STRENGTH AND PERMEATION QUALITY OF CONCRETE THROUGH MERCURY INTRUSION POROSIMETRY

By

RAKESH KUMAR

A thesis submitted
in fulfilment of the requirements
for the degree of

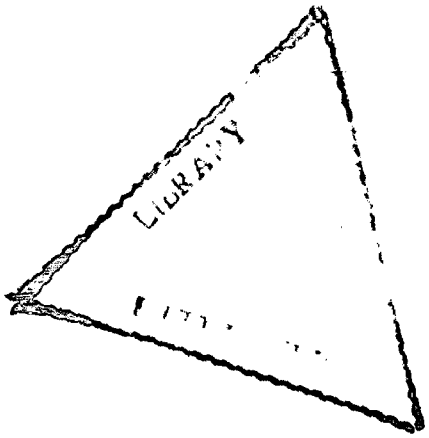
DOCTOR OF PHILOSOPHY

DEPARTMENT OF CIVIL ENGINEERING

INDIAN INSTITUTE OF TECHNOLOGY, DELHI

HAUZ KHAS, NEW DELHI-110016, INDIA

APRIL, 1997



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This is to certify that thesis entitled "**STRENGTH AND PERMEATION QUALITY OF CONCRETE THROUGH MERCURY INTRUSION POROSIMETRY**" being submitted by **Mr. RAKESH KUMAR** to the Indian Institute of Technology, New Delhi, India for award of the "**DOCTOR OF PHILOSOPHY** in Civil Engineering", is a record of bonafide research work carried out by him under my guidance and supervision.

To the best of my knowledge the thesis has reached the requisite standard. The material presented in this thesis has not been submitted in part or full to any other university or institution for award of degree or diploma.

(Dr. B. BHATTACHARJEE)
Assistant Professor
Civil Engineering Department
Indian Institute of Technology, Delhi
Hauz khas, New Delhi-110016,
INDIA

ACKNOWLEDGEMENTS

The author truly admire with all his hearts Dr. B. Bhattacharjee, Assistant Professor, Civil Engineering department, Indian Institute of Technology, Delhi, New Delhi, India, for his perspective supervision, invaluable guidance and constant encouragement throughout the period of the doctoral programme.

The author wishes to extend a special word of thanks to Sri Ch. Badle Ram, of Building Science and Materials Laboratory for his unflagging support. Sri K.K. Bali of Workshop and other staff members of Concrete Structure Laboratory deserve special thanks for their active help in the laboratory.

Special regards are due to Dr. S.Krishnamoorthy, Professor (Retired), Civil Engineering Department, Indian Institute of Technology, Delhi, for his valuable suggestions and encouragement during this study.

I am thankful to my colleagues and friends specially to the team of Mr. Sandeep Kumar, Dr. Rafeeq Ahmad, Mr. M. Nagesh, Mr. L.V.Subramaniam, Mr. Umesh Maheswari, Mr. Vijay Arora, Mr. Cherian, Dr.S. Ahmad, Mr. Avnati and Mr. Abhijit, for the wonderful time spent together. Without them, I would not have enjoyed my stay at IIT Delhi.

Associate Professor H.R. Patel, Professor V.K.Tripathy, Departmetnt of Physics and Sanjay Kumar Lucky deserve especial heart felt thanks for their consistent encouragement and sharing of different views on various issues. The encouragement from my family members undoubtedly urged me to aspire for greater things in life and no words can express my gratitude to each one of them for all that they have done for me.

Last but not least, I would like to record a word of thanks to Mr. D.K.Gore (Computer Science M.Tech. student) who helped in developing the software required for this work and all the rest of good people not mentioned above.

