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ASSESSMENT STRUCTURAL PERFORMANCE OF THE COLUMN BUILDING FACULTY OF EDUCATION AND SCIENCE, UNIVERSITY X USING THE NON-DESTRUCTIVE TEST (NDT) METHOD

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Abstract

Reinforced concrete buildings require assessment to determine the condition of structural elements based on material characteristics and structural responses. This study aims to assess the performance of columns in the Classroom Building of the Faculty of Education and Science, Universitas Swadaya Gunung Jati, using Non-Destructive Test (NDT) methods combined with structural analysis. A quantitative descriptive-evaluative approach was applied to all 138 columns, consisting of 99 K1 columns and 39 K2 columns. The assessment included visual inspection, Schmidt Rebound Hammer Test, and Ultrasonic Pulse Velocity (UPV), followed by structural modeling using ETABS. Visual inspection showed no visible cracks, spalling, honeycombing, or indications of reinforcement corrosion. The Rebound Hammer Test produced estimated concrete compressive strengths of 36–40 MPa, with an average of 39.30 MPa. UPV values ranged from 3.257 to 4.505 km/s, with 29 columns classified as Doubtful, 107 as Good, and 2 as Very Good. Pearson correlation analysis resulted in $r = 0.107$ and $p = 0.211$, indicating a very weak positive and statistically non-significant relationship between estimated concrete compressive strength and UPV velocity. The ETABS Concrete Frame Design results showed that all modeled columns satisfied the capacity check based on the analysis parameters used. Therefore, the assessed columns satisfied the evaluated structural capacity criteria, while the study did not directly assess foundation condition, all structural elements, or reinforcement condition.

Keywords: structural assessment, reinforced concrete columns, Non-destructive testing (NDT), Rebound hammer test, Ultrasonic Pulse Velocity (UPV)

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Introduction

Building is one of the infrastructures that plays an important role in supporting human activities, including educational activities. In reinforced concrete buildings, columns are one of the main elements that function to receive and distribute the structural load to the supporting elements below it (Habirun, 2023; Yudaprasetyo et al., 2026). The condition of the columns during the service life needs to be considered because changes in material quality, concrete inconsistency, and developing damage can affect the condition of structural elements (Akingbonmire & Afolayan, 2024). Therefore, an assessment of existing buildings is needed to obtain an overview of the actual condition based on field data and structural analysis (Alekseytsev & Kurchenko, 2023; Aladum et al., 2025).

Columns are one of the main elements in reinforced concrete structures because they function to channel the load from the structural elements on it to the structural system and foundation (Khan et al., 2022; Kesuma et al., 2025). The condition of the columns is important in the assessment because changes in material quality and cross-sectional capacity can affect the overall structural response (Wong, 2022; Soares & Brazil, 2025). Inspection of column conditions in existing buildings can be carried out by combining visual inspection and Non-Destructive Test (NDT) methods so that surface conditions and concrete characteristics can be evaluated without damaging the elements. (Tiwari & Soni, 2021; Karatosun et al., 2022; Lorenzi et al., 2025).

Schmidt Rebound Hammer is one of the NDT methods used to obtain indications of concrete surface hardness and estimation of concrete compressive strength (Saremi et al., 2023; Hanif et al., 2024). (Robandi et al., 2025) shows that the combination of Rebound Hammer and UPV can be used to evaluate the quality of concrete, while (Khaled et al., 2021; Ingole, 2025) using both methods in the evaluation of concrete on existing structures. In addition, (Fodil & Chemrouk, 2025) using Rebound Hammer and UPV data as part of a quantitative approach in evaluating the condition of concrete structures.

The UPV provides information about the speed at which ultrasonic waves propagate through concrete that can be used to assess the quality and homogeneity of materials (Zarate et al., 2022; Al-Neshawi et al., 2023; Chouhan & Verma, 2023). The use of Rebound Hammer and UPV simultaneously provides different parameters because Rebound Hammer is more concerned with surface characteristics, whereas UPV provides an indication of wave propagation characteristics in concrete (Kencanawati et al., 2021; Kouddane et al., 2022). The difference in the characteristics of the two methods causes the relationship of test results not always to show a strong linear correlation. (Robandi et al., 2025; Hidayat et al., 2024).

Previous research generally focused on evaluating the quality of concrete using one or a combination of NDT methods. This study focuses on the assessment of existing building columns by integrating visual inspection, Rebound Hammer, UPV, analysis of the statistical relationship between the two NDT parameters, and column capacity inspection using structural analysis. This approach is used to obtain an assessment of columns based on visual conditions, measured concrete characteristics, and structural capacity inspection results.

