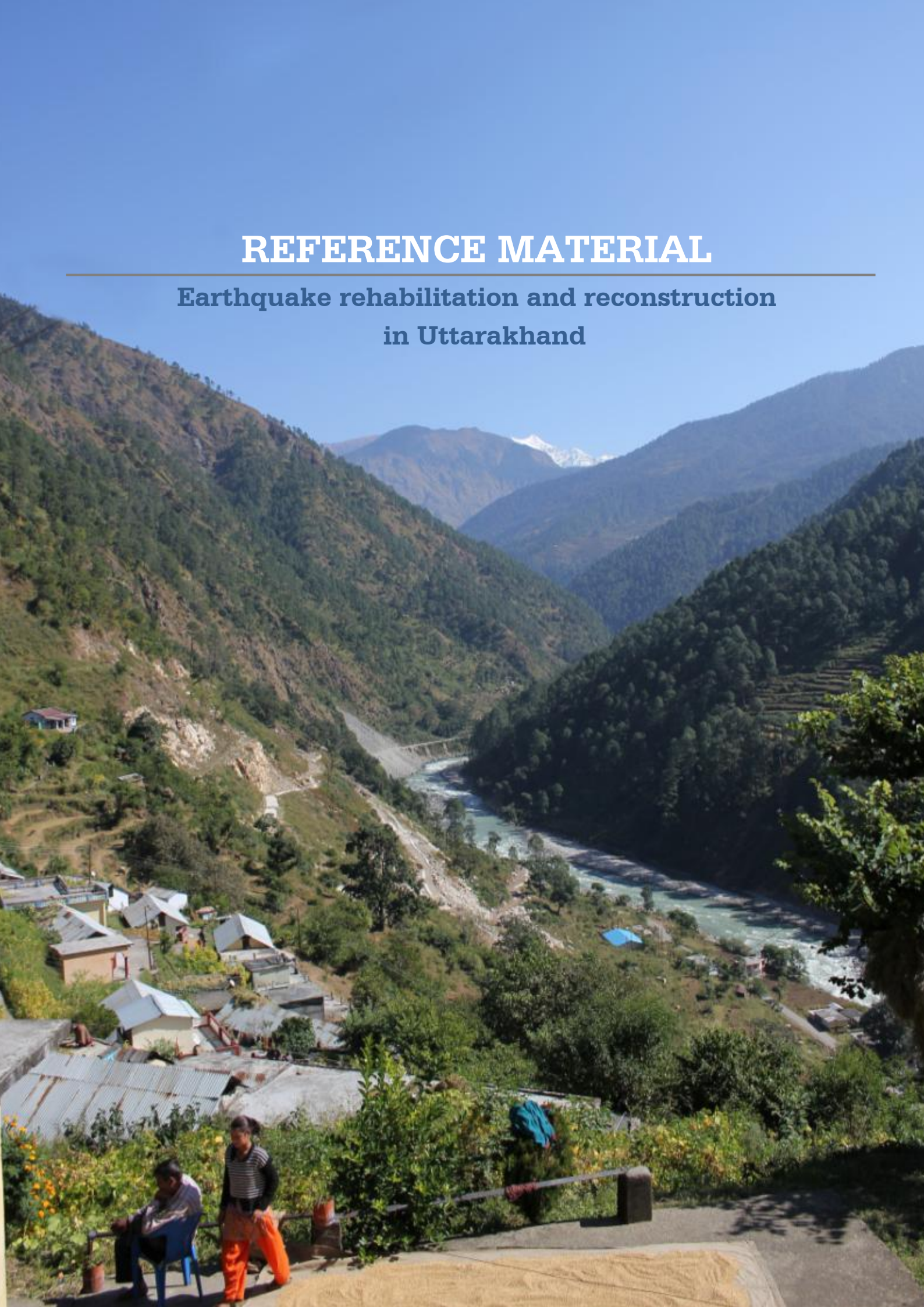
# REFERENCE MATERIAL

## Earthquake rehabilitation and reconstruction in Uttarakhand



# CONTENTS

# REHABILITATION PROJECT AT VILLAGE-AUNGI, DISTRICT UTTARKASHI, UTTARANCHAL (safeguard against earthquake)

## Architect Anant Tankha and Associates - New Delhi

Aungi suffered extensive damage during the earthquake. The Village comprises of 37 Rajput families of drummers and 13 weaver families who keep shunting between the earlier settlement and their temporary shelters. The site chosen is close to existing village so that the same amenities can be used. The villagers chose to abandon the previous settlement and built temporary shelters, thus it was felt that there is a dire need to relocate the village to a safe place.

The participants suggested the foundation to be tied with the plinth beam and plinth beam to be tied to the RCC columns at the corners which are in turn tied to lintel beam. Foundation is designed taking the form of a human foot and in case of natural disaster the wall will tend to fall on the outside. The supporting roof truss to be anchored in the lintel beam and the wall to be sandwiched between the plinth beam and the lintel beam. The wall is further tied up by systematically laid thru stones. The excavation suggested to be about 1.0mt. setback from the back terrace to protect the back wall of the dwelling unit from a possible breaking loose during earthquake. The setback from the edge of terrace to be more than the depth of excavation to avoid dislodging of the terrace edges. If not possible a retaining wall in stone masonry be provided with weeping holes. Longer thru stones are provided at an interval 0.9mt in alternate stone masonry courses binding the wall. Concrete cast corner is designed with 2 nos. of 12mm dia vertical bars. Lintel beam laid with MS bolts to tie door and window chowkat and wooden truss frame. This village rehabilitation project demonstrates the sensitivity with which the traditional and vernacular village planning and building element have been redefined using technologies from the locally available resources.

