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Disaster Shelters: A Comparative Analysis of Tents, Containers, and Prefabricated Shelters

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Abstract – Disaster shelters are a critical component of emergency response and recovery efforts, providing temporary housing for displaced populations. This paper presents a comprehensive analysis of disaster shelters, comparing the advantages, disadvantages, and suitability of tents, containers, and prefabricated shelters for different disaster scenarios. The research finds that prefabricated shelters offer improved durability, safety, and adaptability compared to traditional tents, but their implementation is often hindered by logistical and financial challenges. The paper concludes that prefabricated shelters have the potential to significantly improve disaster response and recovery efforts, and recommends further research and innovation in shelter design and deployment strategies.

Keywords – Disaster shelters, Temporary housing,Tents, Containers, Prefabricated shelters

I. INTRODUCTION

Disasters, whether natural or man-made, often result in the displacement of large populations, leaving them in urgent need of temporary shelter and housing. Providing adequate and appropriate shelter is a critical aspect of disaster response and recovery efforts, as it directly impacts the well-being, safety, and dignity of affected individuals and communities.

Traditional disaster shelters, such as tents, have been widely used in emergency situations. However, these shelters often lack durability, privacy, and basic amenities, leading to suboptimal living conditions for displaced populations. Additionally, the deployment and maintenance of large-scale tent camps can be logistically challenging and resource-intensive.

As the frequency and intensity of disasters continue to rise due to factors such as climate change and urbanization, there is an increasing need for more effective and sustainable shelter solutions. Prefabricated shelters, such as container houses, modular homes, and portable homes, have emerged as potential alternatives to traditional tents. However, the adoption and implementation of these shelters in disaster response efforts have been uneven, with varying degrees of success.

To address this problem, it is crucial to conduct a comprehensive analysis of disaster shelters, comparing their advantages, disadvantages, and suitability for different types of disasters. By identifying the most effective and practical shelter solutions, disaster response professionals can make informed decisions and optimize the allocation of limited resources. Additionally, understanding the challenges and barriers to implementing prefabricated shelters can help guide future research and development efforts in this field.

II. AIM AND SCOPE:

The aim of this article is to provide a comprehensive overview of disaster shelters, focusing on their advantages, disadvantages, implementation cases, and suitability for different types of disasters. The article will delve into various types of shelters, including tents, containers, and prefabricated shelters, such as container houses, modular homes, prefabricated villas, and portable homes. It will analyze the effectiveness, practicality, and challenges associated with each shelter type, offering insights into their deployment in disaster scenarios.

The scope of the article will cover a detailed examination of the different categories of disaster shelters, highlighting the specific features, benefits, and limitations of each type. The article will discuss the suitability of different shelter types for specific disasters, considering factors such as durability, adaptability, cost-effectiveness, and ease of deployment. By providing a comprehensive analysis of disaster shelters, this article aims to inform disaster response professionals, policymakers, and researchers about the diverse options available for providing temporary housing in times of crisis.

Disaster shelters play a crucial role in providing temporary housing and protection for individuals affected by various types of disasters.

III. Methodology:

The article will employ a multi-faceted methodology to provide a comprehensive analysis of disaster shelters,

including tents, containers, and prefabricated shelters such as container houses, modular homes, prefabricated villas, and portable homes. The research will begin with a thorough literature review of academic papers, reports, and case studies to identify the advantages, disadvantages, and implementation cases of different shelter types in various disaster scenarios. Real-world case studies will then be examined to evaluate the effectiveness and challenges faced in deploying and managing these shelters in different disaster contexts. A comparative analysis will be conducted to assess the suitability of each shelter type for different types of disasters based on factors like durability, adaptability, cost-effectiveness, and ease of deployment. Finally, the findings from the literature review for disaster response practitioners, policymakers, and researchers on the optimal use of tents, containers, and prefabricated shelters in different disaster scenarios.

Disaster Shelter Types

Different models of shelters exist worldwide, each with its own set of advantages and disadvantages. These shelters cater to various needs and are designed to address different types of natural disasters such as earthquakes, floods, and hurricanes[1].

1. Tents:

Historical shelter with various types such as frame tent, tunnel frame tent, and wooden pillar/truss tent.

