Assessment Of Structural Soundness And Feasibility Of Additional Floor Over The Existing Administration Building- Case Study

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ABSTRACT

The project work is focused on feasibility study for construction of an additional floor over the existing reinforced concrete administration building of an educational institution. The prime importance in the work is given to the understanding of structural assessment process and its interpretation to know the actual strength, intensity of damage occurred, amount and place of restoration needed. In order to ascertain the structural soundness of the existing building, for the proposed additional floor non - destructive evaluation was carried out. For this purpose, Ultra sonic pulse velocity test, rebound hammer test, carbonation test, half -cell electrical potential test, cover meter studies and chemical analysis on concrete samples were performed. Based on visual inspection & test results some remedies are recommended for repairing the distressed and damaged components of the building.

1.0 Introduction

Non destructive testing (NDT) is generally described as testing that imparts little or no damage to concrete although it usually requires sampling or removing a small amount. NDT has its application in all types of structures including buildings, bridges, dams, foundations and pavements. Assessment of the existing properties of reinforced concrete structures is crucial to evaluate their performance. Therefore, non-destructive evaluation (NDT) has seen significant developments in the last three decades. Most of the times when modifications in the existing structures or additional usages are proposed the process begins with the performance of NDT. NDT is primarily carried out for quality control, identification of problems, assessment of existing condition for retrofitting and quality assurance or concrete repair. The existing administration building of PES college of engineering is a r.c. framed structure with infilled masonry walls comprising ground plus upper floor only.

2.0 Literature Review

Investigation of Structural Defects and Renovation of a RC Residential Building by Dr. Akil Ahmed, Prof. Mehtab Alam, and Dr. Asif Husain [1] The focus of this work was to describe an investigation, about detecting the causes of some structural defects in a multistoried reinforced concrete residential building and its remedies for renovation. For this purpose, non-destructive testing for distressed columns, physical tests for reinforcing bars, chemical tests for concrete and water were carried out. In addition, the structural drawings were checked with the detailed design calculation. Based on the analysis of the test results, visual inspection and design calculation, some remedies are recommended for repairing, and strengthening the distressed and damaged components of the building.

Structural Soundness of Buildings byM. J. Monteiro andN. J. Pathak [2] dealt with methods of estimating the soundness of existing structures whose life has crossed the age of 30 years. As we know concrete is widely used as a construction material because of its high strength-cost ratio in many applications. The deterioration of buildings or damage can be a result of various factors including fire damage, frost action, chemical attack, corrosion of steel etc during the life span of the structure. The investigation of soundness is thus essential for finding the present serviceability of the structure and its scope for future developments or for the change in its utilization. Such an investigation can be carried out using the following methods: a) Visual examination b) Non Destructive Testing c) Partial Destructive Testing. Soundness estimation becomes essential for buildings hit by an earthquake, a bomb blast or any other calamity.

NDT Investigations for Strength and Durability of Chloride-induced Corrosion of rehabilitated RCC structure by M. Raja Shaker and Ramesh R Reddy[3] is focused on extensive and detailed non destructive tests (NDT) evaluation on a reinforced concrete structure exposed to corrosive chemical fumes for 35 years to analyze reasons of distress. Condition assessment was taken up by conducting NDT like ultrasonic pulse velocity, rebound hammer, core extraction for compressive strength, pH, chloride content etc., and half-cell potential and resistivity tests. NDT were conducted on exposure of structure to corrosive chemical fumes for thirty years before patch repairs, three years after patch repairs with polymer modified mortar. On subsequent failure of patch repairs further NDT were conducted extensively on selected structural members from bottom to top of portal frames. Structure was refurbished with M35grade self-compacting concrete. Further monitoring with non destructive tests at specified intervals and embedded corrosion monitoring sensors measurements analysed in terms of electrochemical, chemical and mechanical properties of concrete have confirmed the continuance of alkalinity of concrete with required strength and durability of structure

Assessing the structural integrity of existing building structures by A. D. Abdul'Azeez1, I. K. Zubairu, D. Dahiru and U. A. Ahmed[4] paper presents the results of condition assessment of selected building structures in Ahmadu Bello University, Zaria, Nigeria with a view to establishing structural adequacy, safety and reliability. Visual inspection and detailed condition assessment to obtained general information of the buildings and structural defects, damages, distress, deformation and/or material deterioration was carried using some of the non-destructive test (NTD) techniques. A total of eight buildings were considered and in each building three structural elements (each) namely columns, beams and slabs were studied. Results show that although deterioration was observed which was mainly due to environmental factors, and lack of regular maintenance. The result of the study shows that all the buildings examined have a mean compressive compressive strength, ranging between 51N/mm2 and 57.3N/mm2, which is well over and above the minimum provided by British Standards of 21N/mm2. This is very important in view of the fact that emphasis is made on sustainability in almost all development activities. Thus, this research would enable authorities/management to take an informed decision of maintaining these structures, instead of demolishing them. It also enables users of such buildings to have rest of mind – that the structural integrity of the buildings are, indeed, intact; as such, no need for apprehension

2.1 Summary

In line with the above works, many research works have been carried out for assessing live structures to their actual field strength. The works have underlined the importance of NDT in evaluating the structural strength of distressed buildings.

