Typology of post-disaster relief houses in Palu and Sigi, Central Sulawesi

Aulina Adamy1*, Qurratul Aini1, Meillyta2, and Lisa Maharani3

1Architecture Department, Engineering Faculty, Universitas Muhammadiyah Aceh, Aceh, Indonesia
2Civil Engineering Department, Engineering Faculty, Universitas Muhammadiyah Aceh, Aceh, Indonesia
3Architecture Department, Engineering Faculty, Universitas Syiah Kuala, Aceh, Indonesia

Abstract. It has been five years since the earthquake disaster followed with tsunami, liquefaction, and landslide in 2018 in Central Sulawesi, Indonesia. There are several varieties of house designs due to different type of disasters, locations, and donors. This study objective is to collect the house designs and evaluate it through typology analysis. Qualitative approached was conducted by field observation to redraw the house and taking pictures for analysis. Total five types of relief houses observed from all the different types of disaster. Most of them are grounded with 36m² size except one stilt house size is 72m². The house including two bedrooms and one bathroom but no kitchen. As part of the government innovation of earthquake resistant house named “RISHA”, it is compulsory to use it if the reconstruction source was government fund. From five houses sample, three of them used RISHA while the rest are RIKO and the other one is using conwood panel wall. The main problem found in this house is sustainability issue. As most of the relief house cannot extend using the same structure and materials. Designed for one story only, it is challenging for them to add space with limited land.

1 Disaster in Central Sulawesi

The disaster that happened in Central Sulawesi was a complex phenomenon with four types of disaster almost in the same time: earthquake, tsunami, landslide, and devastating liquefaction period. On September 28, 2018, most of the area of Palu Municipality, the capital of Central Sulawesi Province, along with the surrounding regencies, namely Sigi, Donggala, and Parigi Moutong Regencies around Palu Bay, were devastated by the earthquake, tsunami, liquefaction [1, 2] and triggered landslide [3].

Fig. 1. The map of Central Sulawesi.

The risk of Palu City and its surroundings to earthquakes and tsunamis is already known based on the geological characteristics of the area. There is the Palu Koro fault which is still active causing earthquakes to occur quite frequently. A similar earthquake with a magnitude of 7.6 on the Richter scale occurred in Palu in 1938 with many victims [4]. There were about fourteen earthquakes and tsunamis between 1820 and 1980 [5]. Palu City has a disaster-prone zone of 37,939.5 ha or more than 90% of the total area [6].

The 7.5 Mw tectonic earthquake that hit Palu City on 2018 was followed by tsunami and liquefaction, triggered massive mudflows in Balaroa, Petobo, and Jono Oge areas [7]. According to the study of H. Takagi & M. Heidarzadeh (2023), the tsunami was most likely the result of a dual earthquake and landslide source [8].

The Meteorological, Climatological, and Geophysical Agency (BMKG) reported that the earthquake that hit the city and coastal area caused enormous damages to the settlements and buildings. The casualties and material losses incurred were quite large, with more than 5,547 people dying and around 1,300 people still missing and an estimated economic loss of around IDR 13 trillion. It is estimated that around 100,000 houses were affected and 4,050 houses were lost and 30,000 buildings were badly damaged [9].

Despite, this complex disaster does not categorise as a national disaster where this status effect with the policies implied. Based on Indonesia law [10], if it is national disaster then the coordinator and fund will be the responsibility of the central government. While if not, it goes under the local government [11]. This study objective is to evaluate the relief houses built through typology analysis and occupants’ interviews. From the...
four types of disaster, five relief houses collected in Palu City and Sigi Residency that covered all types of disasters.

2 Methodology

The research methodology in this study was qualitative through field observation, document analysis, and interviews. Field observation was conducted with measuring each of the house types and taking photography documentations. These was done for redrawing the house with AutoCAD application. Then, the drawing and pictures were analysed also using literature reviews. Total there are five houses collected from four types of disasters spread in Palu, and Sigi.

3 Typology of House in Sulawesi

3.1 House Design Timeline in Sulawesi Island

Sulawesi as one of the islands in Indonesia has gone through many cultural periods which have also resulted in changes to their homes. The architectural typology of residential houses in Sulawesi has various shapes, models, and sizes. While previously most of the houses in Sulawesi are in the form of stilts, both on the mainland and on the coast, such as the houses of the Bajo tribe but now modern houses are mostly grounded. The materials used tend to use materials from nature, except for modern houses that have been built with modern materials such as cement, brick and glass:

- Prehistoric Period: prehistoric human habitation in Sulawesi, especially in South Sulawesi, began with living in caves [12]. This is evidenced by pictures of handprints found in many caves such as Petta Kere, PettaÊ, Bird, Ulu Wae, JariÊ, Lanbatorang (Maros), and many more. After that, prehistoric humans lived permanently during farming periods on the banks of the Karama River (the villages of Sikendeng, Minanga Sipakka, Kalumpang District, Mamuju Regency). At the end of prehistoric times, humans then lived in villages in the mountains, lowlands and seaside. The houses used are large pillared houses with curved roofs and have under the house which functioned as a place to raise livestock, as remains of the original settlements in Toraja, for example in Kuoa Pallawa Village.