(RAKESH KUMAR)

ABSTRACT

The most valued properties such as compressive strength and durability etc., of hardened concrete are directly related to its porosity and pore structure. Therefore, it is possible to assess the strength and durability quality of concrete indirectly, from the knowledge of its porosity and pore size distribution when suitable models relating the relevant properties are available. A number of methods are available for the study of porosity and pore structure of cement based composites, among them mercury intrusion porosimetry (MIP) is one of the most suitable methods. Therefore, in this work mercury intrusion porosimetry (MIP) is adopted to acquire relevant information about porosity and pore structure characteristics of concrete. Mercury intrusion porosimetry results may be affected by rate of pressure application during test, type and form of sample including its preparation. Hence, before adopting this method for the present work, the effects of above mentioned factors on porosity and pore size distribution of concrete were analyzed. Analysis of results demonstrated that effect of rate of pressure application on porosity and pore size distribution of concrete is insignificant. From the analysis of results it was also found that mortar adhered with coarse aggregate extracted from concrete is more porous than mortar devoid of aggregate extracted from the same concrete. Further, from the study of porosity and pore size distribution of concrete, small cored samples extracted from concrete beam were found to be more suitable than sample obtained by crushing bigger cores meant for compression testing.

A number of relationships are available between strength and pore structure characteristics (porosity and representative pore sizes etc.) and also between durability quality and pore size characteristics of cement based composites. In the case of concrete, it is generally assumed that its strength and durability quality are governed mainly by the properties of either cement paste or cement mortar. But, it has been found that the porosity and pore structure characteristics concrete are different from that of cement paste and mortar. This behaviour results mainly due to presence of transition zone in mortar and concrete. In past, strength porosity relationships had been used for estimating strength of concrete, but the information about porosity and pore size distribution of

concrete were obtained through testing of either cement paste or mortar extracted from concrete.

In this work data on porosity and pore structure characteristics were generated by performing porosimetry tests on concrete sample extracted from concrete beams. In order to generate sufficient data, beams were cast from six deigned mix proportions by using two types of coarse aggregates. The in-situ strength of concrete in beams were determined through compression testing of 75 mm diameter drilled cores. For introducing maximum extent of variation in porosity and pore structure characteristics of concrete, different modes of compaction, different level of curing, different exposure environment were adopted as factors in experimental design. The relevant data on porosity and pore structure characteristics obtained by testing a variety of concrete cast in this work, were used for evaluating the applicability of most frequently used relationships between the strength and pore structure characteristics of concrete. The analysis of results revealed that most of these relationships do not yield very encouraging result. Therefore, an attempt is made to develop a model by modifying the existing models. Finally, a strength porosity model for in-situ strength of structural concrete is developed and presented whose accuracy is further checked by using the data from an actual structure and the result was found to be satisfactory. This model is based on sound theoretical concept of Griffith's theory and takes into account the porosity and the pore size distribution, cement fraction used in mix, environmental factors causing deterioration etc. The accuracy of the model in assessing strength of concrete is compared with that available from other non destructive test (NDTs) methods used for assessing the strength of concrete indirectly, such as Rebound hammer and Ultrasonic pulse velocity tests. The applicability and accuracy of the suggested model are compared with those of Rebound hammer and Ultrasonic pulse velocity tests by using appropriate statistical yardsticks. On the basis of above statistical analysis it is confirmed that the prediction of strength by using the suggested methodology based on MIP results is as good as that can be done by Rebound hammer or Ultrasonic pulse velocity test. Thus an additional methodology for assessing the strength of concrete from its porosity and pore structure characteristics is suggested.

Most of the durability problems in concrete arise mainly due to the permeation of water through it. Further, all most all transport phenomena through concrete is governed by the characteristics of its pore structure, therefore, it is possible to correlate the durability quality of concrete with its porosity and pore structure characteristics. For the study of this aspect, Initial surface absorption rates of water by concrete beams were determined. The rates of water absorption are then related to some specific characteristics of pore structure such as mean distribution radius of pores, equivalent pore radius etc., in addition to its porosity. From this comprehensive study, a model correlating the in-situ strength of concrete and initial surface absorption rate of water is suggested. Further, the above study of initial surface absorption rates of water and characteristics of pore system of concrete yielded models relating them. Further, it is demonstrated that by using any one of these models and porosimetry test results one can classify the concrete as low, high or average absorption quality, similar to any other durability test of concrete. Therefore a methodology is suggested whereby specific characteristics of pore system obtained from porosimetry test are used for the prediction of durability quality of concrete. The applicability and accuracy of this test methods are also confirmed by using relevant statistical approaches.

Therefore, this work suggest a methodology by which the in-situ strength as well as durability quality of concrete in structure can be assessed by using the results of porosimetry performed on them. The major advantage of this methodology is that the same porosimetry results can be used for assessing both in-situ strength and durability quality of concrete.

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