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Building Assessment Post Earthquake 21 November 2022 in Cianjur District

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ABSTRACT

The earthquake that occurred in the Cianjur area, West Java on Monday 21 November 2022 at 13.21 WIB resulted in 635 fatalities and 56,000 houses that were damaged. The results of the assessment found that many houses and public facility buildings still did not meet the requirements for earthquake-resistant buildings, especially in the use of concrete materials, main reinforcement, stirrups in columns, beams, foundations and beam-column joint, and did not have a strong column-weak beam planning concept. This can be seen from the inability of the column to withstand/ carry the working load which causes the column to collapse and damage. Therefore, it is very necessary to pay attention to building planning in Disaster Prone Areas (DPA) in accordance with earthquake resistant building regulations SNI 1726:2019 and SNI 2847:2019

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INTRODUCTION

On Monday, November 21, 2022, at 1:21 PM WIB, an earthquake with a magnitude of 5.6 on the Richter scale struck Cianjur Regency in West Java Province for 10-15 seconds. The earthquake was located at 6.84 degrees South Latitude and 107.05 degrees East Longitude, with its epicenter 10 km southwest of Cianjur Regency, West Java, and did not generate a tsunami potential (Elferida Sormin et al., 2023; Supendi et al., 2022) . Although it did not cause a tsunami, the earthquake damaged numerous houses, buildings, and other critical facilities in Cianjur Regency and its surroundings, resulting in hundreds of fatalities and injuries. The tremors from the Cianjur earthquake were strongly felt in Jakarta, Depok, Bogor, and South Tangerang. Many public facilities suffered damage, including government buildings, educational facilities, and places of worship, leading to casualties due to buildings collapsing under the quake's impact.

The earthquake in Cianjur is suspected to have been caused by the movement of the Cimandiri Fault. Following this major earthquake, Cianjur experienced 21 aftershocks. In addition to damaging houses, the earthquake also triggered landslides on several main routes in Cipanas, Cianjur Regency, West Java, resulting in road closures. (https://news.detik.com/berita/d-6501898/kilas-balik-duka-cianjur-diguncang-gempa-dashyat).

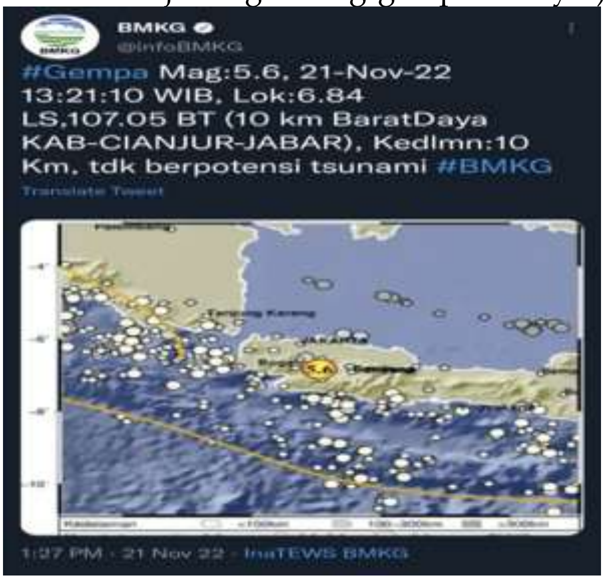


Figure 1. Earthquake Location and Magnitude

Source: BMKG

Given the damage to the buildings, it is necessary to conduct an inspection or assessment to identify the types of building damage, including a thorough examination of structural components and utilities (PuSGen, 2018; Simanjuntak et al., 2022; Wardi & Ramadhani, 2023). Therefore, after an earthquake, it is crucial to ensure the reliability of a building to guarantee its continued operation and prevent accidents in case the building is found to be unreliable. Although a building may appear sturdy after an earthquake, its physical integrity and structural capacity may have actually decreased. Thus, it is important to conduct a rapid post-earthquake inspection to ensure and assess the damage caused by the earthquake (Samsunan, 2018).

