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RESEARCH ARTICLE OPEN ACCESS

THE EMERGENCY ARCHITECTURE - REUSE AND RECYCLE MATERIAL AFTER DISASTERS

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ABSTRACT

These research papers aim to explain the methods and joints of design based on the principles of emergency architecture, which focus on its concepts on reusing and recycling local materials after natural or man-made disasters and crises. In a systematic design framework that is limited by many obstacles, such as the shortage and limited availability of low-cost materials, and the lack of local labor experience. To reduce the negative impacts of disasters in developing and displaced countries, we must highlight the importance of alternative materials that can be regenerated (straw and bamboo), recycled materials, Reused materials, semi-finished materials (earth and clay materials).

I. INTRODUCTION

First of all, shelter and settlement are complementary requirements and aim to provide a safe and healthy living environment for groups displaced after crises and disasters when the dimensions of the area are the first measure of distinction between them, the shelter is located on the scale of the area of the house and the settlement is located on a broader scale to include local and civil societies [1].

In fact, within the concept of shelter and settlement, seven basic criteria aim to mitigate the damage; caused by the crisis and saving the affected groups, and include planning the site in general, and then settling in particular, creating a place to live in, providing the family with tools for housing, providing technical assistance, and creating Safe environments and achieve sustainability standards, but we will discuss the technical assistance standard in detail [2].

Essentially, the shelter is one of the basics needs for life requirements with dignity, as defined in Maslow's hierarchy of needs because it includes models of five levels including receiving technical and humanitarian assistance to ensure mitigation of the negative effects of displacement and the enormous pressure on depletion of local resources [3].

On the other hand, to ensure that people get adequate technical assistance, several key measures include understanding site planning and materials available before the crisis, achieving the "community empowerment " sustainability component, expressing their opinion about shelter or settlement design to achieve the greatest degree of psychological or physical comfort and studying the characteristics of sustainable materials locally to achieve the highest possible quality standards and to ensure that the life of the shelter or settlement increases as long as possible [4].

In fact, it includes the innovation of new building methods and practices (resulting from the improvement of previous local techniques) that are commensurate with the crisis; to reduce the future risks of destroyed home structures and create job opportunities for the local population (people who have a high ability to carry out construction activities) under the supervision of skilled and experienced workers in building standards to increase skills technology for them safely, easily, following the bidding and contracting processes approach to achieve the best

possible management of materials, financing, and labor within the regulatory legal requirements [5].

Then, it supported the idea of sustainability through rationalizing the selection of sources of appropriate environmentally friendly building materials (vernacular materials) and fast building (achieving the concept of adaptation) and focusing on local resources at the reasonable and adequate quality and the use of alternative materials unfamiliar to local culture only when necessary for a negative impact at times. This is to support and raise the economy after the crisis [6].

Finally, define procedures that clarify how to maintain and store familiar, locally available tools and materials with multiple and common uses at reasonable prices; to achieve economic and time benefit (speed), to accomplish tasks with high quality and provide the minimum basic needs for shelter, which is to provide a safe living space [7].

II. LITERATURE REVIEW

What are the main factors in choosing recycled materials after local crises and disasters?

The material extraction location must be close to the disaster site, the use of low-cost manufacturing processes, and the organization of construction operations the work is given to men with greater effort and less effort to women, and to choose building materials with high flexibility and resistance to seismic shocks and natural and industrial hazards [8].

The most popular building materials used in recycling operations after natural or man-made disasters and crises are straw, earth materials, bamboo, and adobe. These materials have proven their effectiveness in crisis areas and their high value and low cost, as they are local materials that require local labor [9].

The state of Nebraska, in the United States, is distinguished by the use of straw, as it is the first country to use it. Where they studied its distinctive properties in terms of the ability to compress and form easily, mechanical strength, insulation capacity, cost, and thermal energy, embodied energy, fire resistance, long life, abundance, and ease of construction and transportation to the site. Where the results were curved for these characteristics positive and of a high degree. Although there are negative qualities of straw, such as lack of resistance, weakness due to moisture, and weak water resistance, its advantages outweigh its disadvantages [10].

When straw material is used in construction, it must be dry and free of grains. A thread is used to tie the bales of straw together to firmly fix them when they are placed on top of each other when building. The world's most common straw the load bearing and the in filling, the post and beam system, Energy-building systems (straw insulation), prefabricated construction (straw bale panels) [11].

Table 1: A comparison of the most common straw systems in the world.

	Construction Methods	Material	Cost	Durable	Long life
The load-bearing &the in-filling	**-First:** beam foundation where long wooden stakes are craved in order to stick the first row of bales. **-Second:** the stakes are stick-on the bales from the top **-Third:** the end of the top row، the entire wall must be framed by a top beam which distributes the roof weight evenly and where the roof beams are laid out. **-Forth:** The rows are compressed through several tight straps between both top and below beam	**Wood stakes**	**Low-cost**	**Low**	**Medium**
The post & beam system	**-First**: conventional wood frame structure where the bales are inserted. **-Second:** compress both bales and beams. **-Third:** cover the bales with clay-based plaster or lime، applying multiple layers to it and allow each material to dry up properly. **-Forth:** ensure that the layers are impervious to water but not to water Vapor.	**Wood, clay-plaster& lime**	**Medium cost**	**High**	**Longest**
Energy- building systems	**Non**	**Local bricks**	**High cost**	**High**	**Longest**
Prefabricated construction	**Non**	**Export wood**	**High cost**	**Medium**	**Shortest**

Source: Author, (2020).

Figure 1: Straw- load-bearing and the in filling.
Source: [12].

Figure 2: Straw - The post and beam system.
Source: [12].

