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Feasibility Study of RC Structure for Additional Floor using Ndt Approach-A Case Study

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Abstract**: Non-Destructive testing is unique approach to check the soundness and feasibility of the structure. It is a type of testing which is carried out to the different members of the structure with-out causing any damage to the structure, NDT is effectively used to assess the structural feasibility and it has been proved best for RC structures. NDT&E is normally used to evaluate the strength of the structure. Aging and defects in the concrete structures leads to failure of the RC members hence NDT can effectively use for the investigation. In recent years, innovative NDT methods, which can be used for assessing the strength of existing structures, have become available for concrete structures, but are still not established for regular inspections. Concrete is normally good in compression and weak in tension so steel is incorporated in concrete to take up the tensile force and aging of the concrete leads to corrosion of steel and it may fail because of its in-efficiency. There are many methods available to assess the strength of the concrete, Normally NDT is carried out in two types surface testing technique and through testing technique. The present paper describes how the site investigation is carried out at site and normally which tests will be suitable at site. For surface tests rebound hammer test is carried out and for through test ultra-sonic pulse velocity test is carried out. The present paper also describes the calibration of these tests & checking the quantity of concrete structural member.**

Keywords—Non destructive testing(NDT), Non destructive testing and evaluation(NDT&E), RC Structures, Rebound hammer, Evaluation, Compressive strength,Calibration

I. INTRODUCTION

It is sometime necessary to test concrete structures after the concrete has hardened to determine whether the structure is feasible enough to with stand its designed load. Ideally such testing should be done without damaging the concrete structures. Non- Destructive Testing is a form of testing to be carried out on various Building and RC members without causing any damage to the structure. NDT is widely used on concrete, the same can be easily applied for other building. Materials /members. Concrete is a complex material and has been used in construction industry for its compressive strength and NDT is a one of the technique to assess its behavior. This paper covers case study of NDT on concrete as well as other building elements.. NDT application to concrete can be broadly divided into two methods i.e. surface testing and through testing.

A. Surface Testing Technique:

In this technique generally Schmidt Hammer & pull off tester. These tests are practically used to determine the compressive strength of concrete. NDT can measure the compressive strength of in situ concrete directly but all the tests measure some other property of concrete like surface hardness, toughness, penetration resistance etc. and the compressive strength is deduced based on empirical formulae. In present case, a study on Schmidt hammer is carried out

B. Through Testing Techniques:

In this technique generally Ultrasonic Pulse Velocity, impact echo, etc.. All these techniques have a common theory of passing some form of waves, either high frequency sound or electromagnetic or mechanical or light etc., through the body of concrete to assess the quality of the same. Non-destructive testing can be applied to both old and new structures. For new structures, the principal applications are likely to be for quality control or the resolution of doubts about the quality of materials or construction. In present case, a study on Ultra-sonic pulse velocity is carried out

II. SITUATIONS WHERE NDT MAY BE USEFUL

The following are the situations where NDT technique can be adopted.

- To know the quality of quality of concrete in precast or cast in-situ structural members.
- To check the workmanship involved in batching, mixing, placing, compacting and curing of concrete.
- To check the strength of existing structure.
- To know the quantity and position of reinforcement in structural members.
- To check the long term changes in the concrete properties
- To check the durability of the concrete.

- To determine the concrete uniformity.

III. METHODOLOGY

The steps involved in assessing the feasibility of a structure are as follows

- Measurement of dimensions of a building.
- Physical observations (if any).
- Conducting Non-destructive test for different structural members.
- Analyzing the structure from the data obtained from NDT Techniques using e-tab or staad-pro software.

A. Measurement of dimention of the building

To prepare the layout of a building, dimensions of different RC members are measured. This dimentional measurement will be usefull in design of the additional floor

B. Physical observations

Physical observations are made to know the distress in building if any like any damage, cracks, settlement of foundation."

C. NDT Tests carried out at site

NDT tests are carried out for structural members to know the quality, strength, reinforcement details, corrosion of steel etc. Following are instruments used to conduct non-destructive test.

- Rebound hammer test.
- Ultrasonic pulse velocity test.
- Profometer /cover meter.
- Carbonation test.
- Half cell potentiometer test.

In this paper discussion about the Rebound hammer test, Ultrasonic pulse velocity test and profometer / cover meter test are carried out & same is presented and the evaluation of structural feasibility for additional floor is discussed

- **Rebound hammer test**

Rebound hammer is the oldest technique used to assess the compressive strength of concrete indirectly and also to compare the various parts of structure. Schimdt rebound hammer is the instrument for this test. Schmidt rebound hammer shown in Fig1 is a simple, handy tool, which can be used to provide a convenient and rapid indication of the compressive strength of concrete. It consists of a spring controlled mass that slides on a plunger within a tubular housing.

