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To cite this article: M A Bahar 2025 *IOP Conf. Ser.: Earth Environ. Sci.* **1439** 012026

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IOP Conf. Series: Earth and Environmental Science **1439** (2025) 012026
doi:10.1088/1755-1315/1439/1/012026

Building Performance Based on Seismic Conceptual Design in Temporary Housing Semeru Eruption 2021

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Abstract. Indonesia's geographical location, which often experiences earthquakes, is important in disaster mitigation programs, especially for earthquake-resistant building planning. This study uses quantitative and case study methods to determine the seismic performance in the design of temporary housing for the 2021 Mount Semeru eruption based on the Seismic Conceptual Design of Buildings. The analysis used a scoring method to measure the similarity of the case study object to seismic theory. The damage caused by the eruption, relocation of settlements, and construction of new houses are very necessary. The 2000 temporary housing units were designed using fast materials, such as light steel and gypsum board, which is not suitable for the main structure of the building. However, with a building area of only 28.8 m2, the building span is shorter, and only one floor with room partitions inside makes the structure more solid. Each building is also given a distance from another building so that vibration waves that hit the building do not spread to other buildings. From the analysis results, the design of this temporary housing has a similarity of 65.9% with the seismic theory. This design has a fairly good building performance in terms of security and safety to reduce the risk of earthquake damage. However, more detailed drawings are needed, such as structural connection systems, technical specifications, and construction guidelines, and there must also be calculations of structural strength by experts.

Keywords: Building Performance, Seismic Conceptual Design, Semeru Eruption, Temporary Housing Design.

1. Introduction

Before the eruption on December 4, 2021, Mount Semeru had experienced several earthquakes, starting with a strength of 6 Mw on April 10, 2021, and 5 Mw the following month, October 2021, with a strength of 5 Mw. [1] On December 1 and 3, 2021, volcanic activity increased, causing 4 hot cloud avalanches. Then, on December 4, 2021, a peak eruption occurred at 14:47 WIB; the hot cloud slid 4 kilometers from the peak. Then, at 15:20, WIB volcanic ash headed towards Curah Kobokan Hamlet, Supiturang Village, Pronojiwo District, Lumajang, East Java. The day after, 8 earthquake eruptions and hot cloud avalanches were recorded. [2]

This eruption significantly damaged settlements around Mount Semeru. It was recorded that five sub-districts experienced severe damage, namely Candipuro, Pasrujambe, Senduro, Gucialit, and Pasirian Sub-district. Cold lava flowing from the peak of the eruption caused approximately

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5,205 houses to be severely damaged (figure 1.a, b). In addition, it also caused the main bridge connecting Lumajang and Malang to be cut off. Residents, public facilities, and agricultural and livestock lands were also lost due to the cold lava. Residents who lost their homes were forced to evacuate to temporary shelters. The shelters were in the green (safe) zone, far from the affected location. After the eruption, it was seen that the evacuees were still traumatized and were following recovery programs from the local government. After seeing the safe conditions and situation, some evacuees checked their houses or belongings that were still left after the cold lava hit.

Figure 1. a) b) Cold lava that hit residential areas. c) Evacuation camp for eruption victims

The evacuation camps are only temporary; therefore, the local government plans relocation for all affected residents (figure 1.c). The government works with various professional agencies/ or organizations to rebuild post-eruption settlements. It is proposed that an area of 81.55 Ha is ready to be built for new settlements that can accommodate 2000 temporary and permanent housing units and also provide public facilities, such as administrative, health, academic, commercial, production, and other public facilities (figure 2.b).

Figure 2. a) Temporary housing structures and materials. b) New settlement

In this case, the local government collaborated with the Indonesian Architects Association (IAI) to plan temporary housing (rear of the house) and the PUPR Ministry for permanent housing (front of the house). The design of the temporary housing uses a main structure of light steel with a continuous riverstone foundation. The cover uses gypsum board and a steel roof (figure 2.a). The bathroom uses bricks with a cement plaster finish and waterproof paint. This concept is based on the ease of construction and availability of materials that carry the concept of healing home housing and re-use of materials. The structure and construction are deliberately made light because the housing is temporary and can be developed or improved in quality in the future. This relocation program also includes planning a master plan for the entire new settlement. The selection of a new location has also gone through a safety and security test, which is a green area, not a cold lava path. The overall building unit planning consists of one floor with a certain distance for each unit as a green open space and development area (growing house).[3]

