

TOWARDS PERMANENCE

A BRIEF GUIDE TO DESIGNING
POST-DISASTER SHELTER IN INDIA



A Brief Guide to Designing Post-disaster Shelter in India

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INTRODUCTION

In 2015, India faced economic losses of USD 3.30 billion and a loss of 1.23 million houses due to disaster events. Less conservative figures for average annual losses due to hazards, put economic damages at USD 9.8 billion per annum.

According to risk analysis firm Verisk Maplecroft,

India is the most disaster vulnerable country in the world

India is the most disaster vulnerable country in the world. This is telling, not only of India's particular proneness to natural hazards, but also of the societal features that make populations more vulnerable: the precarious nature of the building stock, increasing density of population, ill-managed growth of settlements and climate change impacts. Many of these factors speak to the growing challenge of scale in disaster response. Planning and preparing for such losses is becoming increasingly imperative. This guide is aimed at enhancing the preparedness of the disaster response community, particularly shelter practitioners and designers.

This guide aims to streamline the post-disaster shelter design process. Instead of prescribing fixed designs, the guide identifies best-practice components and features. Appropriate shelters can be devised from this, as per the scale, geography and temporality of the disaster response. Each disaster event, has a particular scalar, spatial, temporal and societal context and thus requires a particular response. In this, the guide contends with India's range of natural hazards and climate vulnerabilities. It also looks at India's variety of geographical, material, environmental, market, societal, cultural, skills and capacity contexts. This diversity of housing practices, climates and disaster vulnerabilities renders a one-size-fits-all solution inappropriate. The approach needs to be plural.

Each disaster event, has a particular scalar, spatial, temporal and societal context and thus requires a particular response

The guide is organised into two sections. The first is a set of common principles identified across housing and disaster-response in India. These common guidelines are more concerned with the strategy of delivering sheltering. It stresses that housing should be treated as a process across the construction, occupation and maintenance phases and especially one that is embedded in the site's particular context. This section

also deals with the growing challenge of scale of disaster response and potential associated trade-offs to design (for a detailed discussion, see Motivations section).

The zonal guidelines develop a matrix of best-practice components and features as per a region's climate and hazard context. Here the concern is with the practical design of the shelter. To simplify, a typology of ten shelter zones across India were developed. These zones draw from material and physical conditions which dictate shelter design: geographies of hazards, climate vulnerabilities and material availability (see appended methodology). For each zone, shelter components and features are identified from disaster resilient and culturally appropriate vernacular shelter practices and successful post-disaster shelter designs.



MOTIVATIONS

This guide aims to ease the design process to accelerate action due to the fast and immediate temporalities of disaster response. Responses need to be quick, due to imminent vulnerabilities such as approaching winter or rains, or even societal risks. A guide for response is also required due to the short and intense periods of aid funding for most disasters. Further, for affected households, reconstruction begins from day one. These fast and immediate concerns can sometimes overtake the need for a thorough design process, one which includes community and ecological concerns. Pre-fabricated shelters can be mobilised and erected in the time a context-appropriate shelter takes to be designed. Such temporalities tend to “lock-in” these pre-fabricated, inappropriate structures, which can lead to significant beneficiary disapproval and ecological damage. Pre-fabricated shelters are also entirely alien to local material and maintenance networks, having long-term consequences on local livelihoods and economy.

Challenging these one-size-fits-all solutions, is locally-oriented shelter approach where shelters are constructed appropriate to the granular community and even individual, needs. Shelter that arises from well-devised community-oriented and owner-driven approaches are paragons of such approaches. Here, the community's needs and design input are an integral part of the process. Such shelters see higher longevity and acceptance within the community and also can be delivered at a lower cost. Locally oriented designs also tend to have long term benefits for the local economy. They can circumvent logistical challenges by utilising local materials and skills. Indeed, pre-fabricated shelters or even tents can be very difficult and expensive to deploy in remote, less accessible locations.

However the prevalence of pre-fabricated shelter across India is telling of the challenges of scale posed by disaster responses. Pre-fabricated structures can be delivered faster and at scale as required by the response. The challenge is to find the appropriate

Pre-fabricated shelters are also entirely alien to local material and maintenance networks and can thus have long-term consequences to local livelihoods and economy

balance between the project's scale – the sheer magnitude of disaster- and granularity – the individual, disaggregate requirements of the

peoples and communities affected. Also relevant are the project's logistical challenges. Community-led, vernacular and ecologically appropriate shelter, is a best practice. However, in the face of temporal and scalar challenges, the humanitarian sector faces significant trade-offs from these principles. Solutions at larger scales and shorter temporalities can require elements of mass mobilization, mass manufacture and industrial components.

This guide proposes certain recommendations when contending with these trade-offs, while also noting that scale and granularity are not necessarily mutually exclusive. The ideal design is to achieve a form which is deliverable at scale, affordably and quickly, but is also appropriate as per local cultural, hazard and climatic standards. Disaster responses present us with a set of scenarios where few conclusions can be drawn in abstract as to whether a market-led, owner-community-led or NGO-led approach is better. This is also applicable to techniques of construction. Different disasters require different combinations of indigenous, vernacular or industrially formed techniques. However, guidelines need to be set as to ensure safety from harsh weather conditions, scale of delivery required, correlation with local capacity, ability to sustain lives and livelihoods and indoor comfort.

Recent literature on post-disaster reconstruction has focused strongly on the benefits of community and owner-driven approaches and ultimately the “soft” institutional measures that surround the delivery of the structure. Rightfully so, the work is also focused on the administrative and governance challenges that accompany the structure itself. This also plays into the capacity and organisations required not only to deliver the structure, but also maintain it. A lot has been learnt from these various studies, which are reinforced, in these guidelines.

However there are two lacunae in current shelter guidelines. They excel in providing universal prescriptions and standards regarding shelter, but say little about the design process. Nor do they highlight region specific

The ideal design is to achieve a form which is deliverable at scale, affordably and quickly, but also appropriate as per local cultural, hazard and climatic standards

challenges. So what is missing is a set of guidelines on the design of the shelter itself and how it should be in a particular region. This

lack of guidance leads to the design process tending to start from a blank page, rather than preconceived components. Designing from scratch, means tending to reinvent the wheel. This can both delay the delivery of the structure, crucial time during a disaster response,

but also potentially reduce the quality of the shelter delivered.

