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Assessment of the Structure of an Old Ex-Hotel Building for Change Function into a Shopping Center as Building Permit Approval

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Abstract

This study evaluates the structural condition of the former Hotel Mutiara I building in Yogyakarta, which is undergoing a change of function into a shopping center. In compliance with Indonesian regulations, such as Law No. 28 of 2002 and SNI standards, the structural assessment focuses on safety and feasibility under increased live loads. Using a combination of destructive and non-destructive testing methods, including Core Drill Tests, Pulse Velocity Tests, and Ultrasonic Concrete Tomography, the study analyzes the quality of concrete and reinforcement materials. The findings reveal that the building's concrete compressive strength exceeds the minimum requirement of 21 MPa, indicating acceptable material performance for its age. However, deficiencies, such as plain reinforcement bars and inadequate concrete cover, necessitate compliance upgrades. The increased live load of 6.00 kN/m² due to the change in function requires structural reinforcement, particularly for columns and beams. Recommended measures include applying Carbon Fiber Reinforced Polymer (CFRP) to enhance axial, shear, and bending capacities and addressing non-compliant structural elements. This research underscores the importance of comprehensive structural evaluations for aging buildings undergoing functional changes, offering practical recommendations to ensure long-term safety, compliance, and functionality while preserving historical architectural integrity.

Keywords: Carbon fiber reinforced polymer, coredrill test, hardness test, pulse velocity test, hammer test.

1. Introduction

In the implementation of Government Regulation in Lieu of Law No. 2 of 2022 on Job Creation, every building construction or functional conversion in Indonesia is required to apply for a Building Approval (Persetujuan Bangunan Gedung, PBG). Once technical and administrative requirements are met, buildings deemed functionally feasible will be issued a Certificate of Functionality (Sertifikat Laik Fungsi, SLF). This process is further regulated by Law No. 28 of 2002 on Buildings, Government Regulation No. 16 of 2021, and several ministerial regulations, including Ministry of Public Works and Housing (PUPR) Regulation No. 19 of 2018 and Regulation No. 27 of 2018. These measures aim to ensure the safety and functionality of buildings to support sustainable construction management (Nurokhman, 2024). This becomes particularly relevant for aging structures undergoing functional changes, as such transformations significantly affect the structural load.

The former Hotel Mutiara I, located on Malioboro Street, Yogyakarta, exemplifies a building undergoing a change of function. Established in the 1970s, the building has been an asset of the Yogyakarta Provincial Government since the COVID-19 pandemic and is planned to be converted into a Small and Medium Enterprise (SME) shopping center as part of the relocation and restructuring program for Malioboro street vendors (Hendriyati, 2021; Supeno, 2018). Although the building remains visually intact after enduring the 2006 Yogyakarta earthquake, a comprehensive structural evaluation is necessary to ensure its safety and feasibility under the increased load demands (Muflihul Iman, 2024). The urgency of this study is heightened by the lack of existing technical documentation, such as detailed material specifications, which necessitates additional testing to obtain accurate parameters (Prasetyo, 2006; Ningsih, 2005).

Structural assessment requires standardized testing methods to ensure the safety and durability of buildings. Common tests include non-destructive methods (Non-Destructive Testing/NDT) such as Pulse Velocity Test, Covermeter Test, and Hammer Test, alongside destructive methods (Destructive Testing/DT) such as Core Drill Test. The compressive strength of concrete (f'c) and tensile strength of reinforcement steel (fy) are essential parameters for recalculating building structures (Zacharia & Turuallo, 2020; Sihombing, 2022). Additionally, technologies like Ultrasonic Concrete Tomography (UCT) Test have proven more effective than Ultrasonic Pulse Velocity (UPV) Test, particularly for structures accessible only from one side (Nurokhman H. K., 2024).

In the context of change of function, the change in live load from 4.79 kN/m² (hotel function) to 6.00 kN/m² (shopping center function) as stipulated in SNI 1727:2020 can significantly impact structural stability. Furthermore, earthquake resistance planning as outlined in SNI 1726:2019 is critical, considering the building's location in a seismic-prone area. If structural elements are found to be at risk of failure, strengthening options such as steel plate jacketing with shear connectors or the application of Carbon Fiber Reinforced Polymer (CFRP) can be implemented to enhance structural capacity (Sihombing, 2022).

This study aims to analyze the material quality of reinforced concrete structures, including beams, columns, and slabs, in a building over 50 years old, using destructive and non-destructive testing methods. The novelty of this research lies in its comprehensive approach, combining various testing methods to generate accurate and valid data as the foundation for redesigning the building structure. The findings of this study are expected to make a significant contribution to the management of aging buildings in Indonesia, particularly in the context of change of function and the preservation of historic architecture.

