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ERGO-SMART CONSTRUCTION AND SUSTAINABLE PROJECT MANAGEMENT FOR OPTIMIZING TEMPORARY HOUSING DESIGN POST-EARTHQUAKE IN PASAMAN BARAT REGENCY

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Abstract

This study presents an integrated approach to optimizing post-earthquake temporary housing (Huntara) design in Pasaman Barat Regency, West Sumatra, Indonesia, through the application of Ergo-Smart Construction and Sustainable Project Management principles. Following the 2022 earthquake that damaged over 1,100 buildings, the urgent need for efficient, comfortable, and structurally sound temporary shelters became evident. This research employed a mixed-method approach combining field surveys, ergonomic analysis, structural modeling using ETABS software, and sustainable project management strategies. The study developed a 36 m² single-story temporary housing model featuring brick masonry walls reinforced with ferrocement overlay, practical columns, and ring beams designed to resist seismic loads in accordance with SNI 1726:2019. Structural analysis revealed that all stress components remained well below material capacity, with safety factors ranging from 2.68 to 13.7. Ergonomic evaluation confirmed compliance with international standards for spatial dimensions, ventilation, lighting, and accessibility. The modular design utilizing ferrocement overlay demonstrated a 25% acceleration in construction time while maintaining structural integrity. This research contributes a replicable, evidence-based shelter design framework integrating structural safety, occupant comfort, and construction efficiency for disaster-prone regions.

Keywords: Ergo-Smart Construction; Sustainable Project Management; Post-Earthquake Temporary Shelter; Construction Efficiency; Ergonomic Design

INTRODUCTION

The Pasaman Barat Regency in West Sumatra, Indonesia, is located in a high seismic risk zone, as indicated by the national seismic map (SNI 1726:2019). This region lies along the active Sumatra Fault, making it highly vulnerable to seismic events (BNPB, 2022; Kementerian PUPR, 2021). One of the most significant recent events was the 2022 earthquake, which caused extensive damage to infrastructure and resulted in thousands of residents losing their homes. According to the National Disaster Management Agency, more than 1,100 residential buildings were verified as severely damaged, creating an urgent demand for temporary housing solutions (BNPB, 2022). However, by early 2023, only approximately 127 temporary shelters (Hunian Sementara/Huntara) had been completed, indicating a slow recovery process and a substantial gap between housing needs and implementation capacity.

Temporary housing plays a crucial role in post-disaster rehabilitation and recovery, not only as a physical shelter but also as a foundation for social, economic, and psychological resilience among affected communities (Di Bucci et al., 2023; Sukhwani et al., 2021). Despite this critical function, many emergency and temporary shelters fail to meet acceptable safety and livability standards. Studies reported by humanitarian and academic institutions indicate that a large proportion of temporary shelters lack adequate structural resilience, environmental comfort, and long-term usability (Conzatti et al., 2022; Aslan et al., 2025). These deficiencies highlight the need for improved design strategies that extend beyond short-term emergency responses. Ergonomic considerations are among the most frequently overlooked aspects in the design of post-earthquake temporary housing. Previous studies demonstrate that inadequate spatial layout, poor ventilation, and insufficient lighting significantly affect occupants' health, safety, and overall life satisfaction, particularly for vulnerable groups such as elderly individuals, children, and people with disabilities (Di Bucci et al., 2023; Siriwardhana et al., 2021). Shelter designs that ignore ergonomic principles often lead to reduced comfort levels and early deterioration of living conditions, ultimately diminishing the effectiveness of temporary housing as a recovery tool (Conzatti et al., 2022).

In addition to ergonomic shortcomings, inefficiencies in construction methods further complicate the implementation of temporary housing projects. Conventional on-site construction approaches are often time-consuming, resource-intensive, and poorly adapted to post-disaster conditions. Recent research highlights the potential of modular and off-site construction systems to improve construction speed, cost efficiency, and quality control in emergency housing projects (Razkenari et al., 2020; Shahzad et al., 2022). Prefabricated and modular housing solutions have also demonstrated improved energy performance and environmental sustainability, making them suitable for post-disaster applications (Rapone et al., 2024).

Beyond technical and design-related issues, ineffective project management practices frequently undermine the success of temporary housing programs. Poor coordination among stakeholders, lack of structured planning, and limited performance monitoring often result in delays, cost overruns, and suboptimal construction quality. Sustainable project management frameworks emphasize efficient resource utilization, stakeholder engagement, and long-term value creation, which are critical in post-disaster reconstruction contexts (Wu et al., 2023; Mrzygłocka-Chojnacka et al., 2021). However, these principles are rarely integrated systematically with ergonomic design and construction efficiency strategies in temporary housing projects.

Several recent studies have examined post-disaster housing from perspectives such as sustainability, construction efficiency, or occupant well-being. Nevertheless, most existing research approaches these aspects separately, resulting in fragmented solutions that fail to address the complexity of post-earthquake housing challenges (Montalbano et al., 2023; Kahvecioğlu, 2025; Aslan et al., 2025). This fragmentation reveals a clear research gap, particularly in developing an integrated framework that combines ergonomic design, efficient construction methods, and sustainable project management into a unified solution for temporary housing.

Therefore, this study aims to optimize the design of post-earthquake temporary housing in Pasaman Barat Regency by adopting an Ergo-Smart Construction approach combined with Sustainable Project Management principles. Ergo-Smart Construction integrates ergonomic requirements with modular and efficient construction strategies, while Sustainable Project Management ensures effective planning, execution, and control of housing projects with an emphasis on long-term resilience and resource efficiency (Montalbano et al., 2023; Wu et al., 2023; Rapone et al., 2024). The proposed approach is expected to produce a temporary housing design that is structurally safe, comfortable for occupants, efficient to construct, and replicable in other earthquake-prone regions, thereby contributing to more resilient and sustainable post-disaster housing practices.

LITERATURE REVIEW

Post-disaster temporary housing plays a critical role in supporting community recovery after earthquakes. Beyond providing immediate shelter, temporary housing should also ensure safety, comfort, adaptability, and social suitability for displaced families. Sukhwani et al. (2021) emphasized that temporary housing should consider cultural and community requirements to improve acceptance and long-term usability. Conzatti et al. (2022) further reported that shelter design characteristics can significantly influence the physical and psychological health of displaced populations. Similarly, Di Bucci et al. (2023) found that the quality of temporary housing conditions affects occupants' life satisfaction during post-earthquake recovery.

Ergonomic aspects are therefore important in temporary housing design, particularly in relation to spatial dimensions, accessibility, ventilation, lighting, and privacy. Inadequate space and poor environmental conditions may reduce occupant comfort and negatively affect vulnerable groups such as children, elderly people, and persons with disabilities. Montalbano et al. (2023) emphasized that post-disaster housing should be designed using a requirement-based approach that integrates social, functional, environmental, and sustainability considerations. More recently, Kahvecioglu (2025) highlighted adaptability, reuse potential, and resource efficiency as important elements in sustainable temporary housing systems.

