Visual Assessment and Non-Destructive Test at Bandung City X Hospital

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Abstract

This research aims to evaluate the structural performance of the RSUD X Bandung City building against earthquake loads through visual and non-destructive technical assessments. Bandung City has a high seismic risk due to the Lembang fault, making building preparedness, especially for public facilities like hospitals, crucial. This research method includes visual observation of structural damage, concrete quality testing with Ultrasonic Pulse Velocity, and concrete compressive strength testing with the rebound hammer test. The results of the visual and technical assessments on the RSUD building can be categorized as moderate structural damage with crack thicknesses of 0.2 – 2.6 mm.

Keywords: Hammer Test, UPV Test, NDT, Compressive Strength, Concrete Structure

1. INTRODUCTION

The Bandung city area has a significant potential for earthquake risk. Aji, Prasetyo, & Awaluddin (2018) explain that the Bandung City area has a Lembang Fault Structure that reaches 30 km in length and a displacement rate that can reach 5.00 mm/year, causing small seismic activity forces. This seismic activity creates a time bomb that cannot be controlled by humans and can occur at any time (Iqbal, Rahiem, Fitrananda, & Yusuf, 2021). Therefore, Mildawati and Ade Subarkah in Vasthu P et al (2024) state that there is a need for efforts to avoid losses from a disaster, namely preparedness.

Preparedness in earthquake-resistant building construction needs to be designed, especially for public facilities like hospitals. For this reason, hospitals need to have earthquake-resistant aspects in their structural and non-structural elements that can serve as support against disasters (Gutama & Rahayu, 2021). Hospital buildings are also used continuously, so an assessment is needed to evaluate the feasibility of the object against non-conformities in the construction process, building usage time, and maintenance stages from damage due to disasters (Fadillah M. R., 2020). Therefore, this assessment research in the form of an inspection and evaluation of the condition of existing building structures focuses on the analysis of post-earthquake building structural strength based on the condition at the time of inspection and considering SNI 1726-2019.

The Regional General Hospital (RSUD) has an important role in providing health services for the people of Bandung City. Therefore, the feasibility evaluation carried out on the RSUD building is a visual observation method to observe the building's condition directly, map the structure, and conduct field tests using the Schmidt Rebound Hammer Test equipment to determine the concrete compressive strength.

1.1. Building Investigation

Building investigation is an activity that includes checking, inspection, and data collection aimed at drawing conclusions about the problems that occur. This process includes visual inspection, non-destructive testing, and data analysis as the initial step in performing repair and strengthening analysis on a building that has reached its design life (Muliawan & Taufikurrahman, 2022).

1.1.1. Rebound Hammer Test

Hammer Test is part of checking the feasibility of a building structure related to concrete materials. This test refers to SNI ASTM C 805-02-2012 on Hard Concrete Bounce Number Test Method. According to the National Standardization Agency, 2012, the rebound test method includes determining the rebound number of hard concrete materials using a rebound hammer controlled by an officer.

The bounce test aims to estimate the compressive strength value of the installed concrete based on the hardness of the concrete surface in all parts of the structural components. The working principle is to provide an impact load on the concrete surface using a mass that is activated using a specified amount of energy. Because of the collision between the mass and the concrete surface, the mass will be re-established. The measured mass reflection distance will give an indication of the hardness of the concrete surface. The hardness of concrete can give an indication of its compressive strength. This tool is also very versatile in determining the uniformity of concrete materials in the structure. This tool is also very sensitive to variations in hardness that exist on concrete surfaces. Therefore, it is necessary to carry out several tests around the test site.(Apriani, 2016)

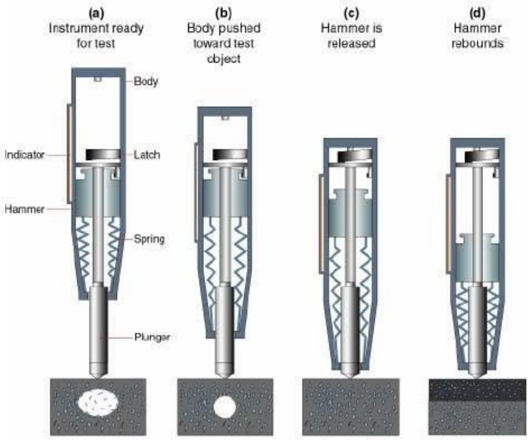

Fig. 1. Procedure in Rebound Hammer Test
Source: CE 165, Concrete Material and Concrete Construction

