

The Factors Affecting Building Damage in Balitata Village Due to 7.2 Magnitude Earthquake

Endah Harisun^{1*}, Hery Purnomo², Haryati³

^{1,2,3} Architecture Department, Faculty of Engineering, Universitas Khairun, Ternate, Indonesia,

Abstract. The strength of the building's response to earthquakes is primarily determined by building construction. The earthquake in the southern part of Halmahera Regency destroyed thousands of homes. Specifically, in Balitata village affected by the earthquake, there were dozens of damaged houses. This study was conducted to determine the cause of house collapse without considering the shear forces caused by earthquakes, while the research method used was qualitative descriptive. The conclusions obtained were many factors that caused dozens of houses to collapse in Balitata village

Keywords: Balitata village, Construction, Earthquake, House Collapsed

1 Introduction

Indonesia is an archipelago that is located between three main tectonic plates, the Pacific plate, the Eurasian plate, and the India-Australia plate. The meeting of the three main plates makes Indonesia one of the countries with a very high level of earthquake risk. This condition is very influential in designing building structures [1]. Indonesia is a country located along a seismically rugged path called the Pacific Ring of Fire. Hence large earthquakes occur every year, starting from West Sumatra, Sulawesi, Buru Island, and Papua at the eastern tip of Indonesia [2]. The region in Indonesia is the most complicated in terms of tectonics. The coverage area is the Sunda, Banda, Sangihe, and Halmahera arcs [3].

The collision zone on the Maluku sea surrounded by Sulawesi Island, Sangihe Islands, Maluku Islands, and Mindanao Islands produced an earthquake, tsunami, and volcano erupting effect [4].

The earthquake in the Southern Halmahera Regency on July 14, 2019, with a scale of 7.2 on the Richter scale, impacted the damage to substantial buildings. The earthquake affected almost all areas on the Halmahera coast in the southern part of the Halmahera Island. There were forty-five villages affected quite severely. According to data from the National Disaster Management Agency (BNPB), there are forty-one refugee points to date.

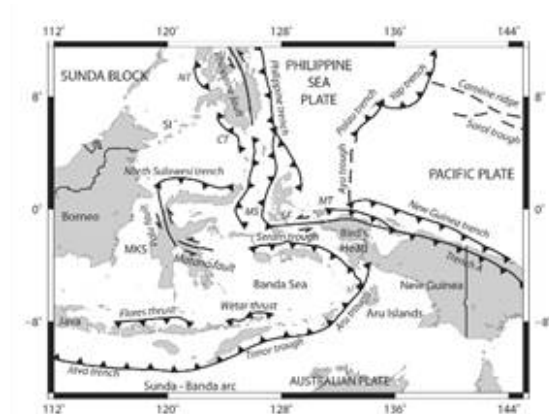


Fig. 1. Broad tectonic overview from eastern Indonesia and southern Philippines[2]

The position of the earthquake was in the location of 0.59 LS 128.06 BT at a depth of 10 Km, or 62 km Northeast Labuha, North Maluku [5]. Affected villages included: Yomen village (170 heavily damaged houses), Karanga village (90 houses severely damaged and 33 lightly damaged), Tawa village (120 heavily damaged houses), Gane Dalam village (271 heavily damaged houses), Gane Luar village (187 houses were severely damaged), Balitata village (sixty-two moderately damaged houses) and several other villages. The factors that cause the vulnerability of structures in residential houses can be caused by faults in house construction, lack of maintenance, not following building standards, and adding to buildings whose application is inappropriate [6]. This study's purpose

* Corresponding author: endah.harisun@unkhair.ac.id

was to analyze the causes of the collapse of residential buildings in addition to factors from earthquakes. Successive earthquakes also occurred in West Halmahera from October 2015 to February 2016. On November 20, 2015, an earthquake with a scale of 4.9 SR caused damage to homes and public facilities in the area [7].