Earthquakes cause casualties, infrastructure and building damage, and require significant funds for rehabilitation and reconstruction. To prevent these consequences, efforts must be made to minimize earthquake-related losses. Based on this, it is essential to prevent a high number of casualties, particularly by ensuring the reliability of buildings during earthquakes through building assessments. These assessments evaluate whether the damaged buildings meet earthquake-resistant standards. The PKM (Community Service) team from the Civil Engineering Program at the Faculty of Engineering, Universitas Kristen Indonesia, as part of their Tridarma Perguruan Tinggi program, has conducted assessments of damaged buildings to determine the causes of the damage from the Cianjur earthquake (Listiawaty et al., 2022; Natawidjaja, 2021).

IMPLEMENTATION AND METHODS

On December 12, 2023, the PKM team from the Civil Engineering Program at UKI conducted their community service activities in the Cianjur area using direct survey and assessment methods to evaluate building damage in Cikancana Village, Babakan Bandung Hamlet, RT 05/RW 02 and RT 03/RW 01, and Cibeleng Hilir Hamlet, Cikancana Village, Gekbrong District, Cianjur Regency, which is one of the villages that suffered significant damage. Figure 2. Shows the PKM team from the Civil Engineering Program at UKI conducting a direct assessment in Cianjur.

Figure 2. Photo of the Earthquake Building Assessment Team in Cianjur (Lecturer and Students of the Civil Engineering Program)

To conduct the field assessment, the PKM team from the Civil Engineering Program at UKI coordinated with the Faculty of Applied Sciences at Surya Kencana University in Cianjur, as shown in Figure 3.

Figure 3. Coordination of the Earthquake Building Assessment Team (Civil Engineering UKI with the Faculty of Applied Sciences, Surya Kencana University Cianjur)

In addition to coordinating with the Faculty of Applied Sciences at Surya Kencana University in Cianjur, the PKM team from the Civil Engineering Program at UKI also coordinated with the National Disaster Management Agency (BNPB) to obtain information about the earthquake conditions and the buildings that were damaged in the Cianjur area. Figure 4 Shows the coordination between the PKM team from the Civil Engineering Program at UKI and BNPB.

Figure 4. Photo of the Coordination between the Earthquake Building Assessment Team (Civil Engineering UKI) and the National Disaster Management Agency (BNPB)

Building inspections were conducted by visiting the sites and directly observing building elements. Data collection involved reviewing buildings and homes, with damage data collected using the following methods:

1. Coordinating with the Faculty of Applied Sciences at Surya Kencana University Cianjur and the National Disaster Management Agency (BNPB) regarding the mapping of earthquake-affected areas in Cianjur.
2. Performing direct assessments of buildings damaged by the earthquake.
3. Inspecting building structures (columns, beams, roofs, and walls) for damage, whether minor, moderate, or severe, to classify the extent of damage.

4. Coordinating with BNPB to verify the buildings assessed in the field, which will then be eligible for material compensation from the central government's Ministry of Social Affairs.
5. Providing education on earthquake-resistant construction to local residents, ensuring they receive guidelines for building earthquake-resistant homes during repairs.

RESULTS AND DISCUSSION

Column Structure Failure

From the assessment conducted by the PKM team from the Civil Engineering Program at FT UKI from December 12 to 17, 2022, several images were obtained showing the damage and collapse patterns of various residential buildings and public facilities in Cianjur. Figure 5 below illustrates the failure that occurred in the column structure due to the column's inability to withstand the applied loads and poor design for supporting axial loads and beams. The image shows that the column can no longer properly support the beams and roof framework.

Figure 5. Column Structure Failure Unable to Support Beam and Roof Framework

Beam Structure Failure

In addition to the column failures, several structural failures in the beams were also identified. Figure 6. below shows the structural failure in the beam due to the inadequate connection between the beam and the column.

Figure 6. Beam Structure Failure Due to Poor Design for Load Bearing

Collapse of Building Walls

Structural damage was also found in the installation of house walls, where bricks or concrete blocks were not anchored during installation. This can be seen in Figure 7 below, where the house wall collapsed due to the lack of anchors to bind the bricks or concrete blocks used.

