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An Analytical Study on the Impact of Interior Design Standards on Lightweight Structures

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ABSTRACT

This comparative analytical study emphasizes the critical role of interior design in enhancing the quality and performance of lightweight structures, which represent a contemporary architectural trend aiming to balance functional efficiency, economic feasibility, and environmental sustainability. Using a descriptive–analytical methodology and a case study approach, the research compares selected local and international examples by analyzing spatial layout, material selection, visual treatment strategies, lighting and ventilation solutions, and the adaptability of spaces to diverse uses. The findings reveal that well-considered interior design—supported by lightweight, modular, and demountable construction systems—significantly improves spatial flexibility, enhances user comfort, reduces construction time and cost, and boosts environmental performance through efficient material use and waste reduction. The integration of digital technologies, such as modular design tools and digital fabrication, was found to foster innovation, accelerate development, and enable customization, particularly in temporary housing, service kiosks, and mobile educational units. Case study results further indicate that designs sensitive to local cultural and environmental contexts achieve higher user satisfaction and ensure greater long-term sustainability. The study recommends adopting flexible, innovative, and context-sensitive interior design strategies for lightweight structures, given their direct impact on improving living experiences and enhancing the sustainability of these architectural models.

Keywords: Interior Design, Lightweight Structures, Modular Design, User Sensory Experience.

1. Introduction

In recent decades, architectural trends have witnessed a remarkable shift, particularly in response to the growing need for flexible and rapid construction solutions that can adapt to environmental, social, and economic changes. Lightweight structures have emerged as one of these solutions, characterized by ease of assembly and disassembly, cost efficiency, and the ability to be relocated or repurposed. These structures are now widely used in various applications, including temporary housing units, service kiosks, mobile educational and healthcare facilities, and have proven vital in emergency and disaster response scenarios.

Given the diversity of these structures and their varying functions, there is a pressing need to study their interior design—not only from an aesthetic perspective, but also in terms of functional efficiency, user comfort, material suitability, and environmental responsiveness. The interior space of lightweight structures must be flexible, adaptable, and capable of providing a comprehensive user experience despite the limited structural capabilities.

1.1 Research Problem

Although lightweight structures are increasingly adopted for diverse purposes—from temporary housing to mobile service units—their interior design aspects remain underexplored compared to their structural and cost-related features. Many designs prioritize speed and affordability but overlook crucial elements such as spatial quality, adaptability, ergonomic comfort, and environmental integration. This lack of holistic interior design approaches limits the potential of lightweight structures to deliver functional, comfortable, and sustainable spaces across different contexts and user needs.

1.2 Research Importance

Studying the interior design of lightweight structures is vital because:

- These structures play a critical role in emergency relief, temporary accommodation, and mobile service provision, where interior efficiency directly impacts human well-being.
- Optimized interior layouts and materials can enhance flexibility, durability, and environmental responsiveness.

- Integrating innovative interior solutions can increase adaptability, extend the service life of structures, and reduce resource consumption.
- Aligning interior design with cultural and environmental contexts ensures higher user satisfaction and better long-term performance.

1.3 Research Objectives

- Identify the key interior design factors influencing the functionality and livability of lightweight structures.
- Compare local and international case studies to extract best practices and innovative design approaches.
- Evaluate the effects of material selection, lighting, ventilation, and spatial organization on user comfort and environmental performance.
- Investigate the role of digital tools—such as modular design systems and digital fabrication—in improving interior efficiency and adaptability.
- Propose design guidelines that promote flexibility, sustainability, and cultural responsiveness in lightweight structures.

2. The Concept of Lightweight Structures

2.1 Definition and Types of Lightweight Structures:

"Lightweight structures" refer to a category of architectural forms that are characterized by low weight, easy assembly and disassembly, and rapid construction. They are used in both temporary and permanent applications and offer a high degree of flexibility in design and function. (Osa, J. L. (2019)

Types include:

- **Timber Structures**: Built using processed, low-density wood, often used in cabins, rural housing units, and temporary buildings.
- **Metal Structures**: Utilize prefabricated metal frameworks, such as light gauge steel or aluminum, known for their durability and lightweight properties.
- **Composite Structures**: Combine various lightweight materials such as wood, metal, and fiber-reinforced plastic.
- **Mobile Structures**: Include repurposed containers, housing trailers, and caravans, designed for portability and reuse.

Figure 1. the adaptive reuse of multiple shipping containers in the structural design of a restaurant-Oxford Rd, Manchester M1 7ED, United Kingdom (URL: https://shorturl.at/Y6seJ)

2.2 Advantages and Disadvantages of Lightweight Structures Compared to Traditional Ones:

- Rapid execution and installation.
- Lower cost in materials and labor.
- Flexibility in design and ease of modification.
- Suitable for temporary or emergency use.
- Lightweight load on the soil, reducing foundation requirements.

