Ain Shams University

Faculty of Engineering

NON-DESTRUCTIVE TESTING FOR CONCRETE COMPRESSIVE STRENGTH

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A Thesis

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in Structural Engineering

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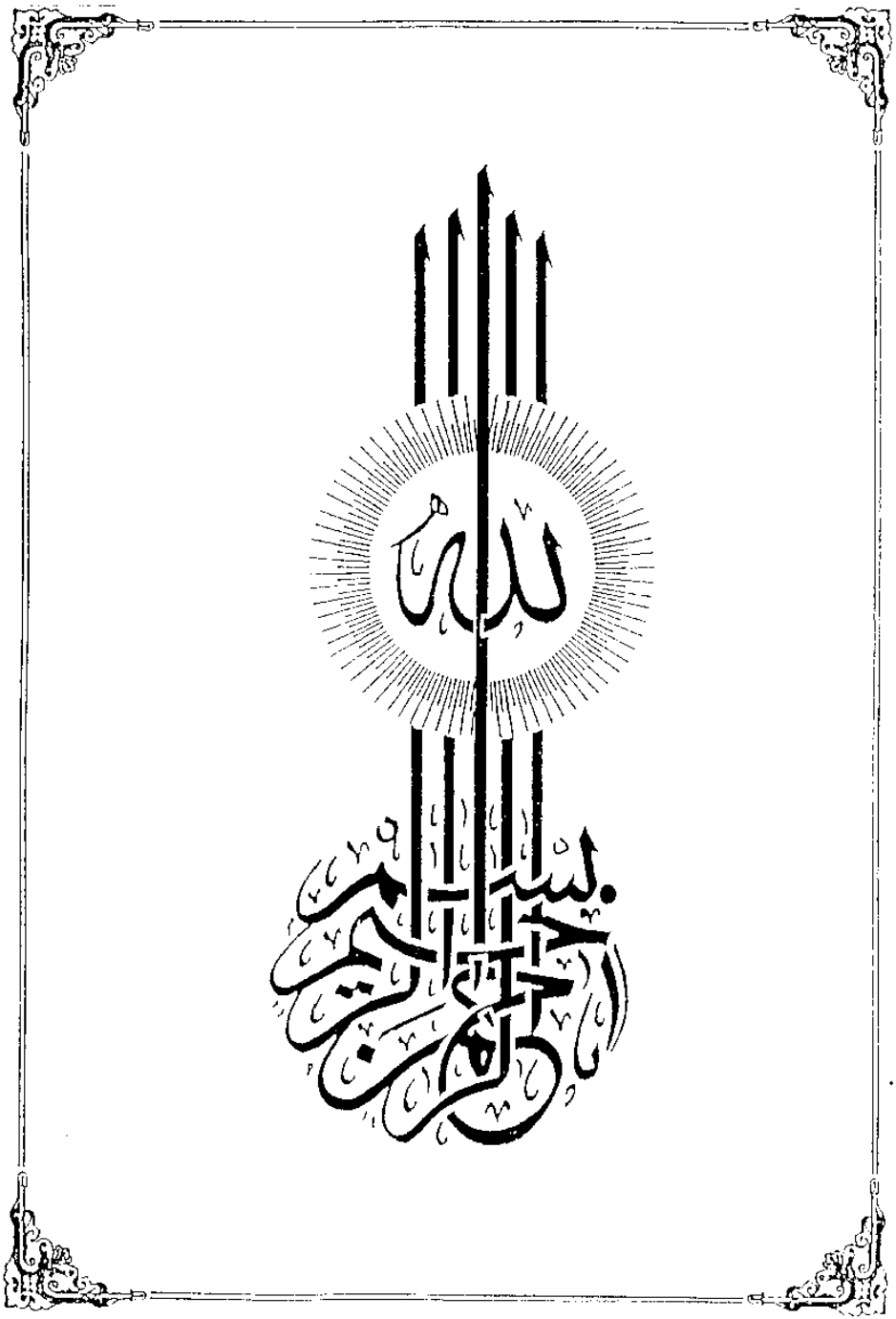

To SOUL OF MY PARENTS

Statement

This dissertation is submitted to Ain Shams University for the degree of MASTER OF SCIENCE in Structural Engineering.

The work included in this thesis was carried out by the author in the department of Structural Engineering, Ain-Shams University, from December 1984 to July 1989.

No part of this thesis has been submitted for a degree or a qualification to any other University or Institution .

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M.SC. Thesis in Civil Engineering
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ABSTRACT

Non-Destructive testing provides a means of estimating compressive strength of plain concrete and reinforced concrete structures during the different stages of construction as quality control tests.

The different methods of Non-Destructive testing universally used in Egypt to determine concrete compressive strength can be given by Schmidit hammer test, ultrasonic pulse velocity test and core test. The degree of accuracy of these tests varies according to the type of test. Besides there are no clear relations between the results of these different tests with each other and with the specified standard cube strength. Therefore the aim of this research is to carry out all over studies in this respect either laboratory or in situ, to clear the previously mentioned problems covering the effect of the following factors on the results of the different test methods: cement content, sand/gravel ratio, fresh concrete slump, nominal maximum size of aggregate, type of cement and presence of steel reinforcement bars.

Besides, measurements of Non-Destructive tests were carried out to check the compressive strength of concrete in situ in the following main projects:

a) Housing of Shubra branch Arab Contractors for employers.
b) El-Menia university hospital.
c) Heliopolis housing near airport Sheraton.