Fig 1. Rebound hammer

It works on the principle that the rebound of an elastic mass depends on the hardness of the surface against which the mass impinges. The correlation of compressive strength of concrete and rebound hammer numbers./indices can be obtained by calibration charts.

Calibration of Rebound hammer

Calibration chart can be obtained by conducting rebound hammer test on concrete cubes of different grades or different mix proportions and the compressive strength of cubes can be determined by testing the in Compression testing machine. Calibration graph is obtained as shown below

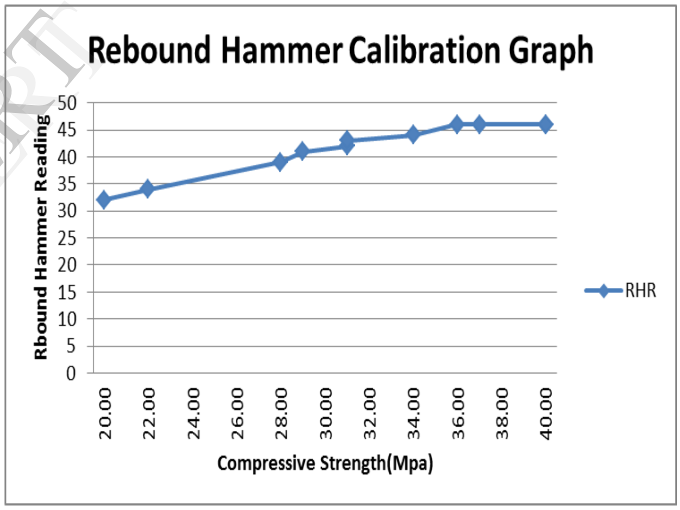

Fig2: Correlation between compressive strength of concrete and rebound hammer number

The calibration chart obtained is used to know the compressive strength or grade of concrete with respect to rebound hammer number.

- **Ultrasonic pulse velocity(UPV) test**

The method consists of measuring velocity of a pulse through concrete with transducer and receiver. A pulse of longitudinal vibrations is produced by an electro-acoustical transducer, which is held in contact with one surface of the concrete under test. When the pulse generated is transmitted into the concrete from the transducer using a liquid coupling material such as grease or cellulose paste, it undergoes multiple reflections at the boundaries of the different material phases within the concrete. A complex system of stress waves develops, which include both longitudinal and shear waves,

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and propagates through the concrete. The first waves to reach the receiving transducer are the longitudinal waves, which are converted into an electrical signal by a second transducer. Electronic timing circuits enable the transit time T of the pulse to be measured.
Longitudinal pulse velocity (in km/s or m/s) is given by:

$$V = \frac{L}{T}$$

where
v is the longitudinal pulse velocity,
L is the path length,
T is the time taken by the pulse to traverse that length.

Fig 3. Ultrasonic pulse velocity testing instrument

Calibration chart for UPV test

The calibration chart between compressive strength of concrete and ultrasonic pulse velocity can be obtained by testing the concrete cubes different grades by ultrasonic pulse velocity testing machine and compressive testing machine. The calibration chart is as shown below.

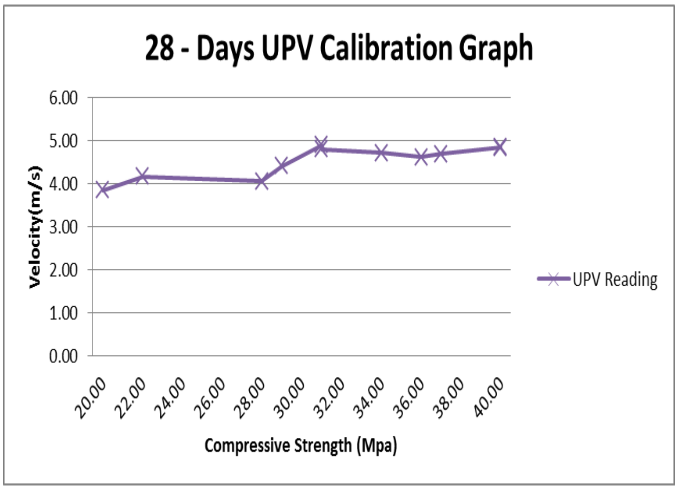

Fig 4 Showing the calibration chart for compressive strength and ultrasonic pulse velocity.

