

# RVS Lombok

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## Rapid Visual Screening (RVS) for School Buildings after Earthquake in Lombok, West Nusa Tenggara, Indonesia

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## Rapid Visual Screening (RVS) for School Buildings after Earthquake in Lombok, West Nusa Tenggara, Indonesia

A Pujianto<sup>1</sup>, H Prayuda<sup>1</sup>, S A P Rosyidi<sup>1</sup>, F Monika<sup>1</sup> and R Faizah<sup>1</sup>

<sup>1</sup>Department of Civil Engineering, Faculty of Engineering, Universitas Muhammadiyah Yogyakarta, Bantul, Daerah Istimewa Yogyakarta, Indonesia

\* pujiantoasat@umy.ac.id ; hakasprayuda@umy.ac.id ; atmaja\_sri@umy.ac.id ; fanny.monika.2007@ft.umy.ac.id ; restu.faizah@umy.ac.id

**Abstract.** This study discusses the results of the rapid assessment of school buildings in Lombok after an earthquake occurs. The earthquake in July 2018 with a high enough intensity caused a lot of damage to the building. The earthquake including the school building affected the entire area of Lombok Island. This study assessed 15 school buildings on Lombok Island. School samples were taken randomly from several districts that were rocked by the earthquake. The results showed that school buildings in all locations were part of a Non-Engineered Building where there were no results of analysis of earthquake resistant buildings. Overall, the condition of the building is categorized as being moderately damaged with non-structural components such as walls not having good connections with columns and beams. In addition, the structure and attributes of the roof are also damaged by a high percentage. In some buildings, it still does not follow good structural rules so that it is very dangerous for building users in the event of a large earthquake. Improvements using the retrofitting method are one of the most recommended ways to improve the performance of buildings that have mild and moderate damage.

Keywords—School Assessment, Earthquake, Rapid Visual.

### 1. Introduction

Geographically, Indonesia is in a very unstable location, namely in the ring of fire, a zone surrounded by very active plates. Indonesia is surrounded by the tectonic plates of Eurasia, Australia, and the Pacific, which are possible for earthquakes with higher intensity [1]. Earthquakes are natural phenomena that often occur in the world, which can cause a lot of loss of life [2].

After the earthquake, it is necessary to check the existing buildings to ensure the condition of the building is still safe or not to be used. The evaluation carried out depends on the method used so that the evaluation results will be concluded whether a building can be used, retrofitting must be done to increase the capacity to modify in order to reduce the danger for the future. In addition, an examination of the possibility of liquefaction is also carried out [3-5].

On 29 July 2018, there were reported earthquakes in the Lombok island region of Indonesia. The earthquake is reported to have a magnitude of 6.4 with vibrations felt up to several other regions in Indonesia. Many of the impacts resulting from the earthquake. It was reported that a lot of damage to homes, schools, health units, and public infrastructure occurred, so rapid evaluation was needed to be able to restore economic activity and conditions in the location immediately.



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In this study, a visual assessment of school buildings in the area of Lombok Island will be conducted to check the structure and non-structural conditions. The structure must be safe from various types of disasters, so it does not affect operations and does not cause death to the users of the building [6]. Many cases reported damage to school buildings caused fatalities in various parts of the world due to natural disasters, some examples such as Pakistan [7], Philippines [8, 9], and Venezuela [10].

Many methods can be used to conduct rapid visual screening after an earthquake occurs. The most commonly used standards are FEMA 154 and FEMA 310 [11, 12] where FEMA 310 is more suitable for developing countries [13]. In this study, we will use a standard commonly used in Indonesia [14] given that the geographical conditions and conditions of most school buildings in Indonesia are part of the Non-Engineered Building. In this method, assessing the three main components of the building are vertical components, horizontal components, and foundation components.

In this study, an evaluation of 15 school buildings in Lombok Island, all schools evaluated were Muhammadiyah schools, which were suspected of being damaged by the earthquake. The school location shown in this study is a location that has been selected from several schools that have been surveyed as a whole. Through this research, it is expected to determine the condition of the building. In this case, the damage to the building is categorized into four, which are not damaged, lightly damaged, moderately damaged and severely damaged. Expected that through this research, it can be the basis of the method of proper repairs to buildings that have been damaged and become a consideration if the building will be used continuously after assessment.

