STRUCTURAL HEALTH MOINTORING OF AN EXISTING BUILDING BY NON-DESTRUCTIVE EVALUATION USING REBOUND HAMMER

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ABSTRACT: The objective of work is to carryout Structural Health Monitoring of building based on Non Destructive testing using Rebound Hammer. For our work we have considered a 5-storey educational building which is nothing but the U-Block of Usha Rama College of Engineering & Technology. There is a need for regular monitoring and maintenance of the structure for achieving increased life and service of the structure. In total there are 509 columns in U-Block. Each floor of the 5-floored structure consists of 102 columns. These are divided in to three parts, one as Part-A: 265mm x 640mm (2 no's), Part-B: 275mm x 375mm (74 no's) and the other as Part- C: 265mm x 270mm (26no's). All the columns were assessed. WTC-Model H Concrete Rebound Test Hammer Non-Destructive equipment is used in the present work. The range of compressive strength values measured on Part-A columns vary from 30 to 50N / mm2, the range of compressive strength values measured on Part-B columns vary from 20 to 50N / mm2 where as the range of compressive strength values measured on Part-C columns vary from 20 to 40 N / mm2 respectively. Similar values were obtained for all the floors. The outcome of the project can be used as the basis for repair and maintenance works to be carried out for enhanced life and service of the structure.
KEYWORDS: Structural Health Monitoring, Non Destructive Testing, Concrete, Rebound Hammer, Compressive Strength.

I. INTRODUCTION

1.1 GENERAL

The process of implementing a damage detection and characterization strategy for engineering structures is referred to as structural health monitoring (SHM). The life of each structure is far from being monotonous and predictable. Much like our own existence, its evolution depends on many uncertain events, both internal and external. Some uncertainties arise right during construction, creating structural behaviors that are not predictable by design and simulations. Once in use, each structure is subject to evolving patterns of loads and other actions. Often the intensity and type of solicitation are very different from the ones taken into account during its design and in many cases they are mostly unknown in both nature and magnitude. The sum of these uncertainties created during design, construction and use, poses a great challenge to the engineers and institutions in charge of building safety, maintenance and operation. Defining service levels and prioritizing maintenance budgets relying only on models and superficial observation can lead to dangerous mistakes and inefficient use of resources. Regular inspection can certainly reduce the level of uncertainty, but still presents important limitations being limited to the observation of the structure's surface during short times spaced by long periods of inactivity.

1.2 NON DESTRUCTIVE TESTING OF CONCRETE

It is often necessary to test concrete structures after the concrete has hardened to determine whether the structure is suitable for its designed use. In recent years, innovative NDT methods, which can be used for the assessment of existing structures, have become available for concrete structures, but are still not established for regular inspections. Therefore, the objective of this project is to study the applicability, performance, availability, complexity and restrictions of NDT. The purpose of establishing standard procedures for nondestructive testing (NDT) of concrete structures is to qualify and quantify the material properties of in-situ concrete without intrusively examining the material properties. There are many techniques that are currently being research for the NDT of materials today. The present work focuses on the NDT methods relevant for the inspection and evaluation of concrete materials.

1.3 OBJECTIVE OF WORK

The main objectives of the present project work are listed below. Due to certain limitations like time, availability of equipment, etc., the experimental work has been limited to the use of Rebound Hammer for evaluation of columns only.

1. To calibrate the Rebound hammer available by correlating the compressive strength obtained from conventional cubes testing and Rebound Values.
2. To evaluate the compressive strengths of all columns of 5 floors of U-Block existing in the campus of Usha Rama College of Engineering & Technology.
3. To provide critical assessment report on the structural health of the structure.
4. To point out various in-situ problems and to suggest various measures to improve the structure's long life.

II. MATERIAL AND METHODS

2.1 CASE STUDY

For the present work of Structural Health Monitoring based on Non Destructive Testing we have considered a 5-storey educational building which is nothing but the U-Block of Usha Rama College of Engineering & Technology. There is a need for regular monitoring and maintenance of the structure for achieving increased life and service of the structure. Several interfering agents from different sources mostly of environmental, geological, earth quake, manmade may cause deterioration. Hence to check the present condition of the structure, the Non Destructive Evaluation was performed using Rebound Hammer Testing.