This guide identifies the design of the shelter as a particularly decisive fulcrum, one that has not been delved into with adequate detail so far. It also identifies design inertia due to division within the shelter debate between large-scale prefabricated shelter and small scale community-driven shelter. It seeks to resolve the two, to open up a new design language.

This guide draws from best practices, situating them as per geoclimatic, hazard, skills and material context and identifies components that practitioners and designers

The guide identifies the design of the shelter as a particularly decisive fulcrum, one which is not necessarily delved into with adequate detail

should be integrating into their shelter. The intention is not to provide prescribed designs for each space, but rather a menu of components that are appropriate for the context. Usage of the guide can help streamline decision making about shelter technologies and design, material procurement and cultural compatibility in an immediate post-disaster context, allowing sectoral practitioners to start delivering incremental structures as soon as possible. It also works towards identifying associated trade-offs and balances between scale and



granularity of intervention as per the disaster's context; its temporality, spatiality, accessibility, magnitude and intensity. For non-specialised

We do not intend to provide prescribed designs for each space, but rather a menu of components that are appropriate for the context

readers, the guide intends

to increase awareness of India's climatic and hazard contexts and lead the preparation of concerned NGOs, material vendors, contractors and masons for future disaster responses in India.

However there are limitations of the guide itself. It is not a comprehensive guide in achieving adequate post-disaster shelter in India. It converses little about the instrumental social, political, financial, administrative and delivery mechanisms required in producing shelter. It does not engage in length with requirements of participation, appropriate financial transfer mechanisms, erection of auxiliary support institutions such as health services, nor the spatial layout of the shelters themselves. These are discussions in which the sector is constantly involved and knowledge has been considerably developed.



COMMON GUIDELINES

This section highlights the importance of a people-centric response approach, of treating the development and usage of housing as a process, of simple, intuitive structural forms for ease of construction and maintenance and crucially of contending with the project's specific scale and not shying away from required trade-offs. The common guidelines have been extracted from the shelter study (detailed in the methodology section) and from workshops and conversations leading to the build-up of this guide. The latter were held with a combination of government civil servants, academics and humanitarian sector practitioners concerned with post-disaster housing in India.



- 1/ Involve the initiative of the affected **people**
- 2/ Keep the structural form **simple**
- 3/ Design, manage and trade off as per **scale**
- 4/ Treat housing as a **process**
- 4A/ Provide a **flexible** form that can be incremented and adapted with new services, materials and structures
- 4B/ Design with **local** capacity and materials
- 4C/ Utilise site's placement in shelter/ material supply chains or **networks**

1/ PEOPLE

Involve the initiative of the affected people

Disasters lead not only to the destruction of shelter, but also livelihoods. The desire to rebuild begins from day one and most capable households already begin the process. Shelter practitioners tend to arrive after this process has already begun; their role ultimately should not be of a provider, but a facilitator. Local affected populations tend to have knowledge of availability of materials and skills. At the same time, when able, they want to provide funds and labour to reconstruct their homes. Their initiative should be incorporated into the response effort, as it builds a sense of responsibility and ownership of the eventual result. The role of the designer is to facilitate solution-making, by providing technical support to challenges identified by the community. Appropriate shelter design then needs to have components which the beneficiaries themselves can design, acquire materials for, build and therefore maintain.



2/ SIMPLE

Keep the structural form simple

Most indigenous and post-disaster structural designs are simple in form. Simple structures are easy to construct. They are thus more affordable and quicker to erect. Crucially however, they are also intuitive. Simple, intuitive structures are easier to teach and allow for the improvement and involvement of the affected population and local skills in the building process. Intuition of a structure, the way that it transfers load and holds itself up, allows both occupants and local masons to identify issues when they arise and reinforce the structure when needed. This potentially leads to longer term maintenance of the structure.



3/ SCALE

Design, manage and trade off as per the scale

Scale is perhaps the key challenge in delivering an adequate disaster response. Delivering at scale requires alternate methods of provision, which in the humanitarian sector have been seen in contrast with a ground-up, people oriented approach. Mass manufacture and associated design implications such as set forms and standardised materials need to be involved to deliver at adequate time, cost and speed. Scale can also generally present trade-offs in quality and involvement of community in the structure's delivery (though this need not be completely excluded). A further trade-off is that decision based on scales can sacrifice initial intentions of shelter. For example the strategic decision to provide a sheet of tarpaulin to many households, rather than less incremental structures to a few.

Lack of shelter, or inadequate shelter forms such as tarpaulin, subjects people to hazards and vulnerability post-disaster. The priority should be the delivery of

incremental shelters to as many families as possible. In an adequate time frame.

Shelter designs should then be wary of and flexible to trade-offs that can achieve adequate scale, without sacrificing local orientation and a people centred approach. Wherever possible, the inclusions of capacity building, local masons, local supply chains and architecture i.e. The granularity of the site, should be made imperative.



4/ PROCESS

Treat housing as a process

Housing policy, design and implementation can be encumbered by a view of housing as a final product. Agencies tend to see their responsibility as the delivery of a structure. As a result, a focus on delivering raw numbers of finished units can dominate design, rather than viewing the project and its impacts as a process. A house, viewed in process, allows designers to see its evolution in the delivery process, changing material and skills as per availabilities, adaptation during occupation and required maintenance. The shelter is a constantly evolving entity, with features and elements added, amended, subtracted and reinforced by forces of nature, economy, society, policies and occupation.

“Housing as a process” or “housing as a verb” is a frequently cited position by shelter guides. It allows the integration of considerations beyond the delivery of the initial structure. It includes the adaptability of the structure to meet future requirements and the

appropriateness of the shelter in its material and networked context.

This section briefly explores these factors, dealing with requirements of flexibility, locality and networkedness. The first point concerns the flexibility to allow for process. The latter two are concerned with the shelter's context and thus systems and networks of supply and maintenance that construct and maintain the household.



4A/ FLEXIBLE

Provide a flexible form that can be incremented and adapted with new services, materials and structures

Post-disaster housing can be underwhelming. Due to budget and resource constraints, at housing provided can have fewer functionalities and smaller areas than previous homes though they tend to have more disaster resilience features. As livelihoods are reconstructed, the housing provided post-disaster can quickly become insufficient. Residents generally invest in improving their household, in its comfort, services and space. Circumstances can also shift, either due to familial, societal or technological changes, requiring reconfiguration. Houses that deny adaptability, investment and increment can soon be abandoned or discarded.

