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LIMITATIONS OF PAPER HOUSING

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Abstract

Natural disaster not only causes loss of life but also causes loss of property. It is observed that there is increase in number of natural disasters over the past years. Post disaster scenario shows there is increase in number of homeless people. After a disaster occurs its role of an architect to provide accommodation to people where people can live with dignity, security and comfort, a space where people can work, rest and sleep. Paper housing are designed to meet the local circumstances. These temporary housing is aid to people who lost there home in disaster until they shift to their permanent accommodation.

Through this literature review and analysis of case studies, these research discusses the materials and its properties, rapid construction techniques and technology used in paper housing. It also explores permanent paper housing example. This research paper aims to do study of limitations of paper housing.

Keywords: Disaster, Temporary housing, Paper housing, Post disaster, Rapid construction

1.0 Introduction

Housing is essential to the well-being and development of most societies. it is most complex asset, with links to livelihoods, health, education, security , social and family stability. Housing act as a social center for family and friends, a source of pride and cultural identity [1]. Over the time, people develops emotional connection with their dwelling. It reflects their lifestyle and personality.

In disaster situations, the destruction of houses is one of the most visible effects because housing is an extremely vulnerable asset [1], and this devastation leads to lose those symbolic references [2]. Thus there is a need for rapid construction technique. Losing a house is more than a shelter but also security, comfort and dignity.

Aftermath of post disaster is necessary. The work of repair and rebuilt takes time. But it should be done quickly to provide accommodation to homeless. Temporary accommodation refers to all the different types of temporary lodging that can be used after disasters [3], and two main types can be identified: (1) shelter (2) housing.

The main difference between sheltering and housing, is that shelters provide a secure place to stay during the period that immediately follows the disaster but suspending daily activities, while housing allows for a return to household responsibilities and daily routine [4]. Since people cannot stay longer in shelters, because they cannot resume daily life in them, and reconstruction works often last long, there is a time gap to bridge and temporary housing seems to be the obvious solution [5]. It not only secure people but also provide privacy and comfort. Additionally, it may promote the success of the overall reconstruction, allowing time for better community planning to reduce risk and improve sustainability of the future construction [6].

However, temporary housing is also a controversial issue of post-disaster reconstruction programs, which has received criticism due to the persistence of some problems [7], [1], [8], [9], [6], [10].

Temporary housing can be defined both as part in the process of re-housing after a disaster, and as a physical type of building used temporarily by families to live during the post-disaster reconstruction works [9]. This research paper aims to do study of limitations of paper housing.

2.0 Rapid construction technique- Panelized construction

Penalization is a construction method in which the structural elements of a building are fabricated off-site in a controlled environment. This process eliminates much of the on-site labor, saving time and money on your project [11].

With penalization, the elements are assembled into two-dimensional walls, floor, or roof components called panels. These panels can be made out of lumber, cross-laminated timber, cold-formed or structural steel, concrete, paper or a combination of more than one of these systems. Then, the panels are transported to the job site and erected [11].

Some panels come with pre-installed windows, plumbing, and electrical rough-ins, but all panels will have the structural skeleton of the frame. They have also already been cut to size and shape, while others may require some on-site trimming [11].

3.0 Paper products and properties

Paper has poor characteristics as compared to other building materials. Paper is combustible and fragile to water. A single sheet of paper cannot be considered as building material, some of the paper products have better characteristics which make them suitable for building material. Some of the famous paper products are mentioned below :

Paper tubes, U-shapes, L-shapes- Linear elements produced by laminating several layers of paper in the desired shape. These products, in particular paper tubes, can be used as structural elements. The tubes are made of fiber so dense that they cannot burn, and they are coated to make them waterproof [12].

Paperboard (PB) – The most basic one of the discussed products, a flat, full layer of paper, usually 1-4 mm thick. Most paperboards consist of a filler layer, made of recycled paper, laminated between two top liners. It does not provide insulation, but when applied in a thicker layer it can act as a fire barrier due to its high density [12].

Corrugated cardboard (CC) – A material composed of alternating flat and corrugated sheets of paper. The most popular flute sizes for building applications are A-flute (approx. 5 mm high), B-flute (3 mm), and C-flute (4 mm). A single sheet of corrugated cardboard usually consists of 2-5 layers of paper, with both surfaces flat, or one flat and one corrugated. Depending on the flute orientation, layers made of this material may have good thermal properties (in the axis perpendicular to the direction of the flute) or mechanical strength (in the axis parallel to the direction of the flute) [12].

