Analysis of Building Damage to the Housing Sector Based on Post-North Lombok Earthquake 2018 Investigations

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Abstract. A major earthquake with a magnitude of 7.0 on the Richter Scale occurred in the Province of West Nusa Tenggara in 2018. Along with the deaths caused by the earthquake, public infrastructural facilities also sustained significant damage. One of the many losses experienced by the people of West Nusa Tenggara, especially those on the island of Lombok, was the destruction of the housing sector. The main impact of the strong earthquake, which had a magnitude of 7.0 on the Richter Scale, was felt on the island of Lombok, namely in the North Lombok Regency. The investigation was carried out based on information gathered during site visits and photographs. It was clearly found that non-engineered construction made up the majority of the demolished homes, with the sloof and foundation taking the most damage. Meanwhile, the walls, columns, and beams were not built according to engineering standards, and the materials used were of very poor quality, making them unfit to endure seismic stresses and other natural forces. Additionally, during an earthquake, the roof structure is torn apart and sustains damage since there is no reinforcing or reinforcement between the roof structure and the walls or beam.

Keywords: Earthquake · The housing sector · Sloof · Foundation · Column · Beam · Roof

1 Introduction

An earthquake is a natural disaster that has a very high destructive power, where its destructive power does not only result in loss of life and damage to buildings but also affects the social and economic life of an area affected by this disaster. In 2018, the Province of West Nusa Tenggara experienced a significant earthquake with a magnitude of 7.0 on the Richter Scale, precisely on Sunday, August 5, 2018, at 18:46:37, with the epicenter at the coordinates of 8.35 South Latitude 116.47 East Longitude at a depth of 15 km and located on land 18 km northwest of East Lombok, this earthquake was the main earthquake (Main Shock) of the 29 July 2018 earthquake (Foreshock). Which, the earthquake not only resulted in fatalities, but public infrastructure facilities also suffered enormous damage. Many losses were experienced by the people of West Nusa Tenggara, especially those on the island of Lombok, one of which was damage to the housing sector.

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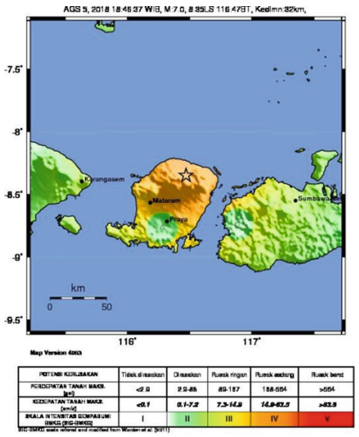

Fig. 1. Lombok Earthquake M7.0 Shock Map

Damage and losses in the housing sector due to the 2018 Lombok Earthquake, especially those that occurred in North Lombok Regency, were very significant and dominant with a percentage of 94% of the total demand for the housing sector. The largest amount of damage to the housing sector is residential buildings. Thus, it is necessary to investigate the causes of the significant damage to this sector after the 2018 Lombok earthquake (Fig. 1).

2 Research Methods

2.1 Location of Observation of Damage to Housing Sector

The observation location was carried out in North Lombok Regency because this area was the most affected area of the 2018 Lombok earthquake, The total loss of infrastructure in North Lombok Regency due to the earthquake was 48.94% of the total damage in West Nusa Tenggara Province [1] (Figs. 2 and 3).

North Lombok Regency is one of the regencies in West Nusa Tenggara Province. North Lombok Regency itself consists of 5 sub-districts, namely Pemenang, Tanjung, Gangga, Kayangan, and Bayan sub-districts, where almost all areas in the 5 sub-districts were damaged in the housing sector (Fig. 4).

2.2 Observation Method

The observation method in this study uses data sourced from secondary data. The secondary data is obtained from Documentation Photos of Damage to the Lombok Earthquake Housing Sector 2018, Literature Studies, and the Internet. The Lombok Earthquake Documentation Data 2018 was analyzed to see structural damage from the dominant house building and classification of damage was carried out, which was then discussed and conclusions were drawn on the condition of the damage to both standard houses built and vice versa.