Based on these conditions, this study aims to assess the performance of the column structure of the Classroom Building of the Faculty of Education and Science, University X using the NDT method combined with structural analysis. The assessment is limited to the column elements that are the object of the research and does not include evaluation of the condition of the foundation, direct examination of the condition of the reinforcement, evaluation of the capacity of all structural elements, and evaluation of structural improvement.

Research Methods

This study uses a descriptive-evaluative quantitative approach with the object of the Classroom Building of the Faculty of Education and Science, University X which consists of three floors with a height between floors of 3.00 m and the main structure is reinforced concrete, while

the assessment object includes all 138 columns consisting of 99 K1 columns measuring 30×30 cm and 39 K2 columns measuring 30×27.5 cm. Data collection was carried out through visual inspection, Schmidt Rebound Hammer Test based on ASTM C805/C805M(Aravina, 2022), and Ultrasonic Pulse Velocity based on ASTM C597(Walker et al., 2025), with the entire column visually inspected and tested using both NDT methods, while the UPV test was carried out with a direct transmission configuration of two points per column and a distance between transducers of 0.50 m(Vasanelli et al., 2025; Nurokhman et al., 2024; Aminuddin et al., 2025). The Rebound Hammer data is processed from 10 readings in each column into the estimated value of the compressive strength of the concrete (Setiyarto & Mustopa, 2025), the UPV data was calculated based on the relationship between the trajectory length and the propagation time of the wave, then the two parameters were analyzed using Pearson's correlation with $N = 138$. Furthermore, the structure was modeled using ETABS based on the existing geometry, material parameters of the test results, die load, live load, and earthquake load with a spectrum response method according to SNI 1726:2019, then the column capacity was checked using Concrete Frame Design based on SNI 2847:2019(Setiawan et al., 2021; Aditya et al., 2025).

Research Results and Discussion

Visual Inspection Results

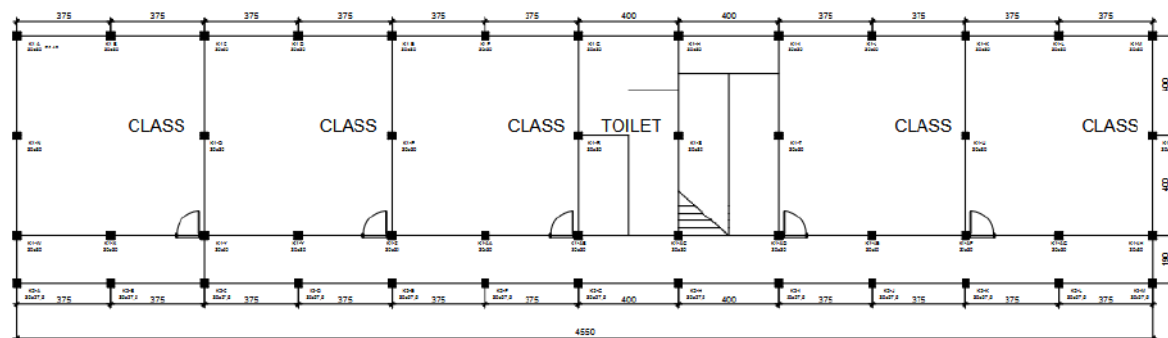


Figure 1. Column Planning Drawings

The building that became the object of the study was a three-storey reinforced concrete building with a height of 3.00 m between floors. The columns examined amounted to 138 elements, consisting of 99 columns of type K1 and 39 columns of type K2. Column K1 has dimensions of 30×30 cm, while column K2 has dimensions of 30×27.5 cm.

Visual inspection was carried out on the entire column to identify damage that could be observed directly on the surface of the element. The results of the inspection showed that no cracks, concrete peeling or spalling, visible honeycomb, nor any indication of reinforcement corrosion on the surface of the column. The results showed that there was no indication of visual damage to the surface of the element being examined.

Table 1. Visual Inspection Results

Parameters	Results
Number columns	138 columns
Crack	Not found
Spalling	Not found
Honeycomb	Not found
Corrosion reinforcement	Not found
Warp	Not found
General conditions	Good

However, the results of the visual inspection cannot be used to conclude the internal condition of the concrete or the condition of the invisible reinforcement. Therefore, the results of the visual inspection are used as one of the assessment parameters and subsequently compared with the results of the NDT test. (Pandey & Sinha, 2023).

Rebound Hammer Test Results

The Schmidt Rebound Hammer test was carried out on all 138 columns. Each column obtained 10 readings, bringing the total number of readings obtained to 1,380 readings. The Schmidt Rebound Hammer tool was calibrated one week before the test was carried out. The test was carried out with the tool positioned perpendicular to the concrete surface and the impact angle was 0°.

