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REINFORCED CONCRETE STRUCTURAL CAPACITY ASSESSMENT OF SWADAYA GUNUNG JATI UNIVERSITY MAIN CAMPUS USING NON-DESTRUCTIVE TESTING

Fajri Nurulfikri[1]*, Fathur Rohman Robandi[2]
Civil Engineering Study Program, Faculty of Engineering, Gunung Jati University, Cirebon, West Java, Indonesia
E-mail: fikrinurulfajrii@gmail.com [1]*

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Abstract

The degradation of structural capacity due to the age of the building is an important issue that requires periodic evaluation, especially in public facility buildings that are actively operating such as the Faculty of Economics and Business (FEB) Building of Swadaya Gunung Jati University. This study aims to assess the capacity of the reinforced concrete structure of the building through a forensic audit based on the Non-Destructive Test (NDT) method, without physically damaging the building. The methods used include visual inspection for crack pattern identification, Schmidt Rebound Hammer (ASTM C805) testing for estimation of concrete surface compressive strength, and Ultrasonic Pulse Velocity (ASTM C597) for concrete internal integrity evaluation, followed by Pearson correlation analysis and validation using software modeling referring to SNI 2847:2019, SNI 1727:2020, and SNI 1726:2019. The results of visual inspection at 120 column points showed damage in the form of non-structural hair cracks with a maximum width of 0.2 cm. Schmidt Hammer testing yielded an estimated f'c of 40 MPa (78%) and 36 MPa (22%), while the UPV showed 77.50% of the elements in the category of Good, 21.67% Doubtful, and 0.83% Poor. The Pearson correlation between the two methods was relatively weak ($r = 0.399$), confirming the importance of the combination of NDT methods. ETABS analysis validates that all column elements have a Demand/Capacity ratio below the critical limit, so the structure is declared safe and functional.

Keywords: Forensic Audit, Non-Destructive Test, Reinforced Concrete, Schmidt Rebound Hammer Test, Ultrasonic Pulse Velocity,

INTRODUCTION

Buildings are physical infrastructure that has a very important role in supporting various activities of its users, including public facilities and educational institutions (Hamzah et al., 2025). As we age, buildings, especially those that function as public facilities such as educational institutions, will experience quality degradation that can affect the performance of their structures (Seputro et al., 2008). This degradation is also often exacerbated by weather factors, negligence in maintenance, and changes in the function of the space (Hermansyah et al., 2025). Therefore, regular inspections to evaluate the reliability and capacity of the structure are crucial (Mardian et al., 2025). This step is important to ensure that the building still meets the standards of safety, comfort, and safety for its occupants (Maverick et al., 2025).

Reinforced concrete structures are widely used in the construction of multi-storey buildings because this material is known to have good strength and rigidity (Hutasoit et al., 2023). In addition, this material also has excellent durability in withstanding static loads (Purna Dewanti & Choiri Windari, 2024). Nevertheless, concrete structural elements such as beams, columns, and slabs remain vulnerable to various forms of damage (Hermansyah et al., 2025). Frequent damage includes cracking, spalling, and deflection that can compromise the integrity of the structure (Olumoyewa D et al., 2025). The presence of cracks in concrete elements is the most common defect encountered and can pose a serious threat to safety if not diagnosed immediately (Mohamad et al., 2025). In addition to physical defects, the reliability of the structure is also greatly affected by changes in the natural frequency of the building, where the degradation of rigidity due to physical damage or constant vibration can lower the value of the natural frequency and trigger the occurrence of material fatigue in the structure (Sembiring et al., 2024).

To identify the level of material degradation and evaluate the feasibility of an existing building, a structural forensic audit action is required (Mardian et al., 2025). This evaluation is very important to find out how much capacity is left of the structural elements as well as to formulate recommendations for efficient and targeted repair methods (Hermansyah et al., 2025). In the implementation of the evaluation of existing structures, the Non-Destructive Testing (NDT) method is highly recommended (Olumoyewa D et al., 2025). The NDT method is able to assess the quality, consistency, and mechanical parameters of materials without causing damage to structural components (Prasetya et al., 2024). Various NDT instruments, such as the Schmidt Rebound Hammer and Ultrasonic Pulse Velocity (UPV), have proven to be effective in estimating the compressive strength value of concrete in-situ, evaluating the homogeneity of concrete, and quickly identifying the depth of internal cracks or cavities (Hamzah et al., 2025). The use of hammer tests, for example, works by applying an impact load to the concrete surface to produce an indication of hardness (Olumoyewa D et al., 2025). The indication of hardness is then converted into an estimate of the compressive strength of the concrete without interfering with the operation or function of the building (Prasetya et al., 2024).