2. Seismic Conceptual Design of Building (SCD)

An earthquake is a vibration or shaking on the earth's surface due to the sudden release of energy from beneath the surface, creating seismic waves. Earthquakes are natural phenomena that have destroyed power and caused huge economic losses and human injuries and deaths [4]. The earthquake was an antiquity natural phenomenon, accompanied by Earth's development. Earthquakes take place more than ten thousand times on Earth every year [5]. Some types of earthquakes are tectonic earthquakes, volcanic earthquakes, collapse earthquakes, landslide/slope failure, liquefaction, and damage to buildings. Building damage due to earthquakes can be categorized as follows; a) Soft Storey, soft floor damage occurs on the floor of a multi-story building: bottom, middle, or top floor. The soft story most often occurs on the ground floor of a building. b) Structure Failure, damage to structures: column-beam joints, floor slabs, core walls, etc. c) Short Columns, Short column damage in a wall void. d) Buckling Damage to structural components that break or bend. e) Pounding Effects, damage due to collision between adjacent buildings (figure 3). [6]

Figure 3. Examples of the impact of earthquakes on buildings [4]

SCD is a standard principle that can be applied to buildings to reduce the risk of building damage. According to Prof. Hugo Bachmann in the book Seismic Conceptual Design of Buildings-Basic Principles for Engineers, Architects, Building Owners, and Authorities [6], there are several Building Principles (BP) as follows.

1) The architect and the engineer collaborate from the outset (BP1)
2) Follow the seismic provisions of the codes (BP2)
3) Costs Efficiency (BP3)
4) Avoid Soft Storey (BP4, BP5)
5) Avoid Asymmetric Bracing (BP6)
6) Avoid Bracing Offset, Discontinuities in stiffness and Resistance (BP7, BP8)
7) Shear Walls (BP9, BP22)
8) Avoid mixed structure materials (BP10, BP11, BP12, BP13, BP14, BP15)
9) Avoid Short Columns (BP16, BP17)
10) Design diagonal steel bracing carefully (BP18)
11) Design steel structures to be ductile (BP19)
12) Separate adjacent buildings by joints (BP20)
13) Favor compact plan configurations (BP21)
14) Ductility of the Structures and Materials (BP23, BP24, BP25)
15) No Openings or Recesses in Plastic Zones (BP26)
16) Standard Structural Connection Details (BP27)

17) Protect Foundation through Capacity Design (BP28)
18) Assess the potential for soil liquefaction (BP30)
19) Softening may be more beneficial than strengthening (BP31)
20) Fasten installations and equipment (BP34, BP35)

3. Methods

This study uses a quantitative method equipped with a case study approach. The analysis was carried out using a scoring system to measure how similar the case study object of the temporary housing design of the 2021 Mount Semeru eruption in Lumajang Regency is to the theory of Seismic Conceptual Design of Buildings-Basic Principles for Engineers, Architects, Building Owners, and Authorities by Prof. Hugo Bachmann. The limitation of this study is only to examine the design level, not the object that has been built. So, this study examines the aspects of architecture, structure, and use of materials in the design drawing documents of temporary housing designed by IAI East Java.

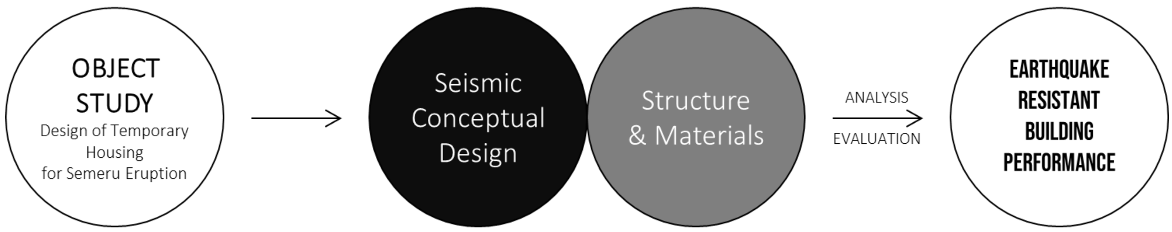

Figure 4. Research methods and stages

This research will begin with a literature review of temporary housing design drawing documents, especially on the structural and material aspects. Then continued with the second study on seismic. From both studies, a similarity evaluation will be carried out by scoring, which can show how much the similarity value is. The final result will be able to know whether this temporary housing design has good building performance, especially for earthquake-resistant buildings. (Figure 4).