2. Method

This study was conducted at the Ex Hotel Mutiara 1 building located on Malioboro Street, Yogyakarta, focusing on structural assessment to support its repurposing into a shopping center. The assessment targeted structural concrete elements, including columns, beams, and floor slabs on the first through fourth floors. Testing employed two primary approaches: non-destructive methods such as Ultrasonic Pulse Velocity (UPV) Testing and Hammer Testing, and destructive methods using core drill testing. The number of samples was determined based on a representative proportion of structural elements on each floor, considering uniformity during fabrication and budget constraints.

Table 1. Number of Test Samples

No	Destructive and Non-Destructive Test	Unit	Quantity
1	UPV Pundit Test (*Homogeneity & Compressive Strength Estimation*)	Point	20
2	Hammer Test Live Digital (*Homogeneity & Compressive Strength Estimation*)	Point	20
3	Profometer/Covermeter Test (*Rebar Scan*)	Point	20
4	Brinell/Hardness Test (*Steel Tensile Strength Estimation*)	Point	10
5	Core Drill Test and *Actual Compressive Strength* in Laboratory	Point	8
6	Foundation Excavation (*Excluding Restoration Work*)	Point	2

Data were collected through on-site fieldwork and laboratory analysis. To ensure testing accuracy, a partnership was established with PT. Qies Nusantara Consultant, a certified institution specializing in structural testing. Compressive strength testing of core drill samples was carried out at the Concrete Construction Laboratory of Tarumanagara University, following a two-day procedure for each sample. The data obtained were analyzed to determine the capacity of the existing concrete structure, serving as the basis for recommendations regarding the building's suitability for repurposing.

3. Results and Discussion

The Ex-Hotel Mutiara 1 building, constructed in 1970, was designed according to structural regulations in effect at that time, prior to the implementation of the current Indonesian National Standard (SNI). Based on the existing data, there was no available information regarding the quality of concrete and steel used in the initial planning. When aligned with SNI 2847:2019, the minimum compressive strength standard for special structure concrete is 21 MPa.

3.1 Results of the UPV Pundit Test

The results of the validity test of all instrument items for the four variables, namely Democratic Leadership

The Ultrasonic Pulse Velocity (UPV) Pundit test was conducted according to BS 1881: Part 203:1986 and ASTM C597-16 standards (Hong, 2020). Three methods of pulse velocity measurement were utilized: Direct Transmission, Semi-Direct Transmission, and Indirect/Surface Transmission (Md. Safiuddin, 2007; Al-Aasm, 2018).

From 20 elements tested with 100 measurements, the ultrasonic pulse velocity ranged between 3000–3500 m/s, categorized as Medium Concrete Condition. Based on the formula from ASTM C597-16, the average concrete strength for the structural elements is as follows:

a. Columns: 28.15 MPa

b. Beams: 25.11 MPa

c. Slabs: 25.60 MPa

These results meet the minimum concrete compressive strength requirement of 21 MPa as stipulated in SNI 2847:2019. To enhance result accuracy, a conversion factor from indirect to direct factors of 10% was applied, in accordance with the Guidebook on Non-Destructive Testing of Concrete Structures, Ch.11.1.4.4, and ASTM C215.

Table 2. Pulse Velocity Values and Concrete Criteria

No.	Location	Type	Quantity	Average Direct Velocity (m/s)	>4500 m/s	3500-4500 m/s	3000-3500 m/s	<3000 m/s
1	Floor 1	Column	3	3377.3	-	-	✓	-
2	Floor 2	Column	2	3240.0	-	-	✓	-
3	Floor 3	Column	2	3211.0	-	-	✓	-
4	Floor 4	Column	2	3275.0	-	-	✓	-
5	Floor 4	Column	2	3185.5	-	-	✓	-
6	Floor 2	Beam	2	3219.0	-	-	✓	-
7	Floor 4	Beam	2	3170.5	-	-	✓	-
8	Roof Floor	Beam	2	3170.0	-	-	✓	-
9	Floor 2	Slab	1	3166.0	-	-	✓	-
10	Floor 4	Slab	1	3167.0	-	-	✓	-
11	Floor 4	Slab	1	3359.0	-	-	✓	-

3.2 Hammer Test Results

The homogeneity of concrete quality was assessed using the Hammer Test, based on BS 1881 Part 202:1986 and ASTM G80S-89, a non-destructive method for evaluating concrete hardness without damaging the structure. In this test, an impact load is applied to the concrete surface using a mass activated by a specific amount of energy. The rebound distance produced from this impact is calibrated to estimate the concrete's compressive strength. The primary advantages of this method are its rapid execution, low cost, and ability to cover large areas in a short time, making it efficient for evaluating the homogeneity of the concrete material.

