Rebuilding Lives: An Assessment of Renovation Strategies for Temporary Shelters in Gaza

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Abstract: Temporary shelters in refugee camps often fail to provide sustainable and livable solutions for prolonged displacement, particularly in regions like Gaza, where hot, dry summers and cool, humid winters, combined with frequent power outages, intensify challenges to indoor environmental quality. This study aims to explore practical and sustainable renovation strategies to upgrade container shelters by enhancing thermal comfort, natural ventilation, and daylighting performance. Four passive interventions were proposed: integrating recycled concrete aggregate (RCA) walls for thermal mass, adding perforated facades to regulate airflow and solar gain, incorporating ventilated air gaps to improve insulation, and applying green systems on roofs or facades. The effectiveness of these strategies was evaluated using different simulations. The results showed indoor temperatures dropped by up to 3.14°C, Relative humidity levels stabilized within the range of 31–66%, and daylight performance improved, with Spatial Daylight Autonomy (SDA) reaching up to 42%. These strategies demonstrated the potential to minimize reliance on mechanical systems while supporting sustainability goals. The study provides a replicable framework for upgrading container shelters in resource-constrained, crisis-affected environments.

Keywords— Refugee Shelters, Container Modules, Thermal Performance, Natural Ventilation, Daylighting, Recycled Concrete Aggregate (RCA), Passive Design, Sustainable Architecture.

I. Introduction

The Gaza Strip has been subjected to recurring military conflicts that have devastated its urban fabric, displaced thousands of residents, and left vast amounts of rubble and destruction in their wake. Between 2008 and 2023 alone, tens of thousands of homes and critical infrastructure assets were either destroyed or severely damaged. As a result, many families have been forced to live in temporary shelters that are often inadequate in terms of comfort, safety, and sustainability.

Conventional approaches to post-disaster housing in Gaza have relied heavily on emergency tents or prefabricated units that fail to meet the region's climatic, cultural, and socio-economic needs. These structures typically offer limited thermal insulation, poor ventilation, and insufficient daylighting, exacerbating living conditions in a region characterized by relatively hot summers and cold, humid winters, and chronic electricity shortages. Furthermore, these solutions often neglect the psychological and social well-being displaced populations or leverage the abundant local construction waste resulting from war damage.

II. Utilizing Recycled Concrete Aggregate (RCA)

Over the past years, the Gaza Strip has suffered from repeated wars that caused massive destruction to infrastructure and residential buildings, leading to the displacement of thousands of families and the accumulation of vast amounts of rubble. For instance, during the 2008–2009 war, approximately 4,100 buildings were destroyed and 17,000 were partially damaged. In 2014, this number surged to 12,000 fully demolished buildings and 160,000 partially damaged. By 2023, the scale of destruction reached unprecedented levels, with more than 52,564 buildings destroyed and 227,591 partially damaged [1]. In response to this ongoing devastation, this study proposes the use of recycled concrete aggregate (RCA) as a primary material for reconstructing sustainable and resilient temporary shelters in Gaza. The choice of RCA is based on four main pillars: environmental, economic, social, and technical considerations.

Environmentally, utilizing RCA helps address the urgent issue of rubble accumulation by diverting construction and demolition waste from already overwhelmed landfills. Gaza's limited landfill capacity is under intense pressure due to repeated conflicts, and improper waste management contributes to dust pollution and soil contamination. Recycling this debris into usable aggregates aligns with circular economy principles, reduces environmental degradation, conserves natural resources, and lessens dependence on scarce virgin materials like sand and gravel, both of which are limited in Gaza due to border restrictions [2], [3].

Economically, RCA offers a cost-effective alternative to natural aggregates, which are both expensive and difficult to import under the blockade. By relying on locally available rubble, RCA reduces construction costs and dependency on external suppliers. Furthermore, the recycling process itself generates employment opportunities—from rubble collection and material processing to actual construction—thus supporting Gaza's fragile economy and addressing high unemployment levels [4].

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Socially, RCA has become a familiar and trusted construction material among residents, particularly due to their repeated exposure to rebuilding efforts over the years. Many families have engaged directly or indirectly in reconstruction using recycled materials, making RCA a culturally recognizable and accepted solution. This familiarity enhances community trust and facilitates smoother integration of RCA in shelter projects, minimizing resistance and enabling faster, more community-centered implementation. Furthermore, the affordability of RCA-based materials supports vulnerable populations by providing accessible housing solutions that are durable, culturally appropriate, and environmentally responsible.

Technically, RCA has demonstrated sufficient mechanical strength and stability for non-permanent shelter applications. When properly processed, it can meet the structural requirements of temporary housing, ensuring safety and reliability during reconstruction phases.