4. Result and Discussion

4.1. Evaluation of Seismic Conceptual Design of Buildings-Basic Principles in The Design of Temporary Houses

In addition to being planned with the concept of Healing Home and Re-use Material, the design of the temporary shelters must consider the post-disaster aspect itself, namely prioritizing the aspects of time and cost efficiency and safety. Time here means that the building can be built quickly and is easy for local workers or volunteers to apply or implement. At the same time, the cost is related to the availability of materials, cheap materials, and standard building sizes for post-disaster housing. This temporary housing is designed with a length of 4.8 meters and a width of 6 meters, consisting of a terrace, dining room (main), bedroom, kitchen, bathroom, and drying area (side terrace). The column structure, beams, and roof frame use light steel, light steel profile C 350x750mm; the floor uses concrete mortar with plaster and cement finishing; the walls use 120x240cm gypsum board; the ceiling uses 120x240cm gypsum board; the roof using steel roof. Meanwhile, a light steel C canal frame and multiplex wood boards will cover the door and window frames (figure 5).

Building design in earthquake-prone areas must consider seismic aspects, especially in eruption areas. Temporary housing is located in a new place (relocation), an area that is declared safe from the cold lava path of the eruption. Therefore, the location aspect here can be declared to be in a green area (safe); furthermore, the design analysis of the seismic aspect consists of 35 Building Principles (BP), which are summarized into 22 aspects.

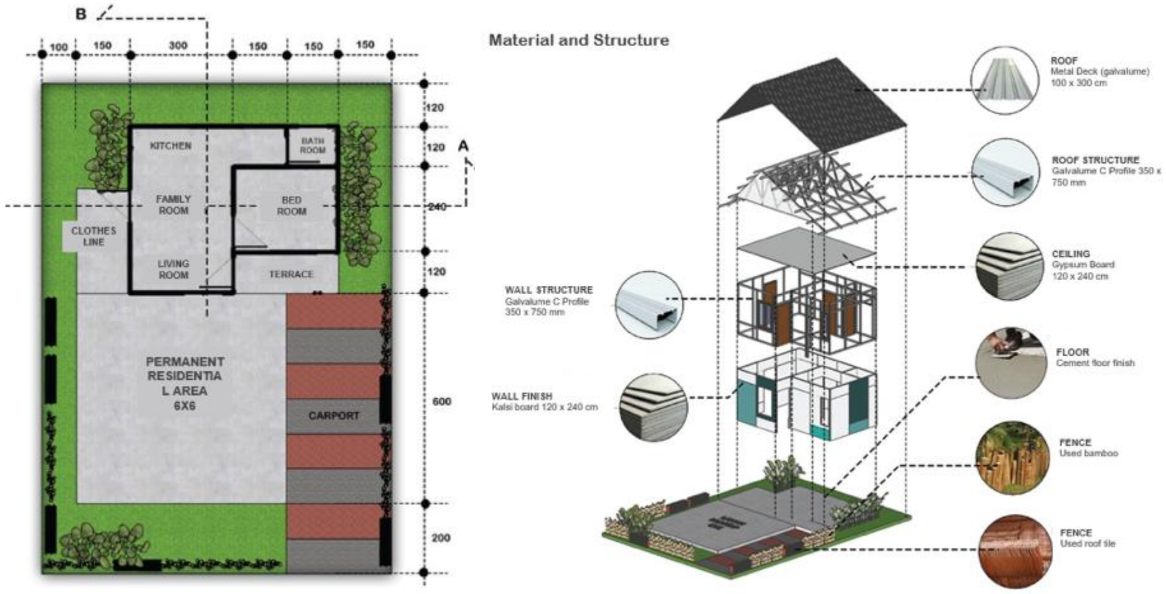

Figure 5. Temporary housing design by the Indonesian Architects Association (IAI)

4.1.1. *The architect and the engineer collaborate from the outset (BP1)*

Cooperation between architects and other engineers must be done since the planning begins. Building design cannot be done with a serial design scheme; architects only work on structural and non-structural design concepts, and engineers calculate the structural strength only. However, both must be involved together, producing a general proposal for the building's structural and non-structural design aspects.[7] Currently, the BIM method is widely used, involving multidisciplinary sciences.[8][9][10] The temporary housing planning process takes a short time because the affected victims are temporarily living in shelter camps that must be relocated as soon as possible, living in a more appropriate and comfortable place. This short time makes the design less time-consuming in terms of consideration and calculation of structural strength.

