KEY EARLY RECOVERY SHELTER DOCUMENTS

2012 Early Recovery Shelter Response Strategy

EARLY RECOVERY SHELTER CLUSTER STRATEGY (FINAL DRAFT)

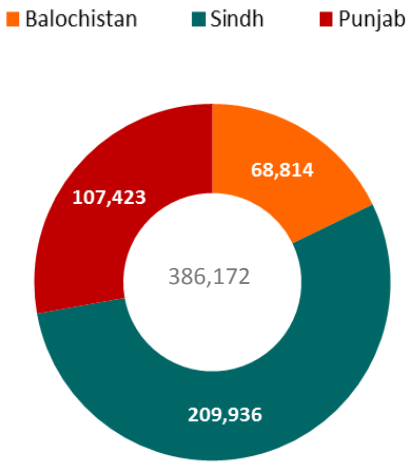
Overall Objective

Provide low-cost shelter support to the most vulnerable families whose houses have become uninhabitable after the 2012 floods, in a way that improves their resilience to future natural disasters.

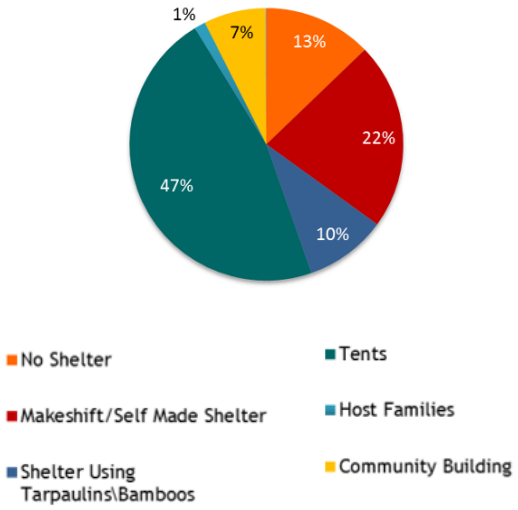
Situation Overview

In September 2012, flash floods due to heavy rains caused widespread damage in 15 districts of northern Sindh, southern Punjab and eastern Balochistan. Results from a roll-out of the Multi-agency Initial Rapid Assessment (MIRA) in September 2012 indicated that 5 million people were affected and 386,172 houses damaged or destroyed. Of the houses affected, approximately 60 per cent were partially damaged, with the remaining 40 per cent fully destroyed.

Houses damaged and destroyed 2012



Living conditions in affected provinces up to the 31st December

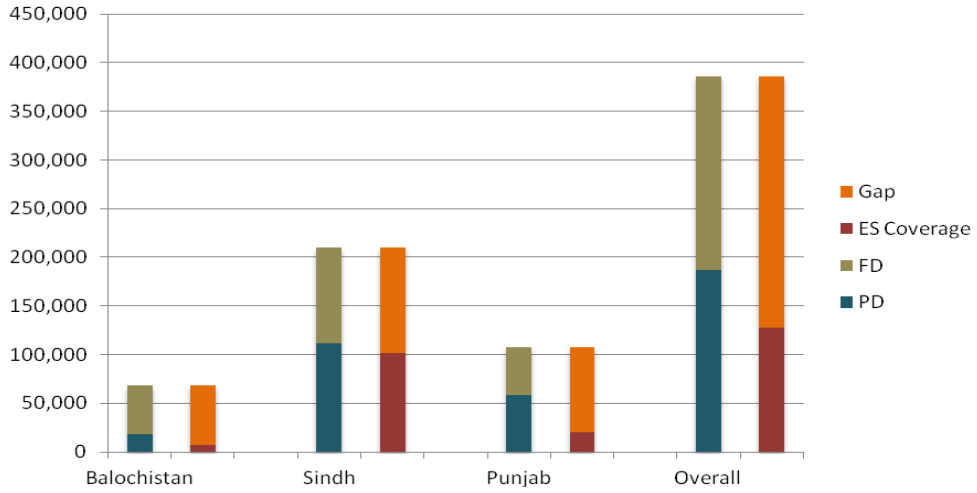


In October and November 2012, the Shelter Cluster's Temporary Settlement Support Unit (TSSU) conducted its first phase of assessments, reporting that the majority of IDPs counted in the MIRA had already left displacement sites. This finding was supported by the second phase of TSSU assessments in December 2012, which demonstrated a consistent trend of return from temporary settlements to areas of origin, with acute humanitarian needs in remaining displacement sites as well as returnee areas.

More than 6,000 families remained in displacement sites in Sindh and Balochistan as of December 2012, with 82 per cent citing inaccessible place of origin as the main obstacle to return. In temporary settlements, 47 per cent of families were without shelter or living in makeshift shelters. In all districts, families who had returned to villages reported similar conditions overall, with 38 per cent of families living in makeshift shelters and 4 per cent without shelter of any kind. (TSSU Phase 2 Assessment)

EMERGENCY SHELTER ASSISTANCE COVERAGE AND GAP ANALYSIS

The Shelter/NFI Cluster initially requested 33 million USD to respond to the immediate emergency shelter needs of families affected by the floods, but only 11 million USD in funding was secured. As of March 2013, only 33 per cent of emergency shelter needs had been met, with 258,181 families still in need of shelter assistance.



(Above) Partially and fully damaged (PD/FD) houses, emergency shelter coverage and gap as of March 2013

EARLY RECOVERY SHELTER STRATEGY

The Shelter Cluster expects that emergency shelter distributions for the 2012 floods will diminish after March 2013, with the focus shifting to early recovery (ER) shelter interventions. Given the frequency of disasters in the affected provinces and lessons learnt from 2010 and 2011 flood responses, the overall objective of the ER Shelter Strategy is to provide low-cost shelter support to the most vulnerable families whose houses have become uninhabitable after the 2012 floods, in a way that improves their resilience to future natural disasters. At present, funding commitments for the ER phase are low, and agencies are therefore encouraged to focus on achieving maximum impact and coverage with minimum inputs.

The Shelter Cluster has established a target of 173,777 ER shelters, representing 50 per cent of affected houses. This target takes into account the self-recovery potential of affected families as measured by the ACCCRA (Assessment of Community Coping Capacity in Return Areas, 2012), as well as the assistance capacity of humanitarian organizations. ER shelter assistance may consist of One Room Shelters (ORS) or roofing kits, per the conditions outlined below.

As reported in the revised Monsoon Humanitarian Operations Plan (MHOP), an estimated 87 million USD are required to meet ER shelter needs. This is based on an average cost of 500 USD per shelter in material or cash support, accounting for variations in cost depending on shelter type (pucca, mud, loh kat). The technical guidelines provide more details on shelter costs.

In view of the limited available resources and widespread needs, it is important to strategically target assistance to the most vulnerable families and adapt ER practices to achieve the broadest coverage possible. Inputs from humanitarian and government actors should support beneficiaries' own self-help efforts to maximise the impact of assistance provided. With this in mind, the Shelter Cluster advocates for the following ER priorities for the 2012 floods:

1. **Avoiding double coverage:** Roofing kits and ORS should not be implemented in the same UC unless both are being provided by one agency. When one agency provides both, there should be a clear strategy to indicate which beneficiaries are targeted for each type of assistance. In order to avoid creating gaps, these recommendations should be adapted in coordination with the Shelter Cluster as appropriate to support the situation in each UC, including consideration of the type of damages and upcoming ORS commitments. For example, if roofing kits were distributed with limited coverage in a large UC during the early stages of a response, this should not necessarily disqualify the UC for ORS projects during early recovery.

2. **Roofing kits as ER assistance:** Distribution of roofing kits should not be restricted to emergency shelter activities. Given limited resources for 2012 ER needs, the Shelter Cluster recommends providing roofing kits to people with partially and fully damaged houses in order to ensure that people with fully damaged houses are not excluded from this type of assistance. All roofing kit distributions should be accompanied with recommendations to beneficiaries on how to use the kits for temporary shelter as well as for reconstruction efforts. Practical demonstrations are encouraged to ensure that beneficiaries are engaged and aware of various roofing kit uses.

Effective coordination is essential to ensure the strategic targeting of assistance to the most vulnerable families. The Shelter Cluster recommends the following principles:

1. **UC ranking:** The Shelter Cluster Assessment Unit is currently conducting a UC ranking exercise using existing data from MIRA and Temporary Settlement Support Unit (TSSU) assessments to prioritise areas with the greatest ER shelter needs. This exercise will form the basis for UC allocation.

2. **One agency per UC:** Ideally each UC should be assisted by a designated agency so that inputs are distributed across as many UCs as possible rather than concentrated in a single area. If the needs of a UC greatly exceed the capacity of one agency, it may be possible for another agency to assist. In this case, agencies should closely coordinate their assistance and avoid working in close proximity to minimise tensions among beneficiaries receiving varying standards of assistance (e.g. roofing kits versus ORS).

3. **Targeting the most vulnerable:** Agencies should target their assistance to the most vulnerable families within a UC. This entails applying strategic beneficiary selection criteria, paired with strong social mobilisation to clarify the selection process, in order to achieve coverage of the most acute needs across the UC.

4. **Prioritisation of agencies in UC selection:** Priority in UC selection should be given to agencies with confirmed funding. Exceptions may be made for agencies planning to assist beneficiaries from their 2010 projects, provided that agencies demonstrate serious plans and eligibility to obtain funding. Organizations whose 2010 shelter projects have been destroyed in subsequent floods are recommended to seek funding to recover damages for the same beneficiaries. Agencies who intend to incorporate a shelter component into existing projects (WASH, livelihoods, etc.) in a particular UC will also be given priority, provided that the agencies have a past record of shelter implementation and reasonable potential to obtain funding for shelter projects.

5. **Flexibility in UC preferences:** Agencies should maintain flexibility in their planning with relation to particular UCs in case other agencies have already confirmed funding and commenced work in the same UCs. Agencies should be realistic in "flagging" the UCs in which they intend to work, in order to avoid gaps created by agencies claiming UCs and then changing plans.

The following **key concepts** are highlighted to guide the planning and implementation of ER shelter activities:

1. **"Shelter is a process rather than a product"[1].** The focus of the shelter programs should not be on delivering a finished product, but rather on the process of engaging with beneficiaries, transferring knowledge on safer construction, and improving the capacity and resilience of communities to respond to future disasters. Beneficiaries should be supported with skills and knowledge that will enable them to make **incremental upgrades** to their shelters over time as their capacity and resources increase.

