SHELTER STRATEGY

Leh Flood

SEEDS - LEDeG
August 22, 2010

Vision

> To build safe and comfortable and environmentally culturally suitable houses for affected families to help them survive the approaching winter.

Highlights

- Use of local material for low enviornmental impact and high safety.
- Local skills to reduce dependence on external aid.
- Improved building material such as stabilized compressed earth blocks to ensure safety from future floods.
- Simple and low cost technologies to reduce earthquake risks in this high seismic risk region.
- Traditional house design to preserve cultural heritage.
- Designs that keep the homes warm in winter and reduce energy consumption.
- Permanent structures, with scope for expansion.
- Participation of families in design and reconstruction of their houses.

Purpose of this strategy document

The flash floods in Leh in August 2010 were unprecedented in nature and scale, and have left a large section of the affected population at the mercy of the harsh climate. One of the most critical needs is to restore houses within the next few weeks so that those rendered homeless can survive the extreme winter.

SEEDS has worked on post-disaster shelter response in most of the major emergencies in the recent past, including Gujarat earthquake, Indian Ocean tsunami, Kashmir earthquake, Rajasthan floods, Orissa floods and Bihar Kosi floods. It has in-house technical expertise on structural safety, architecture, environmental planning, community-based processes and construction work.

LEDeG has been active in the Leh, Ladakh region on the issue of environmentally appropriate shelter, and has established a rural building centre for research and propagating environmentally appropriate technologies. The building centre is located in Choglamsar, one of the worst-affected villages.

Together, SEEDS and LEDeG have developed a shelter strategy that combines the environmental, cultural, temporal and risk reduction needs in the current context. We share this with all stakeholders concerned , including government agencies, fellow organisations extending humanitarian assistance in Ladakh, and the affected families, to get feedback, and to move towards a jointly owned and unified shelter response strategy.

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1 Background

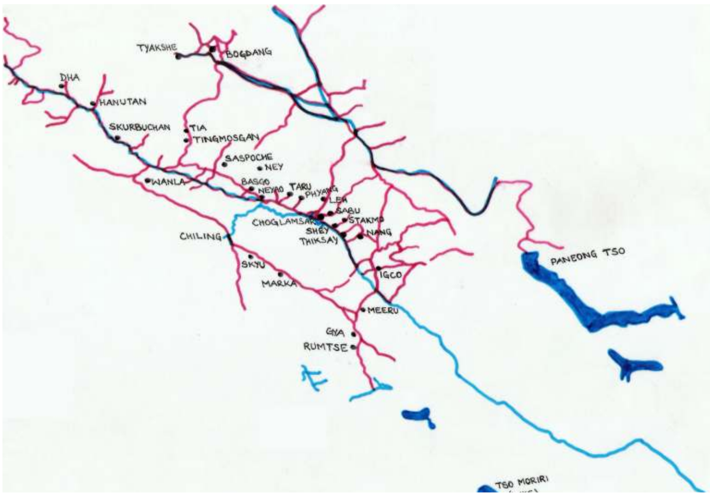
On 6th August a cloudburst hit the area of Leh, Ladakh. Buildings were destroyed, communication lines broken and highways were washed away. A week after the ill-fated night the death toll stands at 187 and 400 are still missing. Thirty-four villages have been affected by the disaster and with some areas still inaccessible the number of dead and missing is expected to rise as more information trickles in from far flung areas.

On August 5 and 6, Leh recorded 12.8 mm of rainfall in 24 hours, which is almost 90% of the total rainfall normally received by the region in the whole month. The damage to community infrastructure has been extensive.

Of the thirty-four affected villages, Choglamsar, situated 6km from Leh, was worst hit. A mudslide passed through the village either flooding the buildings or wiping them out. Most of the other villages have isolated pockets of devastation.

Due to the prolonged winter, scanty rainfall, rugged terrain and limited availability of time and productive land, the sparse population of Leh lives along the river banks surviving on sustenance agriculture and cattle rearing. The rivers that swelled due to the cloud bursts wiped out everything that came in the way. In many places the rivers changed their course and completed the destruction.