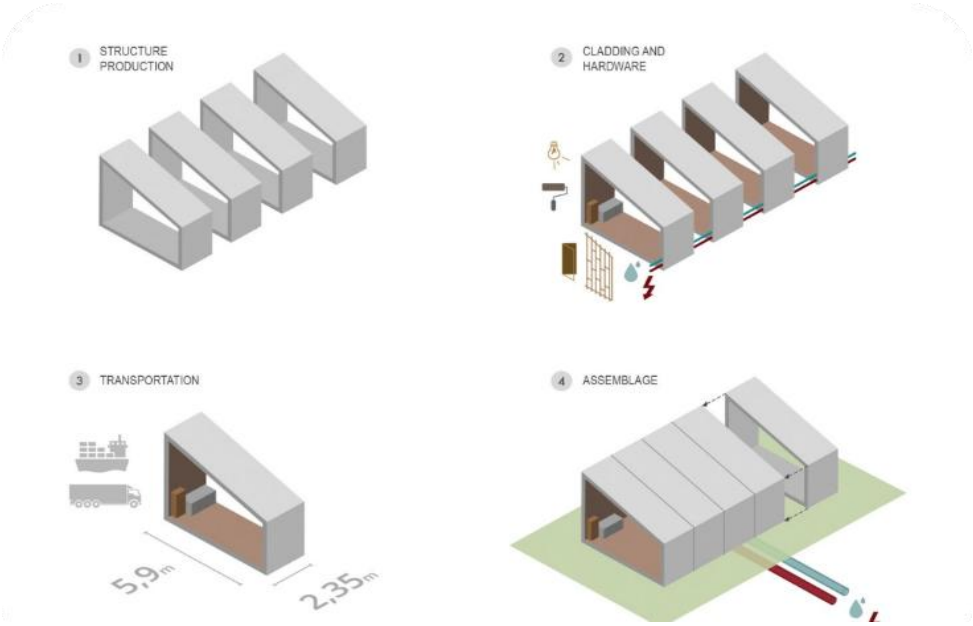

Figure 2. Illustrates the advantages of lightweight structures in terms of fast execution, design flexibility, and ease of modification (URL: https://shorturl.at/bjU9K)

Disadvantages:

- Limited thermal and acoustic insulation performance unless specially treated.
- Relatively shorter lifespan in some types.
- Lower resistance to extreme weather conditions (such as storms and fires) unless reinforced with appropriate treatments.

2.3 Economic and Environmental Factors Leading to the Spread of Lightweight Structures:

• **Economically:** The rising cost of traditional construction and the urgent need for fast, low-cost building solutions—particularly in developing or remote areas—have contributed significantly to the adoption of lightweight structures.

• **Environmentally:** Growing global awareness of environmental issues has created a demand for eco-friendly structures that utilize recyclable materials and require minimal energy for production and operation.

• **Socially:** The increasing frequency of natural disasters and mass displacement has driven the need for flexible, quickly deployable infrastructure capable of responding effectively to emergencies

3. Interior Design Standards for Lightweight Structures:

3.1 What is Interior Design?

Interior design is a branch of architectural design concerned with organizing and shaping interior spaces to achieve optimal levels of functional, aesthetic, and psychological comfort for users. It takes into account environmental factors, cultural context, and evolving human needs. Interior design is not limited to furniture arrangement or color selection; it encompasses spatial elements such as walls, ceilings, and floors, as well as lighting, materials, and acoustic and thermal treatments, ensuring the integration of function and form in a coherent and adaptable way. (Shamma, H. -2024).

Key characteristics of interior design include:

- **High Functionality:** The ability to meet user needs through efficient space utilization, circulation planning, and ensuring both physical and psychological comfort.

- **Flexibility and Adaptability:** Interior design allows for ongoing modification and development in response to changes in function, user numbers, or technical requirements.
- **Aesthetic and Expressive Dimension:** It contributes to the creation of a distinctive spatial identity that reflects the user's taste and culture, achieved through carefully crafted visual composition and the use of materials, colors, and lighting.
- **Integration with Architectural Structure:** Interior design does not function independently of the architectural framework; rather, it interacts with and enhances it to achieve optimal performance in both function and form.

As such, interior design serves as a strategic tool for shaping living and working spaces in an intentional and balanced way, harmonizing technical, aesthetic, and human considerations. This makes it a vital component in the design of all types of buildings—especially lightweight structures, which have unique functional and structural characteristics.

3.2 Foundations and Functional Design Criteria

Achieving functionality is one of the most important criteria in the interior design of lightweight structures, given their temporary or multi-use nature. Therefore, the design must take into account the following:

- **Responding to user needs**: such as the number of occupants and the type of activity (educational, residential, service-oriented, etc.).
- **Space efficiency**: utilizing smart spatial layouts that make the most of every square meter.
- **Environmental comfort**: through improved ventilation, natural lighting, and noise control.
- **Ease of movement and usability**: ensuring fluid circulation and easy navigation within the structure, especially in cases that require accessibility, such as shelters or healthcare facilities.

Figure 3. Demonstrates Functional Efficiency in Temporary Lightweight Structures – Tiny Homes Units – "KODA House" Project, Estonia (UR: https://shorturl.at/CnqFL)

3.3 The Relationship between Interior Design and Lightweight Structural Systems

Interior design in lightweight structures is closely tied to the structural system for several reasons:

- **The structure defines interior partitioning possibilities**: Lightweight buildings often rely on modular or prefabricated systems that determine the placement of partitions and walls.
- **Provision of anchoring and support points**: Furniture and storage units must be designed in alignment with the structural system's load-bearing capacity.
- **Integration of services with structural elements**: Electrical and plumbing systems must be routed within walls and floors without compromising structural efficiency or adding unnecessary weight.
- **Control of weight and balance**: Especially in mobile structures, interior design must prioritize lightweight materials and multifunctional furniture to ensure structural stability and efficient space use. (Nassar, R. A. (2021)

3.4 Adaptability and Expandability in Interior Design

One of the key advantages of lightweight structures is their high flexibility, which requires the interior design to be:

- **Easily modifiable**: through the use of non-permanent partition systems such as movable or demountable walls.
- **Capable of horizontal or vertical expansion**: using modular units that can be added or combined seamlessly.
- **Adaptable to changing functions**: for example, transforming a living space into a workspace or converting an educational area into a temporary clinic.
- **Based on multi-functional units**: such as foldable or convertible furniture that can respond to users' evolving needs.