The shelter form provided should be flexible enough to be replicable or expanded as household requirements shift, as they inevitably do. Area additions also occur vertically – especially in urban settings – and thus structures, where possible and applicable, should be



configured to be compatible to this tendency. This can imply a light enough frame that can act as a second floor with a new ground floor, or a vertically extendable structure.

More relevant to post disaster rehabilitation, the shelter design should have provision to adopt to available materials. Ideal materials need not be on hand during the time of reconstruction. Thus the shelter design should be such to adapt to such constraints. For example, if bamboo has been over-harvested, equivalently dimensioned timber or industrially formed poles can be utilised. This also applies with regards to the “skins” of the structure e.g. Instead of ferro-cement panels, a thick bamboo thatch with a mud plaster can be utilised. Usage of materials should still aim towards providing disaster resilient, climate and cultural appropriate elements. Geographically specific guides and choices concerning material usage will be discussed in the zonal guides.

Finally, a bare shelter is the minimum that constitutes a home. The design should accommodate the integration of basic services which are essential to the running of a household. Namely, to must include lighting, heating, cooking, sanitation, water and storage.

practices and customs. Considerations can include location of the activity (indoor, outdoor, particular part of the household), amount of space and facilities required and internationally prescribed health and comfort standards.



4B/ LOCAL

Design with local capacity and materials

Processes of maintenance, figure a key role in the lifetime of a housing structure and these are generally dependent on local skills and materials. To ensure the long-term sustainability of the structure, techniques that were used to construct the household should have the ability to be maintained and replicated. This implies a conscious and prioritised involvement of local masons, local housing knowledge and available materials in the housing and design development process. The integration of the design into these local networks of construction and maintenance ensures accessibility for beneficiaries towards procuring shelter maintenance and thus longevity of the structure.



4C/ NETWORK

Utilise site's placement in shelter/material/skills supply/value chains and networks

However, our discussion on scale (see point 3) allows us to revisit the “localness” of design in different light. Urban and highly networked settings have a variety of skills and materials at their disposal which need not be co-located with the project. They might even require external resources if local capacity cannot support the required reconstruction effort. This is especially applicable to projects with immense scale that local capacity and resources cannot support. Construction materials and even maintenance services can be acquired from nearby hubs. Supply networks have now exploded beyond local geographies into regional, national and even international realms. These networks, can at times of crisis, remain resilient and still be able to provide materials and expertise at the scale required. The condition should be assessed on a per-project basis, but designs should not shy away from integrating these non-local resources, if the supply of viable alternatives can be ensured for occupation, alteration, expansion and maintenance requirements.













ZONAL GUIDELINES

This section outlines guidelines of shelter, specific to the project's zonal requirements. It is intended to provide specific components and requirements as per the project's zone. Each zone's guidelines can be used standalone from the guideline as a whole, though we recommend that they should be read in tandem with the Common Guidelines section above. The section draws from the shelter best practices in each identified shelter zone (see. Methodology section for details on Shelter Study and development of zones) and identifies:

1. Structural components which mitigate acute risks due to hazards
2. Climatic components which mitigate chronic risks due to vulnerabilities

The shelter zones are developed on the basis of the geo-climate, prevalent hazards and the materials and skills available in the region. They are based on current climatic conditions and are not bounded units.



- | | | | | |
|---|---|---|---|---|
|  |  |  |  |  |
| Cloudy
North West | Cold
North East | Dry
Himalayan | Seismic
North | Composite |
|  |  |  |  |  |
| Warm and
Humid | Seismic
West | Hot and
Dry | Humid
South West | Humid
North East |

Rather they generally designate areas of common conditions which dictate shelter design. They should also be viewed in the context of shifting climate patterns. The zonal areas are in constant shift and thus as are the requirements. The designations provided here, are the best approximations.

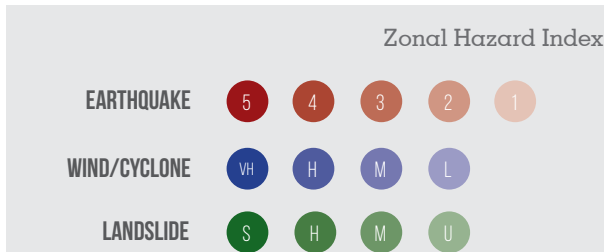
These zones formed the basis of a shelter study (cf. Appendix) which identified best practices from local, vernacular shelter and post-disaster shelter form the basis of the components recommended per each zones.

Each zone is accompanied by a map and a designation of the severity of earthquakes, cyclones & winds and landslides faced by the zone. Floods are place-specific and thus it is recommended a flood analysis and historical survey is conducted for the project site. Hazard designations are those devised and utilised by the Government of India, thus earthquake zones correspond to Highest (Zone 5) to Least Active (Zone 1). Cyclonic and wind zones designate risk damage due to either: "Very High", "High", "Moderate", or "Low". Landslide risk is designated with "Severe", "High", "Moderate", or "Unlikely".

India Flood Map



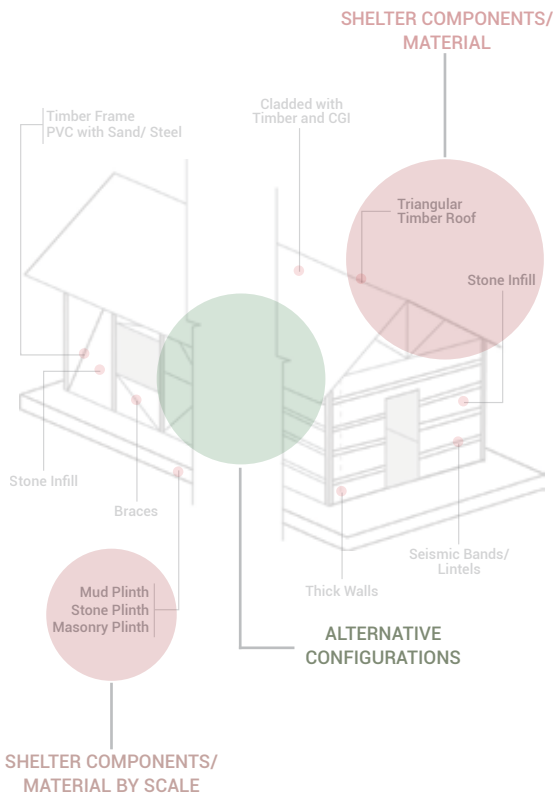
Source: Vulnerability Atlas of India, BMTPC



The following pages provide the zonal guide, that draw from local and social forms of architecture practice, and best-practice post-disaster shelter. The section is divided into structural and climate components which are common in these zones and adapted to the local construction practices, climate and hazards. The components are represented in a schematic diagram, which highlights key components per zone. The drawing is not meant to be a prescriptive design but an array of components and features which are recommended to be included in the shelter. Note that certain components can only be combined with others; reinforced concrete posts should not rest upon bamboo stilts. The diagram thus is not a design, but an exhibition of the available components the designer can build from.