Based on the results of the Hammer Test conducted on 20 structural elements, the average compressive strength of the concrete was as follows:

a. Columns: 27.95 MPa

b. Beams: 31.41 MPa

c. Slabs: 31.20 MPa

These results indicate that the concrete quality meets the minimum compressive strength requirement of 21 MPa, as per SNI-2847-2019 for special structural concrete. Overall, the results of this Hammer Test suggest that the concrete quality is suitable, providing a solid foundation for the building's conversion into a shopping center.

However, it is important to note that this test only measures the strength of the concrete surface. Further testing, such as core drilling (core test), is recommended to assess the condition of the concrete at deeper layers, especially in parts of the structure that may have degraded due to the building's age.

Table 3. Hammer Test Results

No.	Code	Location	Type	Area	Mean Value (kg/cm²)	Standard Deviation Based on Homogeneity (MPa)	fc′f_c′fc′ (MPa)	fc′f_c′fc′ (MPa)
1	K1, K2, K20	Floor 1	Column	H/5, H/4, G/3	331.3	4.58	28.16	
6	K6, K10	Floor 2	Column	D/5, A/2	343.0	3.54	29.16	
11	K11, K14	Floor 3	Column	E/4, F/2	327.0	3.91	27.80	27.95
16	K16, K18	Floor 4	Column	A/6, B/6	314.0	4.89	26.69	
3	B3, B4	Floor 2	Beam	G/3-4, G-H/3	401.0	4.48	34.09	
7	B7, B8	Floor 3	Beam	C/5-6, C-D/5	366.5	3.45	31.16	31.61
12	B12	Floor 4	Beam	E/4-5	369.0	5.28	31.37	
15	B15, B17, B19	Roof	Beam	E-F/4, A/4-6, A-B/6	350.7	3.10	29.81	
5	P5	Floor 2	Slab	G-H/3-4	357.0	9.61	30.35	
9	P9	Floor 3	Slab	C-D/5-6	369.0	4.73	31.37	31.20
13	P13	Floor 4	Slab	E-F/4-5	375.0	5.30	31.88	
				Average	**354.86**	**4.80**	**30.17**	**30.25**

3.3. Covermeter and Scanning Rebar Test Results

The results of the Covermeter and Scanning Rebar Test revealed the reinforcement arrangement in the main structural elements as follows:

a. Column 400x600 mm: Plain reinforcement 10D19 mm, stirrups D8 with 150-200 mm spacing, and concrete cover 15-48 mm.

b. Beam 300x570 mm: Plain reinforcement 14D22 mm, stirrups D8 with 130-200 mm spacing, and concrete cover 25 mm.

c. Slab 10000x10000 mm^2: Plain reinforcement X-direction D8 with 100-160 mm spacing, Y-direction D8 with 100-160 mm spacing, and concrete cover 40 mm.

These results show that both the main reinforcement and stirrups used are plain bars, which contradicts the provisions of SNI 2847-2019, Article 20.2.1.1, which prohibits the use of plain bars for both main reinforcement and stirrups. Additionally, the concrete cover in several columns, beams, and slabs does not meet the minimum requirements set by SNI 2847-2019, Article 20.6.1.3.1, which mandates a cover of at least 40 mm for columns and beams, and 20 mm for slabs. Addressing these issues is crucial for enhancing the durability against corrosion and ensuring the long-term viability of the structure.

3.4. Vibration Frequency Test Results

The vibration frequency test was conducted by comparing the existing vibration frequency with the walking frequency of a person, which is set at 2.5 Hz (according to ISO 2631-2). The test results indicate that the building structure still meets the allowable vibration frequency standards, which is important for the comfort of its occupants. Overall, the compressive strength of the concrete in the columns also meets the minimum requirements of SNI-2847-2019, which specifies 21 MPa, making the structure suitable for conversion.

3.5 Coredrill Test Results

The Coredrill Test was conducted by drilling a core sample from the concrete to directly measure the compressive strength of the structural elements. Based on testing of 8 structural elements, the average compressive strength of the concrete was as follows:

a. Columns: 25.58 MPa

b. Beams: 34.61 MPa

c. Slabs: 35.89 MPa

Using the standards of SNI-2847-2019, these results show that the concrete in the building structure meets the minimum compressive strength requirement of 21 MPa.

