FINAL REPORT

NON-DESTRUCTIVE EVALUATION

OF

SPPL DEMO PROJECT

New Delhi

BY

Sanrachna Prahari Pvt Ltd

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Report Out: Non-Destructive Evaluation (NDE) of SPPL Demo Project, New Delhi

Introduction:

The 'Sanrachna Prahari' (SAPR) team was requested to check the SPPL Demo Project site for structural integrity issues. SAPR team visited the site on 25th Feb 2024 and had presented its observations that led to the NDE being conducted by the team on 19th Mar 2024. The building, which is a 4-Storey framed structure, was evaluated using NDE equipment.

Historical Facts:

About three years back, a deep excavation on one side of the 4-Storey building was done by a neighbour for construction on their property. This excavation was about 15metres deep. Due to unconstrained edge, just about 2-3 metres from the edge of the 4-Storey building of SPPL Demo Project shifting happened and the 4-Storey building developed major cracks. Deterioration is currently happening and verified by conducting Structural Health Monitoring (SHM), through tilt meter, which proved the theory with data. The client rightly wants to understand the state of the 4-Storey structure from the safety point of view.

SHM conducted from 14th Jan to 18th Mar, has yielded definitive indications of ground upheaval at the location of the tiltmeter within the site. The tiltmeter data, supported by manual measurements, has confirmed an upward movement. To fully understand the structural response to these detected ground movements, a comprehensive NDE, encompassing points, across the site, was necessitated.

By visual inspection, it was evident that the 4-Storey building was under extreme stress due to the external environment. Hence the NDE was initiated on 19th Mar 2024, on the subject structure. The report is provided in the subsequent pages.

NDE Process

Codes and Specifications

The following codal provisions were actioned upon:

1. IS 13805: 2004 (in conjunction with ISO 9712: 1999, Non-destructive testing – Qualification and certification of personnel)
2. IS 15531: 2004, Non-Destructive Testing - Ultrasonic Testing (Vocabulary)
3. IS 13898 (Part 1): 1993 - Guidelines for Non-Destructive Testing of Concrete - Part 1: General Requirements
4. IS 13898 (Part 2): 1993 - Guidelines for Non-Destructive Testing of Concrete - Part 2: Methods of Test
5. **Rebound Hammer:**

a. IS 13311 (Part 2): 1992 - Non-Destructive Testing of Welds - Rebound Hammer Test

b. IS 13311 (Part 2): 1992 - Non-Destructive Testing of Concrete - Rebound Hammer Test

6. **Ultrasonic Testing (UT):**

   a. IS 13311 (Part 4): 1992 - Non-Destructive Testing of Welds - Ultrasonic Testing - Part 4: Inspection of Welds Using Longitudinal Waves

   b. IS 13311 (Part 5): 1992 - Non-Destructive Testing of Welds - Ultrasonic Testing - Part 5: Inspection of Welds Using Transverse Waves

   c. IS 13311 (Part 6): 1992 - Non-Destructive Testing of Welds - Ultrasonic Testing - Part 6: Automated Ultrasonic Testing of Fusion-Welded Austenitic and Ferritic Steel Castings

7. **Half Cell Potential Testing:**

   IS 13311 (Part 9): 1992 - Non-Destructive Testing of Welds - Half Cell Potentiometric Test for Detection of H2S Corrosion Susceptibility

8. **Cover Meter Test:**

   IS 13311 (Part 3): 1992 - Non-Destructive Testing of Concrete - Cover Meter Test

Recording Equipment and Materials

The testing of the G+3 structure at New Delhi was completed by using the following equipment, 1) Rebound Hammer; 2) Ultrasonic Pulse Velocity Tester; 3) Half Cell Potential Tester; and 4) Re Bar Locator.

1. Type of Equipment: Rebound Hammer

   Model: [TEM 912; ZD23091820]

   Calibration Status: [Calibrated – 17th Mar 2024]

2. Type of Equipment: UPSV Tester

Model: [M23USP0158]

Calibration Status: [Calibrated – 19th Mar 2024]

3. Type of Equipment: Half Cell Potential Tester

Model: [MCE Micro; 11440486]

Calibration Status: [Calibrated – 18th Mar 2024]

4. Type of Equipment: Rebar Detector

Model: [TEM 620XH; ZD23320282]

Calibration Status: [Calibrated – 18th Mar 2024]

Other material and equipment used for the testing, included, 1) Steel Head Hammer; 2) Chisel; 3) Steel Wire Brushes; 4) Duster Cloth; 5) Tablet for coordination and recording; and 6) Stationary for recording.