The tool is calibrated before use by looking for the following correction numerical values:

$$R = \frac{\sum_{i}^{N} r}{N} \rightarrow AK = \frac{80}{R} \quad \ldots (1)$$

Information:

R = Average rebound rate

N = Number of strokes

r = Rebound value

AK = Correction number (calculated if it is outside the range of 78-82)

Analyze the test results to obtain the standard deviation (sd) with the following formula:

$$sd = \frac{\sum_{i}^{N} (fcr - fci)^2}{N - 1} \quad \ldots (2)$$

With:

FCI = estimated compressive strength of concrete (kg/cm2)

FCR = Estimated compressive strength of average concrete (kg/cm2)

After obtaining the standard deviation value, it can determine the characteristic compressive strength value of concrete with the following formula:

$$\sigma bk = \sigma br - (K_1 \times K_2 \times sd) \ldots (3)$$

With:

Σbk = Compressive strength of concrete characteristics (kg/cm2)

Σbr = average compressive strength of concrete (kg/cm2)

K1 = Constant, for the number of test objects ≥ 20 = 1.645

K2 = standard deviation multiplier when the test specimen is not qualified

sd = Calibration standard (kg/cm2)

1.1.2. Ultrasonic Pulse Velocity Test

Ultrasonic Pulse Velocity Test (UPV) is a test to identify the quality of concrete density by measuring ultrasonic pulses through waves in concrete. This test refers to ASTM C597 on Standard Test Method for Pulse Velocity Through Concrete. The UPV method is carried out by channeling ultrasonic waves from the transducer transmitter placed on the concrete surface through the stemplet material to the transducer receiver and the travel time on the wave is measured using the read-out unit PUNDIT (Portable Unit Non-Destructive indicator Tester) in micro seconds (msec).

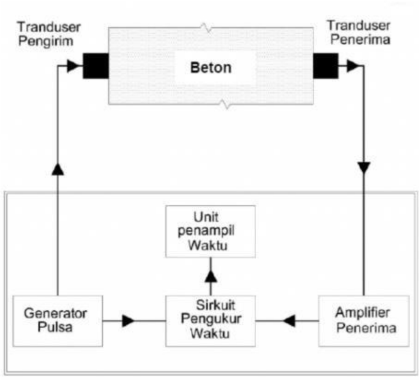

Fig. 2. Procedure in Ultrasonic Pulse Velocity Testing
Source: SNI ASTM C597 : 2012

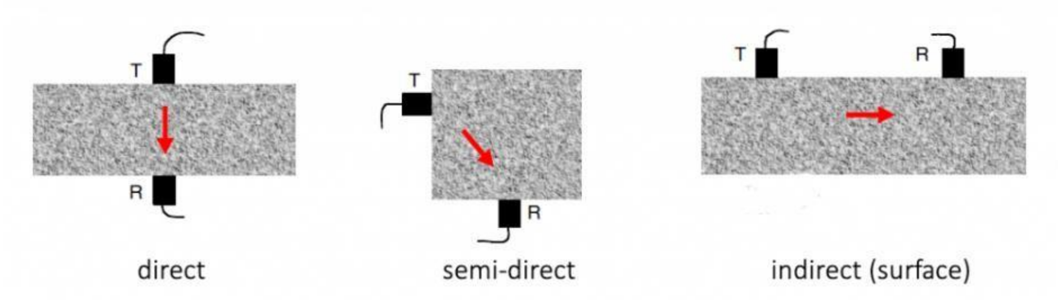

Fig. 3. Ultrasonic Pulse Velocity Reading Type
Source: SNI ASTM C597 : 2012

Table 1: The Relationship of Wave Speed with Concrete Quality

Yes	Fast propagation (km/sec)	Concrete Quality/Homogeneity
1	>4.5	Excellent
2	3,5 – 4,5	Good
3	3,0 – 3,5	Doubtful
4	<3.0	Poor

Source: SNI ASTM C597 : 2012

2. METHOD

The stages of testing in the field in assessing the performance of the RSUD structure include the following aspects:

2.1. Visual Observation

Visual observations are carried out to see the condition of the existing structure so that it can identify any damage that has occurred to the structure. At this stage, physical conditions are observed only in the upper structure of the building which is a building element located above the ground level. The upper structure testing carried out includes the elements of columns, beams, and floor plates. If there is a crack, the scattered crack is measured using a crackmeter.