Cellulose fibre (CF) – Blown-in insulation produced from recycled newspapers, often with an addition of fire retardant. Cellulose provides very good thermal and acoustic insulation as well as low environmental impact. However, being a loose material it requires additional structural elements. This is the only paper-based product widely accepted in the building code [12].

Paper honeycomb panels (HP) – A three-layer product made of a honeycomb-shaped core laminated between two layers of paper. The commonly used panel thicknesses are 50, 25, and 12.5 mm with a standard cell size of 14 mm. Owing to their characteristic structure, the panels have a high compressive strength perpendicular to the surface, despite their low weight. Moreover, honeycomb panels provide relatively good thermal insulation [12].

All of the above products are easily available and affordable. According to Secchi, a 15 mm thick paper honeycomb panel has a lower non-renewable energy demand per kg than any of the conventional insulative materials, i.e., 12% lower than mineral wool and more than six times lower than expanded polystyrene [13]. Furthermore, in Čekon's research paper, honeycomb panels were proven to have a lower environmental impact, during the production stage per amount of material needed to achieve the required insulation performance, than mineral wool and PIR panels [14].

4.0 Case studies

There are various examples of paper housing. Here 4 examples are analyses and presented.

4.1 Paper House

This is the example of the first permanent paper tube structure. It is a residential project located in Japan. The project was completed in 1995 by an architect Shigeru Ban. Plan size is 10m x 10m. It has 110 paper tube columns arranged in the shape, looks like a S. In this 80 paper tubes bear the lateral forces and 10 tubes carry vertical load. When the sliding glass doors open, the horizontal roof over the paper tubes becomes ever prominent, and the interior and exterior become one [15].

Figure 1

Figure 2

Figure 3

Figure 4

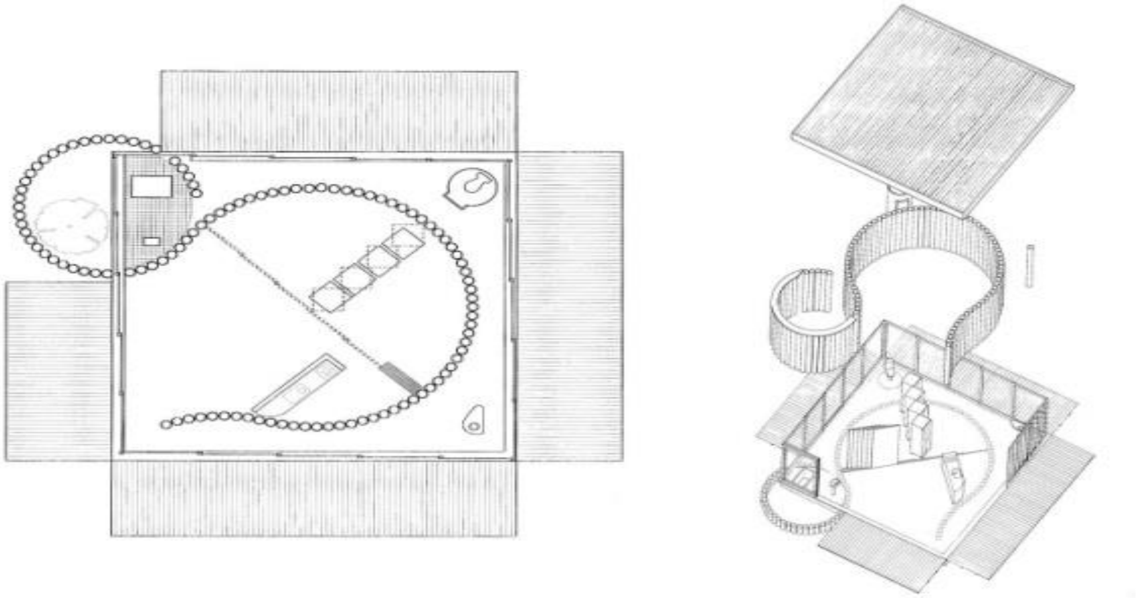

Fig. Paper House (1) Exterior aspect (2) & (3) Interior aspect (4) Plan & axonometric view [15].