## **2. Rapid Visual Screening**

Rapid visual screening is one method for Evaluating Buildings Visually by Filling In The Forms That Have Been Made Before. The Questionnaire Contains Primary Data From The Buildings Reviewed. Vulnerability Assessment Of Buildings Using RVS Sheets, In General, Has Been Set In The Standard [11]. In General, A Number Of Things That Need To Be Considered According To FEMA 154 In Analyzing Building Vulnerabilities Include Location Seismicity, Where Spectral Acceleration Values Are Needed. In Addition, Data Is Also Needed On The Use Of The Building And Its User Population. The Things That Must Be Assessed Are Soil Types, Dangerous Non-Structural Elements That Collapse, Type Or Type Of Building, Number Of Floors, Vertical Irregularities, And Plan Irregularities And The Year The Building Was Built.

In This Study, Evaluations Were Carried Out Specifically For One Or Two-Story Simple Brick Buildings Due To The Earthquake Referring To The Standards As Outlined By The World Seismic Safety Initiative [14]. While The Level Of Damage To Each Component Consists Of:

- a. There Is No Significant Damage.
- b. Lightly Damaged, Damage To Structural Components Only Requires Repair Of The Cover And Non- Structural Components Need To Be Repaired.
- c. Moderately Damaged, Where Structural Damage can still be repaired.
- d. Severely damaged, the damage is too extensive if repaired will have a lot to be replaced or need to be rebuilt.

The evaluation carried out on the building includes vertical components, namely columns and walls, horizontal components namely beams and plates and also foundations. The level of damage to each component starts from 0 to 100 where the greater the value obtained shows the building will be more secure. Some things that must be considered when evaluating the structure and non-structural components include [11]:

- a. Hair cracks on concrete that are less than 0.2 mm or invisible cracks indicate no significant damage.
- b. Cracks on concrete components up to 2 mm wide are not considered dangerous and can be categorized as minor damage.
- c. Cracks on structural components up to 5 mm wide indicate moderate damage.
- d. Cracks on concrete components with a width greater than 5 mm indicate heavy damage and experience a significant reduction in strength.

- e. Cracks or collapsing partitions do not indicate damage to the structure which is quite heavy.

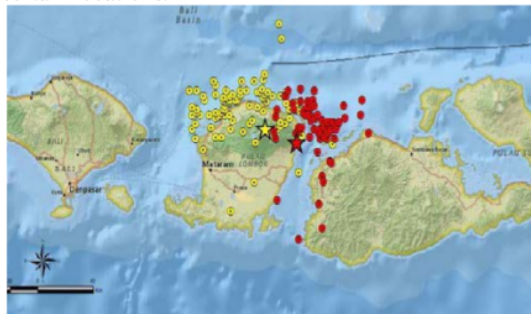
### 3. Research Methodology

In examining the condition of the building, it uses the direct field survey method and records important data regarding the condition of the building being inspected. Before the inspection is carried out, it must be ensured that the building is safe for inspection and the observer team understands the evacuation route that must be followed if aftershocks occur. Some of the steps that must be followed in examining post-earthquake buildings are the following.

- a. Prepare all equipment such as cameras, fill forms and GPS for the data collection process and determine the location of the building to be checked.
- b. Make a location plan and floor plan for each floor. In the process of filling out this form, it is done for each floor, which then results are averaged each time.
- c. Checked components consist of three parts, namely the foundation components, vertical components, and horizontal components. The foundation component consists of river stone foundation, beam foundation, and concrete tread foundation. While the vertical component consists of columns, column beam joints, diagonal cracked walls, cracked walls in beam or column joints, collapsed walls and partition walls. Whereas in horizontal components, checks are carried out only on beams, plates and roof truss.
- d. In filling out the inspection form, the level of damage each is separated into 4 parts, which are not damaged, lightly damaged, moderately damaged and severely damaged. How to determine the level of damage has been determined in the standard that is used according to the width of the crack formed after the earthquake.
- e. After completion of the inspection, the building is given a sign of whether it is suitable for use or must be repaired first or must be replaced with components that are not feasible with the new component.