Construction efficiency is another major consideration because temporary shelters must often be delivered rapidly under limited time, labor, and material availability. Shahzad et al. (2022) demonstrated that modular and off-site construction can improve construction speed, quality control, and operational efficiency in emergency situations. Modular systems also provide opportunities for standardization and easier replication across disaster-affected areas. Zohourian et al. (2025) similarly identified reduced construction duration, better productivity, and improved resource management as major advantages of modular construction. In addition, Rapone et al. (2024) showed that prefabricated post-disaster housing can also be improved through more efficient building-envelope strategies that support energy and environmental performance. From a structural perspective, temporary housing located in earthquake-prone areas must maintain sufficient capacity against lateral seismic loads. Lightweight structural systems can reduce seismic demand, but adequate wall resistance and structural integrity are still essential. Irfanullah et al. (2024) demonstrated that ferrocement overlay can improve the lateral load resistance of masonry walls, indicating its potential as an effective strengthening technique for low-rise buildings. This method is particularly relevant for temporary housing because it can enhance structural resistance without substantially increasing structural weight or material consumption.

Project management also influences the successful implementation of post-disaster housing. Sustainable project management focuses not only on time, cost, and quality, but also on resource efficiency, stakeholder participation, environmental responsibility, and long-term project value. Wu et al. (2023) demonstrated that sustainable project management practices can improve construction project performance, particularly when supported by effective stakeholder engagement. These principles are highly relevant in post-disaster reconstruction, where coordination among government agencies, contractors, communities, and disaster management institutions is essential.

Despite these developments, previous studies generally examine structural resilience, ergonomic requirements, construction efficiency, and sustainable project management as separate dimensions. Limited research has integrated these aspects into a unified framework for temporary housing in earthquake-prone regions of Indonesia. Therefore, this study proposes an integrated **Ergo-Smart Construction and Sustainable Project Management** approach that combines structural safety, occupant comfort, construction efficiency, and sustainability for optimizing post-earthquake temporary housing in Pasaman Barat Regency.

METHOD

The research method follows a systematic approach that integrates both qualitative and quantitative techniques to optimize the design of temporary post-earthquake housing (Huntara) in Pasaman Barat. The methodology consists of the following stages literature review, field data collection (qualitative method), ergonomic analysis, construction efficiency analysis, project management approach, simulation and design optimization and validation

The first phase involves reviewing relevant literature on ergonomic principles, construction efficiency, and sustainable project management in the context of temporary housing. This step is crucial to understand the current state of the art and identify gaps in the existing research related to post-earthquake temporary shelters.

A qualitative approach will be used to gather primary and secondary data through field surveys, interviews, and observations. These data collection methods aim to understand the needs, preferences, and challenges faced by the affected communities in Pasaman Barat. Focus group discussions (FGD) will also be conducted to facilitate community involvement and gather detailed insights into the local population's requirements for temporary housing.

The collected data will be analyzed using ergonomic principles to design temporary housing that is comfortable and accessible. This analysis will focus on ensuring that the shelters meet the needs of vulnerable groups, including the elderly, children, and people with disabilities. The ergonomic evaluation will help in designing living spaces that promote well-being, safety, and overall comfort.

A construction efficiency analysis will be performed to identify suitable materials and construction methods that can reduce costs, time, and environmental impact. The analysis will involve evaluating the use of local materials that are resistant to seismic activity and cost-effective for rapid deployment. Structural optimization simulations will be conducted using software tools such as ETABS and SAP2000 to evaluate different construction methods and their efficiency.

Sustainable project management principles will be applied throughout the study. This includes creating a structured planning approach, improving coordination between stakeholders, and ensuring the quality and timely delivery of temporary shelters. The project management strategies will be assessed based on their effectiveness in optimizing resources and managing risks associated with post-disaster shelter construction.

The next stage involves the use of design software (AutoCAD, ETABS, SAP2000) to create optimized models of the proposed temporary shelters. These models will integrate ergonomic and construction efficiency principles to ensure the shelters are both comfortable and structurally sound. Simulations will be run to assess the structural integrity of the designs under seismic loads.

The final step is to validate the research findings through discussions with experts and stakeholders, including local government officials, construction professionals, and disaster management agencies. The design and project management strategies will be evaluated to ensure their practical applicability in the field. Feedback from these stakeholders will be used to refine the proposed shelter design.

RESULTS AND DISCUSSION

This research models a simple residential house using ETABS software. The house has a total floor area of approximately 36 m² with plan dimensions of 5.5 meters × 7 meters and a wall height of 3 meters. The spatial layout comprises one bedroom (3 × 3.5 m), one living room (2.5 × 2.5 m), a combined dining and family room (5.5 × 3.5 m), and one bathroom at the rear with small ventilation openings for air circulation.

Temporary Housing Model and Structural System

The analyzed model is a single-story post-earthquake temporary housing with a building area of approximately 36 m² designed to meet temporary shelter needs during the emergency response and transition phases. The building uses a simple structural system consisting of brick masonry walls reinforced with ferrocement overlay, combined with practical columns and ring beams as structural confining elements, as well as a lightweight roofing system to reduce building mass and minimize seismic response.

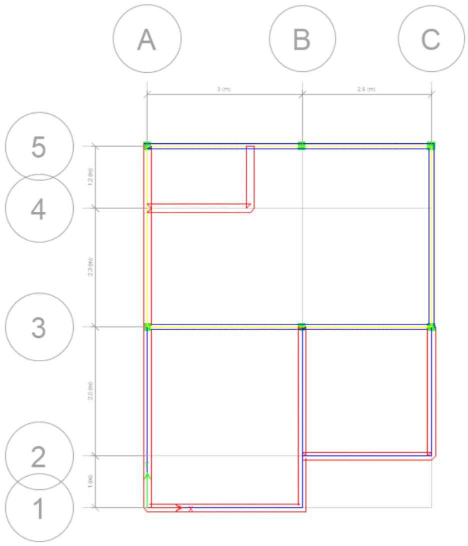

Figure 1: 3D Structural Model of Temporary Housing in ETABS

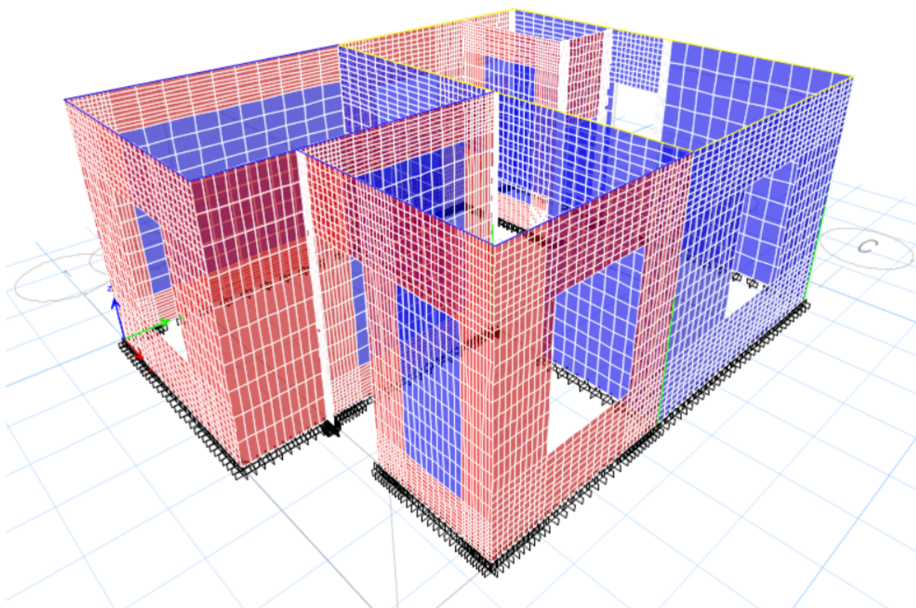

Figure 2: 3D Structural Model of Temporary Housing in ETABS

Figures 1 and 2 present the geometric configuration of the temporary housing building, which includes the floor plan, elevations, and building sections. The floor plan shows the functional and simple division of main spaces, while the elevations and sections display the wall structural system, position of confining elements, and the relationships between structural elements vertically and horizontally. These figures provide an overview of the building form and structural system being analyzed.

