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Structural Health Monitoring of Bridge using Non-Destructive Technique

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ABSTRACT-

Structures are a combination of various load carrying members which transfer the loads to the foundation from the superstructure safely. At the design stage, the loading of the structure is defined and appropriate material choices are made based on their properties. However, the structure deteriorated over the passage of time because of some factors like material aging due to environmental conditions and service loads and due to unpredictable external loads i.e. earthquakes, wind and impact etc. which cannot be avoided.

Consequently, structural failure includes loss of life and economic damage. In recent years, the collapse and failures of various structure increases the concern about structure integrity, durability and reliability. For example, over one half of 690,000 bridges on the federal highway system in US are more than 50 years old and over one third are structurally and functionally obsolete and about 5 billion is spent annually on bridge rehabilitation.

hammer, penetration resistance method, ultrasonic pulse velocity method etc. are used for finding the existing strength and quality of material used in the structure. It was observed that the result given by one method did not confirm the result given by other method. Hence, it is difficult to decide the correct value of strength of material. In the present study an attempt has been made to correlate the strength obtained by rebound hammer, penetration resistance and ultrasonic pulse velocity method.

Keyword: ***ANN, NDT, Bridge, Rebound Hammer, Regression, Penetration.***

I. Introduction

A structure should meet the requirement of safety, durability, serviceability and sustainability for a long-term operation. The performance of a structure deteriorated with the passage of time for its whole life. This deterioration is mainly because of damages due to material aging, environmental conditions and change in nature of service load. This causes catastrophic structural failures which include loss of life and economic disruption. The structural health monitoring technology provides a way to evaluate the safety and durability of a structure during its service life, to ensure its serviceability and sustainability. With increasing number of collapses in major infrastructures, structural health monitoring (SHM) becomes significantly important. To keep a high level of structural safety, durability and performance of the infrastructure in each country, an efficient system for early and regular structural assessment is urgently required. The various important structures like bridges, nuclear plants need regular inspection and testing with reliable technologies. Nondestructive testing (NDT) methods have a large potential to be part of such a technology. A variety of advanced NDT methods have been developed and are available for investigating and evaluating the different parameters related to strength, durability and overall quality of concrete. Each method has its own merits and demerits. Therefore, more than one method generally used in combination so that the strength of one compensates the weakness of other.

II. Objective

In view of the relative limitations, of any one of the methods for predicting the strength and quality of concrete, use of more than one i.e. Ultrasonic pulse velocity (UPV), rebound hammer and Windsor's probe penetration methods was made in combination to compensate the errors arising out of influence of materials, concrete mix and environmental parameters on the respective measurements. Better accuracy of the estimation of concrete strength is achieved by use of such combined methods. Combination of UPV and rebound hammer methods can be used for the assessment of the quality and likely compressive strength of in-situ concrete. Similarly, other combination can also be used for predicting strength and quality of concrete. In the present study, the correlation between the predicted strength and strength obtained from various Non-Destructive Test equipment's has been established, so that a more accurate value of predicted strength could be obtained.

III. Experimental work

Materials:

Concrete: As per the batch on construction site.

Compressive Strength Test:

Compressive strength was calculated through proper procedure with cube size 150*150*150 mm and is cured for 7 and 28 days before testing.

Non-Destructive Test: Test like Ultrasonic Velocity, Rebound Hammer. Windsor probe Penetration.