2. Agencies are encouraged to **minimise direct inputs** in terms of material/financial support**,** but to **maximise the impact** of projects by ensuring the **direct involvement of communities** in the construction process. The low cost shelter approach supports the construction of one basic shelter that can be upgraded in the future.

3. Assistance should **catalyse self-help efforts** through the sharing of key skills for construction, maintenance, repairs and upgrades of shelters. In this way, immediate assistance can sustain long-term impacts by **building the resilience and self-help capacity** of communities. **Knowledge transfer** on safer construction techniques should be incorporated through **technical guidance and trainings**. Trainings should be practical, provided on site, and open to families that are not receiving direct shelter support to ensure maximum coverage and broader potential for replication.

[1] Davis, I: 'Shelter After Disaster' Oxford Polytechnic Press 1978

4. Assistance should be **beneficiary-driven**, informed by a **flexible approach** and offering a **variety of shelter solutions tailored to the needs and capacities of beneficiaries**. Rather than introducing communities to entirely new materials and methods, agencies are encouraged to support the adaptation of vernacular designs and the improvement of the traditional techniques to facilitate the construction of safer and more resilient shelters. These techniques can be improved by incorporating **Disaster Risk Reduction (DRR)** measures, such as strengthened roof, extended roof eaves, and wall structures and elevated flooring, as detailed in the Shelter Cluster's Technical Guidelines.

5. Agencies should **strategically select sites** according to level of needs and **target limited resources to the most vulnerable persons** in each site. Assistance should be guided by the **beneficiary selection criteria** developed in coordination with NDMA and the Protection Cluster[2], which identifies most vulnerable households as those with at least one of the following characteristics:

- With a completely destroyed house
- With no salvaged materials and no means to provide construction materials and/or labour
- With no possibility to return to their place of origin and thus face extended displacement for at least for 6 months
- Whose lives are endangered by weather conditions

Combined with at least one of the vulnerability criteria such as:

- Female-headed households
- Child-headed households
- Older person-headed households
- Households headed by person with disabilities (physical, intellectual, sensory)
- Households headed by person with a chronic disease

Holding the **Identity card** should not be a fact of discrimination neither a criteria of prioritization. Pakistani nationals might have lost their ID during occurrence of a natural or mad-made disaster either during the migration from the original places

6. Agencies should provide guidance to communities on **safer location** for shelter construction, keeping in mind the limitations of land tenure. Agencies can also advocate for the construction of elevated platforms in villages to mitigate the impact of floods.

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The Shelter Cluster highlights that, in conjunction with ER shelter projects, it is important to liaise with government authorities to **advocate for the repair of damaged infrastructure**. Consecutive floods and limited repair of infrastructure undermine the efforts of safer shelter construction and the promotion of communities' resilience to future flood events.

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The Shelter Cluster also advocates for an integrated response and strongly recommends the **inter-sector coordination in order to provide complementary assistance to the affected population**. Agencies are encouraged to seek complementary activities either internally or externally with other partners working in other sectors such as WASH, Health, livelihoods, Food security and Education.

[2] For more information consult *Beneficiary Selection and Targeting Inter-Sectoral Guidelines for Pakistan Endorsed Version August 2011*

→ Early Recovery Shelter

Early recovery approaches the need to begin supporting restoration of basic services, livelihoods, shelter, governance, security and the rule of law as soon as possible[3].

ONE ROOM SHELTER	
Description	**One Room Shelter** starts with the complete construction of one room of the permanent house, offering shelter until the rest of the house is finished. **One Room Shelter is a flexible beneficiary-driven approach, which leads to the final product of a safer shelter**. ORS uses familiar vernacular construction practices improved with DRR measures, to ensure the construction of safer shelter and its maintenance with the participation of beneficiaries. The ORS is a process that : a) Promotes the transferring of knowledge on safer construction techniques to vulnerable groups, as a way to improve communities' resilience to disasters; b) Is a first step towards reconstruction and beneficiaries can upgrade it according to the evolution of their capacities and resources.
Estimated duration	5 to 10 years

[3] IFRC 2012, Shelter Coordination in Natural Disasters

Design Principles

The technical guidelines provide detailed information about One Room Shelter construction in Pakistan, however there are number of overarching principles that should to be regarded when planning a shelter program. These principles aim to promote a more social, cultural and economic adequate shelter assistance and improve the resilience of the affected population.

Indicators	Criteria:	Design Principles:
Climate Suitability	• Ventilation • Winterisation	• Design of the shelter to allow adequate ventilation to reduce internal temperatures (especially in the hot areas) • Where necessary, due to climate conditions, winterisation of shelters is to be applied. • The design should allow a step by step improvement of the climate suitability (e.g. option to include further openings / to add further isolation) (For detailed information refer to refer Shelter Construction Technical Guidelines and Guidelines for winterization)
Social Suitability/ Protection	• Participation • Vulnerability • Gender Balance	• The participation of community throughout the implementation of programs, promotes ownership and facilitates cultural and social suitability of the shelters. • Shelter programs should seek to target the most vulnerable members of the beneficiary communities (refer to Shelter Response Strategy and Vulnerability Criteria for Shelter Support) • Gender sensitive programming is strongly recommended and women should be consulted about a range of issues. (refer to Vulnerability Criteria for Shelter Support)
Social/ economical Suitability	• Adequate materials • Locally available and familiar techniques • Options for further upgrading • Accessibility	• Preferably material should be purchase in local markets; it involves local economy and reduces transportation costs. • Use of well-known materials and techniques will promote the participation of the beneficiaries in the construction process and its maintenance • Options for step by step improvement according to rising income generation needs of beneficiaries. • Shelters should allow the access of disabled people.
Cultural suitability	• Typology/ layout • Integration of beneficiaries' options/capacities of reconstruction.	• Design shelters to meet local needs, household activities, distribution, as well as the local cultural requirements. • The design of the shelter should consider a flexible use space. • Consider design and techniques adopted by beneficiaries when (re)building their own shelter.
Resource effectiveness	• Use salvaged materials. • Allow future reuse of materials. • Minimize impact on natural resources	• The use of salvaged materials is encouraged when in good condition (bricks, door/window-frames, roof beams etc.) • Consider options to reuse the construction materials of transitional shelters for further durable solutions. • Consider options to dismantle materials for reuse. • The choice of materials should avoid increased pressure on natural resources.
Appropriate Location	• Location • Safe location • Land tenure	• When possible, shelters should be constructed at, or near to the existing homestead without inhibiting permanent housing • Transitional shelter not to prevent (re-)construction of permanent housing. • Minimise exposure to hazard: avoid hazardous locations and apply DDR recommendations • Take account of access to livelihoods. • When possible ensure proper land rights - by legal documents or agreement with landlord or neighbors' confirmation.
Risk Mitigation	• Natural Hazards • Fire Hazards	• Refer to Shelter Construction Technical Guidelines • Disseminate information on appropriate safe use of shelter (for reference see annex on Fire Safety for emergency shelter).

2012 One Room Shelter Construction Technical Guidelines

The **One Room Shelter technical guidelines** provide detailed technical guidance on practical implementation of the Shelter Cluster Early Recovery strategy. It is hoped that this will be a useful tool for implementing partners, helping to standardize and ensure coherence among response efforts to improve the resilience of the flood affected communities to future disasters.

These guidelines were developed based on previous shelter cluster technical guidelines (2010 and 2011 Flood) and the valuable input from cluster members which shared the results of their housing damage assessments, and provided key information about the effectiveness of used Disaster Risk Reduction measures in shelter construction.

Each chapter gives detailed information about the construction of the 5 main typologies of shelters found in southern Pakistan: **Loh Kat, Mud, Adobe, Burn Brick and Concrete Brick**. The information is displayed as a step by step construction guidance and detailed recommendations are given to each component of the shelter construction. Each typology is named after the main material used in the shelter construction:

Loh Kat	Mud	Adobe	Burn Brick	Concrete Brick
				

Observations on Housing Damage

The 2012 flood hit some areas that were previously affected by the 2010 flood and where may shelter agencies implemented shelter programs. In the aftermath of the 2012 flood some shelter members undertook damage assessments of the shelters built in 2010 and shared the findings with the Shelter Cluster TWIG and were incorporated in the present guidelines. In summary:

It was observed that serious damages were caused mostly by the combined action of the wind and rain that eroded the layers of roofs and the external surfaces of walls, penetrating in the core of the masonry melting the mud mortar and thus weakening the walls. Moreover, it was observed that the flood exceeded the sill level, reaching the lintel in several areas.

The structures and infrastructures, weakened by the rain-flash and standing in the stagnant water for months, were slowly and progressively eroded with the final result of the total collapse.

The last flood showed that the DRR measures have to be revised on these evidences, raising the protection up to the lintel level at least and improving the waterproofing of the roofing. .

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Further to these guidelines, the Shelter Cluster, within the TWIG, developed the **illustrated guidelines** which aim to provide visual and simple guidance to the shelter practitioners in Pakistan. The illustrated guidelines are distributed separately and will be accessible on the shelter cluster website.

Notes:

These recommendations are not compulsory and the Shelter Cluster is not liable for any future problem that might occur due to bad execution of these guidelines and lack of monitoring during the process of the implementation.

The Shelter Cluster strongly encourages organizations engaged in shelter activities to include an engineer and/or an architect in their teams, to ensure a stronger technical monitoring of shelter construction.

Consideration should be given to Pakistan Building Code Requirements: Earthquakes; Cyclones and other likely Environmental Design Considerations for all construction methodologies.

For more information please contact the Shelter Cluster team: scpakistan.coord2@gmail.com

The LOH KAT shelter is built with a supporting skeleton made of timer poles, bamboo or steel. The skeleton is covered with matting and then filled and plastered with mud. Commonly the roof is made of thatch or other structural system, plastic sheeting with a mud plaster layer, protected with a final waterproofing layer.