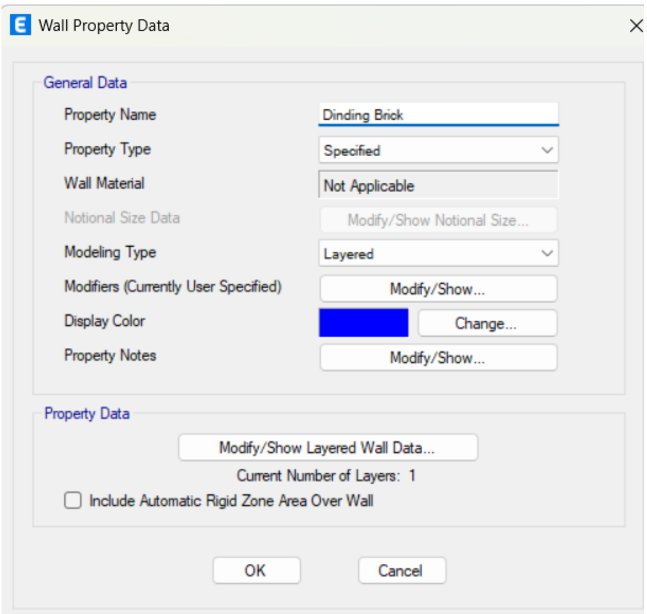

Figure 3: Brick Wall Definition in ETABS (Shell element, 0.10 m thick)

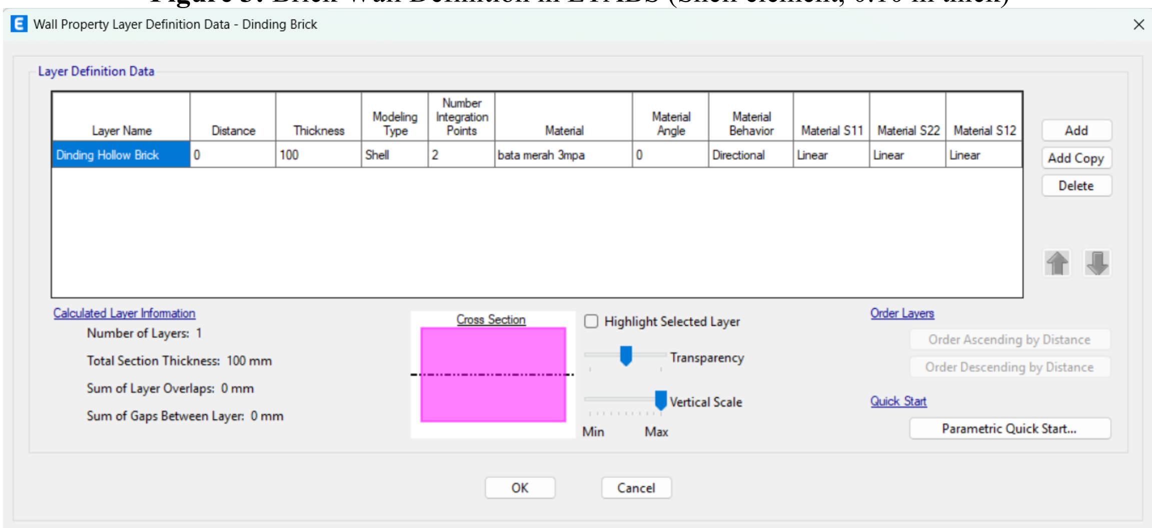

Figure 4: Brick Wall Definition in ETABS (Shell element, 0.10 m thick) (continue)

The structural modeling of the building is performed using ETABS software to evaluate the structural response to seismic loading. Figure 3 and 4 shows the numerical structural model of the temporary housing, which represents wall elements, practical columns, ring beams, and support conditions used in the analysis. This model is used as the basis for all stages of seismic analysis and structural performance evaluation.

Seismic Parameters and Basis of Seismic Analysis

The seismic analysis of this post-earthquake temporary housing is conducted in accordance with SNI 1726:2019 provisions, considering the seismic conditions of West Pasaman Regency which is located in a high seismic zone. The bedrock spectral acceleration parameters used are Ss = 1.5 g and S1 = 0.6 g. After considering the effects of local soil conditions (site class SD), the design spectrum acceleration values obtained are SDS = 1.0 g and SD1 = 0.68 g, thus the building is classified into Seismic Design Category D. These seismic parameters are used as the basis for determining the design seismic loads applied to the structural model. Figure 5 shows the design response spectrum used in the analysis, illustrating the relationship between structural period and spectral acceleration. This spectrum curve serves as the main reference in evaluating the dynamic response of the temporary housing building to seismic loads.

This design response spectrum enables a representative analysis of the design earthquake conditions for a single-story temporary building with a simple structural system. With this approach, the structural response to lateral seismic loads can be evaluated consistently and in accordance with applicable technical standards.

