

Durability of concrete based on the remaining life of the building Case study: reinforced concrete in Klaten District

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ABSTRACT

Concrete durability is the ability of concrete to last as it was originally planned, in the structure of a building can be defined as the ability to maintain function, stability and aesthetics due to environmental influences so as not to incur large maintenance and repair costs during the planned service life. The durability aspect is very important, especially for infrastructure that has a fairly long service life. Building life is the period or time during which a structure is required to continue to function as planned. In building structures whose construction has been completed, both new and old buildings, specific data related to the quality of the concrete and the planned age of the building is quite difficult to obtain, this is because the influence during the implementation of construction is also not good in governance. documentation, both technical documents and other non-technical documents, therefore it is necessary to have a sufficiently representative tool to test the concrete quality of a building that has been completed to comply with the quality of the built concrete.

Keywords: concrete durability; hammer test; building age; influence; quality.

INTRODUCTION

In general, concrete material is made of cement, aggregate and water as a reagent. Besides, sometimes additional material (admixture) is added to improve the properties of concrete. According to SNI 2847-2019, concrete is mixing between portland cement or other hydraulic cement, fine aggregate such as sand, coarse aggregate such as crushed stone and water and can be added with other materials (admixture). As the age of the concrete increases, the properties of the concrete will harden and will reach the desired strength at the age of 28 days. Concrete has a good compressive strength, therefore concrete is widely used as the main structure, the performance of concrete depends on the properties and characteristics of the concrete constituent materials. Based on the Government Regulation of the Republic of Indonesia Number 16 of 2021 concerning Implementing Regulations of Law Number 28 of 2022 concerning Buildings, it is stated in article 29 paragraph 2 (two) that the building structure must be planned to be strong, stable, and meet the serviceability requirements in carrying load during the planned service life by considering the function of the building, location, durability, and ease of construction. While what is meant by serviceability is the condition of the building structure which in addition to meeting safety requirements also provides a sense of security, comfort, and safety for users. In the explanation of Article 29 paragraph 2 (two) it is also stated that durability is a long structure life (lifetime) in accordance with the plan, not easily damaged, worn out, tired (fatigue) in carrying loads. This indicates that the durability of concrete is the main thing in a building structure, while the service life of the structure is the period of time in which the structure is able to meet the behavior required in the repair and maintenance scenario that has been determined (Verma, 2014).

In general, testing the strength of concrete is divided into two, namely testing with loading until the test object is damaged (destructive test) and testing without damaging the test object (non-destructive test). In buildings that have been completed and the function of the building is still being used, destructive testing is not possible because it will risk damaging the building structure and causing losses, so testing of concrete in existing buildings is carried out using a non-destructive method, namely by using a concrete hammer test. According to SNI 03-4430-1997

concerning Methods of Testing Concrete Structural Elements with Type N and NR Concrete Hammers. The difference between N and NR types is that if the N type rebound value is read from the existing scale, then the estimated compressive strength value can be read from the NR type feed conversion diagram, the rebound or rebound value is recorded in the form of a bar chart on lined paper which has a capacity of up to 4,000 collisions.

Concrete hammer test is a concrete quality inspection tool that is carried out by providing a collision load on the surface of the concrete then the rebound value is recorded and analyzed using graphs or conversion tables available.

Concrete is a material composed of a mixture of fine aggregate, coarse aggregate and cement and water is added as a lubricant. The compressive strength of concrete is influenced by many factors. Among them is that concrete will be strong if it has a mixture that is in accordance with existing plans and rules. Concrete regulations require the composition between concrete and additives to be balanced and the value is determined by the concrete regulations (Rulhendri R et.al, 2013; Chayati N et.al, 2017; Putranto FR, Syaiful S, 2019; Syaiful S, 2021).

RESEARCH METHODS

Research Location and Time

This research was conducted in Klaten Regency by selecting 3 (three) buildings as research objects, namely the Meeting Building which is located at Buntalan Village, Central Klaten District, Catering Building which is located at Buntalan Village, Central Klaten District and Rusunawa Building which is located at Barenglor Village, North Klaten District, Klaten Regency. The time of the research was carried out on Monday to Friday without specifying certain days, for buildings with multipurpose functions, they were chosen when the building was not in use.