- The Hindu Buddhist Kingdom Period: in contrast to other regions in Indonesia, such as Kalimantan, Sumatra, Java and Bali, which received a lot of Hindu-Buddhist influence, the island of Sulawesi only received a little influence. There is some evidence showing a slight Hindu influence in Sulawesi, namely the discovery of the Sempaga and Bantaeng statues which show the style of Anarawati art in India and the Lontara script which mentions the events of burning corpses and storing ashes in a jar which is the custom of the Hindu community [12, 13]. However, evidence of relics such as sacred buildings, inscriptions and temples were not found so that the evidence of Hindu-Buddhist settlements in Sulawesi is not known with certainty.

- Islamic Kingdom Period: the development of Islam in Sulawesi began in South Sulawesi by migrant Muslim communities from Malays who later succeeded in Islamizing Luwu, Tallo and Gowa, especially the reigning kings [12]. This development continued until the Sultanate of Buton, which was the last Islamic kingdom in Sulawesi. One example of a building at that time was the Palace of the Sultan of Buton, which was in the form of a stage, consisting of four floors, using a gable roof and made of wood.

3.2 Residential in Manado (North Sulawesi) before 1880

Fig. 3. Residential in Manado (North Sulawesi) before 1880†.
- Post-Independence Era: after Indonesia's independence, most of the houses used modern materials, especially the homes of indigenous people. One example is the Minahasa ethnic house in Talawaan Village, North Minahasa. The foundation for this house during the early period (1873-1939) used stones which were removed directly on the ground surface, but later they used pedestal foundations made of cement, stone, sand and water [17]. Another example is the fishermen's house in the Rangas Majene sub-district, West Sulawesi. This house was built with wooden stilt construction. Previously, most parts under the stilt house were not used, but when additional space was added to the underside, the material used was concrete. The second floor still uses wood as the wall material (see example pictures in table below).

Table 1. Font styles for a reference.

<table>
<thead>
<tr>
<th>House Typology</th>
<th>Drawing</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stilt house fully from timber</td>
<td><img src="image" alt="Stilt house" /></td>
<td>Located on the coast which is a tidal area and shaped like a house on stilts. Made of posi-posi wood for the pillars, nibong trees for floors and walls and thatch leaves for the roof. The plan of the house is rectangular, while the roof uses a saddle shape.</td>
</tr>
<tr>
<td>Stilt house with combinato of wood and concrete</td>
<td><img src="image" alt="Stilt house" /></td>
<td>It is a combination of concrete and wood construction, where the main pillar is made of concrete and the upper structure is made of wood. The floor plan is rectangular with walls and floors made of planks. Using a saddle-shaped roof with zinc material as a cover.</td>
</tr>
<tr>
<td>Grounded house</td>
<td><img src="image" alt="Grounded house" /></td>
<td>It is no longer in the form of a stage and is located on the coastal plains. Using river stone foundations, floors with cast concrete, plank walls and gable roofs made of corrugated iron. The house plan is rectangular.</td>
</tr>
</tbody>
</table>

3.2 House Relief Typology in Central Sulawesi

Next is the compilation of five relief houses collected in this study.

Table 2. Typology of the house relief in Central Sulawesi.

<table>
<thead>
<tr>
<th>House Developer/Donor</th>
<th>Drawing</th>
<th>Description</th>
</tr>
</thead>
</table>
| ARCOM and Government  | ![ARCOM](image) | - Shape: grounded house (RISHA)  
- Size: 36m²  
- Location: Mamboro, North Palu  
- Disaster Risk: earthquake and tsunami. |
| ARCOM and Government  | ![ARCOM](image) | - Shape: stilt house (RISHA)  
- Size: 72m²  
- Location: Mamboro, North Palu  
- Disaster Risk: earthquake and tsunami. |
| BUDDHA TZU CHI        | ![BUDDHA](image) | - Shape: grounded house  
- Size: 36m²  
- Material: structure – steel, wall – conwood panel - zinc, floor – ceramic tile  
- Location: Tondo, Palu  
- Disaster Risk: earthquake and tsunami. |
### Discussion

Until this survey was conducted in 2023, the reconstruction of house relief is still not finish yet. As of April 2019, the total number of damaged houses recorded was 110,214 houses. There are several challenges found such as limited land for relocation [2] and verification of the number of people who are entitled to get it. Since many of the victims are people who rented the house and therefore, there are dispute about their right to get a house as they are not the owner. Most of them also not are migrants who are not registered in the disaster-affected administration area.

On the other hand, there are cases where beneficiaries received double houses [18]. Limited fund was also an issue especially the responsibility of the reconstruction is under the local government [19]. While technically, lack of material and construction workers was found too [1]. Based on the regulation, each house constructed by the government or non-government should follow with the budget of IDR 50 million per house for heavy damage, IDR 25 million for moderate damage, and IDR 10 million for minor damage [20].

