Review of Non-Destructive Testing (NDT) Techniques

Tashnif Sheikh[1], Ranjeet Kumar[2]
[1, 2] Dept of Civil Engineering
[2] Professor and Dean
[1, 2] Shiv Kumar Singh Institute of Technology and Science, Indore-453331, Madhya Pradesh, India

Abstract- *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.*

Keywords- Compressive strength, Durability, Service life, Non destructive testing.

I. INTRODUCTION

Eminence examination of RC structures is commonly done by testing standard specimens. Thus, the direct determination of concrete strength needs preparation and testing of prepared samples. The standard test process gives an idea about the probable concrete strength. Although, the standard tests outcomes may not be similar as that of actual concrete strength as the compaction and curing systems applied in situ and in standard method are fairly different. Accordingly, non-destructive tests are broadly utilized to assess the strength of RC structures. Besides, as the name indicates, non-destructive tests do not make any damage or harm to the concrete and neither influences the performance of structure. These techniques can also be utilized for the well-organized planning of the construction works in giant construction projects, in which it may be required to know strength of concrete structures in order to evaluate the removal time of formwork, the stressing or releasing time for the wires in pre-stressed members, the loading time for the system in post-tensional elements or the time for opening the structure to service safely. There are a variety of non-destructive methods available in order to evaluate the strength of concrete structures.

II. NON-DESTRUCTIVE TESTING

Non-destructive testing (NDT) is a method to locate indirectly the dissimilar parameters of hardened concrete like strength, durability and other elastic properties without loading the specimen till it fails. These methods are based on the principle that few physical and chemical properties of material can be related to the strength and other properties of the concrete. These methods have the great potential to be part of such a technology. A range of advanced NDT methods have been initiated and are accessible for studying and evaluating the different parameters [7].

In the last decade nondestructive testing (NDT) has achieved an important place in the Quality Assurance of hardened concrete and the evaluation of existing concrete structure with regard to their strength & durability. Even though NDT tests are relatively easy to perform & instrument based, the analysis and elucidation of the test data are not simple, since concrete is a complex material, hence the engineers are cautioned that interpretation of the test data should always be carried out by trained specialists in NDT rather than by technicians performing the tests. Non destructive tests used to find out the compressive strength of concrete, the correlation between the measured, mechanical or physical and the strength is generally not unique. This arises from the diversity in the existing relations between the measured characteristic and the factors making up concrete strength, among others: cement contents, type of aggregates, bond between cement: paste and aggregates and water cement ratio.

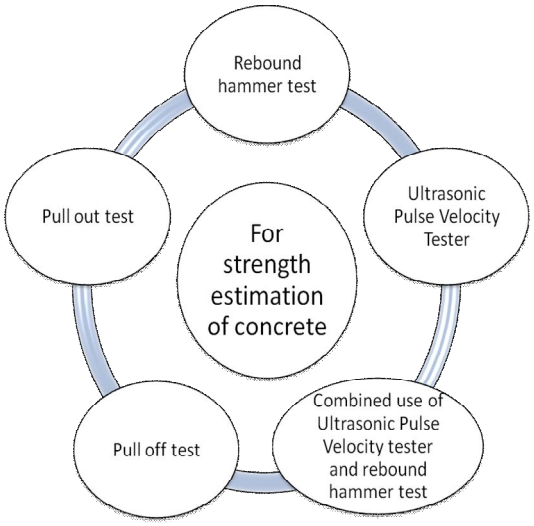

Figure 1-Various NDT methods

III. LITERATURE REVIEW

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

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.

According to **Wang et al. (2014),** non-destructive test methods are more economical and time-efficient as compared to destructive tests; one major disadvantage is that they are not very consistent when the test results are exercised to estimate the concrete compressive strength. For rebound hammer tests, it is observed that concrete compressive strength evaluations have an average of over 22% mean absolute error when it is compared to the "actual" compressive strength assessed through destructive tests.

Park et al. (2014) found that there will be more energy absorption due to lower rebound value**.** In the case of the concrete compressive strength test, low strength and low stiffness concrete will also yields a lower rebound value.

Breccolotti et al. (2013) proposed two formulas based on thickness of the carbonated concrete cover and on the strength of the concrete itself. The formulas have been determined by means of finite elements modelling. Results from finite element modelling showed a good agreement with experimental results.

Liang et al. (2013) examined the predicted carbonation life of an existing concrete viaduct/bridge in the atmospheric environment based on probability and reliability indices. The results showed that both the structures were serviceable and reliable comparing the initiation time calculated using Fick's second law and other methods.

