

Review Paper : Testing of Ultrasonic Pulse Velocity on Concrete

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ABSTRACT

Concrete is most basic material used for any kind of engineering construction. The performance of concrete is been influenced by various factors like water-cement ratio, size of aggregates and its type, the weather conditions, cement type and admixtures. This further results in affecting the compressive strength and the durability of the concrete structure. There are two types of method for determining the strength of concrete; they are destructive and non-destructive method. One of the effective, easiest and less time consuming method of non-destructive in-situ test is Ultrasonic Pulse Velocity. This test determines quality, uniformity, cracks, defects, homogeneity, honey comb voids present in concrete specimens and evaluating dynamic modulus of elasticity. The pulse velocity depends upon the compaction of material, length of the specimen, path length, presence of reinforcement steel, moisture content of concrete, temperature of concrete.

Keywords: Compressive Strength, Dynamic Modulus, Admixtures, Durability, Non-Destructive, Homogeneity, Uniformity, Honey Comb Voids.

I. INTRODUCTION

From the last few decades, the application of Non-destructive test is the field of Civil Engineering has increased and becoming a part of interest in various countries. Concrete is the material used in construction of all structures. Hence, it is mandatory to check the quality and uniformity of the concrete to overcome the failure which may occur in further life of structure. To prevent the deterioration of the structure it is necessary to well maintain it. Application of this non destructive test gives the respective result without spoiling or damaging the specimen. They further can turn out to be an important tool to check the quality.

This non-destructive method is used in number of construction works as it does not affect the workability and appearance. They allow the testing work to be carried out at the original place which helps in frequent monitoring the structure during the life-time. Once the structure is tested then the life span of the structure can be predicted. According to it the maintenance, use, deterioration are worked out. This method helps in determining the various useful properties of the concrete such as its strength, quality, cracks, uniformity, defects, honeycomb voids, homogeneity present in the concrete specimen. Concrete properties mainly depend upon the proportion and quality of the material.

Ultrasonic pulse velocity method generally consists of measuring the time of travelling of an ultrasonic wave

passing through the specimen of concrete. The higher velocity obtained in lesser time when the specimen is good, well compacted whereas when the lower velocity obtained in longer time then it is said to have voids, cracks and other kind of defects in the specimen. The equipment used for this test is Ultrasonic pulse velocity device. The working of the instrument consist of two transducers, they are usually in the form of metallic cylinder heads. One of them is used to transmit ultrasonic pulse wave simultaneously another one receives the wave. They are kept in contact with the surface of the concrete if required greasing is done over the surface to obtain a smooth surface of contact. They are connected by cables to control box where the pulse is generated. The digital display indicates the time taken by the wave to travel between the transmitting and receiving transducers. There are three types of transducers arranged namely direct, semi-direct and indirect transmission.

The benefits and applications of ultrasonic pulse velocity is determining density and elastic properties both of them are related to strength and quality of material. They give out accurate and reliable result regarding the internal properties. Materials homogeneity, defects, presence of voids, and other imperfection in structure are determined by this non-destructive test.

The literature reviews studied are discussed below

Alexandre Lorenzi et.al. 2007 [1]: In their paper they show that it is possible to understand how the variations of tests conditions affect the result of UPV, which can lead into a decrease of errors considering the strength estimation. It also indicates that the UPV tests are sensitive tools to analyse the variations in the homogeneity and the density of concrete. They concluded that it makes possible to contribute to deterioration and structure's quality.

Jason Maximino C. Ongpeng et.al.2017 [2]: In their reference paper they studied regarding detection of damage using UPV for reinforced concrete with corrosion applicable while working on site. It also noted that the multiple cracks propagation going outwards of the diameter of the reinforced steel bars are caused by the corrosion.

Jee Sang Kim et.al.2014 [3]: The UPV as applied on normal concrete can also be used over the geopolymer concrete with same simplicity and conveniently. The progressive damage found in the specimen is reflected in both maximum frequency in frequency domain and pulse velocity in time domain. Also a new equation was derived based on experimental study predicting the compressive strength of geopolymer concrete.

Akash Jain et.al. 2013 [4]: From the experimental study on combined use of non destructive test for assessing compressive strength of concrete they derived the conclusions that the readings of UPV increases with age but the change is very small, it is because the density of the concrete remains same with the increase in age, so UPV alone cannot be used to find the compressive strength. The results obtained of UPV were used to determine the value of compressive strength using correlation curve. It was further observed that there is decrease in UPV readings when the flaws were added in the same mix, this was because due to presence of flaws ultrasonic pulse velocity takes more time to travel.