The building area was surveyed with tape and measurements were taken. The dimensions of columns were also measured. A total of 509 columns were identified. The detailed Plan of U-Block 5 floors from ground floor to fourth floor are shown in the figures 2.1 and the 3D view of AutoCAD is shown in the figure 2.2.

The U –Block data obtained from survey are fed in to STAAD.ProV8i to develop 3-dimensional view of the building for better visual identification and Locations of nodes are shown in figure 2.3. 3D view of framed U-Block structure is shown in figure 2.4.

Figure 2.1 AutoCAD plan of U-block

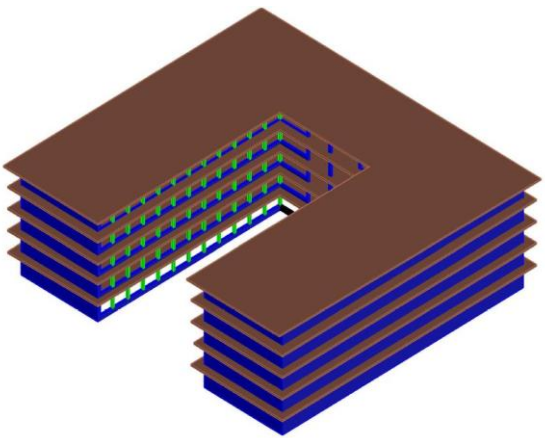

Figure 2.2 3D elevation view of U-Block

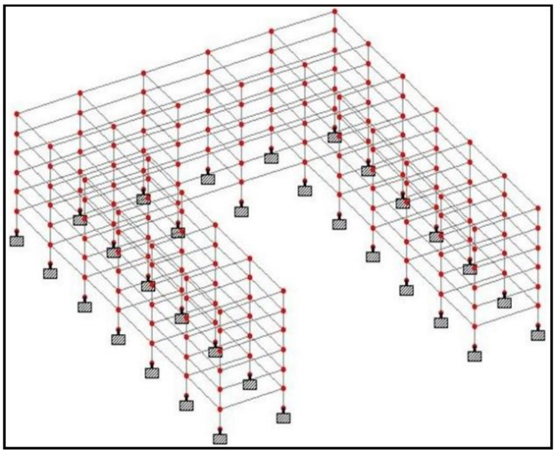

Figure 2.3 Location of nodes in the U-Block

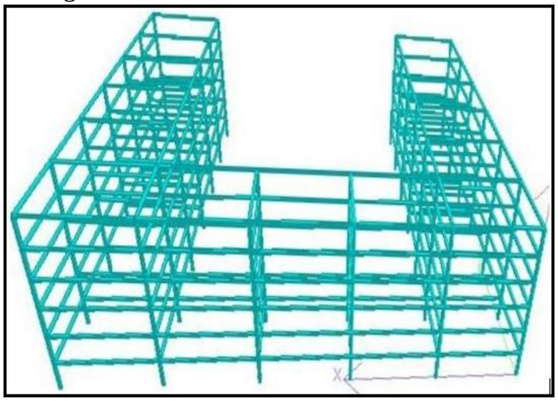

Figure 2.4 3D view of framed U-Block structure

2.1 METHODOLOGY

This section presents the actual method of operation of the available rebound hammer in the field. IS code provides detailed information regarding NDT by rebound hammer in IS-13311(Part 2):1992.