Table 2. Hammer Test Field Data Analysis

Yes	Column Structure Elements	Angle of Stroke	Number of Bounce Tests (R)		Average (R)	R Correction	f _c (MPa)
1	K 1-L1 A	0°	1	50	50,200	50,200	40
			2	51			
			3	51			
			4	50			
			5	52			
			6	49			
			7	49			
			8	51			
			9	50			
			10	49			

The processing results showed two groups of concrete compressive strength, namely 36 MPa and 40 MPa. A total of 24 columns or 17.39% had an estimated compressive strength of 36 MPa, while 114 columns or 82.61% had an estimated compressive strength of 40 MPa. The average value of the estimated compressive strength of the entire column of concrete was 39.30 MPa.

Table 3. Hammer Test Data Recapitulation Results

Classification	Quantity	Percentage (%)
Column with f _c ' 36 Mpa/ K450	24	20%
Column with f _c ' 40 Mpa/ K500	114	95%

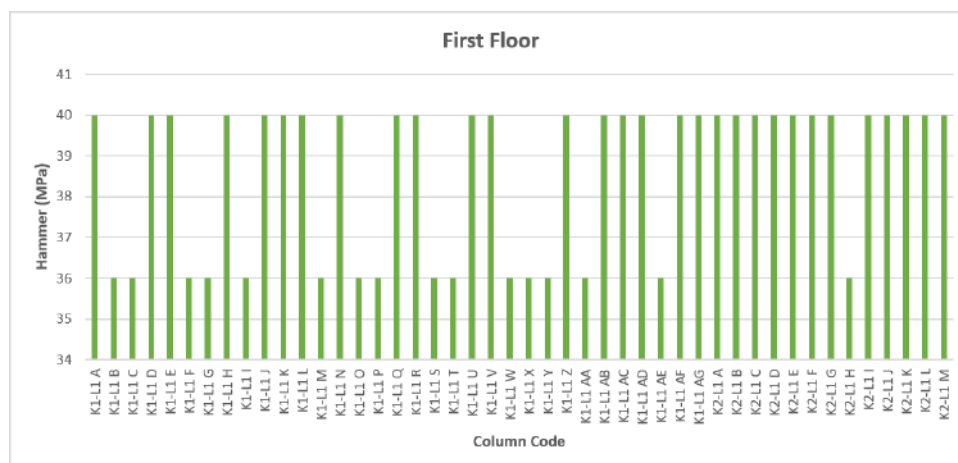


Figure 2. 1st Floor Hammer Test Graph Result

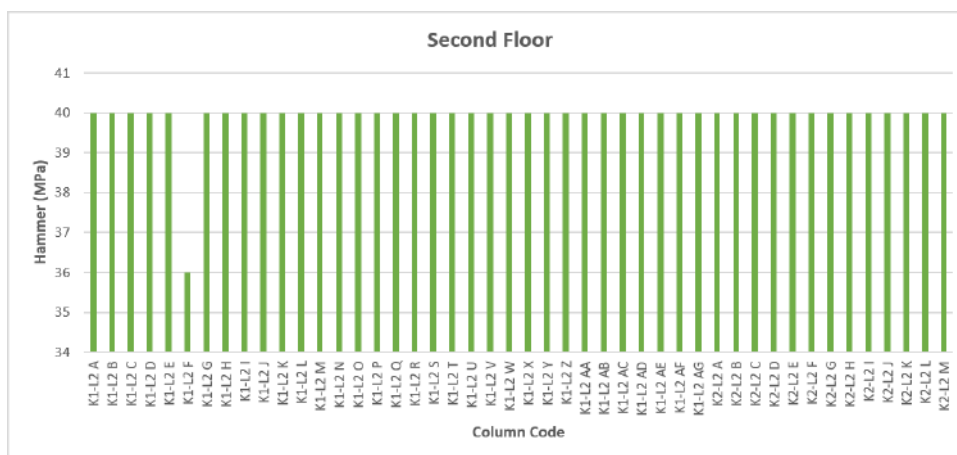


Figure 3. 2nd Floor Hammer Test Graph Result

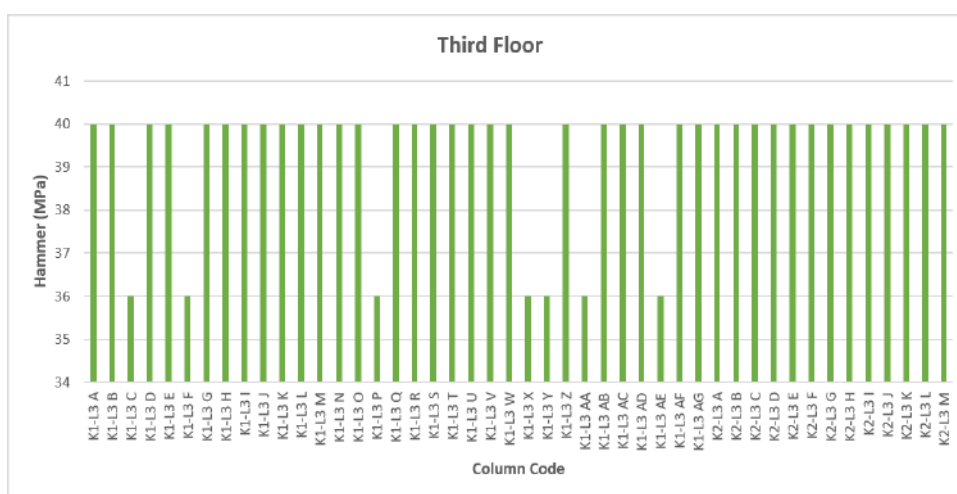


Figure 4. 3rd Floor Hammer Test Graph Result

The dominance of the value of 40 MPa indicates that most columns have an estimate of the compressive strength that is in that quality group. The difference between the value of 36 MPa and 40 MPa indicates that there is a variation in the test results in existing concrete. These variations can come from differences in surface characteristics and local conditions of concrete.