Village AUNGI (Photo shot from school)

**AMENITIES ASSOCIATED TO THE OLD AUNGI VILLAGE:**

| | |
|---|---|
| 'PANIHARA | – Natural water source |
| 'FOREST | -- For fire wood |
| 'GRASS LAND | -- As grazing fields |
| 'FIELDS | -- For Agriculture |

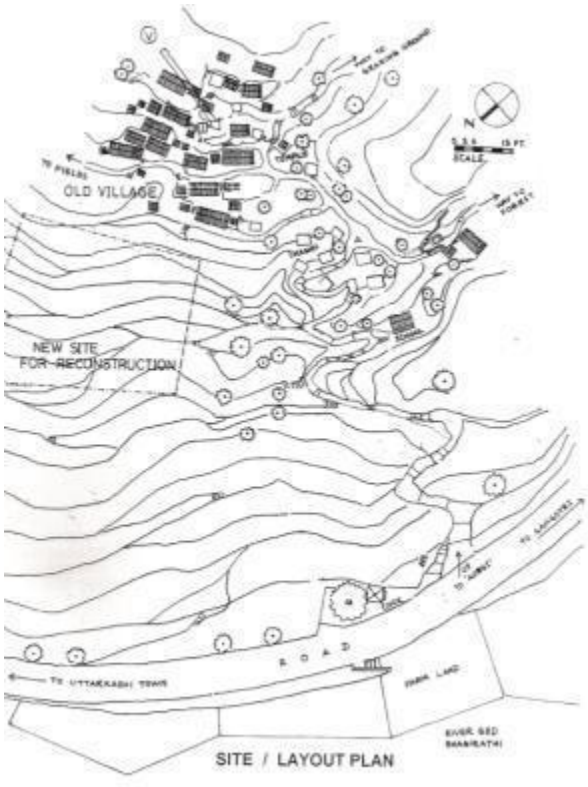
**NEED FOR RELOCATING THE OLD AUNGI VILLAGE:**

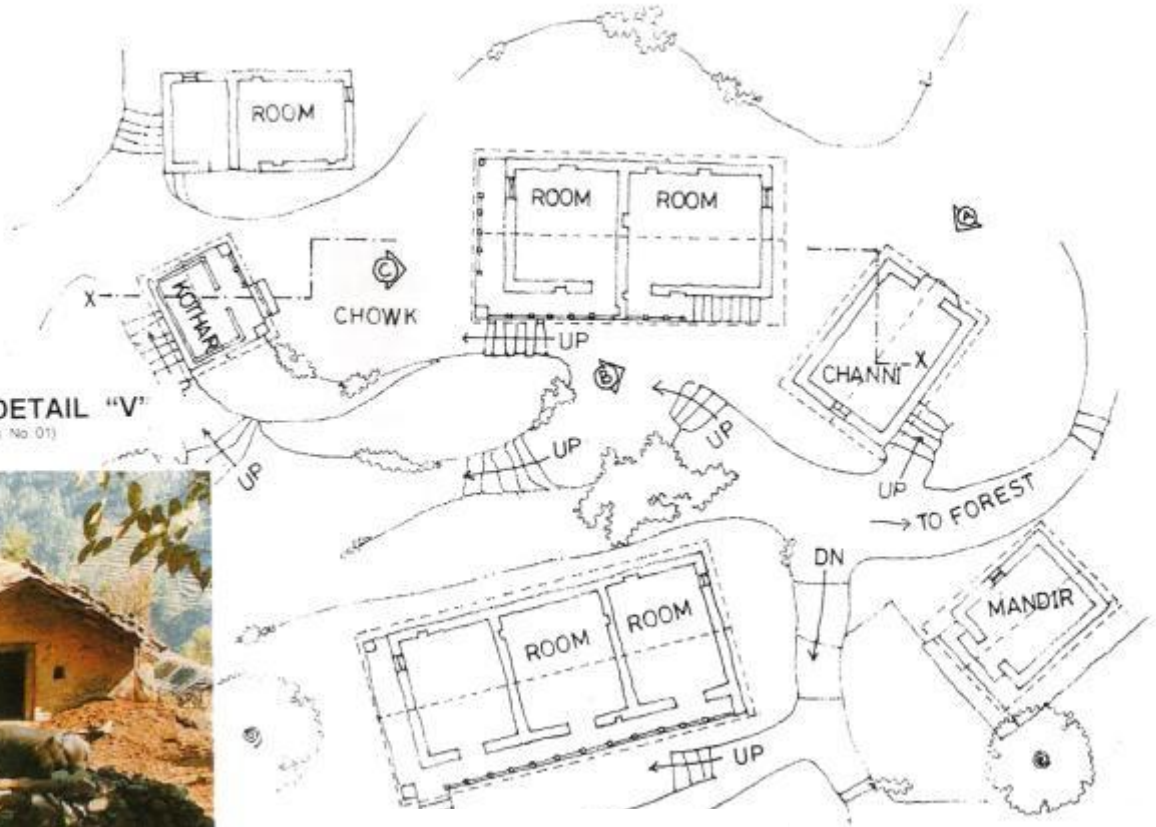
- Village Stepped Terraces have developed cracks
- Village fails under the rock fall Zone

**CRITERIA FOR SELECTING NEW SITE / RECONSRUCTION**

- Close to the existing village, so that the same amenities can be used
- Safe from rock fall/landslide
- Natural Rain water drainage lines not to be disturbed in new construction
- Micro climate, sun side of the hill and effect of high velocity wind.
- Shape of site, uniformly contoured ridge or valley to be discarded
- Acceptance of Local villagers for site being auspicious
- Width of the terraces, for minimum cutting and filling during construction

New site for Relocating Village
(Photo as shot from Channis)






## CLUSTER DETAIL "V"

(Refer Site /Location Plan No 01)

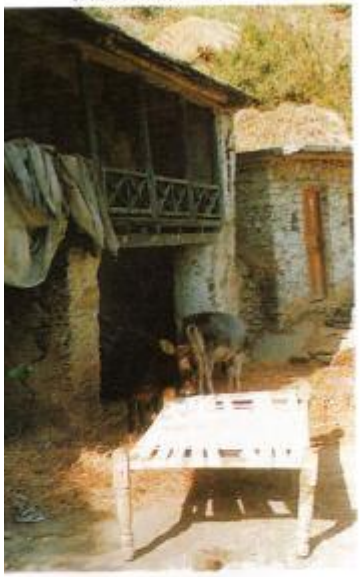
Photograph of CHANNI
( Photo shot from "A" )