4.1.2. *Follow the seismic provisions of the codes (BP2)*

When planning a building, one must always follow the standards or rules that have been determined.[11][12] For international standards such as the International Standardization Organization (ISO), International Building Code (IBC), and others. For local, such as the Indonesian National Standard (SNI), Building Standards (SBG) from the PUPR Ministry, and others.[13][14] The design of this building does not display the standards used; it focuses more on how the building can be built quickly, cheaply, and safely.

4.1.3. *Costs Efficiency (BP3)*

To create an earthquake-resistant building does not always have to be wasteful in making its structure. Strong and cheap must be achieved as effectively as possible, which can be done from the planning approach and applied method stages. From the spatial design, material selection, construction scheme, and total number of units, this building design is considered successful in achieving cost efficiency.[15] The materials are abundant and cheap, and the construction installation is easy and fast. This is the main concept of temporary housing.

4.1.4. Avoid Soft Storey (BP4, BP5)

Soft-story architecture occurs in multi-story buildings, often on the ground and middle floors. Reinforced concrete frames, shear walls, infill walls, etc., provide lateral stiffness. The heaviest load supported by multi-story buildings is at the base of the building (ground floor).[16] If there are only lateral load-bearing columns on the ground floor that are not balanced by shear walls or infills, and with the loads they support, then the lateral load-bearing system is very weak, causing the floor to collapse (soft story).[5][17] The temporary house is designed with only one floor, so the possibility of a soft story is very small (figure 6).

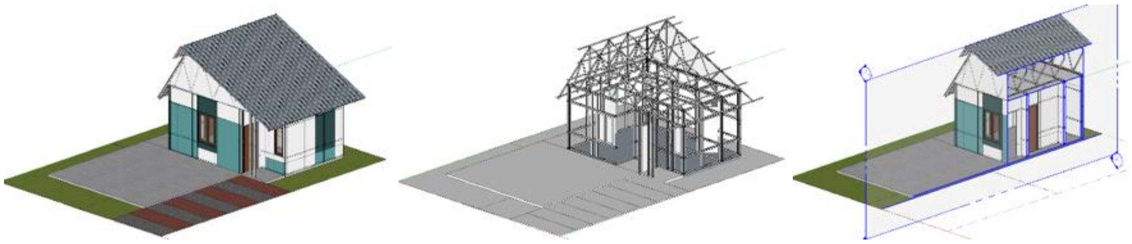

Figure 6. Rigid and compact spatial layout, makes it possible to avoid damage to short storeys.

4.1.5. Avoid Asymmetric Bracing (BP6)

Geometric design or planning is one of the most important factors when considering seismic design principles. Asymmetric bracing causes excessive rotation of the structure.[18][19] This leads to structural failure and can cause the structure to collapse during an earthquake.[20] The higher the distance between the two centers, the higher the torsional movement of the structure.[21] There will be additional shear forces on the vertical elements, which they may be unable to bear. As a result, structural failure may occur. Therefore, we must place the lateral bracing or load-resisting system so that the center of mass and stiffness coincide to avoid or minimize torsional movements.[10] This building design has no diagonal bracing because the space span is short, and the material is dominated by light steel.

4.1.6. Avoid Bracing Offset, Discontinuities in Stiffness and Resistance (BP7, BP8)

The stiffener structure that is not straight or not parallel to the horizontal and vertical lines in the structure of a multi-story building will produce uncontrolled bending moments and force distribution, causing the flow of force to be disrupted, reducing strength, and affecting plastic deformation capacity.[22] Similar to the previous aspect, this building does not require excessive stiffener structures.

4.1.7. Shear wall (BP9, BP22)

To reduce the lateral force of the earthquake, the planning of shear walls needs to be added following the grid line of the structural column.[23][24][25] In the design, there are no shear walls; earthquake resistance is obtained from the material's plastic power and the space span's density (figure 7).