The estimated compressive strength value in this study was obtained through the rebound value conversion process using the conversion relationship used in the test. Thus, the value of 36–40 MPa needs to be understood as an estimate of compressive strength based on the Rebound Hammer method and not as a result of direct compressive strength testing using a concrete test piece. This is important because the results of the Rebound Hammer are influenced by surface conditions, moisture, tool orientation, and concrete material characteristics (Shrestha, 2023; Stella et al., 2024).

Ultrasonic Pulse Velocity (UPV) Results

UPV testing was carried out on all 138 columns using the direct transmission method and two test points on each column. Thus, the number of UPV test points is 276 points. The distance between transducers is 0.50 m and the test points are at a height of about 150 cm from the floor surface.

The propagation speed of the wave is calculated based on the equation:

$$V = \frac{L}{T}$$

with

V = wave propagation speed

L = is the wavelength of the trajectory

T = is the propagation time of the wave.

The test results showed that the travel time was in the range of 111.0–153.5 μs with an average of 135.263 μs . The speed of the UPV was in the range of 3.257–4.505 km/s with an average value of 3.712 km/s.

Table 4. Ultrasonic Pulse Velocity Test Recap Results

Classification	UPV Range	Quantity	Percentage (%)
Very Poor	< 2.0 km/s	0	0,00%
Poor	2.0-3.0 km/s	0	0,00%
Doubtful	3.0-3.5 km/s	29	21,01%
Good	3.5-4.5 km/s	107	77,54%
Very Good	> 4.5 km/s	2	1,45%