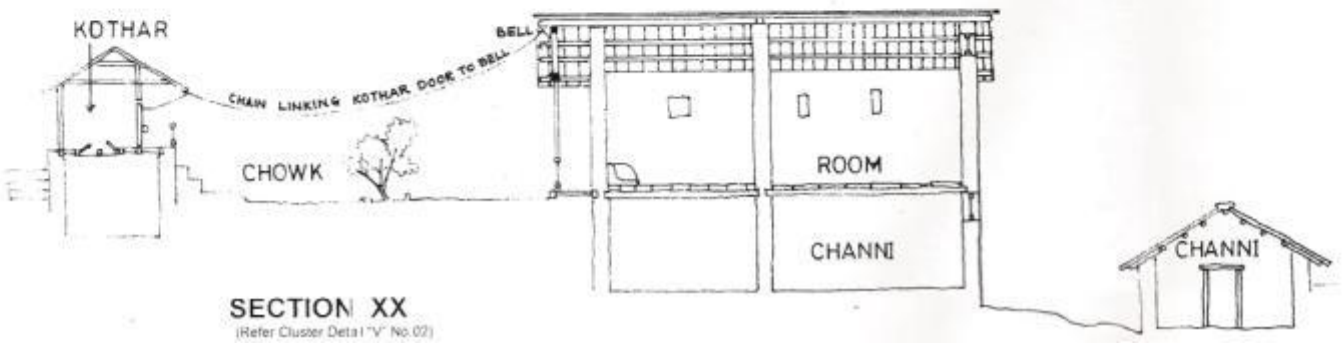
Photograph of Village House
( Photo shot from "C" )

## CLUSTER LEVEL ELEMENTS:

**KOTHAR**
For storing grains
**CHANNIS:**
For keeping livestock
**ROOM UNIT:**
For habitation/cooking
**CHOWK:**
An open terrace for sitting and performing daily cores
**MANDIR:**
For festivals.
**PANCHAYAT GHAR:**
For community Decision
**PEDESTRIAN SPINE:**
Lateral axis joining different terrace levels through steps
**SECURITY:**
*For protection from wild animals, Cows/Buffalos are housed on the Ground floor of the Room unit
*The Door of the kothar is chained to a bell in the house
(Refer section XX)

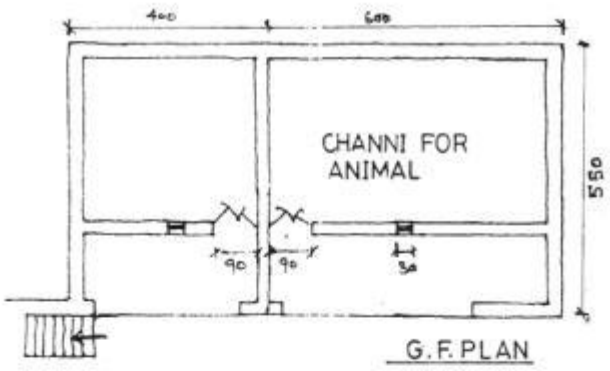
Photograph of Village House
( Photo shot from "B" )

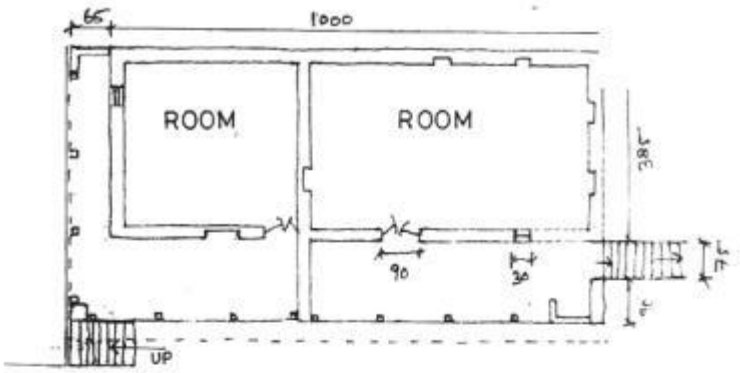




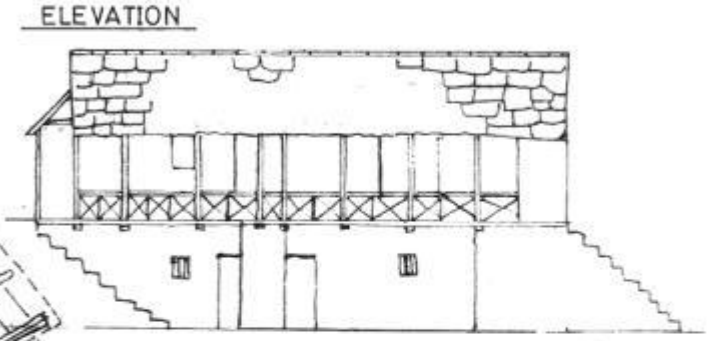

SECTION XX

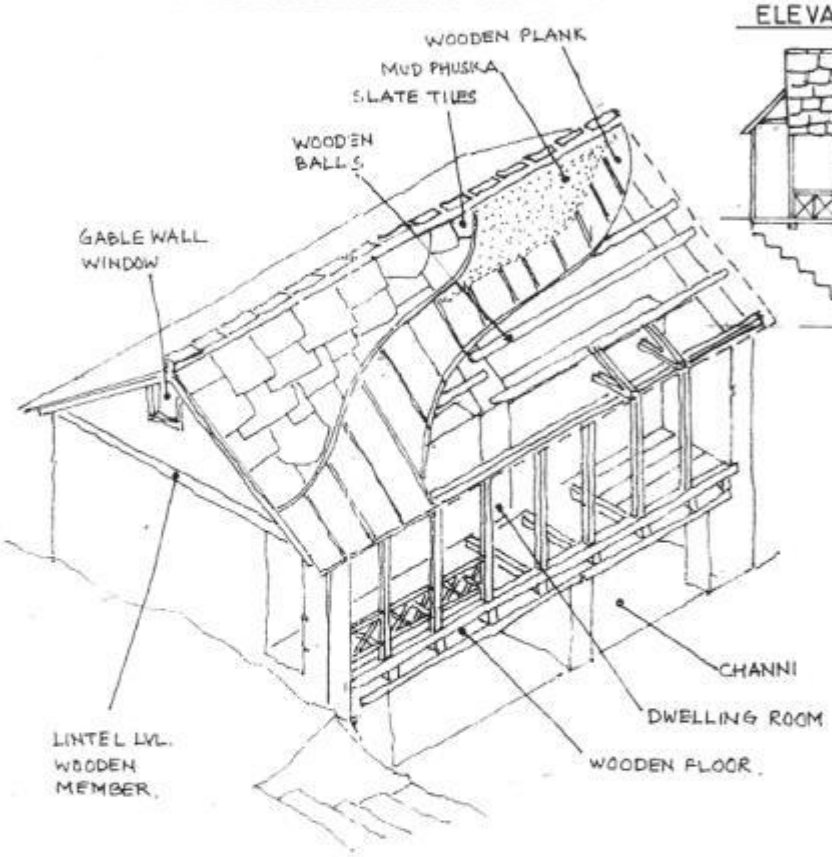
(Refer Cluster Detail "V" No.02)



