Vulnerability Assessment on Non-Engineered Building in Earthquake Prone Area. Case Study: Klaten District, Central Java, Indonesia

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Abstract

Most of the houses in Indonesia are still categorized as non-engineered buildings which do not use good structural analysis in the manufacturing process. The level of education and knowledge about the construction of simple houses is certainly the main cause. The geographical conditions of Indonesia which are quite prone to disasters such as earthquakes, eruptions and cause this condition is one of the real threats to the population of Indonesia. This study discusses the level of vulnerability of buildings in the Klaten area to earthquake hazards. This area is one of the areas affected by the earthquake in 2006, and the community living was rebuilt with funds from the Indonesian government. The results showed that at the time of the initial construction 95% of this building had been calculated to withstand earthquake loads, this was seen from the main building which had a fairly strong structural component and was equipped with a fairly good structural drawing. Along with the growth of the population, most of the buildings have undergone a change of shape, many people have added their own buildings without considering the strength of the construction to withstand earthquake loads. So that buildings that were initially categorized as resistant to earthquake forces are very dangerous if an earthquake occurs.

Keywords: Non-Engineered, Building Assessment, Earthquake, Klaten District.

JEL Classification : fill in this section based on the JEL Codes by American Economic Association; separator uses a semicolon

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Introduction

The earthquake occurred on 26 May 2006 with a strength of 5.9 SR and a depth of 11.3 km, the earthquake occurred in 5 seconds. As a result of the earthquake there was damage to the infrastructure and houses of the community, especially in the Bantul, Klaten and Yogyakarta areas. Based on the results of the investigation that non-engineered building is potentially the most severe damage occurs when an earthquake occurs because development is carried out without design analysis and supervision that meets the qualifications [1]. After the earthquake, the government of the Republic of Indonesia and various organizations provided assistance to reconstruct buildings that had collapsed due to the earthquake. During the process of building the house, the building was designed for earthquake resistant building houses with supervision provided by the government.

After more than 10 years of the earthquake, of course development continues to increase with an increase in population. In this study, we will assess buildings in an area affected by an earthquake in 2006, of course, the area has been educated on how to build constructions that can withstand earthquake forces. The purpose of this study was to assess the building of community houses, specifically houses that had been built after the earthquake from 2006 to 2007. The inspection was conducted to find out whether the building still met the earthquake resistant building rules and what changes had been made.

Methods for evaluating buildings vary greatly, several studies have been carried out using standard released by FEMA [2, 3], using statistical analysis methods [4], to use approach analysis using fuzzy logic programming languages [5-7]. This research will assess 100 houses that also combine several methods that apply in Indonesia and FEMA.

Research Method

This study uses an assessment with meted Rapid Visual Screening to identify buildings based on potential hazard levels observed. This research was conducted in Mlese Village, Klaten Regency, Central Java. The distribution sample can be seen in Figure 2 by taking 100 locations of houses that were built in 2006 and 2007 after the earthquake occurred

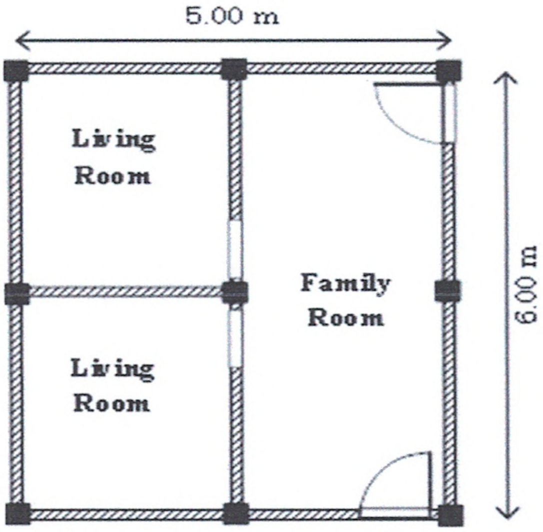

Figure 1. The initial design and shape of the building's initial construction in 2006

Figure 2. Plan location inspection and the number of positions of the building under study

In this study, we will examine houses built after earthquakes. At the beginning of its construction, the house was built on the condition of earthquake resistant buildings as shown in Figure 1. As time went on, the level of change that occurred in the 100 buildings will be checked. Next will be an examination of the level of building vulnerability both in terms of structural and non-structural components. The components examined were structural components, wall conditions, roof conditions, horizontal and vertical vulnerabilities.

