Rapid Deployment of Prefabricated Temporary Shelters for Earthquake-Prone Zones: Evaluating Design, Efficiency, and Resilience.

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***Abstract*—This study investigates how prefabricated temporary shelters can be effective in quickly providing housing in earthquake-prone regions, with a particular emphasis on lightweight, durable, and earthquake-resistant options. The research is centered on assessing materials that are resilient to seismic activity, enhancing the interior layout for both functionality and comfort, as well as investigating the construction techniques employed in creating the shelters. The process includes studying current prefabricated shelter designs by utilizing modeling, literature reviews, and case studies to pinpoint effective strategies and potential enhancements, specifically concentrating on shelters intended for prompt response following an earthquake, emphasizing quick assembly and safety as primary objectives. This study primarily delves into seismic performance, paying minimal attention to other natural hazards, and relies on accessible data and resources that could constrain the examination of specific materials and techniques. The outcomes are intended to enhance the planning and implementation of prefabricated shelters, offering useful insights to architects and stakeholders engaged in disaster relief efforts.**

***Index Terms*—Prefabricated shelter, swift earthquake response, quick deployment, temporary housing, earthquake-proof construction technique.**

I. INTRODUCTION

The temporary structure is that which is built only for a temporary objective, completely on the site, with the consent of the authority for a certain duration, and this should be deleted after the end of the project or the period for which it was authorized. A typical temporary design is created to protect people, objects, car pieces or something else from items. These structures are manufactured by several companies around the world and come in a variety of shapes and forms for different purposes. (Shweta Ghonge, 2022)

A. THE ROLE OF TEMPORARY SHELTER IN DISASTER

The term "temporary structures" refers to the supply of tents and makeshift buildings made from a variety of materials such as wood, plastic, and tin to meet the basic emergency needs of disaster victims. The purpose of this temporary construction is to provide families who have lost their homes in tragic disasters with the necessary shelter to protect their lives from exposure and further suffering. In a world where natural disasters and man-made crises occur on a large scale, the use and importance of temporary shelters is increasing. Temporary shelters play a vital role in these efforts, from providing safe workspace to providing temporary working space for emergency responders. These rapid responses not only provide temporary housing but also provide a safe space for the victims of such disasters. There's no denying that the effects of disasters take a mental and physical toll. In these situations, emergency reception centers help victims recover from the negative effects of the disaster and also help patients get a better start in the recovery phase. The main physical characteristics of temporary shelters are that they can be quickly assembled, dismantled and stored for immediate reuse. They are flexible, easy to install and provide immediate solutions, which is why they are preferred by authorities, local communities and NGOs. (Shweta Ghonge, 2022)

II. DESIGN AND CONSTRUCTION OF PREFABRICATED SHELTERS

A. Materials: Lightweight, Durable, and Seismically Resilient Options

Using lightweight materials is crucial for building temporary shelters in combat support missions. Items like aluminum blends, fiberglass, and light polymers are advantageous for their ease of transportation to faraway places where quick assembly is important. Incorporating these materials enables construction teams to accelerate the construction timeline without sacrificing the structural integrity.

Using lightweight materials in construction helps save money by reducing the amount of labor needed for handling and installing. Moreover, these components have the capability to be pre-made away from the site, which helps decrease the time needed for on-site construction and lessen disturbances in demanding combat support settings. Temporary shelters can be quickly set up to address emergency operational needs, emphasizing efficiency and mobility. Furthermore, the durability of lightweight construction materials ensures that shelters can endure harsh environmental conditions commonly found in combat zones. These materials provide dependable housing for military personnel in challenging locations due to their enhanced durability and sustainability. Temporary shelters can efficiently address the temporary requirements of specific units during military missions by focusing on choosing lightweight options.

B. Construction Techniques: Prefabrication, Rapid Deployment, and Innovations.

In addition to material, construction techniques also have a major impact on safety, durability and cost. It is important to consider your own capabilities and the ease with which you can carry out construction and maintenance when selecting a particular technique or material. Temporary intermediate shelters are designed to last for 2-3 years and must be constructed to be safe against potential risks associated with hazards during this period. Providing a durable, safe and dignified shelter requires proper selection of design, materials and construction techniques. ABCD's basic principle for the danger of temporary shelter construction (National Disaster Management Authority, 2019)To ensure temporary shelters are hazard-resistant, the ABCD principle provides a reliable framework for construction:

- A for Anchorage - Proper anchoring is vital for securing the shelter to the ground. This involves using sturdy foundations or anchors to prevent the structure from being lifted, sliding, or overturning during disasters, ensuring stability and safety.
- B is for Bracing - Diagonal bracing strengthens walls and roofs to resist lateral forces caused by earthquakes and high winds. This triangular reinforcement reduces swaying and structural deformation while maintaining the rigidity and stability of the shelter.
- C is for compounds - The solid and secure connection between the various components of the building is important to maintain an intact structure. The washed capital guarantees that the details are divided or not under pressure by maintaining the overall stability of the shelter during a dangerous event.
- D is for diaphragm - Roof must function as a single plane, not an independent element. The opening of a single roof distributes the load in the structure evenly, increases the resistance, and minimizes the risk of collapse. By implementing the ABCD principle, temporary shelters become more durable, resilient and better equipped to protect occupants from natural disasters. (National Disaster Management Authority, National Guidelines on Temporary Shelters for Disaster - Affected Families, 2019)

C. Space Planning: Principles of Layout Optimization, Functionality, and Privacy

Effective space planning in prefabricated emergency shelters is crucial to ensure that the limited available area is utilized optimally while addressing the needs of occupants. This includes designing a layout that balances functionality, comfort and privacy within the constraints of temporary construction and rapid deployment. Emergency shelters are typically compact structures, so efficient use of space is the key. The layout should allow unimpeded circulation while prioritizing essential activities such as sleeping, eating and hygiene. Modular, multi-functional furniture helps save space, reduces clutter and improves usability by defining zones of activity. Flexible designs that can

adapt to different family sizes and cultural preferences further improve planning efficiency. The design must meet the immediate needs of the occupants and ensure that the shelter is habitable and allows for daily activities. Adequate ventilation, adequate lighting and accessible facilities such as toilets and storage areas are essential. Shelters should also be designed to withstand environmental influences, such as heat or cold, to provide protection and comfort. Even in temporary settings, maintaining privacy is important for the psychological well-being of individuals and families. Separating spaces within a shelter can make different families or different genders feel segregated. Soundproofing and visual barriers can further improve privacy while promoting a suitable living environment.

a. Residential Units in Temporary Shelters

The most important spatial unit of a settlement is the dwelling unit, which determines the location of the other units.

Various kinds of residential units can be considered based on the available space, as follow

- Limited space or Housing Model (H.M)
- Relational spaces, which include the Entrance (En), the External Area (E.A), Service Area (S.A), Storage Area (St. A)
- Complementary spaces, which include Neighborhood Units (N.U), Parking, Green Area (G.A), and Road Network (R.N). (Ali Javan Forouzandeh, 2008)

Three various settings can be considered for residential units:

1. Linear system

In this model, houses are arranged on two or more parallel lines, with green spaces filling the space between these lines. Complementary zones are located at one end, and the road network bypasses the housing units.

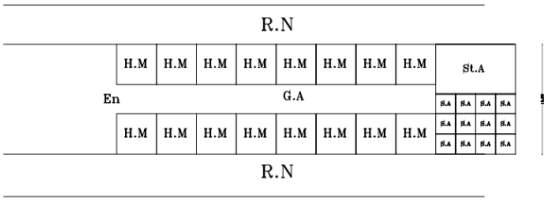

Figure 1. A sample linear settlement model (Ali Javan Forouzandeh, 2008)

2. Central Settlement Model

In this model, houses are arranged in a ring around a large green central space and houses can be expanded into centralized rings if necessary.

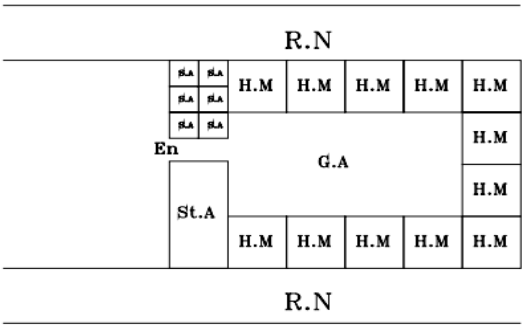

Figure 2. A sample of central settlement model (Ali Javan Forouzandeh, 2008)

3. Linear-Central Settlement Model

This model, as the name suggests, is a combination of two linear models and a central model. Usually, when space is limited, this model fits the available space better.