2 Research Methods

This study uses descriptive analysis method with a qualitative approach. This research method aims to describe or provide a general description of the object of research through data collected or samples observed in the field.

Determination of *Balitata* village as a research sample is caused by several factors including:

- Land transportation routes to other villages affected by the disaster are interrupted.
- Sea transportation lines are blocked by weather conditions that occur during the big wave season.
- *Balitata* village can still be traversed by land line
- there is a lot of damage to houses in *Balitata* village

3 Result and Discussion

Balitata village is one of the villages in the Southern Halmahera district, which 750 people inhabit. *Balitata* village's settlement pattern is still regular, and it has a reasonably good settlement pattern, and the distance

between buildings is large enough so that the collapsed building does not hit another building next to it. All residents in *Balitata* village are now evacuating to high altitudes because they are still traumatized by the occurrence of aftershocks that have the potential to cause a tsunami. This step was part of preparedness efforts for aftershocks that still occur after a large earthquake.

Disaster preparedness efforts are one crucial step to reducing the number of losses due to disasters [8]. Losses caused by earthquakes cause multidimensional damage to a person's life in physical, psychological, and environmental forms. The loss of people who are known and loved and the loss of a home is a psychological pressure for residents that can cause the emergence of PTSD (Posttraumatic Stress Disorder) [9].




According to the earthquake resistance planning standard for building structures (SNI 03-1726-2002), the impact caused by a large earthquake on structural elements and non-structural elements will be damaged, but the main structure of the building may not collapse [10].



Fig. 2. The condition of the refugee camp of the *Balitata* villagers

This study had eight sample houses from sixty-two damaged houses with various damage conditions. The assessment method used is FEMA 154 [11].

Table 1. Explanation of the causes of damage to houses in *Balitata* village

No.	Condition	Explanation
1.		The earthquake caused the first house damage, and the building the walls collapsed due to construction errors at home. The reason is that the wall support column is made of 5/10 lumber, so the column cannot hold the wall load. Another possibility is mixed of certain bricks that do not comply with the standard 1:4 or 1:5 mixtures of cement and sand.
2		Cases in the second house are the same as those in the first house. All columns do not use iron cuttings as a binding wall and only depend on nails specifically for lumber attached to the column. This is compounded by the absence of beam footings that tie the building column.
3		The case of house number three is almost the same as the case of house number one. The timber frame used cannot tie bricks. Coupled with Seismic loading, the damage to the house is getting worse. The kitchen walls and indoor walls collapsed. In the wide wall area, no Cantilever beam binds the wall so that it makes cracks at the wall and worse at some corners of the house which do not use a buffer column.

4		<p>House damage in case number four is the same as that experienced by the last house. The entire back wall of the house collapsed, and now the back wall is replaced with plywood sheets.</p>
5		<p>House damaged in case number six is quite severe. Because in addition to using lumber frames, the wall material is mixing cement with rubble stones, creating a dead load on the wall that the column cannot resist. The absence of this beam footing compound.</p>
6		<p>Damage that occurred in house number seven, the leading cause is the use of wall material from a mixture of cement and stone fragments (same as in-house number six) besides the earthquake factor that caused this damage.</p>
7		<p>In the case of number eight, house damage that occurred in addition to material use errors, and earthquake shocks, the lack of maintenance in the building contributes to the damage to the house (same as the case of house number seven).</p>

From the table above, it can be seen various kinds of construction errors in the method of building houses and the construction errors such as:[12]

- Incomplete wall binder elements (without beam binder on the side of the wall)
- Collapse of column/brick wall without reinforcement / without ties (Building without a robust framework, Wood Column, a brick wall without reinforcement/binder),
- Limited collapse of brick wall structure (confined) (Structural binder elements are less solid and stiff, the corner of the wall has not a practical column, and the opening area was not reinforced)
- Damage to the wall that is bound but not sufficient (the brick wall is bound to the ring beam, which is not strong and less rigid, the area the wall is given a binder element > 9 m2, the wall is weak against earthquake forces that work perpendicular to the wall)
- Material quality and detailing of columns are not good (less porous concrete material with cement, inadequate brick and column wall ties without anchors, wood does not adhere to brick, concrete columns are not able to withstand shocks due to earthquakes) The phenomenon is that the construction of the building almost entirely uses lumber construction. Typologies of buildings using lumber construction are also found in other villages affected by the earthquake.