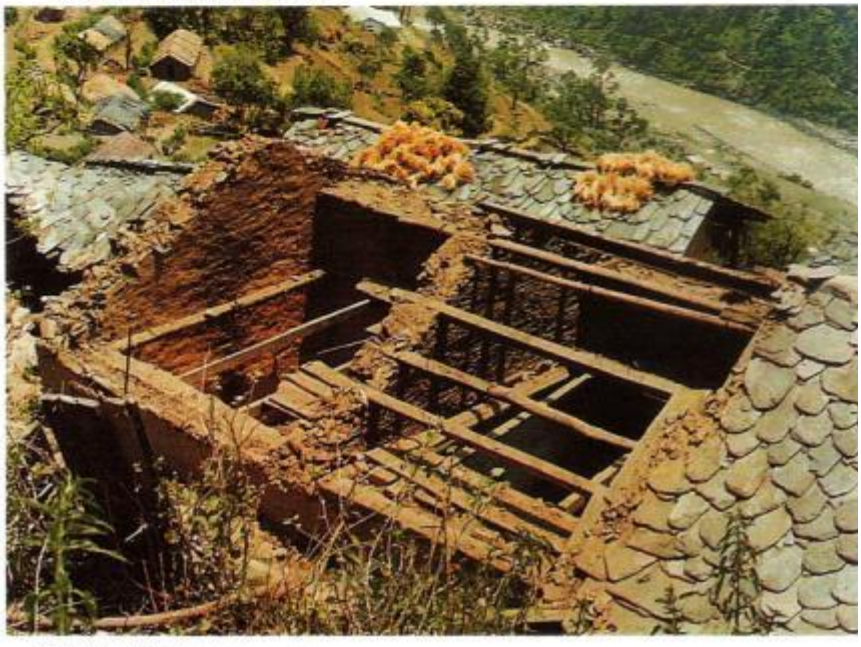




## TYPICAL VILLAGE DWELLING UNIT DESIGN




ISOMETRIC / 3D-VIEW



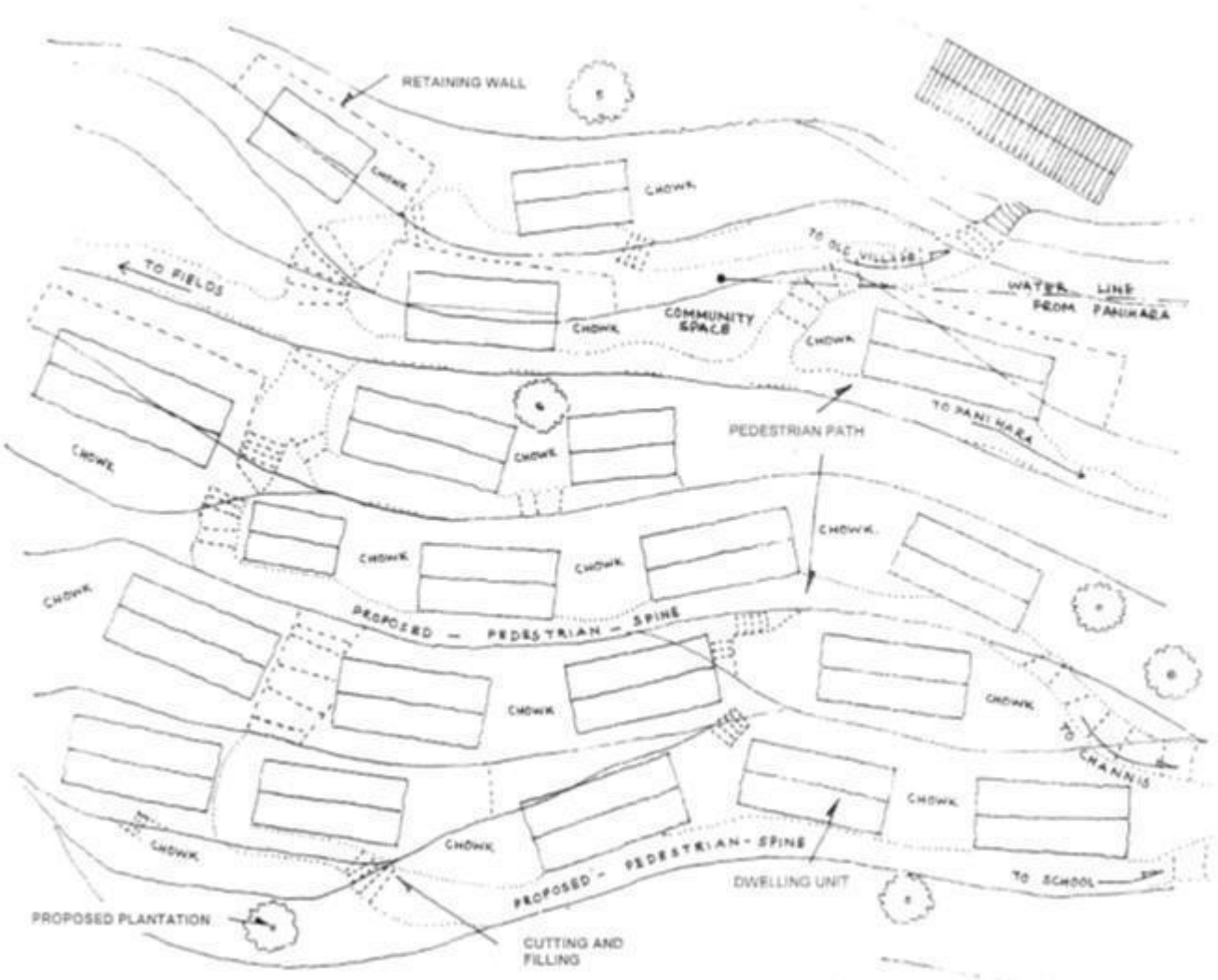
Photograph of Typical Village House –Dalmatia