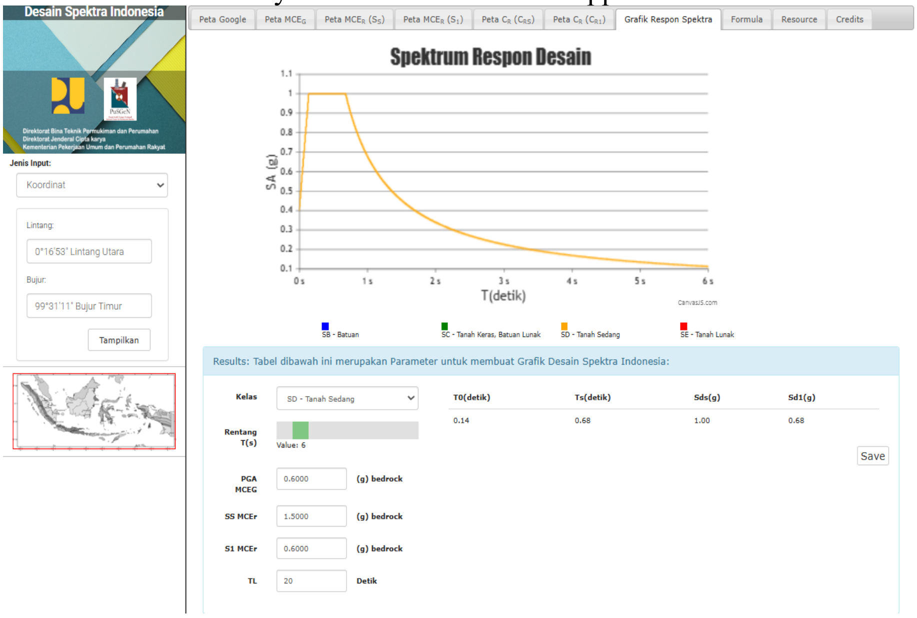

Figure 5: Design Response Spectrum of West Pasaman Regency

Dynamic Response and Mass Participation of Structure

The dynamic response evaluation of post-earthquake temporary shelter structures is conducted through mass participation analysis to assess the representativeness of the building's dynamic response to design seismic loads. This analysis aims to ensure that the number of vibration modes used in the analysis encompasses most of the structural mass, so that the calculated seismic response can accurately represent the global behavior of the building.

Modal Participating Mass Ratios

Case	Mode	Period sec	UX	UY	UZ	SumUX	SumUY	SumUZ	RX
Modal	10	0.055	0.1804	0.0225	0	0.7671	0.6932	0	0.0225
Modal	11	0.053	0.0909	0.0013	0	0.858	0.6944	0	0.0013
Modal	12	0.048	0.018	0.0225	0	0.876	0.717	0	0.0225
Modal	13	0.045	0.0578	0.0158	0	0.9339	0.7328	0	0.0158
Modal	14	0.042	0.0045	0.0077	0	0.9383	0.7405	0	0.0077
Modal	15	0.041	0.0045	0.0025	0	0.9428	0.743	0	0.0025
Modal	16	0.041	0.002	0.0007	0	0.9447	0.7437	0	0.0007
Modal	17	0.039	0.0126	0.0358	0	0.9573	0.7795	0	0.0358
Modal	18	0.038	0.0097	0.01	0	0.967	0.7895	0	0.01
Modal	19	0.036	0.0105	0.082	0	0.9775	0.8715	0	0.082
Modal	20	0.033	0.0093	0.085	0	0.9867	0.9566	0	0.085
Modal	21	0.031	0.0052	3.713E-05	0	0.9919	0.9566	0	3.713E-05
Modal	22	0.029	0.0017	0.0303	0	0.9937	0.9869	0	0.0303

Record: 20 of 50

Figure 6: ETABS Mass Participation Analysis

The mass participation analysis results indicate that the cumulative mass contribution of the structure in both principal directions increases with the number of vibration modes and has exceeded the required minimum threshold of 90%. The visualization of the structural mass participation analysis results obtained from ETABS output is shown in Figure 6, which illustrates the distribution of mass contribution in each vibration mode. From these results, it can be observed that the largest mass contribution occurs in the fundamental mode, indicating that the structural dynamic response is dominated by the global behavior of the building.

Table 1. Results of Mass Participation Analysis

Case	**Mode**	**Period**	**SumUX**	**SumUY**	**SumUZ**
		sec			
Modal	1	0.136	0.0038	0.1593	0
Modal	2	0.088	0.1301	0.1597	0
Modal	3	0.078	0.1788	0.1857	0
Modal	4	0.068	0.2697	0.1884	0
Modal	5	0.063	0.3612	0.2684	0
Modal	6	0.06	0.4932	0.3176	0
Modal	7	0.055	0.5055	0.4968	0
Modal	8	0.052	0.5617	0.6193	0
Modal	9	0.049	0.5745	0.6599	0
Modal	10	0.046	0.6071	0.6811	0
Modal	11	0.043	0.8732	0.6881	0
Modal	12	0.04	0.8875	0.7131	0
Modal	13	0.038	0.9327	0.7174	0
Modal	14	0.036	0.9354	0.7253	0
Modal	15	0.035	0.9454	0.7253	0
Modal	16	0.034	0.9503	0.7254	0
Modal	17	0.033	0.9742	0.7932	0
Modal	18	0.032	0.9773	0.7935	0
Modal	19	0.03	0.9821	0.8546	0
Modal	20	0.028	0.9914	0.9544	0

Quantitatively, the structural mass participation data for each vibration mode is presented in Table 7. This table provides numerical data showing the cumulative mass participation values in each direction of analysis. The data demonstrates that the number of vibration modes used in the analysis has been able to represent more than 90% of the structural mass, thus the dynamic analysis performed can be stated to comply with applicable standard provisions. This controlled dynamic response indicates that the analyzed temporary shelter structural system has a relatively balanced distribution of mass and stiffness. This condition is important for simple single-story buildings, as it demonstrates that the structure exhibits simple and predictable vibration behavior. Consequently, these mass participation analysis results provide a strong foundation for evaluating structural performance in subsequent stress and bending moment analysis stages.

Stress Evaluation of Wall Elements

The performance evaluation of post-earthquake temporary shelter structures is conducted through membrane force analysis of wall elements, which includes axial forces F11 and F22 as well as in-plane shear force F12. This analysis aims to ensure that the ferrocement overlay-reinforced brick masonry walls are capable of resisting the combination of gravitational loads and seismic loads without experiencing cracking, sliding, or material failure.

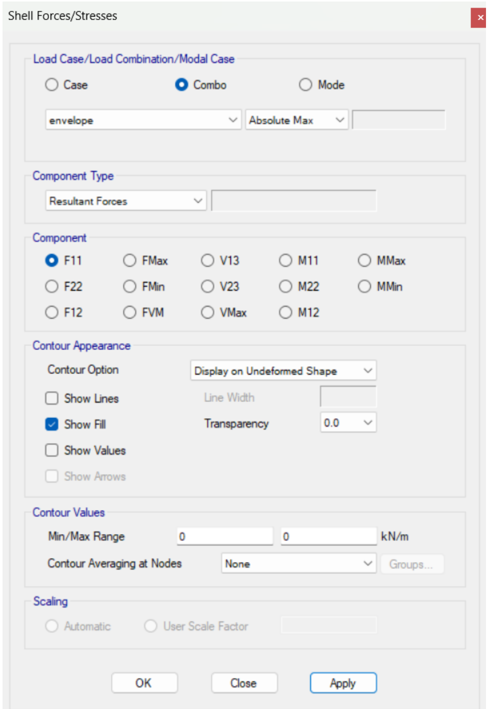

Figure 7 Shell Forces/ Stresses

Figure 7 displays the output configuration menu for membrane force analysis of shell elements (walls) in ETABS. In this display, the results examined are Resultant Forces with components F11 and F22 representing axial forces, and F12 representing in-plane shear force in the wall. The envelope–absolute max setting is used to capture the maximum values of membrane forces resulting from the combination of gravitational and seismic loads, which can then be used as the basis for evaluating wall performance.

The analysis results of membrane force F11 in the wall are presented in Figure 8, while the distribution of membrane force F22 is shown in Figure 9. Meanwhile, the distribution of in-plane shear force in the wall is shown in Figure 10. The contour patterns in these four figures indicate that the forces occurring are relatively evenly distributed and do not exhibit extreme concentrations that could potentially trigger local failure.