Fig. 2. Lombok Island Map (Google Map, 2022)

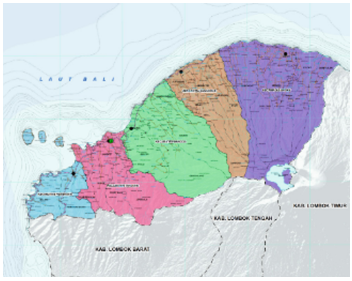

Fig. 3. North Lombok Regency Observation Location Map (www. http://lombokutarakab.go.id, 2022)

Fig. 4. Photo of House Damage due to Lombok Earthquake 2018

3 Results and Discussion

3.1 Analysis of Damage to Foundation and Sloof Structures

The majority of damage to houses in the heavy category, namely buildings that are dangerous to live in during the 2018 Lombok Earthquake, was caused by the absence of

Fig. 5. No foundation and sloof structure in the building

Fig. 6. Sloof Structure is not present in Building

all or one of the lower structures of the house, namely the foundation and sloof, and the materials used were not up to standard (Fig. 5).

The foundation is the lower structure of the building that separates the upper structure of the building from the soil, the foundation itself functions as a load-bearing structure for the upper structure of the building and maintains stability against its load and external forces that arise such as wind pressure and earthquakes on the building. Thus, the absence of a foundation structure in the building (Fig. 5) of the house increases the destructive power of the earthquake and the occurrence of failure of the binding components which in the end the building splits and collapses.

Sloof structure itself is a residential building structure located above the building foundation, its function is useful for channeling the superstructure to the foundation, column binding, and assisting the foundation in stabilizing the building against other forces that arise such as earthquakes. In the absence of a sloof in the house building (Fig. 6), resulting in the absence of a column bond, the load on the structure of the building is directly channeled to the foundation so that the foundation load is heavier so that the condition of the house building is poor in dealing with other forces, especially earthquakes.

Fig. 7. Typical Damage to buildings with sloof and foundation structures

Fig. 8. Damage to the wall in the category of light damage

Typical damage to buildings that have sloof and foundation structures. Typical damage to houses that have sloof and foundation structures tends to experience light damage (Fig. 7), where the damage occurs in the form of hair cracks on the upper structure, but the condition of the building is still very low. Worthy to be occupied.

3.2 Damage Analysis of Walls, Columns, Beams

The wall is one part of the building structure in the form of a vertical plane and is useful for enclosing, dividing, or protecting the contents of the building, besides that, the other function of the wall is also as a recipient of the load from the upper structure and the load is channeled to the lower structure (sloof and foundation). Almost all houses affected by the 2018 earthquake suffered structural wall damage with the classification of damage as light, moderate, or heavy damage. Damage to the wall structure of the house has different characteristics depending on the category of damage.

Wall damage with the category of light damage (Fig. 8) tends to have damage in the form of fine cracks in the plaster, as well as falling stucco flakes covering a limited area, these fine cracks have gaps smaller than 0.075 cm, with wall damage in this category, house buildings only need to be damaged. Only architectural improvements. House buildings with wall damage categorized as lightly damaged by the 2018 earthquake,

Fig. 9. Damage to the wall in the category of moderate damage

Fig. 10. Wall Damage Category Heavy Damage

based on the results of investigations on photo documentation, on average have complete structural components (foundations, sloof, columns, beams).

The condition of the house building after the 2018 Lombok earthquake is categorized as moderately damaged, for the walls of the building, there are large cracks scattered in many places including load-bearing walls (Fig. 9), while cracks in the walls are larger than 0.5 cm. Based on the results of observations, it was found that the damaged walls in the moderately damaged category had structural components, but the existing structural components (foundations, sloof, columns, beams) were incomplete, resulting in increased earthquake damage.

For the condition of the wall structure in a typical damaged house with the category of heavy damage, the entire wall collapsed so that the building became very dangerous to live in (Fig. 10). Most of this type of damage is caused by the absence of structural components, in which there is no binding component in the house building.