In summary, the use of RCA in this study represents a holistic and context-specific solution to the complex reconstruction challenges in Gaza. It promotes waste reduction, supports economic resilience, reinforces social acceptance, and meets technical needs—all while leveraging local resources to deliver sustainable, culturally appropriate, and cost-efficient shelter solutions.

III. Containers As Shelters

Sheltering displaced people during and after the conflict periods, such as in the Gaza Strip, temporary shelters must be rapidly deployable, structurally resilient, and adaptable to local socio-economic conditions. Shipping containers offer a compelling solution to these challenges. Their structural strength, modularity, and global availability make them a practical option for emergency housing. Containers can be quickly deployed and modified to create living units, clinics, or classrooms, offering a flexible response to large-scale displacement [5].

Containers are especially advantageous in Gaza's context due to ongoing import restrictions, limited access to construction materials, and high population density. As metal structures, containers are easily stackable and can be adapted with proper insulation, ventilation, and solar energy systems to meet thermal comfort needs [6]. Moreover, their use minimizes the need for new raw materials and supports the circular economy through adaptive reuse [7].

Despite these benefits, several studies and field experiences point to the challenges of container housing. Without proper insulation and ventilation, containers can become uninhabitable in extreme climates, leading to significant discomfort, as seen in families forced to live in bare steel containers after the 2014 war in Gaza [8]. Therefore, any shelter project based on containers must address thermal performance, ventilation, and privacy to ensure dignity and well-being for displaced residents.

This study addresses the urgent need for more resilient and sustainable shelter strategies by exploring the use of recycled shipping containers as temporary housing units. By integrating recycled concrete aggregate (RCA), passive ventilation techniques, green systems, and daylighting interventions, the study proposes a series of renovation strategies aimed at improving thermal comfort, energy efficiency, and environmental performance. These strategies are not only tailored to Gaza's specific environmental and social context but also scalable and cost-effective for broader post-conflict reconstruction scenarios.

Through simulation-based performance assessments, this research evaluates the effectiveness of four renovation models, emphasizing the role of passive design and local materials in transforming standard container modules into livable, culturally appropriate, and environmentally responsive shelters. The findings aim to contribute to the growing body of knowledge on sustainable post-disaster architecture while providing a replicable model for shelter provision in crisis-affected regions.

IV. Methodology

The study employs a theoretical and simulation-based methodology to evaluate sustainable renovation strategies for container modules repurposed as temporary shelters in Gaza. The approach is grounded in a multi-criteria framework that encompasses five critical dimensions: construction and materials, sociology, ecology, cost, and building physics.

Following a thorough literature review on post-disaster housing and passive design strategies, the research focused on the performance evaluation of a standard steel container module with dimensions of 6.02 m × 2.40 m × 2.70 m. This container served as the baseline model for testing four renovation scenarios that incorporate recycled concrete aggregate (RCA), passive ventilation, insulation layers, and green architectural features. The four renovation plans included:

- Renovation (1). RCA Wall and Roof Integration:

Renovation 1 focused on improving the thermal insulation of the container by applying an interior wall layer and ceiling panel made of recycled concrete aggregate (RCA). The RCA materials act as thermal mass, reducing heat transfer and stabilizing indoor temperatures. A perforated metal sheet was also added to the façade to enhance ventilation and reduce direct solar gain.

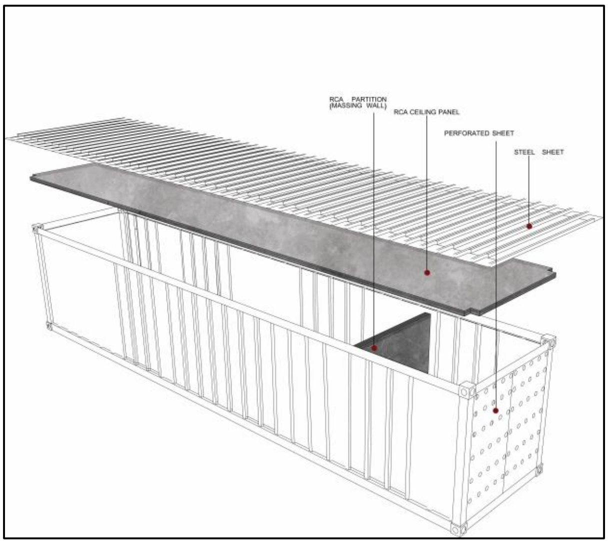

Figure1. Renovation 1 model: adding RCA partition and RCA ceiling layer

- Renovation (2). Perforated Facade System with Adaptive Materials**:**

This renovation examined the impact of different materials for the perforated façade layer, including tent fabric, wood panels, and RCA boards. While the change in materials had minimal effect on indoor temperature, the focus shifted toward optimizing the air gap between the perforated layer and the main wall to improve thermal buffering and spatial functionality.