Rebound Hammer

Before commencement of a test, the rebound hammer should be tested against the test anvil, to get reliable results. The testing anvil should be of steel having Brinell hardness number of about 5000 N/mm2. The supplier/manufacturer of the rebound hammer should indicate the range of readings on the anvil suitable for different types of rebound hammer. For taking a measurement, the hammer should be held at right angles to the surface of the structure. The test thus can be conducted horizontally on vertical surface and vertically upwards or downwards on horizontal surfaces. The correlation between rebound values and compressive strength has been established and used by various works. For this project work the correlation graph adopted is given in Figure 2.6 below. WTC-Model H Concrete Rebound Test Hammer is used in the present work shown in figure 2.5.The correlation between rebound values and compressive strength has been established and used by various works. For this project work the correlation graph adopted is given in Figure 2.7

Figure 2.5 Rebound Hammer used for work

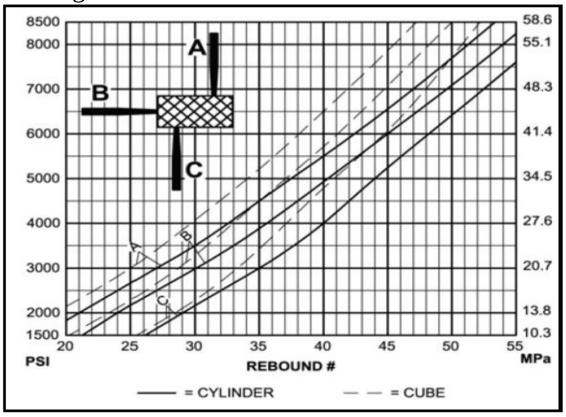

Figure 2.6 Concrete Rebound Hammer correlation curves

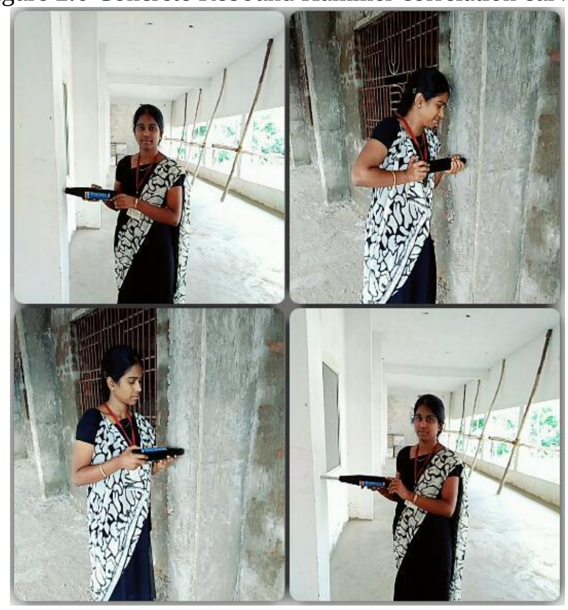

Figure 2.7 Taking reading of column of U Block using Rebound Test Hammer

III. EXPERIMENTAL INVESTIGATION & TEST RESULTS

The experimental work was conducted on U-Block with WTC-Model H Concrete Rebound Test Hammer and readings were taken for all the columns of each floor. The reading for each column was taken at nearly the half height of the column. Like this all the columns in the five floors were tested with rebound hammer and the results were tabulated. Total numbers of columns tested are 509. Some of the results obtained for columns of Part-A, Part-B and Part-C are given in the following Tables 3.1, 3.2&3.3:

Table 3.1 Column Rebound Hammer Test Values for Ground Floor (Part- A)

COLUMN NO	COLUMN DIMENSIONS	REBOUND VALUE	COMPRESSIVE STRENGTH (N/mm^2)
1	265mmX640mm	45	41

Table 3.2 Few Column Rebound Hammer Test Values for Ground Floor (Part- B)

COLUMN NO	COLUMN DIMENSIONS	REBOUND VALUE	COMPRESSIVE STRENGTH (N/mm^2)
1	270mm X 375mm	46	42
2	270mm X 375mm	48	45
3	270mm X 375mm	49	47
4	270mm X 375mm	51	50
5	270mm X 375mm	49.5	48
6	270mm X 375mm	49.5	48
7	270mm X 375mm	46	42
8	270mm X 375mm	46.5	43
9	270mm X 375mm	47	44
10	270mm X 375mm	45	41

Table 3.3 Few Column Rebound Hammer Test Values for Ground Floor (Part- C)