> An unprecedented flash flood ravaged the ecologically fragile region of Leh, Ladakh on August 6, 2010. With their houses gone, the affected families will have to endure extreme winter with temperature as low as -30°C in the coming days



2 Damage to houses

The two main reasons for the damage to houses are –

1. The excessive lateral force exerted by the rushing mixture of water, mud and rocks

2. Use of mud as the only material for walls. Mud loses it ability to bind and eventually dissolves once it comes in contact with water.

The houses have been damaged to varying degrees and forms depending upon the location and the techniques and material used. The damage suffered can be broadly classified into three categories:

a) Damage to the corners of the house: This was due to the absence of any lateral load resisting features in the house

b) Complete failure of walls: This was due to the excessive outward pressure exerted by the rushing mass of mud, rocks and water on the plain mud walls, which are further weekend due to absence of any

c) Damaged openings: Due to the force of rushing mud, rocks and water funneled through small openings

Special comments

a) Complete failure of some RC frame buildings: Lack of know-how and absence of quality control led to poor construction, which caved in under the extra stress exerted by flood waters.

b) Excessive damage to schools and other community buildings.

There are structural damages due to poor strength of material and absence of resistant technologies to face disasters of such magnitude. Construction materials and technologies have to be thus improved

3 Approach

Drawing from our experience, we have followed a holistic approach towards combining both technical as well as social aspects. The few key areas are:

- **Building back better**
  - People-centric approach
  - Being culturally relevant
  - Being locally sustainable

HOUSING STRATEGY

- Community Participation
- Culturally appropriate and locally relevant house
- Environmental-friendly materials
- Resistant to future disasters
- Training of local construction workers
- House design based on IS-CODES and SPHERE Standards

4 Traditional houses

Traditional local houses in Ladakh have evolved over the centuries, the harsh climate and a thriving Buddhist culture being the two main influences. Over the centuries these houses have allowed Ladakhis to lead a self-sufficient and comfortable life with limited local resources. An understanding of the traditional house, and how it responds to social and environmental factors, is key to any successful shelter initiative.

Orientation

a) Three storeys high
b) East facing (considered auspicious)
c) Clustered to reduce heat loss

Layout

Ground level: The ground floor is animal shelter (helps to warm upper levels of the house). Courtyards around the house act as pens for animals.
First Floor: Consists of kitchen, bedrooms (husband and wife sleep separately from children), food storage area, toilets and washing area
Top Floor: Roof courtyard, family chapel (elevated position important, steps up), guest room/bedroom and summer room

Walls

a) Up to 3 feet thick (generally 30 to 40 inches)
b) Four feet deep foundations (not verified)
c) White washed with limestone

Materials Used
Ground level: Stone
Upper levels: Sun dried mud bricks plastered with fine clay 'markala'

Roof and Floors

a) Constructed from *poplar* beams, willow branches, yagdzas (similar to heather) mud and earth
b) Flat roofs (generally little rain, snow can be removed easily)
c) Grass piled on roof over walls (protects from any precipitation)
d) Prayer flags displayed on roof (signifying Buddhist households)

Traditional construction styles have evolved over generations using local material and providing protection from cold climate. Surviving the harsh winter was the primary motive.

Openings

a) Small windows and doors (to reduce heat loss)
b) No openings on north elevation (reduces heat loss)
c) Entrance door with high threshold (to cope with snowfall)
d) Ornate carving on timber lintels and window surrounds

Kitchen

Heart of house – The family spend most of their time here, a place for family gatherings and celebration
Size: Large (6.5m x 4.5m in the case study house, anecdotally informed that this is not much larger than average)

Contains:

a) Low tables and mats for sitting
b) Wooden shelving for elaborate display of pots
c) Stove: focal point of kitchen and elaborately decorated (wood burning stove considered preferable to gas in winters for its space warming properties, even in more modern houses)
d) Timber floor
e) Screen at door prevents drafts

Storage

- Large storage spaces are required due to long winters. Items stored are *chang* (local brew), spices, milk, yoghurt, barley and wheat.
- The kitchen storeroom is on the north side of kitchen with thick walls (keeps cool in summer).
- Grain storage tanks are placed under the kitchen floor.
- Roofs are used for drying apricots and other fruits and vegetables on blankets in the sun (summer), stacked with alfalfa grass for animals and dung or shrubs for fuel.

