Built Form & Changes in Traditional Building Practice

BUILT FORM & CHANGES IN TRADITIONAL BUILDING PRACTICE

The built form and dominant pattern of construction is fairly consistent over the region, with variations because of changes in altitude, local resources and lifestyles. Almost all the houses (except some framed structures in urban areas) are of bearing wall construction. The load from the roof of the house (usually very heavy) is transferred to the ground through the masonry (usually stone) walls.

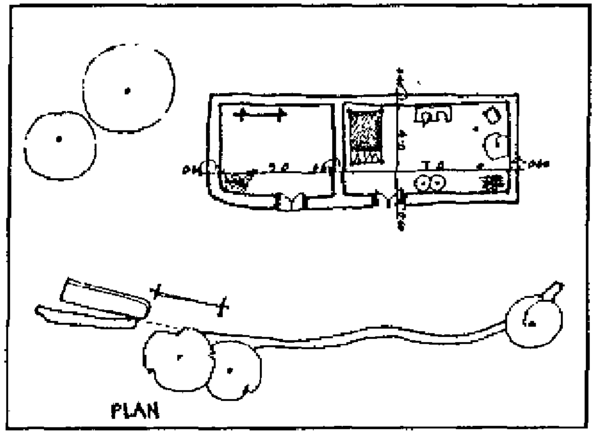


Fig. 3.i PLAN OF A TYPICAL SINGLE STOREY HOUSE IN GARHWAL

The traditional houses in the region are built using local materials: Slate, random Stone rubble, Earth and Timber. This has been because of the ease of availability and low cost of these materials and the relative inaccessibility of most of the villages. This has implied that the bulk of the *"imported"* materials like steel, cement and even stone aggregate have to be moved by mule or headloaded to building sites.

In addition, the bulk of the housing stock in rural areas are more than 20 years old. The typical building cycle is 60 to 80 years, which follows the customary grant of timber and the generation period.

A number of constraints have emerged over the last 20 years to the supply of traditional materials. First, slate mining has been drastically curtailed under government orders (though illegal mining continues). Second, the area has been extensively deforested and the timber access rights curtailed in practice (especially since the promulgation of new Forest laws). Third, the labor costs have risen dramatically, increasing the absolute costs of labor intensive construction techniques (but not the relative costs with respect to RCC).

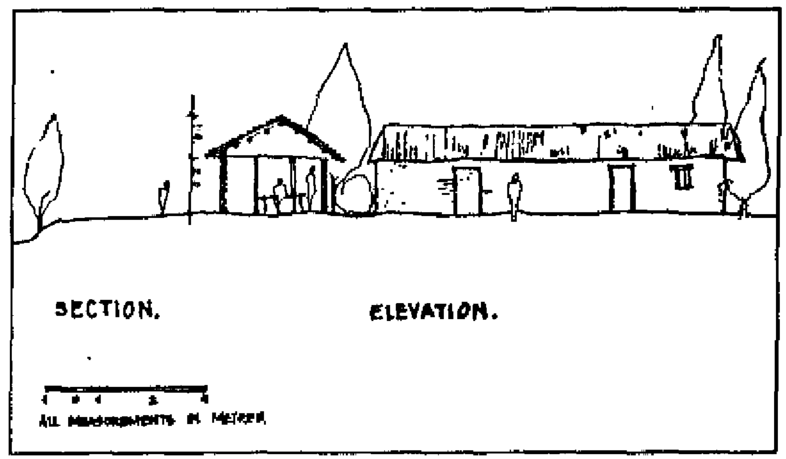


Fig 3.ii ELEVATION AND SECTION OF A TYPICAL SINGLE STOREY HOUSE IN GARHWAL

In addition, due to large scale projects in the area, pilfered building materials like cement are available at below the prevailing market price, which reduces the cost of such construction. The status associated with *"pucca"* buildings has also grown rapidly, especially as the relatively prosperous households in roadside villages along the roadside have slowly shifted into the use of RCC slab roofs on Stone walls.

