TESTING

NDT-Based Assessment of Concrete Strength and Damage in a Reinforced Concrete Building

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Abstract

This paper presents a non-destructive assessment of a reinforced concrete (RCC) office building of Karmachari Sanchaya Kosh (KSK) in Hetauda, Makwanpur, Nepal, following reported damage in September 2025. The study compares an assumed original concrete grade of M20 (20 MPa) with in-situ condition indicators obtained from rebound-hammer (RH) and ultrasonic pulse velocity (UPV) testing. Field inspection and testing covered columns, beams and ceiling slabs, with measurements collected in collaboration with Sagarmatha Engineering Lab. RH-correlated strengths were reported as 48.0–62.0 MPa for columns, 34.0–50.0 MPa for beams and 56.0–62.0 MPa for ceiling elements. In contrast, UPV values ranged from 0.441 to 3.710 km/s, with most locations classified as poor. The marked disagreement between surface-hardness and pulse-velocity indicators shows why RH results should not be interpreted alone. The thesis reports a conservative effective strength estimate of approximately 15.5 MPa, compared with the assumed 20 MPa, and an estimated modulus reduction of about 12%. Visual inspection identified exposed reinforcement, corrosion, spalling and distressed beam–column joints. The findings support targeted verification, immediate attention to critically distressed members and a detailed structural assessment before decisions on occupancy or strengthening. Because core-test calibration and full structural analysis were not available, the strength and residual-life estimates should be treated as preliminary screening results.

Keywords: concrete strength; non-destructive testing; reinforced concrete; rebound hammer; SonReb; ultrasonic pulse velocity

1 Introduction

The assessment of an existing reinforced concrete (RCC) building requires information about both the surface condition and the internal quality of concrete. Non-destructive testing (NDT) offers a means of screening structural members without extracting cores at every test location. The rebound-hammer (RH) test is primarily associated with surface hardness, whereas ultrasonic pulse velocity (UPV) provides an indicator of concrete uniformity and internal defects. Combining the two measurements through a SonReb approach can provide a broader basis for condition assessment than either method used alone [1, 2].

This study examines the Karmachari Sanchaya Kosh (KSK) office building in Hetauda, Makwanpur, Nepal. The building is described in the source thesis as a newly constructed RCC frame that sustained damage in September 2025. In the absence of available structural drawings, M20 (20 MPa) was adopted as the assumed original concrete strength. The study focuses on columns, beams and ceiling slabs and compares the reported NDT indicators with this assumed reference strength.

The objectives are to: (i) assess concrete condition using visual inspection, RH and UPV testing; (ii) compare the reported in-situ strength indicators with the assumed M20 grade; and (iii) identify structural areas requiring further investigation and intervention.

2 Materials and methods

2.1 Case study building and inspection

The case study is the KSK building at Hetauda, Makwanpur, Nepal. Visual inspection was conducted on 8 September 2025 in collaboration with Sagarmatha Engineering Lab. The inspection focused particularly on the ground floor and recorded exposed reinforcement, corrosion, concrete spalling, cracking at beam–column joints and temporary shoring in damaged ceiling areas. The inspected structural system comprised RCC columns, beams and slabs.

2.2 Non-destructive testing

The RH test was reported as having been conducted in accordance with IS 13311 (Part 2):1992. Sixteen rebound readings were taken at each test point, with horizontal or vertical test orientations as applicable. The UPV test was conducted on 21 November 2025 in accordance with IS 516 (Part 5/ Sec. 1):2018. Direct transmission was used where opposite faces were accessible; indirect transmission was used where access was restricted. The test locations included columns C3, D3, D4 and E3, selected beam spans D3–D4, D3–E3 and E3–E4, and several ceiling-slab grid locations.

2.3 Strength interpretation

The thesis reports RH-correlated compressive-strength estimates and UPV classifications separately, and also discusses combined SonReb correlations. Because RH and UPV measure different concrete characteristics, the results were interpreted together. The thesis adopts a conservative effective strength of approximately 15–16 MPa (15.5 MPa for subsequent calculations), rather than relying on the comparatively high RH-only estimates. This value is retained here as a reported screening estimate, not as a substitute for calibrated core-test strength.

2.4 Modulus and residual-life screening

The reported modulus estimates were calculated using the expression $E_c = 5000\sqrt{f_{ck}}$, giving 22,360 N/mm^2 for 20 MPa and 19,685 N/mm^2 for 15.5 MPa. The thesis also presents a linear residual-life screening calculation using a current strength of 15.5 MPa, a critical threshold of 12 MPa and an assumed reduction rate of 0.10–0.12 MPa/year. These assumptions and their limitations are considered in the discussion.

3 Results

3.1 Visual inspection

The inspection documented exposed reinforcement, corrosion, spalling and cracking around beam–column joints, together with temporary shoring below damaged ceiling areas. These observations indicate that damage was not limited to superficial surface blemishes and support the need for member-specific investigation.