4.2 2023 Morocco Earthquake Disaster Relief Project

This is the example of residential project. As response to earthquake occurred in Morocco Ar. Shigeru Ban in collaboration with Voluntary Architects Network along with the National Architecture School of Marrakech built a temporary housing which prototype was built in 2023 Turkey- Syria earthquake. The housing foundation is made up of beer crates filled with sand bags, to built walls wooden panels are used between the columns made up of paper tubes, placed at every 1.2m distance. This is a time saving process. Roof is made up of paper tubes frames and plywood decking. Punchers are made in roof so that workers can work easily and does not need to climb on the roofs to ensure workers safety.

Figure 5

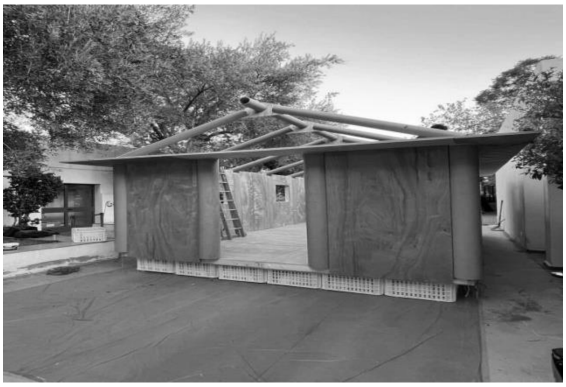

Figure 6

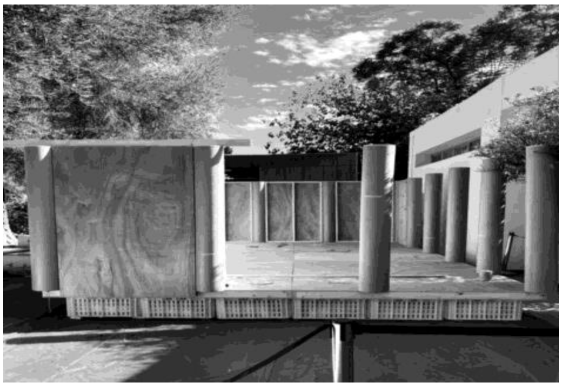

Figure 7

Figure 8

Fig. 2023 Morocco Earthquake Disaster Relief Project (5) & (6) under construction (7) & (8) joinery [16].

4.3 Relief for Noto

The architect visited a residence in the Shosoin district, Japan. It was a 80 years old structure. N number of alterations was already done and was decided to demolition due the undesirable changes caused by earthquake. This paper house was proposed in the yard in front of the house because the current water supply and toilets could be used. This was a residential project. The students from Kanazawa Institute of Technology, Shibaura Institute of Technology, and Keio University SFC participated in the construction from June 3rd to 4th. The paper log house constructed for 13 hours [17]. For foundation beer crates filled with sand bags were used. Paper columns were used. Punchers are made in roof to ensure workers safety. Doors and windows are fixed as per design.

Figure 9

Figure 10

Figure 11

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Figure 12

Figure 13

Figure 14

Figure 15

Figure 16

Figure 17

Figure 18

Fig. Relief for Noto (9) & (10) foundation (11) walls joinery (12) & (13) roofing (14) exterior aspect (15) interior aspect (16) installation (17) 80years old house (18) demolition state [17].

4.4 Paper Log House

This is an example in India. In the year 2001, Gujarat was badly affected by earthquake. For the foundation rubble from destroyed buildings were used, and then topped with mixture of mud and cow dung floorings. Split bamboo was used for vaulted roof. It is supported by vertical bamboo support and main bamboo members. For corners plywood bracing is used. To provide structural support in each paper tube 6mm dia. mild steel rods are passed through. Plywood frame for windows were used. Woven cane mat with small holes is used for ventilation The small holes in the mats provided ventilation, allowing people to cook inside and helping to repel mosquitoes [21].