Loh Kat	Mud	Adobe	Burn Brick	Concrete Brick
	BEARING FOUNDATIONS AND FOUNDATIONS			
Generic Guidance	Foundations and platforms specification, depth and height, dependent on the site characteristics (soil, elevation) and super structure, materials and loads, thus their depth and width have to be designed on a case by case basis. The excavation depth may be more than 2'- 3' in not compacted soils. Generally the width of the platform should be almost one third for each side=1.6-2 times the thickness of the walls. Increasing the width of walls at the base will improve resilience and help keep longer the flood water away from the base of the walls which will extend or prevent the time of disintegration (depending on the time of stagnancy) The foundations need to have a sealed barrier at the base to prevent that the water penetrates into the structure both from the ground (dampness) either from stagnancy. Reinforcing the walls at ground level by adding concrete plaster /pointing layer or mud / lime			
Specific Guidance	-Excavation depth minimum 18" below undisturbed ground or compacted soil. -The wall structure or skeleton (wall columns) needs to penetrate to a minimum of 18" in the ground reaching the solid layer and being reinforced with cement or lime / mud posts, to ensure stability of the shelter			
Notes and recommendations	-Reed, timber, bamboo or other grass structures will have less mass and may have less bulky foundations -The infill trellis or reed material should penetrate to a minimum of 6". -A tapered foundations (continuous plint) better distribute the load to the ground. It can be obtained by ramming in framework well compacted -it is suggest to add lime in the mud plint to waterproofing the structure -Appropriate anchoring details for the foundation should be considered -the end of pole should be treated with bitumen of other water resistant treatment -Bamboo and timber are susceptible to termites. *Adequate treatment should be provided to timber and bamboo materials* in these areas			
Loh Kat	**RAISED PLINTH FLOOR**			
Generic Guidance	The floor level should be raised to at least 1'6"up to 3' above the Natural Surface Level (NSL) adopting a continuous plint. General recommendation is to protect furthermore the foundations below floor level by raising an earth platform 3' wide at the top and tapering to NSL over 6'. (i.e 1 in 2 slope minimum.) The top of this platform should be 6" below floor level. A damp proof course (DPC) at plinth level is compulsory in order to prevent moisture rising into the walls. A DPC is either a thin layer of concrete at plinth level with plastic on one surface or simply a strong plastic layer			
DRR improvements (Flood and earthquake)	-it is suggest to add lime and cement in the mud plint to waterproofing the structure -the end of pole should be treated with bitumen of other water resistant treatment -at the top of the plinth are proposed horizontal reinforcement with bamboos or timber joins well connected with the vertical poles, overlap and tie them at the corners. -Also a reinforced concrete band is advisable			
Maintenance	-re-plaster with lime mud mortar (1:4) the raised plinth at least once an year, before the monsoon season, and whenever necessary -verify the good connection of the pole to the basement -re-treat the base of poles whenever necessary -acknowledge the owners regarding periodic termite treatment			
Loh Kat	**SUPERSTRUCTURE**			
Walls Core materials and	-Loh Kat walls need to have a supporting skeleton of timber, bamboo, steel or other materials. This skeleton will provide the structural frame for the trellis material.			

techniques	-Loh Kat / Reed / Trellis or similar walls need to be skilfully woven, secured or tied to ensure long term durability of walls. -The skeleton is covered with matting and then filled and plastered with mud mortar. -The durability of the walls can be improved by using wattle and daub or quincha instead of simple matting. -In order to have waterproofing resistance of the core it is suggested to add lime to the mortar.
Note and recommendations	The vertical reed structure or skeleton needs to have very strong fastening with an encircling reed rope. The reed trellis material needs to penetrate to a minimum of 6" in the ground reaching the solid layer and being reinforced with cement or lime-mud posts -It is important to treat at least the base of the structure and wall material with termite treatment and to protect the base of the wall from moisture using bitumen paint, plastic sheeting or other methodologies -Some simple local treatments for termites may include the use of lime slurries, kerosene or used engine oil *-Environmental and health and safety issues should be taken into account when using these products*
DRR for earthquake resistance: • Joint and binding • Reinforced bands	-All junctions (vertical and horizontal) need to be individually tied. -Cross bracing should be provided in lightweight wall panels to improve wind-resistance and stability of the frame. -minimum bracing is at corner panels, bracing all the panels is preferable -minimum diagonal bracing, cross bracing is preferable - at the base of the vertical skeleton (top of the plinth) a horizontal reinforcement with bamboos or timber joins well connected with the vertical poles, overlap and tie them at the corners. -Also a reinforced concrete band may be advisable.
DRR flood resistance (plaster as protective and expendable surface)	A lime-mud mix (1 : 3) for plaster may provide some waterproof resistance to the inner structure. Many options are available e.g. a mixture of lime, mud and bhoosa (straw) well mixed and fermented for 24 hours. A mud toe may further protect the bottom of the walls from disintegration
Maintenance	-re-plaster with lime mud mortar (1:3 mix) the walls at least once an year or whenever necessary -verify the good connection of the elements of the structures (pole and bracing) -re-treat the base of poles at least once an year whenever necessary -inform the owners regarding periodic treatments
Openings Doors and windows	-Openings within the wall space should not take up an area greater than 50% of the wall. -Openings should be higher than wider -Windows and doors should be kept a minimum of 2 ft from corners and from each other. -The doors should open outwards for fire safety purpose
Lintels	-In order to bear and distribute the load of the wall above the openings, lintels should to be installed. -Lintels should be minimum 2" thick and 6" longer than the opening on each side. -Lintels should be designed based on the load being carried overhead. -Being this structure in wood, the more appropriate lintels may be a solution with 2-3 tied bamboos or timber plate
Ventilation	The ventilation is very important mainly during the summer that is very hot in several area. Two windows may ensure ventilation. Alternatively one or two ventilators, executed on the opposite side of the window (generally on the back wall) may ensure a good ventilation. The dimensions depend on the size of the shelter, it may be one of 2' x 1' or two 1'x1' In some areas, where the summer is very hot, it may be suggested to increase the height of the shelter to improve the internal ventilation (in this case the entire structure of the shelter has to be re-calculated*) note this will increase the cost of the shelter*
Loh Kat	**ROOF**
Generic Guidance	-Roof design should allow for live and dead loads. Live loads are applied loads such as rain, wind, snow or usage for grain or livestock. Dead loads are those including the makeup of the roof structure such as beams, straw, mud, cement etc. -A bamboo or other lightweight roof can be used for all construction methodologies, while steel girder roof or similar heavy roof requires a strong bearing structure, therefore it is only suitable for fired brick, concrete block, engineered steel frame shelters -A thick mud layer will add a lot of load to the roof and may cause severe, damaging strain to the roof structure and loadbearing walls. -Timber elements may in some cases be larger loads than steel or other alternatives. -Bamboo and timber are susceptible to termites. Adequate treatment should be provided to timber and bamboo materials

	-Timber, bamboo or straw roofs are not suitable for indoor cooking or heating fires. -A conical or four-sided pitched roof is preferable in areas where wind loads are a consideration, particularly cyclone vulnerable areas. -Gable ends or flat surfaces may be more stress by resisting to the wind force -The pitch of a roof will vary based on the wind conditions in the area, however a maximum pitch is advised of 30º for simple pitched roofs. -A mono-pitched roof may have a pitch of up to 10º to allow adequate drainage of rainwater. - In the flat roof a minimum slope should be 3/8" per foot.
Main structure	-Generally double pitched roof with gables. -The main structures may be in bamboos or timber. The design has to consider the loads. Timber of inadequate dimensions can be very heavy. -It is suggested to assemble trusses instead of rafters, since the horizontal bottom chord ties the inclined top chords constraining their pushing outward forces. -Any elements of the roof structure should be tied to each other. -All joists or beams in the roof structure need to be individually tied to purlins. - The roof must also be securely tied to the wall structure. -The trusses may be simple, with rafters and collar tie, for span of 9'-10' length, for span over 10' it would be suggested a trusses with wind brace.
Note and recommendations DRR for earthquake resistance	-All loadbearing elements of the roof structure, columns, beams and joists have to be not placed above door or window openings. Any openings provide weaknesses in the walls, because reduce the portion of bearing walls, thus placing the loadbearing elements right above the openings may cause failure in the walls with cracks and even collapse of the portion interested. -Any elements of the roof structure should be tied to each other. All joists or beams in the roof structure need to be individually tied to purlins. The roof must also be securely tied to the wall structure. Well fastening ensure a good resistance to the strong wind and is a kind of DRR against earthquake -Roofs have different load distribution arrangements, as the concentration of loads underneath the beams, thus in order to distribute equally the roof loads a top plate-band or ring beam should be provided at the top of the walls. It should be continuous encircling the walls, this provides a way of fastening the walls together at the top to prevent pushing outward forces of the roof and in case of horizontal seismic forces -In case of pitched roof with two gables, placing plates-bands at the top of the wall (without gables) distribute the loads and constrains the pushing forces of the rafters outwards. -It is suggested to assemble trusses instead of rafters, since the horizontal bottom chord ties the inclined top chords constraining their pushing outward forces.
Covering package Generic guidance	-Roof topping can be made with many different materials as long as the items are lightweight, strong, durable, secured, waterproof, insulating and maintainable. -Any material that soak water or melt should be avoided -A common practice is the use of a thatch or other structural system, plastic sheeting with a mud plaster layer, protected with a final waterproofing layer. -Lime plaster or a bitumen mixture may provide a water-resistant finish to the roof that should be reapplied prior and after annual rains.
Covering package Specific guidance	-Above the semi structural mat of straw or thatch, a polythene sheet, a layer of stabilized mud have to be applied in 2 coats, the thickness may be 2", or 1" for pitched roof. *Note: the mud layer should not be applied directly on the plastic sheet.* -The last coat should be a waterproofing one. Lime mud plaster may improve the water resistance. Bitumen mixed with stabilized mud mortar is an effective treatment, it is waterproofing and fire resistant. It should be prepared by mixing bitumen with kerosene oil (5:1) and mud (1.5 kg of bitumen for 30 kg of mud).
DRR waterproofing and drainage	-An overhang of the roof, or eaves, of 15" minimum will prevent rainwater from running down mud or plaster of the walls and soaking into the structure and plash the plinth. This will aid the structures resilience. -For flat roof it is important a right slope to allow the rain water to wash away quickly, the stagnancy upon the roof allow the rain water soaking the top layers and penetrate in the core of walls. -Where there is a parapet is compulsory to provide 1 or 2 waterspouts, the slopes have to be arranged accordingly (minimum 1%). -The waterspouts should be minimum 2.5"and project minimum 8". -The waterspouts have to be well sealed with bitumen without any discontinuity in order to prevent water rain to penetrate in the structure of roof and walls above. -Another option may be CGI spout in "U" shape.