Columns and beams are structural components contained in the building, one of which is a house building, in the sense that the column is a structural component that has the task of supporting the axial and vertical loads of the building with a certain eccentricity [2], while the beam is a rigid structure with the function of bearing service load in the transverse direction which causes bending moments, shear forces, and torsion along the span, besides that the beam has the benefit of being a column binder so that there is no change in the position of the column. When an earthquake occurs, the forces that arise are in the form of vertical and horizontal forces [3], these two forces will arise

Fig. 11. Building Houses without Reinforcement of Columns and Beams

Fig. 12. Damage to Columns and Column-Beam Connections in House Buildings

at the point of mass of the structure so that the columns and beams with their functions have a role in reducing the forces that arise due to the earthquake.

In observing the damage to houses in the 2018 Lombok earthquake, significant damage occurred due to houses built with the Unconfined Unreinforced Masonry building structure system, namely a building system consisting of only brick/stone walls, without strong and rigid binding elements, so that in holding Earthquake and gravity forces practically rest on the wall system. As a result, if there is an earthquake forces on the house building, the damage that occurs is included in the category of severe damage (Fig. 11), with a physical average of more than 70%, so that damage in this category access to the house building must be limited.

In houses affected by the 2018 Lombok earthquake, although the building structure is complete (columns and beams) and the construction system uses a Confined Masonry structural system, namely a building system consisting of brick walls that are given binding elements in the form of frame elements on all four sides of the wall, frame elements and boundaries. Together to withstand gravity and earthquake forces in this system, but the quality of natural and non-natural materials used is very poor (Fig. 12), most of the existing concrete materials are porous and appear to lack cement, wide ring reinforcement spacing, and elongated reinforcement, this causes the Columns and Beams to not be strong enough to withstand the earthquake shaking.

On the other hand, houses built with Confined Masonry structural systems with adequate quality natural and non-natural materials, tend to be strong in resisting earthquake

Fig. 13. Condition of House Building with adequate quality concrete material

Fig. 14. The type of gable roof used by the majority of the people of North Lombok

forces, it can be seen that this typical house building does not cause significant damage to both structural elements and non-structural (Fig. 13).

3.3 Analysis of Roof Structure Damage

The roof is a component of the house that serves to protect the house and humans against weather conditions. Based on the results of the investigation conducted on the documentation photo of houses affected by the 2018 Lombok earthquake, most of the people of North Lombok use a saddle-type roof construction, namely a roof type that has two sloping sides, so that a room will be created under the roof structure which is usually covered with a ceiling (Fig. 14).

The term roof structure is defined as the part of the building that holds/flows the roof load. The roof structure is divided into two, namely the roof truss and roof truss support, the roofing structure materials used by the people of North Lombok Regency are dominated by wood and steel materials. As for the roof covering material, most of them use spandex and clay tile materials. Roof damage due to the 2018 North Lombok earthquake, caused by the supporting wall as a support for the roof structure collapsed, due to the collapse of the walls or beams of the house building, causing the support of the roof structure to not exist (Fig. 15).

The roof structure is not solid between the connections, and there is no reinforcement/stiffening between the roof structure and beams or walls so that the earthquake forces that work cause the roof to be damaged, even though the supporting structure of the house building still survives (Beams, Walls) (Fig. 16).

Fig. 15. Roof damage due to collapsing supporting walls

Fig. 16. Roof damage due to the absence of reinforcement/stiffening between the walls or beams with the roof

4 Conclusions

Based on observations of the damage to the housing sector due to the Lombok earthquake in 2018. Most of it was caused by the absence of building structural components such as foundations, sloof, columns, and beams, in addition, the bonds between these structural components were not solid so the level of damage was categorized as heavily damaged. Meanwhile, the damage to the roof structure is due to the absence of solid interconnections, as well as the absence of reinforcement/stiffening between the roof structure and beams or walls, so that the working earthquake forces cause the roof to be damaged, even though the supporting structure of the house building still survives (Beams, Walls). For residential buildings that have complete structural components, tend not to suffer significant damage, the building is still habitable and is categorized as lightly damaged.

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