Figure 3: Straw - energy upgrading with straw building.
Source: [11].

Figure 4: Straw - prefabrication with straw.
Source: [6].

By comparing the techniques of building straw in Table 1, it was found that the best system for building straw is the post and beam system because it contains clay material that creates a cool indoor air quality in summer and warm in winter, in addition to not containing volatile or carbon materials with a negative impact on health, clay is also characterized by its high ability to absorb unpleasant odors and annoying sound waves from outside and naturally regulate air humidity [13].

Figure 5: Straw - The use of clay material in construction.
Source: Author, (2020).

The best application of sustainability principles and strategies is the use of vernacular (local) materials that are embodied by the use of building materials for the earth, as they are widely available everywhere and have a long life, low cost and can be extracted and converted into a building material easily and without much effort, subject to reuse and recycling permanently, You do not need mechanisms to transport it, as it is located on the site itself [14].

Before starting to use the earth materials, an examination should be carried out. The ground must contain a mixture of sand, silt, and clay, provided that the clay percentage is not less than 17% and not more than 35%. The land that contains a lot of clay or sand must be balanced, adding resources to other locals [15].

Earth materials can be found midway to the hills because the soil contains organic matter in low proportions compared to the valley soil that is full of sediments, also the amount of sand is less compared to the tops of the hills where the percentage of soil erosion is greater, the climate is moderate and suitable, unlike valleys and hills that have strong winds and cold most of the time [16].

Table 2: Explanation of the types of ground construction - the monolithic system, the masonry system, the filling system.

	Type of systems
Monolithic system	• Where earth is rammed (taipa) • Where earth is stacked (cob) • Where earth is modelled (façonnage).
Masonry system	• Pressed blocks (BTC) • Cut blocks (sod) • Cast blocks (adobe)
Filling system	• Earth filling • Taipa filling • Earth roofing

Source: Author, (2020).

The last type of material to be recycled after crises and disasters are construction buildings in Taipa (rammed earth) & Adobe. Earth ramming (Taipa) can be defined as a bearing system that requires strengthening of the structural angle with a system called gigantic. But we have to distinguish between the two materials because most architects believe they are one building material [17].

Summarizing the most prominent differences between the two materials is that adobe is more flexible than taipans, and does not require the consumption or production of heat energy due to its dependence on sunlight for drying. The most prominent similarity and the intersection between the two materials are that both of them require no exposure to rainwater or soil moisture. Also, both are durable, stable, and proven efficient in old and restored buildings [6].

Figure 6: Mosque of Djenné, Mali, Portugal-Manitou Cliff Dwellings national monument, Indians.
Source: [11].

If earth materials are used, they must be mixed with clay mainly, because it contains materials of a high degree of hygroscopicity that work to create a healthy and moderate internal environment, it is preferable to put two layers of clay at least of a thickness of (1-2) cm. Sometimes a layer of small straw fibers is applied to avoid cracking of the final layer of gypsum. Mud has a unique ability to absorb high-frequency electromagnetic waves [18].

Countries with the highest exposure to natural disasters are the ones that most use the principle of recycling building materials, such as Portugal, which suffers from the deterioration of the economic system due to its exposure to seismic shocks, they work to encourage the idea of self-construction for social housing, using local materials with low environmental costs and the least negative impact on the environment. Currently, they support the idea of using bamboo to build strong, resilient structures that resist earthquakes [19].

The most important principle in achieving ideal recycling of materials, especially after disasters, is the participation of the

local community in cooperation with experts to preserve the spirit of the place and address the environmental aspects, without ignoring the functional and social aspects, as it reduces the cost of bringing foreign workers, it works to empower and create a working disk, reduce the unemployment rate and support the economy significantly for the displaced areas [20].

We can summarize the construction steps using recycled materials in displaced and earthquake-prone areas: preparing the necessary techniques and materials, preparing the necessary layers of finishes such as (mud and plaster), the use of different types of sand and long-lasting paint, the use of wooden beams and their fixation by using nails vertically to the sand, the clay layer is painted using linseed paint for its ability to give the surface texture and smoothness, the upper part of the building (the facility) is isolated with mosaics to add an aesthetic character [21].

Practical applications on the use of alternative materials in times of economic crisis or after catastrophic events, which focuses on low-cost low-tech architecture with a social purpose in Haiti's:

In response to Haiti's devastating earthquake in - 2010, Dutch architect Pieter, stoutjesdijk has conceived an emergency architectural shelter that can be assembled from a series of parts in a little under five hours.

Figure 7: Natural disaster area, Haiti's.
Source: [2].

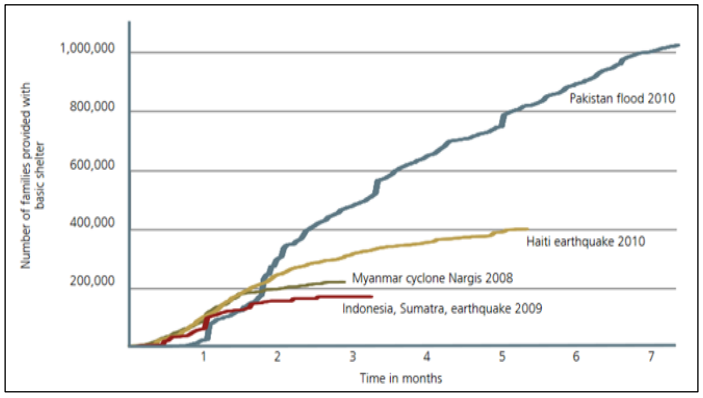

Figure 7: of the distribution against time for major international shelter responses.
Source: Author, (2020).