A 120 cm air gap was selected to serve as a semi-outdoor shaded space, enhancing privacy and usability in crowded camp settings. This configuration contributed to better airflow and provided a social interface, demonstrating how adaptive façade design can enhance both thermal comfort and spatial quality.

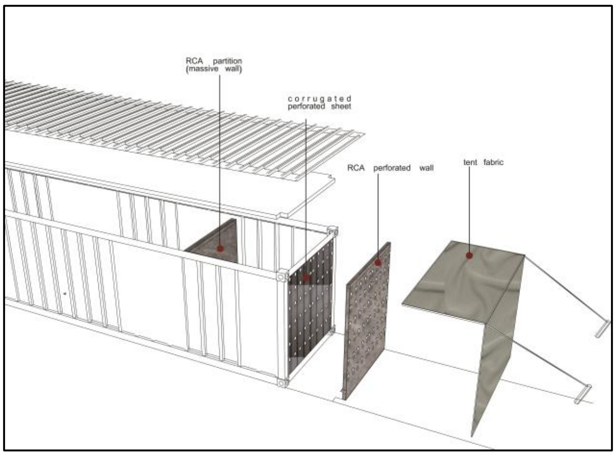

Figure 2. Renovation 2 model: types of material for perforated layer

- Renovation (3). Elevated Structure and Multi-Layered Insulation**:**

Renovation 3 introduced full wall insulation using 5 cm RCA panels combined with a 2 cm air gap, along with elevating the container 60 cm above ground level. This design aimed to minimize heat transfer from both walls and the ground, improving indoor comfort across seasons.

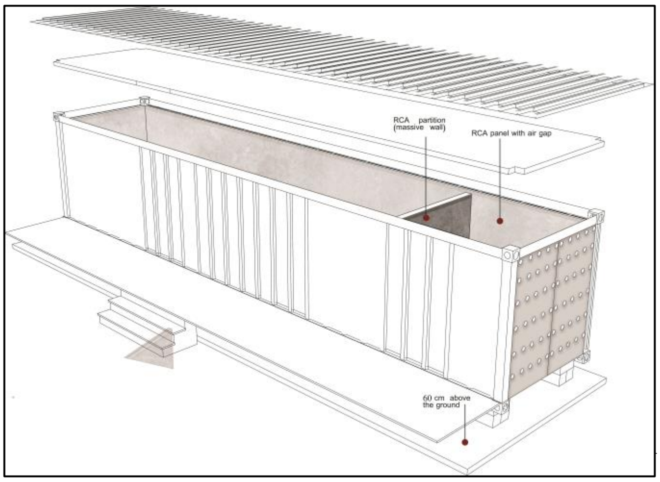

Figure 3. Renovation 3 model: Adding insulation to the walls and elevating the structure above the ground

Vegetation**:**

Integration of green systems, including green roofs and vegetated façades, to examine their role in thermal regulation and environmental performance.

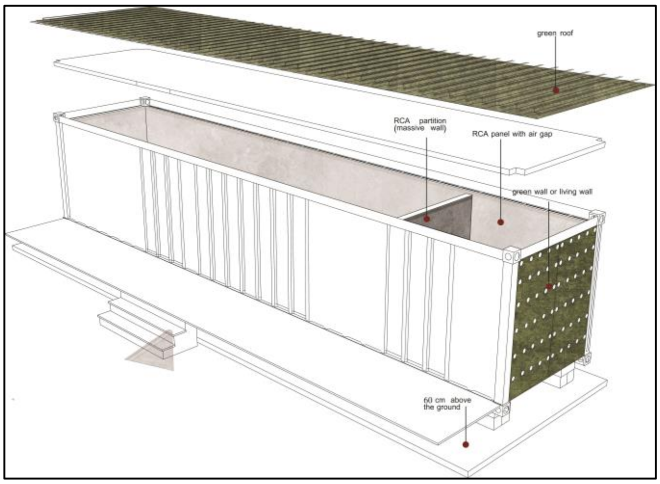

Figure 4. Renovation 4 model: Adding greenery

Thermal performance for all scenarios was assessed using Design Builder as a simulation software that enables analysis of indoor temperature profiles, relative humidity levels, and airflow metrics. Performance metrics such as indoor temperature reduction, humidity optimization, and reduction in energy dependency were used to compare the efficacy of each intervention.

This methodology supports the design of low-cost, sustainable shelter models that are adaptable to the environmental, economic, and social constraints of crisis-affected regions such as Gaza. The findings aim to inform future reconstruction strategies that prioritize local materials and passive solutions.