The Main Campus of Universitas Swadaya Gunung Jati is a vital educational facility that is required to always be able to provide structural security guarantees for its academic community. Considering the potential for a decline in material performance over its operational time, efforts to monitor the health of the building structure are needed. Based on this urgency, this research was conducted. This study aims to assess the strength capacity of existing reinforced concrete through NDT testing, so as to present empirical data related to residual compressive strength and structural integrity of buildings to ensure that buildings are always safe, reliable, and meet the required standards.

METHOD

The research is located on the Main Campus of Swadaya Gunung Jati University, more precisely in a building owned by the Faculty of Economics and Business with the address Jl. Pemuda Raya No. 32, Sunyaragi, Kesambi District, Cirebon City, West Java.

Figure 1. Research Location

This study applies a mixed methods approach. This approach integrates quantitative data derived from Non-Destructive Test (NDT) testing which includes the Schmidt Rebound Hammer Test and the Ultrasonic Pulse Velocity (UPV). Qualitative data was obtained through direct visual inspection of the physical condition of the building structure in the field. This research was conducted at the Faculty of Economics and Business Building, Gunung Jati Swadaya University. The research objects include 120 reinforced concrete columns consisting of 42 K1 with dimensions of 50 x 35 cm, K2 with dimensions of 30 x 30 cm totaling 54 pieces, and K3 with dimensions of 35 x 35 cm totaling 24 pieces. The physical condition data of the columns was taken using the visual inspection method. Furthermore, the estimation of the compressive strength of concrete was taken from the Schmidt Rebound Hammer Test with ASTM C805/805M reference. The homogeneity, quality, and internal integrity of concrete are taken from Ultrasonic Pulse Velocity (UPV) testing with ASTM C597 reference. The test results and field data are then processed using software for the validation process of NDT results. In the process, SNI 1726:2019 is used as a reference for earthquake resistance in building structures, SNI 1727:2020 is used as the minimum load for buildings, and SNI 2847:2019 is used as a structural concrete requirement for buildings. All three standards are used in Concrete Frame Design using software. The relationship analysis between the results of the Schmidt Rebound Hammer Test and the

Ultrasonic Pulse Velocity was carried out with Pearson Correlation to find out how high the correlation of the two test results was.

RESULTS AND DISCUSSION

Visual Inspection Results

Visual inspection was carried out on 120 reinforced concrete columns in the Faculty of Economics and Business Building. The K1 type column is 42 pieces, the K2 column is 54 pieces and the K3 column is 24 pieces. This inspection is carried out to identify damage such as cracking, spalling, honeycomb, and reinforcement corrosion. According to (Kunal & Killemsetty, 2014) Cracks can be classified according to their orientation, diagonal with a width of <1mm, horizontal with a width of 1-2 mm, vertical of 1-2 mm, stair-step with a width of >2mm. According to (Sitara et al, as cited in Mohamad et al., 2025) Cracks can be classified according to their width, thin category with a width of <1mm, medium with a width of 1-2mm, and a wide category with a width of >2mm. According to (Rama et al, as cited in Mohamad et al., 2025) Cracks can be classified according to the extent of damage, the category can be ignored with a width of up to 0.1mm, the very light category with a width of up to 1mm, the light category with a width of up to 5mm, the medium category with a width of 5 to 15mm, the heavy category with a width of 15-25mm, the very heavy category with a width of more than 25mm. The results of the visual inspection showed that the condition of the damage found was still at a mild level and did not indicate a decrease in capacity leading to structural failure. However, a number of structural elements need to be regularly monitored to prevent future damage from escalating.

