Mahatma Education Society's
PILLAI COLLEGE OF ARCHITECTURE
Dr. K.M. Vasudevan Pillai Campus, Sector 16, New Panvel, Mah. India 410 206.
Tel.: 022 2745 6100 /2745 1700 / 27481764 Fax: 022 2748 3208
WEB SITE : www.pica.ac.in Email:pica@mes.ac.in, pica.panvel@gmail.com

To

Date: 04-04-2025

The Evaluation Committee,
National Institute of Disaster Management,
(Ministry of Home Affairs, Government of India),
Plot no. 15, pocket-3, block-b, sector-29, Rohini, Delhi -110042

Subject: **Cover Letter for Entry Submission for 'Best Practices for Knowledge Platform under the theme of Disaster Risk Reduction (DRR) for sub theme Post-Disaster Recovery and Rehabilitation' titled:** Architectural Strategies for Resilient, Rapid Relief Shelters in Indian Disaster Contexts

Respected Sir/ Madam

I am pleased to forward the entry submission for the above-mentioned platform titled 'Architectural Strategies for Resilient, Rapid Relief Shelters in Indian Disaster Contexts' submitted by Suvarna Thakare, Professor, Pillai College of Architecture, under the thematic category '**Post-Disaster Recovery and Rehabilitation'** in response to the call for 'Best Practices for Knowledge Platform on Urban Resilience'.

The submission examines the critical need for rapid relief shelters in the context of various types of disasters that India faces. It further explores the architectural strategies that integrate prefabrication, modular systems, climate responsive design, and use of locally available materials. It emphasizes culturally sensitive approaches and community participation to ensure comfort, dignity, adaptability, and long-term impact. The study also highlights the importance of interdisciplinary collaboration, guided by the NDMA framework, among architects, government agencies, NGOs, and local communities to achieve scalable and sustainable shelter solutions.

This entry is an original work and has not been submitted elsewhere for any award, publication, or recognition.

The submission has been prepared in accordance with the prescribed format and is forwarded for your kind consideration.

Thank you.

Yours Sincerely,

Dr. Sudnya Mahimkar

PRINCIPAL
PILLAI COLLEGE OF ARCHITECTURE
Dr. K. M. Vasudevan Pillai Campus,
10, Sector-16, New Panvel-410 206.

Architectural Strategies for Resilient, Rapid Relief Shelters in Indian Disaster Contexts

Author:

Ar. Suvarna Thakare

Professor at Pillai College of Architecture, New Panvel

1. Abstract

India's susceptibility to natural and man-made disasters demands rapid, resilient shelter solutions to meet the immediate needs of displaced communities. This study explores architectural strategies for designing temporary shelters, tailored to India's natural disaster challenges. It emphasizes the importance of creating culturally sensitive and adaptable shelters that prioritize functionality and dignity.

By examining cases, the paper highlights innovative projects employing prefabricated, modular, and local materials. Technologies like concrete canvas, prefabrication, and climate-responsive design are explored for their potential to deliver rapid, scalable, and sustainable shelter solutions. Community engagement is identified as essential for ensuring locally relevant designs, fostering ownership, and enhancing recovery outcomes.

The research also discusses challenges such as funding, logistical hurdles, and the need for collaboration among architects, construction industries, the National Disaster Management Authority (NDMA), and NGOs. It advocates for integrated approaches combining architectural innovation, local resources, and community participation to develop effective disaster shelter solutions.

Key Words: Emergency Shelters, Rapid relief shelters, short term shelters, temporary shelters, disaster, architecture in shelter design.

2. Introduction

Numerous natural and man-made disasters, including earthquakes, floods, cyclones, landslides, and droughts, occur in India. Many people are frequently forced to flee dangerous places or lose their houses because of these disasters. In such cases rapid relief shelters provide immediate and temporary housing solutions to meet the basic shelter needs of affected populations, offering protection from the natural elements and ensuring safety and security in the aftermath of a disaster. These rapid relief shelters are also called as Emergency shelters, which are made with an objective of immediate protection of life from the harsh environment and to ensure a necessary degree of privacy. Many a times, the process of rapid relief shelters starts spontaneously as a self-protection measure by the affected households before any sort of help may arrive and are only a makeshift arrangement for dire need of shelter immediately after the disaster. This is usually done on their own or with support from within the community and their own social networks. The Government normally sets up relief camps during such emergency situations using existing community and public buildings and infrastructure and may also undertake distribution of cash or shelter materials like plastic sheeting, tarpaulins, etc. to support immediate sheltering (NDMA, 2019).

Rapid relief shelters play a vital role in supporting the early recovery and reconstruction efforts following a disaster. They provide a temporary platform for affected individuals and communities to regroup, assess damage, and begin rebuilding their lives. By promoting community resilience and self-recovery, rapid relief shelters contribute to the long-term recovery and reconstruction process (NDMA, 2019). The design of such shelters needs to be resilient, while doing so one need to understand that one model does not fit perfectly to everyone's need and it will not fit for each disaster type at various geographical location. Therefore, it is necessary to take into consideration of diversity of disaster, geography of the area where disaster has happened, array of affected people.

3. Overview of Indian Disasters and unique challenges in shelter needs

India, due to its vast geography and varied climatic zones, is one of the most disaster-prone countries globally. Natural hazards such as cyclones, floods, earthquakes, landslides, and heatwaves frequently impact various regions. Additionally, man-made disasters, including chemical spills, nuclear incidents, and biological outbreaks, pose significant risks to public safety. This diverse landscape requires tailored disaster management and shelter solutions that consider regional vulnerabilities and cultural contexts (ADRC).

3.1 Types of Disasters in India:

3.1.a. Natural Disasters

Cyclones: With an 8,000 km coastline, India is highly susceptible to cyclones, primarily affecting the east coast due to frequent storms from the Bay of Bengal. Cyclones cause widespread damage to infrastructure and housing, necessitating resilient coastal shelters.

Tsunamis: The 2004 Indian Ocean tsunami highlighted India's vulnerability, especially along the eastern coastline and Andaman & Nicobar Islands. Shelters here must be designed for rapid evacuation and flood resilience.