Reference: Ancient Futures: Learning from Ladakh, Helena Norberg - Hodge

Besides controlling the heat loss, the housing design also catered to the gathering of the family around the bukhari in the kitchen area

5 Shelter Options: Indigenous vs Mainstream

One of the main reasons for the damage to existing houses is mud coming in direct contact with water a causing complete collapse. It is important to protect the mud blocks from direct contact with water. Based on materials and skills locally available, different options for shelter are explored. Every option has its pros and cons in terms of economy and safety. Primarily two methods of construction can be followed –

a) Load bearing construction (Indigenous)

b) Reinforced Concrete frame construction (Mainstream)

Load bearing construction

In this type of construction, the main load carrying elements are the roof and walls. The entire load is transferred from walls to the foundation. There are various options for walling materials available, which can be used as explained below:

a) Mud blocks with cement plaster

One simple solution is to provide a good mix of cement plaster on the external walls of the houses. This reduces the risk of damage during floods. It also allows keeping mud as a basic material for construction, mud is the traditional material of construction in Ladakh. The costs involved are less, but the disadvantage is that in case of heavy floods this can collapse because of low compressive strength of mud.

b) Stabilized compressed earth blocks (SCEB)

Stabilized compressed earth blocks can be the best option here. They are formed by combining cement with mud and then compressed under pressure. The cement stabilizes the earth block increasing its strength and water resisting properties. The primary material still being mud, the cost remains low but the durability increases manifold. This method also helps retain the heat retention capacities of mud.

(For details on SCEB refer to chapter10 on pg.12)

Reinforced Concrete frame structures give significant strength, but raise costs and carbon footprints of buildings

RC frame construction

In this type of construction the main load carrying elements are the columns and beams of the frame. The walls play the role of infill. Even though this construction is safer, the costs are high. Also the material will need to be sourced from outside. Moreover RC frame construction requires a high level of expertise, locally unavailable. This will make future repairs or additions difficult and expensive, and can also compromise the strength of the building.

a) RC frame with mud blocks as infill wall

RC frame forms the basic structure of the building, which is filled with mud blocks. Mud blocks are available locally reducing the costs.

b) RC frame with Stabilized Compressed Earth Blocks

Similar to the one above, in this the mud blocks are replaced by SCEBs, further strengthening the structure. Sturdiest of the lot but the most expensive and time consuming.

Use of mud as basic construction material will keep time, cost and environmental impact low, and thermal comfort high. Mud blocks with cement plaster, or cement stabilized mud blocks will increase resistance to future floods.

6 Shelter design based on traditional houses

The proposed shelter unit has been designed maintaining sensitivity to the Ladakhi way of life, culture, the fragile ecology of the region and the pressing time frame. The shelter meets the sphere standards requirement of 3.5m^2 per person. Based on the census data, average size of a Ladakhi household is 4 or 5. The design given here is of the overall house, but due to time constrains only the core area will be build (Red boundary) before the winters. The house is designed in such a way that it can be easily extended at a later stage and could be done once the winter is over.

Structural elements

Foundation

Foundation will be stepped and constructed with stone, available locally and well known to local construction workers. The depth of the foundation will be up to the hard strata.