The question is why the construction of lumber was selected. Maybe this is related to the habit of people building houses from generation to generation as we know that the construction of wooden houses is one type

of traditional house in North Maluku. Button House (Fala Kanci) is one of the traditional houses in North Maluku.

The system of fala kanci house structure system of lumber material structure both columns and beams with a connection between beams with lumber using a wooden joint or peg [13]. The construction of this traditional house is also very suitable to be used as an earthquake-resistant home.

According to Samad, gaba-gaba is a sago leaf that is very common in the North Maluku region. gaba-gaba material is excellent in material thermal conductivity. Apart from the fact that the material is very light, the overall structure of the building uses bamboo[14]. The same is true with folajikosusreabi traditional houses. The use of bamboo on walls, beams, and columns as well as roofs from katu material (a type of sago palm leaf) as the main construction in the construction of this traditional house [15], allows the building to respond to earthquake shocks.



Fig. 3. Traditional North Maluku houses: a) *Fala kancing*, b) *Fala Gaba-gaba*, c) *Folajikosuebi*

Traditional building technology adapts well to danger. For example, some types of wood and bamboo

structures are earthquake resistant because they are flexible materials [16]. Besides being responsive to earthquakes, traditional North Maluku houses are also very climate responsive, evidenced by the sturdy standing of these traditional houses until now.

This proves that a system of indigenous knowledge from the community is applied to these traditional buildings. Indigenous knowledge in the form of traditional houses is a wealth of knowledge of the Indonesian people [17]. Vernacular buildings have structures and construction systems adapted to earthquake events that have been experienced before [18].

Utilization of traditional North Maluku house construction can be an alternative in innovative post-earthquake housing reconstruction models as part of anticipation for future aftershocks or use the results of research from Handayani [19] on the post-earthquake housing reconstruction model.

The implementation of disaster management in the post-disaster stage includes rehabilitation and reconstruction. The role of Higher Education is to conduct studies and research as material to plan the implementation of disaster management in the pre-disaster, emergency response, rehabilitation, and reconstruction [20].

4 Conclusion

Based on the description above, the cause of damage to houses in the *Balitata* village due to the earthquake was the quality of building materials, topographic factors, as well as the quality of construction implementation or the skills of implementing residential construction.

For pre-disaster communities, it is better to review the resilience of their homes back. In several cases related to earthquake-resistant houses, a number of typical structural and construction problems and errors are often found in reality on the ground. The problem is emphasized in two types of structural systems commonly encountered and used by the community in building buildings: the skeletal structural system and the carrier wall structure system. The skeletal structure system is the structural system most widely used by the community in general because the methods and work methods are more accessible and more straightforward. The construction used can use materials from concrete, wood, or a combination of both.

References

[1] G. F. Waworuntu, M. D. J. Sumajouw, and R. S. Windah, "Evaluation of the Ability of Simple Residential Structure Due to the Earthquake," *J. Static Civil*, vol. **2**, no. 4, p. 191–200, (2014).

[2] F. Løvholt, D. Kühn, H. Bungum, C. B. Harbitz, and S. Glimsdal, "Historical tsunamis and present tsunami hazard in eastern Indonesia and the southern Philippines," *J. Geophys. Res. Solid Earth*, vol. **117**, no. 9, pp. 1–19, (2012).

[3] N. T. Puspito, "Tsunami and earthquake activity in Indonesia," *Proc. Int. Work. Local Tsunami Warn. Mitig.*, no. Figure 1, pp. 138–145, (2002).