Result and Discussion

Buiding Size

In 2007 the Mlese Urban Village carried out the reconstruction of 100 houses damaged after the earthquake. The construction of the house uses aid funds from the government in collaboration with several world organizations. Basically this development was designed following the rules of earthquake resistant houses made by the Ministry of Public Works of the Republic of Indonesia. The house was built with an area of 36 m2 complete with beam and column structures that have been designed to withstand earthquake loads. The house sample according to the rules can be seen in Figure 3. The size of the building used in 2006 was 5 x 6 m.

Figure 3. Recontruction result after earthquake in 2006 until 2007

In 2017 an analysis of changes in the area that occurred in 100 houses was given funding to build houses after the 2006 earthquake. Figure 4 shows the percentage of people changing the condition of the building after 12 years of wider earthquakes. Only 20% of houses do not change the structure of the building so that it remains in accordance with the predetermined design. Whereas 19% of the houses have been added to the area of less than 50 m^2, the addition of areas ranging from 50 to 100 m^2 is around 48% and the addition of area above 100 m^2 is 13%.

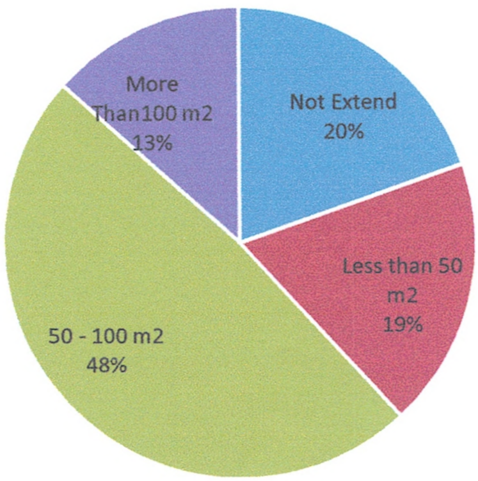

Figure 4. Buiding Size Information

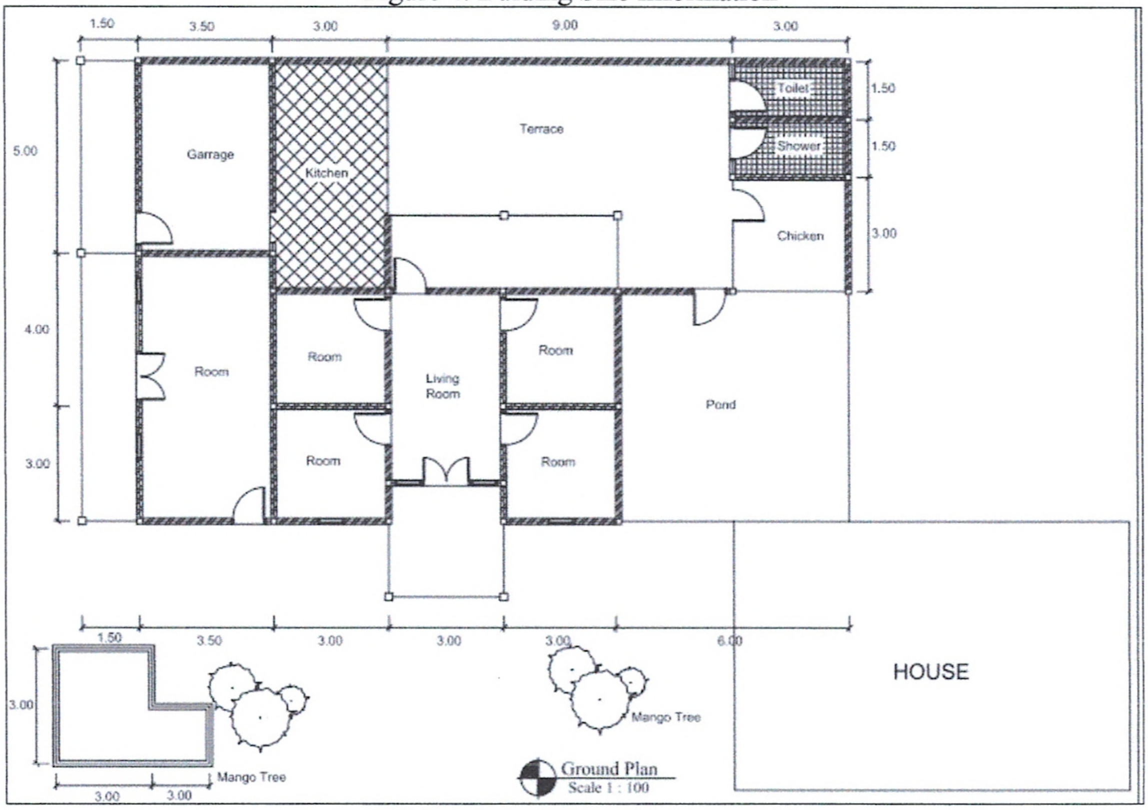

Figure 5. Example building with increase the size

Figure 6. Example building with increase the size

In Figure 5 is a plan of one of the buildings that has increased the area. The building was built without using earthquake resistant building rules as regulated by the local government. So that it is necessary to do further examination regarding the level of vulnerability of buildings to earthquake forces that can occur without predictions beforehand. In addition, the addition of non-permanent extension material is also one of the most widely used components.

Building Assessment

In this study, an assessment of the conditions in the field was carried out regarding the configuration of horizontal shapes, wall material elements, roof structures to connections between old buildings and new buildings. 25.80% of the buildings built with the addition of area up to 2017 do not meet the horizontal configuration standard, the horizontal form of the building still does not take into account the applicable rules. This level of vulnerability needs to be taken into account because it will be predicted to continue to increase every year because growth will continue.

The addition of buildings is of course related to the use of wall elements, the survey results state that the owners of Mrese Village use red bricks without ties of 94.70%, of course this is not very good, although this component is a non-structural component. While the 5.30% addition of walls still uses wood or bamboo. Monitoring and training must be carried out in the development process, because these conditions are very important. The results of the post-earthquake investigation show that the high level of collapse in the wall components without bonding to the structural components will collapse due to an earthquake.