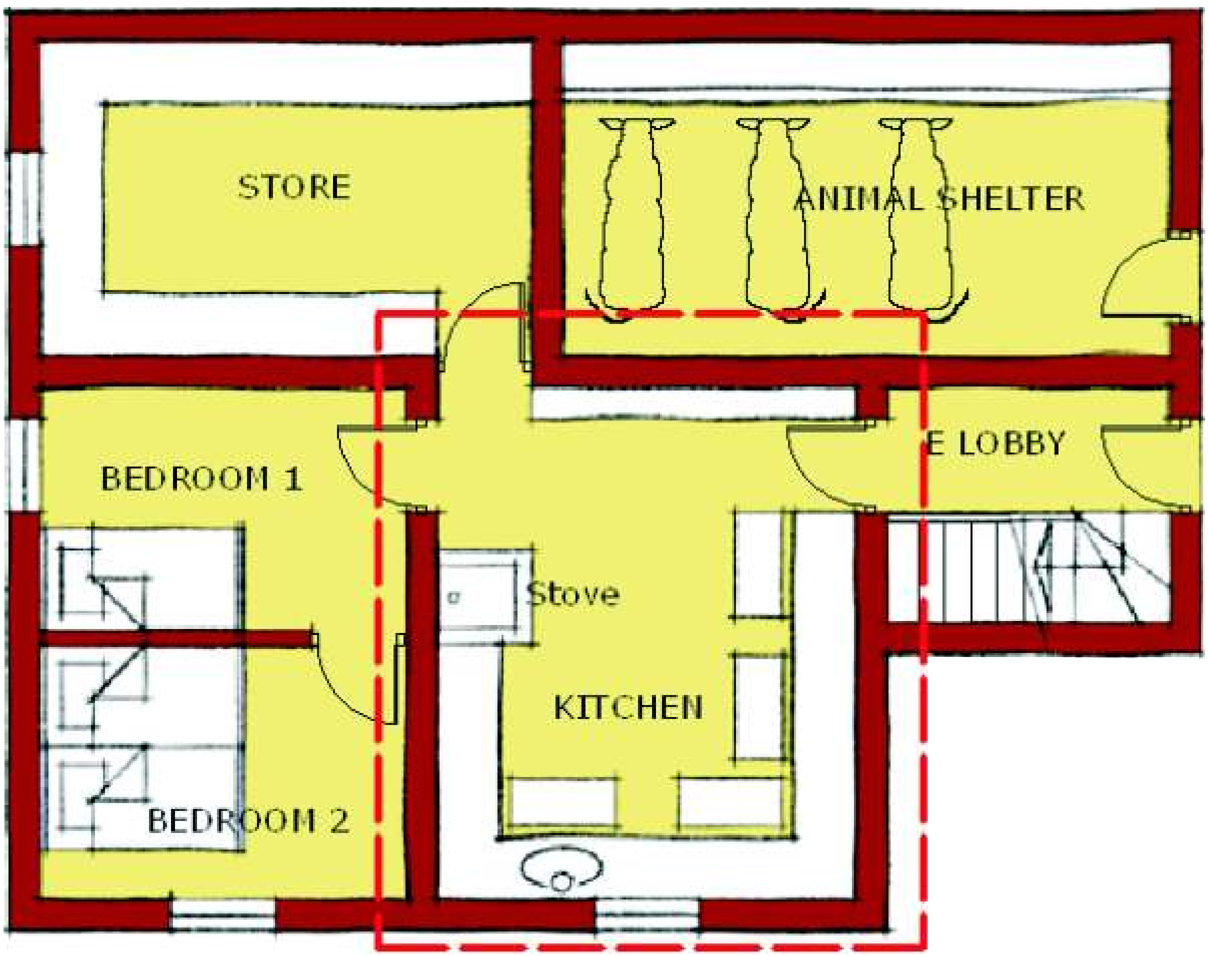
Walls

To be constructed with Stabilized Compressed Earth Blocks. Mud is the traditional medium used for construction locally. The cement will provide the required strength to it without compromising the desired characters like heat retention.

Seismic bands

Ladakh falls in Zone IV in the seismic map of India and it is important to provide lateral load resisting features like seismic bands and corner reinforcement, which will increase the ductility of the shelter. There will be two seismic bands provided in shelter at plinth and lintel levels.

PROPOSED SHELTER DESIGN



Roof
The structure of the roof will be made out of wood available locally. There are primary members of the roof, which act as rafters and secondary members that act as purlins. There will be a layer of locally available straw, which increases the thermal comfort. There will also be a layer of mud on the straw with proper drainage channels. A ladder to access the roof, used for drying of fruits and storage of grass, will be provided. Prayer flags can be added by the occupants if desired.