Figure 1. Research location (Source: Google Earth)

Materials and tools

The material used in this study is in the form of primary data related to existing conditions, such as the visual condition of the concrete and the dimensions of the cross section which were carried out by means of a direct survey to the location. Secondary data is obtained from related service data such as data on the year it was built, the function of the building, the initial quality of concrete and

the age plan of the building. Meanwhile, the tools used in this research are concrete hammer test, grinding stone, scrap or wall tape, survey form, meter, camera and office stationery. To process data computer software used in the form of Microsoft Excel, Microsoft Word, Google Earth and AutoCAD.

Data analysis method

The data obtained in this study include the visual condition of the concrete, the number of reflections or rebounds from the hammer test test and the angle of taking the hammer test test. The data obtained from the hammer test test were then analyzed and presented descriptively in the form of tables and graphs to determine the relationship between the number of bounces or rebounds with the estimated compressive strength of concrete and to determine the relationship or correlation between the compressive strength of concrete and the remaining life of the building.

Research Flowchart

The flow chart of this research is as follows:

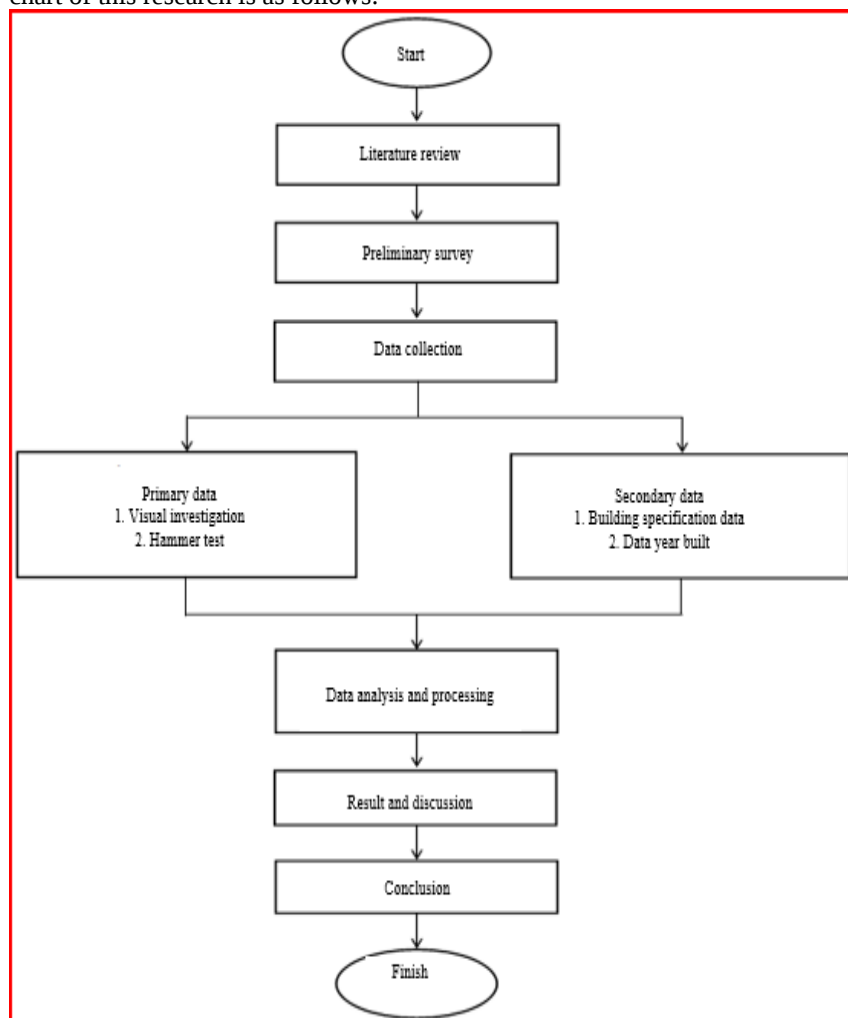


Figure 2. Research Flowchart

RESULTS AND DISCUSSION

After testing the hammer test at the Meeting Building located in Klaten Regency, the data were obtained which were then presented in tabular form. The data obtained include data on resilience values, inclination angles, maximum and minimum rebounds, average readings and also estimated

compressive strength (kg/cm^2). Hammer tests are carried out on column, beam and plate elements which are divided into 4 points at each point consisting of 20 (twenty) punches/shots.