2.2. Rebound Hammer Test

The Rebound Hammer is a tool that can be used as a concrete homogeneity test. The test position of this tool is not the same as the other because it is possible that the structure being reviewed is difficult to reach. So the test position needs to be carefully considered

Fig. 4. Hammer Rebound Testing Examples

Furthermore, the data is processed based on the calculations that have been presented in sub-chapter 1.1.3. The results of the hammer test data processing can be estimated at the value of the compressive strength of concrete characteristics that vary in each structural element. The fluctuating compressive strength of concrete can be caused by the graded properties of concrete. Because coarse aggregate accumulates in certain places or in other parts that are only filled by mortar. This condition states that the compressive strength value of existing concrete is classified as very good and qualified for structural materials.

2.3. Ultrasonic Pulse Velocity

Ultrasonic Pulse Velocity is a tool that can be used as a concrete quality test. The following is an example of an Ultrasonic Pulse Velocity tool which can be seen in figure 3.6

The test field on the structural element must meet the concrete surface i.e. a solid, smooth surface, and the selected test field must be dry and smooth, free from protrusions or holes, and the locations of the test field must be determined according to the dimensions of the structural elements and the number of test values required for the calculation of the estimated flow speed of the wave.

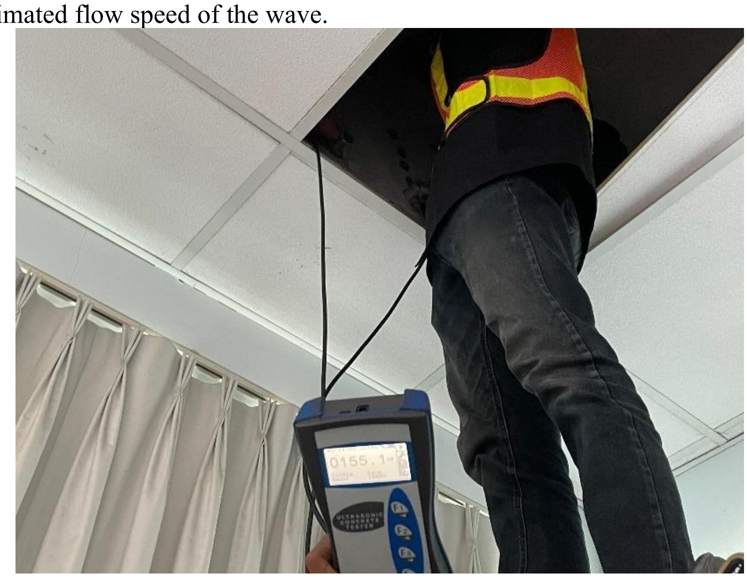

Fig. 5. Sample Testing of Ultrasonic Pulse Velocity Tool

3. Results and Discussion

Results should be clear and concise. Show only the most significant or main findings of the research. Discussion must explore the significance of the results of the work. Adequate discussion or comparison of the current results to the previous similar published articles should be provided to show the positioning of the present research (if available).

3.1. Visual Observation Data of Structures

The first step observed in the visual inspection of the structure in the field is to examine the overall condition of the building structure.

Table 2: Visual Observation of the Structure

No.	Structural Elements	Observation Results
1	Columns and Shear Walls	There are structural columns and shear walls that have hair cracks on the outside of the building, but it is likely that they are only cracked in the stucco of the columns and do not lead to the columns of the structure
2	Beam	There are structural beams that experience vertical cracking, horizontal cracking, and oblique cracking with a thickness of 0.3-1.5 mm which is indicated as cracking due to pure tensile, shearing, and adhesion.
3	Plate	There are several parts of the floor plate that have experienced quite serious cracks because of the thickness of the cracks which reach 0.2 - 2.6 mm.