### 4. Result And Discussion

The earthquake in Lombok began on July 29, 2018, and other major earthquakes still felt until August 19, 2018. Figure 1 shows the number and location of the earthquake occurring from July 29 to August 19. The big earthquake until 6.9 SR was at least felt to Bali Island and some areas in East Java. Because of this earthquake, there was a lot of damage to infrastructure and residential buildings to paralyze the economy of certain locations.



**Figure 1.** Number of points of the earthquake occurring from July 29 to August 19, 2018, on Lombok Island [15]

In Figure 2 it is Shake-map from the earthquake on 29 July 2018. Based on the shake-map it states that the areas of North Lombok and East Lombok feel shocks of SIG III-IV (VI-VII MMI). While the area of West Lombok, Mataram, Central Lombok, West Sumbawa, and Sumbawa Besar feel the shock with the intensity scale of the SIG-II (IV MMI). At the locations of Denpasar, Kuta, Nusa Dua,

Karangasem, Singaraja, and Gianyar, they felt a shock with the intensity scale of the SIG-II (MMI III-IV).

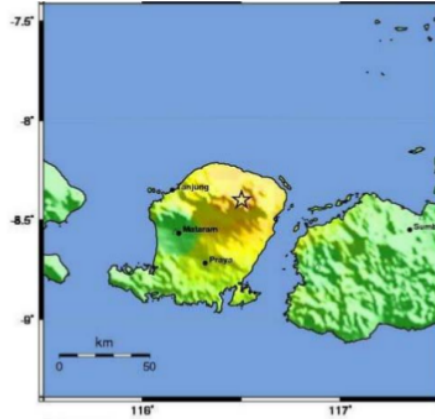


Figure 2. Shake map Lombok Earthquake on July 29, 2018 [15]

In this research, the three main components are divided into vertical components, horizontal components, and foundation components. In the vertical component, the analysis in the form of column conditions, walls, column and wall connections and beam, and column connections. Through the results of this analysis, it was found that only one school that obtained results did not experience significant damage or damage. While 14 other buildings suffered minor damage to moderate damage. The vertical component damage occurs on its special walls on column joints with walls, and there is no connection or reinforcement when there are doors or windows on the wall.

Figure 3 shows that 5 school buildings were moderately damaged, while 9 buildings had moderate damage to vertical components. The damage that occurs is not too damaging to the performance of structural components so that only non-structural components need to be improved. Improvements can use the retrofitting method.

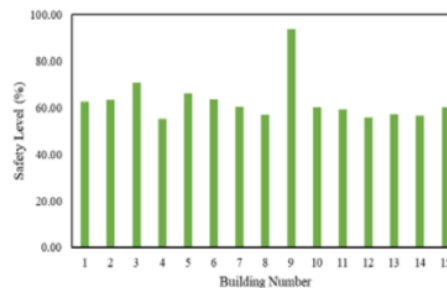


Figure 3. Building safety level in vertical components

As the material for future suggestions, it should be noted how good methods are in the process of building wall components. The damage caused by this earthquake is caused by a poor connection, so it is necessary to think about how good the connection between each building component.

Figure 4 shows the results of the building security level from the side of the horizontal component. This component assesses the feasibility of the beam, plate and roof structure. The results obtained showed that as many as two buildings did not experience significant damage, while 7 buildings suffered minor damage to the plates and roof. A total of 6 buildings were moderately damaged. Most

damage is found on the roof components. Based on the results of direct observation in the field, the roof structure in general still uses wood construction that is quite old.

Apart from age, this damage is also affected by improper construction methods for roof structure work; it can be seen that there is no good connection between tile and easel made of steel structure so that in the event of a shock, tile is very easy to lose and fall. General damage that occurs in the horizontal component in the form of a ceiling drop due to not having a strong bond. While structural conditions only experience mild to moderate cracks, which are not expected to disturb structural conditions if quickly repaired.