Figure 7. Photo of Wall Collapse Due to Poor Design and Lack of Anchors/ Reinforcement in the Columns to Bind the Wall

Roof Structure Failure

Structural failures were also found in the roof structure. The assessment revealed that the connections in the roof trusses were inadequate, resulting in many roof joint failures, as shown in Figure 8 below.

Figure 8. Failure of Connections in the Wooden Roof Frame

Foundation Structure Failure

Cianjur Regency is highly susceptible to earthquakes due to the influence of potential faults that cause ground movements. These ground movements are expected to lead to surface fault hazards and collateral hazards such as ground cracks, subsidence, landslides, and even liquefaction. These issues can potentially reduce the bearing capacity of foundations to support loads. Ground movement can also cause foundation shifting or overturning. Foundations are a critical part of the substructure that must be carefully analyzed and installed in the field. Structural failure of the foundation can result in the collapse of the building, causing columns and beams to fail. Post-earthquake inspections in Cianjur revealed that foundation installations lacked attention to detail in joint connections and reinforcement placement, as shown in Figure 9 below.

Figure 9. Foundation Structure Failure in Supporting Axial and Vertical Loads

Rebar Hook Failure

Failures in rebar hooks are commonly encountered in the field due to a lack of understanding of the use of hooks or stirrups in reinforcement. Proper bending details for rebar/ hooks are crucial to anticipate collapse patterns (shear force/axial force) in beam and column structures (S. P. Tampubolon, 2021b). SNI-2847-2019 specifies standard hook types, including 90˚ hooks, 180˚ hooks, stirrup hooks, and tie reinforcement hooks with < 135˚. Figure 10 shows the use of rebar hooks that do not comply with these standards.

Figure 10. Failure in Rebar Hook Installation in Columns

Column structure failure occurs when columns are unable to withstand loads (especially bending forces), leading to structural failure and column collapse. Therefore, it is crucial to pay attention to the details of stirrup and main bar reinforcement in column design (S. Tampubolon, 2021) . Field inspections revealed that the concept of strong column-weak beam design has not yet been implemented, and improper column reinforcement according to standards has resulted in numerous building collapses and failures, (LE et al., 2019), (S. P. Tampubolon et al., 2022; Winarsih, 2010). Figure 11 below shows the column reinforcement details that should be used.