	-The use of gutters for catch rain water may be considered; obviously the slope has to be adequate in case of flat roof
Maintenance	-re-plaster with lime mud or bitumen mud mortar the roof at least once an year or whenever necessary - periodic cleaning of the waterspouts -verify the good connection of the element of the structures (pole, rafter, purlin and bracing) -re-treat against termite the bamboos and wooden elements once an year or whenever necessary -inform the owners regarding periodic treatment as termite treatment , annual re-plastering of the roof, periodic cleaning of the waterspouts
Loh Kat	**COST ESTIMATE**
Notes	The costs of materials may sensitively increase after any catastrophic events due to the scarcity of materials available on the local markets and the difficulty or impossibility of frequent transportation. In addition of that it has to be noted the costs vary from district to district every semester. Therefore it is suggested to upgrade the cost estimate accordingly to the last official quotations of the price analysis by district-wise.
Estimated Unit Cost	XXX USD

The MUD shelter is built with unreinforced layers of a mixture of mud and straw. The walls need to be at least 18” thick and should be plastered. Care need to be put in the choice of beams and its placement. Commonly the roof is made of thatch or other structural system, plastic sheeting with a mud plaster layer, protected with a final waterproofing layer.

Lok Khat	**Mud**	Adobe	Burn Brick	Concrete Brick
Mud	**BEARING FOUNDATIONS AND FOUNDATIONS**			
Generic Guidance	-Excavation depth minimum 18” below undisturbed ground or compacted soil. -the bearing foundations (under-foundations) should be in stones -The wall structure needs to penetrate to a minimum of 18" in the ground reaching the solid layer and being reinforced with cement or lime / mud posts, to ensure stability of the shelter -minimum dimension for the foundations are 2.5’wide footings founded 2’ below the natural surface level (NSL) dimension may increase with mud mortar			
Specific Guidance	-Excavation depth minimum 18” below undisturbed ground or compacted soil. -If there is a skeleton (wall columns), the wall structure or needs to penetrate to a minimum of 18" in the ground reaching the solid layer and being reinforced with cement or lime / mud posts, to ensure stability of the shelter			
Notes and recommendations	-A tapered foundations (continuous plint) better distribute the load to the ground. It can be obtained by ramming in framework well compacted -The foundations can be in stones, in fired bricks, in concrete; cement-sand mortar should be used - tapering or ramming framework mud may be improved by adding cement and lime for waterproofing -Wall columns in wooden pole or bricks may reinforce the structure (**DRR against earthquake**) - When the mud shelter has a skeleton, appropriate anchoring details for the foundation should be considered			
Mud	**RAISED PLINTH FLOOR**			
Generic Guidance	The floor level should be raised to at least 1’6”up to 3’ above the Natural Surface Level (NSL) adopting a continuous plint. General recommendation is to protect furthermore the foundations below floor level by raising an earth platform 3’ wide at the top and tapering to NSL over 6’. (i.e 1 in 2 slope minimum.) The top of this platform should be 6” below floor level. A damp proof course (DPC) at plinth level is compulsory in order to prevent moisture rising into the walls. A DPC is either a thin layer of concrete at plinth level with plastic on one surface or simply a strong plastic layer			
DRR improvements (Flood and earthquake)	- tapered or ramming framework mud may be improved by adding cement and lime for waterproofing -the plinth may be in stones, in fired bricks in concrete, cement/sand mortar has to be used. -at the top of the plinth is proposed an horizontal reinforcement , with bamboos or timber, well			

	connected with the vertical poles, overlap and tie them at the corners
Maintenance	-re-plaster with lime/mud/cement mortar the raised plinth at least once yearly, before the monson season, and whenever necessary
Mud	**SUPERSTRUCTURE**
Walls Core materials and techniques	Mud walls (mixture of mud and straw) unreinforced with any other materials should be minimum 18" thick at the base (2' -2.5' preferred). Walls should not taper to less than 13" at the top. (1.5' is preferred) The thickness will provide resilience and distribution of the load from roof to ground. -The resistance and the durability of the wall depend on the compaction. -The compaction can be improved by ramming the walls. -Unreinforced mud walls should be built up in layers of not greater than 12" thickness per day. These layers have to be cured or hardened prior to application of subsequent layers. Time of fermentation of mud will vary according to weather conditions at the time of construction. An estimate of 3 to 4 days per layer is suggested. Local knowledge should be sought regarding appropriate length of time for curing. -the right width plinth and the plumb of the walls themselves ensure the stability
Notes and recommendations	The mud used for the walls has to be carefully selected. Sand, lime and cement may be added in different proportions.
DRR for earthquake resistance: • Joint and binding • Reinforced bands	*The mud walls are heavy and will perform badly in earthquake* Mud walls longer than 14' should have intermediate cross partition wall. The use of buttresses may support the stability of long wall and corner. Buttresses can be full or partial height, straight or inclined **DRR earthquake resistance** of mud walls may be improved by vertical and horizontal reinforcement and stiches at corner and intersection of partition walls. -vertical elements as bamboos or timber provide confinement to the walls and directly support the roof -the horizontal reinforcements avoid the separation of the wall, they may be done with steel, wire mesh, timber, bamboo and seven juta rolls. -the band at roof level should be always executed -also stitches as cut timber or cane may be inserted in each corner and junction. they should extend 3' from each side and vertically provided at every 2'
DRR flood resistance (plaster as protective and expendable surface)	-A lime-mud mix (1 : 3 mixture) for plaster may provide some waterproof resistance to the inner structure. -Also bitumen stabilized mud mortar is an effective treatment, it makes waterproofing and fire resistant the walls. It should be prepared by mixing bitumen with kerosene oil (5:1)and mud (1.5 kg of bitumen for 30 kg of mud) -A mud toe may further protect the bottom of the walls from disintegration -The walls have to be plastered till the roof level with 2/3 coats
Maintenance	-re-plaster with lime/mud/cement mortar the walls at least yearly or whenever necessary (worn-out plaster) -re-apply the film of bitumen yearly before the monsoon season
Openings Doors and windows	-Openings within the wall space should not take up an area greater than 50% of the wall. -Openings should be higher than wider -Windows and doors should be kept a minimum of 2 ft from corners and from each other and open outwards. -The doors should open outwards for fire safety purpose
Lintels	-In order to bear and distribute the load of the wall above the openings, lintels should to be installed. -Lintels should be minimum 2" thick and 6" longer than the opening on each side. -Lintels should be designed based on the load being carried overhead -For short spans timber plate or tied bamboos (2-3) may be an option, which sounds more appropriate to the mud structure. -The pre-cast concrete lintel may be a good option -The lintel may be executed with bricks system using n.2 steels #3 and cement mortar.
Ventilation	The ventilation is very important mainly during the summer that is very hot in several area. Two windows may ensure ventilation. Alternatively one or two ventilators, executed on the opposite side of the window (generally on the back wall) may ensure a good ventilation. The dimensions depend on the size of the shelter, it may be one of 2' x 1' or two 1'x1' In some areas, where the summer is very hot, it may be suggested to increase the height of the shelter to improve the internal ventilation (in this case the entire structure of the shelter has to be re-calculated*) note this will increase the cost of the shelter*
Mud	**ROOF**
Generic guidance	-Roof design should allow for live and dead loads. Live loads are applied loads such as rain, wind, snow or

	usage for grain or livestock. Dead loads are those including the makeup of the roof structure such as beams, straw, mud, cement etc. -A bamboo or other lightweight roof can be used for all construction methodologies, while steel girder roof or similar heavy roof requires a strong bearing structure, therefore it is only suitable for fired brick, concrete block, engineered steel frame shelters -A thick mud layer will add a lot of load to the roof and may cause severe, damaging strain to the roof structure and loadbearing walls. -Timber elements may in some cases be larger loads than steel or other alternatives. -Bamboo and timber are susceptible to termites. Adequate treatment should be provided to timber and bamboo materials -Timber, bamboo or straw roofs are not suitable for indoor cooking or heating fires. -A conical or four-sided pitched roof is preferable in areas where wind loads are a consideration, particularly cyclone vulnerable areas. -Gable ends or flat surfaces may be more stress by resisting to the wind force -The pitch of a roof will vary based on the wind conditions in the area, however a maximum pitch is advised of 30º for simple pitched roofs. -A mono-pitched roof may have a pitch of up to 10º to allow adequate drainage of rainwater. - In the flat roof a minimum slope should be 3/8" per foot.
Main structure	-A bamboo or other lightweight roof can be used for all construction methodologies. -As main beams three-four bamboos tied together may work. The number of main bamboos beams should be two. -Timber of adequate section and weight may be an option; a bearing pad should be placed underneath. -Steel girder are not advisable, in case a bearing plate has to be insert underneath the girder in order to distribute its load -The secondary structure of purlin may made by bamboos well sized. The distance between bamboos should be not more than 1' (1 brick), their length has to be enough to overlap the thickness of walls -Above the bamboos a mat of chick, straw, thatch and plastic sheet is generally used. Straw and plastic sheet have to be incorporate in the top of the walls by the final plastering. *Bamboos, timber and straw should be treated against termites.* T-iron and tiles are forbidden for mud walls
Note and recommendations DRR for earthquake resistance	-All loadbearing elements of the roof structure, columns, beams and joists have to be not placed above door or window openings. Any openings provide weaknesses in the walls, because reduce the portion of bearing walls, thus placing the loadbearing elements right above the openings may cause failure in the walls with cracks and even collapse of the portion interested. -Any elements of the roof structure should be tied to each other. All joists or beams in the roof structure need to be individually tied to purlins. The roof must also be securely tied to the wall structure. Well fastening ensure a good resistance to the strong wind and is a kind of DRR against earthquake -Roofs have different load distribution arrangements, as the concentration of loads underneath the beams, thus in order to distribute equally the roof loads a top plate/band or ring beam should be provided at the top of the walls. It should be continuous encircling the walls, this provides a way of fastening the walls together at the top to prevent pushing outward forces of the roof and in case of horizontal seismic forces. -In case of pitched roof with two gables placing plates/bands at the top of the wall (without gables) distribute the loads and constrains the pushing forces of the rafters. -It is suggested to assemble trusses instead of rafters, since the horizontal bottom chord ties the inclined top chords constraining their pushing outward forces.
Covering package Generic guidance	-Roof topping can be made with many different materials as long as the items are lightweight, strong, durable, secured, waterproof, insulating and maintainable. -Any material that soak water or melt should be avoided -A common practice is the use of a thatch or other structural system, plastic sheeting with a mud plaster layer, protected with a final waterproofing layer. -Lime plaster or a bitumen mixture may provide a water-resistant finish to the roof that should be reapplied prior and after annual rains.
Covering package Specific guidance	- Above the semi structural mat of straw or thatch, a polythene sheet, a layer of stabilized mud have to be applied in 2-3 coats, the thickness may be 3" maximum. The mud layer may make heavy the structure. -The last coat should be a waterproofing. Lime /mud plaster may improve the water resistance. -Bitumen mixed with stabilized mud mortar is an effective treatment, it is waterproofing and fire resistant. It should be prepared by mixing (5:1) bitumen with kerosene oil and mud (1.5 kg of bitumen for 30 kg of mud). -Also the animal dump, mixed with mud, may be a kind of waterproofing as an eco-friendly option