V. LITERATURE REVIEW

The sustainable use of RCA has been widely studied due to its potential to reduce environmental impact and improve building performance, especially in regions facing material scarcity and reconstruction challenges. Several key studies have focused on thermal and mechanical properties of RCA-based materials, as well as innovative design approaches to enhance insulation and structural viability. The following subsections summarize the main findings for important recent investigations in this field:

A. Thermal Performance of Treated RCA

Kazmi et al. [9] investigated how different treatment methods affect the thermal conductivity and mechanical properties of concrete containing RCA. Treatments included accelerated carbonation, lime soaking combined with carbonation, and acetic acid soaking. Results showed that untreated RCA concrete had about 27% lower thermal conductivity than natural concrete, which helps reduce heat transfer. Treated RCA improved thermal conductivity closer to natural concrete levels while maintaining adequate compressive strength. The study also developed a regression model to predict thermal conductivity based on treatment type, offering practical guidelines for optimizing recycled concrete in construction.

B. Effect of RCA Replacement Ratio and Block Design on Thermal and Structural Properties

Zhu et al. [10] studied the thermal behavior of RAC with varying replacement ratios and designed recycled concrete blocks with different hole patterns to improve insulation. They found that higher RCA content lowers the thermal conductivity of concrete, enhancing its insulating capacity. Blocks with three staggered rows of holes showed higher thermal resistance (0.63 $m^2 \cdot K/W$) than solid or single-row blocks, by increasing heat flow path length and reducing density. Importantly, these blocks also achieved a compressive strength of 7.53 MPa, making them structurally viable for use as bearing walls.

C. Post-War Reconstruction

The destruction wrought by wars severely hampers social, economic, and infrastructural functions in affected regions. In such contexts, infrastructure becomes the foundation of post-war reconstruction. As Baradan [11] notes, infrastructure restoration is not a singular technical task, but a multi-dimensional process that seeks to achieve a balance between social, economic, and environmental priorities. The rebuilding of essential services such as housing, transportation networks, electricity, and water systems forms the backbone for long-term stability and recovery.

Given the frequent scarcity of resources and environmental degradation in post-conflict settings, recycled materials such as recycled concrete aggregates (RCA) can play a critical role in supporting reconstruction efforts. Barakat [12] emphasizes the importance of adaptable and rapid-deployment temporary housing strategies that meet both structural and thermal comfort requirements. In this regard, integrating RCA into shelter design not only improves thermal and structural performance but also reduces construction costs—especially when guided by innovative, sustainable design principles.

Moreover, UN-Habitat [13] recognizes the urgent need for reconstruction approaches that promote equity and resilience. The agency supports the use of sustainable materials like RCA, which contribute to restoring both physical infrastructure and community integrity. Linking the material properties of RCA with the broader goals of post-war reconstruction offers a promising framework for environmentally and socially responsible rebuilding.

Figure 5. Recycled concrete block with three rows of holes. Zhu et al. [10]

D. *Post-Disaster Housing and Shelter Solutions*

The destruction of housing in war zones leads to long-term displacement, economic collapse, and social fragmentation, requiring specific shelter strategies tailored to both immediate and long-term needs. Emergency shelters provide quick protection but are not suitable for prolonged use. Collective shelters, often established in public buildings, offer temporary refuge but suffer from overcrowding and poor conditions. Temporary and transitional shelters (T-Shelters) bridge the gap between emergency response and permanent housing, allowing displaced populations to stay near their communities while reconstruction progresses. The shelter timeline generally progresses from emergency (weeks), to temporary (weeks to six months), to temporary housing (months to years), and finally to transitional shelters until permanent homes are built. However, delays in reconstruction often extend the use of temporary shelters, highlighting the importance of adaptable solutions that address both safety and long-term stability in post-conflict contexts [14]– [18].

VI. Simulation Results and Performance Analysis

This study aimed to explore and develop passive renovation strategies to improve the environmental performance of container shelters used as temporary housing in displacement contexts, with a focus on the climatic and socio-economic conditions of the Gaza Strip. A set of sustainable architectural interventions was designed to enhance thermal comfort, natural ventilation, and daylighting through detailed digital modeling of a standard container unit using DesignBuilder, which operates based on the EnergyPlus simulation engine. This software was used to evaluate the effectiveness of the proposed strategies under both summer and winter scenarios at the site, analyzing their impact on indoor conditions in terms of temperature, humidity, and natural lighting. The strategies were applied individually and in combination, allowing for a comparative analysis of their integration and effectiveness as replicable solutions in crisis-affected environments.

Despite the promising outcomes derived from the simulation models, this study is limited by the absence of real-world field data and user feedback. The simulations do not account for unpredictable user behavior, variations in occupancy patterns, or behavioral adaptations that may influence thermal comfort and energy use. Future research should incorporate post-occupancy evaluations and field measurements to validate the effectiveness and human-centered impact of the proposed renovation strategies.

