Structural Health Monitoring Various Structure By Using Non-Destructive Test.

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Abstract

Structural health monitoring (SHM) is important when it comes evaluating various structures and infrastructure. This involves the inspection, monitoring, and maintenance to sustain economics, enhance quality of, and promote sustainability in civil engineering. Some buildings have also failed due to faulty design or construction. The various causes of structural failure along with the principles of rehabilitation of structures will be discussed in the following content.

The concept of nondestructive testing (NDT) is to receive material properties of in place specimens without destroying specimen nor the structure from which it is taken. However, the one issue that has been prevalent in the concrete industry for years is that the true properties of an in-place specimen have never been tested without leaving a certain degree of damage on the structure.

The use of the ultrasonic pulse velocity tester is introduced as a tool to monitor basic initial cracking of concrete structures and hence to introduce a threshold limit for a possible failure of the structures. Experiments using ultrasonic pulse velocity tester have been carried out, under laboratory conditions, on various concrete specimens loaded in compression until failure.

Key Words: (NDT- Structural health monitoring, Ultrasonic pulse velocity)

1. INTRODUCTION

Ever so since the start of the 20th century, concrete has become the primary building material used in most constructions. After examining numerous structures constructed with concrete, it has been observed that concrete can be vulnerable to deterioration in varying circumstances, making the assessment and rehabilitation of concrete buildings an important issue. Assessment can be extremely beneficial for identifying potential damage to structures and determining the causes of its likelihood. This investigation, based on non-destructive testing (NDT), aims to access information and structural health monitoring for concrete structures, particularly in the context of historic structures. The benefit of this NDT investigation, which prevents structural damage, is a crucial aspect of this study. The ultrasonic pulse velocity and Schmidt rebound hammer were used for this investigation; these methods have been employed for a considerable period to analyze damage, cracks, voids, and other deterioration in concrete structures. Nevertheless, in an extreme environment with high humidity levels in the atmosphere, significant pollution, the presence of CO_2 and chloride contents in the atmosphere, NDT using ultrasonic pulse velocity or rebound hammer can be effectively utilized to predict the service life of the structure, in addition to quality control for both new and old structures, as well as structural health monitoring.

1.1 The generic features of NDT methods are discussed:

1. Rebound Hammer
2. Ultrasonic Pulse Velocity Test
3. Profoscope

1.1.2 REBOUND HAMMER

The rebound hammer test is a quite common method used in the construction field to assess the strength compressing of concrete structures. It operates by striking the surface of the concrete with a spring-loaded hammer, subsequently measuring the rebound distance. This particular test provides very valuable information about concrete integrity and durability, helping engineers alongside builders ensure the good quality of their constructions

Table 1: Quality of Concrete for different values of rebound number

Average rebound number	Quality of concrete
>40	Very good hard layer
30 to 40	Good layer
20 to 30	Fair
<20	Poor
0	Delaminated

1.1.3 ULTRASONIC PULSE VELOCITY

Ultrasonic pulse velocity testing is a technique that's like, used for evaluating the quality and integrity of concrete structures. It involves sending these high-frequency sound waves through the concrete; like, I mean, measuring the time it takes for the waves, you know, to like, travel through the material. By,, analyzing the velocity these waves, engineers can assess the uniformity, homogeneity, and potential defects within the concrete, you know, helping ensure the safety and durability of buildings and infrastructure

Ultrasonic Pulse Velocity Test is performed on concrete to assess the quality of concrete by passing ultrasonic pulse velocity through it as per **IS: 516(Part 5/Sec 1) – 2018 (Amendment)**

Table -2 : Quality of concrete for different values of UPVT

Sr.no	Average value of Pulse Velocity by cross probing (Km/s)	Concrete quality grading
A)For concrete (<M25)		
1)	Below 3.5	Doubtful
2)	3.5 - 4.5	Good
3)	Above 4.5	Excellent
B) For concrete (>M25)		
1)	Below 3.75	Doubtful
2)	3.75 - 4.50	Good
3)	above 4.50	Excellent

1.1.4 PROFOSCOPE

The Profoscope is a portable, non-destructive tool used in construction to detecting rebar and metal objects embedded in concrete structures. It works by emitting electromagnetic pulses and analyzing the reflecting signals to pinpointing the location, depth, and spacing of reinforcement bars within the concrete. This helping engineers and inspectors assess the structural integrity and safety of buildings and infrastructure without needing for invasive testing.

The Profoscope, a super handy device, is used in construction to identify the metal reinforcement bars, or rebar, inside concrete structures. By sending out electromagnetic signals and analyzing their reflections, it helps determine the precise location, depth, and spacing of the rebar. This non-destructive and super effective method aids engineers and inspectors big time in assessing the strength and integrity of buildings and infrastructure without causing any damage to the concrete.

2. OBJECTIVE OF PROJECT -

1. Early Detection of damages.
2. Evaluation of material properties.
3. Prediction of service life.
4. Monitoring structural behaviour.
5. The location of reinforcement and diameter of rebar by using profoscope test.
6. Detection of discontinuity or cracks, voids in concrete by using ultrasonic test.
7. Strength of the concrete by using rebound hammer test.