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2.2 Objectives

This project work is focused:

- To ascertain the structural soundness of the existing reinforced concrete administration building for the proposed additional floor by nondestructive testing/evaluation.

- To recommend suitable restoration / remedial measures for distressed and deficient individual reinforced concrete elements based on extent and amount of distress.

3.0 Methodology

In order to evaluate the structural soundness of the building following tests are to be resorted:

1. a) Dimensional measurement of building
   b) Inspection of foundation system by making trial pits
2. Non-destructive test to assess the quality / strength of in-situ concrete
   - Ultrasonic Pulse Velocity Test
   - Rebound hammer test
3. Covermeter studies
4. Half-cell potential measurement test on RC members
5. Carbonation test on RC members
6. Chemical analysis on concrete samples
   - Chloride determination test in concrete samples.
   - Sulphate determination test in concrete samples.
   - Determination of pH level in concrete.

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1. **a)Dimensional measurement of structural members:**

As the relevant drawings were not made available, a detailed physical measurement was carried out at site, in order to obtain the dimensions of the various members for making layout drawings of the building. The dimension of typical footings (after exposing typicalcolumnfootings),masonrywalls,columns,beams were physically measured and recorded for theoretical verification.

b) Inspection of founding system by making trial pits:

It was observed that the foundation system for columns consist of r c isolated concentric footings resting on hard rocky strata.

2. **Non-destructive tests to assess the quality / strength of in-situ concrete in RC members:**
   Ultrasonic Pulse Velocity test on RC Columns & Beams: Ultrasonic Pulse Velocity test was conducted on RC columns and beams at random at all accessible regions of the building in all the blocks. The test was conducted using **"PUNDIT"** (Portable Ultrasonic Non-destructive Digital Indicating Tester).
   Rebound Hammer test on RC footings and Slabs: Rebound Hammer test was carried out on the RC footing and slabs at random to assess the surface hardness / quality and strength of in-situ concrete in all the blocks. The tests were conducted using **Schmidt Rebound Hammer from M/s Proceq,** Switzerland as per guidelines in Indian standards IS: 13311-(part -2)-1992-(reaffirmed in 2004)
3. **Cover meter studies to map the disposition and probable dia of peripheral rebars in RC members:** Cover meter test was carried out on RC members at random, in order to assess the thickness of cover concrete, disposition and probable diameter of embedded peripheral rebars. The test were conducted using Profometer -5 from M/s Proceq, Switzerland as per the guidelines furnished by the manufacturer's manual. Results of the tests were recorded for theoretical verification
4. **Half-Cell Potential Measurement test on RC members.** Half-Cell Potential Measurement test was carried out on RC members at random using **Copper-Copper-Sulphate-Half-Cell** to estimate the proneness of corrosion in reinforcing bars. The test was conducted using **CANIN** equipment from M/s Proceq, Switzerland as per the guidelines furnished by the manufacturer's manual.
5. **Carbonation test on RC members:** Carbonation of concrete occurs when the carbon dioxide, in the atmosphere in the presence of moisture, reacts with hydrated cement minerals to produce carbonates, e.g. calcium carbonate. The carbonation process is also called depassivation.Carbonation test was carried out on RC members at random using **phenolphthalein indicator** in 0.1 N methyl alcohol solution to assess the extent of carbonation in cover concrete.
6. **Chemical analysis on concrete samples:**
   In addition to the above tests, concrete samples were collected from r c members and tested in laboratory for determination of following:

a. **Chloride Determination test in concrete samples.**
Chloride determination test is carried out on concrete to estimate the level of chlorides in the concrete. The presence of higher amount of chlorides in concrete surrounding the reinforcement will result in corrosion of rebars. The quantity of chlorides in concrete is determined generally by chemical analysis. As per cl:8.2.5.2 table-7,of IS:456-2000 limits of acid soluble chloride content in reinforced concrete or plain concrete containing embedded metal should not exceed **0.6 kg/Cu.m**

b. **Sulphate determination test in concrete samples**
Sulphate determination test in concrete is carried out to estimate the level of sulphates in the concrete. The presence of higher amount of sulphates in concrete will result in reaction of calcium present in cement with sulphates, resulting in deterioration of concrete. As per cl: 8.2.5.3 of IS: 456-2000 the total water soluble sulphate content of the concrete mix expressed as SO_3 should not exceed **4%** by mass of the cement in the mix.

c. **Determination of pH level in concrete.**
The level of pH in fresh concrete is generally in the range of 12 to 14. Due to carbonation, the pH value of concrete will be reduced considerably. When the pH value

falls below about 10, the alkalinity of the concrete will not be adequate to protect the rebars against corrosion.