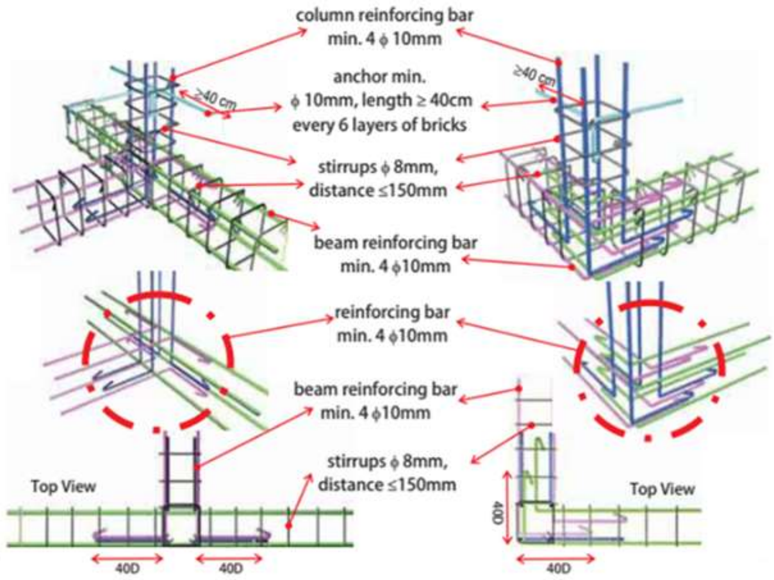
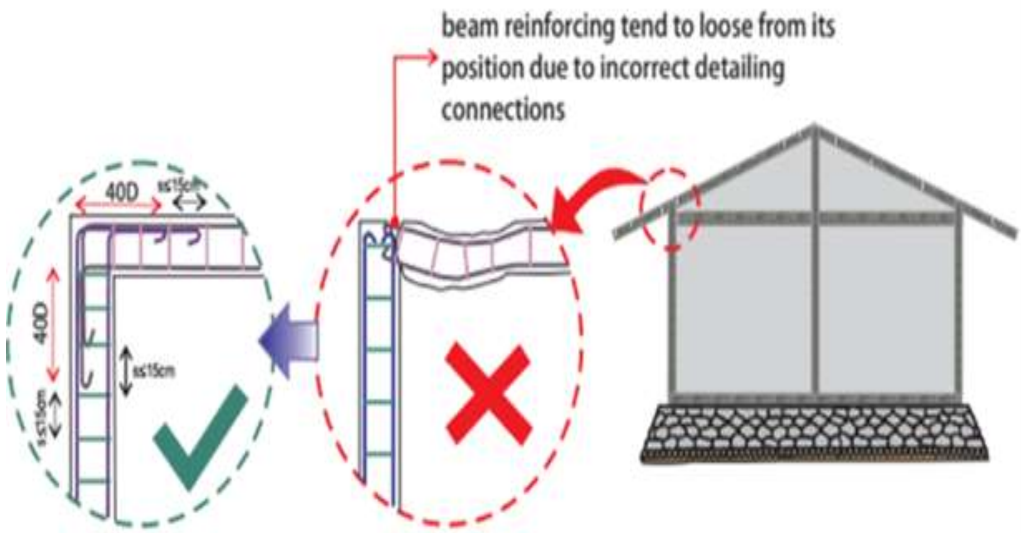


Figure 11. Column Reinforcement Details, (SNI 2847:2019, 2019)

Beams are a key structural component of buildings and require careful design and planning. Beam design must adhere to established rules and standards to prevent and anticipate failures (S. P. Tampubolon, 2021a). A proper understanding of good and correct building design principles is essential when designing structural elements. Many field cases reveal discrepancies between the design concept and actual construction, which can lead to critical structural issues. According to SNI 2847-2019, detailed reinforcement must be accurately designed to mitigate shear failures in the structure. Figure 12 below illustrates the detailing of reinforcement in beams and exterior columns.



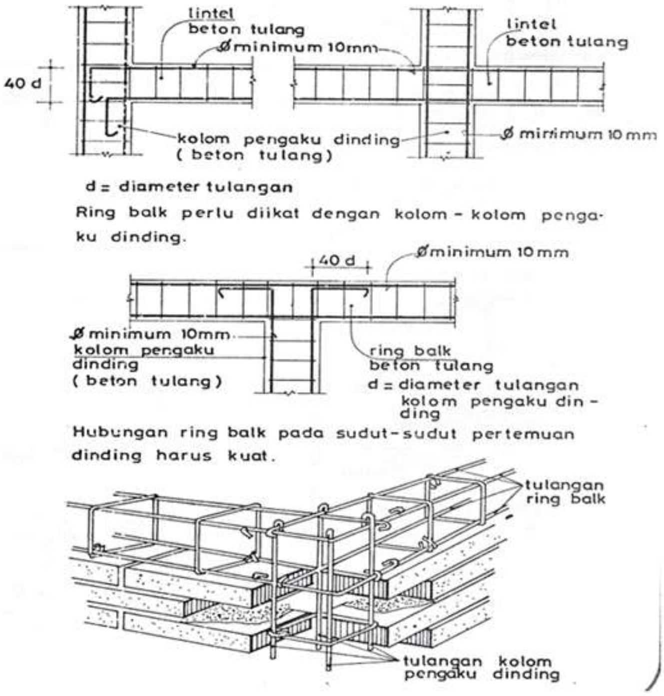


Figure 12. Photo of Reinforcement Detailing in Beam-Column Connections (Interior and Exterior), (SNI 2847:2019, 2019)

To prevent collapse of walls, anchors/ reinforcements should be installed every 6 layers of bricks to secure the bond between the wall and column structure. Figure 13 below shows the details of anchor placement in columns during brick/ block installation.