Figure 4. Shows the design of a restaurant using modular units that can be added or combined "Boxpark" Kiosk – London, United Kingdom (URL: https://shorturl.at/heDVI)

4. Materials Used in the Interior Design of Lightweight Structures:

4.1 Comparison Between Traditional and Modern Materials

In the design of lightweight structures, the choice of materials plays a critical role in achieving efficiency, functionality, and aesthetics. The materials used in interior design vary between traditional and modern ones in terms of characteristics and performance.

Table .1: Comparison between Traditional and Lightweight Materials**:**

Element	Traditional Materials	Modern Materials
Weight	Relatively heavier (e.g., brick, gypsum, solid wood)	Lighter weight (e.g., PVC panels, aluminum, polycarbonate)
Flexibility	Less flexible, require strong supporting structures	Flexible and easily shaped
Environmental Response	Moderate insulation, affected by moisture and weather	Enhanced thermal and acoustic performance, moisture-resistant
Assembly and Dismantling	More complex	Easy to assemble, dismantle, and reuse
Sustainability	Often non-recyclable	Some materials are recyclable and have lower environmental impact

4.2 Use of Recyclable and Lightweight Materials

One of the most prominent contemporary trends in lightweight structure design is the reliance on eco-friendly and lightweight materials, due to their environmental and functional benefits. Among these materials are:

- **Recycled MDF and HDF boards:** Used for wall finishes or furniture manufacturing.
- **Transparent polycarbonate sheets:** Employed to provide natural lighting and reduce structural loads.
- **Coated aluminum:** Lightweight, rust-resistant, and used in roofing or framing.
- **Compact boards or thermoplastics (e.g., PVC):** Easy to clean, moisture-resistant, and lightweight.
- **Cork or rock wool:** Recyclable insulating materials for thermal and acoustic purposes.

4.3 Impact of Material Type on Aesthetics, Thermal, and Acoustic Performance

- Aesthetic Impact:

The material type affects texture, color, light reflection, and the overall visual impression of the space. For example:

- **Natural wood** adds warmth and comfort.
- **Polycarbonate** enhances transparency and visual lightness.
- **Shiny metals** give an industrial or modern touch.

- Thermal Impact:

Materials with low thermal conductivity (such as treated foam or composite panels) contribute to effective thermal insulation, reducing the need for air conditioning in various environments.

- Acoustic Impact:

Selecting materials with appropriate density and porosity (such as felt, treated gypsum, or sound-absorbing fabrics) enhances acoustic comfort within the structure—especially in settings that require sound privacy like offices or clinics.

- Environmental Solutions in Interior Design:

Environmental solutions are fundamental elements in the design of lightweight structures, as they contribute to enhancing energy efficiency and reducing negative environmental impact. One of the key strategies involves using lightweight materials that provide effective thermal and acoustic insulation—such as polyurethane or rock wool insulated panels—which help maintain indoor temperatures and reduce noise without compromising the lightness of the structure.

Natural lighting is also prioritized by incorporating large window openings or transparent polycarbonate roofs to reduce reliance on artificial lighting during daytime hours. Additionally, natural ventilation is achieved through cross-ventilation or smart openings that allow for sustainable air renewal, thereby improving indoor air quality and reducing the need for mechanical cooling systems. (Bell, V., & Rand, P. (2019)

Figure 5. Demonstrates the use of transparent or semi-transparent polycarbonate as a roofing and window covering, along with appropriately placed openings. This provides soft natural lighting, reduces reliance on artificial lighting, and allows for sustainable natural ventilation to maintain indoor air quality (URL: https://shorturl.at/f6E0e)

When comparing structures that implement these environmental solutions with those that do not, clear differences emerge. Environmentally conscious buildings achieve greater energy savings, offer higher indoor environmental quality, and are considered more sustainable in the long term. In contrast, conventional non-ecological structures rely on industrial solutions that consume more energy and lack effective climatic adaptability.

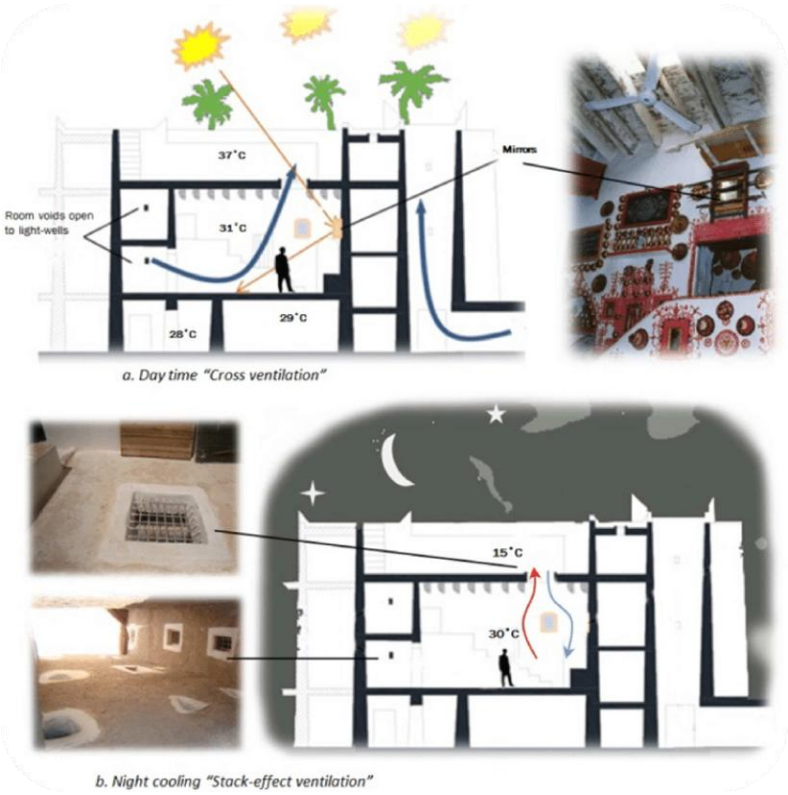

Figure 6. A traditional design that relies on openings and intelligent spatial planning to utilize natural light and thermal-driven ventilation (stack effect), resulting in significant energy savings compared to conventional designs that depend entirely on air conditioning and artificial lighting (URL: https://tinyurl.com/5667p75c)

5. Comparative Study of Interior Use Patterns:

Interior use patterns in lightweight structures vary significantly depending on the nature of the function, whether the structure is residential or service-oriented (such as kiosks and mobile units).