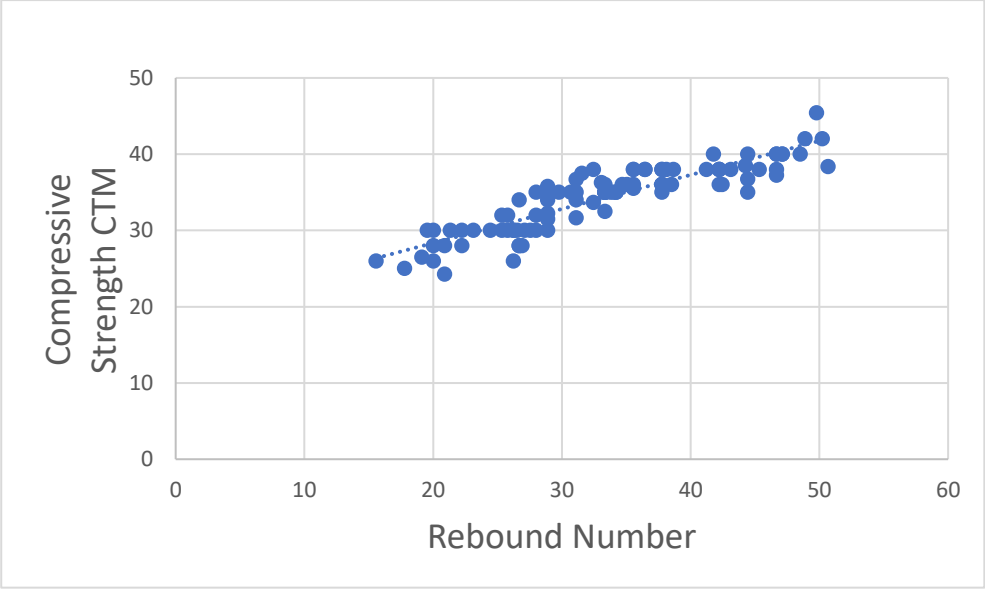
IV. Results & Discussion

NDT:

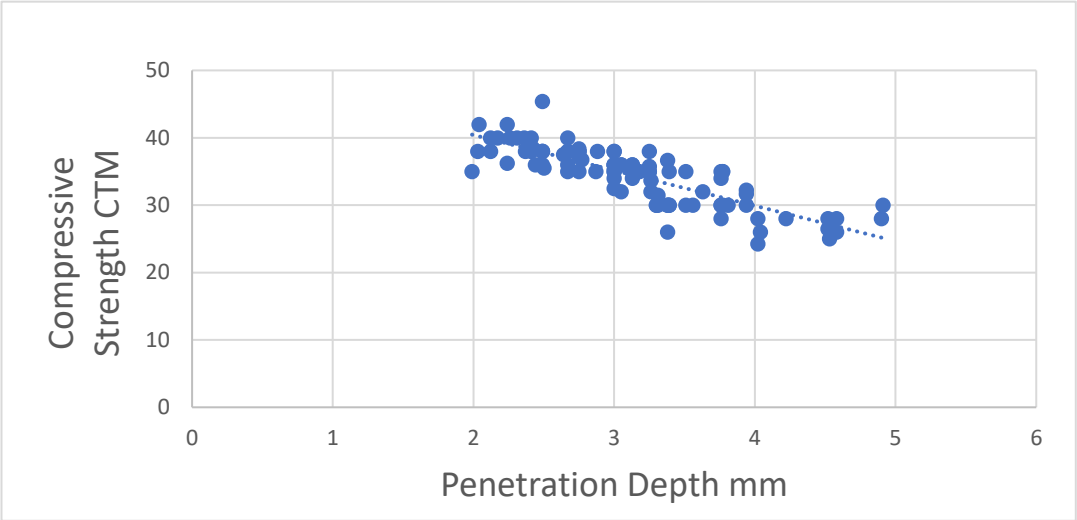
Cube No.	Rebound No.	Penetration Depth (mm)	Pulse Velocity (Km/s)	Compressive Strength using CTM
1	26	4.02	4.918	32.31
2	38.25	2.49	4.688	33.21
3	38	2.75	3.869	35.26
4	38.5	2.24	4.762	31.44
5	36.2	2.87	4.823	34.20
6	30.12	3.30	5.607	32.10
7	30.6	3.43	5.788	35.50
8	31.2	3.43	5.788	54.46
9	34.6	3.39	5.59	34.26
10	32	3.05	5.521	36.63