4.0 Test results

Sl. no	Element assessed	Type of test	Result	Evaluation
1	**RC Column F-28***	UPVT test	Avg.pulse velocity is 3.6km/sec, Estimated compressive strength **19N/sq.mm**	Satisfactory
		Cover meter rest	Range of cover concrete **60to70mm**	Satisfactory
		Half-cell potential diff.measurement test	Measured potential difference **(mv) -460 to -480**	High probability of Corrosion
		Carbonation test	Depth of carbonation **60 mm**	Carbonated
		Chloride test	Chloride content **0.27 kg/cum**	Satisfactory
		Sulphate test	Sulphate content SO_3(%) by mass **2.69**	Satisfactory
		pH test	**9.10**	pH shall not be less than 10 as per studies carried out
2	**RC Slab [L6-L7]* [M6-M7]***	Rebound hammer test	Avg. rebound number is 30,estimated comp strength is **18/sqmm**	satisfactory
3	**RC footing Q19***	Rebound hammer test	Avg. rebound number is 32,estimate comp.strength is **20 N/sqmm**	satisfactory

*Grid identification as per typical layout. Fig 1

5.0 Results and Discussions

a. From the results of the Ultrasonic Pulse Velocity Test, it is inferred that the estimated comp.strength of in-situ concrete in most of the tested r.c. members is in the range of **15.0 N/sq.mm** to **20.0 N/sq.mm** and quality of concrete in the tested r.c. columns and beams is quite satisfactory.

b. From the results of the Rebound Hammer Test, it is inferred that the estimated comp.strength of concrete in the tested r.c. slab is in the range of **16.0 N/sq.mm** to **20.0 N/sq.mm** which is quite satisfactory.

c. The Covermeter studies indicated that the cover concrete provided for reinforcement a of r.c. members confirms to required standard.

d. From the results of chemical analysis, it is found that the chloride and the sulphate

contents in concrete are just within the permissible limits. However, it is observed that pH value of concrete is less than the acceptable limit and the cover concrete has lost its alkalinity due to carbonation effect; resulting in corrosion of rebars especially in peripheral r.c columns and some of the r.c members.

e. From the results of chemical analysis, it is found that the chloride and the sulphate contents in concrete are just **within the permissible limits**. However, it is observed that pH value of concrete is less than the acceptable limit and the cover concrete has lost its alkalinity due to carbonation effect; resulting in corrosion of rebars especially in peripheral r.c columns and some of the r.c members.

f. From the results of the theoretical verification, it is inferred that the construction of additional floor (i.e. second floor) is structurally feasible up to grid 26 only. However strengthening of columns L-11, L-27, P-22 and P-25 of ground floor and first floor is required to be carried out to overcome the existing structural deficiency

Remedial measures for treatment of structurally deficient r.c. columns by encasement:

- The existing plaster to be removed completely by gentle chipping and surface to be cleaned with air and water jet.
- Proposed reinforcement to be fabricated and placed in position as per sketch enclosed.
- A coat of bonding epoxy shall be applied on the prepared surface.
- 75 mm thick, M30 grade concrete encasement with 10mm down size aggregates shall be provided as per specification enclosed using slurry tight shuttering.
- The encased concrete surface to be provided with chemical resistant protective coating such as Polyurethene as per manufacturer's Specification.

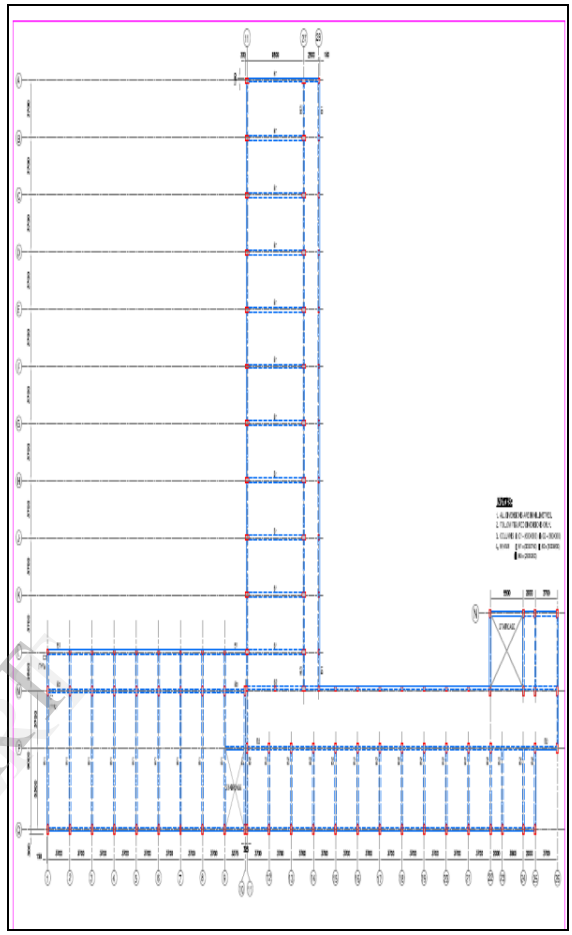

Fig 1 Typical layout of column and beams

5.0 Concluding remarks:

The remedial measures suggested were implemented as per the technical specifications. Based on the results of the feasibility study, construction of one additional floor i.e. second floor above the existing building up to grid-26 is feasible after strengthening the structurally deficient columns and also the corrosion affected columns. On carrying out the recommended remedial measures effectively by an experienced agency under the guidance of experienced technical personnel, the existing building was rendered safe and normal.

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