Following the discussion around scale and network in common guidelines section, effort has been made to provide potential alternative materials and components if a scaled design is needed. Alternative components and materials are listed, with potential increasing scale of delivery as you go down.

Shelter Component Schematic diagram



1/ CLOUDY NORTH WEST

Stretching across Jammu & Kashmir and Northern portion of Himachal Pradesh and Uttarakhand, the Cloudy North West zone is typified by its mountainous topographies, cold temperatures and wet weather. The zone is highly seismic, consisting of Zone V and IV regions. It is severely prone to landslides and flash floods, due to high intensity of rainfall in the summer monsoon months and topography.

The area is abundant in timber and stone, both of which are commonly used construction materials. Indigenous forms tend to be load-bearing and insulated to keep indoors warm during the winter months. Common indigenous typologies in the zone include Taq, Dhajji-Dewari, Kath-Kuni and Koti Banal.



STRUCTURAL

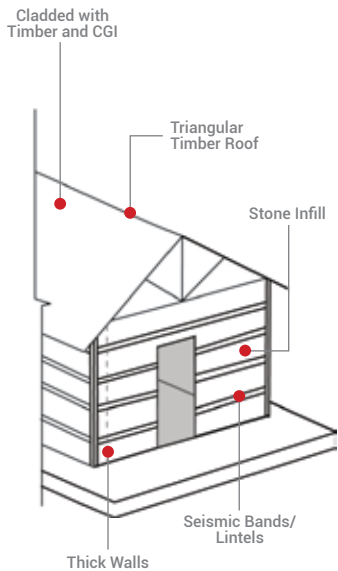
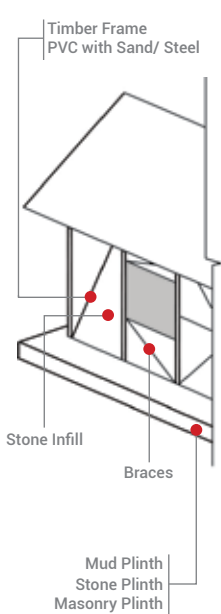
Structures in the zone tend to be load bearing and local houses can be of multiple stories. These features aid in structure's resilience to flooding and upper stories allow for safe storage of valuables and refuge if needed.

The walls are generally composed of a timber framework, filled with load bearing masonry. It is recommended that this is further reinforced with timber lacing. These bands improve the seismic resilience of the structure, managing deflection due to earthquakes.

Roofs are constructed with a triangular timber frame, due to rainfall and generally topped with locally available slate tiling. Timber and CGI sheets are also commonly used. Foundations are built either as stone, rubble or masonry plinths to improve flood resilience.

CLIMATE

Insulation is the prime challenge in the area. Indigenous forms utilise thick walls primarily composed of stone infill to insulate structures. Occasionally these are set with a mud mortar. Small windows are utilised to reduce heat loss.





KASHMIR FLOODS, 2014

Case Study



Jammu and Kashmir in 2014 faced its worst floods in 60 years. The swollen Jhelum, affected nearly 100,000 households across 19 districts. The scale of the disaster, including the relative isolation of the districts, made the response a particularly daunting challenge. Even unideal, temporary shelters such as tents were difficult to garner. Not enough winterised tents were available in the market and logistical challenges impeded their distribution. SEEDS's design response focused on an incrementable, scalable shelter. An eventual 192 interim shelters were erected. Based on a simple A-frame, the bamboo or MS pipe structure was to be erected on a masonry foundation to improve flood resiliency. The bottom half of the super structure was built with brick masonry to improve waterproofing, topped with traditional timber or bamboo-mat boards. The cavity in the roof provided insulation from cold temperatures.

2/ COLD NORTH EAST

This zone occupies northern portions of Arunachal Pradesh, the southern half of Sikkim and the mountainous areas of the North East. It is characterised by cold, wet weather and hilly topography. The zone is an extremely high risk of seismic events, designated under Zone V. It is also under high risk for landslides. The area receives a high amount of rainfall, concentrated during the summer and monsoon months, making it potentially prone to flooding. Southern portions of the zone can also be prone to high winds.

The area has an abundance of bamboo, which is also the most commonly used construction material. Indigenous forms in this zone include Ikra/Ekra construction, Nyishi-style housing in Arunachal Pradesh and stilted huts in Assam and Meghalaya.



STRUCTURAL

Bamboo frames are a familiar structural form in the zone. To cope with the seismicity, **Ekra walls** are utilised to handle lateral deflection. These consist of a combination of and **timber or bamboo bracing** and **split bamboo** or **reed woven mats**. The structure is **tied with cane ropes or bamboo reeds**. The flexibility of the materials allows it to handle seismic deflection.

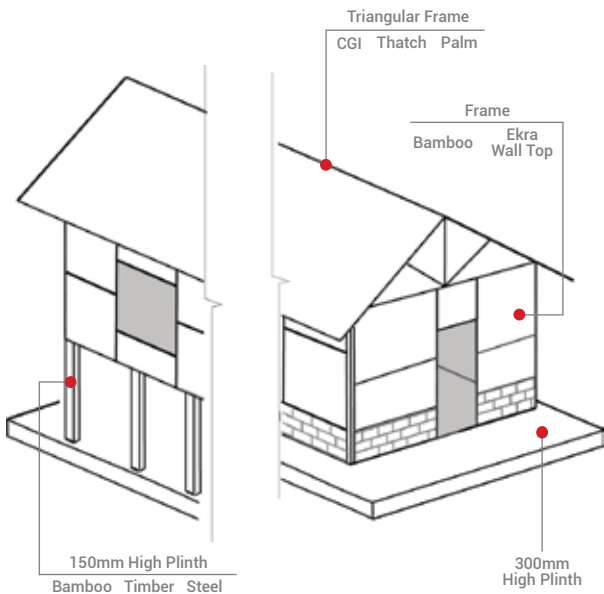
The roof is generally a **triangular frame** formed with bamboo trusses.