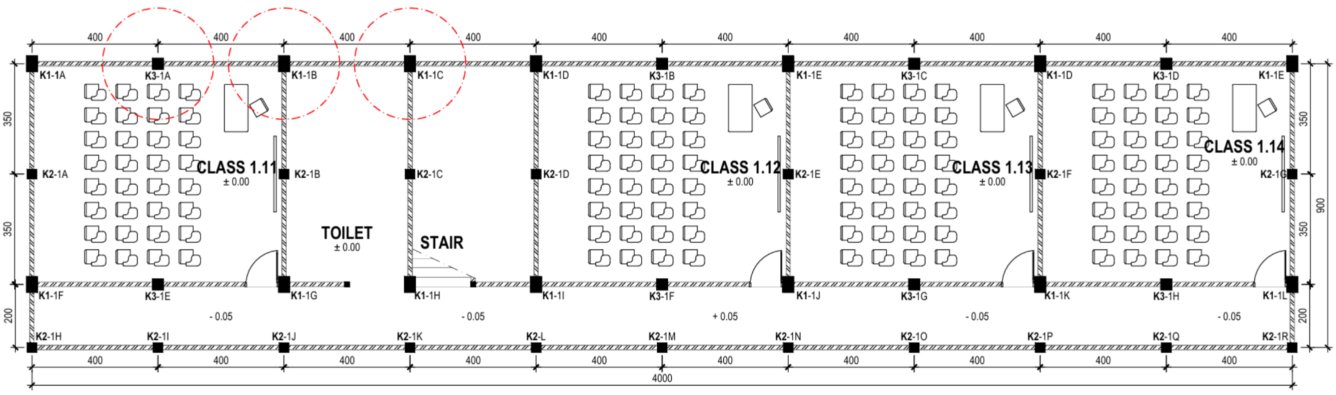

Figure 2. FEB Building Floor 1

Table 1. Visual Inspection Result

No.	Code	Crack No.	Visual Data		Crack Orientation	CrackWidth	Damage Severity
			Length (cm)	Width (cm)			
1.	K 1-1 B	1	255	0,2	Vertical	Thin	Very Slight
		2	110	0,1	Vertical	Thin	Very Slight
2.	K 1-1 C	1	70	0,1	Vertical	Thin	Very Slight
3.	K 3-1 A	1	240	0,2	Vertical	Thin	Very Slight
		2	240	0,1	Horizontal	Thin	Very Slight


Figure 3. Crack Findings 1

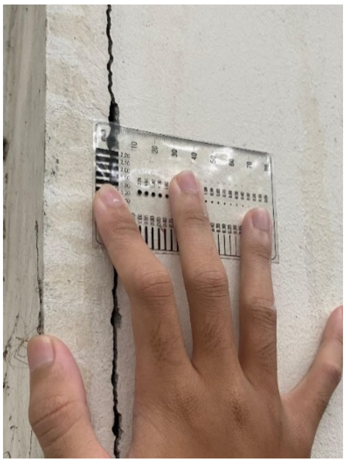
Figure 4. Crack Findings 2

Schmidt Rebound Hammer Test Results

The Schmidt rebound hammer test was carried out on 120 reinforced concrete columns in the Faculty of Economics and Business Building. The K1 type column is 42 pieces, the K2 column is 54 pieces and the K3 column is 24 pieces. This test is carried out to estimate the compressive strength value of concrete surfaces in existing structural elements using the ASTM C805 standard.

Table 2. Schmidt Rebound Test Result

Classification	Quantity	Percentage (%)
Coloumn with f'c 36 MPa	26	22%
Coloumn with f'c 40 MPa	94	78%

The results of the test found that the compressive strength of the concrete surface was in the high quality range, with details as many as 26 columns (22%) identified as having an estimated compressive strength of f'c 36 MPa, and the majority of elements, namely 94 columns (78%) reached an estimated f'c of 40 MPa.


Figure 5. Schmidt Rebound Hammer Test

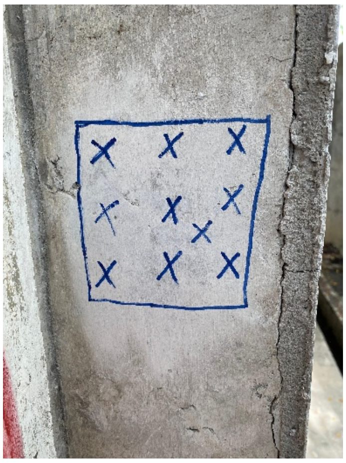
Figure 6. Ten Points of Punch

Results of Ultrasonic Pulse Velocity

The Ultrasonic Pulse Velocity test was carried out on 120 reinforced concrete columns in the Faculty of Economics and Business Building. The K1 type column is 42 pieces, the K2 column is 54 pieces and the K3 column is 24 pieces. The transducer is placed at a distance of 50cm vertically and the highest transducer point is at an elevation of +1.5m from the floor. Calibration of the tool is 43.5 µs. The test results showed an average ultrasonic wave travel time of 132.858 μs, with a minimum value of 111.4 μs in columns K 2-2 P and a maximum of 193.8 μs in elements K 1-1 B. Variations in travel time showed differences in characteristics as well as the degree of homogeneity of concrete at each test point, so these values were used to evaluate the quality of concrete. Refers to (Wang et al., 2023) The quality of concrete according to the propagation speed of UPV can be divided into five categories. The very good category with a UPV value of 4.5 km/s >, the good category with a UPV value of 3.5-4.5 km/s, the Doubtful category with a UPV value of 3.0-3.5 km/s, the Poor category with a UPV value of 2.0-3.0 km/s, and the Very Poor category with a UPV value of < 2.0 km/s.

