



Evaluation of Destructive and Non-Destructive Testing of Existing Hotel Structures for Shopping Centre Conversion

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ABSTRACT:

Changes in the function of a building will affect the structural loading, which, based on government regulations in building permits, must be reviewed for the feasibility of building functions through structural assessment. This research aims to analyze the condition of the concrete quality of building beams, columns, and slabs that are more than 50 years old. The methods used include non-destructive testing (NDT) and destructive testing (DT) on the structures. From the results of the non-destructive UPV (Ultrasonic Pulse Velocity) Test on 20 elements (100 tests) using the PUNDIT tool, the average concrete quality based on BS 1881 and ASTM C597-16 standards was found to be 28.15 MPa for columns, 25.11 MPa for beams, and 25.60 MPa for slabs. The Hammer Test showed an average concrete quality of 27.95 MPa for columns, 31.41 MPa for beams, and 31.20 MPa for slabs. The destructive method using core drilling on 8 structural elements revealed an average concrete quality of 25.58 MPa for columns, 34.61 MPa for beams, and 35.89 MPa for slabs. The hardness test for reinforcing steel indicated an average yield strength of 361 MPa. The compressive strength results of the column structure concrete meet the minimum requirements of 21 MPa for special structure concrete quality based on SNI-2847-2019. It is recommended to recalculate the structure with concrete quality $f_c' 25$ MPa and steel quality $f_y 360$ MPa to identify elements that need structural strengthening.

Keywords: Destructive and Non-Destructive Struktur Test; UPV Test; Coredrill Test.

INTRODUCTION

The existing condition of the Former Hotel Mutiara I Building is located on Jl. Malioboro No.18, Suryatmajan, Danurejan District, Yogyakarta City, DIY has 4 (four) floors. On the ground floor there is an arcade area of the building located at the front. On this floor there is also a lobby, reception desk, reception office, men's toilet, women's toilet, bar & coffee shop, outdoor

restaurant, cashier, electric utility area located in the back corner of the building, canteen, pantry, kitchen, mechanical room, panel room, security post and ATM center. On the 1st (one) floor, the majority of the building is used as rooms and offices. On the 2nd (two) floor this building has the exact same layout as the 1st (one) floor. On the 3rd (third) floor functions as a hotel room, a corridor in front of the stairs, a warehouse, a ballroom and a kitchen located next to the ballroom. On the 4th (four) floor of the building as a room, elevator house, water tank and cooling tower

In the context of structuring the Malioboro area which at the same time grows the scale of DIY MSME businesses, the DIY Regional Government in 2020 has officially acquired the Mutiara Hotel located in the Malioboro area. The 4-storey Mutiara I Hotel building is about 50 years old. In optimizing the use of these assets as an MSME plaza while maintaining the uniqueness and architectural characteristics of cultural heritage which is part of the Yogyakarta philosophy axis area. Furthermore, to strengthen the basis of technical justification in submitting a Building Approval to transfer the function for the Jogjakarta Creative UKM & Cultural Plaza Trading House, a follow-up assessment of the building structure was carried out.

The problem of technical planning supporting data is only found in the working drawings there is no information on concrete quality, steel quality and reinforced concrete specifications which are usually described in the Work Plan and Conditions (Bode et al., 1991; CHAMPLAIN & RIVER, 2017; Choo et al., 1999; Earley & Perry, 1987; Montgomery et al., 2016). Meanwhile, in the recalculation of structural planning due to changes in the transfer of functions that have an impact on enlarging the load, data on concrete compressive strength and steel tensile strength, steel arrangement patterns, and building vibration are needed. One of the research objectives is to analyze the quality of concrete in the structure of blocks, columns and building plates that are more than 50 years old (Hassoun & Al-Manaseer, 2020).

RESEARCH METHODS

This study uses a combination of non-destructive testing (NDT) and destructive testing (DT) to assess the quality of concrete and steel structures on columns, beams, and slabs on four floors of a building. The non-destructive methods used include UPV Pundit Test, Hammer Test, and Profometer/Covermeter Test (Bureau, 2009; Gernay et al., 2018; Magwaza & Tesfay, 2015; Maierhofer et al., 2010; Nath K. & Ramanathan, 2017). Meanwhile the destructive methods used are Coredrill Test and Hardness Test (Karahana et al., 2020; Ritz et al., 2014; Skłodowski et al., 2008; Yarali & Kahraman, 2011). The object of this research is concrete and steel structures in high-rise buildings that include the 1st, 2nd, 3rd, and 4th floors. This study focuses on columns, beams, and concrete slabs to measure homogeneity, compressive strength, and rebar conditions (steel reinforcement) as well as on steel structures to measure tensile strength.