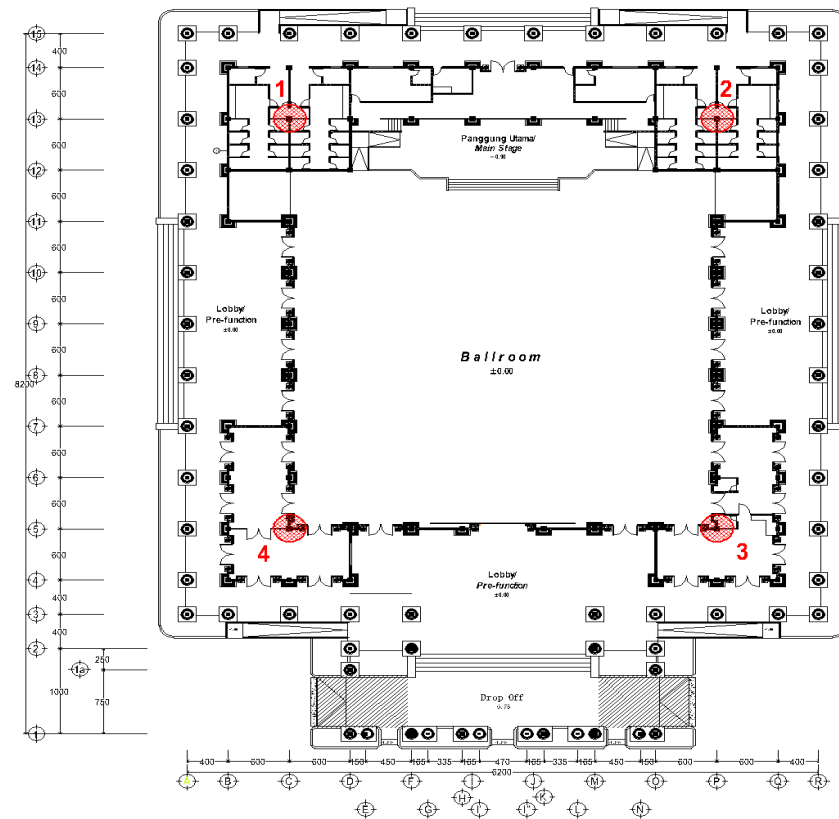


Figure 4. Hammer Test Tests on Columns, Beams and Plates Meeting Building

Table 1. Average Hammer Test Results Meeting Building

Structural element	Shots/Punch (kg/cm^2)			
	1st point	2nd point	3rd point	4th point
Column	459,12	498,64	526,60	438,66
Beam	483,25	492,75	470,71	406,70
Plate	503,77	495,98	475,84	437,94

After testing the hammer test at the Catering Building located in Klaten Regency, the data were obtained which were then presented in tabular form. The data obtained include data on resilience values, inclination angles, maximum and minimum rebounds, average readings and also estimated

compressive strength (kg/cm²). Hammer tests are carried out on column, beam and plate elements which are divided into 4 points at each point consisting of 20 (twenty) punches/shots.