In lightweight residential structures**,** the focus is on achieving living comfort by organizing spaces to support daily activities such as sleeping, cooking, and living. Therefore, interior spaces are often relatively more spacious and flexibly divided using lightweight partitions or multifunctional furniture. These designs also allow for future expansion or modification as needed.

On the other hand, in lightweight service structures, such as kiosks or mobile units, interior design prioritizes high functionality within a compact space. Every square centimeter is utilized to maximize operational efficiency—whether for selling, service delivery, or temporary storage. These spaces are typically compact and clearly defined, employing smart design solutions such as foldable shelves and multifunctional surfaces.

In terms of efficiency, service units excel in delivering fast and direct solutions for specific tasks, while residential units focus on achieving a balance between comfort and flexibility. The comparison reveals that each type presents unique design challenges, requiring innovative interior strategies that respond to the intended use and user movement within the space.

6. User Behavior within Lightweight Structures

Studying user behavior within lightweight structures is a fundamental aspect in evaluating how effectively the interior design meets human needs in a confined space. The limited area requires the designer to think strategically about the distribution and management of elements to accommodate human movement and activities.

6.1 Interaction with Limited Space:

Users tend to adapt their behavior according to the available space. In small environments, multifunctional furniture and spaces become essential, and user movement naturally becomes more constrained to suit the setting. This demands that designers ensure ease of access, well-planned functional distribution, and intelligent storage solutions to minimize clutter.

6.2 Impact of Colors, Lighting, and Materials on Comfort:

- Light colors create a sense of spaciousness and openness, while dark colors may evoke a feeling of confinement if not used carefully.
- Natural lighting plays a vital role in enhancing mood and productivity, while smart artificial lighting improves usability during nighttime.
- Lightweight and comfortable materials (such as natural wood and breathable fabrics) contribute to psychological and physical comfort, whereas cold, industrial materials may negatively affect the feeling of warmth and welcome.(Khalil, D. M. (2020)

6.3 Comparative Study Based on Age and Cultural Background:

- Elderly users require designs that accommodate limited mobility and provide easy access, while children need safe and open areas for play.

- Culturally, some users prioritize complete privacy in interior layouts, while others prefer open and communal spaces.
- Thus, the importance of a flexible and adaptive design approach becomes evident—one that considers the diverse needs of users

7. Future Design Challenges of Lightweight Structures

With rapid technological advancements and the increasing demand for flexible, quickly assembled residential and service solutions, a set of emerging challenges is anticipated for future designers, including: (Al-Sayed, H. M. (2017).

• Integrating Smart Technologies into Compact Spaces:

Achieving a balance between incorporating smart systems (such as intelligent lighting or climate control) and maintaining the simplicity and efficiency of interior design in limited spaces.

• Sustainability:

Designing lightweight structures using recyclable materials with high thermal and acoustic performance poses both environmental and economic challenges.

• Expandable Flexibility:

There is a growing need for interior designs that can be easily modified to adapt to changing user needs—such as transforming a residential space into a service-oriented unit.

• Aesthetic Identity:

Maintaining a unique and appealing visual identity becomes a challenge when designers are constrained by strict material and structural limitations.

• Adaptation to New Lifestyles:

Trends like remote work and home-based education require a rethinking of interior space distribution and functions, even within small units.

Table .2: Future Design Challenges vs. Opportunities in Lightweight Structures (Interior Design Focus)**:**

Aspect	Future Design Challenges	Future Design Opportunities
1. Flexibility and Adaptability	Difficulty achieving full flexibility for complex uses (e.g., precise medical or industrial functions)	High potential for expansion and adaptability to changing uses through modular and prefabricated systems
2. Environmental Performance	Challenges in achieving efficient thermal and acoustic insulation without increasing cost	Availability of new lightweight, high-performance, and recyclable materials offering enhanced environmental comfort
3. Technological Integration	Difficulty integrating smart technologies (e.g., intelligent HVAC, lighting systems) due to infrastructure limitations	Easy integration of smart home technologies and responsive systems into flexible interior spaces
4. Sustainability	Ensuring long-term durability despite the lightweight or temporary nature of materials	Opportunity to design demountable and reusable systems aligned with circular economy principles
5. User Acceptance	Some users may prefer traditional structures due to cultural or psychological reasons	Increasing awareness of sustainability and economic efficiency is improving acceptance of lightweight construction
6. Aesthetic Diversity	Limitations in decoration and detailing due to temporary or minimal construction	Development of lightweight decorative materials (e.g., printed fabrics, flexible panels) enables rich interior aesthetics
7. Cost of Implementation and Maintenance	Fluctuation in the prices of advanced lightweight materials and limited availability in some regions	Reduced transportation and assembly costs provide significant economic advantages over traditional construction

8. Methodologies in Interior Design of Lightweight Structures

Interior design for lightweight structures relies on specific methodologies characterized by flexibility, efficiency, and responsiveness to structural and environmental constraints. The most prominent methodologies include:

• **Modular Approach:**

This methodology is based on designing repeatable and combinable modular units, which facilitate assembly and installation while allowing for easy reconfiguration of interior spaces.