	-In case of flat roof, the coats of plaster have to incorporate the top of the walls and the parapet, protecting the matting of plastic sheet and straw and the structure of roof, as a kind of waterproofing capping. This is a DRR that will avoid the rain water to penetrate in the connection roof/walls.
DRR waterproofing and drainage	-An overhang of the roof, or eaves, of 15" minimum will prevent rainwater from running down mud or plaster of the walls and soaking into the structure and plash the plinth. This will aid the structures resilience. -For flat roof it is important a right slope to allow the rain water to wash away quickly, the stagnancy upon the roof allow the rain water soaking the top layers and penetrate in the core of walls. -Where there is a parapet is compulsory to provide 1 or 2 waterspouts, the slopes have to be arranged accordingly (minimum 1%). -The waterspouts should be minimum 2.5”and project minimum 8”. -The waterspouts have to be well sealed with bitumen without any discontinuity in order to prevent water rain to penetrate in the structure of roof and walls above. -Another option may be CGI spout in “U” shape. -The use of gutters for catch rain water may be considered; obviously the slope has to be adequate in case of flat roof
Maintenance	-re-plaster with lime mud or bitumen mud mortar the roof at least once an year or whenever necessary - periodic cleaning of the waterspouts -re-apply the film of bitumen yearly before the monsoon season -verify the good connection of the element of the structures (beams and purlin) -re-treat against termite the bamboos and wooden elements once an year or whenever necessary -inform the owners regarding periodic treatment as termite treatment , annual re-plastering of the roof, periodic cleaning of the waterspouts
Mud	**COST ESTIMATE**
Notes	The costs of materials may sensitively increase after any catastrophic events due to the scarcity of materials available on the local markets and the difficulty or impossibility of frequent transportation. In addition of that it has to be noted the costs vary from district to district every semester. Therefore it is suggested to upgrade the cost estimate accordingly to the last official quotations of the price analysis by district-wise.
Estimated Unit Cost	XXX USD

The ADOBE shelter is built with sundried mud bricks. The walls need to be at least 13.5” thick and should be plastered. Care needs to be put in the choice of beams and its placement. Commonly the roof is made of thatch or other structural system, plastic sheeting with a mud plaster layer, protected with a final waterproofing layer.

Loh Kat	Mud	**Adobe**	Burn Brick	Concrete Brick

Adobe	**BEARING FOUNDATIONS AND FOUNDATIONS**
Generic Guidance	Foundations and platforms specification, depth and height, dependent on the site characteristics (soil, elevation) and super structure, materials and loads, thus their depth and width have to be designed on a case by case basis. The excavation depth may be more than 2’- 3’ in not compacted soils. Generally the width of the platform should be almost one third for each side=1.6-2 times the thickness of the walls. Increasing the width of walls at the base will improve resilience and help keep longer the flood water away from the base of the walls which will extend or prevent the time of disintegration (depending on the time of stagnancy) The foundations need to have a sealed barrier at the base to prevent that the water penetrates into the structure both from the ground (dampness) either from stagnancy. Reinforcing the walls at ground level by adding concrete plaster /pointing layer or mud / lime
Specific Guidance	-Excavation depth minimum 18” below undisturbed ground or compacted soil. -If there is a skeleton (wall columns), the wall structure or needs to penetrate to a minimum of 18" in the ground reaching the solid layer and being reinforced with cement or lime / mud posts, to ensure stability of the shelter

	-Minimum dimension for the foundations are 2.5'wide footings founded 2' below the natural surface level (NSL) dimension may increase with mud mortar
Notes and recommendations	-A tapered foundations may better distribute the load to the ground, they are also an economic option. -The foundations can be in stones, in fired bricks in concrete, cement/sand mortar has be used - Adobe brick are not suggested for the foundations, but in case cement mortar has to be used and they have to be plastered with cement/sand/lime to improve the waterproofing -Wall columns in wooden pole or bricks may reinforce the structure **(DRR against earthquake)** When the adobe has a skeleton, appropriate anchoring details for the foundation should be considered
Adobe	**RAISED PLINTH FLOOR**
Generic Guidance	The floor level should be raised to at least 1'6"up to 3' above the Natural Surface Level (NSL) adopting a continuous plint. General recommendation is to protect furthermore the foundations below floor level by raising an earth platform 3' wide at the top and tapering to NSL over 6'. (i.e 1 in 2 slope minimum.) The top of this platform should be 6" below floor level. A damp proof course (DPC) at plinth level is compulsory in order to prevent moisture rising into the walls. A DPC is either a thin layer of concrete at plinth level with plastic on one surface or simply a strong plastic layer
DRR improvements (Flood and earthquake)	-the plinth may be in stones, in fired bricks in concrete, cement/sand mortar has been used. -at the top the plinth a reinforce band with 2 bars can ensure the earthquake resistance, in case of concrete plinth it may be reinforced with 4 bars
Maintenance	-re-plaster with lime/mud/cement mortar the raised plinth at least once yearly, before the monson season, and whenever necessary -in case of reinforced band: verify that the bars are not expose and corroded, paint them with red oxidant varnish.
Adobe	**SUPERSTRUCTURE**
Walls Core materials and techniques	-Adobe brick construction should not be built less than 13.5" thick, in order to provide resilience and distribution of the load from roof to ground. -it is important good execution to reduce the weaknesses, start to build the walls from the corners, and get the bond correct, since weak corners make the shelter vulnerable. -lime and cement should be added to the mud mortar to increase the bonding capacity and the waterproofing
Notes and recommendations	-In order to improve the durability it may be used fired bricks for the external face of walls only till the sill level, and the abode brick for the internal. The thickness will be minimum 13.5"'as well. -Another solution may be to used fired bricks walls (full wall) till the sill level and above with the adobe. This increases the bearing capacity and waterproof resistance. -If only adobe brick are available, in order to improve the stability and durability of the shelter, it may be increased the thickness at the base of walls, till sill level, up to 18" -Cement-lime-sand mortar is preferred to the mud mortar, although the walls have to be plastered.
DRR for earthquake resistance: • Joint and binding • Reinforced bands	-Suitable interlocking of adobe brick should be provided to ensure stability and durability of walls and provide earthquake resistance. -in order to reinforce the corners, the wall rows may be overlapped and projected at the corners, this provides such a buttress. Also increasing the thickness at the corners provides buttresses -It is also recommended to use fired bricks as columns for the corners and openings of an adobe structure -Steel bars may be used as vertical reinforcements at the corners and junctions
DRR flood resistance (plaster as protective and expendable surface)	-the Adobe has poor water resistance thus the external walls have to be protected. -the adobe shelter has to be completely plastered externally, while internally at least till the sill level. -A protective layer is compulsory for the external walls and suggested for the internal. -A protective layer has to be applied at least till 3' above the ground level (better sill level). -The protective layer may be a eco-friendly one as lime–mud mixture, or animal dung mixed with mud, or in alternative a film of bitumen mixed with kerosene oil. *bitumen with stabilized mud mortar is an effective treatment, it makes waterproofing and fire resistant the walls. It should be prepared by mixing bitumen with kerosene oil (5:1)and mud (1.5 kg of bitumen for 30 kg of mud)* -It is suggest to use lime/cement plaster till sill level for waterproof resistance (applied on the bitumen film). -Above the sill level the use of lime-mud plaster (1 : 3 mixture) may improve the waterproof resistance to the inner of the upper structure -The coats have to be 2- 3 applied by curing and in sequence till the roof level
Maintenance	-re-plaster with lime/mud/cement mortar the raised plinth at least once an year before the monsoon

	season, and whenever necessary (worn-out plaster) -re-apply the protective film (mixture with lime, or animal dung, or bitumen) at least once an year before the monsoon season or when worn-out -in case of reinforced band: verify that the bars are not expose and corroded, paint them with red oxidant varnish
Opening door window	-Openings within the wall space should not take up an area greater than 50% of the wall. -Openings should be higher than wider -Windows and doors should be kept a minimum of 2 ft from corners and from each other and open outwards. -The doors should open outwards for fire safety purpose
Lintels	-In order to bear and distribute the load of the wall above the openings, lintels should to be installed. -Lintels should be minimum 2" thick and 6" longer than the opening on each side. -Lintels should be designed based on the load being carried overhead -For short spans timber plate or tied bamboos (2-3) may be an option, which sounds more appropriate to the adobe structure. -The pre-cast concrete lintel may be a good option -The lintel may be executed with bricks system using n.2 steels #3 and cement mortar.
Ventilation	The ventilation is very important mainly during the summer that is very hot in several areas. -Two windows may ensure ventilation. Alternatively one or two ventilators, executed on the opposite side of the window (generally on the back wall) may ensure good ventilation. -The dimensions depend on the size of the shelter, it may be one of 2' x 1' or two 1'x1' In some areas, where the summer is very hot, it may be suggested to increase the height of the shelter to improve the internal ventilation (in this case the entire structure of the shelter has to be re-calculated*) note this will increase the cost of the shelter*
Adobe	**ROOF**
Generic guidance	-Roof design should allow for live and dead loads. Live loads are applied loads such as rain, wind, snow or usage for grain or livestock. Dead loads are those including the makeup of the roof structure such as beams, straw, mud, cement etc. -A bamboo or other lightweight roof can be used for all construction methodologies, while steel girder roof or similar heavy roof requires a strong bearing structure, therefore it is only suitable for fired brick, concrete block, engineered steel frame shelters -A thick mud layer will add a lot of load to the roof and may cause severe, damaging strain to the roof structure and loadbearing walls. -Timber elements may in some cases be larger loads than steel or other alternatives. -Bamboo and timber are susceptible to termites. Adequate treatment should be provided to timber and bamboo materials -Timber, bamboo or straw roofs are not suitable for indoor cooking or heating fires. -A conical or four-sided pitched roof is preferable in areas where wind loads are a consideration, particularly cyclone vulnerable areas. -Gable ends or flat surfaces may be more stress by resisting to the wind force -The pitch of a roof will vary based on the wind conditions in the area, however a maximum pitch is advised of 30º for simple pitched roofs. -A mono-pitched roof may have a pitch of up to 10º to allow adequate drainage of rainwater. - In the flat roof a minimum slope should be 3/8" per foot.
Main structure	-A bamboo or other lightweight roof can be used for all construction methodologies. -As main beams three-four bamboos tied together may work. The number of main bamboos beams should be two. -Timber of adequate section and weight may be an option; a bearing pad should be placed underneath. -Steel girder are not advisable, in case a bearing plate has to be insert underneath the girder in order to distribute its load -The secondary structure of purlin may made by bamboos well sized. The distance between bamboos should be not more than 1' (1 brick), their length has to be enough to overlap the thickness of walls -Above the bamboos a mat of chick, straw, thatch and plastic sheet is generally used. Straw and plastic sheet have to be incorporate in the top of the walls by the final plastering. *Bamboos, timber and straw should be treated against termites.* T-iron and tiles are strongly not advisable for adobe.
Note and recommendations DRR for earthquake	-All loadbearing elements of the roof structure, columns, beams and joists have to be not placed above door or window openings. Any openings provide weaknesses in the walls, because reduce the portion of bearing walls, thus placing the loadbearing elements right above the openings may cause failure in the walls with cracks and even collapse of the portion interested.