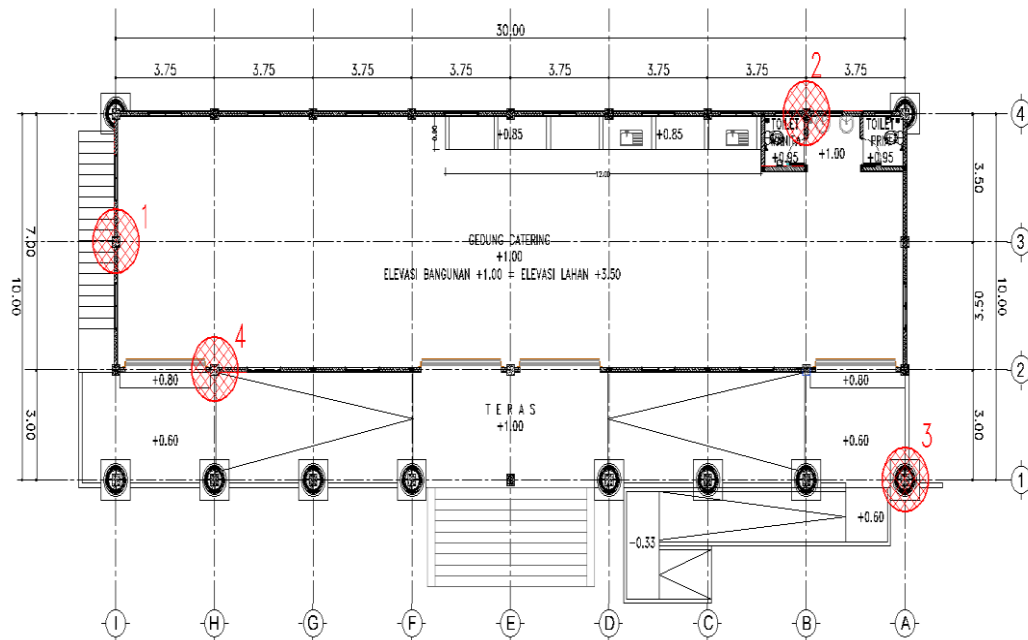


Figure 5. Hammer Test Testing Plan for Catering Building

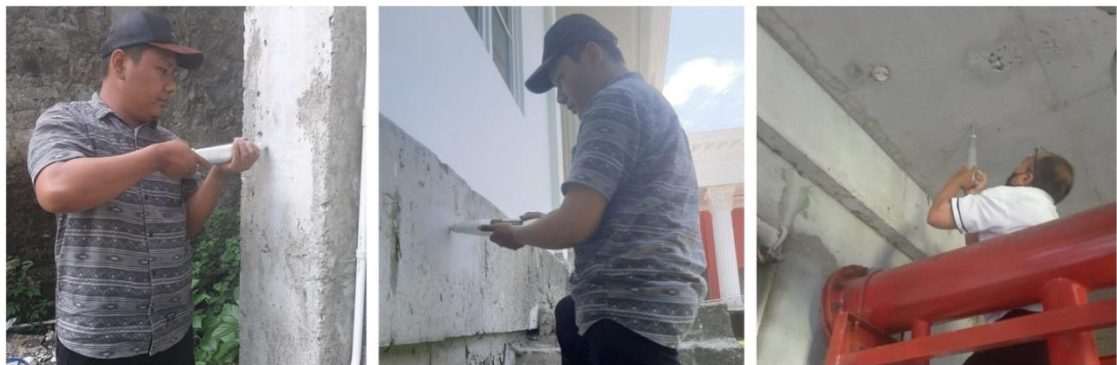


Figure 6. Hammer Test on Columns, Beams and Plates of Catering Building

Table 2. Average Hammer Test Results Catering Building

Structural element	Shots/Punch (kg/cm ²)			
	1st point	2nd point	3rd point	4th point
Column	503,20	434,88	379,50	384,50
Beam	448,56	447,66	433,08	426,49
Plate	507,76	495,79	517,07	435,06

After conducting a hammer test at the Rusunawa Building located in Klaten Regency, the data were obtained which were then presented in tabular form. The data obtained include data on resilience values, inclination angles, maximum and minimum rebounds, average readings and also estimated compressive strength (kg/cm²). Hammer tests are carried out on column, beam and plate elements which are divided into 4 points at each point consisting of 20 (twenty) punches/shots.

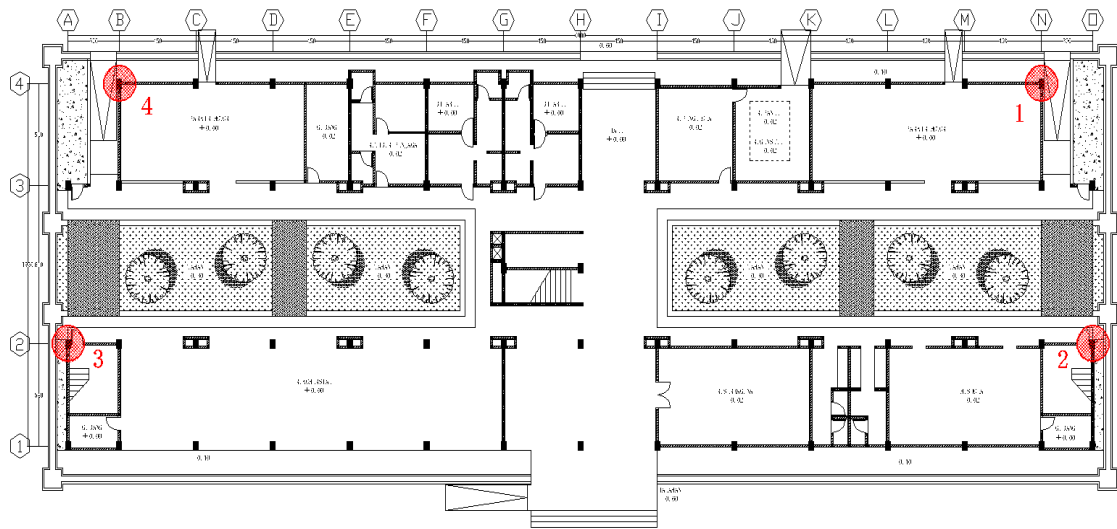


Figure 7. Hammer Test Plan for Rusunawa Building



Figure 8. Hammer Test Tests on Columns, Beams and Plates of Rusunawa Building

Table 3. Average Hammer Test Results Rusunawa Building

Structural element	Shots/Punch (kg/cm ²)			
	1st point	2nd point	3rd point	4th point
Column	374,50	415,85	609,32	442,26
Beam	572,79	643,00	620,15	603,40
Plate	566,14	532,00	588,60	498,07