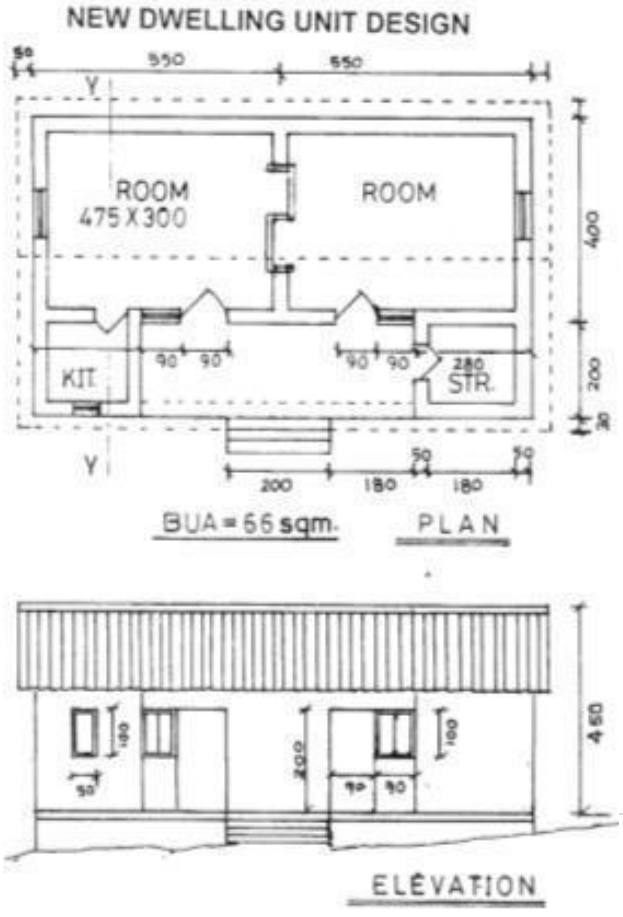
**ELEMENTS OF TYPICAL DEWELLING UNIT DESIGN**
**ARCHITECTURAL**

- Channis on ground floor for livestock for protection from wild animals
- Room for dwelling on first floor
- Small doors and very small windows fenestration area only *5%* of the covered area for harsh cold climate
- East sided varanda. For direct sunlight
- Alcoves for lighting lamps
- No designed space for storage
- Cooking inside room, keeping it warm and sooting wooden members one of the reasons for long life of wood
- Varanda railing, doors and wooden eves of the roof being the only aesthetic part of the design
- Mud floor in channis, and wooden floor on the first floor unit
- The plan is rectangular and unsymmetrical due to the narrow hill terraces. And lack of space for expansion the proportion of length and width of the dwelling units varies 1:2 to 1:5 expanding only laterally

**STRUCTURAL**

- The houses are composite of stone mud wood and slate. All locally and abundantly available in the area
- The houses are 20 to 80 years old and are built over a period of time collecting the best wood stone and slate tile from the forest.
- The roof is made out of wooden ballis laterally placed on side gable walls supporting wooden planks with mudphuska and slate tiles on top
- For ventilation of cooking smoke a window at top of gable wall is provided
- Wooden plank/sq. Balli is provided at lintel level for tying up the whole structure
- Veranda is made of wooden plank floor with corner stone masonry post and intermediate wooden posts supporting the wooden members of the slate tile roof above

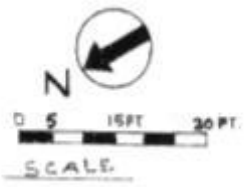



**THE NEW DWELLING UNIT DESIGN**

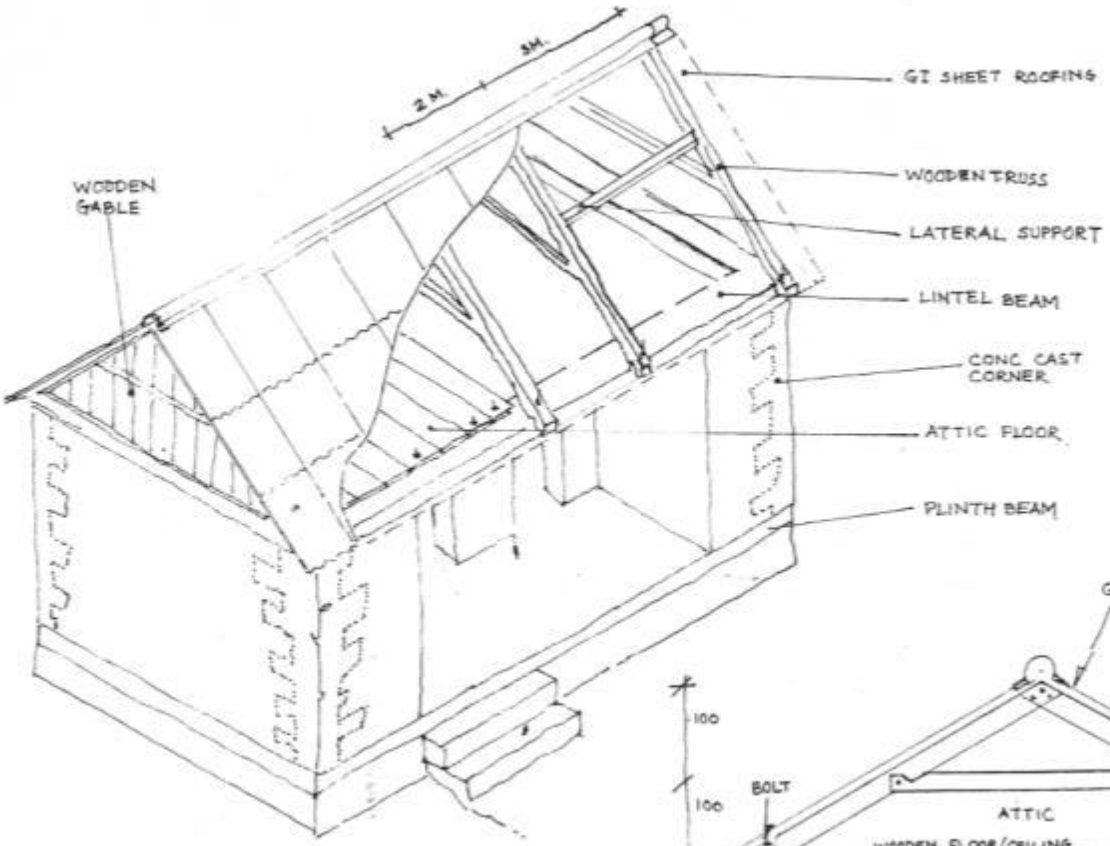
-PLAN is
- *Rectangle, with length width ratio less than 1:2.
- *Symmetrical for balanced loading on foundation
- *Only ground floor structure, in the present context with no danger to livestock from wild animals, it is proposed to convert old village into channis.