Standard tent :

The standard tent, characterized by a square-shaped cube with a triangular prism roof, 400x400x210 cm in size, weighing 70-100 kg. It has a suspended-tension structure, quick assembly with a hammer, and storage precautions against sun and rain[2]. Transportable by air, road, and sea. Materials like steel or wood, with polyester covers, ideal for dry and hot areas. Varying durability in winds and cold, suitable for storage up to 5 years. Standard tents are light, portable, and adaptable to various environments. Easy assembly without special tools. Suitable for different ground conditions but more challenging in rainy or snowy areas. Aid organizations prefer wooden floors for cold regions, though moisture can cause rot. Ongoing research on thermal conductivity in tents by universities and the UN[3].

- Advantages: Easy to set up, portable, cost-effective.

- Disadvantages: Limited durability, lack of insulation, vulnerability to extreme weather conditions.

- Implementation cases: Used in emergency response situations, refugee camps, and temporary shelter solutions.

- Applicable for: Short-term use in mild weather conditions.

Fig1: example of a Standard tent [4]

Framed Prototype Tent (Frame Tent):

A square cube with a prism roof, 515x328x286 cm in size, weighing 180 kg. Metal frame system assembly involves clamping steel profiles together and attaching textile covers. Short installation time with screws or welding tools. Storage requires protection from moisture, sun, and rain. Transportable by air, road, and sea.Metal L profiles, polyester covers, steel piles, fire-resistant textile covers. Heat-proof and suitable for hot and cold climates[5].

Fig 2: example of a Framed Prototype Tent [4]

- Advantages: More durable than standard tents, can withstand moderate weather conditions.

- Disadvantages: More complex setup, requires additional equipment.

- Implementation cases: Used in disaster-prone areas, military operations, and field hospitals.

- Applicable for: Medium-term use in moderate weather conditions.

Tunnel Frame Tent:

Easy setup with few components. Suitable for disaster areas, assembly with a wrench or welding machine. Expandable by placing tents side by side. Fire-resistant cover allows for stove-style heaters. Weakness in joint points under strong wind or external impacts. Issues with tent-ground relationship, prone to leaks from the ground. Designed for disaster areas with cold climates.

Half cylinder shape, 550x1080x310 cm in size. Rod structure with dry joint assembly using screws. Requires wrench and

screwdriver for setup. Storage precautions against moisture, sun, and rain. Transportable by air, road, and sea.

Metal pipe profiles, various tent cover materials for different disaster areas. Steel or wooden piles. Heat-proof textile cover. Suitable for hot and cold climates.

Easy installation with few components. Anchoring vertical profiles to the ground is necessary. Can be set up with a wrench or hammer. Expandable in a modular way with a half-cylindrical shape. Fire-resistant cover allows for stove-style heaters. Interlocking system at junction points of steel profiles. Profiles can be connected without welding. Foundation preparation is required before erection[6].

Fig3: example of a Tunnel Frame Tent [7]

- Advantages: Provides more space, can be interconnected to create larger shelter areas.

- Disadvantages: Requires a larger footprint, more complex setup.

- Implementation cases: Used in disaster response operations, temporary housing for displaced communities.

- Applicable for: Medium-term use in various weather conditions.

Timber Column and Truss Frame Tent:

Square plan with cube-shaped triangular prism roof. 600x700x285 cm in size. Wood stud and wood truss structure. Assembly with wooden posts or timbers using nails. Requires hammer and nails for setup. No storage needed, transported to disaster area. Transportable by air, road, and sea.

The Wooden Truss Tent consists of two main components: wooden timbers and a covering system. The wooden posts need to be securely anchored to the ground in order to stand upright. The installation process is straightforward as it requires minimal components. In case of a disaster, the tent can be easily assembled on-site using a hammer and nails. The roof of the tent is square-shaped and resembles a triangular prism. When used vertically or horizontally, the tent can be expanded in a modular fashion, providing a larger area. The tent cover is designed to withstand strong winds, but it is not resistant to external impacts. Similar to other tents with textile or plastic covers, the wooden scissor tent may not offer optimal security. However, before erecting the tent, the foundation location is carefully determined and excavated. There are three different methods for the basic foundation process:

1. Digging a foundation pit with a depth of 300-500 mm. Steel rollers are placed in the pit and then covered with soil.

2. If the ground is not suitable for the first option, a foundation pit with a depth of 300-500 mm is dug. Steel cylinders are placed in the pit and then sealed with concrete.