Table 3. UPV Results

Classification	Quantity	Percentage (%)
Very Poor	0	0,00%
Poor	1	0,83%
Doubtful	26	21,67%
Good	93	77,50%
Very Good	0	0,00%

Figure 7. UPV Test 1

Figure 8. Calibration

Figure 9. UPV Test 2

Figure 10. UPV Test K1-1B Results

Based on the referred concrete quality classification standards, the test results show that the majority of the building's column structures are in safe condition. A total of 93 points (77.50%) are in the Good category, which means that most of the columns have a good level of density and a solid concrete structure. However, we still need to pay attention to the presence of a small number of points that show a decrease in quality. There were 26 points (21.67%) in the Doubtful category and 1 point (0.83%) in the Poor category. The appearance of this area of dubious quality is in line with the finding of the highest wave travel time of 193.8 μs. These numbers are an early indication of internal variations in concrete, such as small voids or micro-cracks in several locations. Therefore, points outside the Good category need to be the main focus for follow-up inspections to ensure the long-term safety of the building structure.

Schmidt Rebound Hammer Test Relationship Analysis Results

To determine the relationship between the quality of concrete from the Schmidt Rebound Hammer Test and the internal quality of concrete based on the results of ultrasonic pulse velocity (UPV), a correlation analysis was carried out using the Pearson Correlation method.

Table 4. Pearson Correlation Result

		Hammer	**UPV**
Hammer	Pearson Correlation	1	.399**
	Sig. (2-tailed)		.000
	N	120	120
UPV	Pearson Correlation	.399**	1
	Sig. (2-tailed)	.000	
	N	120	120

The results of the Pearson Correlation analysis showed a correlation coefficient value of 0.399 between the results of the Schmidt Rebound Hammer Test and the UPV, which indicated a positive relationship with a low correlation level, This shows that the increase in the estimation of the compressive strength of concrete tends to be followed by an increase in the propagation speed of ultrasonic waves, but the linear relationship between variables is still limited. The low correlation is influenced by the factors of concrete surface conditions, moisture, density and homogeneity of the material, the presence of internal cracks, and the characteristics of each test method.

Validation Results Using Software

Cross-sectional capacity validation was carried out through run analysis and concrete frame design check using software to evaluate the safety of reinforced concrete structure elements based on the Demand/Capacity (D/C) ratio. The ratio value represents the level of cross-sectional capacity due to the combination of working loads. The interpretation of the design results is shown through color indicators, namely light blue (D/C 0.0-0.5) indicates low utilization (oversized), green (0.5-0.7) and yellow (0.7-0.9) indicate safe and economical conditions, purple (0.9-1.0) indicates critical conditions, while red (D/C > 1.0) indicates elements are overstressed so further design evaluation is needed.

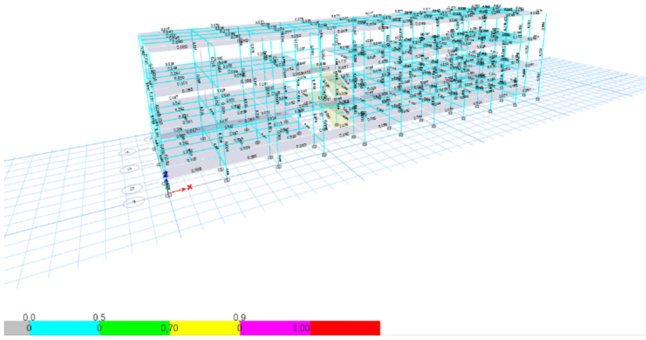

Figure 11. Concrete Frame Design Check Result

Based on the results of the design inspection shown in Figure 2, in general, the majority of column elements in this building show the performance of the structure is safe and declared feasible. This is indicated by the fulfillment of the limit strength requirement (ultimate) where most of the columns are within the permissible capacity ratio limit, so that they are considered able to bear the working loads without the risk of significant structural failure.

CONCLUSION

The results of the evaluation showed that the columns of the Faculty of Economics and Business Building, Gunung Jati Swadaya University were in good condition with the finding of non-structural hair cracks due to concrete shrinkage with a maximum width of 0.2 cm. Schmidt Rebound Hammer testing showed that the quality of surface concrete was dominated by f'c 40 MPa (78%) and f'c 36 MPa (22%), while UPV results showed that 77.50% of the elements were in the Good category. A total of 21.67% of the elements were in the Doubtful category and 0.83% of the columns were in the Poor condition which indicated the potential for the existence of voids or microcracks. Based on the re-analysis using ETABSv22 with the actual concrete quality parameters of NDT results. All column elements have adequate residual capacity with a Demand/Capacity (D/C) ratio below the critical limit so that the structure is declared safe and meets the requirements of SNI 2847:2019 and is functional.

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