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In-Situ Testing of Concrete Structures – A Review

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Abstract - *Several in-situ and laboratory methods such as compression testing machine, rebound hammer, ultrasonic pulse velocity method and other NDT methods are available for determining the strength and other properties of concrete. Methods like rebound hammer and ultrasonic pulse velocity, are comparatively simple to perform and observe the readings. However, the interpretation of test data is not easy because outcomes are considerably influenced by surrounding environment to which structure is exposed. This paper presents review of several in-situ testing methods.*

1. INTRODUCTION

There is a range of non destructive or in-situ techniques available for determining the quality and the strength of concrete. The ultrasonic pulse velocity and rebound techniques are the commonly used methods. The major or chief benefit is the simplicity and high speedy results obtained from these tests. These methods are useful for determining the homogeneity of the material and interrelation of all the properties of the structure.

These tests are useful in determining the differences in concrete quality from one part of a structure to another. Developed in Germany in 1930, the rebound hammer test (RHT), based on ASTM C805 and BS 4408 Part 4, can be utilized for testing concrete surface hardness. In 1948, Schmidt developed the Schmidt rebound hammer test. This device is universally used because of a hardened steel hammer impacted on the concrete by a spring. The RHT is a convenient NDT. The surface of hardened concrete is struck with the hammer, and concrete compressive strength is estimated via the surface hardness rebound value.

Non-destructive tests such as ultrasonic pulse velocity (UPV) and rebound hammer are widely used to assess the concrete properties in structures. Although the application of such techniques is simple and easy, the interpretation of the test results is very difficult due to a number of factors affecting the test results.

2. LITERATURE REVIEW

Requirement has been understood to assess in-situ strength and material integrity and other performance influencing parameters. Generally compressive strength has been measured for assessing the performance. Several national and international codes of practices are now describing the use of these equipments.

The UPV equipment determines the travel velocity of waves through concrete and this velocity has been related to the condition of material under observations UPV test over concrete has been conducted by several researchers –

Amini et al. (2016) developed models for predicting the compressive strength of concrete, without considering the past maintenance record of building. Several destructive and non-destructive tests had been conducted by **Pucinotti (2015)** on a significant historic building in Reggio Calabria.

An experimental study has been conducted by **Malek and Kaouther (2014)** for assessing the compressive strength of concrete through destructive and non-destructive testing at 7, 14 and 28 days.

The compressive strength of several concrete mixes produced using lightweight aggregate has been evaluated using the non-destructive ultrasonic pulse velocity method by **Bogas et al. (2013).** In an experimental study performed by **Jain et al. (2013)** evaluated the effects of concrete ingredients, proportion of concrete mix, and variables related to workmanship on the Rebound Number and Ultrasonic Pulse Velocity of concrete.

Hajjeh (2012) performed several destructive and non-destructive tests several laboratory casted concrete cubes.

Hannachi & Guetteche (2012) used rebound hammer and ultrasonic pulse velocity methods to determine the concrete quality through regression analysis models between compressive strength of in situ concrete on existing structure and the nondestructive tests values.

According to **Lawson et al. (2011)** ultrasonic pulse velocity is the most accepted non-destructive techniques conducted worldwide to assess the concrete properties.

This Ultrasonic pulse velocity technique has been implemented by several researchers previously; few studies **(Tanigawa et al., 1984; Kheder 1999.; Popovics et al., 1990; Turgut, 2004)** concluded a good association among the values of ultrasonic pulse velocity and the compressive

strength of concrete material. **Qasrawi (2000**) used UPV method to detect the internal defects and change in properties of system when compared to each other.

B.S. 1881: Part 202 along with Indian code Is 13311(Part 2) : 1992 conform the use and application of rebound hammer. These methods are known for more than five decades in different formats **(Bungey and Millard, 1996). Carette and Malhotra in 1984** concluded that rebound hammer test is not an acceptable technique for determining the development of all the strengths. There was a large number of disagreements among scholars regarding the accuracy of the results provided by rebound hammer test **(Malhotra and Carino**, **2004).**

Concrete is having very assorted internal core distribution. This may be due to the nature of its constituents and their dimensions and geometry.

Non Destructive Testing and evaluation of this material have motivated a lot of research work and several relations have been proposed **(Corneloup and Garnier, 1995)**. According to **Turgut (2004)** in-situ testing techniques are showing and getting popularity among the researchers in last few decades.

Malhotra (1976) presented a inclusive literature study of these nondestructive methods useful for concrete testing and valuation. **Leshchinsky (1991)** summarized the benefits of in-situ test as –

(a) Reduction in the labor consumption
(b) Smaller amount of structural damage
(c) Testing of concrete strength in structures
(d) Comparatively less expensive testing

As per **Neville (1995), Bungey and Soutsos (2001)** conventional method of concrete testing is acceptable but it does not provide actual structural strength.

The interpretation of the test results of UPV is very difficult and the results are altered by several factors such as surrounding conditions **(Ohdaira and Masuzawa 2000, Davis 1977).**

Popovics (1990) discussed that the ultrasonic method is one of maximum used and reliable method among the in-situ testing methods for determining the characteristics of concrete.

Proverbio and Venturi (2005) studied about the accuracy of in-situ techniques such as rebound hammer and UPV test for determining the strength of concrete.
Pascale et al. (2003) approved out an investigational plan considering both laboratory and in-situ testing.

NDT methods have been used by **Almir and Protasio (2000)** to establish the compressive strength of concrete, and relation among the measured properties and the strength.

Several NDT methods such as visual inspection, hammer sounding, Schmidt hammer, UPV testing including tomography imaging have been used by **Rens and Kim** (**2007**).

Dias and Jayanandana applied several in-situ testing such as visual inspection, scrutiny of drawings, measuring the ultrasonic pulse velocity and other important parameters.

Davis et al. (1997) proposed the use of various in-situ testing such as UPV, and determining the impulse response to evaluate the condition and strength of concrete.

Rens and Greimann (1997) presented the concept and application of using ultrasonic continuous spread-spectrum signal for monitoring and identification of deteriorating infrastructure.

3. DISCUSSION & CONCLUSIONS

From the above review it has been revealed that most of the researchers selected rebound hammer and ultrasonic pulse velocity tests for determining the strength and condition of the concrete structures. Several researchers determined the relation among the destructive and non destructive compressive strengths of concrete for calibrating the in-situ results of rebound hammer.

The reason of making standard procedures for nondestructive testing (NDT) of concrete structures is to meet the criteria and enumerate the material properties of in-situ concrete without interfering examining the material properties. There are several methods that are presently being research for the NDT of materials today.

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