The calibration chart obtained is used to know the compressive strength or grade of concrete with respect to Ultra sonic pulse velocity readings

- **Profometer or cover meter test.**

Electromagnetic methods are commonly used to determine the location and cover to reinforcement embedded in concrete. Battery-operated devices commercially available for this purpose are commonly known as cover meters. A wide range of these is commercially available and their use is covered by BS 1881: Part 204
Electromagnetic cover meters can be used for: quality control to ensure correct location and cover to reinforcing bars .investigation of concrete members for which records are not available or need to be checked. Cover meter not only gives the details of concrete cover but also the steel used and the location of the steel. location of reinforcement as a preliminary to some other form of testing in which reinforcement should be avoided or its nature taken into account, e.g. extraction of cores, ultrasonic pulse velocity measurements or near to surface methods

Fig 5 Cover meter

IV. A CASE STUDY

The production block of Bangalore dairy, BAMUL, KMF Pvt Ltd has been investigated for the feasibility of the structure to accommodate an additional floor in the existing building, A detailed feasibility study was carried out at the site to assess the suitability of the structure to take up the load of the proposed additional floor

Fig 6: Existing Production block of the BAMUL,KMF

As mentioned earlier studies were performed Later depending the results of the of Nondestructive testing the existing building is analysed for the additional floor

For the analysis, a typical frame model and of single storey of height 3 m is modeled using ETABS v9.7.4 software as the building was at the site(Production Block, BAMUL BANGALORE DIARY). The column cross section is taken as 0.45m x 0.45m. Beam size is taken as 0.45m x 0.50 m. The floor slabs are modeled as plates of 0.15m thickness. All the supports are modeled as fixed supports. The material property obtained at the site is as follows by NDT technique

Grade of concrete for columns : $25N/mm^2$
Grade of concrete for beams : $20N/mm^2$
Grade of concrete for slab : $20N/mm^2$

The analytical results shows hat the feasibility of the structural members such as footing, beams, columns, slabs are enough to take the extra load of the proposed additional floor .

V. RESULTS AND DISCUSSIONS

The analytical check of the footing has been done it is shown in Table 1 below and depth of the footing is 300 mm at site so check for depth is also made and found that it is safe as per the ETABS Analysis From the test results it is observed that the depth of footing is sufficient enough to withstand the proposed additional floor load

Table 1: Comparison of Actual and analytical results of footing

Comparison of footing			
Point right portion	***Area(mm2)***	***Actual depth(mm)***	***Depth check(mm)***
1	6.25		241
3	6.25		275
11	6.25		235
20	6.25	**300 mm**	146
29	6.25		196
36	6.25		58
42	6.25		257
left portion			
2	6.25		271
9	6.25		158
14	6.25		79
23	6.25	**300 mm**	117
25	6.25		101
33	6.25		112
52	6.25		280

The analytical check of the Slab has been done it is shown in Table 2 below according to ETABS revealed that, the size and reinforcement provided for the slabs are found to be in order. Steel mapping has been done using cover meter and the results are presented in the Table 2 it is inferred that the steel provided at site is adequate as compared to the analytical results.

Table 2 Comparison of Actual and analytical results of slab

COMPARISION OF DESIGN DATA OF SLAB OF PRODUCTION BLOCK					
Probable reinforcement at the site			***Design data sheet of slab of right portion production block***		
Area locn	spacing 12 ø mm c/c		Area	spacing 12 ø mm c/c	
	Main	Distribution		Main	Distribution
1	120	150	F1	100	300
			F1	101	300
2	110	180	F2	100	300
			F2	101	300
3	120	180	F3	72	300
			F3	73	300
29	100	150	F29	110	300
			F29	112	300
31	110	150	F31	110	300
			F31	300	300
32	100	150	F32	68	300
			F32	300	146

The Analytical check on beams was carried out considering the critical forces from the analysis. From the design check it is observed that the size and area of the reinforcement provided in existing beams are found to be in order.

Table 3: Comparison of Actual and analytical results for Beams

Reinforcement Details according to ETABS			**Probable Reinforcement at the site**	
beam	***No. of 25 dia***		***beam***	***No. of 25 dia***
B4	4	2	4	4
B4	1	5		
B23	2	6	23	4
B23	6	3		
B27	17	13	27	3
B41	0	2	41	4
B41	2	1		
B48	5	3	48	4
B48	1	5		
B50	1	4	50	4
B50	4	2		
B57	5	3	57	4
B57	1	6		

B69	6	3	69	4
B69	2	6		
B77	0	2	77	4
B87	1	1	87	4

CONCLUSIONS

From the results of non-destructive test and analytical study, it is inferred that the quality / strength of concrete in the tested RC Columns, beams and slabs are as follows

[1] The strength of concrete in the tested RC columns, Beams and Slab is found to be 25kN/mm^2, 20kN/mm^2 and 20kN/mm^2 Respectively.

[2] From the cover meter/ profometer study, the cover of concrete provided to the rebar's is adequate in the tested RC structural members

[3] The data obtained from NDT techniques like grade of concrete, cover of concrete, and the reinforcement details, used to evaluate the current strength condition of the building using e-tab software and found satisfactory with existing results.

[4] From the profometer studies it is observed that the reinforcement provided is more than the required as per analytical results.

[5] The results obtained from ultra sonic pulse velocity and rebound hammer were found to be satisfactory

[6] From the theoretical analysis and design verification, it is found that the existing building have enough strength to bare the proposed additional floor loading condition.

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