A. Thermal Performance Enhancement through Renovation Strategies

The thermal performance of the base case container module showed significant inefficiencies, with internal temperatures reaching 36.43°C and relative humidity peaking at 93.25%. The total fresh air value during summer was 0.704, which falls below recommended levels for comfort and health.

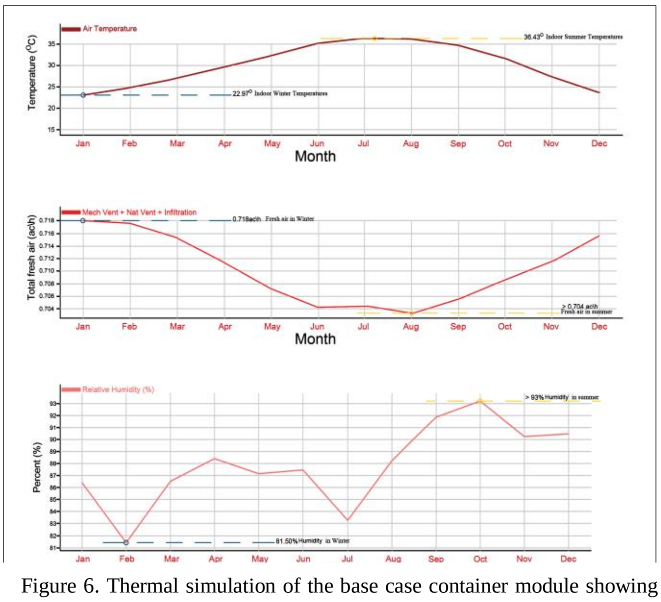

Figure 6. Thermal simulation of the base case container module showing temperature and humidity distribution. Source: generated by the authors using DesignBuilder based on the unmodified container model.

These findings highlight the unsuitability of unmodified containers for use as temporary shelters in hot climates like Gaza, especially considering limited energy access.

Four renovation strategies were simulated and analyzed:

Renovation Plan 1: The incorporation of a recycled concrete aggregate (RCA) wall reduced internal temperatures from 36.43°C in the base case to approximately 33.29°C, reflecting the effectiveness of the wall in enhancing thermal insulation and minimizing heat transfer from the exterior. Furthermore, integrating perforated sheets within the RCA wall substantially improved natural airflow rates compared to the base case value of 0.704, reducing the reliance on mechanical ventilation systems. This enhancement contributes to the sustainability of the design by lowering the energy consumption required to maintain a healthy and comfortable indoor environment. Additionally, the combined effect of improved insulation and ventilation led to a marked decrease in relative humidity, dropping from 93.25% in the base case to values ranging between 31% and 66% throughout the year, thereby improving indoor environmental quality.

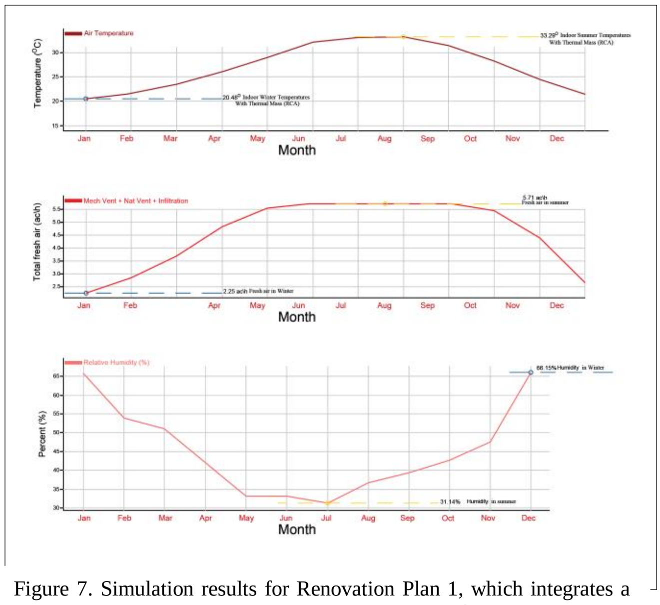

Figure 7. Simulation results for Renovation Plan 1, which integrates a recycled concrete aggregate (RCA) wall with perforated sheets. The graph illustrates the improvements in internal temperature, airflow rate, and relative humidity compared to the base case. Source: Generated by the authors using DesignBuilder.

Renovation Plan 2: Modifying the types of materials used for the perforated façade did not result in significant changes in the internal temperatures of the container. This suggests that a variety of materials can be employed for the external layer without compromising thermal performance, allowing for flexibility in the wall's final composition. Regarding the air gap, various distances—60 cm, 90 cm, and 120 cm—were tested. The 120 cm gap was selected not only for its thermal benefits but also for its potential to function as a semi-outdoor space that enhances privacy. This is particularly valuable in densely populated settings such as refugee camps. Figure (8) presents a comparison of internal temperatures associated with different perforated wall materials.