• **User-Centered Design:**

Focuses on studying users' needs and their interactions with space to ensure the creation of a functional and comfortable environment.

• **Sustainable Design:**

Adopts strategies aimed at reducing the environmental footprint by selecting recyclable materials, optimizing natural ventilation and lighting, and minimizing energy consumption.

• **Participatory Design:**

Involves the end user or stakeholders in the decision-making process to ensure that the design aligns with real-world practicalities

9. Comparative Case Studies

9.1 Urban post-disaster housing prototype for NYC by garrison architects -2014

Project name: urban post disaster housing prototype

Location: Brooklyn, NY, USA

Type: modular housing

Status: complete

Size: 2,100 sqf.

Client: NYC office of emergency management

Project manager: army corps of engineers

General contractor: American manufactured structures and services

Architect: garrison architects

The parameters for the studying cases:

- **Form:** Modular, simple geometric form with neutral metal façades; focused on function over visual appeal.
- **Function:** Prefabricated units for rapid deployment in disaster situations, covering basic living needs.
- **Technology:** Steel modular construction; fully prefabricated; can be installed in under two days; includes basic utilities.
- **Environmental Factors:** Moderate insulation; limited natural ventilation; primarily dependent on mechanical systems.
- **Economic Factors:** Low per-unit cost; designed for immediate use; lifespan is functional but not long-term optimized.
- **Social Factors:** Provides safety and shelter quickly but offers minimal cultural customization or aesthetic comfort

The modular mobile housing prototype was designed in collaboration with the New York City Office of Emergency Management (NYC OEM), aiming to provide rapid shelter for victims of natural or man-made disasters. Multi-story modular units can be deployed in less than 15 hours and installed in vacant urban lots or between existing buildings.

The Emergency Housing Units project by Garrison Architects stands as one of the most prominent contemporary examples of flexible modular interior design in lightweight structures. It clearly embodies the principles of sustainable design, user-centered design, and rapid planning for disaster response.

Figure 7. The prototype stacks three modules to create a multifamily building
(URL: https://humble-homes.com/modular-disaster-housing-garrison-architects/)

The prototype is intended to serve displaced city residents in the event of a natural or man-made disaster. When needed, the living units are delivered to the site, craned into place, and plugged into services. The design utilizes the latest construction technology and adheres to demanding requirements for safety, sustainability, durability, and universality. their flexibility allows for deployment in various urban environments, including vacant lots, private yards, and public spaces.

Figure 8. The prototype interior design & furniture (URL: https://tinyurl.com/7tccd7n4)

Each housing module features a balcony, with floor-to-ceiling entry doors and integrated shading to lower solar gain while providing larger windows. The units are built entirely with recyclable materials, cork floors, a double-insulated shell, and without the use of formaldehyde. The design includes the ability for attachment of photovoltaic panels, which serve to reduce pressure on the city energy grid and allow the structures to be self-sustaining.

Architect james garrison states, ‘aside from the basics of providing shelter after a disaster, the prototype is innovative because it allows residents to remain within their communities instead of being displaced for months, or even years. “shelter in place” allows residents to maintain their support networks – their friends and their families. keeping neighborhoods intact is crucial for successful rebuilding.’

The beauty of the units lies in their inherent flexibility. they can be stacked like legos to create row housing, or they can be interspersed between existing homes and structures. these modules aren’t just for new york city – they were designed to meet the strictest zoning requirements in the US, meaning they can be quickly deployed to any corner of the country.’