3. Alternatively, existing pavers can be installed on the wooden posts to serve as the foundation[6].

Fig 4: example of a Timber Column and Truss Frame Tent [8]

- Advantages: Increased stability and durability, suitable for long-term use.

- Disadvantages: Requires skilled labor for construction, higher cost.

- Implementation cases: Used in long-term disaster recovery efforts, semi-permanent housing solutions.

- Applicable for: Long-term use in various weather conditions.

2. Container:

Containers are essential for global trade, with over 80% of trade being transported by sea. They are typically made of steel but can also be made of aluminum or plastic. There are two main types of containersused for shelters:

1. Standard shipping containers:
Made of strong steel and are completely wind and water-tight
Come in standard sizes like 10ft, 20ft, and 40ft
Can be used as-is or modified for specific needs
Readily available and easy to transport
Can double as the shelter's hold down system for anchoring

2. Custom-built containers:
Designed and fabricated to exact specifications
Offer more flexibility in size, features, and customizations
Can be larger than standard shipping containers
Allow for custom configurations like stacking or connecting multiple units
Provide a completely bespoke solution tailored to the project's requirements
More expensive than standard containers but offer the most flexibility[9].

- Advantages: Durable, secure, and stackable.

- Disadvantages: Limited interior space, expensive transportation costs.

- Implementation cases: Used in urban disaster response, construction sites, and remote areas.

- Applicable for: Medium to long-term use in various weather conditions.

Fig 5:example of Container [9]

Reaction Housing System:

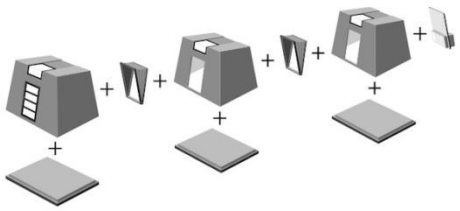
The Reaction Housing System is a flexible and versatile solution for emergency housing. It is designed to be used in various disaster scenarios, such as fires, earthquakes, and hurricanes. The system is made of composite aluminum panels, making it resistant to heat and fire. Each unit of the system consists of two main elements and can accommodate a family. The beds are mounted on the wall for stability, and the floors are waterproof. The system also includes ventilation gaps for fresh air and energy exchange. It is easy to transport and assemble, with lockable doors and windows for security. The units can be stacked to save space during transportation. The system can be transported by train, ship, truck, or cargo plane [10].

- Advantages: Quick assembly, modular design, can be easily transported.

- Disadvantages: Limited interior space, not suitable for extreme weather conditions.

- Implementation cases: Used in emergency response situations, temporary housing for disaster victims.

- Applicable for: Short to medium-term use in mild weather conditions.



Interconnected Configuration

Fig6: example of Reaction Housing System [10]

Uber Shelter:

The Uber Shelter is a portable and versatile solution designed to improve refugee camps and meet the shelter needs of people affected by disasters. It is designed as a rectangular prism with a metal frame system. The shelter is assembled by interlocking portable parts, and no tools are required for assembly. The modular parts are stored horizontally in a box for easy storage and transportation [11]. The shelter is made of aluminum profile and has a textile outer cover that provides thermal insulation. It is resistant to various external effects and impacts. The Uber Shelter project is still in the design phase and has not been implemented yet. It was designed to offer a modern lifestyle and easy clustering, with a focus on being easy to carry, reusable, and foldable. It can be transported by road and sea. The shelter is designed for different climates, terrains, and situations. It consists of two parts: the shelter department and the department that provides additional needs such as a furnace and refrigerator. The Uber Shelter project was shortlisted in the 2008 International Design Excellence Award student competition with the aim of creating a spatial integrity that goes beyond just emergency shelter and meets vital needs[12].

Fig 7: example of a Uber Shelter [13]

- Advantages: Versatile, lightweight, and portable.

- Disadvantages: Limited interior space, requires additional support structures.

- Implementation cases: Used in disaster-prone areas, remote locations, and temporary housing solutions.