3. METHODOLOGY

1. Selection Of Structures
2. Preliminary Inspection
3. Identify Of Problems
4. Preliminary Inspection Report
5. Visual Inspection
6. Detail Inspection
7. Field Testing
8. Structural Analysis Of Based On Testing Result

- **CASE STUDY**

Fig -1: **OLD RCC BUILDING (G+2)**

4. RESULT

- **REBOUND HAMMER TEST READING**

Table 3: REBOUND HAMMER TESTING IN COLUMN

Name and location of column	Average rebound number	Compressive strength N/mm^2	Quality of concrete
C1	31	26	Good layer
C2	28	21	Fair
C3	30	23	Good layer
C4	28	21	Fair
C5	31	26	Good layer
C6	31	26	Good layer
C7	29	22	Fair
C8	30	23	Good layer
C9	29	22	Good layer
C10	31	26	Good layer
C11	27	19	Fair
C12	28	21	Fair
C13	27	19	Fair
C14	25	15	Fair
C15	27	19	Fair
C16	28	21	Fair
C17	30	23	Good layer
C18	29	22	Fair
C19	26	17	Fair
C20	23	14	Fair
C21	25	16	Fair
C22	22	13	Fair
C23	26	17	Fair
C24	30	23	Good layer
C25	24	15	Fair

Table 4 : REBOUND HAMMER TESTING ON BEAM

Name and location of beam	Average rebound number	Compressive strength in (N/mm^2)	Quality of concrete
B1	27	18	Fair
B2	29.5	22	Fair
B3	30	23	Good
B4	25	16	Fair
B5	27	19	Fair
B6	30	23	Good
B7	30	23	Good
B8	25	16	Fair
B9	27	19	Fair
B10	28	21	Fair
B11	30	23	Good
B12	20	12	Poor
B13	25	16	Fair
B14	30	23	Good
B15	25	16	Fair

Table 5 : REBOUND HAMMER TESTING ON SLAB

Name and location of slab	Average rebound number	Compressive strength in N/mm^2	Quality of concrete
S1	30	23	Good
S2	28	21	Fair
S3	26	17	Fair
S4	31	26	Good
S5	29	22	Fair
Stair	27	19	Fair

- **UPVT READINGS**

TABLE 6: UPVT ON COLUMN

Column no	Travel length mm	Velocity (km/sec)	Probing method	Quality of concrete
C1	300	3.85	Direct method	Good
C2	301	3.8	Direct method	Good
C3	300	3.86	Direct method	Good
C4	230	3.4	Direct method	Doubtful
C5	235	3.43	Direct method	Doubtful
C6	230	3.0	Direct method	Doubtful
C7	230	3.8	Direct method	Good
C8	238	3.4	Direct method	Doubtful
C9	233	3.4	Direct method	Doubtful
C10	230	3.9	Direct method	Good
C11	233	3.3	Direct method	Doubtful
C12	285	3.8	Direct method	Good
C13	233	3.8	Direct method	Good
C14	230	3.22	Direct method	Doubtful
C15	233	3.3	Direct method	Doubtful
C16	235	3.1	Direct method	Doubtful
C17	231	3.9	Direct method	Good
C18	232	3.77	Direct method	Good
C19	232	3.4	Direct method	Doubtful
C20	232	3.9	Direct method	Good
C21	239	3.1	Direct method	Doubtful
C22	285	3.1	Direct method	Doubtful
C23	232	3.9	Direct method	Good
C24	233	3.8	Direct method	Good
C25	230	3.2	Direct method	Doubtful

Table 7: UPVT ON BEAM

Beam no	Travel length	Velocity (km/sec)	Probing method	Quality of concrete
B1	230	3.2	Indirect method	Doubtful
B2	233	3.1	Indirect method	Doubtful
B3	230	3.88	Indirect method	Good
B4	232	3.27	Indirect method	Doubtful
B5	230	3.19	Indirect method	Doubtful
B6	230	3.95	Indirect method	Good
B7	235	3.87	Indirect method	Good
B8	232	3.3	Indirect method	Doubtfull
B9	230	3.45	Indirect method	Doubtful
B10	233	3.22	Indirect method	Doubtful
B11	235	3.9	Indirect method	Good
B12	230	3.35	Indirect method	Doubtful
B13	230	3.32	Indirect method	Doubtful
B14	230	3.89	Indirect method	Good
B15	237	3.0	Indirect method	Doubtful

Table 8: UPVT ON SLAB

Slab	Travel length in (mm)	Velocity in(km/sec)	Probing method	Quality of concrete
S1	230	3.8	Direct method	Good
S2	230	3.96	Direct method	Good
S3	230	3.4	Direct method	Doubtful
S4	230	3.78	Direct method	Good
S5	230	3.2	Direct method	Doubtful
Stair	230	3.9	Direct method	Good

