

# ANALYSIS OF THE VULNERABILITY OF EDUCATIONAL FACILITIES TO THE LEMBANG FAULT EARTHQUAKE IN THE JAMBUDIPA VILLAGE AREA, CISARUA, WEST BANDUNG

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## ABSTRACT

Cisarua Subdistrict is located in an area with a high risk of earthquakes due to the presence of the active Lembang Fault, which was the cause of the earthquake that struck this area on August 28, 2011. One of the high-risk areas is Jambudipa Village, which serves as the administrative center of the subdistrict, and is home to a large number of schools. This study was conducted to examine the condition of these buildings, with a specific focus on the quality of the concrete in the primary structural elements. This is particularly important given that many of these schools have been standing for decades and were likely built before current seismic resistance standards were in place. The study employed a mixed-method approach, combining questionnaire data distributed to school principals with direct observation of the physical condition of the buildings. The Schmidt Hammer Test was carried out on columns, beams, and walls to obtain an initial estimate of concrete strength as an indicator of the structural condition of the buildings. Through this study, it is hoped that a useful preliminary picture of concrete quality in these schools can be provided, as well as a foundation for further structural evaluation and earthquake disaster risk reduction efforts in the area.

**Keywords:** *Cisarua, Earthquake, Educational Facilities, Jambudipa, Lembang Fault*

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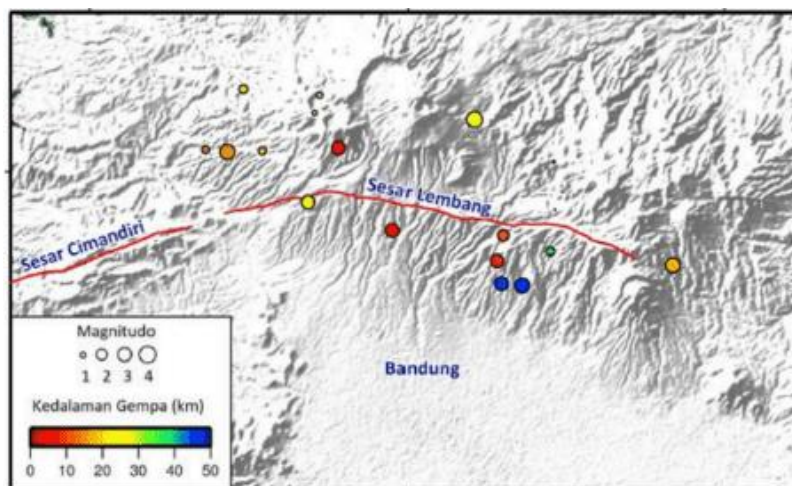


## INTRODUCTION

Indonesia is a country with a relatively high risk of natural disasters, for example earthquakes caused by active fault activity, volcanic eruptions, floods, and landslides. This is due to Indonesia's geographical location at the junction of three tectonic plates: the Eurasian, Indo-Australian, and Pacific plates. Indonesia is also situated within the Pacific Ring of Fire, an area with extremely high seismic activity. Indonesia's tropical climate also contributes to various hydrometeorological disasters, such as floods, landslides, and droughts, which frequently occur throughout the year (Pertahanan 2025).

Among the various types of disasters that occur, earthquakes are one of the most frequently experienced by the Indonesian people. According to data from the National Disaster Management Agency (BNPB), in 2025 there were 1,713 natural disasters recorded in Indonesia. Meanwhile, in West Java Province, the Meteorology, Climatology, and Geophysics Agency (BMKG) recorded approximately 92 earthquakes during the same period (Primananda 2025). One particularly impactful event was the earthquake that occurred in 2011. That earthquake caused damage to approximately 291 homes, as shown in Figure 1 below.

Tectonic activity along the Lembang Fault still poses a potential earthquake threat that requires vigilance, as it has the potential to generate earthquakes with a magnitude of up to 5.5 on the Richter scale. However, the exact timing of such an earthquake is difficult to predict (Primananda 2025). One of the regions in West Java Province directly traversed by this fault line is West Bandung Regency, located in the northern part of the Bandung area. According to information published by the Regional Disaster Management Agency (BPBD), this area requires special attention due to its proximity to the Lembang Fault zone and its relatively high vulnerability to seismic activity. This situation is illustrated in Figure 2.