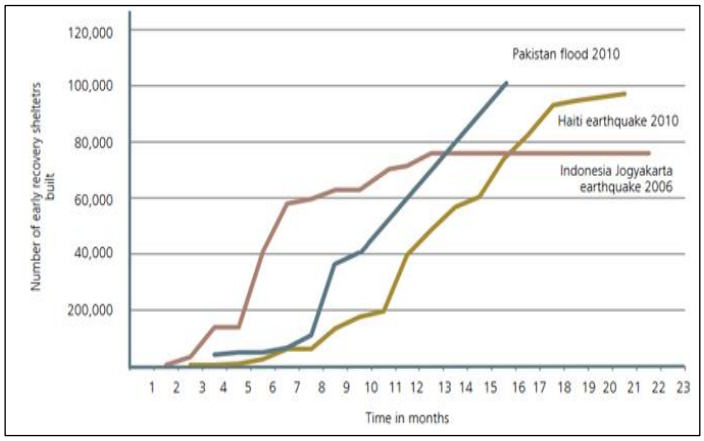

Figure 8: of the number of early recovery shelters built against time for some major international shelter responses.
Source: Author, (2020).

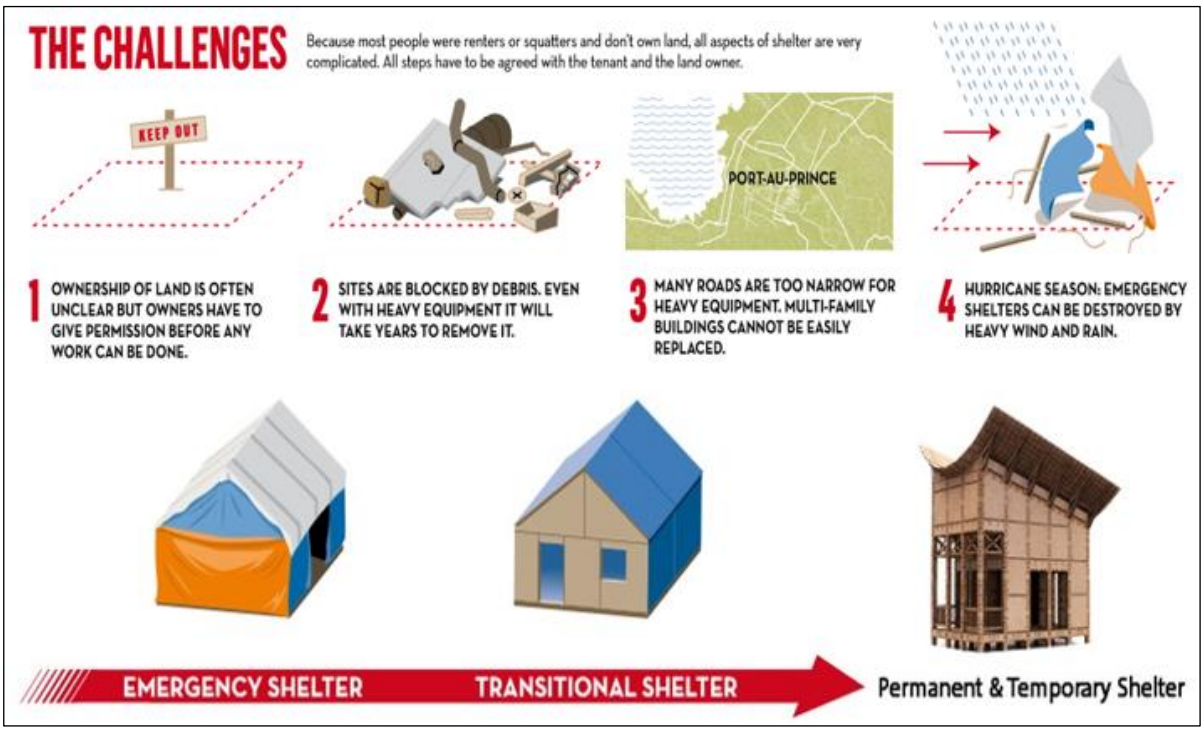

Figure 9: What and how will we face the challenge of devastation after a natural disaster (earthquake?).
Source: Author, (2020).

The thesis of the project (shelter Haiti's) is the Rebirth of the industrial revolution: That mass customization, personalization, and variety can replace 20th-century rigidities of production. Design of the habitat has been suited for the climate and condition of Haiti's tropical temperature (Aesthetic level, Functional level) [22].

The shelter, which can be described as permanent as a result of the January 2010 earthquake, was designed using reused, waterproof wood with nano-coating chemicals, and a local source from Haiti, It takes about 5 hours, the life expectancy is 3-5 years, the construction team is 9 people, the number of buildings is 2000, the approximate cost of materials for each shelter is about 1,560 Swiss francs. The approximate project cost per shelter is around 2,300 Swiss francs, this is the fastest house built in the world [23].

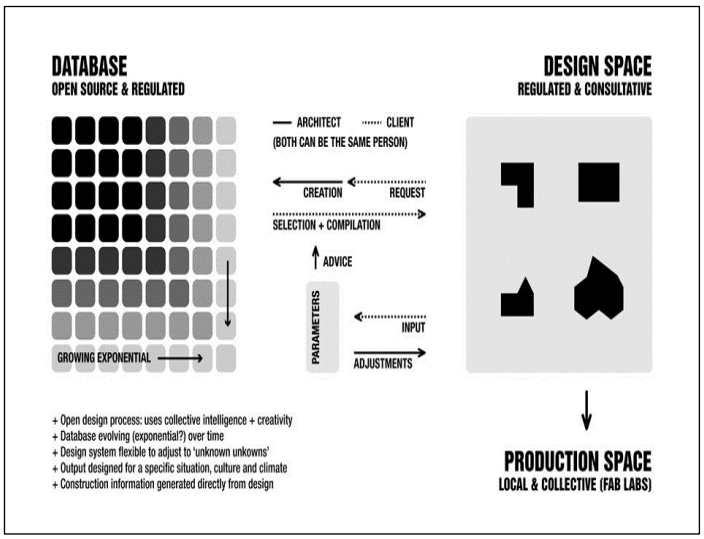

Figure 10: Conceptual Thinking, Haiti's shelter.
Source: [24].