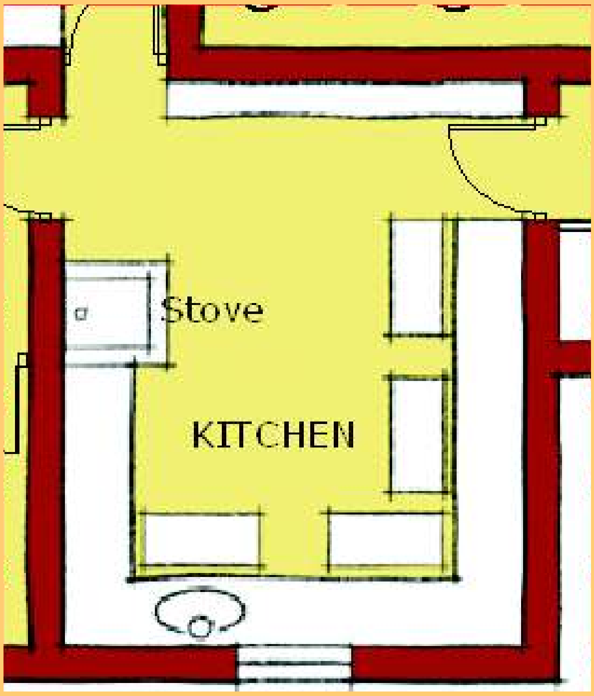
Floor
To be constructed with mud as per the traditional technology used in Ladakhi houses. This increases the thermal comfort inside as mud gains the heat during the day and retains it during the nights.

Other important elements
Entrance
An east facing entrance is considered auspicious in Ladakhi culture. A lobby area helps to keep the house warm during cold winters. The door threshold should be 300mm above ground level so that it doesn't jam after snowfall.

Storage
A storage area will be provided in order to meet the food storage needs of the family. The food storage area will be in the north, where it will remain cool in summer, and will help buffer the kitchen from the cold in winter.

Shelving
A plywood shelving unit will separate the kitchen from the store. This can be removed when the house is expanded. Shelving units are an important element of a Ladakhi kitchen, where they are used to display crockery and metal ware.

AREA TO BE BUILT BEFORE WINTER



Kitchen

The kitchen, which is at the heart of a traditional Ladakhi house, doubles up as a sleeping area at night. Ladakhis spend much of their time in the kitchen, kept warm by the cooking stove. The area is used for preparing and eating food, as well as for entertainment.

During the day, the shelter kitchen looks much like a traditional Ladakhi kitchen, with mats and mattresses for seating along the walls, and small tables for eating. At night these mats can be rearranged for use as beds.

The kitchen has south and east facing windows. These allow ventilation of the kitchen area, and for sunshine to warm the house in winter. The windows are small in order to help reduce heat loss in winter.

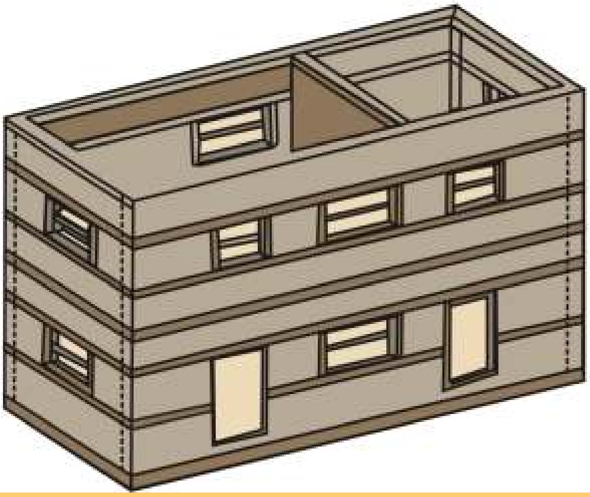
Future Adaptation and Expansion

It is intended that the shelter can be extended by the occupants later. The plywood shelving unit can be removed, and door openings and windows can be reused.