- **PROFOSCOPE READING**

Table 9: PROFOSCOPE ON COLUMN

Column	Size	Main R/F (mm)	Stirrups	Cover (mm)	Mean cover
C1	230*380	16mm 16mm 16mm 16mm	6mm@157mm c/c	45 43 52 56	49
C2	230*380	16mm 20mm 16mm 20mm	6mm@143mm c/c	47 48 52 59	51.5
C3	230*380	16mm 22mm 20mm 16mm	8mm@159mm c/c	41 45 43 51	45
C4	230*380	16mm 16mm 16mm 20mm	8mm@159mm c/c	58 63 58 62	60.25
C5	230*380	16mm 20mm 16mm 16mm	6mm@159mm c/c	53 60 58 56	52
C6	230*380	16mm 16mm 16mm 20mm	6mm@159mm c/c	48 51 53 56	52
C7	230*380	16mm 16mm 16mm 20mm	6mm@140mm c/c	52 53 60 63	56
C8	230*380	16mm 16mm 16mm 20mm	6mm@142mm c/c	61 67 66 68	65
C9	230*380	16mm 16mm 16mm 16mm	6mm@ 130mm c/c	48 52 50 46	49
C10	230*380	16mm 12mm 16mm 16mm	6mm@151mm c/c	47 49 32 56	46
C11	230*380	20mm 20mm 20mm 16mm	6mm@147mm c/c	59 55 56 53	55.75
C12	230*380	20mm 22mm 20mm 22mm	6mm@145mm c/c	61 62 61 60	61
C13	230*380	20mm 22mm 20mm 20mm	6mm@135mm c/c	59 60 58 59	59
C14	230*380	20mm 20mm 22mm 22mm	6mm@145mm c/c	54 57 52 46	52.25
C15	230*380	20mm 16mm 20mm 16mm	6mm@145mm c/c	54 57 52 46	52.25
C16	230*380	16mm 20mm 20mm 16mm	6mm@134mm c/c	49 64 60 59	58
C17	230*380	22mm 20mm 22mm 20mm	6mm@158mm c/c	60 60 60 58	59
C18	230*380	22mm 20mm 22mm 20mm	6mm@144mm c/c	57 58 55 56	56.5
C19	230*380	12mm 12mm 16mm 16mm	6mm@160mm c/c	57 56 51 48	53
C20	230*380	20mm 25mm 20mm 16mm	6mm@135mm c/c	40 38 33 38	37.25
C21	230*380	25mm 20mm 20mm 18mm	6mm@134mm c/c	44 43 45 49	45.25
C22	230*380	25mm 25mm 22mm 22mm	6mm@145mm c/c	46 48 40 47	45.25
C23	230*380	20mm 22mm 16mm 20mm	6mm@143mm c/c	52 45 44 41	45.5
C24	230*380	20mm 16mm 16mm 16mm	6mm@143mm c/c	42 38 40 42	40.5
C25	230*380	16mm 20mm 16mm 16mm	6mm@156mm c/c	45 36 42 45	50

Table 10 : PROFOSCOPE ON BEAM

Beam	Size	Top bar	Cover	Bottom bar	Cover
B1	230*450	20mm	49	12mm	26
B2	230*450	16mm	41	16mm	36
B3	230*450	16mm	52	16mm	39
B4	230*450	16mm	44	16mm	35
B5	230*530	20mm	57	16mm	52
B6	230*450	16mm	51	12mm	49
B7	230*450	20mm	53	16mm	38
B8	230*450	20mm	52	16mm	42
B9	230*530	16mm	48	16mm	39
B10	230*450	16mm	45	16mm	45
B11	230*530	16mm	54	22mm	37
B12	230*450	20mm	50	20mm	52
B13	230*450	20mm	45	16mm	44
B14	230*450	20mm	42	16mm	39
B15	230*450	12mm	32	12mm	34

Table 11:PROFOSCOPE ON SLAB

Slab	Main bar short span	Main bar long span	Thick . of slab	Reinforcem ent
S1	10mmm @ 240mm c/c	10mm@185 mm c/c	100m m	Both way
S2	10mm@24 0mm c/c	10mm@ 157mm c/c	100m m	Both way
S3	10mm@ 240mm c/c	6mm@ 183mm c/c	100m m	One way
S4	10mm@ 240mm c/c	10mm @ 210 mm c/c	100m m	Both way
S5	10mm@ 230mm c/c	6mm @ 210 mm c/c	100m m	One way
Stair	12mm@ 110mmc/c	10mm @ 245 mm c/c	175	1:2:4

3. CONCLUSIONS

Considerable engineering judgment is necessary for accurately evaluating measurements, particularly when poor contact is involved. In certain instances, identifying severely corroded reinforcing bars within low-quality concrete can be challenging. However, detecting poor quality concrete, which often leads to reinforcing bar issues, is feasible. Poor quality concrete permits moisture and oxygen ingress to the reinforcing bars, resulting in corrosion. When concrete property variations impact test outcomes, especially in conflicting directions, relying on a single method may not suffice for studying and assessing the desired property. Employing multiple methods yields more reliable results. For instance, increased concrete moisture content elevates ultrasonic pulse velocity but lowers the rebound number. Thus, employing both methods concurrently reduces errors inherent in using one method alone for concrete assessment.

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