to achieve the stated objectives. The destructive test results were assumed as actual values of the concrete properties. Results were analyzed by rule of statistics, using SPSS ver.14 computer program. It is expected that the results of this study will form the basis of reliability of generalized strength prediction models using those NDT technique for civil engineering applications.

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