4.1.8. Avoid mixed structure materials (BP10, BP11, BP12, BP13, BP14, BP15)

Mixing structural components with non-structural components as load supports will cause an imbalance in the strength of the building. Structural stiffeners must use materials that have flexibility and rigidity characteristics that can withstand compressive, tensile, or torsional forces. If brick material is used as a stiffener structure, then the inside of the brick must be reinforcing steel. For materials that are easily cracked or damaged, they may only be used as partition walls. According to structural connection standards, the connection system between structural and non-structural materials must also be considered. Buildings require bracing frames to withstand lateral loads during earthquakes.[26] However, brick and filler walls are not good choices because they can damage the moment-resisting frame. Therefore, good bracing is shear walls and structural bracing. The materials used have been determined and grouped. For the structure, the main material is a light steel C channel, with a structural frame system that functions as a column and beam that binds the walls and roof supports. The roof frame uses a light steel C channel with a truss structure system. For non-structural materials, gypsum board is used as the wall, and bricks with plaster-sandwich-paint finish are used for the bathroom walls. Here, the mixing of materials has been well considered (figure 7).

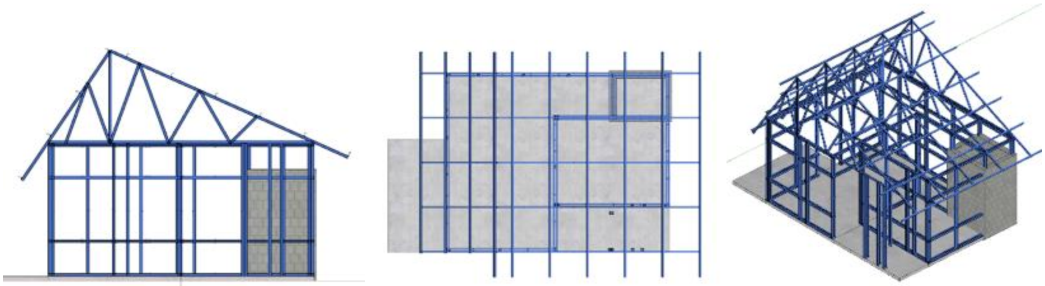

Figure 7. there is no shear wall and also branching structure.

4.1.9. Avoid Short Columns (BP16, BP17)

Short columns act as rigid elements that must not fail. However, there is a high probability of short columns failing due to shear forces.[27] Therefore, the structure of short columns must be reinforced, or complete holes must be avoided from end to end (voids are placed more towards the center). [28] Avoid partially filled frames. There are no openings that can produce the effect of short column damage. The openings in this building are made completely vertical for both windows and doors.

4.1.10. Design diagonal steel bracing carefully (BP18)

It would be very good to use diagonal bracing for buildings with main structures. [29] However, it is necessary to calculate in detail the steel profile used dimensions to the connection system.[30][31] There is no diagonal reinforcement frame on the wall, and even though the columns are filled with gypsum board walls, they will still not be strong enough to withstand the lateral force of the earthquake. There is no bracing system in the design.

4.1.11. Design steel structures to be ductile (BP19)

Steel is a material that often experiences buckling failure.[32] Therefore, having rigid joints at the beam-column joints can reduce the possibility of damage to the beams.[33] Increase the maximum concrete strain.[34][35] Light steel material and bolt or screw jointing systems can produce certain flexibility, but if continuously exposed to earthquake force, this material will bend, and the screws can become loose, causing the jointing to come loose and the building to collapse. The main frame of light steel is arranged with a built-on-site system that forms a frame that binds the columns and beams together.

4.1.12. Separate adjacent buildings by joints (BP20)

Ground motion causes the building to move toward the seismic wave. Thus, there will be a reflection of the building at the top (pounding effect). The maximum deflection of the building can be limited during the design according to the requirements. Then, the maximum deflection can be calculated to determine the safe distance between buildings.[36] There is no reinforced concrete in the columns and beams. However, using the SCD Steel configuration, the frame, columns, and beams of light steel canal C intersect to form a frame.