Heatwaves: Occurring mainly in the northwestern regions, heatwaves result in extreme temperatures that cause health risks, highlighting the need for shelters that mitigate thermal stress.

Landslides: Common in mountainous regions such as the Himalayas, landslides are triggered by monsoons and seismic activity, necessitating shelters that address slope stability and soil erosion.

Urban Floods: With increasing urbanization, cities like Mumbai and Chennai are prone to severe flooding during monsoons. Urban shelters need to incorporate flood-proofing and rapid deployment capabilities.

Earthquakes: Over 59% of India's land is seismically active, including major urban centres. Earthquake-resistant construction is essential in high-risk zones to prevent loss of life and property.

3.1.b. Man-made Hazards:

Chemical: Industrial incidents, like the 1984 Bhopal gas tragedy, underscore the need for emergency shelters near industrial zones.

Nuclear: With expanding nuclear energy infrastructure, India faces the risk of radiological emergencies, demanding specialized shelters with radiation shielding.

Biological: Outbreaks like COVID-19 demonstrate the need for quarantine shelters to manage contagion, especially in densely populated areas.

India’s varied disaster profile demands shelter solutions that are adaptable, resilient, and culturally sensitive. Each type of disaster presents unique challenges, underscoring the importance of regional-specific designs and preparedness strategies.

4. Role of Architectural Strategies in Rapid Relief Shelter Design

Creating resilient rapid relief shelters involves a multi-faceted approach that incorporates various architectural considerations and strategies to ensure these structures can withstand environmental stresses, meet the immediate needs of occupants, and adapt to evolving circumstances. Below are key considerations and strategies that contribute to the resilience of rapid relief shelters:

4.2 Identification and Selection of Sites for Temporary Shelters

Environmental Assessment: Analyse the site for potential hazards such as flooding, landslides, or high winds. Choosing an optimal location minimizes exposure to risks.

Accessibility: Ensure the site is accessible for the delivery of materials and personnel and for future aid and services.

Resource Availability: Proximity to local materials and resources can facilitate construction and sustainability (NDMA, 2019).

4.3 Site and Infrastructure Planning

(NDMA, 2019).

When resettling a community in their original location, site planning is generally more straightforward as essential services such as water, electricity, and sanitation may already exist. These services might only require restoration or repair to be fully functional. However, in relocation sites, numerous new services will need to be installed, though any existing services can be integrated and utilized to minimize redundancy and costs.

It is crucial to maintain the social structure and support systems of the community during the relocation process. Facility requirements should stem directly from the needs of the community, ensuring that the design is both relevant and beneficial. The site layout should incorporate multiple community spaces to foster social interaction and cohesion.

Access to safe social and service infrastructure is vital. Facilities should be designed to be disability-friendly, ensuring inclusivity for all members of the community. The site should have clear and well-connected access routes to other parts of the city and nearby areas to facilitate movement and integration.

Fire risk mitigation measures must be a key consideration in the planning phase to ensure the safety of residents. For new shelter layouts, it is important to plan for street lighting infrastructure to enhance safety and security during night-time. Additionally, the tent layout should be designed to minimize the wind tunnelling effect, which can cause discomfort and potential damage.

Providing adequate WASH (Water, Sanitation, and Hygiene) facilities is essential to maintain good hygienic conditions on the site. These facilities are critical to prevent the spread of diseases and to ensure the overall well-being of the community. By addressing these aspects of site and infrastructure planning, a more resilient and supportive environment can be created for the resettled community (NDMA, 2019).

4.4 Design of Temporary Shelters

When designing temporary shelters, it is essential to consider hazard resistance, functionality, durability, and the potential for owner-driven reconstruction. The community and individuals should be actively involved in every decision-making process, empowering them throughout the design phase. Special attention should be given to the climatic conditions of the site to ensure the comfort of the inhabitants. The design of temporary shelters, especially intermediate ones, should be rooted in local practices and take the surrounding site context into account (NDMA, 2019). Construction needs to be climate responsive.

a) **Considerations in cold climate:** To ensure comfort in cold climates, minimize air flow around door and window openings while providing adequate ventilation for traditional heaters or cooking stoves. Opt for a lower ceiling height, around 2 meters, to reduce the internal volume needing heating. Ensure sufficient insulation within the shelters. For areas prone to snowfall, design roofs with an appropriate slope to prevent snow accumulation.

b) **Considerations in warm and humid climate:** Design shelters to maximize ventilation and minimize direct sunlight entry. The ceiling should facilitate good air circulation. Roofs should include overhangs and an adequate slope for effective rainwater drainage. Avoid large overhangs in areas with high winds unless the roof extends close to the ground.

c) **Considerations in hot and dry climate:** Ceilings should promote good air circulation and ventilation. Carefully select materials that provide thermal comfort amidst fluctuating day and night temperatures. Construction techniques should be resilient to seismic activity. Use double-skinned roofs with ventilation between layers to trap heat, especially when using Corrugated Galvanized Iron (CGI) sheets or tents. Position door and window openings away from the prevailing wind direction to reduce heating by hot winds and heat radiation.

4.5 Cultural Sensitivity and Social Cohesion

The needs of women, the elderly, and disabled individuals must be specifically addressed in the design. For in-situ temporary shelters on the owners' land, the design should allow for upgrades to meet the technical standards of safe permanent housing whenever possible. Cooking areas should be well-ventilated, and materials used around these spaces should be fire-resistant. The need for storage must be acknowledged and adequately provided for in the temporary shelters.

Provision for cattle should be made at both the site and household levels where appropriate. Temporary shelters should also accommodate home-based work such as weaving, handicrafts, broom making, and block printing, among other activities. In some cases, the design can incorporate elements that support livelihood recovery efforts (NDMA, 2019).