7 Special aspects of the design

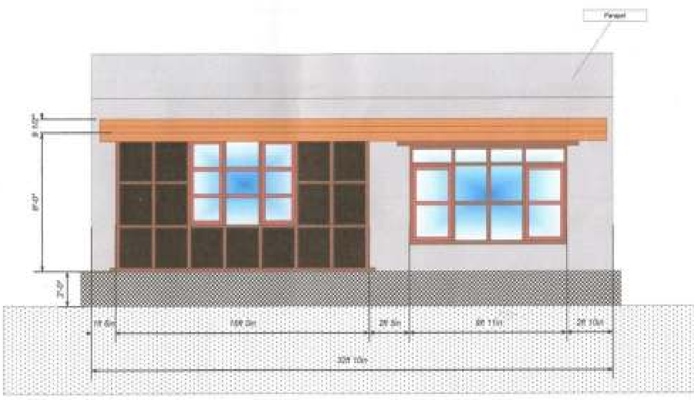
Disaster Risk Reduction

- Future flood resistance through raised stone plinths, with plinth protection on the external surface
- Earthquake and flood resistance through corner reinforcements
- Earthquake resistance through plinth and lintel seismic bands, through stones, corner reinforcements and tying of roofs
- Attention to retrofitting wherever repairs are being carried out
- Retrofitting to include seismic bands, corner reinforcements, strengthening of roofs and headers in walls



Environmental aspect in shelter design

- Solar design, with Trombe wall (night room) and direct solar gain (day room)
- Cavity walls that can include insulation in the form of saw dust infill, or as an alternative EPS sheets
- Roof with insulation, waterproofing (in the form of clay) and a 3% fall
- Doors that are double ply filled with saw dust for insulation
- Windows that have double glazing for insulation
- Orientation with east entrance desirable, west possible if prevailing winds necessitate that. Entrances never to face north or south.



For persons with disabilities

- Door sizes of 900 mm width preferable
- Door thresholds should be flush

8 Sanitation unit: Traditional, Clean and Green

In Ladakh, dry composting latrines provide a highly efficient and safe method of disposal of human waste. Each traditional Ladakhi house has a dry composting latrine, which is emptied once a year and the compost is used as fertilizer in the fields. This eliminates the need for pipe work, saves water and power, and avoids leakages from tanks and thus the chance of water bourne diseases. Dry composting latrines are thus the most appropriate waste disposal system for the proposed shelter.

The latrine takes the form of a small room with a hole in the floor through which human waste drops down one floor to a pit below. Earth, and ash from the kitchen, is shoveled down the hole to cover the waste. This helps to reduce smell, aid decomposition and enrich the waste for use as fertilizer.

9 People centric construction process

Construction process is an important element in a successful rehabilitation programme. Therefore, people based reconstruction process, which allows the family to make the final decisions about the design and construction, is proposed. Involving families in different stages of construction will cultivate a sense of ownership among them..

The families will be provided with a design based on the traditional Ladakhi house with a technological intervention to make it energy efficient and resilient to disasters. Each family will have the freedom to build the house according to its needs. The project team will help in the construction.

While proposing the design, it has been tried, as much as possible, to use traditional and locally prevalent techniques and materials, and improve them with limited technological intervention. This will help in utilizing the existing workforce in the region as they will be familiar with the materials and most of the techniques being used. It also gives a chance to train the workforce in new technologies that can be replicated at a minimum cost. This will supply better construction techniques in the region, increase jobs for local masons and construction workers and make future repairs easier and cheaper.

In the whole process, the role of the project team will be that of facilitators and advisers, with all major decisions taken by the family which will own the house. Under the project, mobile Safe House Clinics will be setup to provide material, technical and man power support. It is also proposed to build a prototype house at the rural building center in Leh to demonstrate the use of proposed designs, technologies and materials. This will give the families a chance to get a feel of their new house. The prototype can be used as a supply-cum-training center during the reconstruction process.