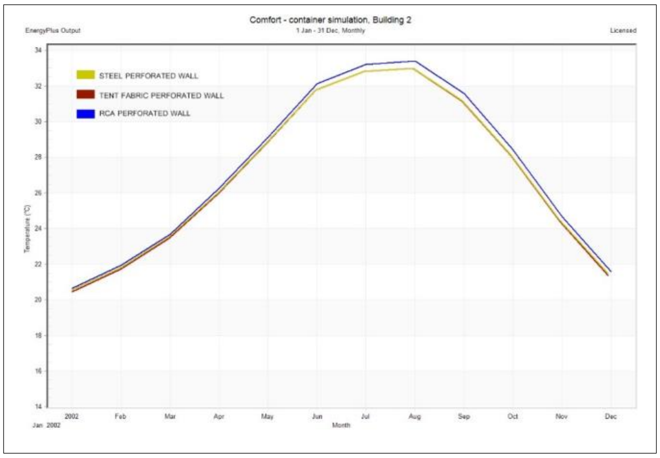

Figure 8. Simulation results for Renovation Plan 2, comparing the impact of different perforated façade materials and the implementation of a 120 cm air gap. This strategy aimed to maintain thermal performance while introducing semi-outdoor space and privacy. Source: Generated by the authors using DesignBuilder.

Renovation Plan 3: Introduced further enhancements to thermal performance beyond the previous strategies. In terms of summer conditions, the indoor temperature was reduced to a level 1.71°C lower than the outdoor environment, marking a clear improvement over the second renovation phase, which had achieved an indoor temperature of 33.29°C. This additional reduction indicates that the RCA wall's insulation performance was further optimized, contributing to better thermal regulation and decreased reliance on mechanical cooling systems. During winter, the indoor temperature in January was 4.62°C higher than the outdoor temperature, demonstrating enhanced heat retention compared to Renovation Plan 2, where the difference was present but not quantified. This improved thermal buffering capacity highlights the growing effectiveness of the renovation strategy in moderating indoor conditions year-round.

Renovation Plan 4: Introduced a nature-based strategy by integrating a green roof atop the container's external metal sheet and/or a green wall positioned in front of the perforated façade. Additionally, the container was elevated 60 cm above the ground to promote airflow beneath the structure. These interventions aimed to enhance the thermal performance of the container by leveraging natural insulation and improved ventilation. Simulation results indicated a significant decrease in indoor temperatures—ranging from 19.04°C in winter to 29.53°C in summer, even during periods of peak external heat. This suggests the strategy's effectiveness in minimizing heat gain and providing better thermal regulation, reducing the container's dependence on mechanical cooling systems. Furthermore, relative humidity levels during summer were significantly reduced to a range between 35.50% and 47.30%, compared to outdoor levels that typically exceed 60%. These findings highlight the positive impact of green systems in moderating indoor humidity and enhancing thermal comfort, ultimately contributing to healthier and more livable shelter conditions.

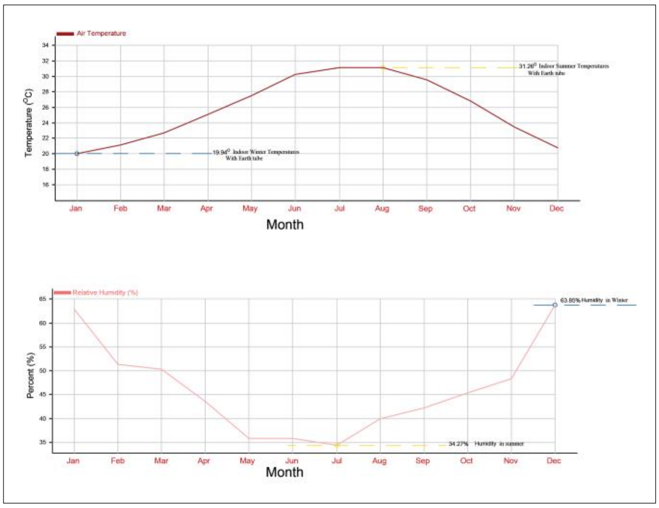

Figure 9. Simulation results for Renovation Plan 4, illustrating reductions in indoor temperature and relative humidity achieved through the integration of green systems and container elevation. Source: Generated by the authors using DesignBuilder.