Whereas the extension structure system used 92.1% using practical columns and beams, 2.30% using wood reinforcement while using concrete frame structures only 5.70% of the 100 houses were inspected. Using practical columns and beams this is good enough, and uses a fairly good shear and bending system. The overall roof truss structure is in the form of wood or bamboo construction, with 95.50% using tile roof coverings.

In addition, based on the results of the analysis, 95% of houses carried out by extension do not take into account the connections of old and new buildings, so the strength of the extension building needs to be analyzed in detail. Connections between old buildings and new buildings will be very dangerous in the event of an earthquake.

The analysis was also carried out using FEMA 154, based on the results of the analysis that had been carried out, the buildings were mostly categorized as C3 type (Concrete Frame with Unreinforced Manson infill), with very varied Plan Irregularity levels and Type E Soil (1-3 stories). The results of the analysis show that 58.76% obtained a value of RVS of 0.3 and 41.28% obtaining a value of 0.8. Based on FEMA 154 all of these buildings do not include buildings that are safe from earthquake forces.

Conclusion

Based on the results of the examination and discussion above, it can be concluded that the level of vulnerability is increasing if the addition of building area continues without regard to the level of vulnerability to earthquake forces. In addition, the level of vulnerability of other buildings will continue to increase so that regular supervision needs to be carried out so that it will be able to control the development of the area.

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References

[1] K. S. Pribadi., M. H. Zulfiar., M. Foralisa. Study of Construction Industry Contribution in Achieving Safer Building on Disaster. Report of Joint Research ITB and BP Construction. Jakarta. (2012).

[2] S A E-Batar. Seismic Vulnerability Evaluation of Existing R.C. Buildings. Housing and Building National Research Center Journal. 14. Pp. 189-197. (2018).

[3] D. Perrone., M. A. Aiello., M. Pecce., and F. Rossi. Rapid Visual Screening for Seismic Evaluation of RC Hospital Buildings. Structures. 3. Pp. 57-70. (2015).

[4] M. C. Ningthoujam., and R. P. Nanda. Rapid Visual Screening Procedure of Existing Building Based on Statistical Analysis. International Journal of Disaster Risk Reduction. 28. Pp. 720-730. (2018).

[5] S. A. Allali., M. Abed., and A. Mebarki. Post-Earthquake Assessment of Buildings Damage Using Fuzzy Logic. Engineering Structures. 166. Pp. 117-127. (2018).

[6] Z. Sen. Rapid Visual Earthquake Hazard Evaluation ef Existing Buildings by Fuzzy Logic Modelling. Expert Systems with Applications. 37. Pp. 5653-5660. (2010).

[7] K. Demartinos., and S. Dritsos. First Level Pre-Earthquake Assessment of Buildings Using Fuzzy Logic. Earthquake Spectra. 22. Pp. 865-885. (2006).