P. H. Arundas et.al. 2016 [5]: They concluded that from the study on ultrasonic pulse velocity test for the prediction of compressive strength of concrete a mathematical expression was developed using the line of regression. The predicted compressive strength was compared with the actual compressive strength. From the tests it was observed that compression reduces frequency and ultrasonic pulse velocity values, reduction of ultrasonic pulse velocity as an indication

of crack formation, it was found reducing deeply up to the failure.

Grini Abdelouaheb et.al. 2016 [6]: In this experimental study the UPV is used to diagnose the homogeneity of concrete in terms of segregation. It is proved through the tested concrete mixes that the proportion of water is determinant parameter in manifestation of the segregation. Through this study, it was made possible for characterizing segregation of concrete by a non-destructive method easily and speedily. The results observed show the effectiveness of proposed approach.

Tarun Gehlot et.al. 2016 [7]: In this study they worked over the quality of concrete assessment of structural elements, in which they concluded that the poor quality of concrete allows the ingress of oxygen and moisture to the reinforcement bars and due to this corrosion occurs. The pulse velocity test is the ideal method through which uniformity of concrete can be establish for both existing as well as under construction. If presence of large difference in pulse velocity is found than there is strong reason to presume that deteriorated concrete is present. Unlike the other work, this research ended with important and useful charts that require no previous knowledge of the constituents of the tested concrete.

II. CONCLUSION

The basic study of Ultrasonic Pulse Velocity on concrete structures is focusing over the requirement of their quality and durability. Hence, Non-Destructive test aims on understanding the capacities and limitations on tests. The research indicates that testing with UPV is sensitive device towards the determination of homogeneity and density of concrete. Further we conclude that testing with UPV gives quick assessment and relevant results such as estimating the depth of cracks, internal flaws and poor patches formed in concrete specimens.

III. REFERENCES

- [1]. IS 13311 (Part-1)-(1992). Methods of Non-Destructive Testing of Concrete: Part-1: Ultrasonic Pulse Velocity.
- [2]. IS 456:2000 Code of Practice for Plain and Reinforced Concrete.
- [3]. ASNT, "Introduction to Non-Destructive Testing." The American Society for Non-Destructive Testing. <http://www.asnt.org/>, 2006.
- [4]. Lin, Y., Kuo, S-F, Hsiao C., Lai, C-P "Investigation of Pulse Velocity- Strength Relationship of Hardened Concrete" ACI Materials Journal, V. 104, NO. 4, July- Aug 2007, pp.344-350.
- [5]. Tanigawa, Y.; Baba, K.; and Mori, H., "Estimation of Concrete Strength by Combined Nondestructive Testing Method," In-Situ/nondestructive Testing of Concrete, SP-82, V. M. Malhotra, ed., American Concrete Institute, Farmington Hills, Mich., 1984, pp. 57-76.
- [6]. Sturup, V. R.; Vecchio, F. J.; and Caratin, H., "Pulse Velocity as a Measur of Concrete Compressive Strength," In-Situ/nondestructive Testing of Concrete, SP-82, V. M. Malhotra, ed., American Concrete Institute, Farmington Hills, Mich., 1984, pp. 201-227.
- [7]. Iraqi Specification IOS 45-1984.
- [8]. Tarun R. Naik, V. Mohan Malhotra and John S. Popovics, "The Ultrasonic Pulse Velocity Method" in the handbook of Nondestructive Testing of Concrete, Chapter 8, 2004.
- [9]. Breyse, D. (2012). "Nondestructive Testing of Concrete Strength: An historical review and a new perspective by combining NDT methods." Construction and Building Materials, 33, 139-163.
- [10]. Wu, T.T. and Lin, T.F., The stress effect on the ultrasonic pulse velocity variations of concrete under repeated loading, ACI materials Journal, Vol.95, No.5, pp. 519-524(1998)
- [11]. Stauffer, J. D. Woodward, C. B. and whit, K.R.(2005) Nonlinear ultrasonic testing with

resonant and pulse velocity parameters for early damaging concrete, ACI Materials Journal, Vol.102, No.2, pp. 21-28.

- [12]. Chang, H. S. A Study on Ultrasonic Pulse Velocity and Rebound Hardness Method for Structural Concrete with Mixed Fly ash according to the Replacement Ratio of Recycled Aggregate, M. E. Thesis, Hanyang University, (2011), (in Korean).
- [13]. Lee J. H. Strength Characteristics of Geo-Polymer Grout, Journal of the Korean GEO-Environmental Society 13(4), 2012.4, 52-59 (in Korean).
- [14]. Santhanam M. Ultrasonic characterization of damage in concrete. tech science press. 2010;3(2);111-25.
- [15]. Kalyan ST, Kishen CJM. Experimentalevaluation of cracks in concrete by ultrasonic pulse velocity. 2013; 95(1):27-36.
- [16]. A Benouis, N Khaldi and ML Benmalek, Uncertainties of strength concrete estimation by ultrasonic NDT (Admixture effects).