4.1.13. Favor compact plan configurations (BP21)

Converting irregular structures into more regular structures is recommended whenever possible. This conversion can cause the structure to behave more simply.[37][38] A dilation (separation) structure system can minimize the impact of creepage or tensile damage to the building for large or long buildings. [39] In terms of pattern or grid structure, the design of this building is arranged with a regular grid and maximizes the size of the available materials, minimizing waste materials. A separate structure (dilation) between temporary and permanent housing has been planned. In terms of time, temporary housing can stand alone and is in the middle of the site or land, but temporary housing is built attached; even though the dilation system has been implemented, the pounding effect can occur (structural collision between temporary housing and permanent housing) (figure 8).

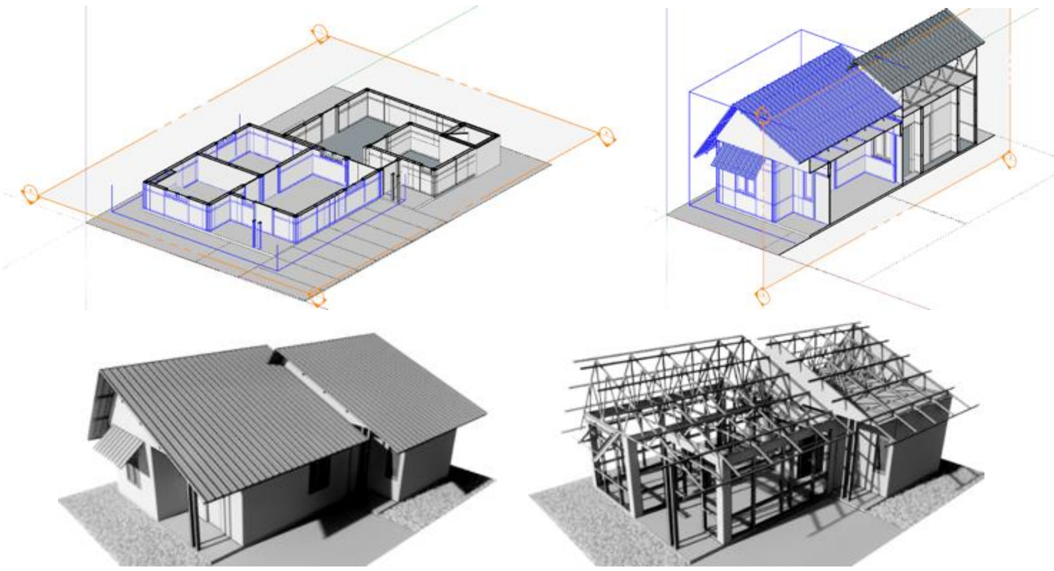

Figure 8. Space organization and separation of structures between temporary and permanent housing that can minimize the impact of seismic vibrations.

4.1.14. Ductility of the Structures and Materials (BP23, BP24, BP25)

Rigid structures tend to fail in earthquakes due to the reduced strength of the structure from the seismic event. Ductile structures can absorb energy and deform with the application of loads. The type of load applied to the structure will stabilize and absorb the energy by deforming it and its flexibility. Furthermore, tensile behavior allows the structure to undergo plastic deformation.[40]

The following methods can improve the flexibility of the structure: a) Increase compression (pressure) strengthening, b) Increase the compressive strength of concrete. For columns to roof frames, already use light steel material, but for foundations or floors, only use cement so that the jointing between the light steel structure and the floor is only screwed. This is very vulnerable if there is a lateral force that can cause the screw to break.

4.1.15. No Openings or Recesses in Plastic Zones (BP26)

There should be no openings or holes without structural calculations on the structural walls, columns, beams, or floor plates.[41][42] Although its function is as a utility path, this action will affect the strength of the building structure. This temporary residence is a simple building with a simple utility system, so no utilities interfere with structural components.

4.1.16. Structural Connection Detail Standards (BP27)

Most beam and column failures occur near the beam-column joints with high stress due to loading (lateral-axial forces). Therefore, proper calculation and detailing of the beams must be prepared to withstand earthquakes. In addition to damage near the beam-column joints, damage inside the joints also causes structural failure. The failure is mainly caused by the lack of confining reinforcement inside the joints.[43] Reinforcement and concrete quality are very important for joints. However, too tight reinforcement will create weak joints that may even have internal holes. There is no place for the concrete to flow.[44] The design of this building uses a light steel frame beam column structure with a bolt or screw jointing system according to the installation standards for light steel, but the details are not shown.