resistance	-Any elements of the roof structure should be tied to each other. All joists or beams in the roof structure need to be individually tied to purlins. The roof must also be securely tied to the wall structure. Well fastening ensure a good resistance to the strong wind and is a kind of DRR against earthquake -Roofs have different load distribution arrangements, as the concentration of loads underneath the beams, thus in order to distribute equally the roof loads a top plate/band or ring beam should be provided at the top of the walls. It should be continuous encircling the walls, this provides a way of fastening the walls together at the top to prevent pushing outward forces of the roof and in case of horizontal seismic forces. -In case of pitched roof with two gables placing plates/bands at the top of the wall (without gables) distribute the loads and constrains the pushing forces of the rafters. -It is suggested to assemble trusses instead of rafters, since the horizontal bottom chord ties the inclined top chords constraining their pushing outward forces.
Covering package Generic guidance	-Roof topping can be made with many different materials as long as the items are lightweight, strong, durable, secured, waterproof, insulating and maintainable. -Any material that soak water or melt should be avoided -A common practice is the use of a thatch or other structural system, plastic sheeting with a mud plaster layer, protected with a final waterproofing layer. -Lime plaster or a bitumen mixture may provide a water-resistant finish to the roof that should be reapplied prior and after annual rains.
Covering package Specific guidance	- Above the semi structural mat of straw or thatch, a polythene sheet, a layer of stabilized mud have to be applied in 2-3 coats, the thickness may be 3" maximum. The mud layer may make heavy the structure. -The last coat should be a waterproofing. Lime /mud plaster may improve the water resistance. -Bitumen mixed with stabilized mud mortar is an effective treatment, it is waterproofing and fire resistant. It should be prepared by mixing (5:1) bitumen with kerosene oil and mud (1.5 kg of bitumen for 30 kg of mud). -Also the animal dump, mixed with mud, may be a kind of waterproofing as an eco-friendly option -In case of flat roof, the coats of plaster have to incorporate the top of the walls and the parapet, protecting the matting of plastic sheet and straw and the structure of roof, as a kind of waterproofing capping. This is a DRR that will avoid the rain water to penetrate in the connection roof/walls.
DRR waterproofing and drainage	-An overhang of the roof, or eaves, of 15" minimum will prevent rainwater from running down mud or plaster of the walls and soaking into the structure and plash the plinth. This will aid the structures resilience. -For flat roof it is important a right slope to allow the rain water to wash away quickly, the stagnancy upon the roof allow the rain water soaking the top layers and penetrate in the core of walls. -Where there is a parapet is compulsory to provide 1 or 2 waterspouts, the slopes have to be arranged accordingly (minimum 1%). -The waterspouts should be minimum 2.5"and project minimum 8". -The waterspouts have to be well sealed with bitumen without any discontinuity in order to prevent water rain to penetrate in the structure of roof and walls above. -Another option may be CGI spout in "U" shape. -The use of gutters for catch rain water may be considered; obviously the slope has to be adequate in case of flat roof
Maintenance	-re-plaster with lime mud or bitumen mud mortar the roof at least once an year or whenever necessary - periodic cleaning of the waterspouts -re-apply the film of bitumen yearly before the monsoon season -verify the good connection of the element of the structures (beams and purlin) -re-treat against termite the bamboos and wooden elements once an year or whenever necessary -inform the owners regarding periodic treatment as termite treatment , annual re-plastering of the roof, periodic cleaning of the waterspouts
Adobe	**COST ESTIMATE**
Notes	The costs of materials may sensitively increase after any catastrophic events due to the scarcity of materials available on the local markets and the difficulty or impossibility of frequent transportation. In addition of that it has to be noted the costs vary from district to district every semester. Therefore it is suggested to upgrade the cost estimate accordingly to the last official quotations of the price analysis by district-wise.
Estimated Unit Cost	XXX USD

The BURN BRICK shelter is built with fired bricks. The walls need to be at least 9" thick and should be plastered. Care needs to be put in the choice of beams and its placement. Commonly the roof is made of thatch or other structural system, plastic sheeting with a mud plaster layer, protected with a final waterproofing layer.

Loh Kat	Mud	Adobe	**Burn Brick**	Concrete brick

Burn Brick	**BEARING FOUNDATIONS AND FOUNDATIONS**
Generic Guidance	Foundations and platforms specification, depth and height, dependent on the site characteristics (soil, elevation) and super structure, materials and loads, thus their depth and width have to be designed on a case by case basis. The excavation depth may be more than 2'- 3' in not compacted soils. Generally the width of the platform should be almost one third for each side=1.6-2 times the thickness of the walls. Increasing the width of walls at the base will improve resilience and help keep longer the flood water away from the base of the walls which will extend or prevent the time of disintegration (depending on the time of stagnancy) The foundations need to have a sealed barrier at the base to prevent that the water penetrates into the structure both from the ground (dampness) either from stagnancy. Reinforcing the walls at ground level by adding concrete plaster /pointing layer or mud / lime
Specific Guidance	-Excavation depth minimum 24" below undisturbed ground or compacted soil. -The wall structure or columns (reinforced masonry) should extend to the same depth of 24" to reach the solid layer and ensure stability -Minimum dimension for the foundations are 2'wide footings founded 2' below the natural surface level (NSL)
Notes and recommendations	-Brick masonry has heavy load and require a concrete, stone or brick foundation to distribute the load to the ground and thus ensure stability of the wall -Appropriate anchoring details for the foundation should be considered -the plinth can be plastered with cement/sand/lime for improve the waterproofing -burnt brick may be a better option for foundation due to their waterproofing characteristics -in order to improve the stability of the trench, a layer of cement/soil may be poured under foundation. The suggested mixture (stabilized soil) is sand(27%) soil (70 %) cement (3 %); the thickness should be 6" minimum.
Burn Brick	**RAISED PLINTH FLOOR**
Generic Guidance	The floor level should be raised to at least 1'6"up to 3' above the Natural Surface Level (NSL) adopting a continuous plint. General recommendation is to protect furthermore the foundations below floor level by raising an earth platform 3' wide at the top and tapering to NSL over 6'. (i.e 1 in 2 slope minimum.) The top of this platform should be 6" below floor level. A damp proof course (DPC) at plinth level is compulsory in order to prevent moisture rising into the walls. A DPC is either a thin layer of concrete at plinth level with plastic on one surface or simply a strong plastic layer
DRR improvements (Flood and earthquake)	-the plinth may be with fired bricks or in concrete, cement/sand mortar has be used. -the plinth can be plastered with cement/sand/lime for improve the waterproofing - at the top the plinth a reinforce band with 2-4 bars can ensure the earthquake resistance, in case of concrete plinth it may be reinforced with 4 bars
Maintenance	-re-plaster with lime/mud/cement mortar the raised plinth at least once yearly, before the monson season, and whenever necessary -in case of reinforced band: verify that the bars are not expose and corroded, paint them with red oxidant varnish
Burn Brick	**SUPERSTRUCTURE**
Walls Core materials and techniques	-Fired brick walls may differ in size depending on structural design. -The minimum requirement is 9", i.e. the length of a brick -Increasing the thickness provide stability, durability and waterproofing, it may be 13.5" i.e. 1.5 brick's length.

	-Alternate the displacement of the brick each rows to ensure the interlocking -Construct from corners to center -Ensure good connection from plinth to walls and interlock bricks at corners -Reinforce long walls at centre -Avoid too wide vertical joints, and too thick bedding joints -Hollow block walls should be reinforced using steel or similar materials -Cement or lime and sand based mortar should be used for bonding. -Cement Mortar for General Purpose Use (but the mix can be harsh) 1 Cement: 4 Fine Sand -Cement Lime Mortar for Block and Bricklaying, plasters and Renders: 1 Cement: 1 Lime: 6 Sand -Lime Mortar for Block and Bricklaying: 1 Lime: 3 Sand
Notes and recommendations	All junctions of the wall - at base, top and corners - need to be tied, either through interlocking or reinforcement elements like timber or steel. Care should be taken to ensure salt in the sand is of very low levels, as salt will damage the mortar It is not advisable to build more the 3 shelters in line, since long walls have a negative seismic response
DRR for earthquake resistance: • Joint and binding • Reinforced bands	-Thickness and good execution consist in DRR themselves. -Reinforced band at floor level, sill level, lintel level and roof level are DRR measures against earthquakes. -The bands have to be continuous, interlocking the bars at corners. -The number of bars may be 2-4 depending on the height of the band. -The floor and top bands are suggested to be 3”-4” with 4 bars#4, while the ones at sill and lintel may be 2” with 2 bars#3. -The top band should be provided in any case as a basic DRR against earthquake. -Vertical reinforcements with steel bars collaborate to the stability and seismic resilience of the shelter. -The vertical bars have to be interlocked with the horizontal ones. Columns in reinforced concrete, along with reinforced horizontal bands improve the seismic resistance. This kind of structure, named “CONFINED MASONRY” is the more suitable in seismic areas, but obviously it is expansive.
DRR flood resistance (plaster as protective and expendable surface)	-The external plastering is always a good practice, since it protects the masonry from rain, wind and stagnant water , prolonging its durability. -It is suggested cement/lime/plaster at least till the sill level. -Pointing is an option from the sill level up to the roof. -Plastering the whole walls is preferable. -Plastering is mandatory for mud/lime mortar execution. -While pointing is suggested anyway in case of good quality of bricks, cement mortar and good execution of the masonry.
Maintenance	-re-plaster with lime/mud/cement mortar the raised plinth at least once an year before the monsoon season, and whenever necessary (worn-out plaster) - re-plaster the external walls at least once an year before the monsoon season, and whenever necessary -in case of reinforced band: verify that the bars are not expose and corroded, paint them with red oxidant varnish
Opening door window	-Openings within the wall space should not take up an area greater than 50% of the wall. -Openings should be higher than wider -Windows and doors should be kept a minimum of 2 ft from corners and from each other and open outwards. -The doors should open outwards for fire safety purpose
Lintels	-In order to bear and distribute the load of the wall above the openings, lintels should to be installed. -Lintels should be minimum 2” thick and 6” longer than the opening on each side. -Lintels should be designed based on the load being carried overhead -For short spans timber plate or tied bamboos (2-3) may be an option, which sounds more appropriate to the adobe structure. -The pre-cast concrete lintel may be a good option -The lintel may be executed with bricks system using n.2 steels #3 and cement mortar.
Ventilation	The ventilation is very important mainly during the summer that is very hot in several areas. -Two windows may ensure ventilation. Alternatively one or two ventilators, executed on the opposite side of the window (generally on the back wall) may ensure good ventilation. -The dimensions depend on the size of the shelter, it may be one of 2’ x 1’ or two 1’x1’ In some areas, where the summer is very hot, it may be suggested to increase the height of the shelter to improve the internal ventilation (in this case the entire structure of the shelter has to be re-calculated*) note this will increase the cost of the shelter*
Burn Brick	**ROOF**
Generic guidance	-Roof design should allow for live and dead loads. Live loads are applied loads such as rain, wind, snow or