In flood prone areas, the housing is erected on **stilts**. It is also common to have the **lower portion of the wall in masonry** to allow for water tightness.

CLIMATE

The primary challenge of these homes is the water tightness and insulation in colder areas.

Roofs have **eaves** which direct water away from the walls. Roofs and walls are covered with locally available **palm leaves** (in Arunachal), **paddy straw** (in Assam and Meghalaya) or a **thick bamboo thatch** (throughout). CGI is also commonly utilised in urban settings. The façades are meant to keep the structure water tight. In colder regions, a **mud plaster** can aid in insulation.





KALINMPONG EARTHQUAKE, 2011

Case Study

A 6.9 earthquake destroyed houses Nepal, Sikkim and portion of West Bengal. This was exacerbated with recurring landslides and heavy rainfall. CASA facilitated a community-led reconstruction effort which combined a reinforced cement concrete foundation which provided resiliency against earthquakes and landslides. The foundations were constructed through a centralised pre-fabrication effort which enhanced scale and quality control. The bottom 30 inches of the superstructure was also constructed using cement brick blocks, to improve flood resiliency, however they were completed with ekra walling with sill and lintel bands to improve seismic resiliency. This was a feature incorporated with community input. Roofs were constructed with bamboo mats, CGI, or timber, as per beneficiary preference and familiarity.



3/ DRY HIMALAYAN

This zone is composed of in eastern Jammu and Kashmir and northern portions of Sikkim and Arunachal Pradesh. Mountainous, it is characterised by dry weather. Recent events have also indicated that is prone to flooding. It has a high seismic risk, falling under Zone IV. The zone is characterised as having very high damage risk: due to winds, especially the portion in Jammu & Kashmir. The Sikkim and Arunachal Pradesh areas have high landslide risk.

These areas are logistically isolated and have less accessibility to timber or bamboo. Stone is more commonly available. Common indigenous forms include the Western Himalayan form in Ladakh province and Himachal's Lahaul-Spiti district. The Shee Khim form is prominent in Sikkim.



EARTHQUAKE



WIND/CYCLONE



LANDSLIDE



STRUCTURAL

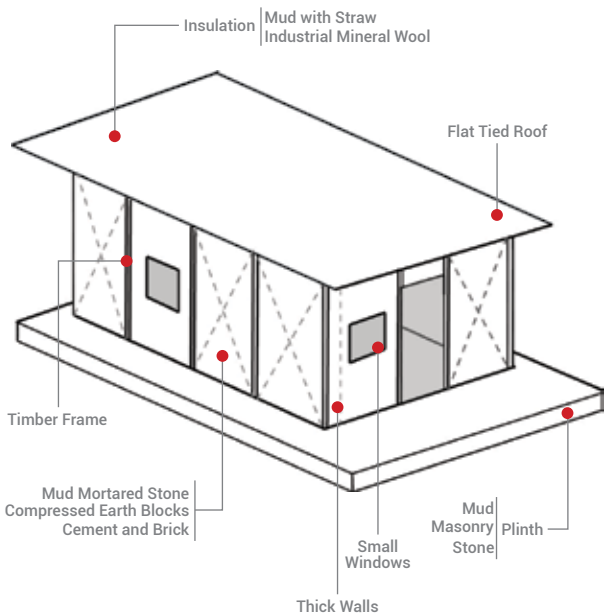
Structures are **load bearing** in the area and tend to be constructed utilising **packed mud** for more kaccha structures, to **mud-mortared brick or stone** for more pukka structures. Some are also formed using **timber bracing**.

A **flat timber roof** is utilised, due to low incidence of rainfall. In areas of higher rainfall, such as in portions of Sikkim, a pitched roof is common. **Roofs ties** should be utilised due to high winds in the area. If pitched, **shallower pitches** should be utilised to prevent roof lift.

Following, recent flood events, it is also recommended to place the structure on a **raised masonry plinth**.

CLIMATE

Insulation is the primary challenge. Roofs are well insulated with a combination of **mud and thick straw**. **Thick walls** with high heat capacity also aid in insulation. Trees are frequently placed on the windward side acting as a **wind barrier**.





LEH FLOODS, 2011

Case Study

Leh suffered anomalous flash flooding in the August of 2006. SEEDS reconstructed 35 shelters for the most vulnerable populations and two community centres. Due to the relative small scale of the project, effort was made to include the local population in disaster response efforts and utilised local, natural materials. Structures were load bearing, as per local cultural practice either utilising masonry or an adapted, traditional “rammed earth” technology, further stabilised with a 7% cement mix. Stone plinths and retaining walls to improve flood resilience, seismic bands to improve earthquake resilience, tying off roofs to improve wind resilience were the key disaster risk reducing measures. Double-glazed windows, passive solar design, insulated and waterproofed roofs with clay and straw and sawdust filled wall cavities aided in the insulation from cold weather.



4/ SEISMIC NORTH

This zone stretches across southern portions of Himachal Pradesh and Uttarakhand, northern Punjab and Haryana, Delhi and northern and western Uttar Pradesh. It is characterised by its cold winters, hot summers and high seismicity. Most of the area falls under seismic zone IV. It is also prone to very high damage risk due to winds. It faces riverine flooding due to intense rainfall during the monsoon period.

This is a densely populated and highly networked area with a high density of road and rail infrastructure. The area has access to timber, bamboo, limestone and granite. It also has access to fly-ash from local power stations which can be compacted to form blocks. Indigenous architecture takes many forms, from mud-packed huts, to courtyard centred havelis.



EARTHQUAKE



WIND/CYCLONE



LANDSLIDE



STRUCTURAL

Houses tend to be both load bearing and framed, either utilising bricks or a timber/bamboo frame. For load bearing structures, it is also possible to incorporate load bearing **fly ash bricks** to the design, due to availability.

Braced frames improve rigidity of the structure in the case of high winds. **Reinforcing corners with posts** also enhances wind damage resilience.

Seismic bands which reduce structural deflection are a recommended seismic risk reducing measure.