Government policy in housing sector reconstruction is to build earthquake resistant house [1]. The central government through Directorate General of Housing under the Ministry of Public Works and Housing (PUPR) has created an earthquake resistant house named Healthy Instant Home (Rumah Instan Sederhana Sehat) or “RISHA”. RISHA is a knock down construction technology invention that can be built quickly (hence it is called instant technology), using reinforced concrete as its main structure [21]. For the rehabilitation and reconstruction in Central Sulawesi, relief houses funded by the government are compulsory to build RISHA [1].

From five sample houses studied, three are adopting RISHA. The other two, as not government funded are using a different type of house design. Based on the Lombok reconstruction study, these are several types of houses as the most popular prototypes chosen by the community during reconstruction beside RISHA: conventional confined masonry house (RIKO), timber structured house (RIKA), and steel structured house (RISBA) [22].
drawbacks in terms of limited module sizes, as well as structural durability which is limited to 1-2-storey buildings, so they cannot meet the criteria for multi-storey housing [23].

Fig. 6. Inevitable fact with relief house expansion.

The expansion cannot be avoided since the relief house size average 36m² is too small and usually categorised as a core house. It is obvious in the field that many houses already expanded with additional rooms. This happened even there are donors banned to expand or renovate the core house in certain years as part of the contract during the house handover. Ethically it is raised question with the requirement for the occupants not to renovate the relief house, which need to further study. Based on observation, none of the extension using the original structure and material since it is not available in the market. While the core houses are calculated save for earthquake disaster, the additional part is not clear.

People prefer to build conventional type houses (RIKO) compared to other types of houses because the implementation of RIKO type construction is easier [1]. However, the RIKO house built for landslide disaster by Yayasan Bumi Tangguh in Sigi have a unique additional structure that taking up most of each side of the house. Due to this additional element, it is difficult for occupant to modify the wall.

Fig. 7. RIKO house in relocation area for landslide disaster.

Relief houses built by ARCOM collaboration with the government is the only one in this study applied community participation approach. Theoretically, many previous studies stated that the principle of project success involves community participation from all stakeholders, especially affected communities in reconstruction [24]. As challenging in nature, the coordinator field of ARCOM admitted not all of their assessments was succeeded. Yet, one of the villages that included in this study is considered as the best example from ARCOM approach. While the rest relief houses are using contractor approached.

To compared with the house design in the time line study, most of the relief houses are different expect the stilt house by ARCOM that are still similarities. While according to the occupant, the reason to choose stilt house is because the size is bigger (72m² as the ground floor is included) even though they have to add with their individual money for it.

Fig. 8. The only stilt house built by ARCOM and government.

As for the location, there are several schemes in the reconstruction in Central Sulawesi: (1) relocation to a large residential area from the Government (such as district of Duyu, Tondo-Talise, and Pombewe Olobuju), (2) relocation to satellite land (relocation on a smaller scale than the first option was proposed by the prospective beneficiaries in groups), (3) Independent relocation. This relocation scheme is considered as an alternative option if individual residents or very small groups have land that they can use for their new permanent homes [1]. All the sample of the houses in this study falls into the 1st scheme where relocation land is provided by the government expect for the houses helped by ARCOM that is categorised as independent relocation. Relocated houses that have been decided by the Central Sulawesi Governor [11] are in Duyu Village, Palu City, Pombewe Village, Sigi Regency, and Tondo-Talise Village, Palu City.

5 Conclusions

As most of the relief houses in the Central Sulawesi reconstruction are finish during the survey, this study analysed five sample houses that located in four different types of disaster; earthquake, tsunami, landslide, and liquefaction. First of all, the reconstruction is under the coordinator of the local government. Related with relief house, the central government policy is if government funded project should use RISHA as the house type design. From five, three of the sample applied this type of house. The same type of house is used for different type of disasters: earthquake/tsunami and earthquake/liquefaction. The other two houses are using a conwood panel and RIKO with a specific frame design structure. The last one applied for the landslide relocation.

While most of the house using in-site fabrication materials, it is obvious it is not sustainable for extension of the house. Occupants using materials that are more likely available in the market and ordinary frame structure that being questionable for the safety. The other issue raised is that these in-site fabrication type of houses was not design for second story which become challenging for
vertical extension in the future that required bigger land to able add space horizontally.

Related with the design style, all using ordinary simple modern house that are commonly used after the independent especially for the middle- and lower-class community. Except for the house built by ARCOM together with the government, they provide option of stilt house with local architecture ornament. This too can be done because ARCOM is the only one from all the five samples in this study using community approach.

Relocation, land availability and beneficiary verification are the issues during the reconstruction that have not finish yet after 5 years. While for the relief houses, sustainability is the major concern especially for houses that were constructed with contractor approach. Community will not able to extend their houses vertically as the house is not design and built for second story. While limited land become challenging for them to extend the house horizontally. In-site pre-cast structure and materials that are not available in the market and not commonly applied for the local will encouraging people to build houses with less secure structures.

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