**Figure 1.** Map of the Distribution of Historical Points Along the Lembang Fault (Source: Daryono, 2021).



2022). Tectonic earthquakes are the most common type and are generally caused by the movement of tectonic plates (Anita et al. 2025). One of the active fault zones in West Java is the Lembang Fault. According to (Tjia 1968), the Lembang Fault is classified as a left-lateral fault with an additional normal fault movement component. This tectonic activity increases the earthquake risk in the northern Bandung region.

In earthquake-prone areas, mitigation efforts are important, especially through evaluating the condition of existing buildings. Educational facilities are important public buildings because they are used daily by many students and teachers. Therefore, assessing the structural condition of school buildings is necessary to understand their ability to withstand seismic loads.

One method commonly used for preliminary structural assessment is the Schmidt Hammer Test, which estimates the compressive strength of concrete in structural elements such as columns, beams, and walls. Although this method cannot fully represent the overall seismic performance of a building, it can provide an overview of concrete quality and structural condition in the field without damaging the structure (Saremi, Setare G., Dimitrios G. Goulias and Akhter. 2022). For this reason, assessing the condition of the structural components of educational facilities can help minimize the risks posed by earthquakes, especially in areas located near active fault zones such as the Lembang Fault.

### **Lembang Fault Tectonics.**

The Lembang Fault is one of the most prominent geological features in the Bandung Highlands. Located on the southern slope of Mount Tangkuban Perahu, its presence indicates that fault activity is still ongoing in the Bandung Basin (Brahmantyo 2005).

Based on its natural features, the Lembang Fault can be identified by the presence of a north-facing fault scarp. This fault is estimated to have existed since the Quaternary period more specifically, during the Pleistocene epoch, approximately 500,000 years ago. Geologically, its formation is linked to the collapse of the massive Sunda volcano in the distant past, which caused part of the volcano's body to collapse, leaving only a few parasitic cones. The collapse of the volcano created a void in the magma chamber, causing the rocks resulting from the eruption of Mount Sunda to fracture and form a fault. This fault structure extends from east to west, with the eastern section showing a more pronounced dip compared to the western section (Rasmid 2014).

### **Earthquake-Resistant Buildings**

An earthquake-resistant building does not mean a building that is completely free from damage during an earthquake. The concept of an earthquake-resistant building refers to a structure that may sustain damage but will not collapse. In other words, such a building is designed to sustain controlled damage so that it remains standing and protects its occupants during an earthquake (Wibowo 2022). The implementation of earthquake-resistant building standards is a crucial aspect of disaster risk mitigation and reduction efforts, particularly in areas with a high risk of earthquakes (Prihantony et al. 2020). The concrete quality classifications used as a reference for interpreting the estimated compressive strength of concrete obtained from Schmidt hammer tests are presented in Table 1.

**Table 1.** Concrete Quality Characteristics

Quality Class	Compressive Strength (MPa)	Compressive Strength (kg/cm <sup>2</sup> )	General Use
K-175	14,5	175	Non-structural, concrete curb
K-200	16,6	150	Lightweight structure, essential for building construction
K-225	18,7	200	Residential building
K-250	20,8	250	Light- to medium-duty multi-story buildings
K-300	24,9	300	Mid- to high-rise buildings
K-350	29,1	350	Special structures, high-seismic zones

(Source: Suwandi, 2025)

A building's seismic performance is influenced by its stiffness, structural configuration, and strength. The assessment of vulnerability in existing buildings can begin with a preliminary survey, followed by a more in-depth evaluation of buildings identified as having a higher risk level (Zhafira, Widorini, and Crista 2023).

### Characteristics of Educational Buildings

Educational buildings, particularly elementary schools, have distinctive typological characteristics compared to other civil structures. According to Ministry of Education Regulation No. 24 of 2007, school buildings are required to meet safety, health, and comfort standards, as well as provide ease of use to support the learning process. From a structural perspective, school buildings are generally designed with simple span systems and a regular, repetitive spatial layout, allowing for more efficient and easily implementable structural systems (Suwandi, Hendryarto, and Widiastuti 2025).