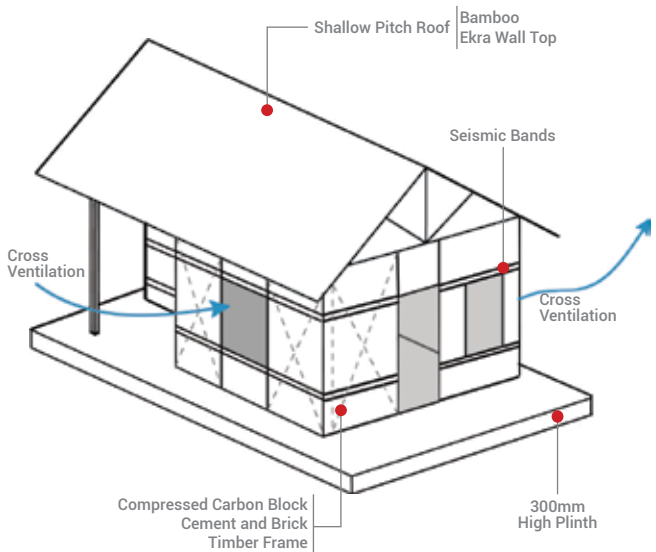
A **high plinth** composed of either packed mud or masonry will improve the flood resilience of the structure.

A **triangular framed, sloping roof** is common in the zone. To reduce chances of roof lift it should be adequately **tied with shallow pitch**. **Large eaves** also keep water off the structure.

CLIMATE

Deep eaves also provide shade during the summer months. **Thick earthen walls or straw filled cavities** are common measures to improve indoor thermal comfort in the hot seasons.

Structures frequently incorporate a front courtyard or verandah, which acts as a **transitional space**, used both for cultural activity and for the purposes of climatic comfort. Shelters should also be oriented to gain from **cross ventilation**.



5/ COMPOSITE

The Composite zone covers a large portion of Punjab, Haryana, north-eastern Rajasthan, eastern Uttar Pradesh, Madhya Pradesh, Chhattisgarh, Bihar, Jharkhand and the Deccan plateau. It has similar climate characteristics to the Seismic North zone with long hot summers, cool winters and monsoon rains. The area has a low seismic risk and receives moderate to low rainfall. Portions however are located near flood-prone rivers, especially in the Gangetic plain. Portions of the area are also classified in the high damage and moderate damage risk zones for wind and cyclonic damage.

The area has a high availability of bamboo. It also has access to timber, limestone, granite and fly ash.



EARTHQUAKE



WIND/CYCLONE



LANDSLIDE



STRUCTURAL

Due to the abundance of bamboo, a **bamboo framed** structure is recommended. Common features to improve resiliency against wind include **bracings** and **reinforced corner posts**.

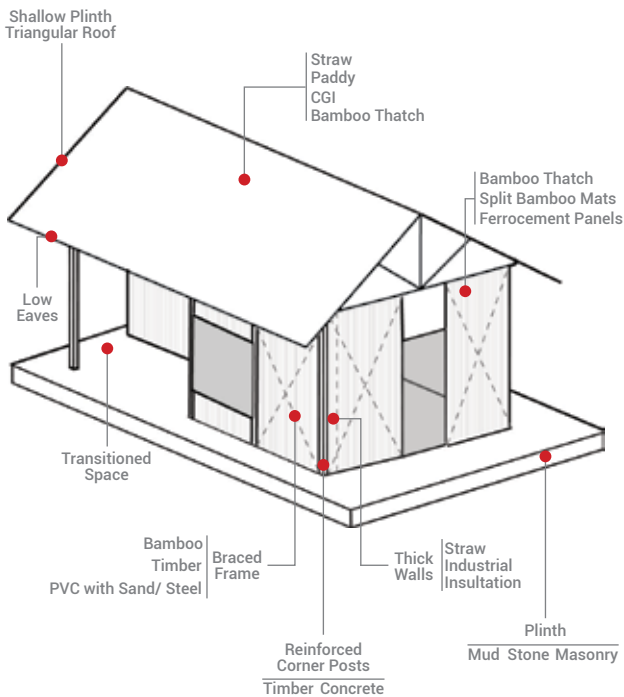
The frame can be skinned and the roof covered with a **thick bamboo thatch or split bamboo mats**.

For flood prone zones, shelters should be erected on a **plinth**.

A **triangular framed, sloping roof** is common in the zone and an adequately **tied and shallow pitch** will reduce chances of roof lift. **Large eaves** also keep water off the structure.

CLIMATE

See considerations highlighted in Seismic North section.



6/ WARM AND HUMID

This zone covers Tamil Nadu, most of Karnataka, Andhra Pradesh, Telangana, Odisha and West Bengal. It also includes southern and western portions of Maharashtra. The area is characterised by its year round warm and humid weather. The area is prone to riverine floods. It also has low seismic risk. Seaside areas on the eastern coast face very high damage risk from coastal winds and is highly prone to Tsunamis. The eastern coast also faces intense rainfall during the winter monsoon, which can cause flooding.

The area is well connected by rail and road. It has access to timber, bamboo, limestone, granite and fly ash. It has a rich diversity in indigenous architecture including Chuttillu from Andhra Pradesh and the eponymous Odisha and Bangal styles.



EARTHQUAKE



WIND/CYCLONE



LANDSLIDE



STRUCTURAL

Design here is dependent upon resistance to cyclonic winds and flooding either from riverine floods, or tsunamis.

The primary element is a **cyclone resistant roof** ie. one that has a **low-angle pitch**, is clad with **thick thatch, straw, or secured tiles and is tied down**. Materials to tie down the roof depend on location, with **palm reeds and steel ties** as recommended options if available. Securing the roof with **grounded poles** is also a potential solution.