4.6 Materials and Construction Technology

It is important to consider peoples' own ability and ease to execute construction and maintenance while opting for certain technology and materials. Temporary intermediate shelters, estimated to last for 2 to 3 years, should be constructed in a manner that they are safe in case of any potential risks due to hazards during this period. Durable design, materials and construction technology should be chosen accordingly to ensure a safe and dignified shelter. For hazard resistant construction of temporary shelters, the basic ABCD principle must be followed (NDMA, 2019).

i) A for Anchorage: The shelter should be anchored well to the ground.

ii) B for Bracing: The walls and roof of the shelter should be diagonally braced.

iii) C for Connections: All connections and joineries of various building components must be tied well with each other and be strong enough to resist natural forces.

iv) D for Diaphragm: Roof should act as a single plane diaphragm, and not as separately moving elements.

4.6.1Assembly-based Temporary Shelters

4.6.1.a Shelter Kits:

Shelter kits are vital in emergency responses. Their provision should be based on rapid assessments to determine necessity and advantages over other options. Capacity assessments should ensure timely procurement. Pre-positioning and stockpiling of select kits regionally facilitate immediate distribution during disasters. Kits must be transportable over long distances. Distribution provides an opportunity for training and dissemination of repair manuals. Kits should undergo periodic review and adaptation. Materials must suit local contexts and damage levels. Basic training for communities should cover kit usage and maintenance. Vulnerable individuals may need additional support, like cash for labour hiring. Community tool kits should be provided where feasible, promoting shared resources (NDMA, 2019).

4.6.1.b Tents:

Tents serve as temporary shelter solutions primarily during the emergency phase of recovery. They must be durable to withstand various climatic conditions, preferably double-layered for better protection. Regional storage in dry, ventilated environments ensures their preservation. Transport should be feasible and economical for homeowners and vulnerable individuals. Tents can help non-displaced people remain on their land after house destruction, but support for makeshift shelters using local materials is crucial. Displaced people require additional services in ex-situ camp settlements. Site planning by experts minimizes risks like fire. Clustering tents in camp settlements is preferable to long rows. Support mechanisms, including tools and training, aid disaster-affected communities in tent erection and site preparation (NDMA, 2019).

4.6.2 Prefabricated shelters

The decision to use prefabricated shelters should be based on the choice of house owners and market availability from manufacturers. Guidelines include pre-identifying manufacturers for timely supply, using design options with common specifications for modification, and improving climatic performance. Locally sourced materials are preferred to support the local economy and ensure quick assembly. Adequate training for repair and maintenance is essential to prevent degradation. External aids like cranes and skilled operators may be necessary. Disposal plans for non-recyclable materials must be in place. Prefabricated shelters can be assembled on relocation sites and offered through rental assistance to prevent land encroachment, with plans for easy dismantling (NDMA, 2019).

4.6.2 a Modularity and Scalability

Prefabricated Components: Design modular units that can be quickly assembled and disassembled, allowing for scalability and adaptability.

Standardization: Use standardized parts to simplify construction, facilitate repairs, and ensure compatibility across different units and sites.

4.6.3 Construction-based Temporary Shelters

Various materials from the viewpoint of ease of availability, construction and maintenance, management of resources and environmental impact need to think about.

4.6.3.a. Material Selection

Material selection for temporary shelters is crucial for their durability and suitability to local conditions. Local materials like stone, mud, bamboo, wood, and thatch are preferred due to their widespread availability and community familiarity. Their use promotes owner-driven construction and facilitates easy repairs over time. Priority should be given to locally sourced materials, minimizing transportation costs and environmental impact. However, materials such as mud, wood, and bamboo may require frequent repairs and extra protection against erosion and decay. Industrial materials like CGI sheets and tarpaulins are lightweight and easy to install but may not be climate-responsive and require frequent maintenance. Salvaging materials from debris for shelter construction is a sustainable approach, reducing the burden of acquiring new materials. A comprehensive debris management plan involving local communities should be implemented to promote reuse or safe disposal. Roofing materials should be prioritized in cases where complete shelter construction is not feasible. It's essential to assess the potential and limitations of various building materials to ensure the resilience of temporary shelters (NDMA, 2019).

4.6.3.b. Construction Technology

Construction of temporary shelters must follow hazard-resistant construction principles, with adjustments based on local conditions. Tents may not need foundations but should be securely anchored against high winds. If foundations are needed, they should be at least 300 mm deep, considering soil type and site conditions. The plinth should be raised at least 150 mm above the highest expected flood level. Adequate surface water drainage should be ensured, considering the raised plinth. Temporary shelters should be well anchored, diagonally braced if using bamboo or wooden posts, and have strong connections between components. Walls should ideally be low (900 to 1200 mm) and made of lightweight materials, with thickness not exceeding 350-450 mm. Masonry units should be laid using water level and plumb, with staggered joints. Stones and corner stones should be placed according to standard specifications. Walls should have a band on top for reinforcement. Diagonal bracing should be provided, and joineries should be strong to withstand stresses. Heavyweight roofs should be avoided, and lightweight roofs should be well anchored, especially in cyclone-prone areas. Roof joints should be strong and leak-proof. Technical support should be available for construction supervision and quality assurance (NDMA, 2019).

4.7 Rental Assistance for Temporary Shelters

Rental assistance for temporary shelters is very appropriate in many circumstances particularly in urban areas where there may be sufficient housing units be available for use in case of disaster. This option provides flexibility to the owners to choose accommodation as per the preference of location, size, cost, services, etc (NDMA, 2019)

5. Case Studies of Rapid Relief Shelter Projects

Disasters have profound impacts on victims, affecting them not only physically but also mentally and emotionally. These events often result in significant grief, as victims may lose their possessions, homes, or even family members. Therefore, a swift recovery process is essential to reduce the impacts of the disaster and alleviate the suffering of those affected. In this case rapid relief shelter plays an important role. In this section we are going to see various types of rapid relief shelter used in different disasters in the globe.