- Applicable for: Short to medium-term use in various weather conditions.

Fhiltex-& Housing Unit:

The Fhiltex-x Housing Unit, a project initiated in the 1990s by MMW Architecture and completed in 1995, embodies principles of transience and nomadism. This innovative unit, designed in Norway, combines 20 and 40 feet containers to create a 50 m2 structure featuring standard amenities like a bedroom, kitchen, and toilet. It stands as a self-sufficient entity with solar panels, clean and waste water tanks for energy production. Transported by four steel carriers from two container junctions, the unit is securely fastened with cross ropes for stability against external elements. Steel ladders ensure ground connection, while windows and steel balconies enhance the container's exterior, offering panoramic views from all sides [14]-[15].

Fig 8: example of a Fhiltex-& Housing Unit [16]

- Advantages: Quick assembly, energy-efficient, customizable.

- Disadvantages: Higher cost, requires skilled labor for construction.

- Implementation cases: Used in disaster recovery efforts, sustainable housing projects.

- Applicable for: Medium to long-term use in various weather conditions.

The All Terrain Cabin:

The ATC cabin project was designed by Bark Design Collective in 2006. It consists of the use of a single unit cell container that can be easily adapted in mountainous regions. 20 containers are used in the ATC cabin. The cabin consists of wet area, bed section, living, dining, kitchen and terrace units that open out. Long sidewallsare used as floors in order to make more use of the floor space of 20-inch containers. Thus, the usage area of the cabin is tripled. There is also a generator and a water tank inside the unit [15].

Fig 9: example of The All Terrain Cabin [17]

- Advantages: Off-grid capabilities, compact design, environmentally friendly.

- Disadvantages: Limited interior space, may require additional utility systems.

- Implementation cases: Used in remote disaster-prone areas, eco-friendly housing initiatives.

- Applicable for: Medium to long-term use in mild to moderate weather conditions.

TED (Transportable Emergency Dwelling):

The Transportable Emergency Dwelling, a novel housing design by U.S.-based student Craig Mackiewicz, ingeniously repurposes shipping containers into cost-effective homes. Each container can house two families comfortably, expandable to accommodate more, and includes essential utilities like kitchens, bathrooms, and storage. Designed for sustainability, the units feature slanted roofs for rainwater harvesting, capable of storing 350 gallons, and utilize solar panels for electricity. These self-sustaining units can collect water and generate energy, offering a unique and efficient solution for future housing needs, with the potential for refurbishment and reuse after deployment[18].

Fig10: example of TED (Transportable Emergency Dwelling) [19]

- Advantages: Quick deployment, modular design, energy-efficient.

- Disadvantages: Limited interior space, may require additional support structures.

- Implementation cases: Used in disaster response operations, temporary housing for displaced communities.

- Applicable for: Short to medium-term use in various weather conditions.

Minimum Mobile Module:

The Minimum Mobile Module, designed by Lab Zero in 2002, is a modified 20' container for Afghan refugees and homeless people. It features movable modules that increase the floor area and soften the container's sharp contours, providing both functional and aesthetic qualities. The module contains ready-made units like a kitchen, WC, bed, and bathroom, which can be removed and installed by the user. The container's cross mechanism allows it to be used in various terrain conditions, and it includes additional items like a steel ladder, water tank, and canopy[18].

Fig11: example of Minimum Mobile Module [20]

- Advantages: Portable, customizable, can be combined to create larger living spaces.

- Disadvantages: Limited interior space, may require additional facilities for sanitation and utilities.

- Implementation cases: Used in disaster response operations, temporary housing solutions.

- Applicable for: Short to medium-term use in various weather conditions.

3. Prefabricated Shelters:

Prefabrication involves assembling building components offsite for efficient construction. It aims to enhance speed, resource utilization, and cost-effectiveness. Modular construction typically involves design, factory assembly, transportation, and on-site erection of modules. In developing countries, prefabrication often utilizes local materials and decentralized, low-tech approaches, involving small-scale entrepreneurs for post-disaster reconstruction. This method offers rapid, cost-effective solutions, especially in emergency housing scenarios, showcasing its potential for sustainable and efficient construction practices globally[21].