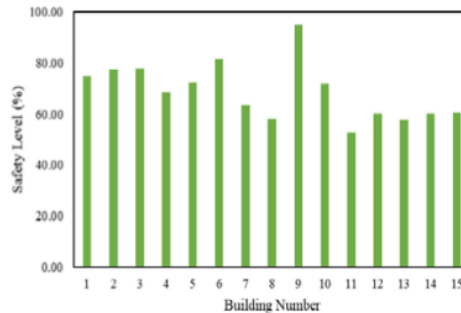


Figure 4. Building safety level in horizontal components

The foundation component shown in Figure 5 shows that most of the buildings did not experience significant damage. 11 buildings were not damaged on the foundation, and 4 buildings were damaged on the foundation. This damage occurs on the sloop, which appears to have a small crack. In some buildings that are quite old, the lack of maintenance on the foundation components causes some components to be long enough damage.

In examining these foundation components, there are quite a number of obstacles. Direct inspection methods that rely on visual vision are certainly not 100% can conclude the foundation is in good condition or not good. It is necessary to examine the foundation with better technology so that it can be known with certainty the foundation condition whether it is still functioning properly or not. Visual inspection can only detect damage if in the building area, especially in it there is a decrease in soil or sloop conditions that are clearly visible from outside the building.

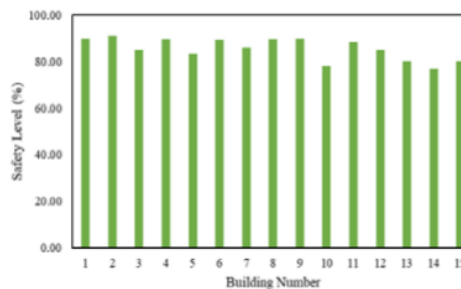


Figure 5. Level of building security on foundation components

Figure 6 describes the level of security of the building as a whole. Based on the results of the analysis, it was found that only 1 building was not damaged, while 6 school buildings suffered minor damage and 8 school buildings suffered moderate damage. There were no buildings that were severely

damaged. In Figure 6, it explains the percentage of damage to buildings, and this shows that 53% of school buildings were moderately damaged and 40% of buildings suffered minor damage.

The thing that really needs to be noticed in the field inspection is the level of damage to each component whether or not it can endanger the user. For example, some buildings do not experience significant damage to the foundation components but are experiencing moderate damage to vertical or horizontal components. Mathematically, it is possible that the building will be in a slightly damaged condition because it has a good level of security on the components of the foundation. Therefore, it needs to be taken into account if there is one component that is categorized as heavily damaged or damaged while eating the building has the potential to endanger its users.

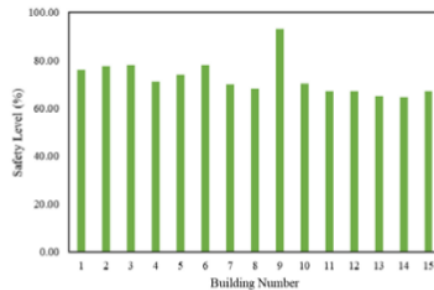


Figure 6. The overall building safety level

The level of damage obtained is one of the considerations of whether the building is suitable for use in the near future or not. Due to frequent aftershocks that make the building user feel traumatized. After obtaining the results, it needs to be explained to building users about a good method for maintenance and repairs that can be done, so that with these improvements, the building becomes safer and the durability of the building does not drop rapidly in a short time.

Figure 8 shows, the results of the percentage of damage that occurs in each component examined. 45% of the damage that occurs in all buildings comes from vertical components, while from horizontal components is 38% and from the foundation, components are 17%. This shows that vertical and horizontal components are very vulnerable to damage when an earthquake occurs.

The foundation component is the smallest component, which contributes damage to buildings due to using the rapid visual method. The level of difficulty obtained using this method is greater in assessing damage to the foundation. While the other components tend to be easier to assess because these components can be monitored properly.