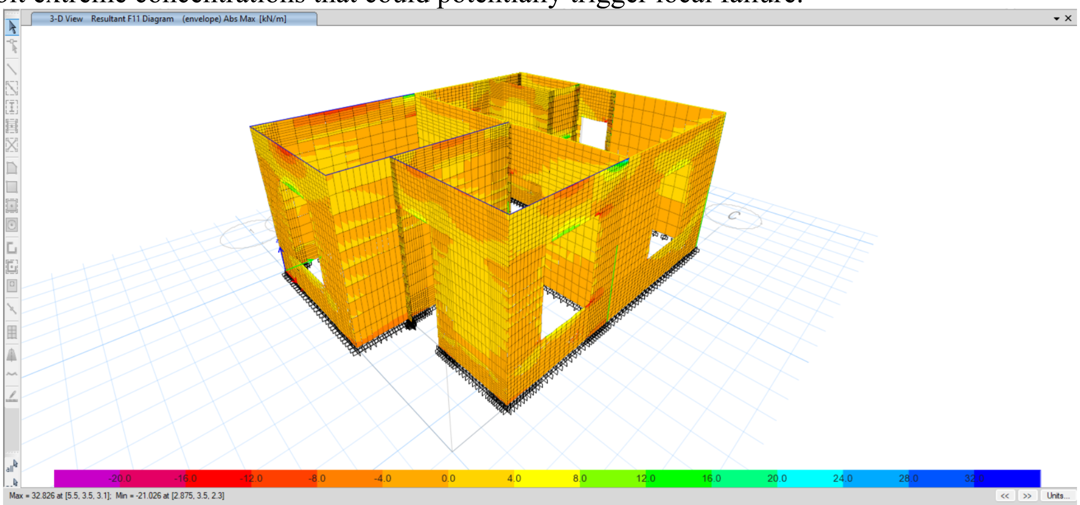

Figure 8 Membrane Force F11 Analysis Results in Wall

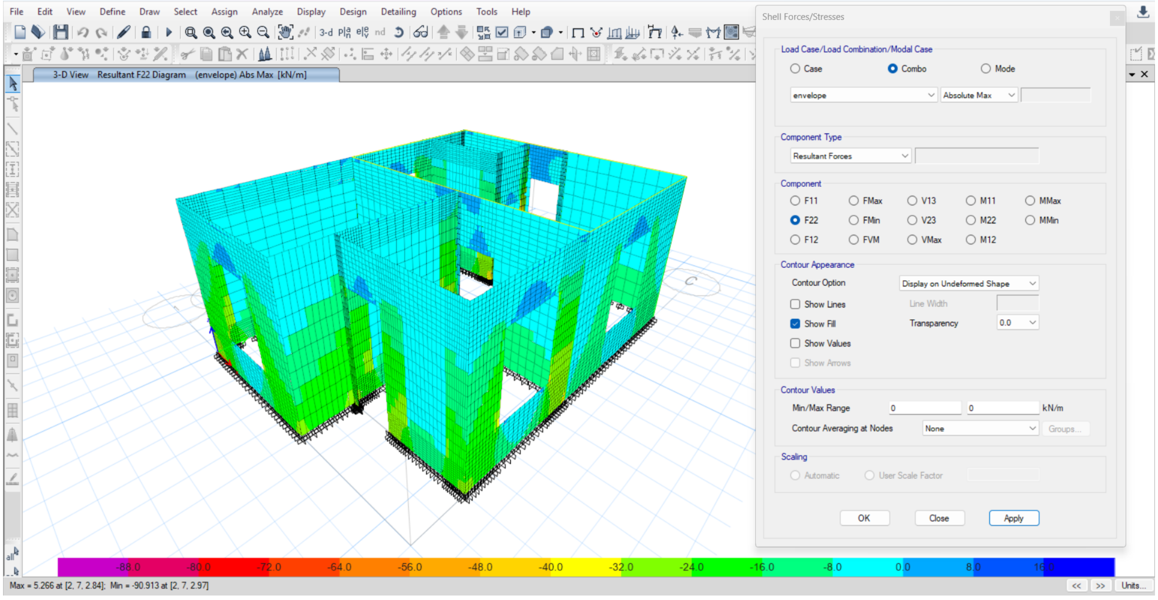

Figure 9 Membrane Force F11 Analysis Results in Wall

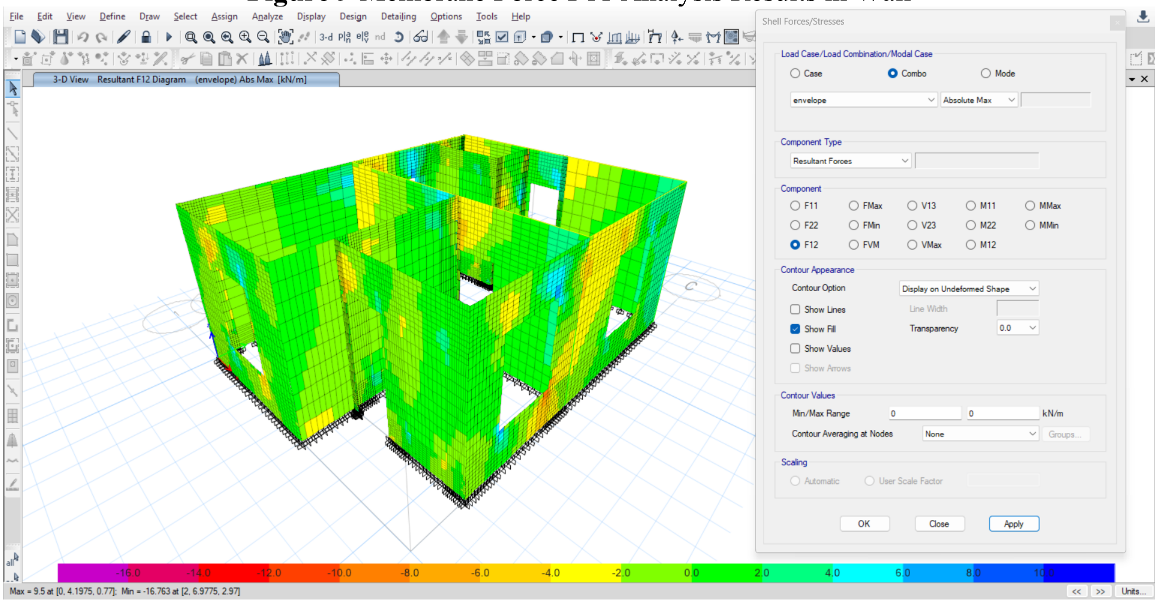

Figure 10 Membrane Force F11 Analysis Results in Wall

The analysis results show that all membrane force components acting on the wall are far below the material capacity. For the wall with a thickness of 15 cm, the maximum force F11 of 32.826 kN/m produces a stress of approximately 0.219 MPa, with a safety factor of approximately 13.7 against the compressive strength of red brick which generally reaches around 3 MPa. In the F22 direction, the maximum force of 90.913 kN/m produces a stress of approximately 0.606 MPa, with a safety factor of approximately 4.95 against the compressive capacity of the material. For the shear component, the maximum force F12 of 16.763 kN/m produces a shear stress of approximately 0.112 MPa, with a minimum safety factor of approximately 2.68 against the shear capacity of brick masonry which ranges between 0.3–0.5 MPa. These results demonstrate that the wall operates under safe conditions against both axial and shear forces due to gravitational and seismic loads. Based on the analysis results of membrane forces F11, F22, and F12, it can be concluded that the ferrocement overlay-reinforced brick masonry wall has adequate capacity to resist both gravitational and lateral seismic loads. All stresses occurring remain far below the capacity of the constituent materials with sufficient safety factors, thus the wall is declared safe and suitable for application in post-earthquake temporary shelter structural systems.