COLUMN NO	COLUMN DIMENSIONS	REBOUND VALUE	COMPRESSIVE STRENGTH (N/mm^2)
1	265mm X 270mm	44	39
2	265mm X 270mm	42	36
3	265mm X 270mm	44	39
4	265mm X 270mm	40	34
5	265mm X 270mm	41	35
6	265mm X 270mm	41	35
7	265mm X 270mm	42	36
8	265mm X 270mm	44.5	40
9	265mm X 270mm	40	34

IV. ANALYSIS OF RESULTS

Table 4.1 Compressive strength classes for Part-A: 265mm X 640mm

Category Attributed	Compressive strength values in N / mm^2
Excellent quality	50-46
Good quality	45-41
Medium quality	40-36
Poor quality	35-30

Table 4.2 Compressive strength classes for Part- B: 270mm X 375mm

Category Attributed	Compressive strength values in N / mm^2
Excellent quality	45-50
Good quality	40-44
Medium quality	30-39
Poor quality	20-29

Table 4.3 Compressive strength classes for Part- C: 265mm X 270mm

Category Attributed	Compressive strength values in N / mm^2
Excellent quality	36-40
Good quality	31-35
Medium quality	26-30
Poor quality	20-25

The rebound values obtained from the experimental work are used to estimate the compressive strength. The resulting compressive strength values for all the 102 columns are studied for analysis. It was observed that compressive strength values measured on large columns are bigger than the compressive strength values measured on small columns. This peculiar difference may be due to the less importance given to the columns at the construction time. The range of compressive strength values measured on small columns vary from 20 to 40N / mm^2 where as the range of compressive strength values measured on large columns vary from 35 to 50 N / mm^2.Base on the test results obtained from the experimental procedures the data can be classified in to Four classes. Hence the compressive strength values obtained for large columns and small columns are suitably divided in to four classes for analysis. The Compressive strength classes for Part-A: 265mm X 640mm (2 no's) are shown in the Table 4.1 and the Compressive strength classes for Part- B: 270mm X 375mm are shown in Table 4.2 and Part C: 265mm X 270mm are shown in table 4.3.

V. RESULTS AND DISCUSSION

The minimum, maximum and average values of compressive strengths of columns of each floor of the building are given in the Table 5.1 below.

Table 5.1 Minimum, Maximum and Average values of compressive strengths

FLOOR	COLUMN DIMENSION	COMPRESSIVE STRENGTH MIN	MAX	AVERAGE
GROUND FLOOR	265mmX640mm	-	41	41
	270mmX375mm	22	50	43.38
	265mmX270mm	20	40	33.60
FIRST FLOOR	265mmX640mm	47	49	48
	270mmX375mm	20	50	43.66
	265mmX270mm	21	40	33.87
SECOND FLOOR	265mmX640mm	46	47	46.5
	270mmX375mm	26	50	43.55
	265mmX270mm	20	40	34.60
THIRD FLOOR	265mmX640mm	46	49	47.5
	270mmX375mm	26	50	40.08
	265mmX270mm	23	40	35.03
FOURTH FLOOR	265mmX640mm	35	47	41
	270mmX375mm	26	50	41.25
	265mmX270mm	24	40	34.24

The compressive strengths of columns for five floors are shown in the form of bar-graphs from Figure 5.1, Figure 5.2 and Figure 5.3