	usage for grain or livestock. Dead loads are those including the makeup of the roof structure such as beams, straw, mud, cement etc. -A bamboo or other lightweight roof can be used for all construction methodologies, while steel girder roof or similar heavy roof requires a strong bearing structure, therefore it is only suitable for fired brick, concrete block, engineered steel frame shelters -A thick mud layer will add a lot of load to the roof and may cause severe, damaging strain to the roof structure and loadbearing walls. -Timber elements may in some cases be larger loads than steel or other alternatives. -Bamboo and timber are susceptible to termites. Adequate treatment should be provided to timber and bamboo materials -Timber, bamboo or straw roofs are not suitable for indoor cooking or heating fires. -A conical or four-sided pitched roof is preferable in areas where wind loads are a consideration, particularly cyclone vulnerable areas. -Gable ends or flat surfaces may be more stress by resisting to the wind force -The pitch of a roof will vary based on the wind conditions in the area, however a maximum pitch is advised of 30º for simple pitched roofs. -A mono-pitched roof may have a pitch of up to 10º to allow adequate drainage of rainwater. - In the flat roof a minimum slope should be 3/8" per foot.
Main structure	This structure is supposed to be more resistant, thus the solution of the bamboos beam is not suitable, neither the less is not forbidden. -Timbers of adequate size and steel girders are suitable options. -The girder "I" beam size should depends on the number (1 or 2), loads of the roof and thickness of walls -Suggested sizes are 4"x6" or 4"x8", also 5.5"x2.5" may be used. -Bearing plate, or pad, has to be inserted underneath the girder in order to distribute its load. -A steel plate may be 12"x8"x0.5", a concrete tile or wooden board may be on option. *Anti-oxide treatment is suggested for the iron/steel elements*. -The secondary structure of purlin may made by bamboos well sized. -The distance between bamboos should be not more than 1' (1 brick), their length has to be enough to overlap the thickness of walls -Above the bamboos a mat of chick, straw, thatch and plastic sheet is generally used. Straw and plastic sheet have to be incorporate in the top of the walls by the final plastering. *Bamboos, timber and straw should be treated against termites*. -An alternative to the "I" girder may be a concrete precast beam. -An alternative to the bamboos and straw are the "T" beams (T-iron) and tiles of cement or burned clay.
Note and recommendations DRR for earthquake resistance	-All loadbearing elements of the roof structure, columns, beams and joists have to be not placed above door or window openings. Any openings provide weaknesses in the walls, because reduce the portion of bearing walls, thus placing the loadbearing elements right above the openings may cause failure in the walls with cracks and even collapse of the portion interested. -Any elements of the roof structure should be tied to each other. All joists or beams in the roof structure need to be individually tied to purlins. The roof must also be securely tied to the wall structure. Well fastening ensure a good resistance to the strong wind and is a kind of DRR against earthquake -Roofs have different load distribution arrangements, as the concentration of loads underneath the beams, thus in order to distribute equally the roof loads a top plate/band or ring beam should be provided at the top of the walls. It should be continuous encircling the walls, this provides a way of fastening the walls together at the top to prevent pushing outward forces of the roof and in case of horizontal seismic forces. -In case of pitched roof with two gables placing plates/bands at the top of the wall (without gables) distribute the loads and constrains the pushing forces of the rafters. -It is suggested to assemble trusses instead of rafters, since the horizontal bottom chord ties the inclined top chords constraining their pushing outward forces.
Covering package Generic guidance	-Roof topping can be made with many different materials as long as the items are lightweight, strong, durable, secured, waterproof, insulating and maintainable. -Any material that soak water or melt should be avoided -A common practice is the use of a thatch or other structural system, plastic sheeting with a mud plaster layer, protected with a final waterproofing layer. -Lime plaster or a bitumen mixture may provide a water-resistant finish to the roof that should be reapplied prior and after annual rains.
Covering package Specific guidance	- Above the semi structural mat of straw or thatch, a polythene sheet, a layer of stabilized mud have to be applied in 2-3 coats, the thickness may be 3" maximum. The mud layer may make heavy the structure. -The last coat should be a waterproofing. Lime /mud plaster may improve the water resistance.

	-Bitumen mixed with stabilized mud mortar is an effective treatment, it is waterproofing and fire resistant. It should be prepared by mixing (5:1) bitumen with kerosene oil and mud (1.5 kg of bitumen for 30 kg of mud). -Also the animal dump, mixed with mud, may be a kind of waterproofing as an eco-friendly option -In case of flat roof, the coats of plaster have to incorporate the top of the walls and the parapet, protecting the matting of plastic sheet and straw and the structure of roof, as a kind of waterproofing capping. This is a DRR that will avoid the rain water to penetrate in the connection roof/walls.
DRR waterproofing and drainage	-An overhang of the roof, or eaves, of 15" minimum will prevent rainwater from running down mud or plaster of the walls and soaking into the structure and plash the plinth. This will aid the structures resilience. -For flat roof it is important a right slope to allow the rain water to wash away quickly, the stagnancy upon the roof allow the rain water soaking the top layers and penetrate in the core of walls. -Where there is a parapet is compulsory to provide 1 or 2 waterspouts, the slopes have to be arranged accordingly (minimum 1%). -The waterspouts should be minimum 2.5”and project minimum 8”. -The waterspouts have to be well sealed with bitumen without any discontinuity in order to prevent water rain to penetrate in the structure of roof and walls above. -Another option may be CGI spout in “U” shape. -The use of gutters for catch rain water may be considered; obviously the slope has to be adequate in case of flat roof
Maintenance	-re-plaster with lime mud or bitumen mud mortar the roof at least once an year or whenever necessary - periodic cleaning of the waterspouts -re-apply the film of bitumen yearly before the monsoon season -verify the good connection of the element of the structures (beams and purlin) -re-treat against termite the bamboos and wooden elements once an year or whenever necessary -inform the owners regarding periodic treatment as termite treatment , annual re-plastering of the roof, periodic cleaning of the waterspouts
Burn Brick	**COST ESTIMATE**
Notes	The costs of materials may sensitively increase after any catastrophic events due to the scarcity of materials available on the local markets and the difficulty or impossibility of frequent transportation. In addition of that it has to be noted the costs vary from district to district every semester. Therefore it is suggested to upgrade the cost estimate accordingly to the last official quotations of the price analysis by district-wise.
Estimated Unit Cost	XXX USD

The CONCRETE BRICK shelter is built with reinforced concrete or cement bricks and plastered with cement mortar. The walls need to be at least 8” thick and should be plastered. Care needs to be put in the choice of beams and its placement. Commonly the roof is made of thatch or other structural system, plastic sheeting with a mud plaster layer, protected with a final waterproofing layer.

Loh Kat	Mud	Adobe	Burn Brick	**Concrete Brick**
Concrete Brick	**BEARING FOUNDATIONS AND FOUNDATIONS**			
Generic Guidance	Foundations and platforms specification, depth and height, dependent on the site characteristics (soil, elevation) and super structure, materials and loads, thus their depth and width have to be designed on a case by case basis. The excavation depth may be more than 2’- 3’ in not compacted soils. Generally the width of the platform should be almost one third for each side=1.6-2 times the thickness of the walls. Increasing the width of walls at the base will improve resilience and help keep longer the flood water away from the base of the walls which will extend or prevent the time of disintegration (depending on the time of stagnancy)			