10 Stabilized Compressed Earth Blocks

Stabilized Compressed Earth Block (SCEB) technology offers a cost-effective, environmentally sound masonry system. The product, a stabilized compressed earth block, has a wide application in construction for walling, roofing, arched openings and corbels. The blocks are made by compressing raw material earth mixed with a stabilizer such as cement or lime under a pressure of 20 - 40 kg/cm^2 using a soil press. The basic principal is compressing raw earth to attain dense, even sized masonry. One can also make interlocking blocks. These interlocking blocks are highly suitable for quick and mortar less construction. SCEB Technology helps in offsetting the use of fuel wood, which is expensive. On the other hand, the use of cement as stabilization for gaining the required strength slightly increases the cost.

Product

The Stabilized Compressed Earth Block is a masonry unit in the shape of a cube. This may be solid or hollow or interlocking. The shape and size of a block is defined by the equipment used in its making. SCEBs can be used for load bearing construction up to three storeys. The cost of a block depends on a variety of factors like quality and price of available soil, amount of stabilization, labour productivity, equipment and overhead costs. The degree of stabilization has the maximum influence on the cost of the product.

Stabilized Compressed Earth Block is a very appropriate technology for the region. It falls between the low-cost local mud blocks that are weak, and the strong cement concrete houses that are expensive and polluting

Raw Material and Manpower

The primary raw material for the production of SCEB is raw earth or soil. Cement in small quantities and water are the other constituents. Coarse sand or stone dust may be added depending on soil quality. The grain size distribution of a soil determines its suitability for the manufacture of SCEB. Two to four people are required to operate a manual machine. The hydraulic machines require around six to eight people. In both the machines one skilled worker is required while the rest can be semi-skilled. Workers can be trained to operate both machines in three to five days.

Application

Stabilized Compressed Earth Blocks can be used in almost all the applications of burned clay bricks or stone.

Energy Effectiveness

Costs are often limited to monetary value, but another important aspect to consider is the low energy consumption of the material. The production of earth-based materials consumes much less energy and pollutes much less than fired bricks or concrete. SCEB and stabilized rammed earth are much more eco-friendly than industrial materials.

They have the following advantages compared to fired bricks:

Pollution emission(Kg of CO_2/m^2)	Energy consumption (MJ)
2.4 times less than wire cut bricks 7.9 times less than country fired bricks	4.9 times less than wire cut bricks 15.1 times less than country fired bricks

Ecological comparison of building materials				
Product and thickness	No of Units (per m^2)	Energy consumption (NJ per m^2)	CO_2 emission (Kg per m^2)	Dry compressive crushing strength (Kg/cm^2)
CSEB-24 cm	40	110	16	25-60
Wire Cut Bricks-22 cm	87	539	39	75-100
Country Fired bricks-22cm	112	1657	126	30-100
Concrete blocks-20 cm	20	235	26	75-100

11 Bill of quantities (BOQ) and indicative budget for core shelter

S. No	Activity	Material	Quantity	Unit	Rate	Amount (Rs.)
1	Excavation		23.54	m^3	200	4,710
2	Foundation	Stone	14.82	m^3	1100	16,302
3	Walling	Block masonry	12.68		3500	44,380
4	Seismic bands	RCC	1.323		8000	10,584
5	Roofing	Wood and mud	Lump sum		30000	30,000
6	Flooring	Mud	Lump sum		15000	15,000
7	Shelves	Wooden ply/wood for frames	12.32	m^2	700	8,624
8	Openings	Wood	12	m^2	500	6,000
Cost of the core unit						**1,35,600**
9	Toilet	Stone, SCEB, Door, Ventilator	Lump sum			22,000
10	Thermal and environmental efficiency features		Lump sum			35,000
Total Cost						**1,92,600**

Note:

1. Cost taken for estimation are based on the data collected from Leh
2. Cost is calculated for core shelter part of the house to be built immediately. Area = 20 m^2
3. Cost escalations that are often seen in post-disaster times have not been included

- **Core shelter assistance will be provided to families irrespective of whether they get shelter assistance immediately or not. The aim is to give all affected families a safe and comfortable home before winter.**
- **In case the beneficiary is getting cash compensation from the government, the Safe House Clinic will provide technical assistance for adding risk reduction and energy efficient features. Additional material support for these features will be provided whereever necessary.**

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