NON-DESTRUCTIVE EVALUATION OF STRUCTURAL HEALTH OF A BUILDING USING REBOUND HAMMER

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ABSTRACT

The objective of work is to carryout Structural Health Monitoring based on Non Destructive Testing. For this we have considered a 5-storey educational building which is nothing but the R-Block of Usha Rama College of Engineering & Technology. It has an age of 8 years. 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 725 columns in R-Block. Each floor of the 5-floored structure consists of 145 columns. These are divided in to two parts, one as Part-A: 620mm x 260mm (112 no's) and the other as Part- B: 290mm x 290mm (33no's). All the columns were assessed. WTC-Model H Concrete Rebound Test Hammer is used in the present work. The range of compressive strength values measured on small columns vary from 20 to 45 N / mm² where as the range of compressive strength values measured on large columns vary from 20 to 50 N / mm². Average compressive strengths in Ground floor for large columns and small columns are 43.38 N/mm², 33.60 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*

1. INTRODUCTION

Structural Health Monitoring is the process of implementing a damage detection and characterization strategy for engineering structures like Buildings, Bridges, tunnels, and Dams etc. This has become the latest central topic in the process of repair and rehabilitation of structures, assessment of structural safety and allied structural engineering sciences.

1.1 Structural Health Monitoring

Structural Health Monitoring (SHM) aims to give, at every moment during the life of a structure, a diagnosis of the "state" of the constituent materials, of the different parts, and of the full assembly of these parts constituting the structure as a whole. The state of the structure must remain in the domain specified in the design, although this can be altered by normal aging due to usage, by the action of the environment, and by accidental events. Thanks to the time-dimension of monitoring, which makes it possible to consider the full history database of the structure, and with the help of Usage Monitoring, it can also provide a prognosis (evolution of damage, residual life, etc.). If we consider only the first function, the diagnosis, we could estimate that Structural Health Monitoring is a new and improved way to make a Non-Destructive Evaluation. This is partially true, but SHM is much more. It involves the integration of sensors, possibly smart materials, data transmission, computational power, and processing ability inside the structures. It makes it possible to reconsider the design of the structure and the full management of the structure itself and of the structure considered as a part of wider systems.

The first part of the system, which corresponds to the structural integrity monitoring function, can be defined by: i) the type of physical phenomenon, closely related to the damage, which is monitored by the sensor, ii) the type of physical phenomenon that is used by the sensor to produce a signal (generally electric) sent to the acquisition and storage sub-system. Several sensors of the same type, constituting a network, can be multiplexed and their data merged with those from other types of sensors. Possibly, other sensors, monitoring the environmental conditions, make it possible to perform

the usage monitoring function. The signal delivered by the integrity monitoring sub-system, in parallel with the previously registered data, is used by the controller to create a diagnostic.
Mixing the information of the integrity monitoring sub-system with that of the usage monitoring sub-system and with the knowledge based on damage mechanics and behavior laws makes it possible to determine the prognosis (residual life) and the health management of the structure (organization of maintenance, repair operations, etc.). Finally, similar structure management systems related to other structures which constitute a type of super system (a fleet of aircraft, a group of power stations, etc.) make possible the health management of the super system. Of course, workable systems can be set up even if they are not as comprehensive as described here.
Structural Health Monitoring aims to provide more reliable and up-to-date information on the real conditions of a structure, observe its evolution and detect the appearance of new degradations. By permanently installing a number of sensors, continuously measuring parameters relevant to the structural conditions and other important environmental parameters, it is possible to obtain a real-time picture of the structure's state and evolution. Instrumental Monitoring is a new safety and management tool that ideally complements traditional methods like visual inspection and modeling. Monitoring even allows a better planning of the inspection and maintenance activities, shifting from scheduled interventions to on-demand inspection and maintenance.