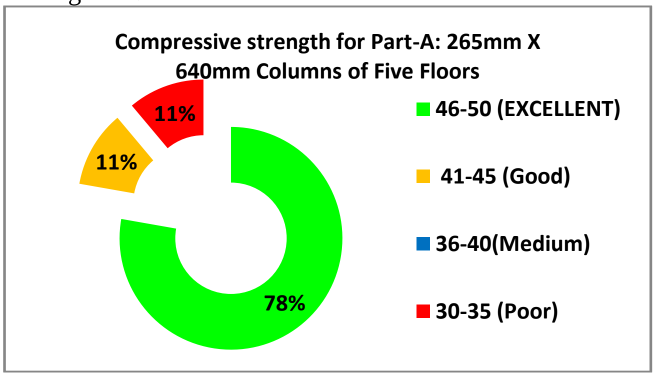

Figure 5.1 Compressive Strength of Part-A columns of five floors

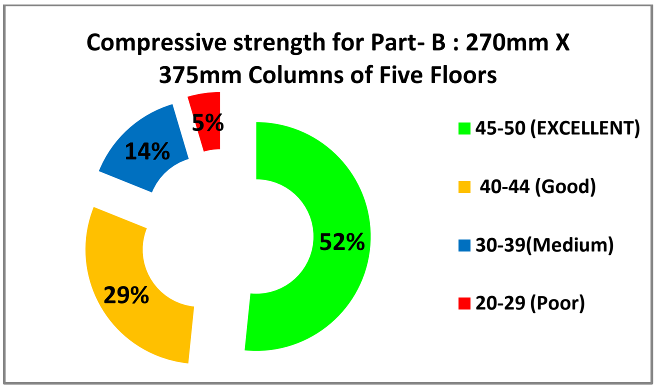

Figure 5.2 Compressive Strength of Part-B columns of five floors

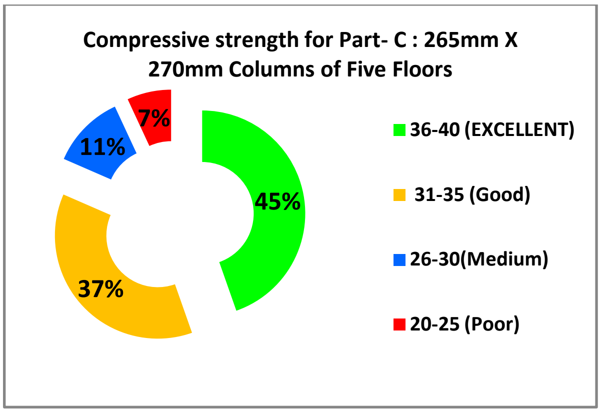

Figure 5.3 Compressive Strength of Part-C columns of five floors

VI. CONCLUSIONS

The following are the conclusions summarized:

1. The building consists of columns of three different sizes viz., 265mm X 640mm (Part-A),270mm X 375mm(Part-B) and 265mm X 270mm (Part-C)
2. The work has been limited to the testing of columns only.
3. Each Floor consists of 102 columns and total 509columns were tested.
4. WTC-Model H Concrete Rebound Test Hammer is used in the present work.
5. The instrument was first calibrated with cubes testing and found reasonable.
6. Each floor column compressive strength values are divided in to four classes as per the data ranged availability.
7. Compressive strength in the range 35-30 N/mm^2 classified as Poor quality, 40-36 N/mm^2 classified as Medium quality, 45-41 N/mm^2 classified as Good quality and 50-46 N/mm^2 classified as Excellent quality for Part-A columns. This classification is purely based on the data ranges available.
8. Compressive strength in the range 20-29 N/mm^2 classified as Poor quality, 30-39 N/mm^2 classified as Medium quality, 40-44 N/mm^2 classified as Good quality and 45-50N/mm^2 classified as Excellent quality for Part-B columns.
9. Compressive strength in the range 20-25 N/mm^2 classified as Poor quality, 26-30 N/mm^2 classified as Medium quality, 31-35 N/mm^2 classified as Good quality and 36-40 N/mm^2 classified as Excellent quality for Part-C columns.
10. Average compressive strengths in Ground floor for Part-A, Part-B and Part-C columns are 41 N/mm^2, 43.38 N/mm^2 and 33.60 N/mm^2 respectively. Average compressive strengths in First floor for Part-A, Part-B and Part-C columns are 48 N/mm^2, 43.66 N/mm^2 and 33.87 N/mm^2 respectively. Average compressive strengths in Second floor for Part-A, Part-B and Part-C columns are 46.5 N/mm^2, 43.55 N/mm^2 34.6 N/mm^2 respectively. Average compressive strengths in Third floor for Part-A, Part-B and Part-C columns are 47.5 N/mm^2, 40.08 N/mm^2 35.03 N/mm^2 respectively. Average compressive strengths in Fourth floor Part-A, Part-B and Part-C columns are 41 N/mm^2, 41.25 N/mm^2 34.24 N/mm^2 respectively.
11. Over all the structure has adequate compressive strength in all the columns of five floors.

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