Figure 19

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Figure 20

Figure 21

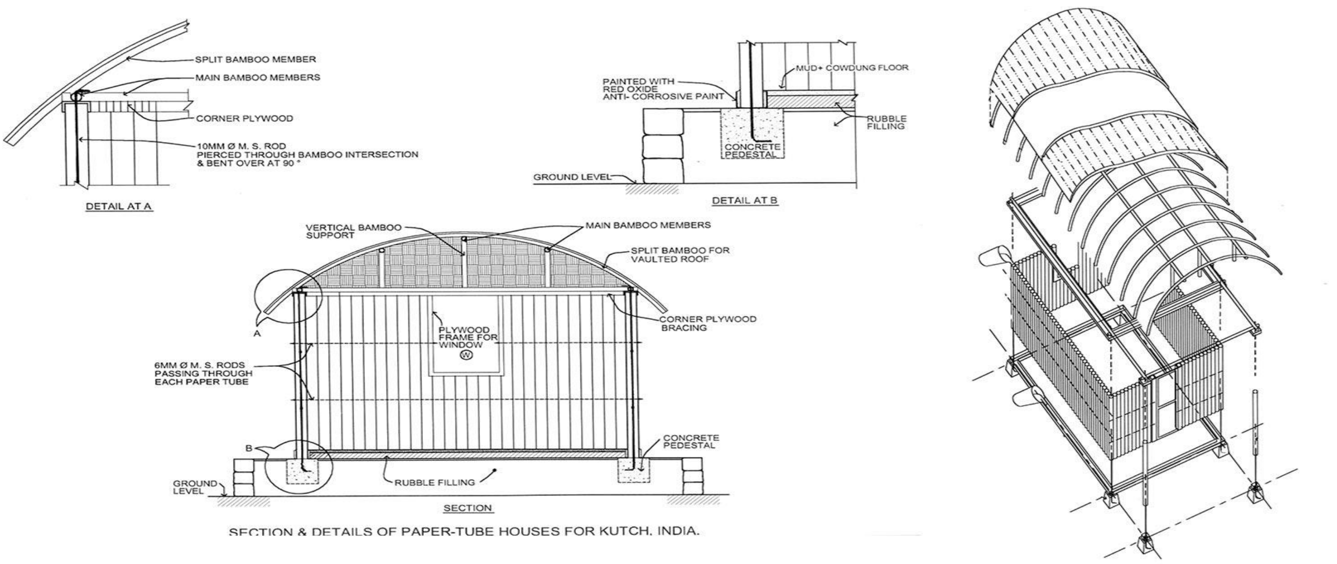

Figure 22

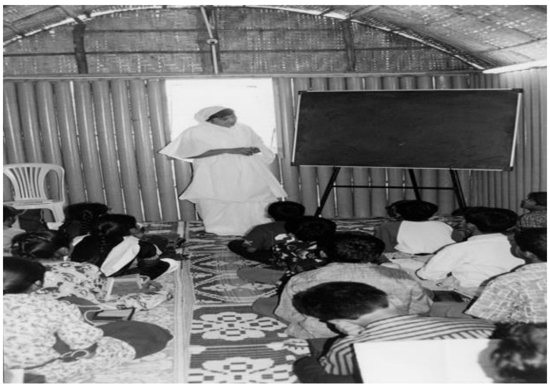

Figure 23

Fig. Paper Log House (19) & (23) exterior aspect (20) interior aspect (21) section and detail of paper-tube houses for Kutch, India (22) interior aspect [18].

5.0 Conclusions

Based on the analysis it can serve as a source of information on the basis of case studies. I would like to draw reader's attention towards limitations of paper as building materials are mentioned below:

1. The structure external layer cannot be left without the coat of protective layer. The protective layer should be covered with non-paper material.
2. The material of protective layer should be non-flammable and non-fragile to ensure user safety.
3. Panels should be ventilated to avoid damage due to condensation inside the paper structure. Breather membranes and cladding with an air cavity between them can be used [12].
4. Water protection on the internal surface is very important. Use of double protection technique is necessary to ensure water tightness of surface. Metal or plywood can be combined with polymer films or vanishes,
5. To ensure long life span of structure, adequate mechanical joints should be provided. As a small joint problem can cause moisture to penetrate deep into the core.
6. The envelope design should allow for separation and recycling of the different materials used, thus mechanical joints can be used between different materials if possible. It should be also considered that conventional mechanical joints (such as screws) are often not suitable for paper-based materials. Therefore it is advised to incorporate more durable materials e.g. wood in the joined area and avoid single-point connections [12].
7. Proper knowledge of adhesives is required.
8. When a fusuma of sliding door separates a room, you can feel the presence of people in the next room. In addition, you can hear the voices of people in the room even from the hallway.In a sense, you could say that there is no privacy [20]. There is no noise barrier.
9. Requires skilled team of Architect, Engineers, Contractors and labors. .

Some points I consider to be the most important for reader's to know is after their usage, the units are easily dismantled and the material easily recycled, leaving the place completely recovered since the foundations do not cause irreplaceable damages on the ground [21]. There is no need for the high technology tools or solutions. Materials can be transported to the site. People can transform their space according to their need.

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