5.1 Uttarakhand – 2013, Flash Flood and Associated Landslide

Figure 1: Tent Camp, Uttarakhand Flood 2013, India. Source: (Indian Red Cross Society, 2013)

In the devastating floods in Uttarakhand in 2013, affected 12 out of the 13 districts in Uttarakhand. The 4 districts that were worst affected were Rudraprayag, Chamoli, Uttarkashi and Pithoragarh (Indian Red Cross Society, 2013). More than 4,000 villages were affected and 3,320 houses were completely damaged. Disaster was aggravated by an ongoing Hindu pilgrimage and especially busy tourist season. Thousands were stranded when heavy flooding washed away bridges, roadways, and other infrastructure, requiring the mobilization of the Indian Army, Air Force, and Paramilitary troops to help evacuate more than 110,000 people from affected areas (The World Bank, 2014). In the shelter relief work Family tents (Figure 1) (to accommodate upto 8 persons each), family packs (including kitchen sets, clothing, buckets etc.), stoves, lanterns and tarpaulins etc were provided (Indian Red Cross Society, 2013).

5.2 Gujarat – 2001, Earthquake

On January 26, 2001, an earthquake of shattering intensity of 7.9 on the Richter scale occurred 20km northeast of Bhuj in the dry and arid district of Kutch at Gujarat. The earthquake left 20,005 dead, 166,812 injured, 600,000 homeless and 212.6 billion Indian rupees in damage (BAPS, 2001). People were rescued in tent camps where size of each tent (Figure 2) was 11’ x 12’ for each family, and Tin Shead (Figure 3) of size 11’ x 11’ for each family in the initial days as they were afraid to go inside the building due to the fear of building collapse because of the aftershock of the earthquake.

Figure 2: Tent camp as a Short-Term Temporary relief shelter, Source: (BAPS, 2001)

Figure 1: Tin Shead as a Short-Term Temporary relief shelter, Source: (BAPS, 2001)

Within a few weeks, transitional shelters were built through a collaboration between 22 local organizations, including architects with a focus on development, and an international organization. Each shelter measured approximately 4m x 2.5m, providing 10 square meters of covered space per family. These dimensions were chosen to prioritize earthquake safety. The low-cost design featured 1-meter-high walls, a bamboo frame, and a thatched grass roof. However, as the need to conserve grass for animal feed arose, the roofs were later replaced with locally made Mangalore clay tiles. After initial construction, roofing issues were identified and resolved by adding four 1.5-meter bamboo braces for additional support (UN-HABITAT , 2008).

5.3 Odisha - - 2019, Cyclone Fani

Figure 4: Multipurpose cyclone shelters Source: (OSDMA, 2012)

On May 3rd, Cyclone Fani, a Category 4 storm, struck three Indian states—Odisha, Andhra Pradesh, and West Bengal—with Odisha being the hardest hit. Over 15 million people in Odisha were affected, including 4.8 million children. Cyclone Fani was unusual, as it was one of the rare summer cyclones, the first in 43 years, and only one of three to impact Odisha in the last 150 years. Although significant loss of life was avoided, the cyclone severely disrupted the lives and livelihoods of more than 28 million people across the three states. To minimize fatalities, state authorities in Odisha, Andhra Pradesh, and West Bengal implemented preparedness measures, evacuating residents from low-lying areas to multipurpose cyclone shelters (Figure 4) before the cyclone made landfall. Additionally, tarpaulin sheets, bamboo, and medical kits were provided for emergency needs (IRFC, 2019).

5.4 Bihar – 2008, Kosi River Floods

Figure 5: Tent Camp run by NGOs during Kosi River Flood. Source: (UNDP and IHD, 2009)

The massive Kosi floods of 18 August 2008, caused by an extensive breach in the Kosi River, resulted in unprecedented loss of lives, livelihoods, infrastructure and property in north-eastern Bihar. The Kosi burst its embankments and changed course, inundating areas of Bihar that had not experienced such flooding for half a century. About 1,000 villages in five districts (Araria, Madhepura, Purnia, Saharsa and Supaul) were affected, involving three million people. One third of households shifted to Government camps located nearby, during the flood, while only four percent took shelter in the camps run by NGOs/charitable organizations (Figure 5). About one in four households made their own arrangements to move out of flood-affected villages (UNDP and IHD, 2009)

5.5 Tamil Nadu – 2004, Tsunami

For the country, the tsunami disaster was unheard off. It was unprecedented in its intensity, magnitude and spread, which extended from the Andaman & Nicobar Islands in the heart of the Indian Ocean 1400 Kms away from the mainland, to the coastal States of Andhra Pradesh, Tamil Nadu, Kerala and the Union Territory of Pondicherry. A total of 27.92 lakh people: 1.96 lakh in Andhra Pradesh, 13.00 lakh in Kerala, 8.97 lakh in Tamil Nadu, 0.43 lakh in Pondicherry and 3.56 lakh in A & N Islands were affected in 1,089 villages. The tsunami destroyed over 2.35 lakh dwelling units; 481 in Andhra Pradesh, 13735 in Kerala, 1,90,000 in Tamil Nadu, 10061 in Pondicherry and 21,100 in A & N Islands. Apart from their homes people lost their livelihoods (reliefweb, 2005).

In initial days people were rescued and provided shelter in schools, marriage halls, churches, and other worship places, after few weeks construction of temporary shelters were undertaken by the state government with the help of builders.

Figure 6: Temporary shelters built by Government using GI corrugated sheets, wooden ballies, nails brick to level up the ground at Tamil Nadu. Source: (Murty, Jain, Sheth, Jaiswal, & Dash, 2006).

In Tarangambadi, Tamil Nadu, temporary shelters were constructed only 350m from the coast, less than the 500m mandated by coastal regulations. The shelters (Figure 6) were often in low-lying areas with floors at ground level, leading to flooding risks, especially during rains. Roofs, simply nailed on, could detach in high winds; the government discouraged the use of thatch roofs due to fire concerns after a recent tragedy. The kitchens were positioned outside with limited space between shelter rows, leading to congestion. Ventilation in row housing was inadequate, trapping hot air. Garbage collection systems were mostly absent, and toilets, though built with septic tanks, were improperly used due to lack of training, leading some to resort to open defecation (Murty, Jain, Sheth, Jaiswal, & Dash, 2006).

Figure 7: Housing units of jute-bitumen corrugated sheets constructed on the wrong side of the highway remained unoccupied, because of the hazard of crossing the road while coming from and going to the coast. Source: (Murty, Jain, Sheth, Jaiswal, & Dash, 2006).