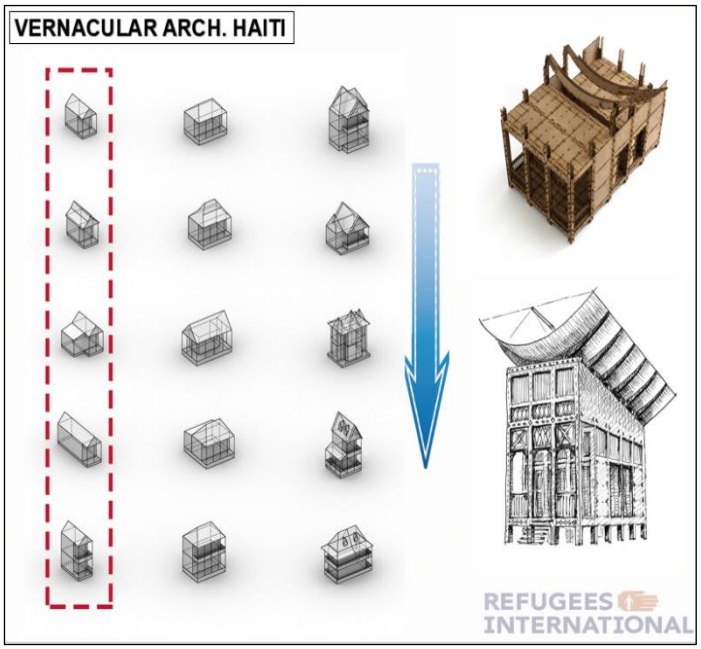

Figure 11: KAY HOUSE, The typology is Kay's houses were formerly used as slave shack and now symbolizes pride and independence, 2-4 rooms long, to be extended at the back; the triangle in the gable roof is a strong symbolic element, originally made from wooden posts and beams with a thatch roof.
Source: [25].

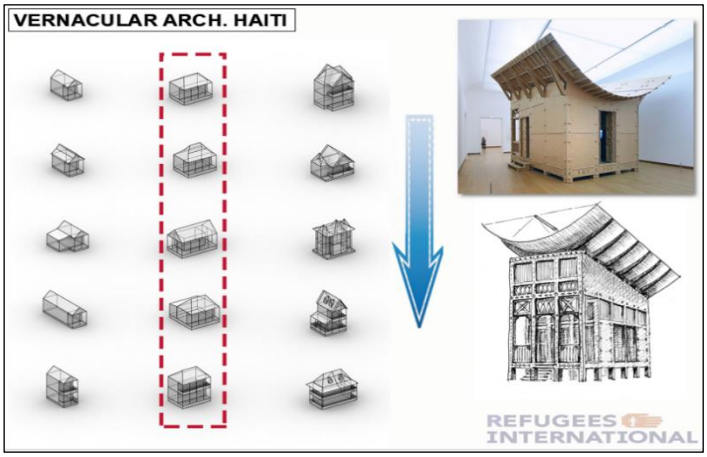

Figure 12: CREOLE HOUS, This type was first used in the late 1700s by Plantation owners and still belongs to the upper class, Characteristic is its overall symmetry and its long porch parallel to the road, The hipped roof is shaped to resist storms, Usually, the floor is raised several feet above the ground.
Source: [25].

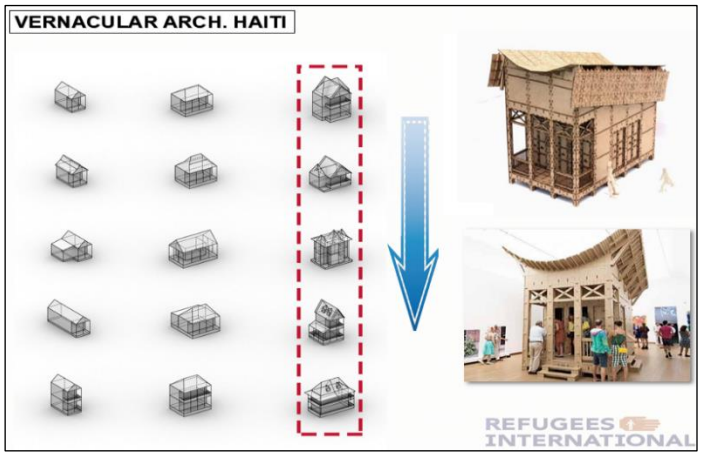

Figure 13: GINGER-BREAD HOUSE, Housing type was introduced in the post-colonial period, Therefore acts as a vital symbol for rebuilding Haiti, Characteristic is its intricate ornament and steeply pitched roofs, The construction of wooden sheets and beams has proved to be seismically resistant's.
Source: [25].