V. Analytical study

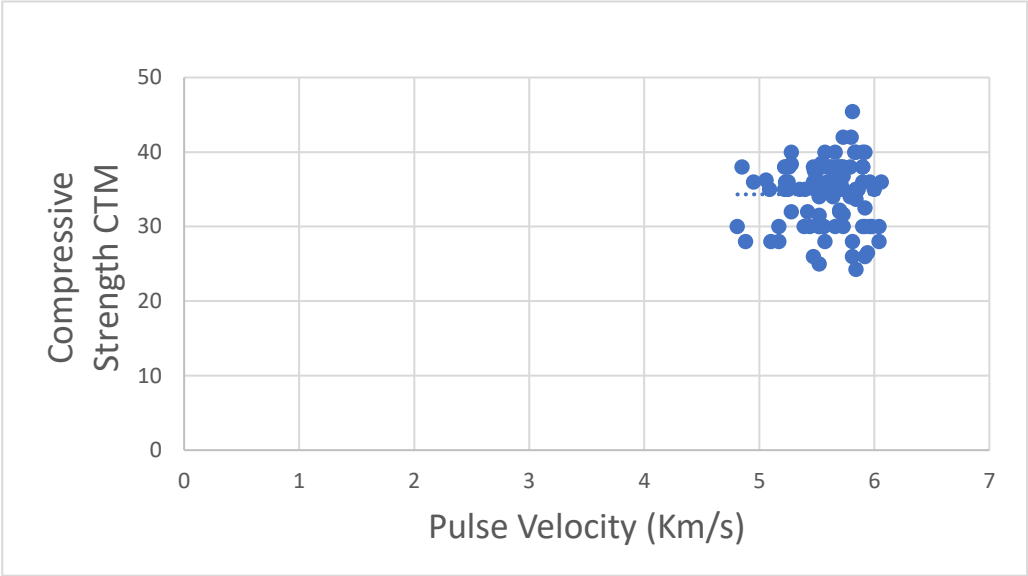
Relationship between Rebound and Actual Compressive Strength using CTM



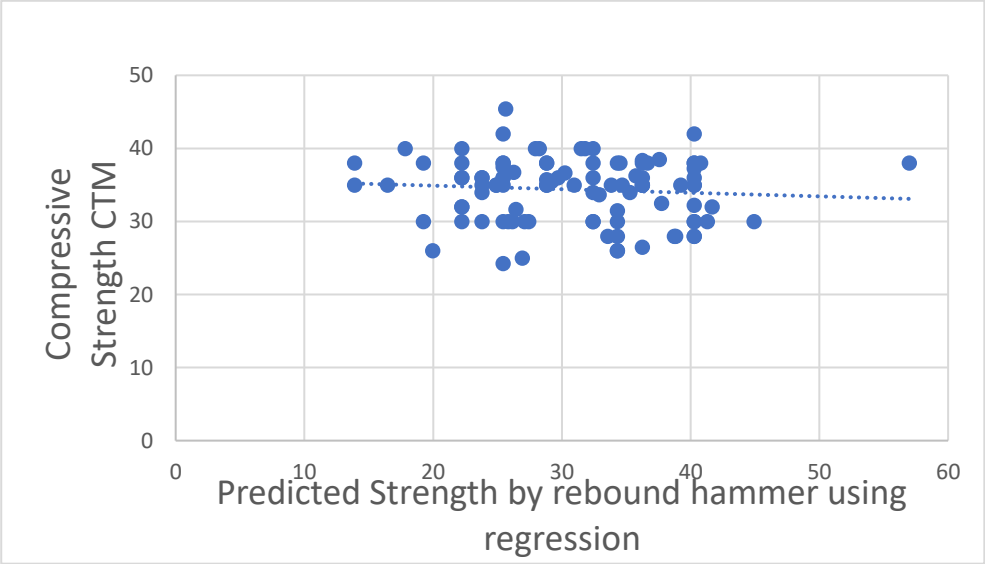
Relationship between Probe Penetration Depth and Actual Compressive Strength using CTM