Figure 8: Fisherman pegged their own informal tents to live on the other side of the highway, which was on the same side as the ocean. Source: (Murty, Jain, Sheth, Jaiswal, & Dash, 2006).

Figure9: Temporary Shelters built with asbestos sheet. Source: (Murty, Jain, Sheth, Jaiswal, & Dash, 2006).

Figure 10: Temporary Shelters built with Jute-Bitumen Sheet. Source: (Murty, Jain, Sheth, Jaiswal, & Dash, 2006).

There was wide variation in the type of shelters. Some shelters were built dangerously close to the East Coast Highway (Figure 8), creating risks for fishermen crossing the road, therefore people erected informal tents towards sea side with the help of available resources (Figure 9) . Some builders chose to make long sheds in the early efforts, and only a limited number of them were made as individual houses. But later this received significant criticism from the users, and then individual houses were made. Additionally, materials like asbestos and jute-bitumen sheets were used (Figure 10 and 11), posing health risks and overheating issues in Tamil Nadu's climate. Pre-determined guidelines on acceptable materials for disaster response could mitigate such issues in the future (Murty, Jain, Sheth, Jaiswal, & Dash, 2006).

5.6 West Bengal and Odisha – 2020, Cyclone Amphan

On May 20, 2020, Tropical Cyclone Amphan struck India and Bangladesh, making landfall in the eastern Indian states of West Bengal and Odisha with wind speeds reaching up to 210 km/h. The cyclone impacted nearly 60 million people across India, claiming at least 95 lives, forcing hundreds of thousands into temporary shelters, and damaging or destroying over 2.9

million homes. The storm devastated approximately 1.7 million hectares of cropland and aquaculture farms, killing 2.1 million animals (Ober, 2020). This disaster unfolded amid the COVID-19 pandemic, compounding the challenges faced by affected communities (Mondal & Chowdhury, 2021).

Odisha and West Bengal, known for their recurring floods and cyclones, have long histories of disaster impacts on thousands each year. Over time, the Indian Red Cross Society (IRCS) and its state branches in Odisha and West Bengal have bolstered their disaster response capacities, with trained personnel, volunteers, and well-equipped cyclone shelters in Odisha. In close collaboration with the Indian Meteorological Department and State Disaster Management Authorities, these branches issued early warnings, activated Social Emergency Response Volunteers (SERV), and pre-positioned essential food, hygiene supplies, and non-food items. They also enforced COVID-19 safety measures, including social distancing, at cyclone shelters and other safe locations (IRFC, 2021).

Working alongside government authorities, IRCS volunteers assisted communities in cyclone-prone areas with evacuations to safer locations. Post-cyclone, volunteers aided in damage assessment, distributed emergency relief, provided first aid, and promoted personal hygiene awareness. The IRCS swiftly distributed tarpaulins and mosquito nets to those who had lost their homes, providing immediate relief to those in need (IRFC, 2021).

6. Innovative Technologies and Solutions

The advent of innovative technologies and novel solutions has brought significant advancements in disaster response and recovery. These developments contribute to enhancing the efficiency and effectiveness of relief operations, while also providing sustainable and resilient options for affected communities.

6.1 Concrete canvas shelters- UK

These shelters are made with Concrete Canvas (Figure 12), a fabric that hardens when sprayed with water, creating a waterproof and fireproof concrete layer. The material is sold in large rolls which can be manipulated into shape onto the ground, on slopes and on existing concrete. The shelters, comes in two sizes - 25 and 50 square metres. They are packed in a large wooden box, attached to an electric fan which inflates the structure until it can support itself. Then the water is applied and the structure is ready to use within 24 hours, complete with doors for access. It can be constructed by two people without any training in less than an hour (Hickey, 2015).

Figure 11 Concrete Canvas Shelters Source: (Concrete Canvas, n.d.)

Sales of these shelter as emergency shelters faced challenges. In the aid sector, there were political complications in setting up semi-permanent structures in disaster-affected areas, as authorities are often reluctant to acknowledge that the recovery process might extend beyond a few months (Hickey, 2015).

6.2 Earthbags

Figure12: Earth-bag Shelter, Source: (Paul, 2013)

Nader Khalili, a Persian architect, developed earthbag houses (Figure 13) that are affordable, eco-friendly, and resistant to earthquakes, floods, fires, and hurricanes. This technique involves filling sandbags with earth and stacking them in circular layers that corbel near the top to form a dome. Barbed wire placed between layers prevents shifting, enhancing earthquake resistance, while the dome’s aerodynamic shape resists hurricanes, sandbags provide flood resistance, and the earth offers insulation and fireproofing. These shelters are sustainable, as they require minimal training and can be constructed by the occupants themselves. The design is flexible, allowing for varied structure sizes and arrangements to suit different social and ecological needs, and can also serve as permanent housing, turning disaster relief into long-term opportunities (Paul, 2013).

6.3 AbleNook

Figure13: AbleNook prefabricated emergency shelter, Source: (Borgobello, 2013)

The AbleNook (Figure 14), developed by architects Sean Verdecia and Jason Ross as a flexible, affordable solution for emergency housing, is designed to provide rapid and efficient shelter in disaster-hit areas. This modular system is highly adaptable for diverse needs. Each unit offers 64 square feet (6 square meters) of interior space, with the option to connect multiple modules to create larger living areas with separate zones.

Built from aircraft-grade aluminium and structural insulated panels (SIPs), AbleNook's design allows for easy assembly with minimal tools and labor. Its adjustable leg jacks enable deployment on uneven terrains, often eliminating the need for costly foundations. The flat-packed design makes transportation economical and straightforward, while the aluminium frame, with built-in electrical conduits, offers easy access to power.

Natural ventilation techniques and frosted glass windows regulate the indoor temperature without the need for air conditioning, while allowing sufficient daylight. The robust structure can withstand low-level hurricanes, making it suitable for disaster-prone regions. Although it lacks bathroom and kitchen facilities, the unit opens onto a protected terrace, providing outdoor space for added comfort and flexibility **(Borgobello, 2013)**.

