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STRUCTURAL HEALTH MONITORING OF RCC STRUCTURE USING NDT UNDER DIFFERENT EXPOSURE CONDITION – A CASE STUDY

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Abstract:- *This review paper analyzes why and how nondestructive testing (NDT) measurements can be used in order toassess on site strength of concrete. It is based on (a) an in-depth critical review of existing models; (b) an analysis of experimental data gathered by many authors in laboratory studies as well as on site, (c) the development and analysis of synthetic simulations designed in order to reproduce the main patterns exhibited with real data while better controlling influencing parameters. The key factors influencing the quality of strength estimate are identified. Two NDT techniques (UPV and rebound) are prioritized and many empirical strength-NDT models are analyzed. It is shown that the measurement error has a much larger influence on the quality of estimate than the model error. It is based on the use of a prior double power law model, with only one parameter to identify. The analysis of real datasets from laboratorystudies and from real size buildings show that one can reach a root mean square error (RMSE) on strength of about 4 MPa. Synthetic simulations are developed in order to better understand the role played by the strength range and the measurement error. They show that the number of calibration cores can be significantly reduced without deteriorating the quality of assessment. It is also shown that the optimal calibration approach depends on the number of cores.*

Keyword:*Rebound hammer, core strength, cube strength, Non-destructive tests,Impulse Response and Ultrasonic Pulse Velocity*

I. INTRODUCTION

Cement concrete is the most extensively used material for construction of different types of structures or components such as buildings, bridges and shell roofs and also for precast products such as pipes, poles, sleepers, etc. in the past and even at the present times, too much emphasis is placed on concrete compressive strength rather than on environmental factors, which is known to affect concrete durability. Construction activities account for a major component of the budget of our country. A very large part of the infrastructure in our country is made of concrete, providing the basis of economic and social development. These are often damaged due to ageing, environmental agents, overloading, vibrations and other causes. A great variety of damage situations can occur, as micro cracking and cracking due to material and structural damage, material discontinuity and surface degradation. Non-destructive testing (NDT) methods are techniques used to obtain information about the properties or internal condition of an object without damaging the object. Non-destructive testing is a descriptive term used for the examination of materials and components in such way that allows materials to be examined without changing or destroying their usefulness. NDT is a quality assurance management tool which can give impressive results when used correctly. It requires an understanding of the various methods available, their capabilities and limitations, knowledge of the relevant standards and specifications for performing the tests. NDT techniques can be used to monitor the integrity of the item or structure throughout its design life. The greatest disadvantage of the conventional methods of testing concrete lies in the fact that in-situ strength of the concrete can not be obtained without damaging the actual structure. Also the test specimens are destroyed, once the test is performed and subsequent testing of the same specimens is not possible. Thus the effect of prolonged curing, weathering action and other time dependent characteristics cannot be correctly calculated. No matter how well a concrete mix is designed, there are variations in mixing conditions, amount of compaction or curing conditions at site which cause the variations in the final product. The variability between the batches of concrete of the same mix proportion is assessed by testing test specimens under load in the laboratory. Such tests enable the variability of constituents of the mix to be controlled, but they cannot take into account the differences of compaction and actual curing conditions between the test specimens and the corresponding concrete in a structure. It is these differences, which are difficult to assess by conventional strength tests, Also, conventional method of testing is not sufficient to predict the performance of the structures under adverse conditions e.g. exposure to liquid, gas, and chemicals radiation, explosion, fire, extreme cold or hot weather, marine and chemical environment. All such severe exposure conditions may induce deterioration in concrete and impair the integrity, strength and stability of the structure. Thus, conventional strength test does

not give idea about the durability and performance of the actual concrete in the structure. This gave the impetus to the development of non-destructive methods for testing structural concrete in-situ.

In laboratory many techniques can be used to examine and test hardened concrete to assess a wide. Varity of properties. Nondestructive and semi-destructive methods play an important role in Evaluating the existing structure conditions 1)Nondestructive test methods are used to indicate Properties other than strength 2) British Standard defined nondestructive testing as a test that Does not impair the intended performance of the element or member under investigation 3) the nondestructive evaluation techniques are used to assess the condition of concrete structures, to predict Future performance and allow minor repair system. The best known nondestructive evaluation Techniques use ultrasonic waves, core testing, and Schmidt hammer test. The estimation of in place Concrete strength requires that a known relationship between the results of in-situ testing and the Strength of concrete. For existing construction the relationship has to be assessed on site correlating Non-destructive test results to strength of core. There was no any relation between core strength and Cube strength of hardened concrete.

II. EXPERIMENTAL WORK AND DISCUSSION

Various non destructive test such as visual inspection ,rebound hammer test , ultrasonic pulse velocity test, core cutter test , carbonation depth test were carried out for two different exposure condition of the building like away from sea shore and near sea shore .

Visual inspection :

First step of condition assessment is visual inspection. Visual inspection of structure is carried out as follows. Different types of cracks and defects has been observed and even spelling of concrete is observed on slab.




2. Rebound hammer and UPV test :

Rebound hammer and UPV test were carried out for different exposure condition and it gave the following result for column ,beam and slab.