Overall, the Coredrill Test results align with the findings from the Hammer Test and demonstrate that the concrete structure is in good condition.

If a redesign is carried out, the compressive strength used for structural elements will be fc' = 25 MPa, which generally meets the minimum requirements as per SNI-2847-2019.

Table 4. Coredrill Test Results

No.	Code	Compressive Force (kN)	Stress (N/mm^2)	Stress (N/mm^2)	Average Element (N/mm^2)	Average Element (N/mm^2)
1	CD1-KOLOMLT1	37.5	23.59	26.76	24.33	25.58
2	CD2-KOLOMLT1	30.7	19.31	21.90		
5	CD5-KOLOMLT2	43.1	27.11	30.75	30.75	
6	CD6-KOLOMLT3	32.1	20.19	22.90	22.90	
3	CD3-BALOKLT2	38.3	24.09	27.33	34.60	34.60
4	CD4-BALOKLT2	58.7	36.93	41.86		
7	CD7-PLATLT2	39.9	25.10	28.47	28.47	35.89
8	CD1-PLATLT3	60.7	38.19	43.31	43.31	
		43.0	26.81	30.41	30.73	30.73

3.6 Hardness Test Results

A Hardness Test was conducted to assess the tensile strength of the reinforcing steel. The test results showed that the average tensile strength for plain reinforcement was 363 MPa. This value meets the minimum requirements specified in SNI 2052-2017, which requires a minimum tensile strength of 350 MPa for reinforcing steel. The adequate tensile strength of the steel indicates that the structural elements with plain reinforcement still meet the necessary strength capacity to support the building's new function.

Table 7. Hardness Test Results

No.	Code	Test Location	Diameter (D) (mm)	Area (As)	Average (HB)	Tensile Strength (MPa)	SNI 2052-2017 (MPa)	Remarks
1	B-01	Column Floor 1	19	G/3	116	385	350	OK
2	B-02	Column Floor 1	8	G/3	110	370	350	OK
3	B-03	Beam Floor 2	22	G/3-4	110	370	350	OK

4	B-04	Beam Floor 2	8	G/3-4	103	350	350	OK
5	B-05	Beam Floor 2	22	F-G/3	106	360	350	OK
6	B-06	Beam Floor 2	8	F-G/3	103	350	350	OK
7	B-07	Slab Floor 2	8	G-H/3-4	106	360	350	OK
8	B-08	Slab Floor 2	8	G-H/3-4	106	360	350	OK
					363			

3.6 Analysis of the Impact of Function Change and Structural Reinforcement

Converting the building from a hotel to a shopping center will have an impact on space planning, architecture, and mechanical-electrical systems. One significant change is the increase in live load, which is calculated based on SNI 1727:2020. This shows an increase of 125% from 4.79 kN/m² (hotel function) to 6.00 kN/m² (shopping center function).

Based on the results of the structural testing and calculations, it was found that although the concrete quality and steel reinforcement meet the requirements, some structural elements, particularly the columns and beams, need to be reinforced with Carbon Fiber Reinforced Polymer (CFRP). Reinforcement with MAPEI CFRP on the columns can increase axial capacity by 139%, shear stress in the beams by 543%, and bending moment by 109%. These reinforcement measures are essential to ensure the building's structure can accommodate the additional loads resulting from the functional change and comply with the required safety standards.

4. Conclusion

The assessment of the Ex-Hotel Mutiara 1 building reveals that it's concrete and steel quality meet the minimum requirements of SNI-2847:2019 and SNI-2052:2017, respectively. The average concrete compressive strength for columns, beams, and slabs surpasses the required 21 MPa, indicating satisfactory material conditions for the building's age. However, using plain reinforcement bars and inadequate concrete cover in some structural elements do not comply with current standards, necessitating corrective measures. Furthermore, while the building's vibration frequency and structural integrity align with safety benchmarks, the increased live load of 125% due to the change in function to a shopping center mandates additional structural reinforcement.

Critical structural elements, especially columns and beams, should be reinforced using carbon fiber reinforced polymer (CFRP) to address these findings. This method can significantly enhance axial, shear, and bending capacities, ensuring the structure can safely accommodate the increased loads. Moreover, addressing non-compliance issues, such as replacing plain reinforcement bars and ensuring adequate concrete cover, is essential to meet modern standards and enhance the structure's durability. These measures will help ensure the long-term safety and functionality of the building as a shopping center.

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