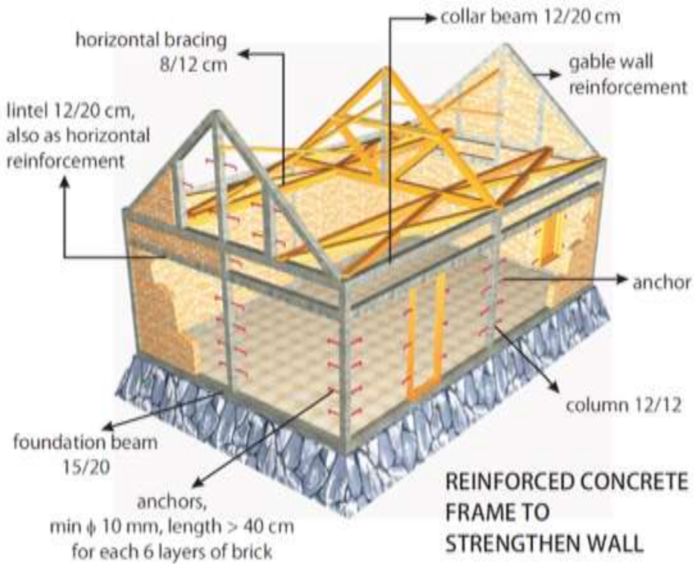


Figure 13. Detail of Anchor Installation and Spacing in Brick/Block Masonry

To prevent failures in the roof, detailed roof installation must be carried out as shown in Figure 14 below.

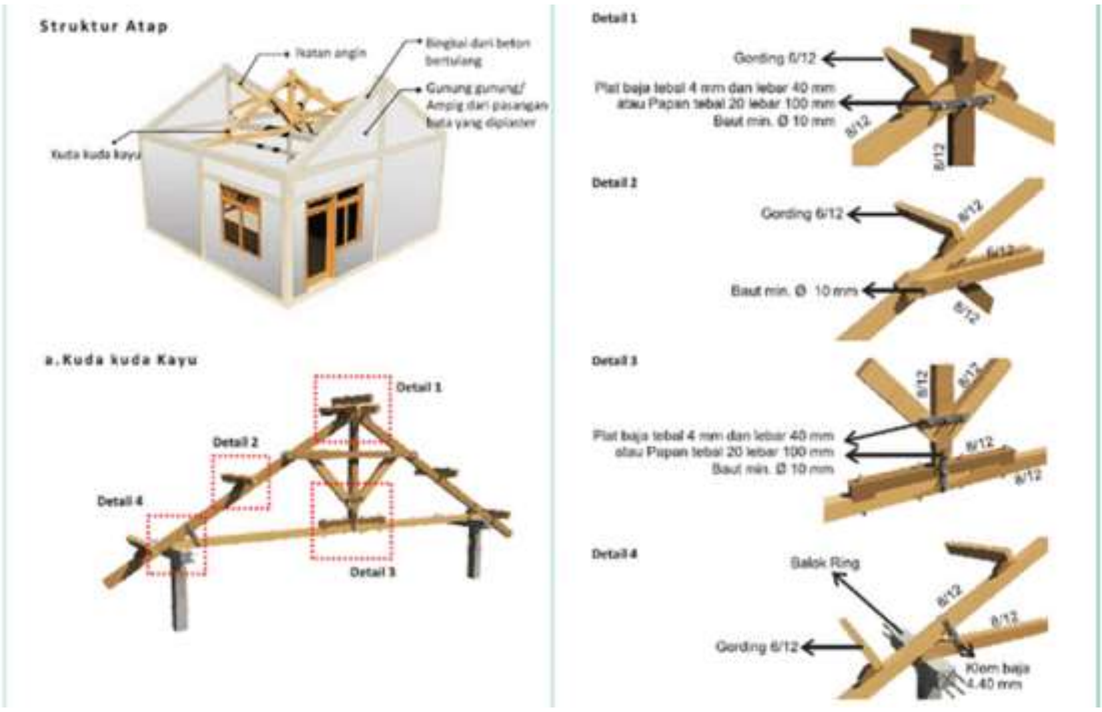


Figure 14. Detail of Roof Truss Connection Installation

To prevent failures in the foundation, careful attention must be given to the installation of reinforcement and steel anchors used in the foundation. Figure 15 below shows the details of reinforcement installation in the foundation and the anchors used in the footings.