Source: Research Survey, 2025

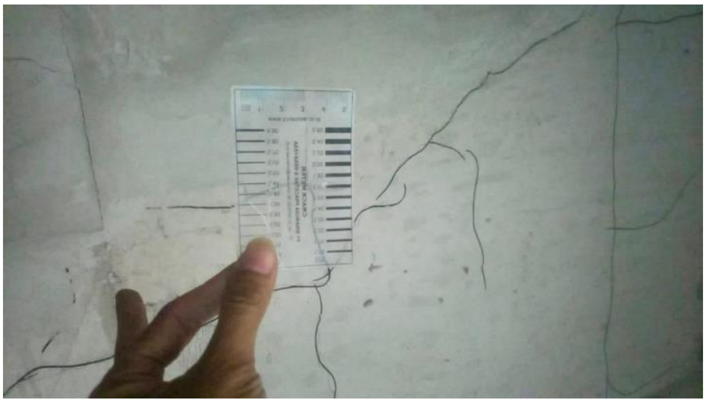

Fig. 6. Examples of Cracks in Beams in the Structure of RSUD X Bandung

Significant cracks in the structural beams are possible due to the earthquake that occurred centered in Cianjur and Bandung Regency and is possible because the structure is unable to withstand the additional load on it. Therefore, damage to the RSUD building can be categorized as moderate structural damage. Because there is a crack thickness of more than 0.6 mm.

3.2. Ultrasonic Pulse Velocity Test Results Data

Ultrasonic Pulse Velocity testing aims to estimate the hardness of concrete based on the relationship of the Ultrasonic Pulse Velocity wave speed through concrete media. This test is carried out on the structural elements of columns, beams, plates, and shear walls. The method used in the testing of column, beam, and shear wall elements is the semi-direct method while for plate elements the in-direct method is used.

Table 3: Results of Ultrasonic Pulse Velocity Test on Beam Structural Elements

Yes	Component	Axis	Floor	V (km/s)	Concrete Quality
1	Beam	4-5/E	Dak	3,09	Doubthful
2	Beam	D-E/6	12	3,70	Good
3	Beam	D-E/2	12	3,14	Doubthful
4	Beam	3-4/E	11	2,34	Poor
5	Beam	2-3/E	10	3,04	Doubthful
6	Beam	D-E/4'	9	1,22	Very Poor
7	Beam	12-12'/C	8	3,01	Doubthful

Yes	Component	Axis	Floor	V (km/s)	Concrete Quality
8	Beam	4-5/B	7	3,13	Doubthful
9	Beam	E-E'/10'	6	2,17	Poor
10	Beam	D-E/10'	5	3,46	Doubthful
11	Beam	E-E'/8	4	4,00	Good
12	Beam	5-6/E	4	3,51	Good
13	Beam	9-10/D	3	2,12	Poor
14	Beam	3-4/C-D	2	1,31	Very Poor
15	Beam	5-6/D	1	3,17	Doubthful
16	Beam	F-G/11'	1	1,77	Very Poor
17	Beam	A-B/7	1	2,26	Poor
18	Beam	B-C/7	Basis	2,74	Poor
19	Beam	D-E/11'	B1	3,32	Doubthful
Average				2,76	Poor

Table 4: Results of Ultrasonic Pulse Velocity Test on Column Structure Elements

Yes	Component	Axis	Floor	V (km/s)	Concrete Quality
1	Column	2/E	11	3,42	Doubthful
2	Column	1/C	10	2,57	Poor
3	Column	10/D	9	2,55	Poor
4	Column	12'/B	8	1,48	Very Poor
5	Column	3/B	7	1,55	Very Poor
6	Column	8/D	6	3,03	Doubthful
7	Column	1/E	5	3,15	Doubthful
8	Column	9/E''	5	2,52	Poor
9	Column	10/F	5	2,30	Poor
10	Column	10/C	4	3,51	Good
11	Column	11/G	3	4,64	Excellent
12	Column	2/C	3	4,14	Good
13	Column	10/D	2	2,82	Poor
14	Column	6/D	1	2,74	Poor
15	Column	12/C	1	3,31	Doubthful
16	Column	10/D	0	2,58	Poor
17	Column	7/B	0	3,18	Doubthful
18	Column	6/C	B1	3,42	Doubthful
19	Column	9/C	B1	3,48	Doubthful
20	Column	9/C	B1	3,50	Doubthful
21	Column	8/C	B2	3,34	Doubthful
22	Column	11/E	B2	2,28	Poor
23	Column	5/C	B2	2,94	Poor
24	Column	11/C	B2	1,43	Very Poor
25	Column	7/C	B2	3,82	Good
Average				2,95	Poor