4.1.17. Protect Foundation through Capacity Design (BP28)

The foundation is the first structural component that comes into contact with earthquake waves.[45] It is important to determine the right type of foundation based on the soil, building load, and other factors.[46] The new land for settlement relocation has been declared a green area (safe zone), the solid soil structure of the former pine forest. The design needs to clearly show the foundation structure, and concrete floor slabs are used only.

4.1.18. Develop a site-specific response spectrum (BP29)

Determining soil characteristics and building functions must be done to build resistance to earthquakes. The hardening of the ground surface and foundations must be improved according to building standards at a particular location. Peak Ground Acceleration (PGA) is the same as the maximum ground acceleration when an earthquake occurs at a location.[47] Considering the maximum PGA in the design, the building will be more prepared for earthquake resistance in the future.[19] In the design, there is no or less mention of PGA considerations.

4.1.19. Assess the potential for soil liquefaction (BP30)

Identification of character and soil testing is important to be done as an effort to prevent liquefaction during an earthquake.[48][49] In the design, there is little or no mention of soil liquefaction considerations.

4.1.20. Softening may be more beneficial than strengthening (BP31)

Common systems, such as moment frames, shear walls, etc., can resist lateral loads applied to the structure. In addition, dampers can also be used to reduce the vibration effects caused by earthquakes. [50] In the design, there are no additional components to withstand earthquakes. The small dimensions of the building with a short space are considered capable of withstanding or reducing the earthquake force that will occur.

4.1.21. Anchor façade elements against horizontal force (BP32, BP33)

Building damage due to earthquakes occurs not only on the inside but also on the exterior. When installing facade components, they must be strong and able to withstand the lateral forces of the earthquake.[51] This design does not have additional facades or non-structural components; the whole thing is designed with functional and efficient aspects.

4.1.22. Fasten installations and equipment (BP34, BP35)

Seismic waves cause buildings to vibrate. All installations attached to the building must be installed firmly and tightly to minimize damage from an earthquake.[52][53] The structural system and building components have been described, but more details should be mentioned.

Here is the table of analyst calculations. If it has conformity with the SCD principle, the value is 2; if it is less, the value is 1; and if it does not conform, the value is 0; then the table and percentage figures can be illustrated as follows.

Table 1. Seismic Conceptual Design (SCD) assessment of temporary housing design

No.	SCD	Conclusion	Point
1	The architect and the engineer collaborate from the outset (BP1)	No structure calculation	0
2	Follow the seismic provisions of the codes (BP2)	It is not clearly stated what standardization is used	0
3	Costs Efficiency (BP3)	Cheap materials, widely available, easy and fast in the construction process	2
4	Avoid Soft Storey (BP4, BP5)	The possibility of a soft story is very slight because it only consists of one floor and uses a light steel frame structure system with many room divisions to strengthen each other.	2
5	Avoid Asymmetric Bracing (BP6)	The design does not require bracing	2
6	Avoid Bracing Offset, Discontinuities in stiffness and Resistance (BP7, BP8)	The design does not require bracing	2
7	Shear Wall (BP9, BP22)	It doesn't have a shear wall, but a brick wall for the bathroom can help with the lateral forces.	1
8	Avoid mixed structure materials (BP10, BP11, BP12, BP13, BP14, BP15)	There is a mixture of materials, but the structural and non-structural materials have been designed and separated properly.	2
9	Avoid Short Columns (BP16, BP17)	It does not have small openings that trigger short columns. The openings in the design are made continuously vertical, and standard ventilation window holes	2
10	Design diagonal steel bracing carefully (BP18)	Diagonal bracing is not added to the design	0
11	Design steel structures to be ductile (BP19)	The structural material uses light steel, which has good elasticity.	2
12	Separate adjacent buildings by joints (BP20)	The building is attached to a permanent residence, but this temporary residence can stand alone (separate structure)	2
13	Favor compact plan configurations (BP21)	The building is attached to a permanent residence, but this temporary residence can stand alone (separate structure)	2