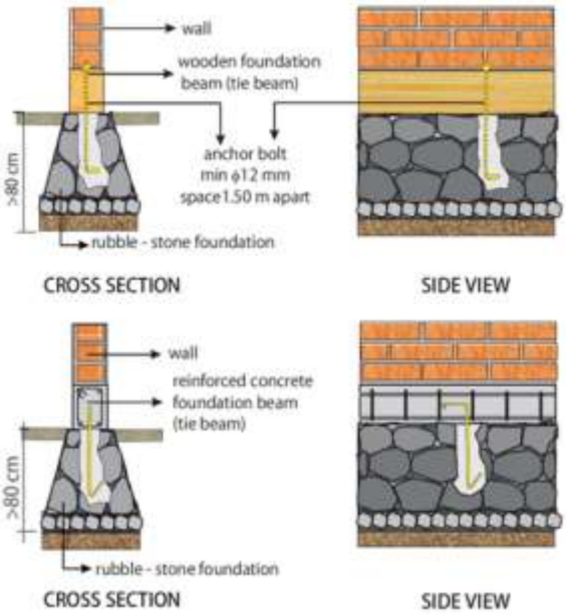


Figure 15. Detail of Foundation Reinforcement and Anchor Installation in Footings (Agisna et al., 2022)

Therefore, the installation of rebar hooks must adhere to standards as shown in Figure 16 below (Pujianto et al., 2019; SNI 03-2847-2019, 2019).

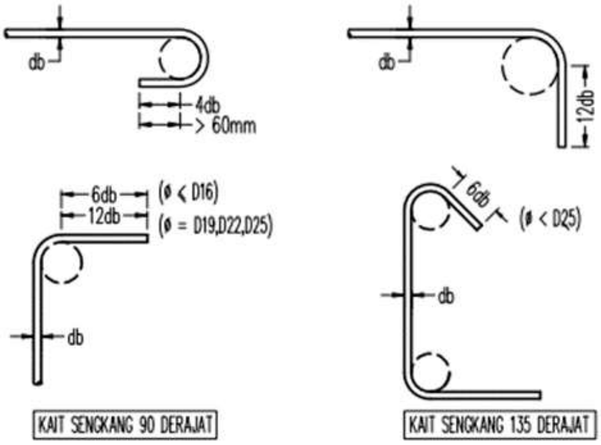


Figure 16. Rebar Hook Details

CONCLUSIONS AND RECOMMENDATIONS

From the survey and direct assessment conducted on building damage in Cikancana Village, Babakan Bandung Hamlet RT 05/RW 02 and RT 03/RW 01, and Cibeleng Hilir Hamlet, Cikancana Village, Gekbrong District, Cianjur Regency, the following structural damage was observed Strong column-weak beam concept has not been applied in the construction of houses. This is evident from columns that are not designed to withstand axial forces, resulting in many columns being broken and damaged. The column reinforcement does not meet SNI 2847-2019 standards. Beam structures were not designed to resist bending moments and shear forces. This is observed from shear reinforcements lacking 90˚ and 135˚ hooks, leading to beam cracking and failure. Beam-column connections were poorly designed. This is evident from numerous joints being damaged and broken, causing floor slabs to collapse. Foundation reinforcement details were not properly installed according to standards, causing the foundation to be unable to support the forces transferred from the columns. Walls and roofs experienced cracking and damage due to the lack of anchors in the walls and improper detailing and construction of the truss connections, leading to many truss connections breaking.

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