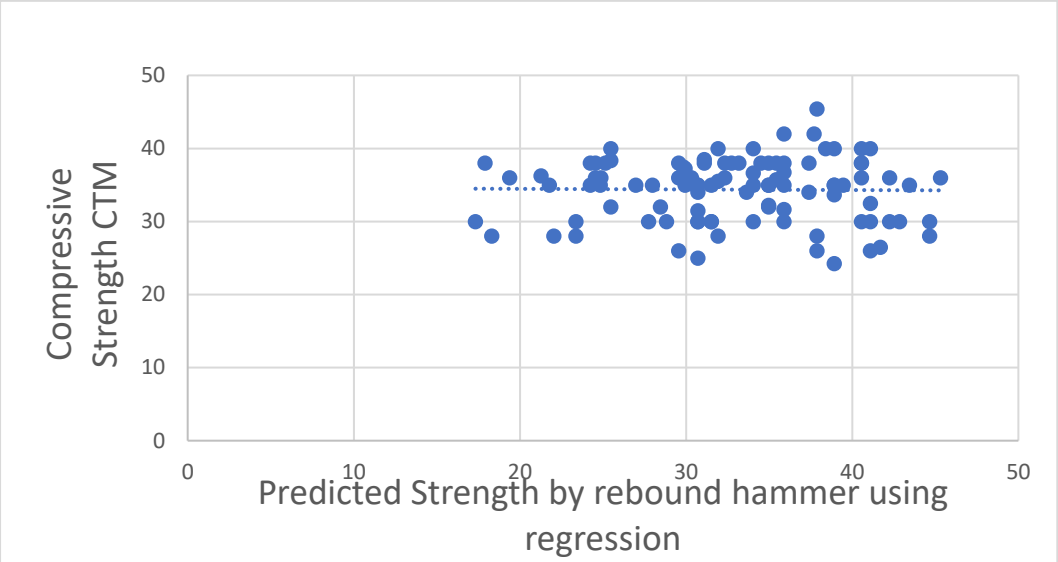
Relationship between Pulse Velocity and Actual Compressive Strength using CTM



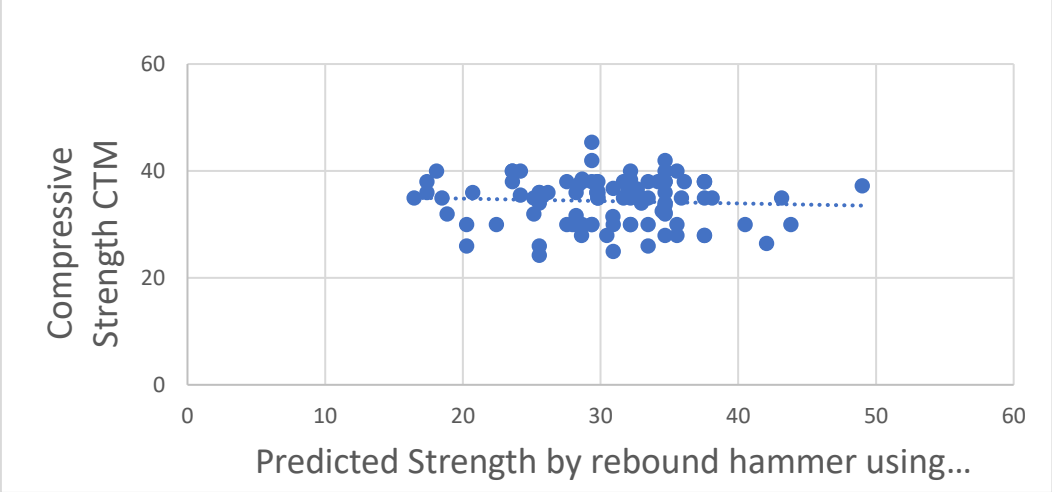
Comparison between predicted compressive strength by regression and actual compressive strength using CTM based on Rebound Number



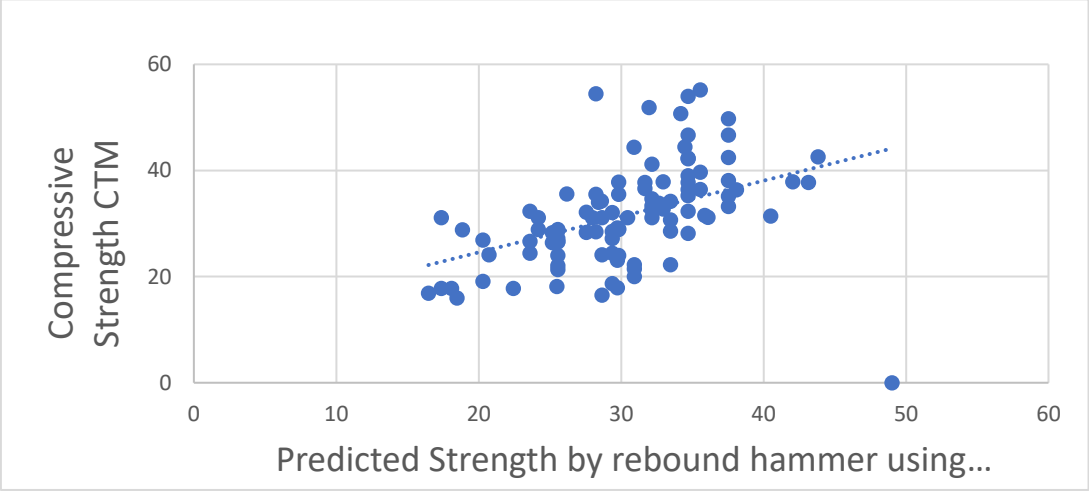
Comparison between predicted compressive strength by ANN and actual compressive strength using CTM based on Rebound Number