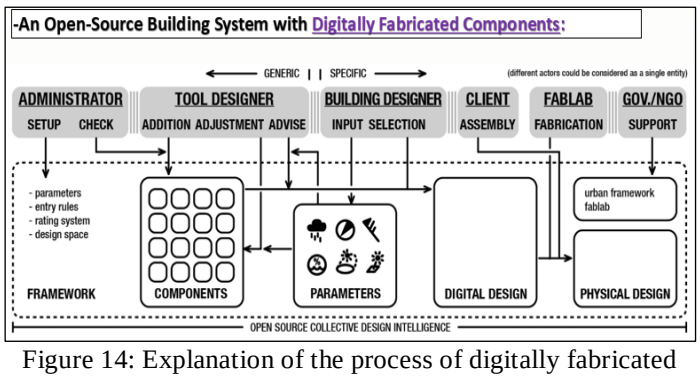

Figure 14: Explanation of the process of digitally fabricated components.
Source: [14].

A design and production process that makes optimal use of the predicted next industrial revolution. The influence of Computer-Aided Design (CAD), which has rapidly grown throughout the past decades, is currently complemented by a growing influence of Computer-Aided Manufacturing (CAM).

Digital fabrication creates a direct link between our digital and physical worlds and has the potential to increase the performance of construction processes [9].

Figure 15: Installing parts such as Lego pieces, where a special adhesive is used for fifteen years.
Source: [23].

Building a Designer can also be understood by non-experienced designers and can run on simple platforms like mobile phones. A CNC milling machine that laser-cuts the required 2484 parts out of fiberboard for a house that can be assembled, without any external material as the parts are simply slid together thanks to friction fit, a technique somewhat similar to Lego blocks or click furniture. Each separate component has been designed with special joinery, allowing it to perfectly fit its neighboring piece. The framework, flooring, roof, and walls are all made from individual, interlocking sections that link together like puzzle pieces [10].

Figure 16: Made entirely from digitally fabricated components, a CNC milling machine laser-cuts the necessary pieces out of fiberboard, which can be assembled without the need for any additional materials like screws and fixtures.
Source: [10].

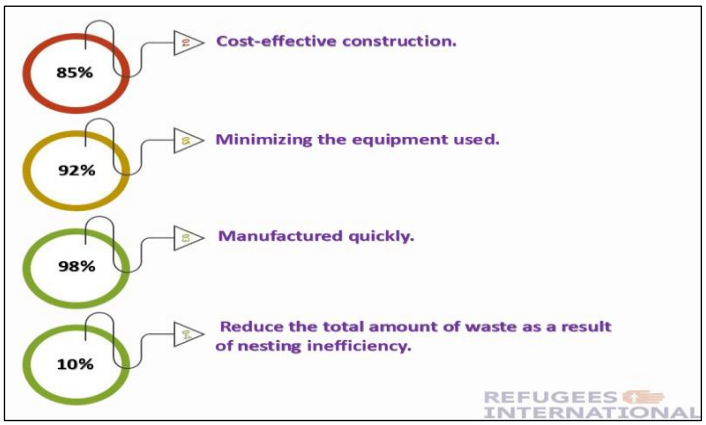

Figure 17: Post-use occupancy, Haiti's shelter.
Source: Author, (2020).

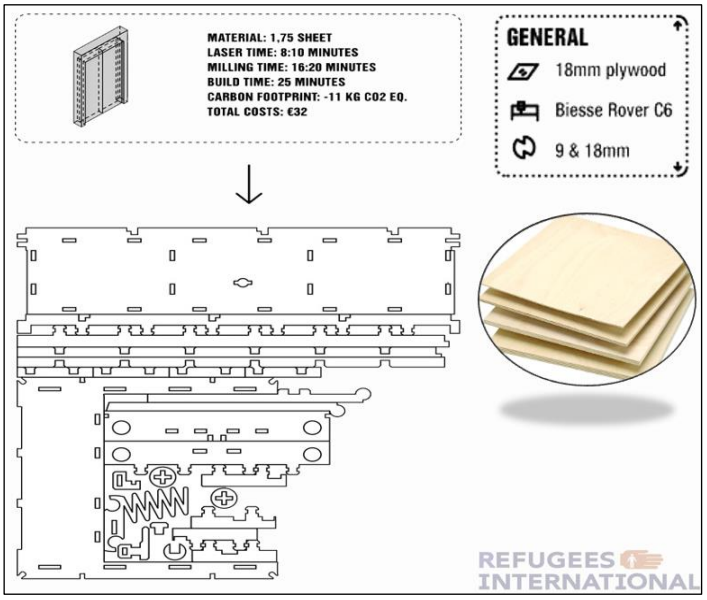

Figure 18: Materials used, each CNC-milled panel, made of reused-wood &waterproofed with Nano-coating chemicals, would be jointed in three directions, thereby creating a strong bond without the use of metal fittings, screws or glue.
Source: [15].

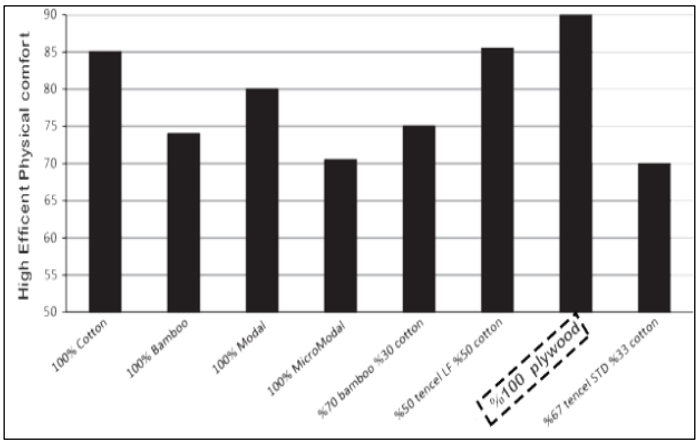

Figure 19: Post-use occupancy, Materials Haiti's shelter.
Source: Author, (2020).