Container houses:

The container houses are constructed by assembling durable materials, ensuring safety and longevity. Typically single-story and compact, these prefab container homes offer versatility with optional loose parts and flat packing. They feature various insulation materials like EPS, glass wool, and polyurethane for thermal efficiency and fire resistance. Easy to assemble and disassemble, these structures are customizable in color and design, suitable for diverse uses like offices, hotels, and bathrooms. With a lifespan exceeding 20 years and recyclable nature, they provide sustainable and long-lasting solutions[22].

Fig12: example of Container houses [23]

- Advantages: Quick assembly, durable, customizable.
- Disadvantages: Limited interior space, may require additional insulation.
- Implementation cases: Used in disaster recovery efforts, affordable housing projects.
- Applicable for: Medium to long-term use in various weather conditions

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Modular homes:

Modular homes are becoming increasingly popular as they offer customization, faster construction, cost-effectiveness, quality control, and lower environmental impact. These prefabricated units are produced off-site in controlled factory settings and assembled on-site[24].

Some key advantages of smaller modular homes include:

- Efficient use of space: Manufacturers can pack a lot into a smaller footprint, with homes as small as 586 square feet featuring living rooms, kitchens, dining rooms, bedrooms, and bathrooms.
- Versatility: Smaller modular homes can serve as guest houses, backyard cottages, accessory dwelling units (ADUs), or investment rentals.
- Customization: Even small modular homes can be customized with luxury finishes, open floor plans, and added features like dens or porches.

Manufacturers offer a wide range of small modular home models, from tiny houses under 400 square feet to larger options around 1,200 square feet with multiple bedrooms and

bathrooms. These homes can be placed on foundations in various settings, from rural areas to urban backyards.

As the demand for affordable, sustainable housing grows, smaller modular homes are becoming an increasingly attractive option for individuals, couples, and small families looking for a high-quality, customizable living space[24].

Fig13: example of Modular homes [25]

- Disadvantages: Modular homes tend to have a higher upfront cost compared to other types of shelters. They may require additional permits and inspections during the installation process. Additionally, transportation costs can be significant, especially for remote or inaccessible areas.

Prefabricated Villa:

Prefabricated villas are large, luxurious houses catering to extended families or high-income individuals. They can have a similar appearance to traditional villas and are widely used for hotels, offices, resorts, supermarkets, entertainment centers, and other buildings. Steel structures are easy to install, stable, earthquake-proof, waterproof, energy-conserving, and environmentally friendly[26].

Fig14: example of Prefabricated Villa [27]

- Advantages: Prefabricated villas offer a higher level of comfort and quality compared to other types of shelters. They are designed to resemble traditional homes and can include amenities such as kitchens, bathrooms, and living spaces. They can be quickly assembled and disassembled, making them suitable for temporary housing needs.

- Disadvantages: Prefabricated villas are often more expensive than other shelter options due to their higher quality and additional amenities. They may require skilled labor for assembly and may not be suitable for areas with limited access or challenging terrains.

Portable Homes:

Portable homes are easily transportable, making them ideal for temporary housing needs. These small, single-story structures are typically factory-built and can be quickly assembled on-site, providing a convenient and cost-effective solution for those requiring temporary accommodations, such as construction workers, disaster relief efforts, or individuals seeking a flexible living arrangement. Portable homes are designed to be easily disassembled, moved, and reassembled in a new location, offering a practical alternative to traditional construction methods when flexibility and mobility are essential requirements[28].

Fig15: example of Portable Homes [29]

- Advantages: Portable homes are compact, lightweight, and designed for easy transportation. They are typically made from durable materials and can withstand various weather conditions. They are often customizable and can include basic amenities such as sleeping areas and small kitchens.

- Disadvantages: Portable homes have limited interior space, making them suitable for short-term or emergency housing needs. They may not provide the same level of comfort as larger shelters and may require additional facilities for sanitation and utilities.

Prefabricated shelters, including container houses, modular homes, prefabricated villas, and portable homes, offer a range of options for temporary housing in disaster situations. The specific choice of shelter depends on factors such as the duration of use, budget, location, and specific needs of the affected population. It is important to consider the local climate, available resources, and the capacity to transport and assemble the shelters in a timely manner.