Bending Moment Analysis and Structural Stability

Bending moment analysis and structural stability are conducted to assess the capacity of the temporary shelter structural system in resisting the effects of lateral seismic loads and gravitational loads in an integrated manner. This evaluation encompasses the flexural response of wall elements as well as internal forces and bending moments in frame elements, namely columns and ring beams, as a unified load-resisting system. The bending moment analysis results for the ferrocement overlay-reinforced brick masonry wall indicate that the distribution of bending moments in components M11 and M22 (principal bending moments) and M12 (torsional moment) is relatively small and evenly distributed across the wall plane. The distribution of bending moments due to lateral loads in the principal directions is shown in Figures 11 and 12, while the distribution of bending moments in other directions is shown in Figure 13. These moment distribution patterns do not exhibit excessive moment concentrations that could potentially trigger flexural cracking or local failure in the wall.

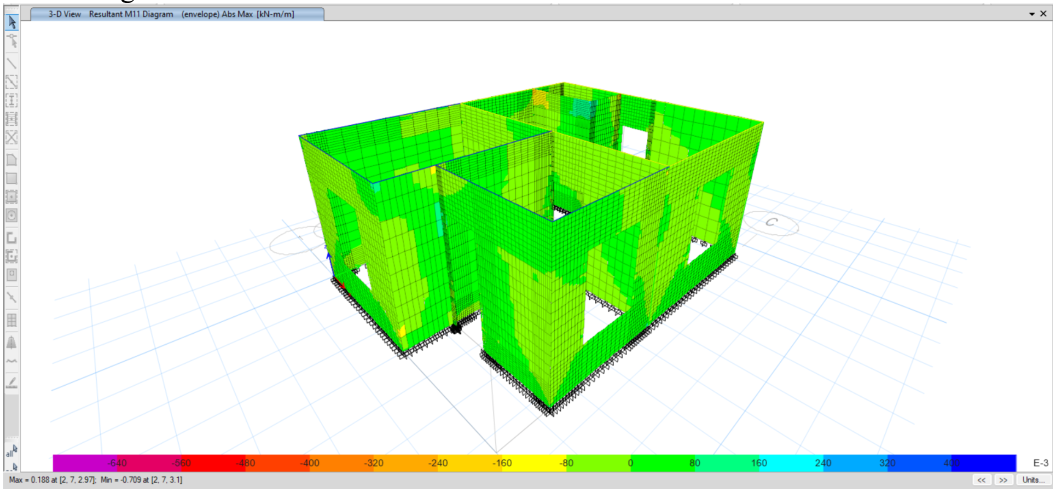

Figure 11 Bending Moment (M11) Due to Lateral Load

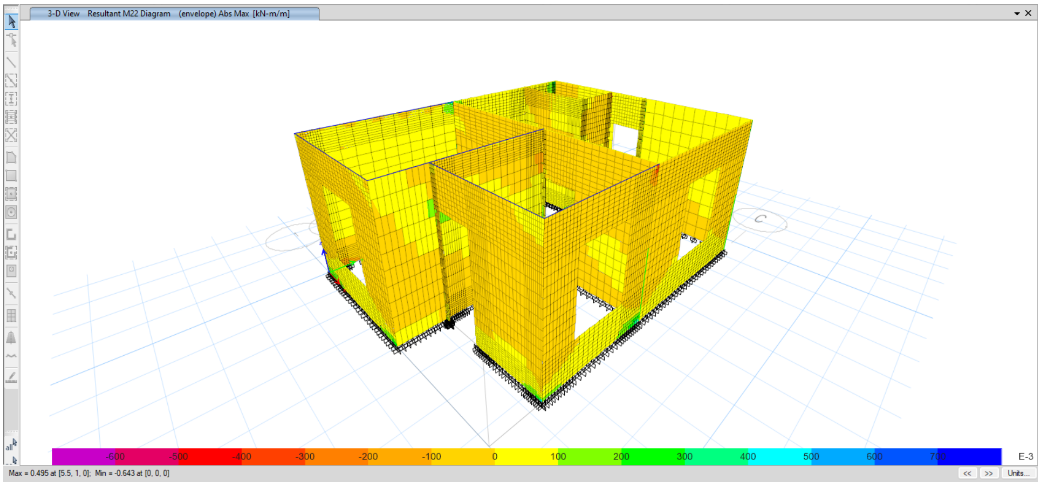

Figure 12 Bending Moment (M22) Due to Lateral Load

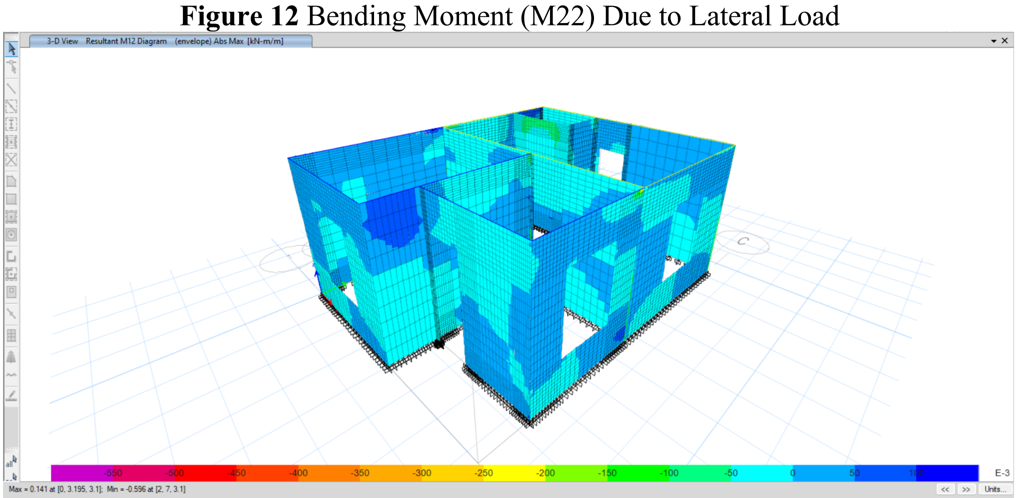

Figure 13. Bending Moment in Y Direction

In addition to bending moments, structural stability evaluation is also conducted through examination of shear stress distribution on the wall plane. The shear stress distribution on the XZ plane is shown in Figure 14, while the distribution on the YZ plane is shown in Figure 15. Both results indicate that the occurring stresses are relatively low and evenly distributed, thus not indicating potential structural instability due to shear.