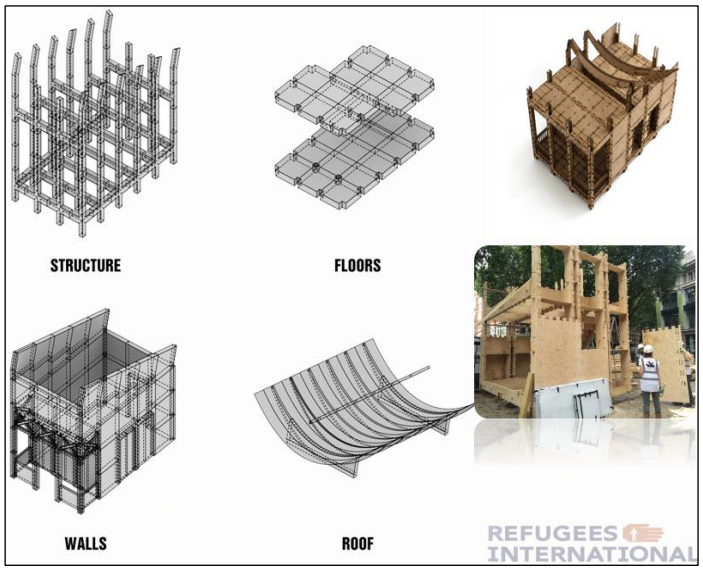

Figure 20: Structure Element and phase, Haiti's shelter.
Source: [9].

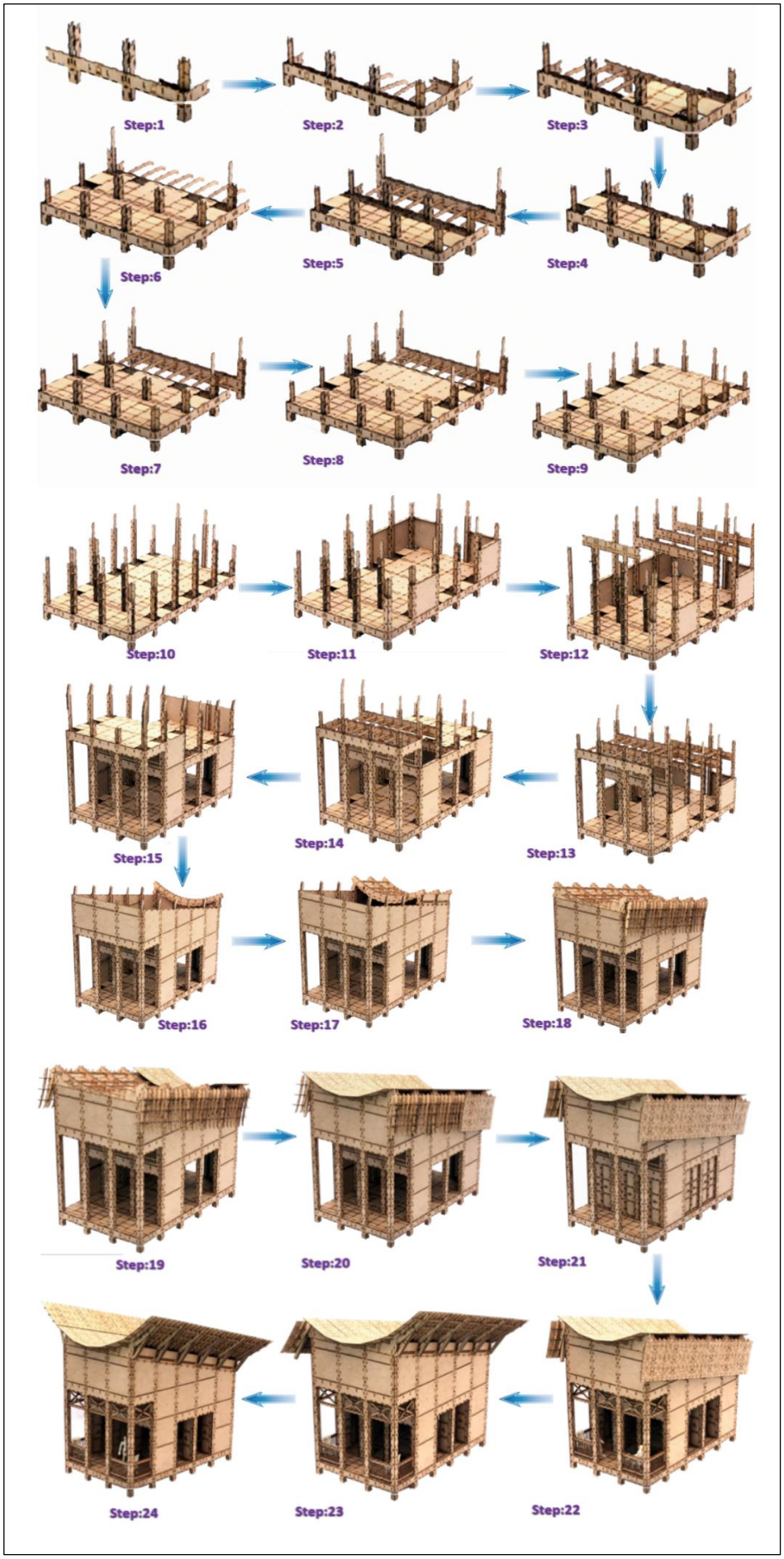

Figure 21: Structure Element and Construction Phase, Haiti's shelter.
Source: Author, (2020).