A relationship between experimentally obtained strength and forecasted strength by the model has been presented by **Singh and Kotiyal (2013)**. NDT are those that can be used to calculate the strength without damaging the structure. In this research paper, the compressive strength of concrete is forecasted by using Artificial Neural Network. The forecasted strength was compared with the experimentally acquired actual compressive strength of concrete and equations are developed for dissimilar models. In addition to this, relation has been developed using two NDT techniques for calculation of strength by regression analysis.

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. The combined method has been used and equations are derived using statistical analysis to estimate compressive strength of concrete on site. The reliability of the technique for prediction of the strength has been discussed for a case study.

Sharma and Mukharjee (2011) calculated corrosion rate using ultrasonic guided waves in bars at different stages in different surroundings. In the present study, RC beam is formed and corrosion rate in oxide and chloride surroundings are checked independently, the variation in the corrosion rate is related effectively to the combination of the guided waves. More the corrosion rate more will be the possibility of the wear and tear. Ultrasonic test results interrelated with destructive test.

Sangoju et al. (2011) studied corrosion caused by interference of chloride ions in cracked OPC and PPC at dissimilar w/c ratios by using a U-shaped sample with precracks under flexural load. sample is provided with reinforcement of 12 mm rebars with clear cover of 20 mm. amount of corrosion is calculated by chloride ion penetrability, PPC sorptivity, half cell potential, resistivity, total charge passed and galvanometric weight loss. However this study concludes that the ppc plays the better and significant role than OPC in both the conditions i.e. precracked and uncracked, when they are kept in chloride rich environment. Chloride ion penetration is around 3 times lesser in case of PPC, PPC indicating superior performance. Half cell method confirms that PPC has higher resistance to corrosion.

IV. CONCLUSION

From above literature review it has been noted that in order to get compressive strength of existing concrete elements. Rebound hammer and UPV methods are utilized by several researchers. It has been found that there is requirement for in-situ testing method of concrete for determining the quality and factors influencing the performance of existing structures.

REFERENCES

[1] R. Malkin, A. Franklin, R. Bevan. M. Mongelli, H. Kikura, B. Drinkwater, "Surface reconstruction accuracy using ultrasonic arrays: Application to non-destructive testing". NDT & E International., 12 March 2018.

[2] T. Mandal, J. Tinjum, T. Edil, "Non-Destructive Testing Of Cementitiously Stabilized Materials Using Ultrasonic Pulse Velocity Test, "Transportation Geotechnics"., Volume 6, March 2016, Pages 97-107.

[3] Wang, Y.R.; Kuo, W.T.; Lu, S.S.; Shih, Y.F.; Wei, S.S. Applying support vector machines in rebound hammer test. Adv. Mater. Res. 2014, 853, 600–604.

[4] Park, S.; Kim, J.; Shin, E.; Han, S. Compressive strength evaluation of underwater concrete structures integrating the combination of Rebound Hardness and Ultrasonic Pulse Velocity Methods with artificial neural networks. Int. J. Civil Environ. Struct. Constr. Architect. Eng. 2014, 8, 17–21.

[5] M. Breccolotti, M. Bonfigli,. M. Materazzi "Influence of carbonation depth on concrete strength evaluation carried out using the SonReb method". NDT & E International. 59:96–104 · October 2013.

[6] M. Liang, R. Huang, S. Fang "Carbonation service life prediction of existing concrete viaduct/bridge using time-dependent reliability analysis". Journal of Marine Science and Technology, Vol. 21, No. 1, pp. 94-104 (2013) Carbonation service life prediction of existing concrete viaduct/bridge using time-dependent reliability analysis.

[7] V.P. Singh, Y.C. Kotiyal, "Prediction of Compressive Strength Using Artificial Neural Network," International Journal of Civil, Structural, Construction and Architectural Engineering Vol:7, No:12, 2013.

[8] S. Hannachi and M. N. Guetteche, "Application of the Combined Method for Evaluating the Compressive Strength of Concrete on Site," Open Journal of Civil Engineering, 2012, 2, 16-21.

[9] Sharma S. and Mukherjee A. (2011). "Monitoring corrosion in oxide and chloride environments using ultrasonic guided waves". Journal of Materials in Civil Engineering, 23(2), 207-211.

[10] B. Sangoju; R. Gettu; B. H. Bharatkumar; and M. Neelamegam, "Chloride-Induced Corrosion of Steel in Cracked OPC and PPC Concretes: Experimental Study," Journal of Materials in Civil Engineering, Vol. 23, No. 7, July 1, 2011.