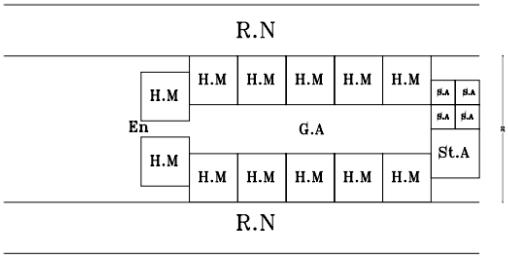

Figure 3. A sample of linear-central settlement model

III. CASE STUDIES (1999 DÜZCE EARTHQUAKE IN TURKEY)

The 7.2 magnitude Düzce earthquake in Turkey in 1999 caused widespread destruction, displacing thousands of people. The disaster highlighted the critical need for effective emergency shelters, as the affected population needed immediate solutions to provide shelter in harsh winter conditions. In the immediate aftermath of the earthquake in Türkiye, the government and NGOs faced the challenge of quickly providing shelter to large numbers of displaced people. Many people relied on emergency shelters such as tents, temporary structures, and makeshift camps near their destroyed homes. To address the

urgent need for shelter, the Turkish government implemented an emergency shelter strategy, prioritizing the distribution of tents to affected communities. Winter tents (Figure 4.) were widely provided due to the harsh winter conditions, and many families built makeshift shelters or set up informal camps near their damaged homes. These solutions emphasized the need for flexible and immediate evacuation options in recovery efforts after claiming. (Guha, 2018)

Figure 4. Winterized tents (Johnson, 2002)

Figure 5. Self-built shelters (Johnson, 2002)

Two months later, the Turkish Ministry of Housing provided prefabricated homes (Figure 6.) to house up to 151,000 people affected by the earthquake. Other governments also sent container units (Figure 7.) which were sent by Japan.

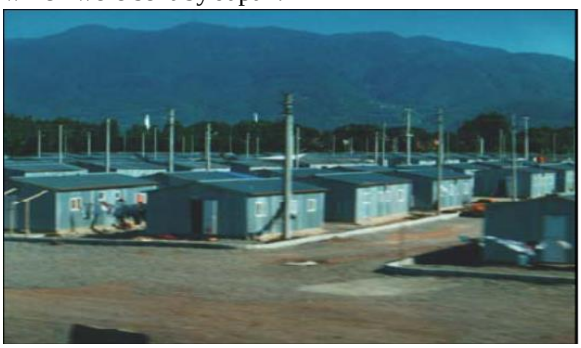

Figure 6: Prefabricated temporary houses (Johnson, 2002)

Figure 7: Paper temporary house (Johnson, 2002)

A. Issues in post disaster emergency housing

Relief programs are primarily designed to benefit the victims, but the challenge is to focus on their needs without letting other factors hinder the process. In this case, factors that can limit the effectiveness of the relief plan include inadequate planning, logistical problems, adverse weather conditions, and lack of coordination. (Guha, 2018)

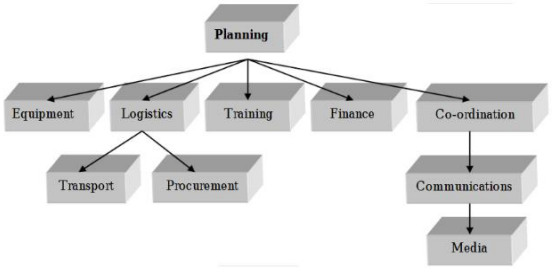

Figure 8: challenges in post disaster emergency houses

IV. CONCLUSION

This study highlights the importance of prefabricated temporary shelters in providing rapid and effective housing options in earthquake-prone areas. The paper examines the 1999 Düzce earthquake in Turkey to show how prefabricated solutions can meet urgent needs while ensuring safety, durability and adaptability in challenging environments.

Key findings highlight the importance of lightweight, seismically resistant materials, as well as new construction approaches such as modular prefabrication and rapid deployment. The ABCD concept ensures resilience to hazards, while space planning principles enhance functionality, privacy and comfort even in limited layouts. The use of prefabricated shelters after the Düzce earthquake

demonstrated that they could bridge the gap between rapid relief and long-term recovery, despite logistical delays and thermal inefficiencies.

To improve future applications, it is essential to integrate the input of the community into the design processes, adopt sustainable materials and develop efficient planning planning practices. Prefabricated emergency shelters offer a practical path to resilient management of catastrophes, acting as a milestone of the architectural responses to the crises. Architects, politicians and rescue organizations can draw on this study to perfect refuge projects and implementation strategies, ultimately contributing to more effective and human rescue efforts of catastrophe.

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