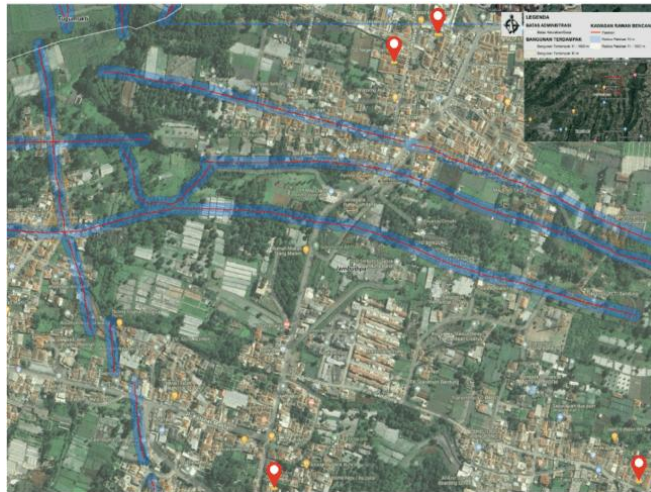
## METHODS

The approach used in this study is a mixed-methods approach that combines quantitative and qualitative analysis (Creswell 2021). This approach is based on specific philosophical principles and supported by an appropriate theoretical framework. The research was conducted in stages, beginning with the identification of the locations and physical conditions of the buildings selected as case study subjects.

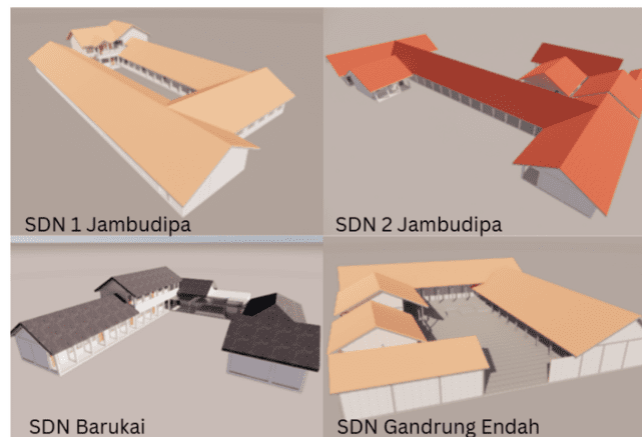
### Research Subject

The research focused on educational facilities located in Jambudipa Village, Cisarua Subdistrict, West Bandung Regency, West Java Province. These schools are scattered across several residential areas, namely RT 03 RW 11, RT 03 RW 04, and RT 03 RW 10, as shown in Figure 3.

The four schools shown in Figure 4 were selected using a purposive sampling method based on several specific criteria:



**Figure 3.** Jambudipa Village  
(Source: Personal Documentation, 2025).



**Figure 4.** A Perspective on School Buildings in Jambudipa Village  
(Source: Personal Documentation, 2025).

1. These four schools are located within or near the Lembang Fault zone.
2. The buildings were generally constructed in the 1950s, before current earthquake-resistant construction regulations were enacted.
3. These four schools represent all elementary schools operating within the study area of Jambudipa Village.

Based on these characteristics, the four selected schools are considered appropriate subjects for evaluating the structural condition of educational buildings in the context of earthquake risk associated with the Lembang Fault.

Measurements of the structure were taken on the columns, beams, and walls. The measurement points are shown on the existing floor plan below:

### Measuring Instruments

The testing method used in this study is the Schmidt Hammer Test, a non-destructive testing method widely used in assessing the structural condition of existing buildings. In addition to its practical advantages of being portable, easy to operate, and cost effective (Saremi, Setare G., Dimitrios G. Goulias and Akhter. 2022), the Schmidt Hammer Test is

scientifically justified for this study for several reasons. First, concrete compressive strength is a fundamental parameter in determining the load-bearing capacity of structural elements such as columns, beams, and walls components that play a crucial role in a building's ability to resist lateral forces during an earthquake (Zhafira, Widorini, and Crista 2023). Second, in the absence of original construction documents a common occurrence in older buildings such as those constructed in the 1950s the Schmidt Hammer Test serves as a reliable method for obtaining an initial on site estimate of concrete quality (Suwandi, Hendryarto, and Widiastuti 2025). Although this method does not cover all aspects of seismic vulnerability, such as reinforcement details and structural layout, it provides an important initial indicator of whether a building structure meets the minimum concrete quality standards required for structures in earthquake-prone areas.

