A Review: Non-destructive Testing Methods

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Abstract— Civil engineering constructions are combination of several members resisting the imposed load which can transfer the load safely to the earth through foundations. The major property which defines the quality of concrete is the strength of composing material. Deterioration of RC structures made an alarming situation for researchers and scholars for focusing on the durability affecting parameters along with crushing strength, various uncontrollable parameters like environmental or exposure conditions are equally important for the service life of structures. Rusting of reinforcement in reinforced concrete diminishes the service life and exacerbates concrete structures causing early stage failure of structures. Therefore, assessing present condition of reinforced concrete structures is essential for planning, repairs and replacement of structures.

Key words: Compressive Strength, Durability, Service Life, Non Destructive Testing

I. INTRODUCTION

Our thirst for development as humans is replicated by our continuous research activities in diverse areas leading to countless useful emerging applications and technologies.

Nondestructive testing in present scenario has gained a great significance in practical and engineering values. In last few years, this subject has received growing attention, particularly the quality depiction of damaged concrete structures using Nondestructive testing (NDT).

There are numerous advantages of Non Destructive testing such as less requirement of labour, negligible effect structure health due to testing, no need of drilling cores and less expensive testing equipment required as compared to Destructive testing. All these advantages are valuable only if the results are reliable, representative and as near as possible to the actual strength of the tested element of the structure.

II. IN-SITU TESTING METHODS

RC structures designed to operate for long periods of time, such as 50 to 100 years. However, several unpredictable and uncontrollable factors reduce their expected performance and life cycle. Lack of performance of these systems may significantly impact a nation's economy. Hence, regular in-situ inspection of structures is required for assessing its properties. Several methods are developed and reviewed by researchers to determine the in-situ compressive strength of concrete. Few popular methods are listed in table 1.

In-situ method	Workability	Principle
Schmidt's hammer	Rapid but not so reliable.	bounce back of needle presents strength
Method based on UPV	Portable, easy, moderate cost and provides uneven results in the presence of humidity.	Transfer speed of wave in any medium represents the quality
Pulling of ring	Can destruct the surface but, provide very quick results.	Force is measured to pull the and used to determine the strength
Catch and pull out	Significant damage to the surface but reliable, need skills	Ring is stretched and compared to strength

Table 1: NDT Methods for Determining Compressive Strength (Verma et al. 2013)

However, the term in-situ test is specified to any investigation which does not harm the structural integrity. They, also leave the structure after testing in a condition which has been useful for the buyer.

III. LITERATURE REVIEW

Several researchers used different NDT equipments in order to assess the condition of RC structures.

Villain et al. (2018) addresses the utilization of non-destructive testing methods to evaluate indicators for both the concrete durability and mechanical properties of RC structures. NDT results are achieved by means of ultrasonic or electromagnetic techniques and then showed a relationship with these durability and mechanical indicators. The obtained conversion model are utilized to transform observables into indicators, depends on the authentic concrete design mix. If this conversion model is not available for the RC structure under study, then the assessment may be not enough due to high indecision on the results. This paper suggests a calibration method to develop a conversion model suitable for the structure by use of a least number of cores in order to perk up the on-site assessment. Results found by analyzing more than 1600 data fully validate the tested calibration method.

According to Neves et al. (2018), by measuring cover depths and carbonation of drilled cores of carbonated reinforced concrete structures residual service life of structures can be assessed. The "square root law" for the progress of the carbonation has been assumed by the researchers.

A model has been presented, based on numerous non-destructive experimental data, through which the carbonation rate can be predictable by means of air-permeability kT.

As per Shams et. al. (2018), In order to expose the position of corrosion or fracture in prestressed concrete structures the Magnetic Flux Leakage technique can be used nondestructively. Using numerical simulations factors with the greatest influence on the performance of the MFL system has been examined. The Magnetic Flux Leakage technique is based on two permanent magnets to magnetize

embedded strands and Hall-effect sensors to sense normal MFL. In order to simulate the MFL system effectively, the system is evaluated using magneto static and transient numerical analysis. Finally Results were verified by laboratory and field experiments. For better identification of magnetic signals at the corrosion zone, both normal and axial Hall-effect sensors were modeled.

Bagheri et. Al. (2018) conducted a series of finite element analyses to explain the modal properties of a large population of bridges with dissimilar geometric features Outcomes and geometric inputs were used to establish ANN model that foresees the flexural rigidity of a bridge based on the computed modal frequencies obtained from vibration testing. Because of ambiguity in internal geometry of concrete, nondestructive methods are presented to achieve the cross-section measurements of bridge as well as the compressive strength and elastic modulus of concrete. Results show that the suggested nondestructive technique can be used to suitably establish the load rating factor of the test bridge and can eventually be employed for load rating of concrete slab bridges lacking information of structures.

Palimeno et al. (2018) worked on non-destructive testing methodology for damage evaluation of RC structures after seismic events. In this research, ultrasonic and sonic wave propagation in the solid matter was used in order to identify and investigate the modifications stimulated by the seismic load on RC structures. The adopted methodology was experimented through table shaking tests reproducing numerous earthquakes. Table shaking tests were executed at ENEA Casaccia Research Centre on a full-scale 2-storey RC frame building designed under the current Italian code (NTC2008). Among the applied NDT techniques, direct and indirect sonic methods, as well as partial and complete methods for ultrasonic tomography application was explored.

Ghafari et. al. (2018) investigated the possibility of using piezoelectric-based sensors to distinguish the compressive strength put on procedure of cement paste mix together with supplementary cementitious materials (SCM). The electromechanical impedance (EMI) method was used for in-situ monitoring of the strength gain of cement pastes. The investigational result specifies that EMI may be used as a nondestructive testing technique to facilitate in-situ computation of strength gain process of cement paste with SCM.

According to Malkin et al. (2018), accurate non-destructive assessment of engineering structures using ultrasonic immersion imaging needs a precise representation of the surface of the structure. In this research, the relationship between surface geometry, surface measurement error using ultrasonic arrays and the total focusing method (TFM) and how this impacts on the ability to image a feature within a component has been investigated. Surfaces shaped as sinusoids covering grouping of surface wavelengths and amplitudes are studied. It is also been observed that very poor results are attained if the surface gradient is excessively steep.

In this research, non-destructive testing of cementitiously stabilized materials was studied using UPV by Mandal et al. (2016). Flexural strength and flexural modulus tests were carried out on CSMs and their constrained modulus were observed. The influence of compaction, curing time, and binder amount was assessed. The result shows that the P-wave velocity reduces with decrease in density, whereas P-wave velocity enhances with increase in curing time and binder amount.

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 this study almost 84 separate compositions have been tested after 3 and 180 days of curing, compressive strengths of these samples is ranging about 30 to 80 MPa.

IV. CONCLUSION

From above literature review it has been found that for obtaining compressive strength of existing concrete elements, Rebound hammer and UPV methods are employed by several researchers. Need for in-situ testing methods of concrete for determining the superiority and factors influencing the performance of existing structures.

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