1.2 Non Destructive Testing Of Concrete

Structures are assemblies of load carrying members capable of safely transferring the superimposed loads to the foundations. Their main and most looked after property is the strength of the material that they are made of. Concrete, as we all know, is an integral material used for construction purposes. Thus, strength of concrete used, is required to be 'known' before starting with any kind of analysis. In the recent past, various methods and techniques, called as Non-Destructive Evaluation (NDE) techniques, are being used for Structural Health Monitoring (SHM).

1.3 Objective of the Present 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 R-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.

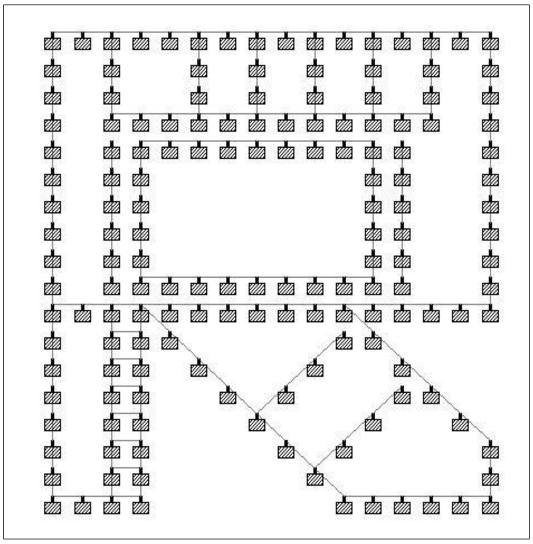
2. MATERIALS & METHOD

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 R-Block of Usha Rama College of Engineering & Technology. It has an age of 8 years. 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.

In total there are 725 columns in R-Block. Each floor of the 5-floored structure consists of 145 columns. These are divided in to two parts, one as Part-A: 620mm X 260mm (112 no's) and the other as Part- B: 290mm X 290mm (33no's). All the columns were assessed.

The building area was surveyed with tape and measurements were taken. The dimensions of columns were also measured. A total of 145 columns were identified. Figure 2.1 shows the Plan map for the R-Block in STAAD.Pro The 3-D view of the structure with 5 floors is shown in the Figure 2.2



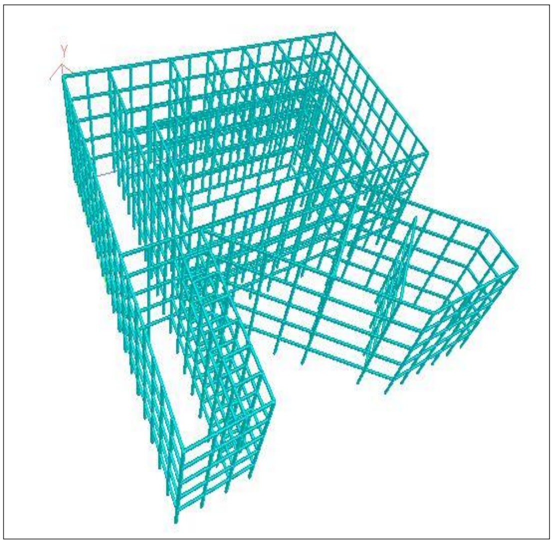


Figure 2.1 Plan map for the R-Block in STAAD.Pro **Figure 2.2 The 3-D view of the structure with 5 floors (R-Block)**

2.2 METHODOLOGY

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. Figure 2.3(a) & (b) shows the WTC-Model H Concrete Rebound Test Hammer is used in the present work.

Figure:2.3(a) WTC-Model H Concrete Rebound Test Hammer is used in the present work. **Figure:2.3(b) Taking reading of rebound value**

3. EXPERIMENTAL INVESTIGATION & TEST RESULTS

The experimental work was conducted on R-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 725. Some of the results obtained for columns of Part-A and Part-B are given in the following Tables 3.1 &3.2:

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

COLUMN NO	COLUMN DIMENSIONS	REBOUND VALUE	MEAN COMPRESSIVE STRENGTH (N/mm^2)
1	620mm X 260mm	46	42
2	620mm X 260mm	48	45
3	620mm X 260mm	49	47
4	620mm X 260mm	51	50
5	620mm X 260mm	49.5	48
6	620mm X 260mm	49.5	48
7	620mm X 260mm	46	42
8	620mm X 260mm	46.5	43
9	620mm X 260mm	47	44
10	620mm X 260mm	45	41
11	620mm X 260mm	35	28
12	620mm X 260mm	50	49
13	620mm X 260mm	51	50
14	620mm X 260mm	48	45
15	620mm X 260mm	46.5	43

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

COLUMN NO	COLUMN DIMENSIONS	REBOUND VALUE	MEAN COMPRESSIVE STRENGTH (N/mm2)
1	290mm X 290mm	44	39
2	290mm X 290mm	42	36
3	290mm X 290mm	44	39
4	290mm X 290mm	40	34
5	290mm X 290mm	41	35
6	290mm X 290mm	41	35
7	290mm X 290mm	42	36
8	290mm X 290mm	44.5	40
9	290mm X 290mm	40	34
10	290mm X 290mm	37	30

Table 3.3 The Compressive strength classes for Part-A: 620mm X 260mm Part-A: 620mm X 260mm

Excellent quality	45-50
Good quality	40-45
Medium quality	30-40
Poor quality	20-30

Table 3.4 The Compressive strength classes for Part - B : 290mm X 290mm Part- B : 290mm X 290mm

Excellent quality	40-45
Good quality	35-40
Medium quality	30-35
Poor quality	20-30

4. DISCUSSION OF TEST RESULTS

The rebound values obtained from the experimental work are used to estimate the compressive strength. The resulting compressive strength values for all the 725 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 45 N / mm^2 where as the range of compressive strength values measured on large columns vary from 20 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: 620mm X 260mm are shown in the Table 3.3 and the Compressive strength classes for Part- B Part- B : 290mm X 290mm are shown in Table 3.4. The percentage of strengths of columns for each floor are shown in the form of pie-charts in Figure 3.2

Table 3.5 Minimum, Maximum and Average values of compressive strengths

FLOOR	COLUMN DIMENSION	COMPRESSIVE STRENGTH		
		MIN	MAX	AVERAGE
GROUND FLOOR	620mm X 260mm	22	50	43.38
	290mm X 290mm	20	40	33.60
FIRST FLOOR	620mm X 260mm	20	50	43.66
	290mm X 290mm	21	40	33.87
SECOND FLOOR	620mm X 260mm	26	50	43.55
	290mm X 290mm	20	40	34.60
THIRD FLOOR	620mm X 260mm	26	50	40.08
	290mm X 290mm	23	40	35.03
FOURTH FLOOR	620mm X 260mm	26	50	41.25
	290mm X 290mm	24	40	34.24