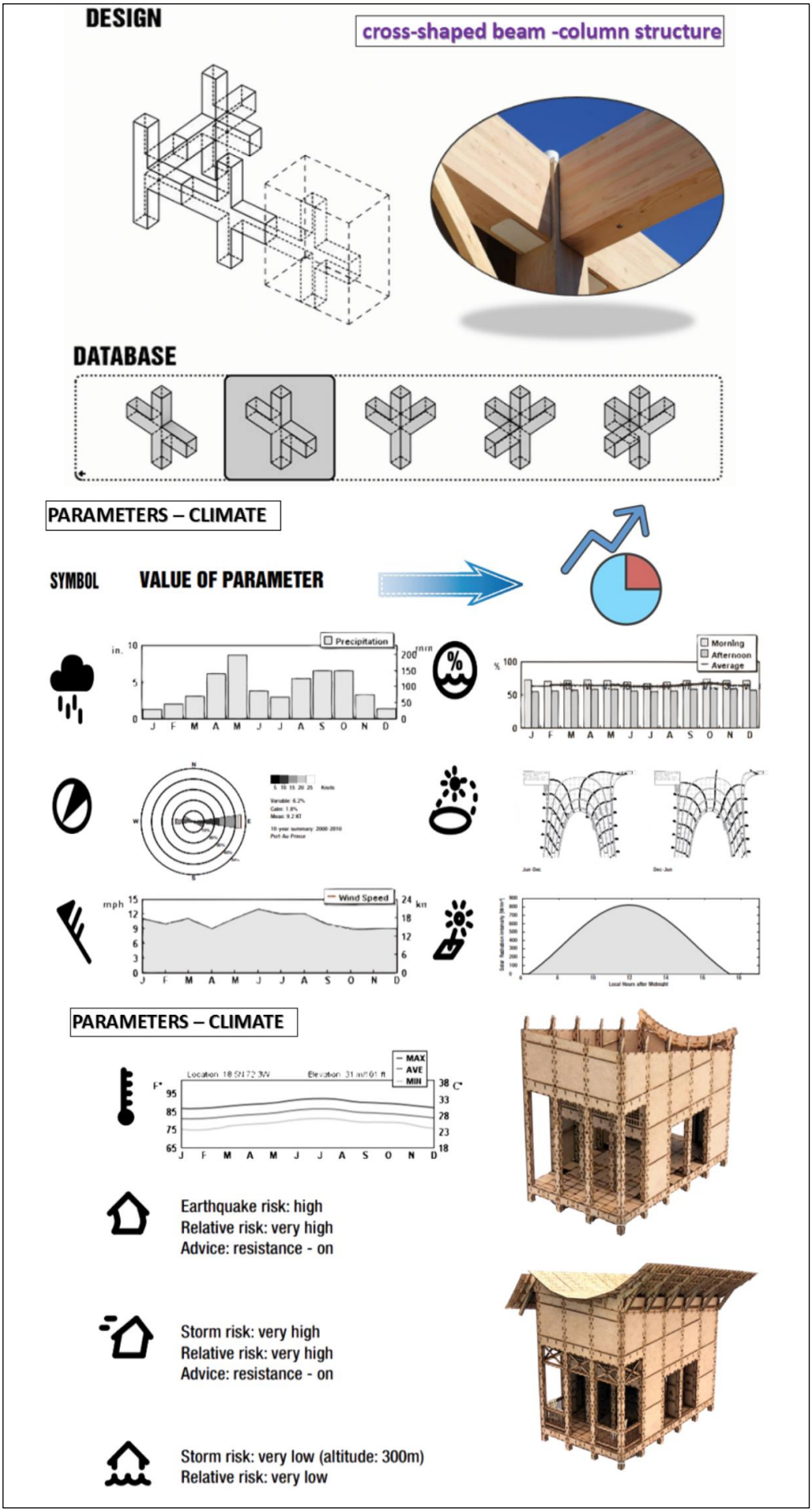

Figure 22: Climate Consideration, Haiti's shelter.
Source: [25].

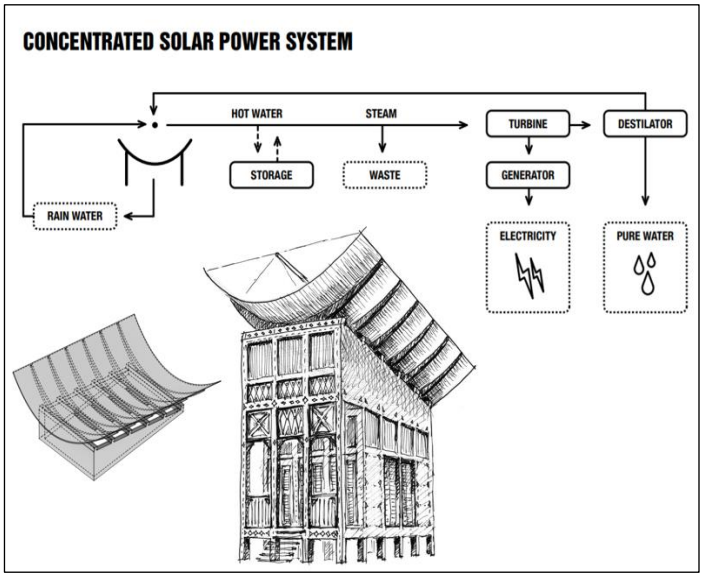

Figure 23: SUSTAINABLE FEATURES, The roof plays a key role in providing the three most basic needs of homeless people.
Source: [25].