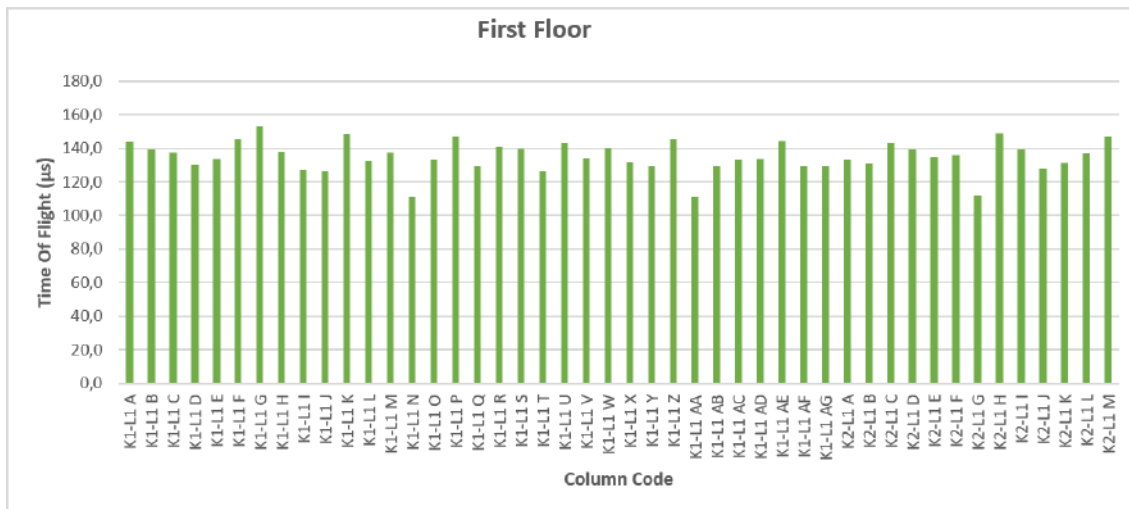


Figure 5. UPV Results Graph 1st Floor

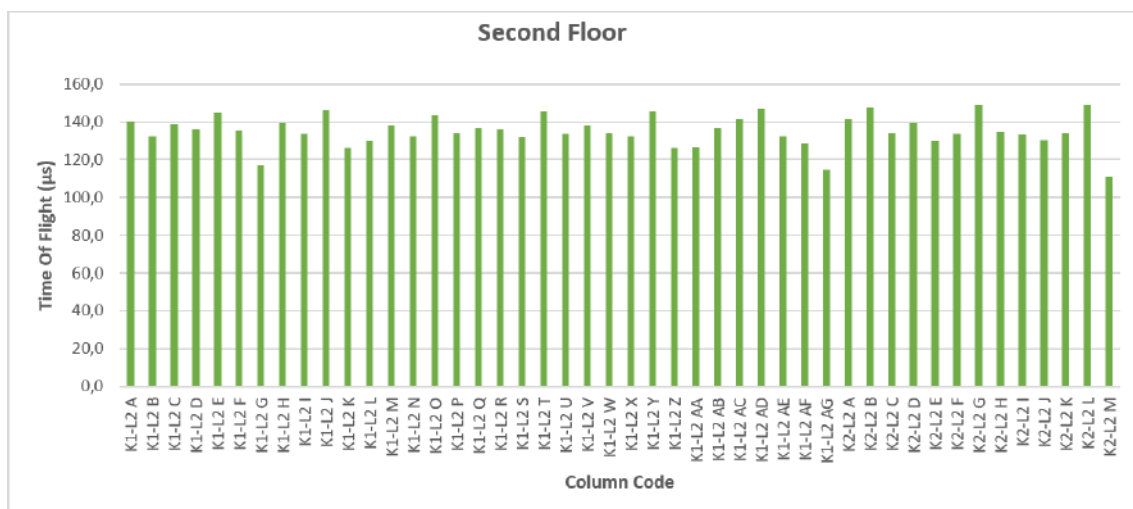


Figure 6. UPV Result Graph 2nd Floor

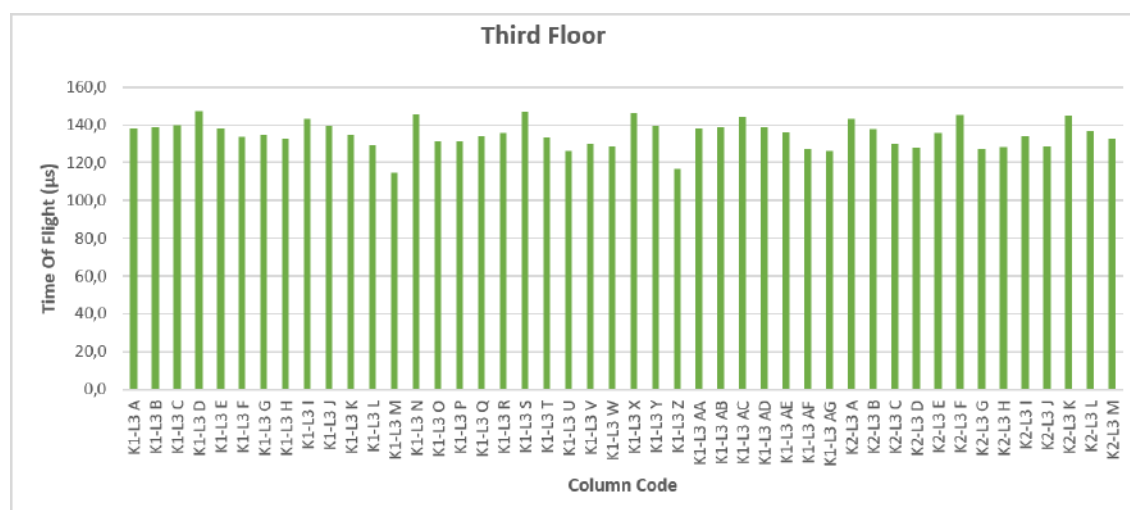


Figure 7. UPV Result Graph 3rd Floor

Most of the columns are in the Good category, which is 107 columns or 77.54%. A total of 29 columns or 21.01% are in the Doubtful category and two columns or 1.45% are in the Very Good category. There are no columns in the Poor or Very Poor category.

The Doubtful results do not directly mean that the columns have a structural failure. The category indicates that the propagation velocity is in a range that requires more careful interpretation because the UPV provides an indication of the quality and homogeneity of concrete, rather than a direct measurement of the structure capacity. The distribution of Doubtful values also needs to be read together with the results of visual inspection, Rebound Hammer, and structural capacity analysis. (Citra et al., 2024; Herki et al., 2023)

The columns that belong to the Doubtful category are spread across several floors and column types. On the 1st floor, there are K1-L1 G, K1-L1 K, K1-L1 P, K1-L1 U, K1-L1 Z, K1-L1 AE, K2-L1 C, K2-L1 H, and K2-L1 M. On the 2nd floor there are K1-L2 J, K1-L2 O, K1-L2 T, K1-L2 Y, K1-L2 AD, K2-L2 B, K2-L2 G, and K2-L2 L. On the 3rd floor, there are K1-L3 X, K1-L3 AC, K2-L3 A, K2-L3 F, and K2-L3 K. The data shows that the Doubtful category does not only appear on one floor or one type of column.