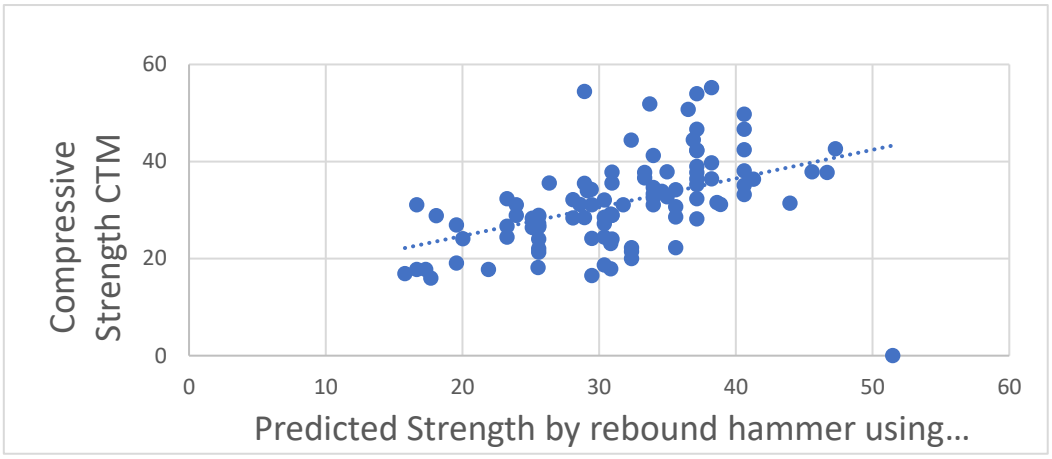
Comparison between predicted compressive strength by regression and actual compressive strength using CTM based on probe penetration depth



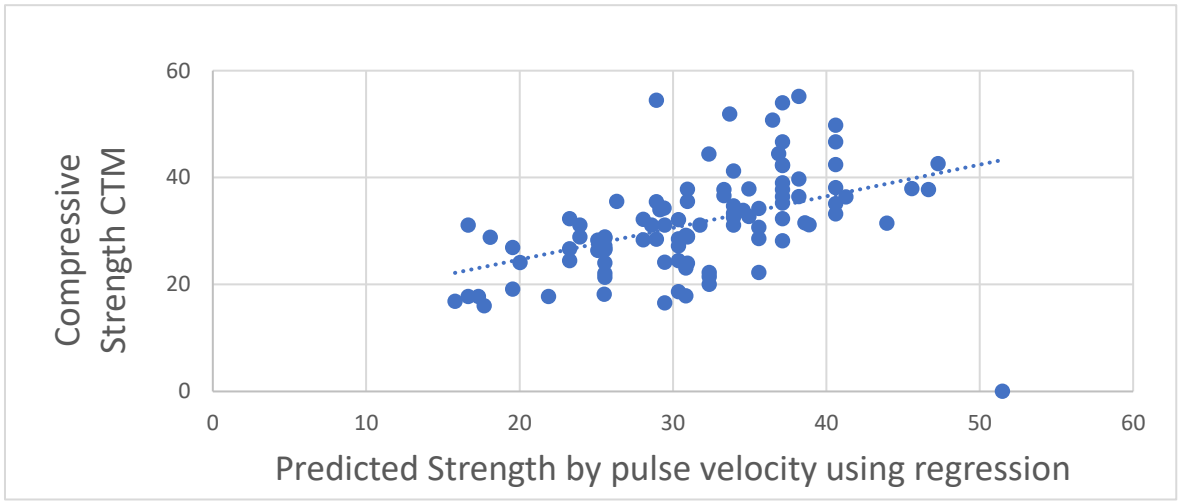
Comparison between predicted compressive strength by regression and actual strength based on pulse velocity