6.4 Shelter In A Day

Figure14: Shelter In A Day

The "Shelter In A Day" disaster relief house (Figure 15) is designed to support individuals displaced by natural disasters like hurricanes, earthquakes, or floods. Constructed with a Tool-Free Joint system and interlocking panel edges, these shelters are built for durability and stability. Made from 100% recycled wood fiber, each shelter is precisely cut using advanced computerized technology to reduce waste.

The shelter can be set up on an existing concrete slab or on various local materials, such as stone, rubble, concrete blocks, pavers, or even mud bricks. Screw-type earth anchors can be manually installed around the base or embedded in a concrete slab for added stability, while steel straps running through the exterior walls help secure the shelter against strong winds. All structural elements come pre-drilled, allowing temporary extensions or attachment points for personal belongings inside.

Although the shelter's roof is sturdy, it requires additional waterproofing material, as it is not fully waterproof. The galvanized steel roof, raised 2 inches above the structural roof, provides heat control in tropical climates. Remarkably, the shelter can be assembled in under a day without the need for tools or electricity. The base model measures 12’ x 12’ but can be expanded in 4-foot increments to sizes such as 12’ x 16’, 12’ x 20’, or longer, based on needs. Equipped with lockable doors and windows, the shelters are portable, allowing them to be dismantled, relocated, and reused as needed (Shelter In A Day, 2024).

6.5 Shigeru Ban Paper Log House

Figure 15: Paper Log House India, Bhuj

Japanese architect Shigeru Ban is renowned for his innovative use of paper materials, especially recycled cardboard tubes, to provide quick and efficient shelter for disaster victims. In 2001, under Shigeru Ban's guidance, the Paper Log House (Figure 16) concept was adapted for victims of the Bhuj earthquake in India. Although Ban originally developed this type of shelter in 1995, the design in India featured unique adaptations for the foundation and roof. Instead of beer crates used in the original design, rubble from collapsed buildings served as the foundation, topped with a traditional mud floor. For the roof, split bamboo was used for the rib vaults, with whole bamboo supporting the ridge beams. Over the bamboo structure, a locally woven cane mat was laid, followed by a clear plastic tarpaulin for rain protection, and another cane mat on top. Ventilation was provided through small holes in the cane mats at the gables, allowing air circulation. This setup not only facilitated indoor cooking but also helped repel mosquitoes (Architect, 2014).

7. Community Engagement and Participation

In disaster recovery, housing support, including temporary shelters, is a fundamental entitlement that must be provided equitably and transparently to all affected individuals. Recognizing impacted communities as active agents in their recovery, rather than passive victims, enables the process to leverage local knowledge, skills, and resilience. Community involvement fosters a sense of ownership, aids emotional healing, and ensures shelters are disaster-resistant, cost-effective, and culturally appropriate (NDMA, 2019).

Special attention is essential for marginalized groups, ensuring equitable support for vulnerable individuals such as single women, the elderly, and socially disadvantaged. Community-led reconstruction, as seen in the Gujarat earthquake and Uttarakhand floods, has demonstrated faster, more satisfactory, and durable outcomes (NDMA, 2019).This approach builds trust and collaboration, empowering communities to guide their own recovery.

Top-down “build back better” agendas risk disrupting architectural identity and social fabric. Engaging residents in planning helps preserve cultural values, spatial belonging, and historical continuity, integrating local insights often missed by external decision-makers (Naaseh, 2023). Examples, like the recovery after the Gujarat earthquake and Uttarakhand floods, demonstrate that community-led reconstruction leads to faster, more satisfying, and durable outcomes (NDMA, 2019). Community-led planning enhances sustainability, resilience, and relevance to local needs, creating a disaster recovery process that is inclusive, culturally respectful, and resilient for the future

8. Challenges and Opportunities

Post-disaster reconstruction and recovery are complex processes that present numerous challenges for both affected communities and the government. In urban areas, these challenges differ significantly from those in rural settings, particularly due to the larger number of families requiring immediate shelter support. Urban populations often reside in diverse housing types, such as multi-occupancy buildings, informal settlements, and rental properties. Special consideration is essential for those living in informal settlements and rental housing, as eligibility criteria based on property or land ownership can lead to their exclusion from recovery support (NDMA, 2019).

Emergency Shelters are quick to build (which is in line with the UNHCR Shelter Design Catalogue) but fail in other aspects of design, such as comfort, sustainability, safety & access. Conversely, Durable Shelters are slow to build but perform better design aspects other than the preconstruction stage, such as protection from the environment, comfort and lifetime and maintenance. Transitional shelters performed better in various design issues such as comfort, safety, privacy compared to Emergency Shelters, but their performance was weaker compared to Durable Shelters (Kuchai, et al., 2024). Traditional construction methods fall short in disaster relief due to being time-consuming, resource-intensive, and lacking adaptability. They often involve lengthy processes, demand significant resources, and are limited in adapting to varying environmental conditions and needs (Kaarwan, 2024). Designing disaster relief shelters for India requires cultural sensitivity and logistical planning. Shelters should accommodate extended families and communal spaces, reflecting local customs. Partnerships with NGOs, government, and private entities are vital for funding and implementing scalable shelter solutions. Effective shelter design should address both community needs and the logistical challenges of delivering aid (Kaarwan, 2024).

The design and implementation of disaster relief emergency shelters offer significant opportunities for architects, the construction industry, and government bodies to develop resilient and context-sensitive solutions. In India, The National Disaster Management Authority (NDMA), established under the Disaster Management Act of 2005, plays a crucial role in formulating policies, coordinating resources, and setting standards for disaster relief and recovery. NDMA's involvement ensures that shelters meet minimum standards for safety, comfort, and dignity while providing a framework for equitable and transparent allocation of resources in disaster-affected areas. This legal and organizational structure strengthens the collaboration between government agencies, architects, and construction firms to address disaster response more systematically.

Architects have a critical role in designing adaptable and culturally sensitive shelter solutions that go beyond basic protection. They can introduce modular and flexible designs that accommodate diverse family structures and community spaces, which are essential for emotional and social recovery. Culturally appropriate designs ensure that shelters are more than just temporary structures; they are spaces that reflect the identity and needs of the affected communities.