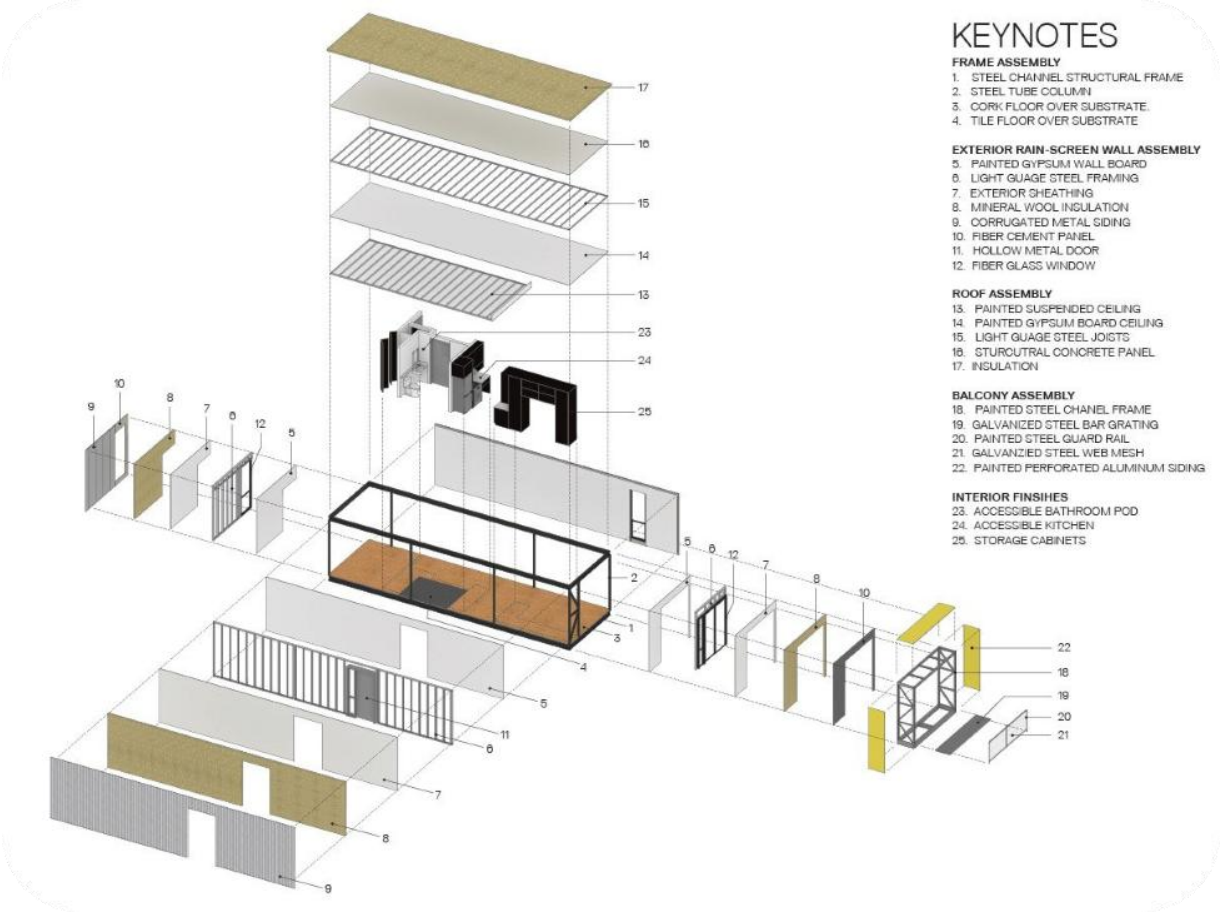

Figure 9. The components and layers of the living module (URL: https://tinyurl.com/yc27283z)

Interior Design and Details

- **Interior Configuration:**

The units come in one-bedroom or three-bedroom layouts and include a living area, fully equipped kitchen, bathroom, and storage space.

- **Materials and Finishes**:

Cork flooring is used throughout, and the walls are double-insulated and formaldehyde-free.

- **Functional Flexibility:**

Furniture is integrated and multi-functional, such as foldable beds and concealed storage units, allowing space to be adapted to usage needs or number of occupants.

- **Light and Ventilation:**

Floor-to-ceiling windows and balconies reduce solar gain while maximizing natural light.

Upper openings allow for natural ventilation, and the units can be equipped with solar panels for energy self-sufficiency.

- **Sustainability:**

The units are constructed with recyclable materials and designed to accommodate photovoltaic panels, reducing grid dependency and enhancing renewable energy use.

They are also designed according to universal design standards, ensuring accessibility for people with disabilities.

Performance and Outcomes

- **Installation:**

  The prototype was installed in Brooklyn in less than 13.5 hours, with the unit ready for occupancy within two days after delivery and assembly.

- **Pilot Use:**

  The units underwent temporary occupancy testing by students and research teams over several years at the official site near Cadman Plaza.

- **Awards and Recognition:**

  The project received the **AIA/NYS Design Merit Award**, the **MASterworks Award** from the Municipal Art Society of New York, and the **Built Environment Award** from Core77 in 2015.

9.2 Tetra Pod / Stilt Studios-2021

Project name: 2 Tetra Pod / Stilt Studios
Location: Uluwatu, Bali, Indonesia
Type: sustainable house
Status: complete
Size: 64 m2
Architect: stilt studios

The parameters for the studying cases:

- **Form:** Distinctive geometric shape with slanted rooflines; uses warm, natural timber for visual integration with surroundings.
- **Function:** Adaptable interior layouts for tourism, temporary housing, or flexible living needs; allows for expansion.
- **Technology:** Elevated stilt system for flood resilience; sustainably treated timber; fully demountable and re-assemblable.
- **Environmental Factors:** Maximizes daylight and natural ventilation; minimizes environmental footprint; uses renewable materials.
- **Economic Factors:** Higher initial investment but reusable, movable, and adaptable, reducing long-term costs.
- **Social Factors:** Creates visually pleasant and adaptable spaces that fit various cultural and social contexts

Stilt Studios present the first finalized Tetra Pod Studio in Uluwatu, Bali. A prefabricated tiny house using recycled Tetra Pack Cartons as wall and roof material, bringing together unique design while playing a part in the local, circular economy. The Tetra Pod is a 64sqm home with all living amenities elevated 40cm off the ground, built from wood, steel, glass and recycled materials. The architecture seeks to blend into its surroundings by making use of the recycled materials' reflective characteristics, while strategically placed openings carefully frame view corridors. The diagonally oriented floor plan creates exciting spaces that exude outward into the exterior. The balanced compromise of open facades and the use of space make this small home elegant and spacious.

Figure 10. The Tetra Pod living module (URL: https://tinyurl.com/ymvdcknn)

- **Eco-Friendly Materials:**

The project utilized recycled Tetra Pak containers in parts of the walls and roof, along with solid wood, steel, and glass, contributing to integrating the design within the local circular economy and reducing waste.

- **Construction Techniques and Environmental Impact Reduction:**

The unit is elevated approximately 40 cm above the ground using simple base supports, which reduces impact on the soil, allows air circulation underneath, and helps avoid

- **Natural Lighting and Ventilation:**

The design relies on large openings and operable glass doors that provide cross-ventilation, while the angled roof overhang helps reduce direct sunlight and enhances passive cooling.