The research data was obtained through direct testing in the field using special testing tools and through laboratory analysis of concrete samples taken from buildings. Additional data is taken

from the technical records of the building construction project, including data on the specifications of the materials used and the maintenance history of the structure. The population in this study is all structural elements on the four floors of the building. Samples were taken based on representative estimates that included 20 test points for the UPV Pundit Test, Hammer Test, and Profometer/Covermeter Test, 10 points for the Brinell/Hardness Test, and 8 points for the Coredrill Test. In addition, foundation excavation was carried out at 2 points.

The non-destructive testing techniques used include the UPV Pundit Test using BS 1881: Part 203:1986 and ASTM C597-16 standards to measure the velocity of ultrasonic pulses passing through concrete; Hammer Test uses BS 1881 Part 202:1986 and ASTM G80S-89 standards to measure the homogeneity and hardness of concrete surfaces through mass impact; and Profometer/Covermeter Test to detect the position and condition of rebar (steel reinforcement) in concrete. Destructive testing techniques used include the Coredrill Test using ASTM C42 and SNI-1974-2011 standards to sample concrete cylinders which are then tested for compressive strength in the laboratory, and the Hardness Test (Brinell Test) using the ASTM E140 standard to measure the hardness of steel and correlate it with tensile strength values.

Data obtained from field and laboratory tests are analyzed to assess the quality of concrete and steel structures. The analysis is carried out by comparing the test results with relevant standards, such as BS and ASTM. Data from UPV Pundit Test and Hammer Test were used to evaluate the homogeneity and estimation of concrete compressive strength, while data from Profometer/Covermeter Test was used to assess the condition of rebar. The results of the Coredrill Test provide the actual compressive strength value of concrete, while the Brinell Test provides the tensile strength value of steel. This analysis allows for a thorough evaluation of the building's structural condition and the identification of potential structural issues that may need to be repaired or strengthened.

RESULTS AND DISCUSSION

From the results of the collection of planning documents, it turned out that no information was found on the quality of concrete and the quality of reinforcement as the basis for calculating the structure. Meanwhile, when the building was erected in that year, of course, it was treated by the Indonesian Concrete Regulation PBI 1971 NI-2 and in line with the revision, changes were made up to almost every 10 years, starting from SKNI T-15-1991-03 to SNI 03-2847-1992, then SNI 03-2847-2002, then SNI 2847-2013 and changed again to SNI 2847-2019. If it is associated with the current regulation, namely SNI-2847-2019 as a standard for compressive strength requirements for the quality of concrete structures of a minimum of 21 MPa. In addition, there is no Work Plan and Conditions (RKS) document or description of concrete and steel quality in the DED, so that in testing the quality of concrete in order to find the average quality range which will be used as the basis for the calculation of the restructure.

Visual Survey Results

Based on the results of the visual survey, it can be seen that the condition of the column structure, beams and slabs is still quite good, but it can be seen that some concrete parts of the beam structure are segregated. The condition of the joint between the column structure and the beam is also still quite good. No structural damage was found in the columns, beams and plates.



Figure 1. Existing Condition of Ex. Hotel Mutiara 1 Building

Non-Destructive Testing on Existing Structures

UPV Pundit Test Results

From the results of the Concrete Quality Density Test (UPV Test) on 20 elements (100 tests), the test method was carried out with the PUNDIT tool speed criteria on concrete quality based on BS 1881 Concrete Quality Based On Pulse Velocity at 3000 - 3500 m/s including Medium Concrete Condition. For the quality of concrete according to the formula based on ASTM C597 - 16 Standard Test Method for Pulse Velocity Through Concrete, the average quality of column concrete is 28.15 MPa, beam concrete is 25.11 MPa, slab concrete is 25.60 MPa. These results have met the minimum requirements for concrete compressive strength of 21 MPa for the quality of concrete for special structures based on SNI-2847-2019.