Figure 5 shows the visual representation of the hammer test device and a sketch of the distribution pattern of the test reflection points used in this study. Additionally, Figure 6 shows the distribution of hammer test points on structural elements such as columns, beams, and walls in the floor plans of the four schools.

This test provides an initial indication of concrete strength by measuring rebound values at several points on the concrete surface. These values are then processed and compared with the Schmidt Hammer chart to determine the concrete compressive strength ( $f_c$ ) in MPa, and subsequently converted into concrete quality class (K).

### Data Collection

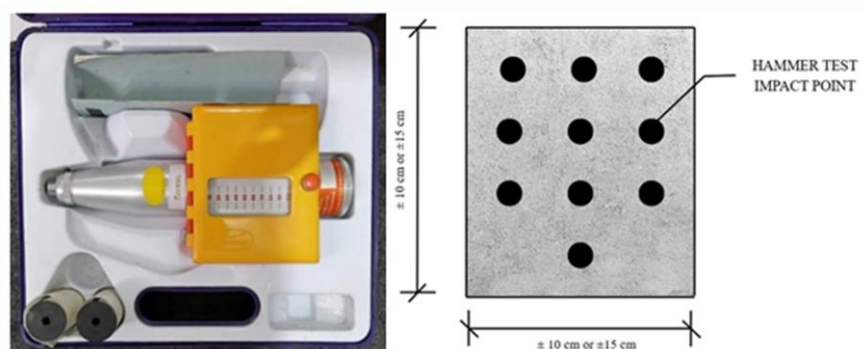
In this study, data were collected using several methods, including:

a. Observation

Observations were conducted to assess the structural condition of school buildings in Jambudipa Village by testing the structural condition via the Rebound Hammer Test on columns, beams, and walls.

b. Interviews

Interviews were conducted with the principal or a teacher representative from each school included in the study to gather information on the age of the



**Figure 5.** Hammer Test Equipment & Sketch of the Hammer Test Area (Source: Personal Documentation, 2025).



**Figure 6.** School Building Floor Plan in Jambudipa Village  
(Source: Personal Documentation, 2025).

building, the year it was built, the most recent renovations, and damage caused by the earthquake. The questions were then formulated to reflect the actual conditions on the ground as simply as possible.

c. Documentation

Documentation was carried out concurrently with the Rebound Hammer Test.

### Data Analysis

Data analysis in this study was conducted using a qualitative descriptive approach and was carried out in stages, as follows:

a. Data Reduction

The data collected through hammer tests and questionnaires was then grouped according to the research objectives, so that the information presented could focus on the structural condition of these buildings.

b. Data Presentation

The data that has been collected and categorized is then presented in the form of descriptive explanations, tables, and documentation to illustrate the condition of the building.

c. Drawing Conclusions

Conclusions were drawn based on the results of field observations, supported by Schmidt Hammer Test data, to explain the extent of the buildings' structural resilience and condition.

## RESULT AND DISCUSSION

The hammer test is conducted in the following steps:

1. Determining the test location for the hammer test, prioritizing areas where the concrete surface is still in good condition and relatively flat.
2. Clean and level the concrete surface to be tested to minimize the possibility of data discrepancies.
3. Conduct the test by applying an impact load 10 times, with a minimum distance of 20 mm between impact points.
4. Recording the concrete strength values based on the test results obtained.

Hammer tests on the columns, beams, and walls previously identified in Figure 6 above were documented during the course of the study in the classrooms of several schools, namely SDN 1 Jambudipa (see Figure 7), SDN 2 Jambudipa (see Figure 8), SDN Barukai (see Figure 9), and SDN Gandrung Endah (see Figure 10).