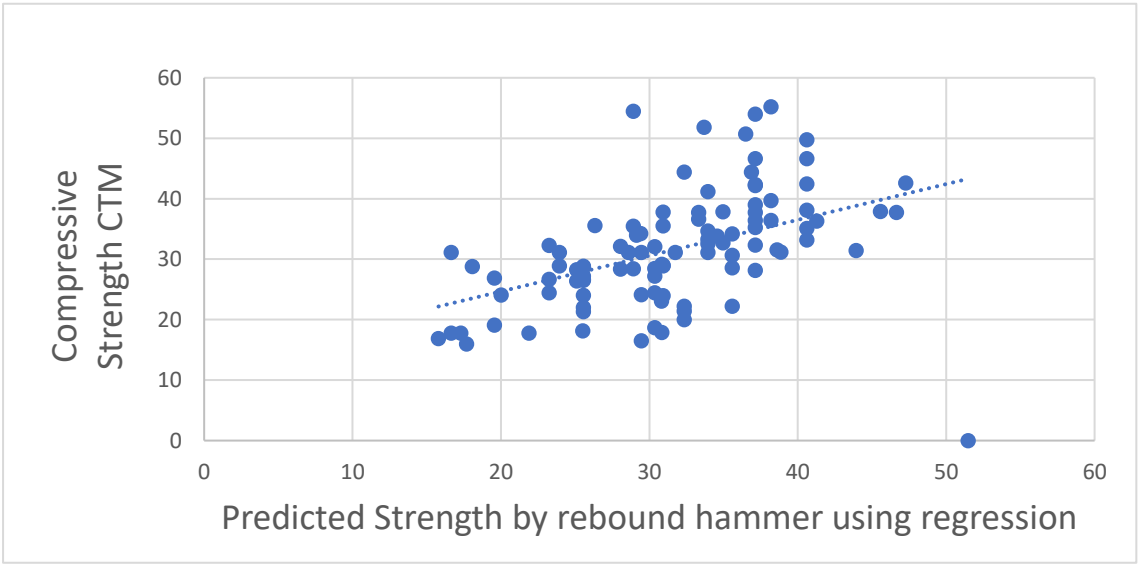
Comparison between predicted strength by ANN and actual strength using CTM based on pulse velocity



Predicted Comparison by regression and actual strength using CTM based on pulse velocity



ANN Predicted compressive strength by combined model of rebound number and penetration depth



VI. Conclusion

In the present study, Correlation has been developed for single and multiple NDT parameters with actual compressive strength by regression and ANN model. The following conclusions have been made:

• In case of single NDT technique, it was found that the prediction of strength using rebound hammer was more suitable which makes engineering judgment quite easy. The use of the rebound hammer methods yields more reliable and closer results to the actual strength with high coefficient of determination and %age root mean square error for regression and ANN was found 15.861 and 16.720 respectively.

• An acceptable level of accuracy was achieved for strength estimation of concrete using Windsor' probe penetration method but it is not recommended to be used alone to predict strength of concrete.

• It has been observed that Ultra sonic pulse velocity method can't be used as alone for prediction of strength, which shows worst relationship between predicted strength and actual strength. This could be explained of the fact that the pulse velocity is most affected by concrete composition in comparison to other NDT 114 method. However, in the present study, the strength has been predicted by ANN. The formula used for the prediction of strength represents a good correlation between pulse velocity and compressive strength and could be used to predict the strength. The percentage root mean square error is 14.349 and 12.758 by regression and ANN model respectively.

• A combined model developed in ANN by using inputs from rebound hammer as well as penetration predicts more accurately in comparison to prediction made by model having input from single NDT techniques. The %age root mean square error was found 3.240 and 3.144 by regression and ANN model respectively.

• The developed equations in the present study for different NDT techniques could be used to predict more accurate results.