Based Guidebook on Non-destructive testing of concrete structures, Ch.11.1.4.4 based on ASTM C215 Test Method for Fundamental Transverse, Longitudinal, and Torsional Resonant Frequencies of Concrete Specimens konversi Indirect factor ke direct factor by increasing the velocity result by 5% - 30%. In this case, an indirect factor value of 10% was taken.

Table 1. Pulse Velocity Value and Concrete Criteria

No.	Test Location		Quantity	Average Direct Velocity	>4500 m/s	3500-4500 m/s	3000-3500 m/s	<3000 m/s
	Location	Type		[m/s]	Excellent	Good	Medium	doubtfull
1	1st Floor	Column	3	3377,3	-	-	√	-
2	2nd Floor	Column	2	3240,0	-	-	√	-

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3	3rd Floor	Column	2	3311,0	-	-	√	-
4	4th Floor	Column	2	3275,0	-	-	√	-
5	2nd Floor	Beam	2	3185,5	-	-	√	-
6	3rd Floor	Beam	2	3219,0	-	-	√	-
7	4th Floor	Beam	2	3271,0	-	-	√	-
8	Roof Floor	Beam	2	3170,5	-	-	√	-
9	2nd Floor	Plate	1	3166,0	-	-	√	-
10	3rd Floor	Plate	1	3167,0	-	-	√	-
11	4th Floor	Plate	1	3359,0	-	-	√	-
			20	3249,2				

Hammer Test Results

The results of the Hammer Test for the compressive strength of concrete on 20 structural elements were obtained, so the average quality of column concrete was 27.95 MPa, beam concrete was 31.41 MPa, and slab concrete was 31.20 MPa. These results have met the minimum requirements for concrete compressive strength of 21 MPa for the quality of concrete for special structures based on SNI-2847-2019.

Table 2. Hammer Test Results

No	Code	Location			Mean Value (kg/cm ²)	Standard deviation Base on Homogeneity Concrete Strength (Mpa)	fc' (Mpa)	fc' (Mpa)
		Location	Type	As				
1	K1, K2, K20	1st Floor	Column	H/5, H/4, G/3	331,3	4,58	28,15 75	
6	K6, K10	2nd Floor	Column	D/5, A/2	343,0	3,54	29,16	27,95
11	K11, K14	3rd Floor	Column	B/4, F/2	327,0	3,91	27,8	
16	K16, K18	4th Floor	Column	A/6, B/6	314,0	4,89	26,69	
3	B3, B4	2nd Floor	Beam	G/3-4, G-H/3	401,0	4,48	34,09	
7	B7, B8	3rd Floor	Beam	C/5-6, C-D/5	366,5	3,45	31,15 5	31,61
12	B12	4th Floor	Beam	E/4-5	369,0	5,28	31,37	
15	B15, B17, B19	Roof Floor	Beam	E-F/4, A/4-6, A-B/6	350,7	3,10	29,81	
5	P5	2nd Floor	Plate	G-H/3-4	357,0	9,61	30,35	
9	P9	3rd Floor	Plate	C-D/5-6	369,0	4,73	31,37	31,20
13	P13	4th Floor	Plate	E-F/4-5	375,0	5,30	31,88	
					354,86	4,80	30,17	30,25

Covermeter and Scanning Rebar Test Results

The results of the Covermeter and Scanning Rebar Test for the inspection of the test of the rebar steel arrangement on the main column structure are 400x600 mm, plain reinforcement 10D19 mm, plain crossbar D8, spacing 150-200 mm, concrete blanket 15-48 mm. Beams 300x570 mm, plain slats 14D22 mm, plain slats D8, spacing 130-200 mm, concrete blankets 25 mm. Slabs 10000x10000 mm² plain reinforcement X direction D8 spacing 100-160 mm, Y direction D8 spacing 100-160 concrete limout 40 mm. From the results of the covermeter test above, it can be seen that the reinforcement used for both the main reinforcement and the sengkang reinforcement is using plain reinforcement, so if it is related to the regulations when it does not meet the SNI 2847-2019 article 20.2.1.1 it is not allowed to use plain reinforcement for the main reinforcement and sengkang reinforcement. Similarly, the thickness of the concrete blanket in several columns, beams and slabs has not met the requirements of SNI 2847-2019 article 20.6.1.3.1, which is 40 mm for beam column structures and 20 mm for slab structures.