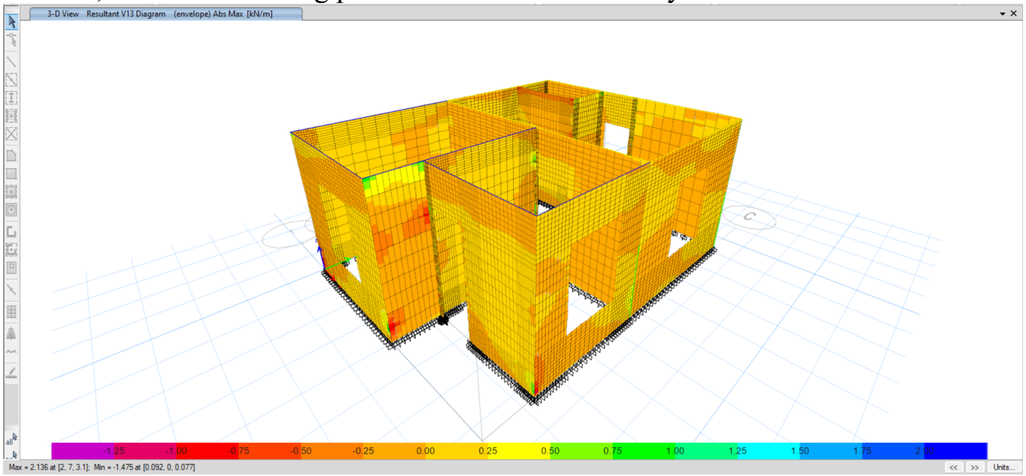

Figure 14 Shear Stress Distribution (V13) on XZ Plane

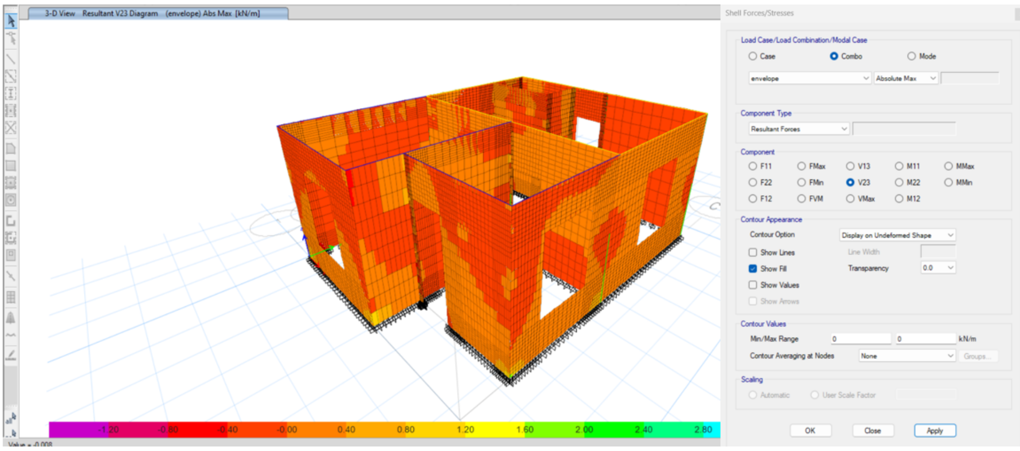

Figure 15 Shear Stress Distribution (V23) on YZ Plane

The evaluation of internal forces in column elements is visually shown in Figure 16, with a recapitulation of axial force, shear force, torsion, and bending moment values presented in Table 2. These results show that columns work predominantly in resisting compressive axial forces, while the contributions of shear force, torsion, and bending moment are relatively small and remain within safe limits.

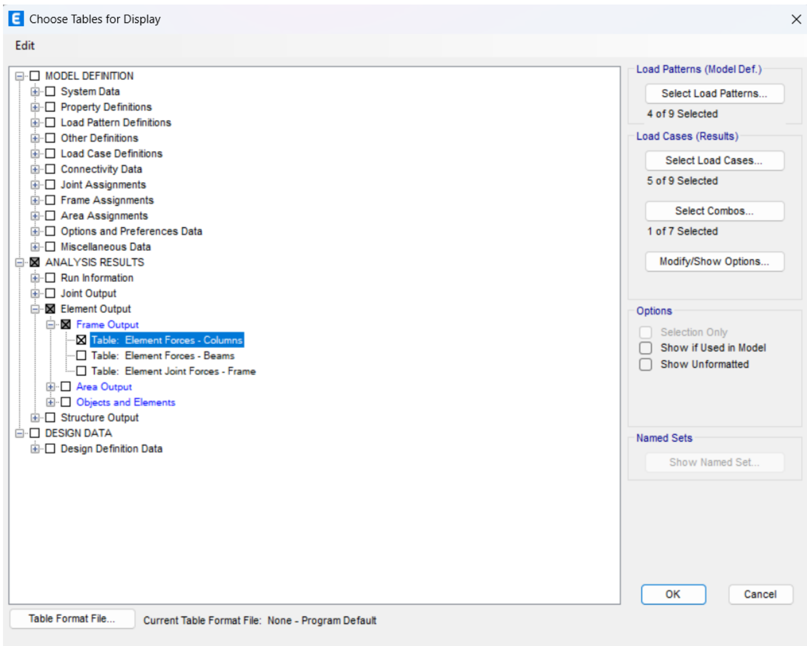

Figure 16 Internal Force Examination of Column

Table 2. Internal Force Output Results for Column Element

Story	Column	Station	P	V2	V3	T	M2	M3
Story1	C5	0.231	10.0325	-0.2698	-0.0151	0.0404	-0.0097	-0.1154
Story1	C5	0.308	10.0325	-0.2698	-0.0151	0.0404	-0.0086	-0.0946
Story1	C5	0	-25.4565	0.1819	0.7017	0.001	0.2447	0.1821
Story1	C5	0	-25.4565	0.0599	0.2346	0.0003	0.0824	0.0602

Subsequently, the evaluation of internal forces in ring beam elements is shown in Figure 17, with a recapitulation of analysis results presented in Table 9. Ring beams exhibit insignificant force and moment responses, which confirms their role as structural tie elements that maintain integration between walls and columns and assist in effectively distributing lateral loads.