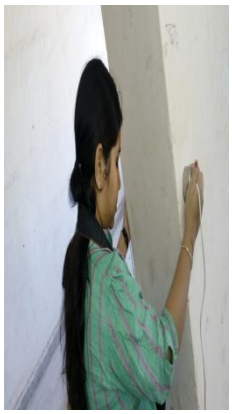

Table :1 Result and discussion of Rebound hammer and UPV test near seashore

ACTUAL STRUCTURE	STRUCTURAL ELEMENTS	MEAN COMPRESSIVE STRENGHT (MPa)	QUALITY OF CONCREAT FROM UPV
Ground floor	Column	24.87	Medium
	Beam	20.12	Poor
	Slab	18.15	Medium
First floor	Column	23.15	Medium
	Beam	15.21	Poor
	Slab	16.45	Poor

Table :1 Result and discussion of Rebound hammer and UPV test away from sea shore

ACTUAL STRUCTURE	STRUCTURAL ELEMENTS	MEAN COMPRESSIVE STRENGHT (MPa)	QUALITY OF CONCREAT FROM UPV
Ground floor	Column	25.66	Excellent
	Beam	20.40	Good
	Slab	18.35	Good
First floor	Column	25.01	Excellent
	Beam	20.96	Good
	Slab	18.23	Good
Second floor	Column	19.35	Good
	Beam	19.20	Medium
	Slab	18.32	Medium
Third floor	Column	18.32	Good
	Beam	21.89	Good
	Slab	18.00	Good

3.CORE CUTTER TEST :-

Test procedure were carried out as per IS :516 -1959 .

Table 37: Result of Core cutter test (As per IS: 516-1959)

CORE MARK	SPECIMEN -1	SPECIMEN -2
Mean dia. of core (mm)	97.2	96.2
Mean height of core(mm)	200	200

H/D ratio	2	2
Correction factor for H/D ratio(K)	2	2
Correction factor for diameter (Cs)	1	1
True crushing load (KN)	135	140
Compressive strength of core cylinder(f0) (N/mm2)	18.19	19.26

CORE-CUTTER TEST NEAR SEASHORE :

Table 38: Result of Core cutter test (As per IS: 516-1959)

CORE MARK	**SPECIMEN -1**	**SPECIMEN -2**
Mean dia. of core (mm)	95.8	96.2
Mean height of core(mm)	200	200
H/D ratio	2	2
Correction factor for H/D ratio(K)	2	2
Correction factor for diameter (Cs)	1	1
True crushing load (KN)	95	93.1
Compressive strength of core cylinder(f0) (N/mm2)	13.18	12.80

4.CARBONATION TEST :-
This test is performed to detect quality of concrete, corrosion and erosion of concrete.

Test procedure:

The core were extracted from the actual structure with the core cutter. After which the cores were cleaned made smooth and dry and also the excess part of the cores were removed and were done as per the required size.After which as per standard guidelines, core was kept into compression test machine and broken into split tensile.After prepaid a 1% phenolphthalein (pH value between 8.2 to 10) solution as per guidelines and filed into the container, which has mounted spray.Carbonation may be determined simply by spraying a freshly exposed surface of
concrete with 1% phenolphthalein solution.After observed the concrete the calcium hydroxide is coloured pink and carbonated portion remain as it is or un colored.If carbonation exist in concrete, it is found in terms of un colored portion which can be measured with the help of scale or vernier scale.

The 1% Phenolphthalein solution is made by dissolving 1gm of Phenolphthalein 90 cc ofethanol. The solution is then made up to 100 cc by adding distilled water. On freshly Extracted cores the core is sprayed with phenolphthalein solution, the depth of the un colored layer (the carbonated layer) from the external surface is measured to the nearest mm at 4 or 8 positions, and the average taken. If the test is to be done in a drilled hole, the dust is first removed from the hole using an air brush and again the depth of the un colored layer measured at 4 or 8positions and the average taken. If the concrete still retains its alkaline characteristic the colour of the concrete will change to purple. If carbonation has taken place the pH will have changed to 7 (i.e. neutral condition) and there will be no colour change. Another formula, which can be used to estimate the depth of carbonation, utilizes the age of the building, the water-to-cement ratio and a constant, which varies depending on the surface coating on the concrete.

$$y = \frac{7.2}{R^2(4.6X-1.76)^2} C^2$$

Where,

Y = is age of buildings in years,
x = is water to cement ratio,
c = is carbonation depth
r = is a constant ($R = \propto \beta$)

Negligible amount of the carbon was observed in the core of the concrete when the carbonation test was performed. It suggests that the quality of the concrete was good.
The depth of carbon was observed 54.62mm in the core of concrete when the carbonation test was performed .it suggest that the quality of concrete was not good .

III. CONCLUSION

- Visual inspection of the structure was done only from inside as the building was covered with white wash on the exterior. It was observed that at some places in building cracks were visible in non structural member. However, no distress was observed in the structural members. The same thing was observed in entire structure among all the floors of bahumali building junagadh which is away from sea shore were accessible

- The average compressive surface strength observed in columns, beam and slabs from rebound hammer test in all the floors comes out to be 22.58 N/mm2, 20.86 N/mm2, & 18.30N/mm2 in bahumali building junagadh while the building near sea shore it can be found out 23.42 N/mm2, 17.53N/mm2, & 17 .12N/mm2 respectively .

- The UPV test in the structure shows overall condition to be GOOD QUALITY OF CONCRETE of building away from sea shore while the quality of concrete were poor of building near sea shore

- The cores which were extracted from the bahumali building junagadh exhibited an average compressive strength of 18.75 N/mm2.while it can be 12.99 KN/mm2 found in building near seashore .

- Carbonation depth test were carried out for both the exposure condition and it was negligible for the building away from sea shore while it was 54 mm for core extracted from building near sea shore

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