	The foundations need to have a sealed barrier at the base to prevent that the water penetrates into the structure both from the ground (dampness) either from stagnancy. Reinforcing the walls at ground level by adding concrete plaster /pointing layer or mud / lime
Specific Guidance	-Excavation depth minimum 24" below undisturbed ground or compacted soil. -The wall structure or columns (reinforced masonry) should extend to the same depth of 24" to reach the solid layer and ensure stability -Minimum dimension for the foundations are 2'wide footings founded 2' below the natural surface level (NSL)
Notes and recommendations	-Concrete brick masonry has heavy load and require a concrete, stone or brick foundation to distribute the load to the ground and thus ensure stability of the wall. -Appropriate anchoring details for the foundation should be considered -the plinth can be plastered with cement/sand/lime for improve the waterproofing burnt brick may be a better option for foundation due to their waterproofing characteristics -in order to improve the stability of the trench, a layer of cement/soil may be poured under foundation. The suggested mixture (stabilized soil) is sand(27%) soil (70 %) cement (3 %); the thickness should be 6" minimum
Concrete Brick	**RAISED PLINTH FLOOR**
Generic Guidance	The floor level should be raised to at least 1'6"up to 3' above the Natural Surface Level (NSL) adopting a continuous plint. General recommendation is to protect furthermore the foundations below floor level by raising an earth platform 3' wide at the top and tapering to NSL over 6'. (i.e 1 in 2 slope minimum.) The top of this platform should be 6" below floor level. A damp proof course (DPC) at plinth level is compulsory in order to prevent moisture rising into the walls. A DPC is either a thin layer of concrete at plinth level with plastic on one surface or simply a strong plastic layer
DRR improvements (Flood and earthquake)	-the plinth may be with fired bricks or in concrete, cement/sand mortar has be used. -the plinth can be plastered with cement/sand/lime for improve the waterproofing -at the top the plinth a reinforce band with 2-4 bars can ensure the earthquake resistance, in case of concrete plinth it may be reinforced with 4 bars
Maintenance	-re-plaster with lime/mud/cement mortar the raised plinth at least once yearly, before the monson season, and whenever necessary -in case of reinforced band: verify that the bars are not expose and corroded, paint them with red oxidant varnish
Concrete Brick	**SUPERSTRUCTURE**
Walls Core materials and techniques	Concrete brick walls and reinforced concrete walls may differ in size depending on structural design. Concrete block walls should be at least 8" thick -Alternate the displacement of the brick each rows to ensure the interlocking -Construct from corners to center -Ensure good connection from plinth to walls and interlock bricks at corners -Reinforce long walls at centre -Avoid too wide vertical joints, and too thick bedding joints -Hollow block walls should be reinforced using steel or similar materials -Cement or lime and sand based mortar should be used for bonding. -Cement Mortar for General Purpose Use (but the mix can be harsh) 1 Cement: 4 Fine Sand -Cement Lime Mortar for Block and Bricklaying, plasters and Renders: 1 Cement: 1 Lime: 6 Sand -Lime Mortar for Block and Bricklaying: 1 Lime: 3 Sand
Notes and recommendations	All junctions of the wall - at base, top and corners - need to be tied, either through interlocking or reinforcement elements like timber or steel. Care should be taken to ensure salt in the sand is of very low levels, as salt will damage the mortar It is not advisable to build more the 3 shelters in line, since long walls have a negative seismic response
DRR for earthquake resistance: • Joint and binding • Reinforced bands	-Reinforced band at floor level, sill level, lintel level and roof level are DRR measures against earthquakes. -The bands have to be continuous, interlocking the bars at corners. -The number of bars may be 2-4 depending on the height of the band. -The floor and top bands are suggested to be 3"-4" with 4 bars#4, while the ones at sill and lintel may be 2" with 2 bars#3. -The top band should be provided in any case as a basic DRR against earthquake. -Vertical reinforcements with steel bars collaborate to the stability and seismic resilience of the shelter. -The vertical bars have to be interlocked with the horizontal ones.
DRR flood resistance (plaster	Although the blocks are enough resilient to the water, the external plastering is always a good practice, since it protects the masonry from rain, wind and stagnant water, prolonging its durability.

as protective and expendable surface)	
Maintenance	-re-plaster with lime/mud/cement mortar the raised plinth at least once an year before the monsoon season, and whenever necessary (worn-out plaster) - re-plaster the external walls at least once an year before the monsoon season, and whenever necessary -in case of reinforced band: verify that the bars are not expose and corroded, paint them with red oxidant varnish
Opening door window	-Openings within the wall space should not take up an area greater than 50% of the wall. -Openings should be higher than wider -Windows and doors should be kept a minimum of 2 ft from corners and from each other. -The doors should open outwards for fire safety purpose
Lintels	-In order to bear and distribute the load of the wall above the openings, lintels should to be installed. -Lintels should be minimum 2" thick and 6" longer than the opening on each side. -Lintels should be designed based on the load being carried overhead -The pre-cast concrete lintel may be an appropriate option for this typology -The lintel may be executed with bricks system using n.2 steels #3 and cement mortar.
Ventilation	The ventilation is very important mainly during the summer that is very hot in several areas. -Two windows may ensure ventilation. Alternatively one or two ventilators, executed on the opposite side of the window (generally on the back wall) may ensure good ventilation. -The dimensions depend on the size of the shelter, it may be one of 2' x 1' or two 1'x1' In some areas, where the summer is very hot, it may be suggested to increase the height of the shelter to improve the internal ventilation (in this case the entire structure of the shelter has to be re-calculated*) note this will increase the cost of the shelter*
Concrete Brick	**ROOF**
Generic guidance	-Roof design should allow for live and dead loads. Live loads are applied loads such as rain, wind, snow or usage for grain or livestock. Dead loads are those including the makeup of the roof structure such as beams, straw, mud, cement etc. -A bamboo or other lightweight roof can be used for all construction methodologies, while steel girder roof or similar heavy roof requires a strong bearing structure, therefore it is only suitable for fired brick, concrete block, engineered steel frame shelters -A thick mud layer will add a lot of load to the roof and may cause severe, damaging strain to the roof structure and loadbearing walls. -Timber elements may in some cases be larger loads than steel or other alternatives. -Bamboo and timber are susceptible to termites. Adequate treatment should be provided to timber and bamboo materials -Timber, bamboo or straw roofs are not suitable for indoor cooking or heating fires. -A conical or four-sided pitched roof is preferable in areas where wind loads are a consideration, particularly cyclone vulnerable areas. -Gable ends or flat surfaces may be more stress by resisting to the wind force -The pitch of a roof will vary based on the wind conditions in the area, however a maximum pitch is advised of 30º for simple pitched roofs. -A mono-pitched roof may have a pitch of up to 10º to allow adequate drainage of rainwater. - In the flat roof a minimum slope should be 3/8" per foot.
Main structure	This structure is supposed to be more resistant, thus the solution of the bamboos beam is not suitable, neither the less is not forbidden. -Timbers of adequate size and steel girders are suitable options. -The girder "I" beam size should depends on the number (1 or 2), loads of the roof and thickness of walls -Suggested sizes are 4"x6" or 4"x8", also 5.5"x2.5" may be used. -Bearing plate, or pad, has to be inserted underneath the girder in order to distribute its load. -A steel plate may be 12"x8"x0.5", a concrete tile or wooden board may be on option. *Anti-oxide treatment is suggested for the iron/steel elements*. -The secondary structure of purlin may made by bamboos well sized. -The distance between bamboos should be not more than 1' (1 brick), their length has to be enough to overlap the thickness of walls -Above the bamboos a mat of chick, straw, thatch and plastic sheet is generally used. Straw and plastic sheet have to be incorporate in the top of the walls by the final plastering. *Bamboos, timber and straw should be treated against termites*. -An alternative to the "I" girder may be a concrete precast beam. -An alternative to the bamboos and straw are the "T" beams (T-iron) and tiles of cement or burned clay.

Note and recommendations DRR for earthquake resistance	-All loadbearing elements of the roof structure, columns, beams and joists have to be not placed above door or window openings. Any openings provide weaknesses in the walls, because reduce the portion of bearing walls, thus placing the loadbearing elements right above the openings may cause failure in the walls with cracks and even collapse of the portion interested. -Any elements of the roof structure should be tied to each other. All joists or beams in the roof structure need to be individually tied to purlins. The roof must also be securely tied to the wall structure. Well fastening ensure a good resistance to the strong wind and is a kind of DRR against earthquake -Roofs have different load distribution arrangements, as the concentration of loads underneath the beams, thus in order to distribute equally the roof loads a top plate/band or ring beam should be provided at the top of the walls. It should be continuous encircling the walls, this provides a way of fastening the walls together at the top to prevent pushing outward forces of the roof and in case of horizontal seismic forces. -In case of pitched roof with two gables placing plates/bands at the top of the wall (without gables) distribute the loads and constrains the pushing forces of the rafters. -It is suggested to assemble trusses instead of rafters, since the horizontal bottom chord ties the inclined top chords constraining their pushing outward forces.
Covering package Generic guidance	-Roof topping can be made with many different materials as long as the items are lightweight, strong, durable, secured, waterproof, insulating and maintainable. -Any material that soak water or melt should be avoided -A common practice is the use of a thatch or other structural system, plastic sheeting with a mud plaster layer, protected with a final waterproofing layer. -Lime plaster or a bitumen mixture may provide a water-resistant finish to the roof that should be reapplied prior and after annual rains.
Covering package Specific guidance	- Above the semi structural mat of straw or thatch, a polythene sheet, a layer of stabilized mud have to be applied in 2-3 coats, the thickness may be 3” maximum. The mud layer may make heavy the structure. -The last coat should be a waterproofing. Lime /mud plaster may improve the water resistance. -Bitumen mixed with stabilized mud mortar is an effective treatment, it is waterproofing and fire resistant. It should be prepared by mixing (5:1) bitumen with kerosene oil and mud (1.5 kg of bitumen for 30 kg of mud). -Also the animal dump, mixed with mud, may be a kind of waterproofing as an eco-friendly option -In case of flat roof, the coats of plaster have to incorporate the top of the walls and the parapet, protecting the matting of plastic sheet and straw and the structure of roof, as a kind of waterproofing capping. This is a DRR that will avoid the rain water to penetrate in the connection roof/walls.
DRR Waterproofing and Drainage	-An overhang of the roof, or eaves, of 15" minimum will prevent rainwater from running down mud or plaster of the walls and soaking into the structure and plash the plinth. This will aid the structures resilience. -For flat roof it is important a right slope to allow the rain water to wash away quickly, the stagnancy upon the roof allow the rain water soaking the top layers and penetrate in the core of walls. -Where there is a parapet is compulsory to provide 1 or 2 waterspouts, the slopes have to be arranged accordingly (minimum 1%). -The waterspouts should be minimum 2.5”and project minimum 8”. -The use of gutters for catch rain water may be considered; obviously the slope has to be adequate in case of flat roof -The waterspouts have to be well sealed with bitumen without any discontinuity in order to prevent water rain to penetrate in the structure of roof and walls above. Another option may be CGI spout in “U” shape.
Maintenance	-re-plaster with lime mud or bitumen mud mortar the roof at least once an year or whenever necessary - periodic cleaning of the waterspouts -re-apply the film of bitumen yearly before the monsoon season -verify the good connection of the element of the structures (beams and purlin) -re-treat against termite the bamboos and wooden elements once an year or whenever necessary -inform the owners regarding periodic treatment as termite treatment , annual re-plastering of the roof, periodic cleaning of the waterspouts
Concrete Brick	**COST ESTIMATE**
Notes	The costs of materials may sensitively increase after any catastrophic events due to the scarcity of materials available on the local markets and the difficulty or impossibility of frequent transportation. In addition of that it has to be noted the costs vary from district to district every semester. Therefore it is suggested to upgrade the cost estimate accordingly to the last official quotations of the price analysis by district-wise.
Estimated Unit Cost	XXX USD

Map illustrating flood affected areas in 2010, 2011 and 2012