After analyzing the impact of renovation strategies on the thermal performance and ventilation of containers, key criteria were identified to select the optimal design. These criteria included the container orientation, window-to-wall ratio (WWR), energy consumption, and the thickness of the recycled concrete aggregate (RCA) insulation wall. An optimization analysis was conducted using DesignBuilder to determine the best-case scenario. The results showed that the optimal design achieved the lowest energy consumption among all scenarios, reflecting its high efficiency. A window-to-wall ratio (WWR) of 36% provided an optimal balance between daylight access and thermal insulation. The cooling and heating setpoint temperatures of 28.0°C and 18.8°C, respectively, ensured thermal comfort while reducing energy use. The container orientation at 66 degrees enhanced natural ventilation and minimized radiant heat impact. Finally, the RCA insulation wall with a thickness of 0.2 meters provided effective thermal insulation, improving the sustainability and performance of the housing unit.

B. *Daylighting Performance and Design Adaptations*

A comprehensive daylighting analysis was conducted for the container module as a temporary shelter using key metrics such as Spatial Daylight Autonomy (sDA) and Daylight Factor (DF) to evaluate the effectiveness of natural light distribution within the space. The sDA results revealed poor performance in the lower zones of the unit, with values dropping to 0%, while areas near the windows reached approximately 46%, indicating significant disparities in daylight access. Similarly, the DF map showed higher values in the upper portions of the space—peaking around 15%—and extremely low values below 0.5% in the lower sections, suggesting imbalances in window placement, façade orientation, or potential obstructions. To address these deficiencies, a design intervention was introduced by adding two windows along the longer façade adjacent to the perforated wall. This modification aimed to improve the penetration and distribution of daylight while minimizing glare and excessive brightness. The new configuration achieved a more balanced interior lighting environment, enhancing visual comfort and reducing dependence on artificial lighting during the day. In the context of Gaza—where power outages are frequent and access to stable energy is limited—maximizing natural daylight becomes a crucial strategy. Such passive design solutions not only enhance occupant comfort but also align with broader sustainability goals in resource-constrained and crisis-affected environments.

The daylighting performance of the improved container module was evaluated using Daylight Factor (DF) and Spatial Daylight Autonomy (sDA) analyses.

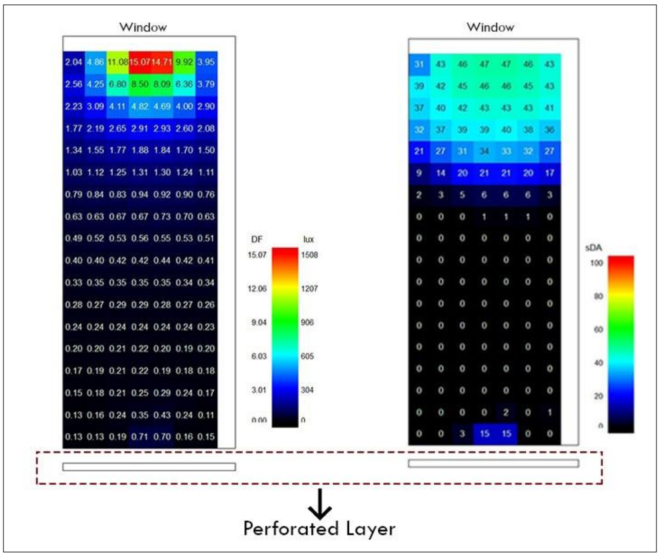

Figure 10. Daylighting simulation results of the base case container module, extracted from DesignBuilder. The sDA and DF maps reveal insufficient daylight in lower zones and uneven distribution, emphasizing the need for design interventions to enhance natural lighting.

The DF map indicates a relatively even distribution of daylight, with values ranging from 0.86% to 5.49%. Higher DF values were observed near the windows, where daylight penetration was more effective, while lower values appeared in areas farther from the openings. Although the presence of a perforated layer slightly reduced overall light intensity, it helped diffuse incoming sunlight and minimize glare, contributing to a more uniform light distribution. The sDA analysis revealed a significant disparity across the space, with areas near the windows achieving a maximum sDA of 42%, while deeper zones remained underlit. This analysis identified three critical aspects: (1) inadequate daylight levels in interior zones, which would necessitate artificial lighting; (2) effective glare reduction near openings due to the perforated layer; and (3) potential for enhanced energy efficiency if daylight penetration is improved. Given Gaza's chronic energy shortages and frequent power outages, enhancing passive lighting strategies is essential. Incorporating targeted design interventions, such as optimized window placement and light-diffusing elements, can significantly reduce reliance on artificial lighting, improve visual comfort, and support sustainable, livable conditions for vulnerable communities.