The difference in UPV results can be influenced by the internal conditions of concrete, the level of homogeneity, humidity, and wave trajectory conditions. Therefore, UPV results are used as one of the indicators of concrete quality and are not treated as the only basis for determining the capacity of the structure (Lencis et al., 2024; Harahap et al., 2024).

Relationship Between Rebound Hammer Test *and* Ultrasonic Pulse Velocity

The relationship between the estimation of the compressive strength of the concrete produced by the Rebound Hammer and the propagation speed of the UPV wave was analyzed using Pearson correlation. The analysis was carried out on 138 pairs of column data, with the first variable being an estimate of the compressive strength of the concrete resulting from the Rebound Hammer and the second variable in the form of the speed of the UPV.

Table 5. Pearson Correlation Results

		UPV	HAMMER
UPV	Pearson	1	.107
	Correlation		
	Sig. (2-tailed)		.211
	N	138	138

HAMMER	Pearson	.107	1
	Correlation		
	Sig. (2-tailed)	.211	
	N	138	138

The correlation coefficient of 0.107 indicates a very weak positive relationship between the estimated compressive strength of the concrete and the velocity of the UPV. The p-value of 0.211 is greater than 0.05 so the relationship is not statistically significant at a significance level of 5%.

These results show that the increase in the estimation of concrete compressive strength based on the Rebound Hammer has only a very small tendency to be followed by an increase in the UPV value in the study data. Thus, the two methods did not show a strong linear relationship in the 138 columns reviewed.