-No gable wall
-Fenestration area 15% for hygienic ventilation
- Doors and windows away from wall corners, thus not waking the corner joints of the wall.
-Separate room for cooking, opening inside, thus keeping the house warm and also not sooting the house.
-A symmetric room as "store" traditional "kothar" in its contemporary context.

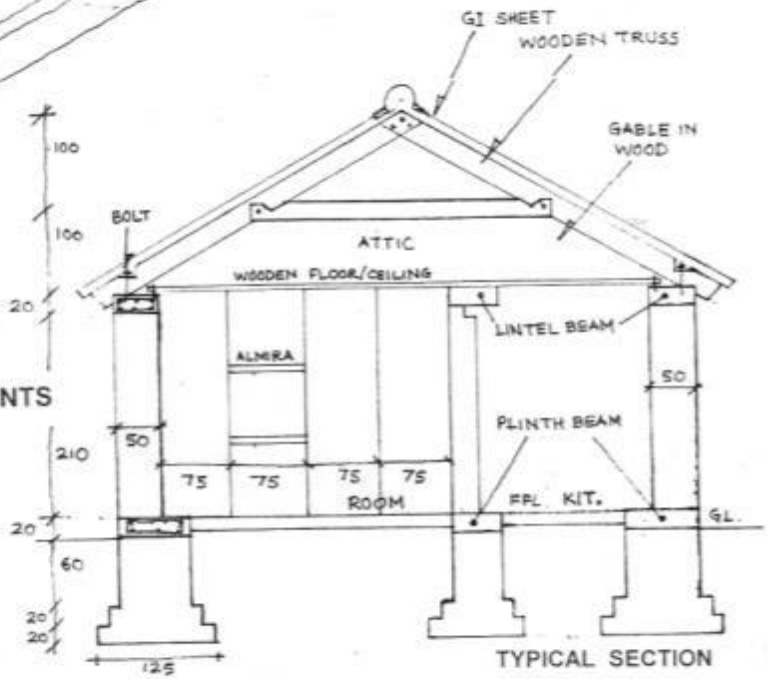



**THE "NEW VILLAGE" LAYOUT**

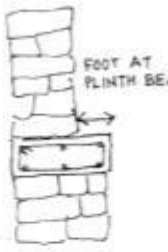
- Old village pedestrian tracks extended to design/link the fabrik of new village
- Enough space all around the new dwelling units in form of chowks:
*For sitouts
*Day today cores
*Possibility for additional rm
*Enough safety from adjoining structure
- Minimum cutting and filling of terraces for constructing new dwelling units and linking pedestrian spine. Thus not disturbing existing topography and drainage lines
- In case for construction of dwelling units on high terraces, retraining wall provided




NEW DWELLING UNIT DESIGN - IT'S COMPONENTS

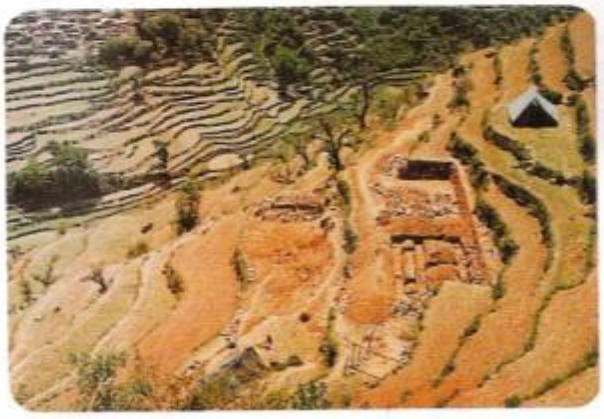


TYPICAL SECTION



Foundation


Human foot


Terrace cutting and excavation

## EXCAVATION

Excavation for foundation to be done leaving at least 1.0 mtr setback from the back terrace, to protect the back wall of the dwelling unit from a possible breaking loose of terrace during earthquake

The setback from the edge of the terrace (Refer drawing on left, marked "a") to be more then the depth of excavation (marked "b") to avoid dislodging of the terrace edges

The excavated earth and building material %r construction should not be dumped on the outer edge of the terrace, resulting in dislodging of the terrace edge.

However if above are not possible due to restriction of the width of the terrace and dwelling unit design, a retaining wall in stone masonary Be provided with weeping holes.

**FOUNDATION**

The Foundation is designed for a depth of 0.75m to 09m as the Height of the most of the terraces vary from 1.8mto2.0m

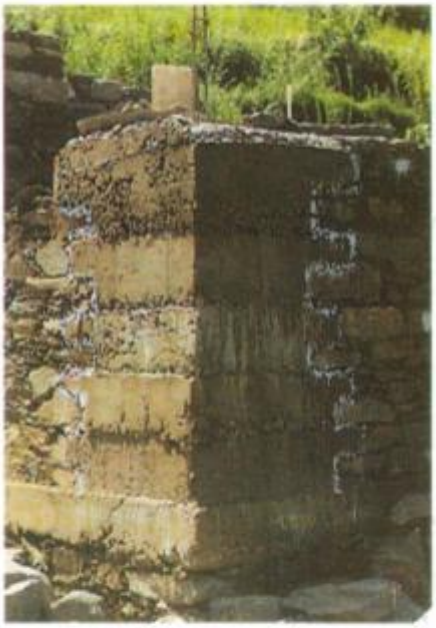
It is designed taking the form of a *Human Foot (*Ref. Drawing on left), in case of remote failure of the wall in persistent earthquake the wall will tend to falls only on the outside thus not hunting the people inside the house.

**PLINTH BEAM**

Is laid all over the foundation wail, tying up the superstructure avoiding any possibility of failure of walls due to unequal settlement of earth during earthquake.

2 Thru stone marked with white lime

3 Corner casin g in Cement Concrete



4 Toothed Sh aped Casting of Corner

STONE MASONARY WALL

The wall is a composite of Stone. Mud and Stone chips (Kattal), the wall is designed for 20 inch. Thickness considering the workability any size of the stone

--Quality of stone

The stone to be greyish blue in color, the darker stones are not porous and are more strong, thus good for construction.