**Figure 7.** The Hammer Test Process at SDN 1 Jambudipa  
(Source: Personal Documentation, 2025).



**Figure 8.** The Hammer Test Process at SDN 2 Jambudipa  
(Source: Personal Documentation, 2025).



**Figure 9.** The Hammer Test Process at SDN Barukai  
(Source: Personal Documentation, 2025).



**Figure 10.** The Hammer Test Process at SDN Gandrung Endah  
(Source: Personal Documentation, 2025).

### Hammer Test Results

The rebound values from the hammer test, which were obtained from each school, were then processed and calculated using Microsoft Excel, and are presented in Tables 2, 3, 4, and 5.

**Table 2.** Results of the Hammer Test at SDN 1 Jambudipa

Average	Components	Direction of Fire	Floor	Conversion of Corrected Compressive Strength Values for Concrete in the Form of	
				Cylinder (f'c)	Cube (K)
29	Column	→	1	22	270.29
29.2	Column	→	1	22.5	276.43
28	Column	→	1	20	245.72
28.2	Beam	↑	1	21.5	264.14
28.5	Beam	↑	1	21	258.00
27	Wall	→	1	19	233.43
27.8	Wall	→	1	20.5	251.83

(Source: Personal Documentation, 2025)

**Table 3.** Results of the Hammer Test at SDN 2 Jambudipa

Average	Components	Direction of Fire	Floor	Conversion of Corrected Compressive Strength Values for Concrete in the Form of	
				Cylinder (f'c)	Cube (K)
30.2	Column	→	1	24	294.86
27	Column	→	1	19	233.43
26.1	Column	→	1	18.5	227.29
28.9	Beam	↑	1	22	270.29
23.9	Beam	↑	1	20	245.72
27	Wall	→	1	19	233.43
22.2	Wall	→	1	16.8	206.40

(Source: Personal Documentation, 2025)

**Table 4.** Results of the Hammer Test at SDN Gandrung Endah

Average	Components	Direction of Fire	Floor	Conversion of Corrected Compressive Strength Values for Concrete in the Form of	
				Cylinder (f'c)	Cube (K)
27	Column	→	1	19	233.43
30.4	Column	→	1	22.5	276.43
23.3	Column	→	1	18.2	223.60
34.2	Beam	↑	1	24	294.86
30.1	Beam	↑	1	24.5	301.00
26.9	Wall	→	1	18	221.14
26	Wall	→	1	18.2	223.60

(Source: Personal Documentation, 2025)

**Table 5.** Results of the Hammer Test at SDN Barukai

Average	Components	Direction of Fire	Floor	Conversion of Corrected Compressive Strength Values for Concrete in the Form of	
				Cylinder (f'c)	Cube (K)
32.2	Column	→	1	26.2	321.89
29.2	Column	→	1	22.1	271.52
30.4	Column	→	1	22.5	276.43
32.9	Beam	↑	1	26.2	321.89
29.7	Beam	↑	1	22.6	277.66
27	Wall	→	1	19	233.43
26.1	Wall	→	1	18.5	227.29

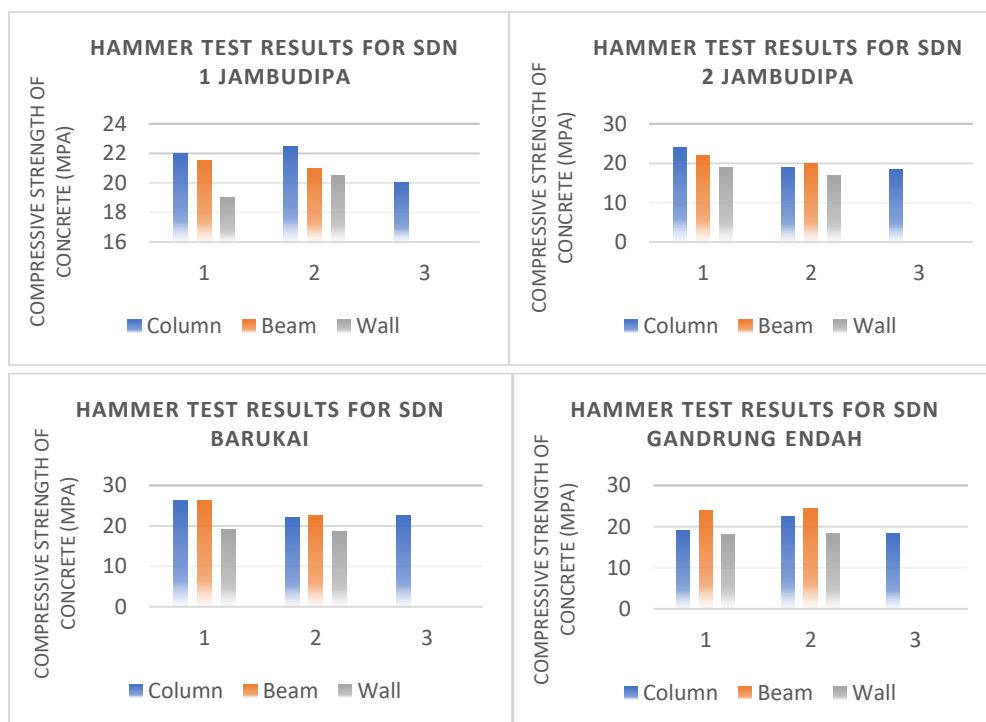
(Source: Personal Documentation, 2025)