Table 5: Ultrasonic Pulse Velocity Test Results on Shear Wall Structure Elements

Yes	Component	Axis	Floor	V (km/s)	Concrete Quality
1	Shear Wall	4-4'/B'	12	1,69	Very Poor
2	Shear Wall	4-5/B'	6	1,31	Very Poor
3	Shear Wall	B-B'/4	4	3,14	Doubthful
4	Shear Wall	4-5/B	2	1,77	Very Poor
5	Shear Wall	4'-5/B'	Basis	1,15	Very Poor
6	Shear Wall	10/B-C	B1	0,96	Very Poor
7	Shear Wall	B-C/10	B2	1,39	Very Poor
Average				1,39	Very Poor

Based on the results of the Ultrasonic Pulse Velocity test, it can be concluded that the average wave speed for the beam is 2.76 km/s (2 km/s <2.7 km/s<3 km/s) so that it is categorized as quite good quality concrete. For columns, an average wave speed of 2.95 km/s (2 km/s <2.95 km/s<3 km/s) is obtained, so it is categorized as quite good quality concrete. For shear walls, an average wave speed of 1.39 km/s (1.39 km/s < 2 km/s) is obtained, so it is categorized as poor quality concrete.

3.3. Rebound Hammer Test Results Data

The rebound hammer test aims to obtain the approximate value of the compressive strength of the concrete characteristics on the existing structure, this test is carried out on the structural elements of columns, beams, slabs, and shear walls. The data from this test was processed based on SNI 03-4430-1990/ASTM C.805-97. The number of data taken for this rebound hammer test for the entire building is 96 test points.

Beating/firing for hammer rebound testing is carried out 5 times at each test point, then the results are averaged. From the average results, the test results were then corrected with an average of ±5. Then the average correction is plotted on the relationship curve of the Hammer test value to the compressive strength of a standard concrete cylinder.

Table 6: Rebound Hammer Test Results on Beam Structure

Yes	Component	Axis/Code	Floor	α⁰	R	R Correction	Corrected Compressive Strength
					Average		Mpa
1	Beam	4-5/E	Dak	0	39,70	39,70	39,9
2	Beam	D-E/5'	Dak	0	42,70	42,70	44
3	Beam	D-E/5	Dak	0	41,90	41,90	42,5
4	Beam	D-E/5'	Dak	0	42,70	42,70	44,1
5	Beam	D-E/5	Dak	0	41,90	41,90	43
6	Beam	D-E/2	12	0	38,60	38,60	37,8
7	Beam	D-E/6	12	0	45,70	45,70	50,1
8	Beam	3-4/E	11	+90	43,60	43,60	37,8
9	Beam	12-13/G'	11	0	42,30	42,30	42,1
10	Beam	D-E/9	11	0	39,80	39,80	39,5
11	Beam	D-E/6'	11	0	30,80	30,80	24,2
12	Beam	2-3/E	10	0	37,10	37,10	34,8
13	Beam	B-C/3	10	0	45,60	45,60	50
14	Beam	12-12'/C	8	0	39,80	39,80	32,2
15	Beam	4-5/C'	8	0	34,70	34,70	30,9
16	Beam	12-13/G	7	0	42,00	42,00	43,8
17	Beam	F-F''/10	6	0	37,40	37,40	33,8
18	Beam	11-11'/G	5	0	40,20	40,20	40,7
19	Beam	F'-G/11	4	0	40,30	40,30	40,5
20	Beam	E-E'/8	4	0	42,60	41,25	42,2

Yes	Component	Axis/Code	Floor	α⁰	R Average	R Correction	Corrected Compressive Strength Mpa
21	Beam	5-6/E	4	+90	60,50	60,50	62
22	Beam	13-14/F	3	+90	45,10	45,10	42,5
23	Beam	10-11/D	3	0	41,40	41,40	42,1
24	Beam	F-G/11'	1	0	42,10	42,10	44
25	Beam	A-B/7	1	0	31,30	31,89	25,9
26	Beam	9-10/E	Basis	0	45,90	45,90	51,3
27	Beam	9-10/B	Basis	0	43,70	43,70	46,1
28	Beam	B-C/7	Basis	+90	39,80	39,80	32,4
29	Beam	C-D/8	B1	0	44,00	44,00	47,5
30	Beam	D-E/4'	B1	0	42,60	42,60	42,7
31	Beam	C-D/3'	B1	0	42,60	42,60	42,7
32	Beam	B-C/2	B1	0	35,60	35,60	32,1
			Average Beam				40,79

