Abstract
We conducted a study to determine the morphological features and structural performance of slanted columns in traditional houses of Rumah Gadang, Indonesia. The slanted columns are believed to be connected in one point below the main pillar, thus makes the structure of rumah gadang to be stronger. We studied the power distribution of the main pillar to the slanted columns and conducted technical tests from several rumah gadang to see if the columns would meet on one point by measuring the angle of each slanted columns and projected in on computer simulation. We found that the slanted columns doesn't always meet on one point but to be distributed below the main pillar. After further study we found that the function of slanted columns are not limited only to distribute the building weight, but also to stabilize the weight that occured on the building. When one side of the building receive a weight force, the structure will produce an equal reaction on the opposite direction. We conclude that the angle formed by each slanted columns would produce an irregular shape of pyramid that met under the main pillar and play big part in power distribution of the building which reinforce the structure strenght.

Keywords: Minangkabau; Rumah Gadang; Slanted Columns; Technical Function; Morphological Features

1. Introduction

Rumah Gadang or Great House are the traditional houses from Minangkabau, Indonesia. Located along the pacific ring of fire makes Indonesia vulnerable to natural disaster such as earthquakes (Parwanto and Oyama 2014). Despite living in earthquake prone areas, people of Minangkabau used slanted columns made of wood as the main structure of their traditional houses rumah gadang. While a conventional straight column structure are known to be stronger and rigid (Ziemian 2009).

Altough it is built on earthquake prone areas, most of the rumah gadang in West Sumatra are still in a good condition (Setijanti, Silas, and Firmaningtyas 2012). The columns on rumah gadang are installed with a

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certain of inclination, it is believed that the bottom end of each columns are directed to the same point below the main pillar, and will increase the building endurance to the earthquake (Dewi 2010). The attempt to read the structural features of rumah gadang has been done before (Ihsan 2008), but the research are limited in explaining the features of foundation system and the overall structure system. We do not know how the slanted columns morphological features in particular can help to reduce the occurred earthquake effects on the building. But understanding the structural performance of rumah gadang will allow us to create a guideline for earthquake friendly building in earthquake prone areas.

The purpose of this study was to test the hypothesis about the morphological features and structural performance of slanted columns on rumah gadang that makes the structure of rumah gadang to be more robust.

To answer to the question, we conducted a technical test from several rumah gadang in West Sumatera, Indonesia, by measuring each angle of installed slanted columns in rumah gadang continued by projecting the acquired data into digital simulation to see if each slanted columns would meet on one point below the main pillar or not, and study the generated shapes of the whole building to determine the structural features and performance of rumah gadang.

2. Methods

2.1 Study Design

We surveyed 10 rumah gadang which is in a good condition in several areas of West Sumatra, including monuments and residential house. Then we measure and record the angle from each slanted columns from surveyed rumah gadang, followed with projecting the acquired angles data of each slanted columns into digital simulation using 3D modeling computer program, to determine the morphology output of rumah gadang structures, and evaluated the simulation results based on structural analysis from the formed geometry.

Fig.1. Selected Rumah Gadang.


2.2 Materials

To record and measure angle of inclination from every slanted columns in surveyed rumah gadang, we used a smartphone (Lenovo Vibe K5 Plus smartphone) and an inclinometer sensor application (Clinometer from Plaincode). Continued with projecting the acquired data into a 3D modelling computer program (Sketchup Pro 2016 64 bit) and rendered the output image using 3D computer Graphics rendering plug-in (V-Ray 2.0 for Sketchup).
2.3 Analysis

To determine if every slanted columns would connected on one point below the main pillar, we compared the structural morphology produced from projected computer model, to see if the formed morphological structure has the same result in every selected rumah gadang or not. We performed an analysis of the structure to learn the similarities and differences structure performance of the selected rumah gadang, and grasp the unique features from the slanted columns.

Fig.2. Imagined morphological structure of rumah gadang.

3. Results

Fig.3. MCDIC Column Plan (1).

Fig.4. Yulliar's House Column Plan (6).

Fig.5. Irmawati's House Column Plan (2).

Fig.6. Helmy's House Column Plan (7).
4. Discussion

In this study we compared the morphological features produced by the slanted columns from several rumah gadang to determine the structural performance of slanted columns on rumah gadang and to test the hypothesis about the slanted columns would connected on one point below the main pillar of rumah gadang.

In the simulations, every rumah gadang produced a shapes that resembles a reversed pyramid (figure 13 to 22). If we drag an imaginary line from the bottom end of each slanted columns, we found that each imaginary lines doesn't always connected on one point below the main pillars line but to be distributed randomly along it. Due to technical error in the installation of slanted columns and the lack of tools and proper angle measurement, resulting the slanted columns are installed differently to each other rumah gadang, which varies between 0,1° and 6,8° (figure 2 to 11), where usually the outer slanted columns should have larger angle than the inner columns (Nurdiah 2011)

The shape of inverted pyramid produced by the slanted structures divide the load path distribution of the building equally throughout the building. Resulting in building's weight stabilization. The building will produce an equal reaction on the opposite direction of every weight load occured on the building. This structural
features can only be achieved because of the Umpek or Sandi foundation system which is always used in rumah gadang, where the foundation help building structure to be muffled in very quick period (Ihsan 2008), because the foundation are not planted into the ground but placed on top of the ground instead, this allow the structure to shake more freely to adapt with earthquakes tremor and prevent structural failure. We need further study to determine the effective use of slanted columns with concrete materials. Where the usage of concrete foundation system could increase the stress level of the building structure.

Fig.23. Weight Load Distribution in Rumah Gadang

5. Conclusion

Our simulation provide an evidence that slanted columns would not always connected on one point below the main pillar, but randomly connected along the the main pillar projection instead, creating a random shape of pyramid. Slanted columns help the whole building to be more tolerant of shocks and tremor, this structural features caused by the shape of pyramid that distribute weight loads of building equally and thoroughly. Which is assisted by umpek foudation to reduce the occured shocks in the building.

By applying slanted columns into building structure, will improve the building tolerance and resistance toward earthquakes. This study provides an alternative of structure system that can be used effectively in earthquake prone areas.

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