3.2 Rebound-hammer results

The thesis reports rebound-correlated strengths of 48.0–62.0 MPa for columns, 34.0–50.0 MPa for beams and 56.0–62.0 MPa for ceiling elements. The reported element-wise averages and standard deviations are summarised in Table 1. These estimates exceed the assumed M20 strength, but represent surface-hardness correlations and should not be treated as definitive in-situ compressive strengths.

Table 1. Reported rebound-hammer strength summary

Element	Mean (MPa)	SD (MPa)	Reported range (MPa)
Columns	56.5	5.8	48.0–62.0
Beams	38.0	8.5	34.0–50.0
Ceilings	57.5	2.9	56.0–62.0

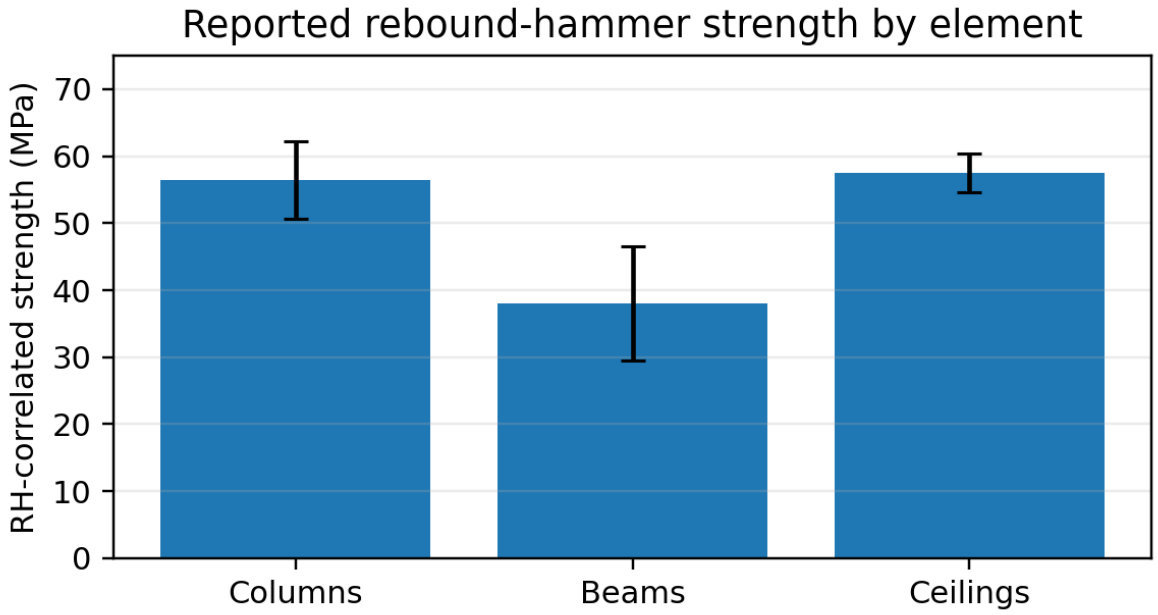


Figure 1. Reported RH-correlated strength averages and standard deviations

3.3 Ultrasonic pulse velocity results

UPV values ranged from 0.441 to 3.710 km/s. The reported ranges were 0.675–3.710 km/s for columns, 0.625–0.937 km/s for beams and 0.441–1.318 km/s for ceiling elements. Most readings were classified as poor under the quality bands cited in the thesis. The contrast between relatively high RH-correlated strengths and low UPV readings suggests that surface hardness alone may overstate the condition of the internal concrete.

Table 2. Reported UPV ranges and quality interpretation

Element	UPV range (km/s)	Reported interpretation
Columns	0.675–3.710	Mixed; mostly poor, one doubtful direct result
Beams	0.625–0.937	Poor