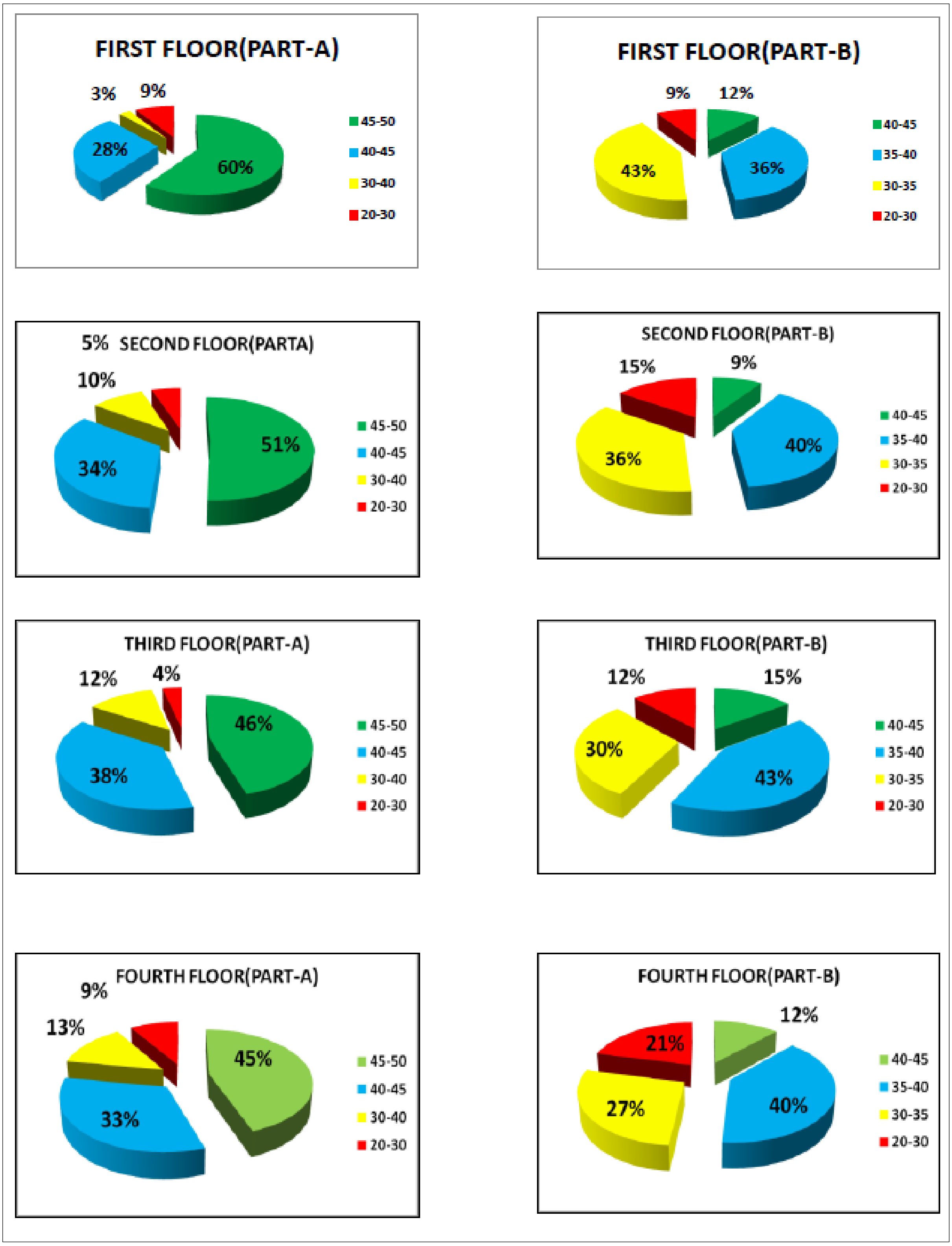


Figure: 3.2 Percentages Of Strengths Of Columns For Each Floor

5. CONCLUSIONS

Various NDT methods can be used depending upon the type & age of structure to check the integrity of structure. USPV, rebound hammer can be applied to newly constructed structures to check the quality of concrete, adequacy of cover before applying live load to the structures.

Non-destructive testing of concrete structures yields valuable information for the engineer when investigating problems and can reveal unanticipated or hidden deterioration. The repair of the structure is guided by the results of the testing. The types of repair will vary by method and cost. In general, repairs need to protect both the undamaged and contaminated concrete elements from future deterioration. However, the structure will still experience some future corrosion, since any repair generally slows down the deterioration process but does not totally eliminate it. From Rebound hammer test results, some of roof slabs showed an average compressive strength of 24 N/mm2 and 21 N/mm2 are need to be repaired to increase the strength. From Rebound Hammer test results, columns and beams have an adequate compressive strength. From Ultra Sonic Pulse Velocity test, a column in ground floor showed a value less than 3000m/s, which falls under doubtful case. However further tests have to be carried out for evaluating concrete grading quality. However the building shows an adequate strength, if actual concrete materials and mix proportioning adopted in a particular structure are available, a suitable correlation can be established between the pulse velocity and compressive strength of concrete

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