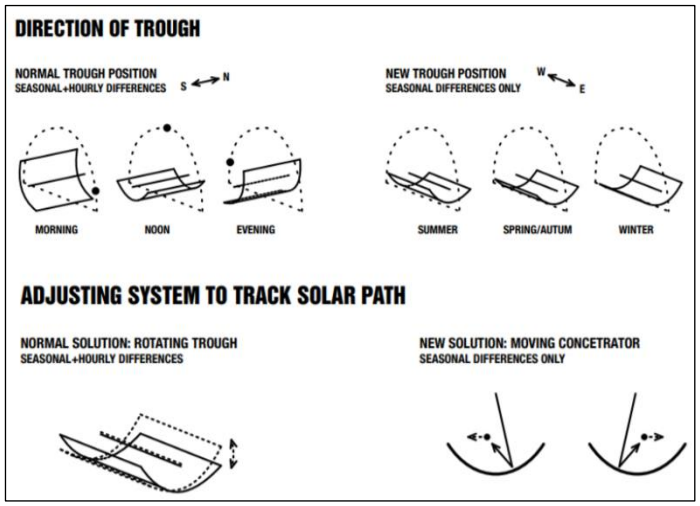

Figure 24: The roof design is following the principles of sustainability in architecture.
Source: [12].

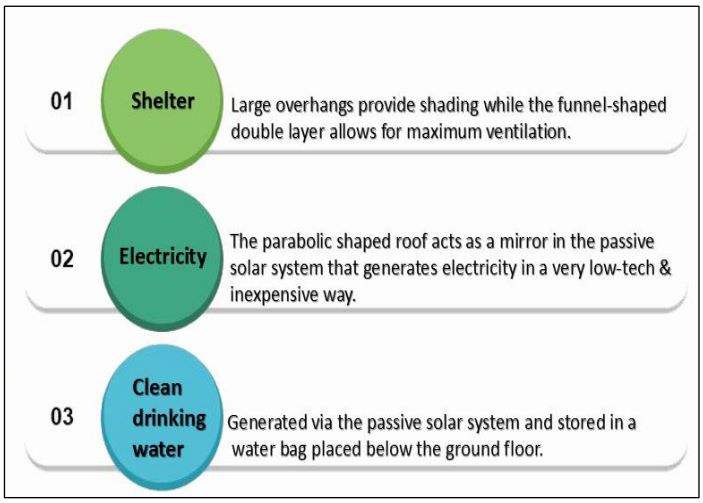

Figure 25: Sustainable Features, The roof plays a key role in providing the three most basic needs of homeless people, Haiti's shelter.
Source: [20].

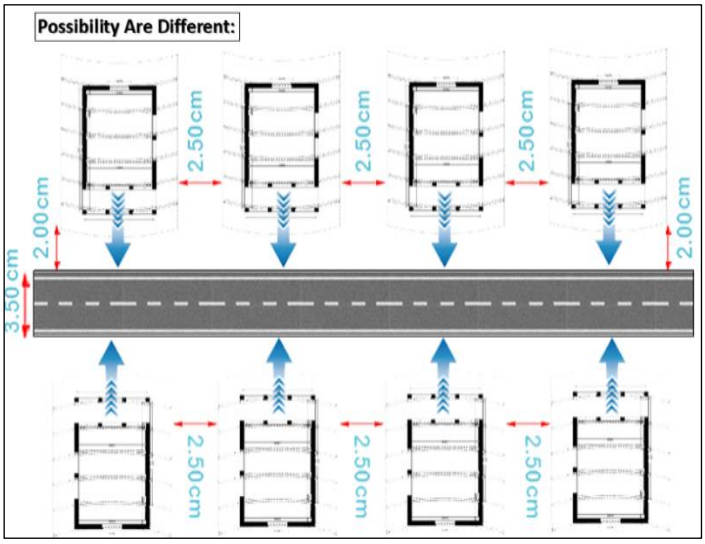

Figure 26: Way puts unite; the units are placed next to each other so that the short side that contains the balcony is directed directly to the street, Haiti's shelter. Haiti's shelter.
Source: Author, (2020).

Summarizing the strengths of designing Haiti's shelter, wall thickness can be adjusted to meet insulation requirements, the building designer relied on assembling the components in a compact size to make the building lose its heatless, determining the quantitative and qualitative performance metabolites in a balanced and effective manner without restricting site freedom, ease of adaptation and expansion of the building system while reducing its complexity, and the new building system is a mix between the balloon system and the column & beam system, this combination increases the efficiency of materials while allowing the physical [26].

III. CONCLUSION

It can be concluded that most sites in developing countries are characterized by disasters and crises that destroy housing systems. A quick, constructive solution must be found to house the displaced groups and achieve the minimum level of rest, encouraging construction in recyclable and reusable natural materials such as bamboo, straw bale, rammed earth, and adobe in economic & environmental crises, supporting the idea of self-construction and local employment without using large amounts of resources and importers, leading to the integration of more solutions, and it is important to take into account climatic conditions in crisis areas to understand how the local workforce manages the project and to create sustainable environmental remedies in the shelter and settlement to provide the minimum level of physical and psychological comfort for internally displaced groups.

IV. AUTHOR'S CONTRIBUTION

Conceptualization: Zaid Mohammed Al-Zrigat.
Methodology: Zaid Mohammed Al-Zrigat.
Investigation: Zaid Mohammed Al-Zrigat.
Discussion of results: Zaid Mohammed Al-Zrigat.
Writing – Original Draft: Zaid Mohammed Al-Zrigat.
Writing – Review and Editing: Zaid Mohammed Al-Zrigat.
Resources: Zaid Mohammed Al-Zrigat.
Supervision: Zaid Mohammed Al-Zrigat.
Approval of the final text: Zaid Mohammed Al-Zrigat.

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