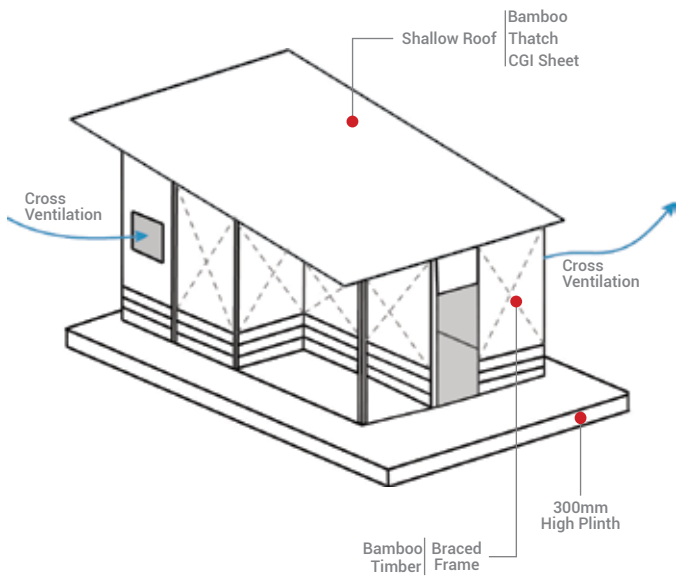
Framed structures should be **braced**.

To mitigate the flood and tsunami risk, homes should be constructed on **high plinths** especially in coastal areas.

CLIMATE

Due to the warm, humid climate, **cross-ventilated** indoors are important, as are the integration of **transitional spaces** between indoor and outdoors such as verandahs and courtyards suited to local usage.

Houses general use a **mud mortar or mud blocks** to aid in insulation.





ODISHA CYCLONE, 2013

Case Study



A category 5 cyclone hit the Odisha coast in 2013 and houses were afflicted with severe and flood surge damage. SEEDS intervention involved the design and reconstruction of a shelter which incorporated DRR elements. A braced bamboo frame with concrete footings was erected on a packed mud plinth. This aided the structures resiliency to lateral loads due to winds and floods. Walls were constructed with a split bamboo mat finished with a mud or cement plaster to aid in strength and painted with bitumen for waterproofing. The roof was tied down with j-hooks and was pitched at a long angle improving wind resiliency. The design was flexible enough to utilised locally available and salvaged materials eg. in some cases Timber poles for the frame were used instead.

7/ SEISMIC WEST

This zone has similar climate conditions to the Warm and Humid zone, but with the added consideration of being in a zone of extreme seismic risk (zones V, IV). Located in western Gujarat, it covers the district of Kutch and portions of Saurashtra. It also faces very high damage risk due to cyclonic winds from the Arabian Sea.

A common indigenous architecture is the Bhunga hut which is a circular, load bearing structure composed of mud blocks and a conical roof.



EARTHQUAKE



WIND/CYCLONE



LANDSLIDE



STRUCTURAL

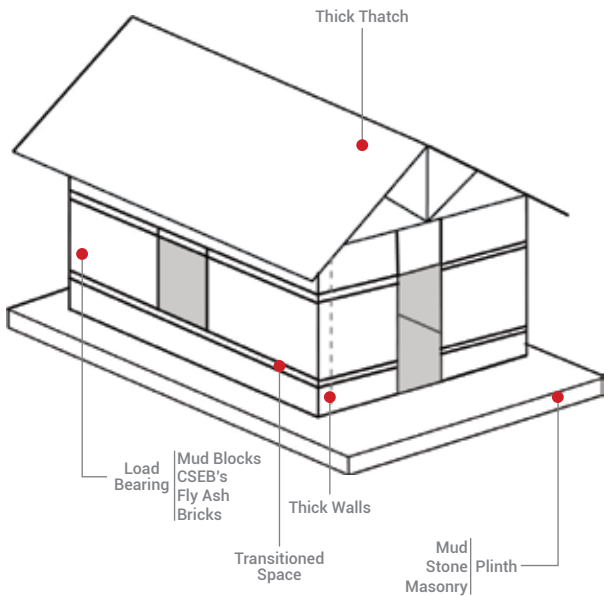
Similar to the considerations in the Warm and Humid zone, roofs should be **cyclone resistant** (see zone 6 for further details).

In addition, the structures should be seismically resistant. The additions of **seismic bands or frames** which reduce deflection are a potential solution. Strengthening locally used mud blocks, which can consolidate during seismic or flood events, is a suggested option.

CLIMATE

Due to the warm climate, **thick walls** are recommended to aid in insulation.





8/ HOT AND DRY

This zone is located in the desert and dry belt cutting across Rajasthan, eastern Gujarat, western Maharashtra and portions of Madhya Pradesh. The area is relatively not at risk from seismic hazards. Portions of the area are prone to riverine floods. The area is also windswept and prone to very high to high damage risk from wind damage.

The area is generally arid and has low availability of timber with some access to bamboo.

Limestone and granite are also accessible, as is fly ash.

Mud is a common construction material. The area's local architectural forms – Rajasthan's Dhaani, Gujarat's Bungha and the local Maharashtra form – all utilise cob as a structural material.



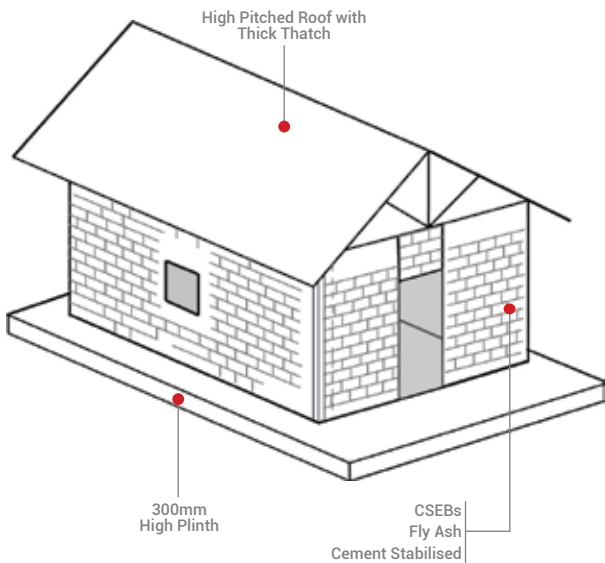
STRUCTURAL

Local structural forms are **load bearing** and rely on **mud blocks or cob walls with mud plaster**. It is recommended to **compress and stabilise the earth into blocks**, with a concrete mixture if further strength is required.

In Rajasthan and Gujarat, roofs tend to be conical and are topped with **thick straw or thatch**.

CLIMATE

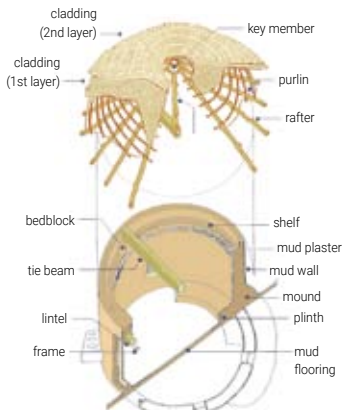
Thick walls and small openings for the purposes of insulation from the heat reduce vulnerability due to the hot climate.