Vibration Frequency Test Results

The results of the existing vibration test were then compared with the vibration frequency of the walking person, which was 2.5 Hz (based on ISO 2631-2). The compressive strength results of column structure concrete have met the minimum compressive strength requirement of concrete of 21 MPa for the quality of concrete for special structures based on SNI-2847-2019.

Destructive Testing on Existing Structures

Coredrill Test Results

The results of the Coredrill Test are destructive testing in the form of sampling by punching holes in the structure for compressive strength testing. In 8 structural elements, a core drill with a size of D45 mm L = 90 mm and a shape factor for the standard sample is required, so corrections are needed $f_{ud} = 1.00$ $f_{dia} = 1.07$ $f_{mc} = 1.00$ and $f_d = 1.06$ until the average quality of column concrete is 25.58 MPa, block concrete is 34.61 MPa, and slab concrete is 35.89 MPa. From the test results, an analysis of the average compressive strength of concrete for each structural element will be carried out for equality with SNI-2847-2019 regulation as a standard for compressive strength requirements for minimum structural concrete quality of 21 MPa.

Table 3. Coredril Test Results

No	Code	Push Force (kN)	Tegangan (N/mm ²)	Tegangan (N/mm ²)	Average elements (N/mm ²)	Average elements (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	

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3	CD3-BALOKLT2	38,3	24,09	27,33	34,60	34,60
4	CD4-BALOKLT2	58,7	36,93	41,88		
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	26,81	30,41	30,73	30,73

If taken in replanning for all structural elements then f_c' 25 MPa is taken. In general, it meets the requirements of SNI-2847-2019 quality for a minimum compressive strength $f_c' = 21$ Mpa.

Result Hardness Test

From testing the melting strength of steel by means of hardness test at 8 points, the average tensile strength of plain rebar has been obtained = 363 MPa. The average result of the tensile strength of plain reinforcement has met the minimum requirements based on SNI 2052-2017, which is 350 MPa.

Table 4. Hardness Test Results

No.	Code	Location Test			Average	Tensile Strength		
		Location	Type	As		Test Field (MPa)	SNI 2052-2017 (MPa)	Ket.
1	B - 01	Ground Floor Column	Ø 19	G/3	116 HB	385	350	OK
2	B - 02	Ground Floor Column	Ø 8	G/3	110 HB	370	350	OK
3	B - 03	2nd Floor Beam	Ø 22	G/3-4	110 HB	370	350	OK
4	B - 04	2nd Floor Beam	Ø 8	G/3-4	103 HB	350	350	OK
5	B - 05	2nd Floor Beam	Ø 22	F-G/3	106 HB	360	350	OK
6	B - 06	2nd Floor Beam	Ø 8	F-G/3	103 HB	350	350	OK
7	B - 07	Floor Plate 2	Ø 8	G-H/3-4	106 HB	360	350	OK
8	B - 08	Floor Plate 2	Ø 8	G-H/3-4	106 HB	360	350	OK
						363		

In general, the Ex Hotel Mutiara 1 Yogyakarta Building, which will be converted into an MSME shopping center, will certainly have an effect on architecture, spatial planning, electrical systems, plumbing and of course the burden of life will increase. The live load used in this analysis refers to the SNI Loading Regulation for Building 1727:2020, namely for the roof of 0.96 kN/m², and as a shopping center function of 4.79 kN/m². Testing the quality of concrete and reinforcing steel through destructive and non-destructive tests has obtained the quality of f_c' 25 MPa concrete and plain rebar f_y 360 MPa. Some parameters such as plain reinforcement and the

thickness of the concrete blanket that are not in accordance with SNI 2847-2019 cannot be used as a basis for concluding compliance with the regulations.

CONCLUSION

In the change of building function in accordance with regulations related to the PBG Building Approval and SLF Functional Fitness Certificate, it is necessary to review the fulfillment of building reliability in structural technical requirements. In the calculation of the structure in addition to the load change parameters, data on concrete quality, rebar steel quality and vibration influence are needed so that destructive and non-destructive tests of the structure with a sufficient number are needed. The test results showed the quality of f_c' 25 MPa concrete and f_y 360 MPa plain reinforcing steel. Some parameters such as plain reinforcement and the thickness of the concrete blanket that are not in accordance with SNI 2847-2019 cannot be used as a basis for concluding compliance with the regulations. Next, a calculation of the structure is carried out to find out which structural elements need to be strengthened.

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