[4] A. R. Gusman, A. D. Nugraha, and H. A. Shiddiqi, "Hypocenter relocations and tsunami simulation for the 15 November 2014 Northern Molucca Sea earthquake in Indonesia," *J. Geofis.*, vol. **15**, no. 01, pp. 1–9, (2017).

[5] "BNPB Strategy in Data Collection on South Halmahera Refugees Post M Earthquake 7.2 - National Agency for Handling ..." [Online]. Available: <https://www.bnpb.go.id/strategi-bnpb-in-s-Efforts-pendataan-pengungsi-halmahera-selatan-pasca-gempabumi-m-72>. [Accessed: 21-August-2019].

[6] J. F. Audefroy, "Haiti: Post-earthquake lessons learned from traditional construction," *Environ. Urban.*, vol. **23**, no. 2, pp. 447–462, (2011).

[7] A. Dian Nugraha *et al.*, "Hypocenter Relocation of Earthquake Swarm in West Halmahera, North Molucca Region, Indonesia by using Double-Difference Method and 3D Seismic Velocity Structure," *IOP Conf. Ser. Earth Environ. Sci.*, vol. **62**, no. 1, pp. 3–7, (2017).

[8] C. A. Paramesti, "Society Preparedness of the Port Ratu Bay Region Against the Earthquake and Tsunami Disaster," *J. Reg. City Plan.*, Vol. **22**, no. 2, pp. 113–128, (2011).

[9] A. Novianty, "Long-term Hamlet Adjustment in Terms of Post-Earthquake Community Resilience," *J. Psikol.*, Vol. **38**, no. 1, p. 30–39, (2011).

[10] R. Earthquake and P. S. Barat, "Identification of Dominant Factors Causing Damage to Buildings in Regions," vol. **17**, no. 2, p. 116–125, (2014).

[11] M. H. Zulfiar, A. Jayady, and N. R. Jati Saputra, "Damage to Buildings of Cultural Heritage Houses in Yogyakarta," *J. Karkasa*, vol. **4**, no. 1, p. 5, (2018).

[12] E. Terpasang, "Akibat gempa," pp. 1–4.

[13] F. Marasabessy and A. A. Muhammad, "Typology of House in Earthquake Disaster Area: A Case Study of Bobanehena Village, West Halmahera," *Aceh Int. J. Sci. Technol.*, vol. **8**, no. 1, pp. 12–19, (2019).

[14] S. Indexed, S. Samad, R. T. Lopa, and R. Wikantari, "GABA) AS WALL MATERIAL MATERI AL AND ITS," vol. **8**, no. 7, pp. 876–885, (2017).

[15] E. Harisun, "Folajikusesurabi Traditional House," vol. **1**, no. Icst, pp. 364–371, (2018).

[16] J. Twigg, "Disaster Studies Working Paper No . 15 Technology , Post-Disaster Housing Reconstruction And Livelihood Security," *Benf. Hazard Res. Cent. Disaster Stud. Work. Pap. No. 15*, no. January (2002), 2002.

[17] S. Triyadi and D. A. Harapan, "Local Wisdom of Vernacular Homes in Southern West Java in Responding to Earthquakes," *J. Science and Technology. GOLD*, vol. **18**, no. 2, (2008).

[18] S. Triyadi, I. Sudradjat, and A. Harapan, "Local Wisdom on Vernacular Houses in Bengkulu in Response to Earthquakes, Case Study: Vernacular Houses in *Duku Ulu* Village," *Local Wisdom*, vol. **2**, no. 1, p. 1–7, (2010).

[19] D. I. Yogyakarta and D. A. N. Klaten, "Model of Post-Earthquake Reconstruction Houses," no. 1, (2011).

[20] BNPB, "Regulation of the Head of the National Disaster Management Agency Number 10 of 2008 Concerning Guidelines for Disaster Emergency Response Command," *Bnpb*, p. 13, (2008).