The results of the Schmidt Hammer test conducted at SDN 1 Jambudipa, SDN 2 Jambudipa, SDN Barukai, and SDN Gandrung Endah indicate that there are differences in concrete quality across various parts of the building structures. Based on the average test results, the compressive strength of the concrete in columns was 21.37 MPa, in beams was 22.72 MPa, and in walls was 18.62 MPa.

Based on the data shown in Table 1, K-225 concrete has a compressive strength of approximately 18.7 MPa, which is the minimum standard generally used for structures ranging from residential homes to educational facilities. According to this standard, most of the hammer test results for the four schools tested fell well within the K-225 range. However, it should be noted that for some hammer test points on certain structural components particularly wall components the values fell below the specified standard limit. These assessment results are considered a warning sign that some structural components may require further evaluation or repair.

It is important to recognize the limitations of the hammer test in this assessment. Although the hammer test can provide a practical estimate and assessment of the compressive strength of concrete in a structural component, it does not provide a comprehensive picture of a building's seismic performance. Factors such as reinforcement details and the overall integrity of the structural components are equally important in determining how a building will behave during an earthquake. (Zhafira, Widorini, and Crista 2023). Given these limitations, the results of this study serve as a preliminary assessment of the hammer test on structural components of educational facilities.

The graph of the hammer test results shown in Figure 11 provides a summary of the compressive strength values of the concrete for the four school buildings that were the subject of this study. In general, the average concrete compressive strength values for the structural elements columns, beams, and walls did not show significant differences among the four schools. Columns have higher compressive strength values compared to beams and walls because they serve as the primary load-bearing structural elements. In contrast, wall elements have lower compressive strength values. Although there are slight -



**Figure 11.** Summary of Hammer Test Results at the Four Schools  
(Source: Personal Documentation, 2025).

differences among the four buildings, the overall results of this test indicate that the concrete quality at the four schools is relatively similar, with no major differences. Therefore, the results of this Hammer Test can be used to provide an initial assessment of the condition of the building's structural elements and serve as a basis for conducting more detailed follow-up inspections if necessary.

## CONCLUSION

The results of the hammer test and the analysis of data collected from the four schools in Jambudipa Village namely, SD Negeri 1 Jambudipa, SDN 2 Jambudipa, SDN Barukai, and SDN Gandrung Endah show that the compressive strength of the concrete in the structural components of these buildings generally complies with the standard specifications for K-225 concrete. These results indicate that the concrete in the columns, beams, and walls is still in a condition capable of meeting the structural requirements of simple buildings, including educational facilities.

However, it should be noted once again that this study is a preliminary assessment based on estimates of concrete compressive strength obtained through the hammer test. This assessment of concrete compressive strength using the hammer test does not take into account other factors that affect a building's seismic performance, such as reinforcement details and foundation conditions. Therefore, the results of this assessment of concrete compressive strength should not be interpreted as a conclusion regarding the overall seismic safety of the educational facility.

Given that Jambudipa Village is located near the still-active Lembang Fault, it is recommended that further structural evaluations be conducted using more comprehensive methods. Regular, large-scale maintenance is necessary to ensure the long-term safety and resilience of these buildings, especially given the ongoing risk of earthquakes in the Lembang Fault zone.

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