- **Thermal Insulation and Environmental Control:**

The large sloped roof is designed to drain rainwater and cool the unit, while the use of reflective materials minimizes heat absorption. The project's EDGE Advanced Certification indicates a design that achieves high efficiency in energy and water usage and reduces CO_2 emissions

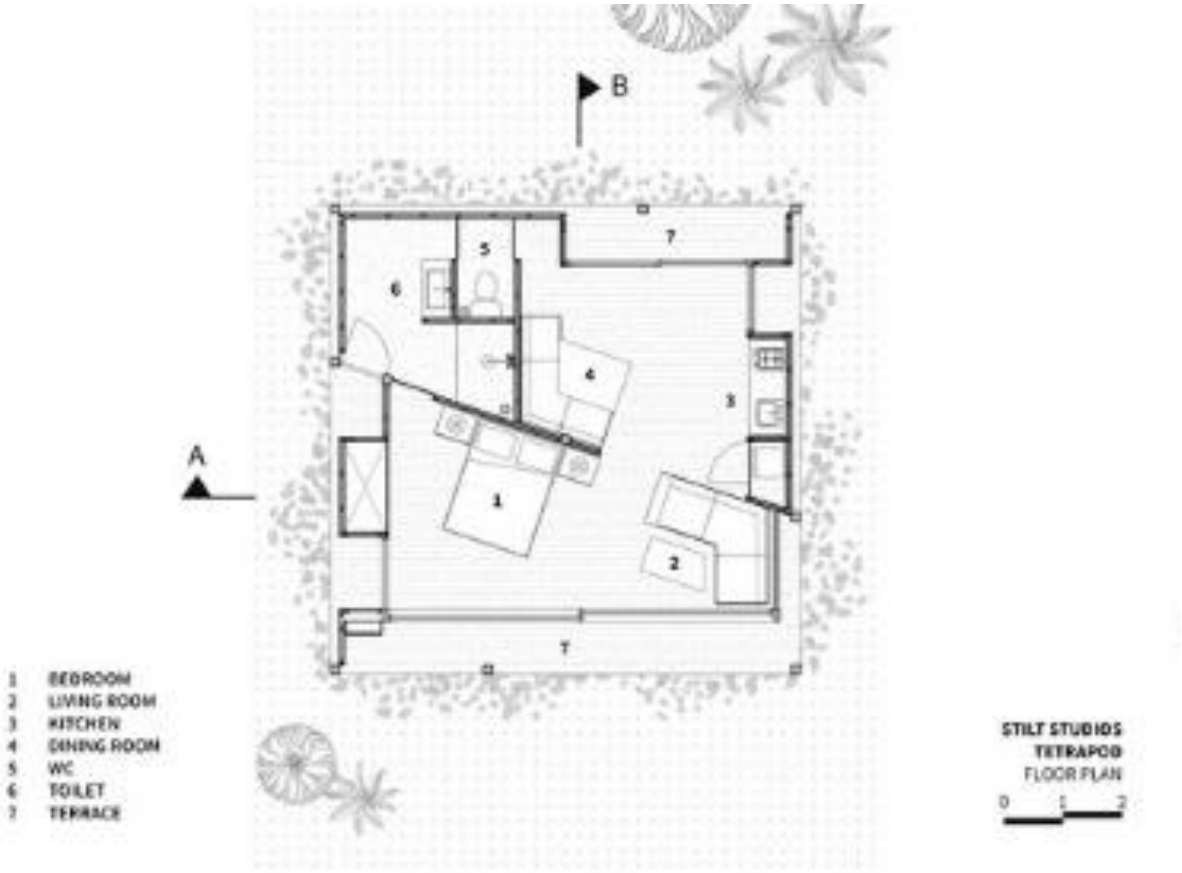

Figure 11. The Tetra Pod living module plan (URL: https://tinyurl.com/wde9mkbf)

- **Smart layout and Compact Spaces:**

The unit includes a bedroom, en-suite bathroom, open-plan living area, compact kitchen, and a multi-purpose space, all within only 64 m².

The design creates a sense of openness through glass doors that connect directly to the outdoor deck.

- **Furniture and Accessories:**

The interior features custom-built, integrated furniture made of teak wood, such as a built-in dining table and chairs, enhancing the quality of the user experience while offering multi-functional use within the limited space.

Figure 12. The Tetra Pod living module interior (URL: https://tinyurl.com/2ud5anth)

Results and Impact

1. Fast Implementation and Portability:

The model was installed in approximately 8 weeks**,** and it features easy disassembly and relocation to new sites thanks to its prefabricated industrial construction system**.**

2. Affordable Cost:

The estimated construction cost is around USD 45,000**,** while construction drawings can be purchased for about USD 5,000 per set**,** enabling global implementation without high design expenses.

3. Environmental Certification:

The project received the EDGE Advanced certification from the Green Building Council in Indonesia, confirming its commitment to reducing energy and water consumption and minimizing environmental impact**.**

Table .3: Comparison Table between Two Lightweight Structure Projects from the Perspective of Interior Design Standards

Criterion / Project	Urban Post-Disaster Housing Prototype – NYC (Garrison Architects, 2014)	Tetra Pod (Stilt Studios, 2021)
Main Purpose	Provide high-efficiency temporary housing for disaster response in urban areas	Create mobile, eco-friendly luxury housing units in natural or tourist locations
Flexibility & Adaptability	Modular design allows rapid assembly and relocation to various sites	Units on stilts that can be easily transported and adapted to different terrains
Interior Layout	Compact, well-organized spaces to maximize functional efficiency, with separate living and sleeping areas	Open-plan layout integrating living areas and kitchens, with panoramic environmental views
Psychological Comfort	Provides basic comfort with a focus on safety and privacy in post-disaster environments	Creates a relaxing, luxurious atmosphere using natural light, ventilation, and open visual spaces
Interior Materials	Industrial, water- and fire-resistant materials that are easy to maintain	Natural materials such as recycled wood and aluminum, with high-end design finishes
Lighting	Basic artificial lighting supported by openings for balanced natural light	Extensive use of natural light through glass facades, with integrated LED lighting
Environmental Sustainability	High energy efficiency with potential integration of solar power	Solar energy systems, rainwater harvesting, and eco-friendly materials
Applied Standards	Safety and accessibility standards (ADA), temporary housing requirements	Sustainable design concepts, green building principles, eco-hospitality standards
Aesthetics	Simple, functional design with neutral colors to reduce stress during crises	Contemporary, elegant design blending simplicity and luxury with warm colors and natural patterns
Construction Timeframe	Few weeks from manufacturing to installation	Moderate manufacturing period with quick on-site assembly

10. Results and Recommendations:

10.1 Results:

- **Efficiency of Lightweight Structures in Meeting Contemporary Needs**:

The study demonstrated that lightweight structures offer rapid, cost-effective, and sustainable architectural solutions, particularly in emergency, transitional, and resource-limited contexts. The integration of well-planned interior design maximizes spatial efficiency and adaptability.