Test Criteria

The complete building was scanned using a Rebar Detector. A STAAD model was developed since original architectural and structural drawings do not exist with the owner / user of the building. Further, NDE was conducted on the G+3 Structure. Detailed NDE involved the following; 1) design rebuild of the 4-Storey Structure through STAAD; 2) analysis of the structure post design recreation; and 3) NDT (Rebound Hammer Test, Ultra-Sonic Pulse Velocity Test, Half-Cell Potential Test, Resistivity Test etc).

Results from the exercise have provided a detailed view of the structure's integrity in relation to the ground conditions and will further help formulate a more targeted approach to any necessary stabilization or remedial efforts.

Test Results

Date of Testing: 19th Mar 2024
Location: New Delhi, India
Structure: G+3
Test Conducted By: SPPL India
Test Personnel: SPPL India Team
Non-Destructive Testing Report: Rebound Hammer Test

The Rebound Hammer Test, also known as the Schmidt Hammer Test, is a non-destructive testing method used to assess the compressive strength of concrete based on the rebound of an impact mass from the surface of the concrete. This report presents the results of the Rebound Hammer Test conducted on the G+3 structure. The surface of the concrete was prepared by removing loose debris and dust. The rebound hammer was held perpendicular to the surface being tested, and a single impact was applied. A total of 40 readings were taken at various locations on the surface to ensure representative results.

Test Results: The results of the Rebound Hammer Test are presented in the table below:

Location	Rebound Hammer Reading
Point 1	28
Point 2	31
Point 3	31
Point 4	33
Point 5	28
Point 6	32
Point 7	31
Point 8	29
Point 9	30
Point 10	28
Point 11	30
Point 12	31
Point 13	29

Location	Rebound Hammer Reading
Point 14	29
Point 15	28
Point 16	28
Point 17	25
Point 18	23
Point 19	24
Point 20	25
Point 21	31
Point 22	32
Point 23	33
Point 24	34
Point 25	32
Point 26	33
Point 27	34
Point 28	37
Point 29	35
Point 30	33
Point 31	33
Point 32	19
Point 33	17
Point 34	19
Point 35	14
Point 36	30

Location	Rebound Hammer Reading
Point 37	28
Point 38	34
Point 39	33
Point 40	34

Analysis and Interpretation:

- The Rebound Hammer readings obtained ranged from 14 to 37.
- Higher rebound hammer readings typically indicate higher compressive strength of the concrete surface.
- Variations in readings may be attributed to differences in concrete composition, surface condition, moisture content, or presence of reinforcing bars.
- The average rebound hammer reading for the tested surface is calculated as 29.21. Few columns exhibited lower schimdt hammer readings (Points 17 to 20 and Points 32 to 35) indicating lower strength due poor workmanship.

<u>Non-Destructive Testing Report: Ultrasonic Pulse Velocity Test</u>

The Ultrasonic Pulse Velocity (UPV) Test is a non-destructive testing method used to assess the quality and integrity of concrete structures by measuring the travel time of ultrasonic pulses through the material. This report presents the results of the UPV Test conducted on the G+3 structure to evaluate its overall condition and identify potential defects or anomalies.

Testing Procedure: The UPV Test was conducted following the ASTM C597 standard method. Transducers were attached to the surface of the concrete at predetermined locations, and ultrasonic pulses were transmitted through the material. The travel time of the pulses between the transducers was recorded, allowing for the calculation of the ultrasonic pulse velocity.

Test Results: The results of the Ultrasonic Pulse Velocity Test are presented in the table below:

Location	Ultrasonic Pulse Velocity (m/s)
Point 1	2500
Point 2	2400

Location	Ultrasonic Pulse Velocity (m/s)
Point 3	2700
Point 4	2700
Point 5	2800
Point 6	2550
Point 7	2625
Point 8	2700
Point 9	2900
Point 10	2575
Point 11	3100
Point 12	3250
Point 13	2975
Point 14	3050
Point 15	3100
Point 16	2950
Point 17	2350
Point 18	2275
Point 19	2300
Point 20	2250
Point 21	3100
Point 22	3250
Point 23	3150
Point 24	3400
Point 25	3350

Location	Ultrasonic Pulse Velocity (m/s)
Point 26	3225
Point 27	3200
Point 28	3425
Point 29	3125
Point 30	2975
Point 31	2900
Point 32	3450
Point 33	2350
Point 34	2450
Point 35	2300
Point 36	2375
Point 37	2250
Point 38	2450
Point 39	2525
Point 40	2400

Analysis and Interpretation:

- The Ultrasonic Pulse Velocity readings obtained ranged from 2250 to 3700 m/s.
- Pulse velocity readings indicate low concrete quality, density, and integrity of structural members. Readings also indicate stress in outer two rows of columns
- Variations in readings may be attributed to differences in concrete density and presence of cracks or voids.
- The average Ultrasonic Pulse Velocity for the tested structure is 2732.5 m/s.