14	Ductility of the Structures and Materials (BP23, BP24, BP25)	The structural material uses light steel, which has good elasticity	2
15	No Openings or Recesses in Plastic Zones (BP26)	There are no other components that damage the structure.	2
16	Structural Connection Detail Standard (BP27)	There are no connection details in the design drawing	0
17	Protect Foundation through Capacity Design (BP28)	There are no foundation details and soil structure calculations	0
18	Develop a site-specific response spectrum (BP29)	There are no Peak Ground Acceleration (PGA) calculations	0
19	Assess the potential for soil liquefaction (BP30)	There are no Soil Liquefaction calculations	0
20	Softening may be more beneficial than strengthening (BP31)	The design does not require additional earthquake-dampening materials	2
21	Anchor façade elements against horizontal force (BP32, BP33)	The design does not require additional facade elements	2
22	Fasten installations and equipment (BP34, BP35)	The temporary housing design is simple, with a simple MEP installation.	2
		Total point	29

Source: Research results; similarities between temporary housing design and Seismic Conceptual Design (SCD) theory

The total maximum value of the SCD parameters with this scheme is 44 points; if the minimum eligibility limit is 60%, then the minimum points must be achieved is 26.4 points. The table above shows that the number of temporary housing points is 29 points or 65.9%, according to the SCD principle. Therefore, the results of the seismic conceptual design theory analysis of the design of temporary housing buildings for the eruption of Mount Semeru in 2021 are based on the SCD principle which is able to reduce damage due to earthquakes that occur. The most likely parts that will be damaged are the wall and ceiling material. As for the structure, there is a possibility of deformation in the connection system.

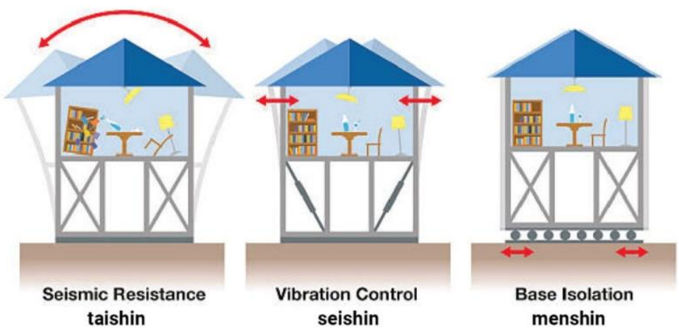

Figure 9. Example of an illustration of an earthquake-resistant house developed by Japan.[54]

As another comparative example, earthquake-resistant housing, especially those developed by the Japanese government (figure 9).[55] Japan, which is often hit by earthquakes because of its location in the Pacific Ring of Fire, is one of the pioneers in earthquake-resistant housing technology and design.[56] They use a flexible and strong structural system. Then it is also equipped with vibration dampers on the upper structure with the lower structure. Installation of seismic isolation bearings that respond to horizontal earthquake vibrations. The use of modern earthquake detection technology to activate automatic protection.[57] Housing is also built with a modular system that makes construction and repair processes easier and

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faster.[58] In addition, it also involves prefabricated buildings so that quality standards are maintained.[59] From that, it can be seen important factors that have been applied there to be adopted with earthquake-resistant housing in Indonesia, especially for the design of this temporary housing.

4. Conclusion

Handling and responding to eruption victims must be handled as quickly as possible to minimize greater losses. Relocation and making temporary housing designs after the 2021 Mount Semeru eruption prioritize efficiency, time effectiveness, cost, and safety, especially earthquake-resistant building design. From the theoretical analysis of temporary housing designs, 65.9% were found to have similarities with the Seismic Conceptual Design (SCD) theory by Prof. Hugo Bachmann. The dimensions of the building, the rigid galvalume structure, and the lightweight materials support the strength of the building against earthquake forces. However, the installation system, starting from the material cutting method, dimensions, connection systems, bolts, and other details, must be clearly described to facilitate construction and maintain the quality of the structural strength.

This Temporary Housing Design focuses too much on the speed of construction and low cost. Structural calculations and involvement of other multidisciplinary sciences are less considered. With this design, temporary housing buildings will be easy to realize, but are vulnerable to damage if an earthquake occurs, especially if the location is still around Mount Semeru. Designing earthquake-resistant housing must be planned by involving the government, academics, practitioners and trained communities who can together create and implement Earthquake Resistant Building Codes, Earthquake Simulation and Training, Post-Earthquake Housing Projects, Research and Development Innovation.

From this study, further research needs to be done to find out how strong the vibration resistance or force or Richter scale can be withstood by this temporary housing design, not only in terms of design, but also by testing on buildings that have been built. So that in the future, this temporary housing design can be more optimal, easy to build, safe, and has good seismic building performance standards.

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