Prefab building systems offer many significant advantages in construction. These advantages include:
-Accelerating Construction Time: Ensuring rapid completion of building construction by shortening the construction period.
-Minimizing Labor Requirements: Reducing on-site manufacturing in construction sites to minimize the need for labor.
-Reducing Error Rates: Standardized production in prefabricated elements helps decrease error rates.
-Minimizing Formwork Labor: Requiring minimal formwork labor for on-site produced elements outside the foundation.

-Creating Highly Insulated Structures: Offering various insulation options based on insulation material choices to construct highly insulated buildings.
- Environmentally Friendly Production: Being eco-friendly due to increased use of recyclable materials in factory production.
-Reducing Energy Consumption: Lowering energy consumption by assembling prefabricated elements on-site.
-Obtaining High-Quality Building Components: Achieving high-quality building elements through continuously improved standard production.
-Ensuring Longevity of Comfort Conditions: Securing long-lasting comfort conditions in buildings.
- Enhancing Energy Efficiency: Decreasing heating/cooling energy consumption in the construction of high-energy-efficient buildings.

IV. RESULTS AND DISCUSSION

Prefabricated shelters, such as container houses, modular homes, and portable homes, offer several advantages over traditional disaster relief shelters like tents for providing temporary housing in the aftermath of disasters.

Key advantages of prefabricated shelters include:

- Faster deployment and assembly compared to on-site construction.
- Ability to be customized to meet specific needs and expanded over time.
- Improved durability, weather resistance, and safety compared to tents.
- Potential for reuse, relocation, and repurposing after the initial disaster response.
- Potential for lower overall costs when considering the entire sheltering process.

Prefabricated building systems offer many important advantages in construction:

Faster Construction

- They allow buildings to be completed more quickly by shortening the construction time.
- They reduce the amount of on-site manufacturing, minimizing the need for labor.

Higher Quality

- The standardized prefabricated components have lower error rates.
- There is minimal need for formwork for the non-foundation elements produced on-site.

Insulation and Energy Efficiency

- They allow for different insulation options to create highly insulated buildings.
- The factory-based production uses more recyclable materials, making them environmentally friendly.
- The assembly of prefabricated components on-site reduces energy consumption.

Durability and Comfort

- The continuously improved standard production yields high-quality building components.
- They ensure long-lasting comfort conditions.
- They enable the construction of energy-efficient buildings with reduced heating/cooling energy needs.

Shelter Type	Advantages	Disadvantages
Tents	- Quick deployment	- Lack of durability
	- Cost-effective	- Limited privacy
	- Easy to transport	- Basic amenities
	- Temporary solution	- Vulnerable to harsh weather
	- Flexibility in setup	- Maintenance challenges
Containers	- Durable and weather-resistant	- Limited mobility
	- Provides better security and privacy	- Higher upfront costs
	- Can be repurposed or reuse	- Requires suitable infrastructure
	- Offers more amenities and comfort	- Challenges in deployment and setup
	- Potential for customization	
Prefabri-cated Shelters	- Faster deployment and assembly	- Higher initial investment
	- Customizable to specific needs	- Site and infrastructure requirements
	- Improved durability and safety	- Logistical complexities
	- Potential for reuse and relocation	- Challenges in coordination and planning
	- Adaptable to different disaster scenarios	

Table 1: summarizes the main advantages and disadvantages of different types of temporary shelters.

V. CONCLUSION

Prefabricated shelters have been successfully ımplemented in various disaster scenarios, ıncluding earthquakes, floods, and conflicts that have displaced populations. They are particularly well-suited for providing temporary housing in the intermediate and transitional phases after a disaster, when emergency tents are no longer sufficient but permanent housing is not yet available.

However, prefabricated shelters also have some limitations, such as the need for a suitable site and infrastructure, and the potential for higher upfront costs compared to tents.

Careful planning and coordination are required to ensure prefabricated shelters are deployed effectively as part of a comprehensive disaster response strategy.

In conclusion, prefabricated shelters offer a promising solution for providing safe, durable, and adaptable temporary housing in the aftermath of disasters. As the humanitarian sheltering field continues to evolve, further research and innovation in prefabricated shelter design and deployment will be crucial for ımproving disaster response and recovery efforts worldwide.

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