Table 4. Recapitulation of the Average Results of the Hammer Test

Building name	Elemen Struktur		
	Column (kg/cm ²)	Beam (kg/cm ²)	Plate (kg/cm ²)
Meeting hall	480,755	463,353	478,383
Catering Building	425,520	438,948	488,920

Rusunawa Building	460,483	554,798	546,203
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From the table above, it can be seen that the quality of concrete is not the same as each other. The homogeneity of concrete varies greatly in each structural element, this can happen due to factors in the method of implementation and also supervision during construction.

Table 5. Percentage of Increase in Compressive Strength of Concrete by Building Age

No	Building	Building age (years)	Remaining life of the building (years)	Average percentage increase in compressive strength (%)
1	Meeting hall	3	47	58,05
2	Catering Building	3	47	50,38
3	Rusunawa Building	11	39	48,71

The compressive strength of concrete has increased varying, this is possible because the homogeneity of the concrete is not the same in each structural element when the work is carried out. The age of the building in accordance with the applicable regulations requires that for 50 (fifty) years the building is still functioning according to its designation without experiencing significant damage.

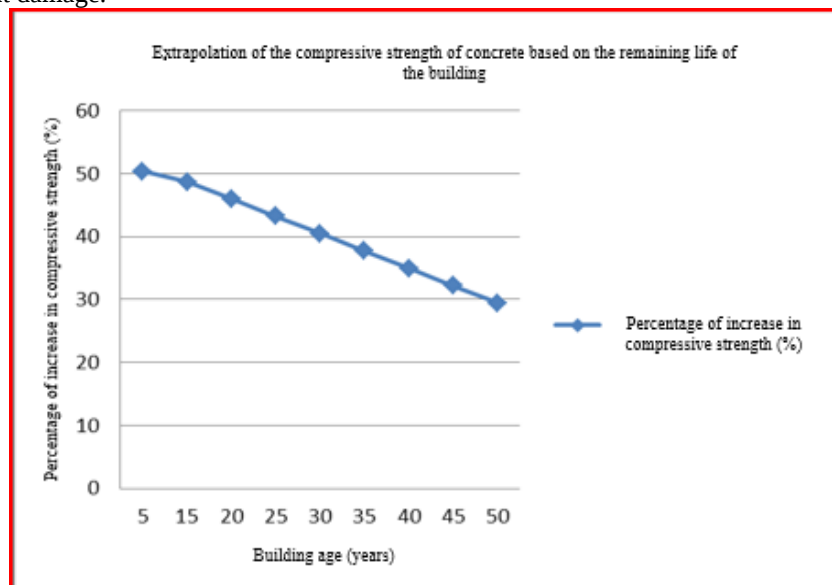


Figure 9. Extrapolation of Compressive Strength of Concrete Based on Remaining Life of the Building

From the graph above, it can be seen that the remaining life of the building affects the compressive strength or durability of the concrete. However, the durability of the concrete is still in good condition to work to carry the loads on it until the planned service life. The compressive strength of concrete is estimated to have a tendency to decrease over time and the age of the building, the results of this research are based on field data that has been taken in the three buildings, namely the Meeting Building, Catering Building and Rusunawa Building.

CONCLUSION

After analyzing by processing hammer test data, it was concluded that according to SNI 2847:2013 concerning Requirements for Structural Concrete for Buildings (SNI status is still valid) and is also contained in SNI 2847:2019 concerning Requirements for Structural Concrete for Buildings

and explanations (SNI status is still valid until now), it is required for structural concrete, the compressive strength should not be less than 17 MPa, which means the research results meet the requirements for structural concrete for buildings. So that the results of this study can be evaluated according to existing regulations and can be used as initial data for further evaluation of the structure. The durability of the concrete of the building is still good in the remaining life of the building to bear the loads on it. The homogeneity or uniformity of concrete varies in each structural element, this is inseparable from the method of implementation and supervision during the construction process.

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