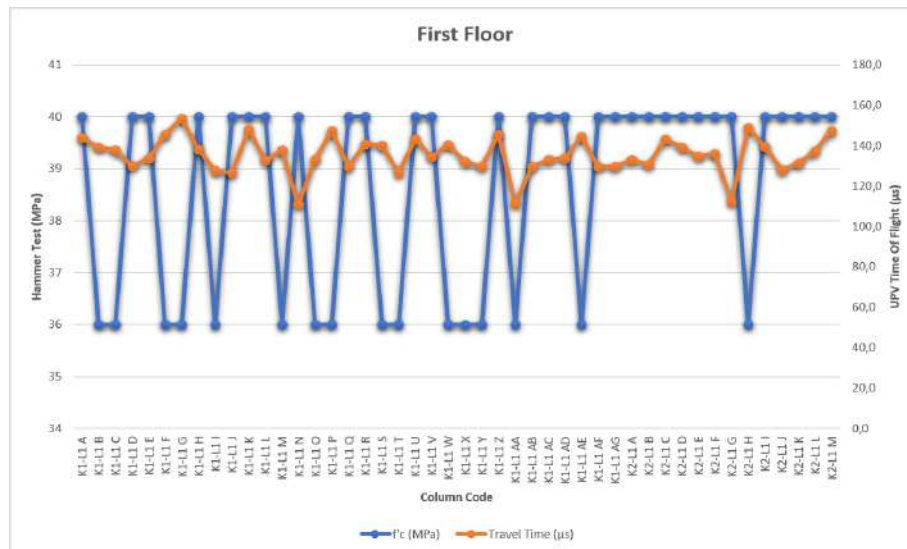


Figure 8. Graph of Hammer and UPV Relationship 1st Floor

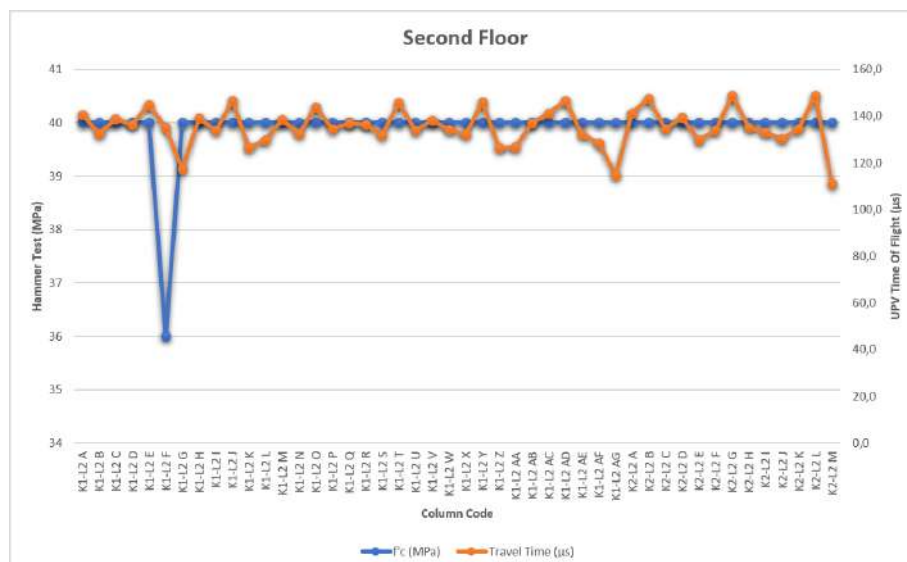


Figure 9. Graph of Hammer and UPV Relationship 2nd Floor

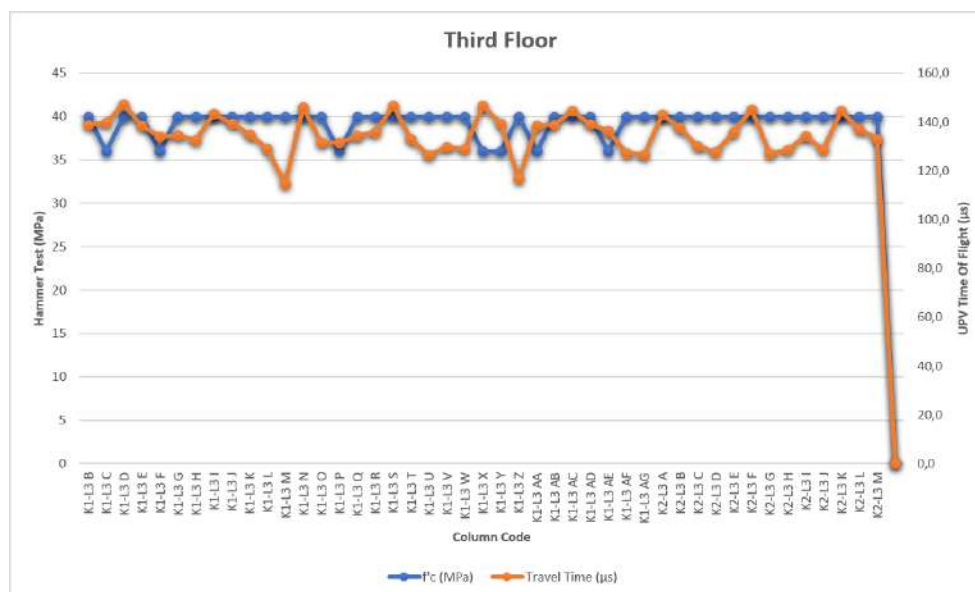


Figure 10. Graph of Hammer and UPV Relationship 3rd Floor

The results can be explained based on the characteristics of both methods. The Rebound Hammer mainly responds to the hardness of the concrete surface, while the UPV represents the propagation characteristics of waves through concrete (Gomez et al., 2024). Therefore, both methods measure different aspects of concrete and the relationship between them can be influenced by the surface conditions as well as the internal conditions of the concrete. These findings are in line with the research (Kencanawati et al., 2021; Rahim et al., 2021) which shows that the use of a combination of Rebound Hammer and UPV can provide complementary information regarding the characteristics of concrete.

Thus, the correlation value of 0.107 cannot be used as a direct indicator of the safety or insecurity of the structure. The correlation only shows the level of statistical association between the two parameters of the NDT test results.

Structural Validation Analysis Using Software

Structural analysis was carried out by making a three-dimensional model based on the existing configuration of the building. The model consists of three floors with a height between floors of 3.00 m and a reinforced concrete structure system. Column K1 is modeled with dimensions of 30×30 cm, while column K2 is modeled with dimensions of 30×27.5 cm. The number of columns analyzed is 138 elements.

Table 6. Building Modeling Data

PARAMETERS	MODELING DATA
Building Name	Education and Science Classroom Building,
Building Function	Classroom Building
Number of Stories	3 Story + Roof
Height of each floor	3 m
Age of the Building	6 Years
Structural Systems	Reinforced concrete frame
Building Location	Cirebon City, West Java
Earthquake Analysis Method	<i>Response Spectrum</i>
Reference Standards	SNI 1726:2019 and SNI 2847:2019

Modeling was carried out using ETABS. The concrete material parameters in the model refer to the results of the Rebound Hammer, namely the quality group of 36 MPa and 40 MPa for the columns. For the block elements, the concrete quality parameter of 30 MPa was used as per the modeling data in the research report. Longitudinal reinforcement was modeled using BJTS 420A and transverse reinforcement used BJTS 280 based on the model data used.