The Construction Industry can support these efforts by deploying advanced materials and modern building techniques, such as prefabrication, modular construction, and 3D printing. These technologies enable the rapid assembly of shelters at a large scale, addressing urgent needs in the immediate aftermath of a disaster. The use of sustainable and locally sourced materials reduces environmental impact and encourages community involvement, which can help in building resilience and reducing costs.

The Disaster Management Act of 2005 also facilitates collaboration by establishing funds such as the Disaster Response Fund (DRF) and the Disaster Mitigation Fund (DMF), which provide financial resources for immediate relief and long-term resilience projects. This funding mechanism supports public-private partnerships, bringing together NGOs, private companies, and local governments in a coordinated effort to develop scalable shelter solutions. Collaborative approaches that engage local communities and stakeholders help to ensure that designs are culturally relevant and practical, fostering a greater sense of ownership and easing integration with local lifestyles. The involvement of local artisans and communities in shelter construction also promotes skill-building and long-term economic benefits, creating opportunities for local employment.

In summary, the combined efforts of NDMA, architects, the construction industry, and local communities enable the development of effective, resilient, and culturally sensitive disaster relief shelters. These collaborative approaches, supported by the legal framework of the Disaster Management Act of 2005, create an integrated response that enhances both short-term relief and long-term recovery, making shelters not just transitional spaces but also foundations for sustainable redevelopment and resilience.

9. Conclusion

Designing resilient rapid relief shelters for Indian disasters requires a comprehensive approach that addresses immediate needs while laying the groundwork for long-term recovery. Urban and rural challenges vary significantly, particularly with the complexity of housing types and vulnerable populations in urban areas, where diverse settlements such as multi-occupancy dwellings and informal housing prevail. To meet these challenges, architects must design shelters that are adaptable, culturally sensitive, and sustainable, using innovative materials and construction techniques. Examples like Architect Shigeru Ban Paper Log House for Gujrat Earthquake incorporating paper roll, eco-friendly materials, employing modular and lightweight construction techniques, highlight the successful integration of local context and sustainable practices. Earth bag shelter uses the locally available material in cooperation with the community help for the construction.

The National Disaster Management Authority (NDMA) plays a pivotal role in guiding and coordinating disaster response, facilitating the deployment of shelter solutions through the Disaster Response Fund (DRF) and Disaster Mitigation Fund (DMF). These funds enable collaboration between government bodies, NGOs, architects, and the construction industry, supporting scalable and cost-effective shelter solutions while ensuring equitable distribution of resources.

Technological innovation is also key in disaster shelter design. The use of prefabricated panels, Concrete rolls, and modular construction techniques has revolutionized the speed and scalability of shelter deployment. These technologies enable rapid construction of shelters that can be customized to specific environmental conditions, provide better insulation, and are easier to transport and assemble. These techniques can significantly reduce construction time and resource use. Similarly, modular shelters, which are pre-designed and manufactured off-site, allow for faster assembly and the flexibility to adapt to different site conditions and family structures.

Involving local communities in shelter design and construction enhances the cultural relevance, sustainability, and social recovery. Local artisans, builders, and communities can contribute traditional knowledge alongside modern techniques, facilitating skill-building, local employment, and greater ownership of the recovery process. This collaborative approach ensures shelters are not merely temporary spaces but integral components of the long-term rebuilding process, strengthening both community resilience and social cohesion.

In conclusion, a holistic strategy integrating technological innovation, architectural expertise, and community involvement—guided by the NDMA's framework—can ensure that disaster relief shelters are not only effective in meeting immediate needs but also resilient and sustainable for future generations. By using cutting-edge technologies and locally sourced materials, while aligning designs with socio-cultural contexts, temporary shelters can become foundational to the long-term recovery and resilience of disaster-affected communities.

10. References

ADRC. (n.d.). *DISASTER RESPONSE IN INDIA : AN OVERVIEW.* ADRC. Retrieved March 3, 2024

Architect. (2014, 03 23). *Paper Log House India*. Retrieved from Architect: https://www.architectmagazine.com/project-gallery/paper-log-house-india

BAPS. (2001). *Gujarat Earthquake Rehabilitation and Relief Work Report.* BAPS.

Borgobello, B. (2013, 1 18). *AbleNook portable dwelling assembles in two hours*. Retrieved from New Atlas: https://newatlas.com/ablenook-portable-dwelling-assembles-in-2-hours/25858/

Concrete Canvas. (n.d.). *The company behind the inflatable concrete shelter*. Retrieved from Concrete Canvas: https://www.concretecanvas.com/blog-concrete-canvas-the-company-behind-the-inflatable-concrete-shelter/

Government of Bangladesh. (2008). *Cyclone Sidr in Bangladesh Damage, Loss and Needs Assessment For Disaster Recovery and Reconstruction.* Dhaka: Government of Bangladesh. Retrieved November 5, 2024, from https://modmr.portal.gov.bd/sites/default/files/files/modmr.portal.gov.bd/publications/83ccdd3b_1e9f_4e43_9583_cafeed377d73/AssessmentReport_CycloneSidr_Bangladesh_2008(Worldbank).pdf

Hickey, S. (2015, January 18). *Gimme shelters ... the inflatable concrete that's spread across the world*. Retrieved from The Guardian: https://www.theguardian.com/business/2015/jan/18/concrete-canvas-shelters-construction-projects

Indian Red Cross Society. (2013, June 27). *Indian Red Cross Society*. Retrieved November 5, 2024, from Indian Red Cross Society: https://www.indianredcross.org/press-rel27-june2013.htm

IRFC. (2019). *Emergency Plan of Action Final Report, India: Cyclone Fani.* IRFC. Retrieved November 6, 2024, from https://reliefweb.int/report/india/india-cyclone-fani-emergency-plan-action-final-report-dref-n-mdrin022

IRFC. (2021). *Final Report India: Cyclone Amphan.* IRFC. doi:https://reliefweb.int/report/india/india-cyclone-amphan-final-report-dref-n-mdrin025