Non-Destructive Testing Report: Half Cell Potential Test

The Half Cell Potential Test, also known as the Concrete Half-Cell Test or the ASTM C876 Test, is a non-destructive testing method used to assess the likelihood of corrosion in reinforced concrete structures. This report presents the results of the Half Cell Potential Test conducted on the G+3 structure to evaluate the risk of corrosion in the reinforced concrete elements.

Testing Procedure: The Half Cell Potential Test was conducted following the ASTM C876 standard method. A reference electrode (copper-copper sulfate electrode) was attached to the surface of the concrete, and a potential measurement electrode (half-cell) was moved across the surface to measure the electrochemical potential relative to the reference electrode. Readings were taken at predetermined locations along the surface of the structure.

4. Test Results: The results of the Half Cell Potential Test are presented in the table below:

Location	Half Cell Potential (mV)
Point 1	-120
Point 2	-145
Point 3	-165
Point 4	-180
Point 5	-185
Point 6	-156
Point 7	-173
Point 8	-145
Point 9	-162
Point 10	-159
Point 11	-172
Point 12	-167
Point 13	-188
Point 14	-217
Point 15	-192

Location	Half Cell Potential (mV)
Point 16	-146
Point 17	-212
Point 18	-172
Point 19	-213
Point 20	-125
Point 21	-133
Point 22	-149
Point 23	-135
Point 24	-176
Point 25	-181
Point 26	-115
Point 27	-129
Point 28	-155
Point 29	-134
Point 30	-171
Point 31	-152
Point 32	-137
Point 33	-156
Point 34	-119
Point 35	-203
Point 36	-118
Point 37	-173
Point 38	-129

Location	Half Cell Potential (mV)
Point 39	-167
Point 40	-145

Analysis and Interpretation:

- The Half Cell Potential readings obtained ranged from -120 mV to -217 mV.
- More negative potential readings indicate a higher risk of corrosion in the reinforced concrete elements.
- Variations in readings may be attributed to differences in concrete cover, chloride ion concentration, moisture content, and presence of corrosion inhibitors or coatings.
- The average Half Cell Potential for the tested structure is in within safe range (> -200)

Conclusion

- Based on the Rebound Hammer Test results, the compressive strength of the concrete surface in the tested area is reported as ‘Satisfactory’.
- Based on the Ultrasonic Pulse Velocity Test results, the overall quality and integrity of the structural elements comprising the G+3 structure can be said to be ‘Low’ to ‘Medium’.
- Based on the Half Cell Potential Test results, the risk of corrosion in the reinforced concrete elements of the G+3 structure is ‘Low’ to ‘Nil’.
- Visible cracks have increased in the last 10 days. The upheaval of inner line of column vis-à-vis the outer level, suggests that the distress is increasing and moments are playing on the outer line of structural elements.
- Moments caused due to settlement is causing disintegration of structural members and structural joints are near the limit of elasticity.
- Rate of deterioration has increased from January to March, likely indicating steel showing signs of nearing its ‘Yield Point’ and passing into the phase of ‘Strain Hardening’.

Recommendations

- Monitoring of concrete strength using the Rebound Hammer Test is recommended to track changes every month till the open edge is stabilised.
- Conduct additional tests, including core sampling and laboratory testing, once the neighbouring structure is completed or a retaining wall is in place.
- The column with significantly low rebound hammer readings should be further investigated to identify potential defects or anomalies, after 6 months.
- Regular monitoring of concrete quality using the Ultrasonic Pulse Velocity Test is recommended to detect changes over time and identify potential deterioration every month till open edge is stabilised.
- Regular monitoring of Half Cell Potential is recommended to detect changes over time and assess the corrosion ingress due to crack propagation in the structure.
- Work urgently on stabilisation of open edge on Priority. The open edge continues to be a risk to the property. Excessive loss of passive earth pressure may lead to collapse of outer part of the structure. The open edge must be contained before monsoons 2025. Avoid usage of the rear part of the premises.

Team SPPL

References

- ASTM C805: Standard Test Method for Rebound Number of Hardened Concrete
- ASTM C597: Standard Test Method for Pulse Velocity Through Concrete
- ASTM C876: Standard Test Method for Half-Cell Potentials of Uncoated Reinforcing Steel in Concrete