Results of the experimental laboratory and field tests are presented in the form of tables and graphs.

These studies reach interesting conclusions with respect to the relations and proper validity of use of these Non-Destructive tests as reasonable descriptive measures of concrete compressive strength compared to the standard specified cube strength.

Keyword : *Non-Destructive test, Schmidit hammer, ultrasonic pulse velocity, core test, ordinary portland cement, blast furance slag cement, sand/gravel ratio, nominal maximum size, steel reinforcement .*

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CONTENTS

NOTATIONS

- N.D.T. : Non-Destructive Tests.
- O.P.C. : Ordinary Portland Cement.
- B.F.S.C. : Blast Furance Slag Cement.
- W/C : Water -Cement Ratio.
- C.C : Cement Content.
- S/G : Sand-Gravel Ratio.
- N.M.S : Nominal Maximum Size.
- P.V. : Pulse Velocity.
- f_{cu} : Standard Cube Compressive Strength after 28 Days.
- f_{cy} : Standard Cylinder Compressive Strength after 28 Days.
- $f_{(non-destructive)}$: Cube Compressive Strength Estimated by Non-Destructive Tests.
- f_{h} : Compressive Strength Estimated by Rebound Hammer Test.
- $f_{p.v.}$: Compressive Strength Estimated by Ultrasonic Pulse Velocity Test.
- f_{co} : Compressive Strength Estimated by Core Test.
- $f_{h.cy}$: Cylinder Compressive Strength Estimated by Rebound Hammer.
- A_s / A_c : Area Steel/Area Concrete

INTRODUCTION

Non-Destructive testing provides a means of estimating concrete strength of the structure itself in site describing the behaviour of the actual erected concrete, while the laboratory test specimens may not necessarily be representative of the concrete of the structure. Besides different methods used in Non-Destructive testing (e.g. Schmidit hammer test , ultrasonic pulse velocity test and core test) may lead to some discripency between each other in determining concrete strength due to variation in apparatus and method of testing.

Therefore, it seems that concrete strength can not be accurately reproducable and a link between the results of laboratory tests and those of in site Non-Destructive testing required to state the degree of reliability for each of Non-Destructive test result of strength as compared to the equivalent compressive strength stated by standard specifications and codes of practice.

The aim of this research is to express this previously mentioned link by illustrating the values and relations between strengths of different concrete for mixes of variable proportions of ingradients (cement content , fine / coarse

aggregate ratio and water/cement ratio). Such illustrations may be of value nowadays to quality control engineers for concrete constructions in Egypt .

This thesis aimed to carry out experimental investigations in the laboratory and in site to reach accurate results of compressive strength with dependable values for each Non-Destructive test . Therefore the thesis studied the follwoing objects:

1- Study the effect of concrete mix proportions in Non-Destructive test results on (15x15x15 cms) concrete cubes using schmidit hammer method, ultrasonic pulse velocity method and core method, that is for different mixes with cement content (300, 350, 400 kg/m^3), sand/gravel ratio (1 : 1 , 1 : 1.5 , 1 : 2 , 1 : 2.5) and fresh concrete slump (70 , 150 mms) , also study the effect of using blast furance slug cement concretes with the following variations:

sand/gravel ratio (1:1 , 1:2) where slump of fresh concrete (70, 150 mms) and cement content 350 kg/m^3 .

The compressive strength was estimated by each method with standard cube compressive strength. The results were tabulated and plotted and the obtained relations were discussed.

2- Study the effect of nominal maximum size variation of gravel in the previously mentioned non-destructive test results by using different concrete mixes with nominal maximum size of gravel (40 , 30 , 20 , 10 mms) that for different cement content (300, 350, 400 kg/m³) where slump of fresh concrete (70, 150 mms) . The results was tabulated and plotted and the obtained relations for this respect were discussed.

3- Study the effect of persence of steel reinforcement on the results by using reinforcement concrete prisms and tested by the previously mentioned non-destructive tests and the results compared with the result of non-reinforced specimen, also , the quality control for the results was carried out and the obtained results were discussed . That is for concrete mix with cement content 350 kg/m³ , sand/gravel ratio 1 : 2 and slump of fresh concrete 100 mms. The used steel reinforcement were of different diameters 4Ø10, 4Ø13, 4Ø16, 4Ø19 mm it were placed to make a different covers 1,3 and 5 cms.

4- Study the field results of non-destructive test to check the compressive strength of concrete structures in some projects.

The previously mentioned study leads to interesting conclusions with respect to advantages, discripencies and uses of the carried out non-destructive tests of Schmidit hammer test, ultrasonic pulse velocity test and core test. The effects of the presence of reinforced steel in concrete are studied . The recommendation resulted from the laboratory and field studies are illustrated giving advantageous tool for determination of concrete compressive strength with respect to these three mentioned Non-Destructive tests.

CHAPTER I

REVIEW OF LITERATURE

1-1 General

Non-Destructive test is defined by british standard institution (BSI) no. 1881 part 201 : 1983 as follows:

"The test that does not impair the intended performance of the element or member under investigation ".

J.F. Hinsley , in his text "Non-Destructive testing" 1959 , defined the non-destructive testing as follows " The science of examining materials or manufactured articles, in order to determine there fitness of certain purposes without impairment of their desirable properties ".

Non-Destructive testing offers significant advantages speed, economy in cost and lack of damage in comparison with destructive tests. The immediate availability of results may also be an important advantage of this type of testing.

The range of properties that can be assessed using Non-Destructive techniques is large and includes fundamental parameters of the concrete such