Kaarwan. (2024, October 26). *Disaster Relief Shelters in India: Mobile Designs for Moments That Matter*. Retrieved Noember 8, 2024, from Kaarwan:

https://www.kaarwan.com/blog/architecture/disaster-relief-shelters-india-mobile-designs-moments-that-matter?id=1046

Kaarwan. (2024, June 04). *Parametric Design for Disaster Relief Shelters*. Retrieved November 8, 2024, from Kaarwan: https://www.kaarwan.com/blog/architecture/parametric-design-for-disaster-relief-shelters?id=501

Kuchai, N., Albadra, D., Lo, S., Saied, S., Paszkiewicz, N., Shepherd, P., Coley, D. (2024, October). Improving the shelter design process via a shelter assessment matrix. *Progress in Disaster Science, 23*. doi:https://doi.org/10.1016/j.pdisas.2024.100354

Mondal, D., & Chowdhury, S. (2021, January to June). Coping with Disaster: Lesson Learnt from Super-Cyclone Amphan in India. *Disaster & Development, 10*(1), pp. 177-194. Retrieved November 6, 2024, from https://nidm.gov.in/journal/PDF/Journal/NIDMJOURNAL_JanJun2021/NIDMJOURNAL_JanJun2021m.pdf

Murty, C., Jain, S. K., Sheth, A. R., Jaiswal, A., & Dash, S. R. (2006, 6). Response and Recovery in India after the December 2004 Great Sumatra Earthquake and Indian Ocean Tsunami. *Earthquake Spectra, 22*, S731–S758. doi:10.1193/1.2206137

Naaseh, W. (2023). *A framework for participatory decision-making in the context of post-disaster housing reconstruction : case studies from three post-disaster reconstruction programs in the 2000s.* Laboratoire Architecture, Ville, Urbanisme, Environnement, Laboratoire Architecture, Ville, Urbanisme, Environnement, Paris. Retrieved from https://theses.hal.science/tel-04500964/

NDMA. (2019). *National Guidelines on Temporary Shelters for Disaster - Affected Families.* New Delhi: NDMA. Retrieved November 7, 2024, from https://nidm.gov.in/PDF/pubs/NDMA/24.pdf

NDMA. (2019). *National Guidelines ON TEMPORARY SHELTERS FOR DISASTER - AFFECTED FAMILIES.* National Disaster Management Authority, New Delhi. Retrieved March 03, 2024

NDMA. (2019). *National Guidelines ON TEMPORARY SHELTERS FOR DISASTER - AFFECTED FAMILIES.* New Delhi : NDMA.

NDMA. (n.d.). *Biological*. Retrieved from NDMA: https://ndma.gov.in/Man-made-Hazards/Biological

NDMA. (n.d.). *Chemical*. Retrieved from NDMA: https://ndma.gov.in/Man-made-Hazards/Chemical

NDMA. (n.d.). *Cyclone*. Retrieved March 3, 2024, from National Disaster Management Authority: https://ndma.gov.in/Natural-Hazards/Cyclone

NDMA. (n.d.). *Earthquakes*. Retrieved from NDMA: https://ndma.gov.in/Natural-Hazards/Earthquakes

NDMA. (n.d.). *Floods*. Retrieved from NDMA: https://ndma.gov.in/Natural-Hazards/Floods

NDMA. (n.d.). *Heat Wave*. Retrieved from NDMA: https://ndma.gov.in/Natural-Hazards/Heat-Wave

NDMA. (n.d.). *Landslide*. Retrieved from NDMA: https://ndma.gov.in/Natural-Hazards/Landslide

NDMA. (n.d.). *Nuclear*. Retrieved from NDMA: https://ndma.gov.in/Man-made-Hazards/Nuclear

NDMA. (n.d.). *Tsunami*. Retrieved from National Disaster Management Authority: https://ndma.gov.in/Natural-Hazards/Tsunami

NDMA. (n.d.). *Urban Floods*. Retrieved from NDMA: https://ndma.gov.in/Natural-Hazards/Urban-Floods

Ober, K. (2020, October 7). *Complex Road to Recovery: COVID-19, Cyclone Amphan, Monsoon Flooding Collide in Bangladesh and India*. Retrieved from Refugees International: https://www.refugeesinternational.org/reports-briefs/complex-road-to-recovery-covid-19-cyclone-amphan-monsoon-flooding-collide-in-bangladesh-and-india/

OSDMA. (2012). *Hand Book for Management and Maintenance of Multipurpose Cyclone/ Flood Shelters.* Bhubaneswar: OSDMA. Retrieved from https://www.osdma.org/publication/multipurpose-cyclone-shelter/#gsc.tab=0

Paul, A. (2013, 6 30). *Technology for Disaster Resistant Shelters and Post-Disaster Shelters*. Retrieved from Civildigital: https://civildigital.com/technology-for-disaster-resistant-shelters-and-post-disaster-shelters/

reliefweb. (2005, 6 3). *reliefweb*. Retrieved from reliefweb: https://reliefweb.int/report/india/india-tsunami-report-nation

Shelter In A Day. (2024). *Shelter In A Day | Disaster Relief Housing*. Retrieved from Shelter In A Day: http://www.shelterinaday.com/faq.html

The World Bank. (2014). *Stories Of Impact Rapidly Assessing Flood Damage in Uttarakhand, India.* The World Bank. Retrieved November 5, 2024, from https://www.worldbank.org/content/dam/Worldbank/document/drm/gfdrr-stories-of-impact-uttarakhand.pdf

UNDP and IHD. (2009). *Kosi Floods 2008 How we coped! What we need? Perception Survey on Impact and Recovery Strategies.* United Nations Development Programme. Retrieved November 5, 2024, from https://www.undp.org/india/publications/kosi-floods-2008-how-we-coped-what-we-need-perception-survey-impact-and-recovery-strategies#:~:text=Households%20across%20social%20groups%20also,(US%24%20195%20million).

UN-HABITAT . (2008). *IASC Emergency Shelter Cluster SHELTER PROJECTS 2008.* UN-HABITAT . Retrieved November 6, 2024, from https://www.shelterprojects.org/shelterprojects2008/ref/UN_Habitat_shelter_projects_2008.pdf