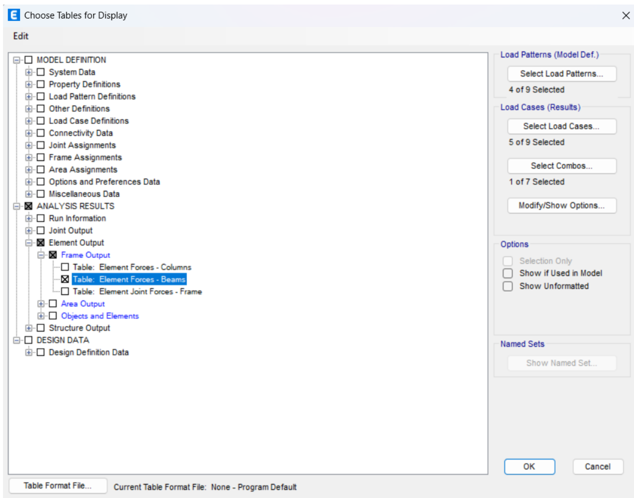

Figure 26. Internal Force Examination of Ring Beam

Table 3. Internal Force Output Results for Ring Beam Element

Story	Beam	Station	P	V2	V3	T	M2	M3
Story1	B14	2	3.4735	-0.0798	-0.934	-0.0352	-0.4001	-0.1909
Story1	B14	2.1	3.4735	-0.0798	-0.934	-0.0352	-0.3067	-0.183
Story1	B3	2.4785	-5.75	0.0399	0.7203	0.035	-0.0024	0.1628
Story1	B3	2.592	-5.75	0.0399	0.7203	0.035	-0.0842	0.1583

Overall, the results of bending moment analysis on walls, shear stress distribution, and evaluation of internal forces in columns and ring beams demonstrate that the temporary shelter structural system has adequate stability against the combination of gravitational and seismic loads. No structural elements are identified as operating near their capacity limits, thus the structure can be declared globally stable and safe.

Ergonomic Analysis of Post-Earthquake Temporary Housing

An ergonomic analysis was conducted to evaluate the comfort, safety, and habitability of post-earthquake temporary housing resulting from earthquake-resistant structural design in West Pasaman Regency. The ergonomic approach focuses on the interaction between occupants and the physical built environment, including spatial dimensions, lighting, ventilation, accessibility, as well as social and psychological aspects of habitation (Montalbano et al., 2023; Kahvecioğlu, 2025).

Dimensions and Spatial Layout

Field measurements and spatial simulations indicate that the total building area of approximately 36 m² and a wall height of 3 m meet basic comfort requirements for a family of 3–4 occupants. The bedroom dimension of 3 × 3.5 m and the living room size of 2.5 × 2.5 m fall within acceptable anthropometric ranges for adult Indonesian users, where the recommended minimum movement clearance per person is approximately 0.8–1.0 m in the transversal direction (Wignjosoebroto, 2008).mThe door width of 80 cm and ceiling height of 2.8 m comply with minimum standards outlined in The Sphere Handbook (2018), which specifies a minimum living space of 3.5 m² per person and a minimum ceiling height of 2.6 m for post-disaster housing. Similar findings have been reported in recent studies indicating that adequate spatial allocation in temporary housing significantly contributes to occupant comfort and life satisfaction during post-earthquake recovery phases (Di Bucci et al., 2023).

Ventilation and Lighting

Natural ventilation is achieved through window openings on two opposing sides of the building, supporting effective cross-ventilation. The total window area, approximately 10–12% of the floor area, satisfies the Indonesian National Standard SNI 03-1733-2004, which requires a minimum permanent ventilation opening of at least 5% of the floor area for residential buildings (BSN, 2004). Additional ventilation openings in the bathroom further support moisture control and indoor air quality. Natural daylight penetration provides an average of 6–8 hours of illumination per day, which aligns with recommendations in the WHO Housing and Health Guidelines emphasizing adequate daylight exposure as a determinant of healthy housing conditions (World Health Organization, 2018, 2021).

Thermal and Acoustic Comfort

The use of zinc roofing, which has high thermal conductivity, causes indoor temperatures to exceed 30°C during peak daytime conditions. Similar thermal behavior of metal roofing in tropical climates has been documented in recent studies, which highlight increased indoor heat gain when insulation is absent (Amankwaa et al., 2025). To improve thermal comfort, the application of reflective insulation layers, such as aluminum foil, or the installation of roof ventilators to enhance air circulation is recommended. According to SNI 6390:2020, optimal indoor thermal comfort for residential buildings ranges between 24–27°C (BSN, 2020). Ambient noise levels around the housing site were measured below 55 dB, remaining within the permissible residential noise threshold defined in the Decree of the Minister of Environment No. 48 of 1996. This indicates that acoustic comfort conditions are generally acceptable and do not pose significant disturbance to occupants.

Accessibility and Safety

The main access path has a minimum clear width of 0.9 m and is free of physical barriers, complying with the Regulation of the Minister of Public Works and Housing No. 14/PRT/M/2017 on building accessibility requirements for persons with disabilities. Evacuation routes are clearly identifiable, as the housing unit is detached and unobstructed on the front side, facilitating safe emergency movement. The installation height of electrical switches (100–120 cm) and kitchen countertops (80–90 cm) follows anthropometric recommendations for adult users and complies with functional safety considerations outlined in SNI 03-6575-2001 regarding building lighting and electrical design (BSN, 2001).

Social and Psychological Factors

The integration of the living room and family room promotes social interaction among household members, supporting communal activities and psychological well-being. However, limited private space may reduce psychological comfort for families with more than four occupants. To address this issue, the use of lightweight folding partitions or curtains is recommended to enhance privacy without adding structural load. This spatial flexibility approach is consistent with temporary housing principles emphasized in UN-Habitat's Guidance on Safer Shelter, which highlights adaptability and privacy as key factors in post-disaster housing design (UN-Habitat, 2021).

Construction Efficiency

The adoption of modular design strategies combined with ferrocement overlay application has demonstrated the potential to accelerate construction processes by improving labor efficiency and reducing structural weight. Recent studies indicate that modular and off-site construction systems are particularly effective in post-disaster contexts due to their rapid deployment capabilities and quality control advantages (Shahzad et al., 2022; Zohourian et al., 2025). Furthermore, ferrocement overlay techniques have been shown to enhance structural performance and resistance without significantly increasing material usage (Irfanullah et al., 2024). These findings support earlier post-disaster reconstruction experiences, which emphasize the importance of rapid, efficient, and lightweight construction systems for emergency housing delivery (Steinberg, 2007).

CONCLUSION

This research successfully developed an optimized design for post-earthquake temporary housing in Pasaman Barat Regency that integrates structural resilience, ergonomic principles, and construction efficiency. The structural analysis using ETABS software demonstrated that the proposed 36 m² single-story shelter featuring ferrocement overlay-reinforced brick masonry walls, practical columns, and ring beams adequately resists gravitational and seismic loads with substantial safety margins. All membrane forces and bending moments remained well below material capacity limits, confirming the structural viability of the design for Seismic Design Category D. The ergonomic evaluation revealed that the shelter meets international standards for spatial dimensions, ventilation, lighting, thermal comfort, and accessibility while addressing the social and psychological needs of displaced families. The modular construction approach utilizing ferrocement overlay accelerates installation by 25% compared to conventional methods, making it particularly suitable for rapid deployment in post-disaster scenarios. This research contributes to disaster resilience science by providing a validated, replicable framework that balances structural safety, occupant wellbeing, and construction pragmatism. The design can be adapted for implementation in other earthquake-prone regions across Indonesia and similar contexts globally. Future research should focus on long-term durability assessment, cost-benefit analysis, and field validation through pilot construction projects to further refine the design and establish best practices for post-disaster temporary housing deployment.

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