--Through Stones

Longer thru stones are provided at an interval of 0 9m in alternate stone masonary courses, binding the wall

--Excavated Earth / Mud for Construction

The mud used for construction to be sieved clear of stones/pebbles/dry leaves grass. The water soil ratio to be tested for optimum saturation level defined as the quantity of water added to a specified volume of excavated and sieved earth such that the dry volume and the wet volume of the soil block remain same, thus the mud mortar with optimal water content for construction does not shrink after it dries and hence does not leave any air gaps in the masonary wall.

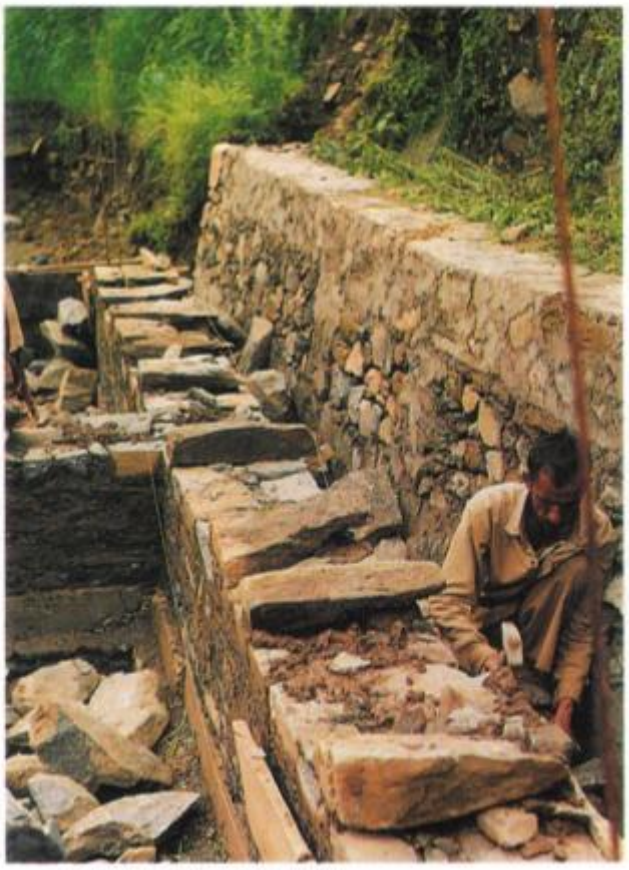
--Katta stone chips

Kattas/stone chips are used with mud mortar for balancing and placing largo stone pieces in a composite wall.

--Wall Corner and junctions

Engineering a cross structured wail corner or junction in stone masonary Wall is impossible as such a concrete cast corner is designed with 2no. 12 dia tor vertical bars for shear. The corners are casted simultaneously with each course of stone masonary, such that it makes toothed joint corner at the wall junction.

6 Construction of dwelling unit



1 Thru Stone for Stone Masonary wall

10 MS member bolted to Plinth beam To house wooden chaukats

9 Alcoves

**DOORS AND WINDOWS**

The doors and windows are provided at a distance of 0.6m or more from the wall corner or junction.

The door chaukhat in wood is firmly tied to plinth beam with ms frame and bolts at plinth level, and lintel beam, thus it does not lead to distortion of door chaukht during the earthquake jamming the doors.

**LINTEL BEAM**

The lintel beam is laid at lintel level with casted MS bolts to tie door and window chaukhat and wooden truss frame

**GABLE WALL**

The gable is made light weight with wooden planks or GI sheets fixed to the side of wooden truss frame thus leaving no possibility of failure in case of earthquake.

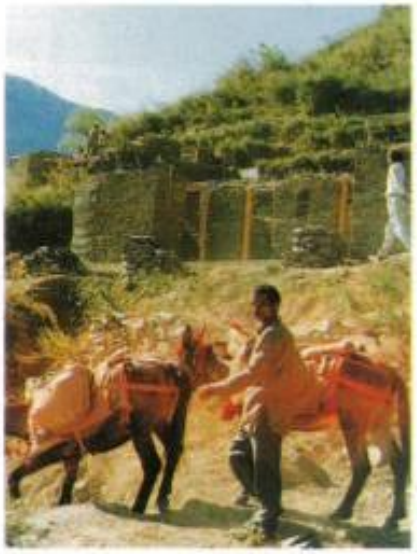
**ROOF**

The roof is designed with wooden truss, resting on long walls tied with bolts to the lintel beam, with corrugated GI sheets on top.

The roof being the most light weight and flexible component of the dwelling unit even a partial collapse of wall or crack will only distort the roof but will not lead to its collapse.

An attic is designed by providing wooden false floor at lintel level resting on the lintel beam for sound and thermal Insulation of the house, due to the GI nature of the roofing. The space in attic to the used for dead storage further increasing the insulation standards

7 Construction of dwelling unit



8 Construction: mules as means of Tnsr sporting stone

5 Construction of Dwelling unit

To understand the connectivity of all components of the dwelling unit design, the body of a passenger bus can be compared/quoted, which is rectangular in shape and travelling thru potholes on roads it shakes with flexibility, all members, floor, door, windows, roof snaking with flexibility damping the effect.

In a similar fashion for the new dwelling unit, the foundation is tied with plinth beam ------- the plinth beam is tied to wall corners thru concrete cast corners ------- which are in turn tied to lintel beam ------- supporting roof truss anchored in the lintel beam ------- the wall is sandwiched between plinth beam, lintel beam and cast corners ------- the wall is further tied up in itself by systematically laid thru stones

The components are interlinked and ties, with enough flexibility to damp the Earthquake shock.

# UTTARKASHI EARTHQUAKE RECONSTRUCTION PROGRAMME

This programme was executed in two villages, namely, Aungi and Gadhbhatyara. In the former, 53 housing units were constructed while in the latter, 18 - making for a total of 71 units. Of these, 11 were 3 room houses, 18 were 2 room ones and two were single room units. The sizes of the houses varied according to the number of families they had to accommodate. Being a mountainous region, transportation of construction material to the sites extremely difficult and time consuming. Much of this was done on mule back. With the completion of the houses, the rehabilitation phase also terminated. However, according to our policy of moving on to long-term development wherever possible on the conclusion of an emergency or rehabilitation programme, we our planning just such an effort in the area. The credibility that we have established among the people during the relief and rehabilitation phases will be put to good use.