BARMER FLOODS, 2006

Case Study



Total area of shelter: 16.2m²

Following unusual, heavy rainfall, Barmer suffered flooding which swept away structure made of untreated mud. 300 houses, across 15 villages, were to be rehabilitated and SEEDS built each an interim shelter. The shelter was load bearing and in a circular form, following the local architectural practice. To improve the disaster resilience of the structure, the house was constructed with seismic risk reducing cement-stabilised compressed mud blocks. The foundation was constructed with stone masonry, on top of concrete footings. It was secured with structural bands for strength. The thick walls, along with the thick roof thatch aided in insulation from the hot, desert conditions.

9/ HUMID SOUTH WEST

This zone is centred on the Western Ghats and also includes the Lakshadweep islands. The area has relatively low seismic and wind related risks. The area is prone to intense rainfall during the summer months. The zone is also partially mountainous and thus areas are high to severely prone to landslides.

The area has access to timber, bamboo, granite and fly ash. Common typologies include Kerala's Eksala and Karnataka's Guthu Mane.



STRUCTURAL

Reinforced and deep foundations along with a **plinth** will improve the structure's resiliency against landslides.

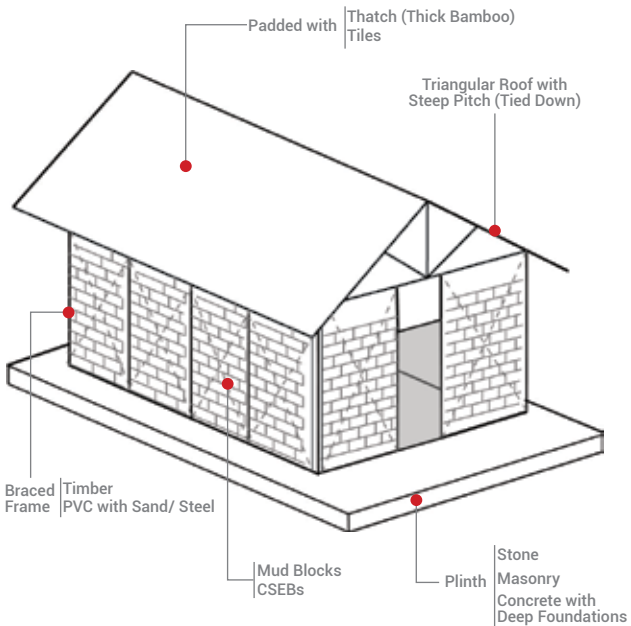
Construction in the area tends to be of a **composite or semi-load bearing nature**. A combination of **timber framing, compressed earth blocks with mud mortar** is utilised by indigenous forms.

Roofs are commonly cladded with locally available **tiles, or with a thatch**.

CLIMATE

Coping with the intense rainfall, roofs tend to have a **steeper pitch and lower eaves** to keep the water off the structure.

Cross ventilation and courtyards are also commonly utilised.



10/ HUMID NORTH EAST

The zone is centred around of the North East and also includes the Andaman and Nicobar islands. It is highly disaster prone. It is at extreme seismic risk all of the area under Zone V designation. The area, is also at very high damage risk due to cyclones, especially in the southern areas. It faces intense rainfall during the monsoon months. As a result, the area has portions which are at very high to high risk due to landslides. The area is also extremely flood prone, especially on the areas in the Brahmaputra valley. The Andaman and Nicobar islands are also extremely prone to tsunamis.

The area is relatively isolated and has a sparse road and rail network. Bamboo is highly abundant in the area and most local architecture involves it in construction.



EARTHQUAKE



WIND/CYCLONE



LANDSLIDE



STRUCTURAL

A **braced bamboo or timber frame** should be utilised.

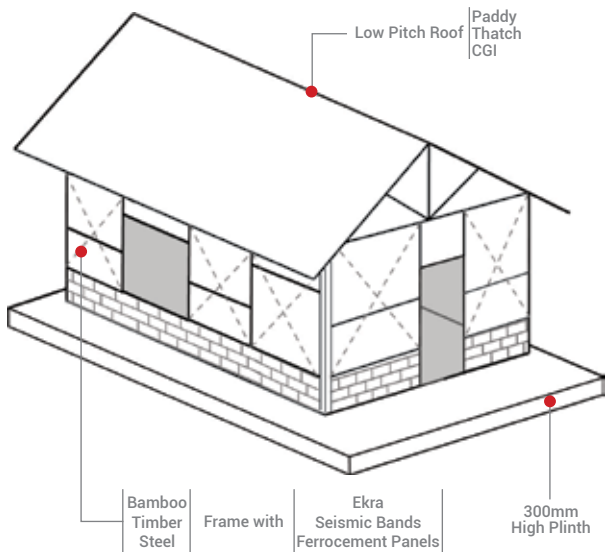
Ekra walls are recommended as they along with the bamboo frame, aid in managing deflections during seismic events. With other forms, **reinforced concrete or timber seismic bands** can be utilised with mud formed structures.

In cyclone-prone areas, **cyclone proof roofs** which have **low pitches** and are **tied down**.

Where possible, deep reinforced concrete foundations and high plinths should anchor the structure.

CLIMATE

Paddy, straw, palm or bamboo thatch are commonly used cladding materials.





METHODOLOGY

The report's guidelines were primarily drawn from a pan-India shelter study conducted by SEEDS India. The study aimed to learn from indigenous architecture and post-disaster shelter design in a methodological manner. Its premise was that shelter is primarily designed according to its material and physical conditions i.e. its location within geographies of hazards, climate vulnerabilities and material availability. The study first developed ten shelter zones across India, constituted from their geo-climatic, hazard and material context. Within these zones, shelter features were identified from disaster resilient and culturally appropriate shelter practices. A total of 35 shelter typologies were investigated. The study paid close attention to both the structural characteristics of the shelter practices which primarily mitigate hazard risk and the climate-adaptive characteristics which mitigate climate vulnerabilities. The shelter survey also catalogued how local materials and mason skills, were incorporated and reflected in each architectural form. The result of the study is a matrix of ten shelter zones pan-India and corresponding, appropriate shelter features per zone.

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