So that
Number of test specimen (n) = 32 pieces
Stat. Constant. 5% Defect (k2) = 1.64
Stat. Constant. N>20 (k1) = 1
Average Compressive Strength (fcr) = 40.79 MPa
Standard Deviation (sd) = 1.62 MPa
Compressive Strength Characteristics (fc') = 38.14 MPa

Table 7: Rebound Hammer Test Results on Column Structure

Yes	Component	Axis/Code	Floor	α⁰	R Average	R Correction	Corrected Compressive Strength Mpa
1	Column	10/C	12	0	31,80	31,80	25,8
2	Column	10/D	12	0	35,70	35,70	32,1
3	Column	5/E	12	0	45,40	45,40	49,8
4	Column	10/C	12	0	31,80	31,80	23,9
5	Column	10/D	12	0	35,70	35,70	32
6	Column	5/E	12	0	45,90	45,90	50
7	Column	2/E	11	0	40,40	40,40	41
8	Column	13/D	11	0	37,30	37,30	35,6
9	Column	10/C	10	0	41,20	41,20	42,1
10	Column	6/E	10	0	33,30	33,30	28,3
11	Column	12/G	10	0	48,60	48,60	53,8
12	Column	10/D	9	0	41,20	41,20	42,1
13	Column	14/F	9	0	39,90	39,90	39,8
14	Column	12/D	9	0	50,10	50,10	59,5
15	Column	12'/B	8	0	48,10	48,10	53,7
16	Column	3/C	6	0	41,80	41,80	43
17	Column	1/E	5	0	49,30	49,30	57,8
18	Column	9/E"	5	0	36,90	36,90	32,1
19	Column	10/F	5	0	40,40	40,40	41
20	Column	11/F	3	0	41,80	41,80	42,5
21	Column	10/D	3	0	39,80	39,80	39

Yes	Component	Axis/Code	Floor	α⁰	R	R	Corrected Compressive Strength
					Average	Correction	Mpa
22	Column	3/C	3	0	49,00	49,00	56,1
23	Column	2/C	3	0	37,10	37,10	35
24	Column	13'/E	2	0	33,00	33,00	28
25	Column	10/D	2	0	40,00	40,00	39,9
26	Column	12/C	1	0	47,30	47,30	53,8
27	Column	6/D	1	0	48,20	48,20	55,7
30	Column	6/C	B1	0	37,40	37,40	45,9
31	Column	6/C	B2	0	42,20	42,20	44
Column Average							42,56

So that

Number of test specimen (n)	= 31 pieces
Stat. Constant. 5% Defect (k2)	= 1.64
Stat. Constant. N>20 (k1)	= 1
Average Compressive Strength (fcr)	= 42.56 MPa
Standard Deviation (sd)	= 1.68 MPa
Compressive Strength Characteristics (fc')	= 39.8 MPa

TABLE 8: REBOUND HAMMER TEST RESULTS ON SHEAR WALL STRUCTURE

Yes	Component	Axis/Code	Floor	α⁰	R	R	Corrected Compressive Strength
					Average	Correction	Mpa
1	Shear Wall	4-4'/B'	12	0	46,00	46,00	50,8
2	Shear Wall	B-B'/10	10	0	41,20	41,20	42,1
3	Shear Wall	B-B''/4	4	0	45,30	45,30	49,9
4	Shear Wall	4-5/B-C	2	0	53,60	53,60	66
5	Shear Wall	4'-5/B'	Basis	0	50,90	50,90	59,9
Average Shear Wall							53,74

So that

Number of test specimen (n)	= 5 pieces
Stat. Constant. 5% Defect (k2)	= 1.64
Stat. Constant. N<20 (k1)	= 1.54
Average Compressive Strength (fcr)	= 53.74 MPa
Standard Deviation (sd)	= 1.5 MPa
Compressive Strength Characteristics (fc')	= 49.95 MPa

4. Conclusions

The results of visual assessment and technical assessments on the RSUD building can be categorized as medium-level structural damage in buildings with crack thickness of 0.2 – 2.6 mm. Meanwhile, the results of the technical assessment were obtained from the results of the Ultrasonic Pulse Velocity Test (UPV) and the rebound hammer test. It is hoped that the compressive strength measurement data and the results of this assessment will be useful input in an effort to evaluate the strength of a building structure.

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