Element	UPV range (km/s)	Reported interpretation
Ceilings	0.441–1.318	Poor

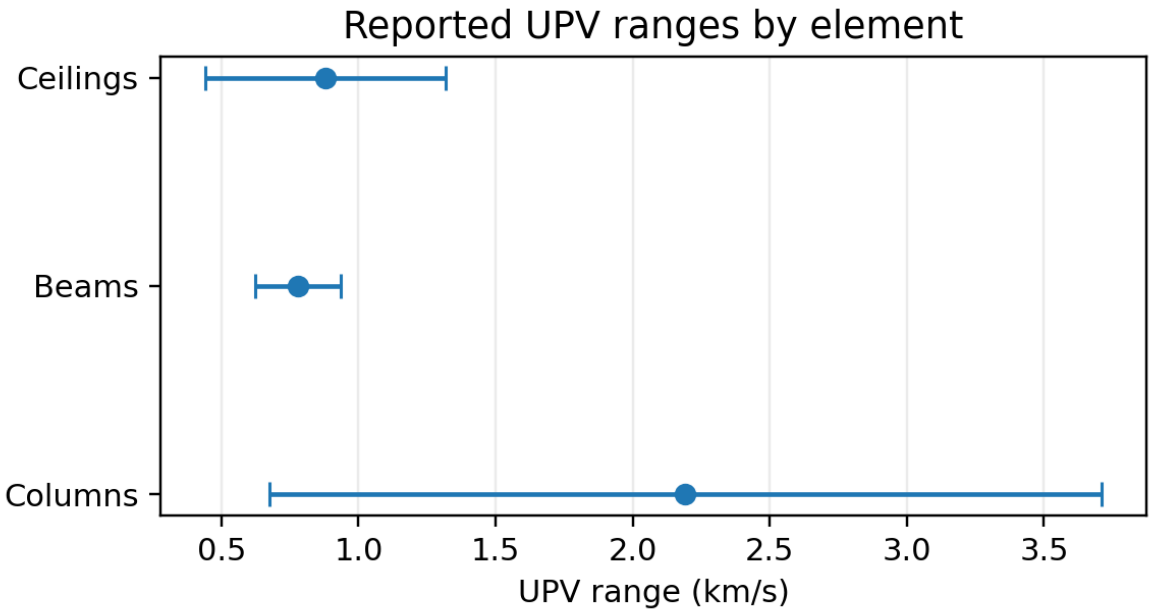


Figure 2. Reported UPV ranges by structural element. Bars indicate minimum–maximum values.

3.4 Combined interpretation and strength comparison

The source thesis reports a conservative effective concrete strength of approximately 15–16 MPa, using 15.5 MPa in the subsequent calculations, compared with the assumed original M20 value of 20 MPa. On this basis, the estimated strength reduction is 4.5 MPa (22.5%), and the retained strength is approximately 77.5%. The thesis also reports a very low RILEM-based estimate of approximately 6.4 MPa for beam D3–D4, indicating a potentially critical local condition. The member-level variation means that a single building-wide strength value cannot represent all structural components.

Table 3. Overall comparison reported in the thesis

Parameter	Value
Assumed original strength	20 MPa (M20)
Conservative current strength used	15.5 MPa
Estimated reduction	4.5 MPa (22.5%)
Retained strength	77.5%
Reported beam D3–D4 estimate	Approximately 6.4 MPa

4 Discussion

The principal finding is the disagreement between RH and UPV indicators. RH-correlated strengths are comparatively high, while most UPV measurements indicate poor concrete quality. This pattern is consistent with the complementary roles of the two tests: a hard surface does not necessarily demonstrate sound concrete through the member depth. The very low indirect UPV values reported

for beams and slabs warrant verification because indirect measurements are sensitive to surface condition, path length and coupling. The transmission method and test geometry should therefore be documented and considered when interpreting the values.

The source thesis estimates that the modulus of elasticity decreased from 22,360 to 19,685 N/mm^2, a reduction of approximately 12%. This estimate follows directly from the adopted 20 MPa and 15.5 MPa strength values and the stated empirical expression. It is an inferred modulus comparison, not a direct modulus test. The visual evidence of exposed reinforcement, corrosion, spalling and joint cracking reinforces the need for a complete structural evaluation, including reinforcement condition and member capacity.

The residual-life estimate requires particular caution. The thesis calculates 29–35 years from the assumed linear reduction rate of 0.10–0.12 MPa/year and reports a conservative range of 25–30 years. However, the building is described as newly constructed and damaged in 2025, and the available material does not establish a long-term time series from which a degradation rate can be measured. Accordingly, the residual-life figure is a scenario-based projection under the stated assumptions; it should not be interpreted as a validated prediction of safe service life.

Likewise, SonReb correlations require local calibration against destructive core tests. The source thesis itself notes that some calculated correlation outputs may be unrealistic or overestimated. The conservative 15.5 MPa value is therefore presented as the thesis's adopted screening estimate, while the low beam estimate is treated as a warning requiring direct verification. No occupancy or safety certification can be made from the NDT summary alone.

5 Conclusion and recommendations

The NDT-based assessment of the KSK building identified substantial variation in concrete condition across columns, beams and ceiling slabs. RH-correlated strength estimates were generally higher than the assumed M20 grade, whereas UPV readings were predominantly classified as poor. The divergence demonstrates the importance of combining surface and internal-quality indicators and avoiding reliance on rebound-hammer results alone.

Using the conservative effective strength adopted in the thesis (15.5 MPa), the estimated reduction relative to the assumed 20 MPa reference is 22.5%. The corresponding modulus estimate is approximately 12% lower. Visual inspection also identified exposed reinforcement, corrosion, spalling and distressed beam–column joints. The reported low strength estimate for beam D3–D4 warrants urgent member-specific verification and strengthening design.

Further work should include: (i) representative concrete-core tests to calibrate the RH–UPV/SonReb relationships; (ii) repeat UPV measurements with documented path lengths and transmission arrangements; (iii) reinforcement scanning and corrosion assessment; and (iv) a code-based structural and seismic analysis using verified material and geometric properties. Repair, strengthening and occupancy decisions should be made only after this comprehensive assessment.

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