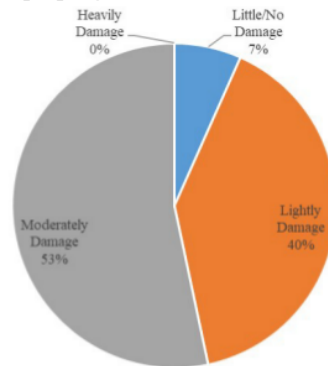
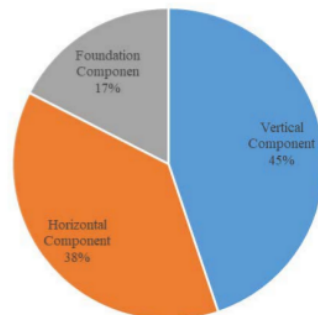


Figure 7. Percentage of damage to school buildings



As the biggest contributor to damage, it should be a concern during the construction process or maintenance of vertical components, besides being very vulnerable to damage, this component has the potential to damage and hoard humans in the event of a collapse. Even though a wall is one component of a building that is not considered to be a load restraint, if it does not have sufficient strength, the construction of a building can be categorized as not good.

In general, in addition to the building that has been assessed as old, it needs to be a concern also the method of development carried out. Many are found in buildings that do not use a connection system that can accommodate loads when an earthquake occurs. The knowledge that has not developed in several regions regarding good methods of development is one of the main obstacles that occur in the field. Thus, the government should strictly conduct searches to various earthquake-prone areas to be able to check the condition of buildings and provide training on how to repair and maintain the durability of these buildings.

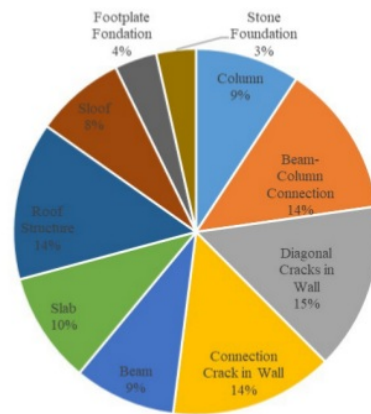


**Figure 8.** Percentage of causes of damage to buildings after the earthquake

Figure 9 is the percentage level of damage that occurs in each component that is carried out the assessment. Overall on the three main components, divided into 10 components. The results of the analysis show that the wall components that have diagonal cracks, wall connections with beams or columns and beam-column joints are the biggest part, which is damaged at 14% and 15% followed by damage to the roof structure with a damage rate of 14%.

It can be concluded that these four components are the components that are most prone to damage and can endanger the building user. Meanwhile, other components also contribute to damage in the event of an earthquake, structural components such as beams, plates, and columns contribute to damage of 9% to 10% and Sloop accounts for damage of 8%. This component of the structure also needs to be taken care of in the construction process.

The slab component can only be detected if the building is more than 1 floor, while on the ground floor of the building only damage occurs when the ceramic used is broken, and there are a few small cracks on the plate. Overall, hollow beam component cracks occur in the Drag section of the beam, and it can be concluded that shear and flexural damage often occurs together this is evident from the crack position that always occurs in the sliding location and bending location. Meanwhile, some column components experience sliding damage.



**Figure 9.** Percentage of damage to each component of a building

In Figure 10 through Figure 14 are some common examples of damage caused by earthquakes. In general, the damage that occurs in these locations.



**Figure 10.** Damage to wall components that do not have good connections with doors and windows



**Figure 11.** Damage to beam joints and columns



**Figure 12.** Damage to the roof frame structure



**Figure 13.** Damage to column components



**Figure 14.** Horizontal cracks occur on the wall

#### **9 Conclusion**

Based on the results of the analysis above, conclusions can be taken as follows:

1. Damage to 15 buildings consists of 53% moderately damaged, 40% lightly damaged and 7% not damaged.
2. The most damaged components are vertical components of 45%, horizontal components of 38% and foundation components as fast as 17%.
3. The most damage is on the wall, the wall connection with the beam or column, the connection on

the beam and column and on the roof structure.

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