Table 7. Seismic Parameters

Parameters	Value
PGA	0.358 g
SS	0.786 g
S1	0.352 g
SDS	0.470 g
SD1	0.190 g
T0	0.080 seconds
Ts	0.400 seconds
TL	20 seconds
Site class	SB

Table 8. Axial Force Result

Pu		Vu		Mu	
MIN	MAX	MIN	MAX	MIN	MAX
-783.54 kN	110.5008 kN	V2 -82.9195 kN	82.9173 kN	M2 -75.7221 kN	78.1156 kN
		V3 -84.8084 kN	88.9979 kN	M3 -71.0822 kN	72.1289 kN



Figure 11. Axial Force ETABS

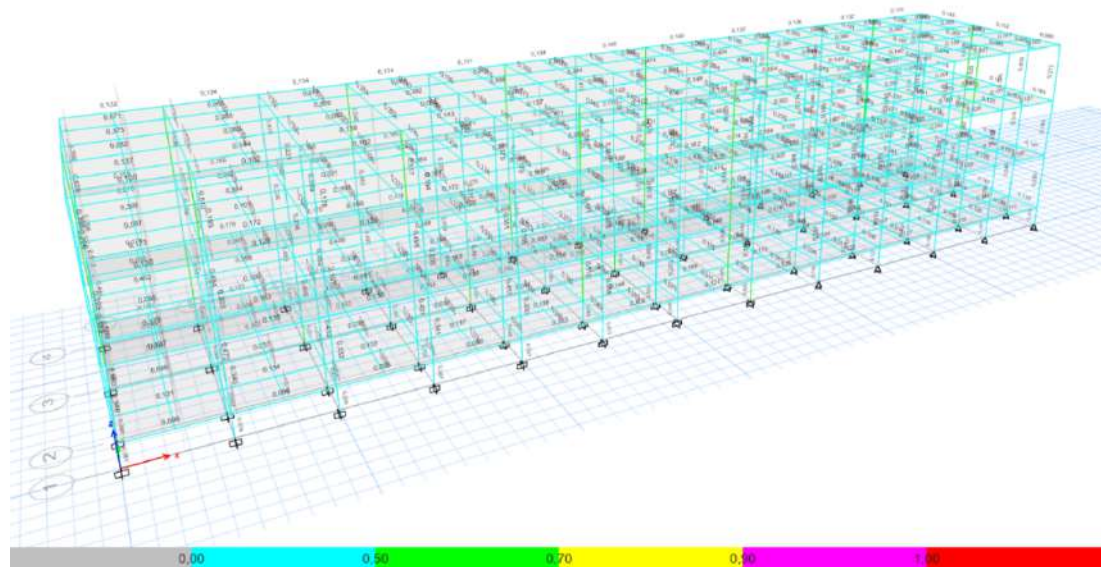


Figure 12. Design Check Result

The results of the structural analysis produced the inner force in the column in the form of the inner force range obtained was axial force -783.54 to 110.5008 kN, V2 -82.9195 to 82.9173 kN, V3 -84.8084 to 88.9979 kN, M2 -75.7221 to 78.1156 kN·m, and M3 -71.0822 to 72.1289 kN·m.

Capacity evaluation was carried out using the Concrete Frame Design facility at ETABS based on the provisions of SNI 2847:2019. An examination was carried out on the modeled column elements to determine the fulfillment of capacity based on the styles in the analysis results. The results of the Design Check showed that all column elements analyzed met the capacity check on the model.

These results need to be interpreted according to the scope of the analysis. The fulfillment of the Design Check shows that the modeled columns meet the capacity criteria based on the material, geometry, loading, and modeling assumptions used. These results do not directly show that all existing building systems, foundations, and reinforcement conditions have been thoroughly evaluated

Conclusion

Assessment of 138 columns of the Classroom Building of the Faculty of Education and Science, University X showed that the results of the visual inspection did not find cracks, spalling, honeycombs, nor any indication of reinforcement corrosion visible on the surface of the columns. The Rebound Hammer test produced an estimated compressive strength of concrete of 36–40 MPa with an average value of 39.30 MPa, while the UPV test with the direct transmission method produced a speed of 3.257–4.505 km/s with 107 columns in the Good category, 29 columns in the Doubtful, and 2 columns in the Very Good category. The relationship between the estimated compressive strength of the concrete from the Rebound Hammer and the UPV velocity resulted in a Pearson correlation of $r = 0.107$ with $p = 0.211$, so the relationship between the two was very positive and not statistically significant. The results of structural analysis using ETABS with Concrete Frame Design showed that all modeled columns met capacity checks based on the material, geometry, loading, and modeling parameters used. Thus, based on the aspects examined, the columns that were the object of the research met the criteria for the capacity of the evaluated structure, while the results could not be generalized as a comprehensive assessment of the

condition of the foundation, all structural elements, the condition of the reinforcement that was not directly inspected, or the overall safety of the building.

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