References

[1] Bashar S. Mohammed, N. J. Azmi, M. Abdullah! "Evaluation of rubbercrete based on ultrasonic pulse velocity and rebound hammer tests," Civil Engineering Department, College of Engineering, Universiti Tenaga Nasional, KM7, Jalan Kajang-Puchong, 43009 Kajang, Selangor, Malaysia, construction and building material 25 1388-1397 (2010).

[2] BIS 13311(PART 1) 1992 Non-Destructive Testing Of Concrete methods Of Test.

[3] BIS 13311(PART 2) 1992 Non-Destructive Testing Of Concrete Methods of Test.

[4] BS: 103 Guidelines on non-destructive testing of bridges, research design and standards organization Lucknow (2009).

[5] D. Breysse, "Nondestructive evaluation of concrete strength: An historical review and a new perspective by combining NDT methods," Construction and Building Materials, 33, 139-163 (2012).

[6] E. A. Whitehurst, "Use of the soniscope for measuring setting time of concrete," ASTM Proceedings, vol. 51, pp. 1166-1183 (1951). 116

[7] E. Schmidt, "Experiments with the new concrete test hammer for determining the quahty of concrete". Schweizer Archiv fur angewandte Wissenschaft und Technik, vol. 17, no. 5, pp. 139-143. (1951).

[8] I.S. Buyuksagisa, R.M. Goktanb, "The effect of Schmidt hammer type on uniaxial compressive strength prediction of rock," International Journal of Rock Mechanics & Mining Sciences 44 299- 307 (2007).

[9] J. Alexandre Bogas, M. Gloria Gomes, Augusto Gome, "Compressive Strength Evaluation of Structural Lightweight Concrete by Non-Destructive Ultrasonic Pulse Velocity Method," DECivil/ICIST, Instituto Superior Tecnico, Technical University of Lisbon, Av. Rovisco Pais, 1049-001 Lisbon, Portugal (2012).

[10] J.H. Bungey, M.N. Soutsos, "Reliability of partially-destructive tests to assess the strength of concrete on site," Construction and Building Materials, 15, 81-92 (2001).

[11] Jen-Chei Liu, Mou-Lin Sue, Chang-Huan Kou, "Estimating the Strength of Concrete Using Surface Rebound Value and Design Parameters of Concrete Material," Department of Civil Engineering and Engineering Informatics, Chung-Hua University, Hsin Chu, Taiwan 300, R.O.C. Tamkang Journal of Science and Engineering, Vol. 12, No. 1, pp. 1-7 (2009). Ill

[12] J. Kolek, "An appreciation of the Schmidt hammer". Magazine of Concrete Research, vol. 10, no. 28, pp. 27-36 (1958).

[13] M. D. Machado, L. C. D. Shehata, and A. E. M. Shehata, "Correlation Curves to Characterize Concretes Used in Rio de Janeiro by Means of Non-destructive Tests," Volume 2, Number 2 p. 100 - 123 ISSN 1983-4195 (2009).

[14] Manish A. Kewalramani, "Concrete compressive strength prediction using ultrasonic pulse velocity through artificial neural networks," Civil Engineering Group, Birla Institute of Technology and Science, Pilani, Rajasthan-333 031, India Automation in Construction 15 374 - 379 (2006).

[15] Miirsel Erdal, "Prediction of the compressive strength of vacuum processed concretes using artificial neural network and regression technique," Gazi University, Technical Education Faculty, Construction Department, 06500, TeknikokuUar, Ankara, Turkey,Vol.4 (10), pp. 1057-1065, (2009).]

[16] R. Jones, "A non-destructive method of testing concrete during hardening". Concrete and Constructional Engineering, vol. 44, no. 4, pp. 127-128 (1949).

[17] R. J. Wheen, "Non-Destructive Testing of Concrete". BMHT Sci. Vol. 9, pp. 157 166, Printed in Great Britain (1974). 118

[18] Samia Hannachi, Mohamed Nacer Guetteche, "Application of the Combined Method for Evaluating the Compressive Strength of Concrete on Site," Civil Engineering Department, Faculty of Engineering Sciences, University Mentouri, Constantine, Algeria. Open Journal of Civil Engineering, 2012, Published Online (2012).

[19] Sandor Popovics, Joseph L. Rose, John S. Popovics, "The Behavior of Ultrasonic Pulses in Concrete Cement And Concrete research". Vol. 20, pp. 259-270 (1990).