- **Interior Design as a Core Factor for Functional and Aesthetic Performance**:

Findings revealed that carefully planned interior design is essential for enhancing operational efficiency, physical comfort, and psychological well-being within lightweight structures. Smart space planning, multifunctional furniture, and optimized circulation patterns transformed compact spaces into practical and flexible environments.

- **User-Centered and Participatory Approaches**:

Projects involving active user participation—such as Incremental Housing in Chile and Participatory Shelter in Nepal—proved more culturally appropriate, socially accepted, and functionally efficient, fostering a stronger sense of ownership and community engagement.

- **Integration of Sustainability Principles and Global Standards**:

Successful case studies incorporated passive cooling, natural lighting/ventilation, and recycled materials, aligning with recognized international frameworks such as LEED for Interior Design and Construction (ID+C), WELL Building Standard, and EDGE Certification. These frameworks provide measurable benchmarks for health, environmental responsibility, and energy efficiency within lightweight interior solutions.

- **Economic Viability of Intelligent Interior Design**:

Case studies such as the Tetra Pod House and Modular Pods by Crisis UK demonstrated that high-quality interior design can be achieved without excessive budgets, provided that projects employ scalable modules, cost-effective materials, and resource-efficient planning

Table .4: illustrating the key differences between lightweight structures when interior design standards are applied versus when they are not, with a focus on functional, aesthetic, and environmental aspects."

Item	With Application of Interior Design Standards	Without Application of Interior Design Standards
Interior Space Quality	Organized layout, optimal space utilization	Disorganized layout, wasted or overcrowded spaces
User Comfort	High levels of thermal, visual, and acoustic comfort	Poor ventilation, inadequate lighting, high noise levels
Flexibility & Adaptability	Easy to modify or reconfigure spaces for different uses	Difficult to reconfigure or adapt to new needs
Aesthetic Aspect	Clear and attractive design identity, harmony between colors and materials	Weak overall appearance, lack of visual harmony
Environmental Performance	Improved energy and material efficiency, reduced waste	Higher energy consumption, use of non-sustainable materials
Space Lifespan	Extended lifespan due to quality finishes and materials	Rapid deterioration due to poor material selection
User Satisfaction	High satisfaction by meeting functional and aesthetic needs	Low satisfaction, frequent complaints about poor design

10.2 Recommendations:

- **Integrate Interior Design in Early Planning Stages**:

Planners and designers should ensure that interior design strategies are incorporated from the initial project concept stage to maximize space utilization, enhance comfort, and ensure adaptability in lightweight structures.

- **Adopt Modular and Flexible Interior Layouts**:

Developers and implementing agencies are advised to adopt standardized modular layouts that can be reconfigured over time to accommodate evolving user needs, such as remote work or family expansion).

- **Apply User-Centered and Participatory Design Approaches**:

Government bodies and non-profit organizations should involve end-users in the design process, particularly in social housing, disaster relief shelters, and temporary housing, to ensure higher cultural relevance and user satisfaction.

- **Promote the Use of Sustainable and Recycled Materials**:

Construction companies and suppliers should prioritize locally sourced, recycled, or renewable materials to improve thermal and acoustic performance while reducing the carbon footprint.

- **Incorporate Smart and Passive Environmental Systems**:

Designers and engineers should leverage natural lighting, natural ventilation, and passive heating/cooling strategies to minimize reliance on mechanical systems and improve energy efficiency.

- **Provide Open-Source Design Models**:

Academic institutions and leading firms should publish successful design layouts (as in the *Tetra Pod* project) on open-access platforms to encourage knowledge sharing and global adaptation.

- **Invest in Research and Prototyping**:

Governments, universities, and the private sector should collaborate to develop new interior solutions that enhance urban resilience, address post-crisis housing needs, and align with Sustainable Development Goals (SDGs).

11. Conclusion:

This research has demonstrated that lightweight structures represent an effective architectural solution to contemporary challenges such as sustainability, flexibility, rapid construction, and cost efficiency. However, the study reveals that their success depends not only on structural systems or materials, but—critically—on the efficiency of interior design, which acts as the key link integrating functionality, aesthetics, and user-centered responsiveness.

Through the case studies, it has been shown that smart and adaptable interior design can transform compact spaces into fully functional environments that provide both psychological and physical comfort, while also supporting sustainability principles through natural lighting, efficient ventilation, and multifunctional built-in furniture. Moreover, user-centered and participatory approaches enable communities to actively shape spaces that reflect their identity and needs, fostering a stronger sense of belonging and social engagement.

The unique contribution of this study lies in establishing a direct and evidence-based framework that positions interior design as a strategic driver for the performance and social value of lightweight structures—a perspective that has been underexplored in prior research. By integrating design strategies with structural and environmental considerations, this research provides architects, urban planners, and policymakers with actionable guidelines to enhance quality of life, reduce environmental footprint, and address the evolving demands of modern societies, particularly under the pressures of digital and environmental transformations.

- **Conflict of Interest**

The author confirms that there are no conflicts of interest.

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