Assessing The Condition And Durability Status of Existing Structures

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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.*

Experiments using ultrasonic pulse velocity tester and rebound hammer have been carried out on several existing structures, to monitor the strength and health of the structures. . The aim of this article was to obtain calibration graphs for the Rebound Hammer and Ultrasonic pulse Velocity Tester through laboratory testing. These Non Destructive Instruments were then used to test the columns, beams and slabs of several structures situated in Bhopal city. To evaluate present condition of existing RC structures on the basis of parameters such as age of structure, compressive strength, concrete cover and visual inspection, a condition rating system related to maintenance, inspection and replacement priorities has been proposed.

Keywords- NDT techniques, ultrasonic pulse velocity method, rebound hammer, correlation curves.

I. INTRODUCTION

Concrete is a mixture of aggregate and paste of cement and water, this paste binds the aggregates. Quality of concrete depends upon the quality of paste and aggregates. Deterioration of concrete, caused by several physical and chemical attacks, result in the degradation of performance with time. Experimental and field results are necessary to develop rational service life and deterioration models used in whole life performance assessment of existing concrete structures. Using material properties obtained from field data is advantageous, because actual properties can be used instead of assumed values. Combining experimental data with theoretical or probability concepts provide more reliable results. If any previous inspection or maintenance records are not available, the useful life can be predictable by distributing concrete infrastructures as per time period after construction and visual or in-situ condition, from the surveyed record worsening tendency can be determined by projecting these records.

As it is not possible that all the components of a concrete structure were made from identical concrete mix, hence, testing the concrete mix for determining the characteristic of whole structure is not a correct method. On the other hand, test samples can be overstated by distinction in sample type and category of curing. Consequently, in-situ testing of strength and assessment of real condition is an necessary act, for more consistent data. For the implementation of above requirement various in-situ testing systems were invented. These systems were follow the rule - a small number of physical and chemical properties of any substance or structure can be linked to the strength and other characteristics of the concrete. In the current study rebound hammer and ultrasonic pulse velocity techniques with visual inspection had been performed on structures of Bhopal city for assessing their conditions.

II. REBOUND HAMMER AND ULTRASONIC PULSE VELOCITY TEST

- Rebound hammer test is done to find out the compressive strength of concrete by using rebound hammer as per IS: 13311 (Part 2) - 1992. The hammer can be used in different positions (horizontal, vertically overhead or vertically downward) as well as at any transitional angle, but it should be perpendicular to the surface under test.
- Pulse Velocity technique is a suitable technique for examining structural concrete. The fundamental principle of evaluating the quality of concrete is that relative higher velocities are achieved when the superiority of concrete in terms of homogeneity, density and consistency is excellent. In case inferior quality of concrete, lesser velocities are found. If there is a void, fracture or flaw within the concrete which appears in the way of diffusion of the pulses, the pulse strength is attenuated and it passes around the discontinuity, thereby making path length longer. Consequently, lower velocities are obtained. The actual pulse velocity obtained depends primarily upon the material and the mix proportion of the concrete. Density and modulus of elasticity of aggregate also significantly

affect the pulse velocity.

III. LITERATURE REVIEW

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

Amini et al. (2016) developed models for predicting the compressive strength of concrete, without considering the past maintenance record of building. Performed ultrasonic pulse velocity (UPV) and rebound hammer (RH) tests over several cylindrical samples of concrete.

Several destructive and non-destructive tests had been conducted by **Bungey and Soutsos (2015)** on a significant historic building in Reggio Calabria. It has been observed from results that due change in the in-situ mechanical properties of the concrete; it is needed to calibrate the strength determined by non-destructive testing of concrete.

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. For destructive testing compression test and for non destructive testing rebound hammer tests have been conducted. Effect of several parameters on the modulus of elasticity has been investigated through pulse velocity test. These parameters are the age of concrete and the water/ cement ratio.

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.

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. In this study combined use of both the NDT techniques had been determined.

Andrade and Andrea (2010) calculated the initiation and propagation periods using the electrical resistivity of concrete structures.

Okasha and Frangopol in (2010) presented computational methodology for the life cycle prediction and service life estimation of bridges using advanced modeling tools, this methodology employed incremental nonlinear FEA.

Agarwal et al.(2010) described a 7 scale condition rating used to calculate the deterioration rates for each bridge element. Bridge condition rating scale ranges from 7 to 1, 7 being new and 1 being failed condition.

IV. EXPERIMENTAL RESULTS

During the in-situ testing twenty five concrete structures were tested and parameters such as age, compressive strength and ultrasonic pulse velocity were determined. The values obtained for above parameters are summarized in table 1. Here the values of UPV and compressive strength are the average of the respective values obtained for various elements of that structure.

S.No	Structure	Strength (MPa)	Corrected strength (Mpa)	UPV (m/sec)	AGE (years)
1	Building 1	20	21.92	4200	5
2	Building 2	20	21.92	4025	8
3	Building 3	19	20.92	3904	10
4	Building 4	17	18.92	3986	16
5	Building 5	16	17.92	3800	20
6	Building 6	16	17.92	3740	24
7	Building 7	16	17.92	3624	29
8	Building 8	14	15.92	3560	32
9	Building 9	14	15.92	3508	33
10	Building 10	23	24.92	3400	36
11	Building 11	13	14.92	3310	38
12	Building 12	22	23.92	3260	38
13	Building 13	12	13.92	3200	39
14	Building 14	12	13.92	3255	40
15	Building 15	12	13.92	3145	40
16	Building 16	21	22.92	3180	42
17	Building 17	13	14.92	3020	44
18	Building 18	14	15.92	3120	45

19	Building 19	22	23.92	3000	45
20	Building 20	23	24.92	2980	45
21	Building 21	16	17.92	3085	48
22	Building 22	17	18.92	2940	52
23	Building 23	13	14.92	2860	55
24	Building 24	18	19.92	2820	56
25	Building 25	19	20.92	2746	60

Table 2 -Classification of structures based on compressive strength

S. No.	Compressive strength (MPa)	Category
1	**< 15**	**Low “1”**
2	**>=15 and <=20**	**Medium “2”**
3	**>20**	**Good “3”**

Table 3 – Classification of structures based on UPV as per IS: 13311 (Part 1) – 1992

Pulse velocity (m/sec)	**Concrete quality**
>4000.0	Very good
3500 to 4000	Good, but may be porous
3000 and 3500	Poor
2500 and 3000	Very poor

2000 and 2500	Very poor and low integrity
<2000and reading fluctuating	No integrity, large voids suspected

V. CONCLUSION

1. Degradation of concrete structures with increase in age is a normal phenomenon. However, rate of deterioration depends upon several parameters such as age, compressive strength, quality of concrete or other influencing parameters.
2. Nondestructive testing methods were applied in this research for condition monitoring of concrete structures. Almost 25 structures were surveyed in this research.
3. Parameters determined are age of structure, compressive strength through rebound hammer, UPV and structures were also assessed through visual inspection.
4. Structures of different age group ranging from new to 50 years were selected from different locations of Bhopal.
5. Rebound hammer is calibrated in laboratory before testing the structures, and a correction factor of +1.92 is obtained.
6. Most of the surveyed structures are having low compressive strength; almost all of these structures are residential buildings.
7. Through UPV testing it has been revealed that after 32 years of age condition of structures become POOR.
8. Four categories of structures were identified through visual inspection of structures - new structures without any cracks, structures with minor cracks, structures with wide cracks (needs immediate maintenance), and structures with high cracks and failure of concrete cover, these conditions are nominated as very good, good, poor and very poor.

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