During the rehabilitation phase itself, CASA organised training programmes for local masons. Four such programmes were conducted for 80 professionals masons from 4 blocks of Uttarkashi district. Training was provided in earthquake resistant construction techniques so that local residents could benefit in the long-run. These candidates were broken up into four separate groups of 20 each and were provided intense training for 4 days. At the end of the training the conclusion of the participants was that they had derived practical knowledge which they would put to use in their day-to-day work. The programme was also greatly appreciated by the district administration.

*Construction work in full swing at Uttarkashi. In the background are completed houses.*

# CHURCH'S AUXILLIARY FOR SOCIAL ACTION (CASA)

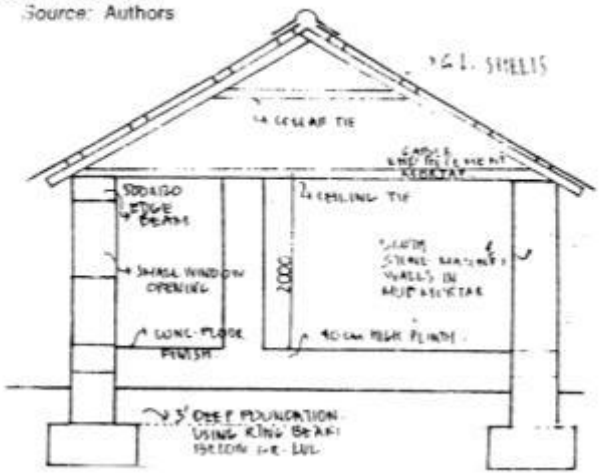
The village Aungi, located 19 kms from Uttarkashi in the upper reaches of Maneri, is reached by a steep climb of around 3 kms through a mountain trail starling from the Gangotri Uttarkashi highway. It is basically a pastoral village with agriculture done only to provide for the basic needs. The area receives abundant snow-tall during the late winter months of January and February.

The old village to a large extent was built in the true traditional style, as result that there were only 27 causalities resulting$_9$ from partial damage like a wall or roof collapse. Though we feel that retrofitting could easily have retrieved most of the losses, CASA after doing extensive surveys came to the conclusion that the village needs to be resettled. It has been observed on careful analysis that quite a few houses had faced damage due to rockslides which occurred after the earthquake Experts believe that the upper part of the hill has chances of crumbling further. This justifies the step taken by CASA.

**Design:**

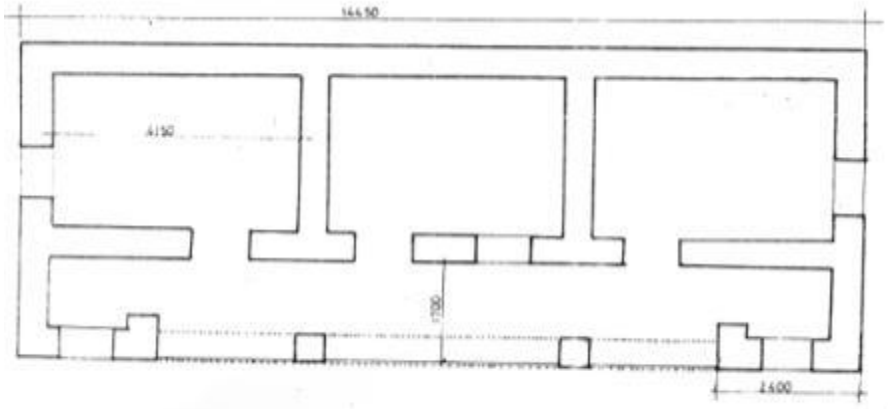
Owing to problems in rubble clearing, the entire village had to be relocated below the existing old village. Nineteen structures were built by the organization. Though the houses have been built in the fields of individuals, traditional planning has been retained to large extent both in terms of orientation and the spatial relationships. Houses in rows face narrow streets cut like terraces into the hill and a vertical spine connects the streets at various levels.

F49. Jnit section
Source: Authors



In terms of the plan as well as the choice of materials, these houses are the nearest to their traditional counterparts. Living rooms are arranged in a row, all entered from the verandah in the front. Apart from these, a kitchen and store has also been provided. Walls are made of stone laid in mud mortar with bands of concrete at various strategic levels. Heavy timber rafters support the CGI roof on top.

The only point where these houses make a departure from the traditional scheme is the number of storeys. All these structures are single storeyed and the animals are still housed in the old village.



F50. Unit plan
Source: Authors

**People's Opinion**
The people had very little to complain and were largely satisfied with the work done by CASA. The only thing that troubled them was that the sizes of their fields had got reduced.

**Organization's Opinion:**
Church's auxiliary for social action (CASA) has been working in the field of social work and disaster relief since 1947, The organisation is the social service arm of the Protestant Churches of India and is active in almost all the states working towards short and long term development measures. "The aim of the organisation is to provide relief to the poor and destitute".

Due to the inability to meet the chief monitoring officer of the organisation for Uttarkashi reconstruction, Mr. Nirmal Singh, in person, questionnaires were sent to CASA. The summary presented here is based on the answers received from him on behalf of the organisation.

**Management Aspects:**
Having gone through the list of affected villages, a survey was carried out by the relief team of the organisation. The allotment was obtained from the government after choosing the desired village. As a first step towards relief, immediate aid items like clothing, kitchen utensils, tarpaulins and Gl sheets were provided.

**Design Aspects**
On the design aspect he said that though the organisation has a relief cell which conducts research on disaster mitigation, but in case of Uttarkashi there was a specialised need to provide earthquake resistant houses, thus they had to collaborate with other NGO's namely TARU based in Deharadun and the University of Roorkee. These two groups did the designing and the implementation was done by CASA, The structure they designed was to perform as a complete house which also incorporated features for further expansion.

The house he said were put up on the land given to them by the villagers. He also added that the option of locating the structures rested with both parties. The organisation intervened at times when they had to look above the need of an individual, to see the betterment of the whole village. On being asked about the peoples' response to the reconstruction he said that most people were satisfied and the few who complained were not happy about the number of rooms provided.

## AUTHORS ANALYSIS

**Merits**:

- Traditional village planning has been retained to a large extent
- Traditional materials have been intelligently blended with modem techniques to bring about a sturdy, earthquake resistant structure without losing the identity of a traditional home.
- Plan sizes exactly confirm to those in the old houses and there were no complaints regarding spatial characteristics.
- Through most of the houses have been built in the fields of separate individuals, they have been located such that the entire settlement attains a degree of compactness
- The houses are oriented properly and the materials used provide adequate thermal comfort.

**Demerits**: None