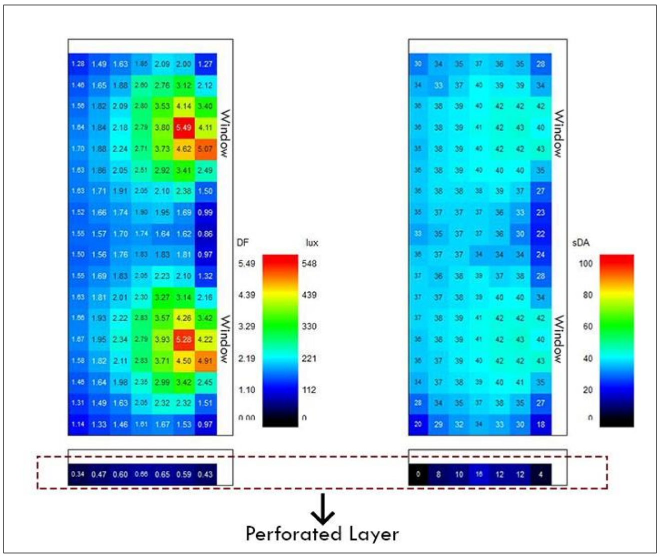

Figure 11. Enhancing Natural Lighting in Container Units Used as Temporary Shelters: An Analysis of Renovation Variables. The simulation illustrates the impact of perforated façades and window modifications on daylight distribution, emphasizing improved glare control and the need for deeper daylight penetration.

VII. Conclusion

This study assessed a set of passive and adaptive renovation strategies aimed at enhancing the thermal and daylighting performance of container modules used as temporary shelters in Gaza. The findings demonstrate that targeted design interventions—such as the integration of RCA walls, perforated façades, green roofs, and optimized window configurations—can significantly improve indoor environmental quality, even under extreme climatic and infrastructural constraints.

Thermal simulations demonstrated a significant reduction in both indoor temperature and relative humidity across various renovation scenarios. The most effective configuration reduced summer indoor temperatures to 29.53°C and humidity levels to 35.5%, indicating a decreased reliance on mechanical systems—an essential consideration in areas experiencing frequent electricity shortages. Similarly, the daylighting analysis underscored the positive impact of modified window placements and shading techniques. While challenges persist in deeper interior zones, the adoption of passive lighting strategies improved spatial daylight autonomy and effectively reduced glare near windows. Table (1) summarizes the results of the four renovations compared to the baseline scenario

Renovation Scenarios	Indoor Temperature (°C)	Relative Humidity (%)	Effectiveness Notes
Base Case Container	36.43 (summer peak)	93.25 (peak)	The space is uninsulated, with very high humidity, elevated temperature, and poor lighting.
Renovation Plan 1	~33.29	31 - 66	The use of RCA walls and perforated sheets improved insulation, resulting in a significant reduction in temperature and humidity.
Renovation Plan 2	~33.29 (no significant change)	No significant change	Adaptive perforated facade with 120 cm air gap creates a semi-outdoor shaded space, improving airflow and privacy.
Renovation Plan 3	1.71°C lower than outdoor temp	No significant change	Enhanced wall insulation and elevated container; better thermal regulation and improved heat retention in winter.
Renovation Plan 4	19.04 (winter) - 29.53 (summer)	35.50 - 47.30	Green roof and green wall integration, container elevated 60 cm; notable improvements in temperature, humidity.

Table 1: Quantitative Comparison Table summarizing temperature & humidity across all renovation scenarios.

In addition to the environmental improvements achieved through the proposed renovation strategies, it is equally important to address the human dimension of shelter design—particularly user comfort, perception, and long-term well-being. While typical shipping containers are constructed from thin metal sheets that often produce harsh, temporary, and psychologically detached living environments, the use of recycled concrete aggregate (RCA) panels introduces a more familiar and architecturally grounded material system. In the Palestinian context, RCA panels resemble conventional building methods, offering not only improved thermal performance but also a spatial and material language that aligns more closely with users' cultural expectations. This shift is expected to foster greater psychological comfort, reduce the sense of impermanence, and increase overall user satisfaction.

In light of Gaza's unique socio-political and economic context, this study emphasizes the value of cost-effective, low-tech, and sustainable architectural solutions. The proposed optimized design model offers a replicable framework for emergency housing in other conflict-affected or resource-constrained regions. Future research is encouraged to integrate user feedback and evaluate the long-term durability and effectiveness of the applied renovation materials under local conditions.

The proposed renovation strategies are not only contextually relevant for Gaza but also offer adaptability to a wide range of climatic and geographic conditions. The use of recycled concrete aggregate (RCA) panels, which demonstrated effective thermal insulation, makes these solutions applicable in both hot and cold climates where minimizing thermal transfer is essential. Additionally, the design allows for flexible manipulation of the outdoor interface -such as perforated facades or adjustable openings-enabling enhanced cross-ventilation in humid areas to reduce moisture, or closure in regions with harsh wind conditions. Such design flexibility allows for minor adaptations based on local conditions, making the system suitable for various climates and increasing its relevance for broader use in post-conflict or disaster-prone areas.

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