Local masons and householders, in conversation earlier in the year, were very clear about the relative effectiveness of traditional houses in responding to the severe climatic stresses of the area. In addition they know how to repair and maintain slate roofs. They claimed that the layer of earth between the substructure and the slates provides good insulation, while RCC houses were *"freezing"* in winter as the roofs were thin and the floors very cold. This is especially significant, as a few households have furniture and most activities are performed on the floor. Slates are easily reusable and a market for recycled slates exists, especially among the poorer households.

Largely because of low quality materials and lack of knowledge of RCC technology, the quality of RCC roof construction was found to be bad. Stone aggregate and sand was found dirty, badly graded and aggregate often contained rounded stones. Water cement ratios were not maintained. Slabs are typically over-reinforced and supporting columns under-reinforced, with inadequate bar spacing. Cover is rarely maintained and tamping is inadequate leading to exposure of bars and voids in the concrete. The net result is that a large number of slabs leak and the reinforcement corrodes. The local solution is to use bitumen tar to fill the cracks.

The perception of local people has changed after the earthquake. They are unhappy with two storey buildings, because most of their cattle, penned in the lower floor have died. Traditional stone walled houses have been severely damaged in the earthquake but local people found that the slate roofs often collapsed in segments, allowing people to escape relatively easier than when they were pinned under an RCC slab. Houses with RCC roofs or column-slab-infill construction have also suffered severe damage. The series of aftershocks, have made the survivors afraid, in many locations, of entering these buildings.

CGI sheets have been distributed by the government and NGOs working in the area. The felt need at the moment is for facilitating the use of these sheets in the temporary shelters that the villagers have erected, such shelters would be used by them as complete reconstruction activities would start only after the risk. It is important that people be also assisted in evaluating their current settlement site (or alternate sites) for risks of future earthquakes and landslides/rockslides.

SETTLEMENT LAYOUT,SPACE USE & UNIT AREA

The settlement layout in this region is usually along the contours of the hillside result in a linear pattern of houses. The orientation of most houses is in an East-West or South-East/North-West direction to ensure that light and heat enter the verandah and the front court. The houses are clustered together to avoid the wind. The rear face of the house is either built into or shielded by the hill slope for additional insulation and cost. The houses are built to get large usable area in the front, where most of the daily activities are performed. The houses face the field so that a check can be kept on the crops.

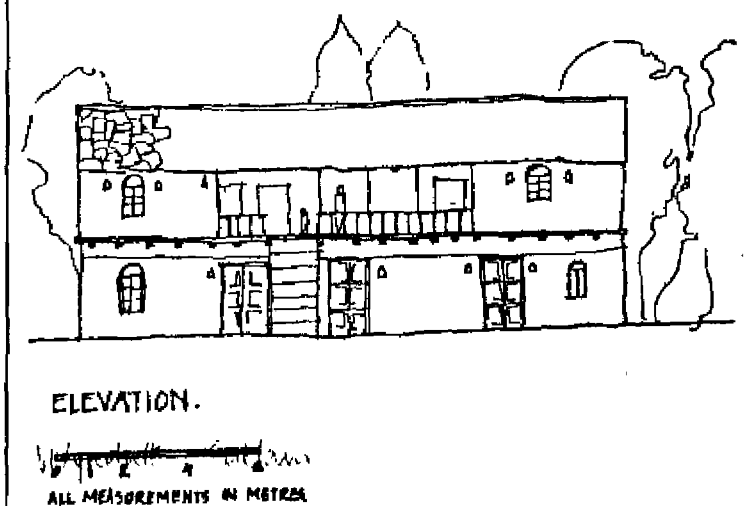


Fig 3.iii **ELEVATION OF A TYPICAL TWO STOREY HOUSE IN GARHWAL**

The well-off families in the area have two houses: the "*chaan*" or summer house with a thatch roof, which is in the (higher elevation) forested area, which the family moves to in the summer and the village or winter house, which is the permanent residence. The lower income and caste households usually have a single storeyed house in the village.

The two-storey village houses have a with place for animals, fodder and storage on the ground floor. The upper floor has 2 to 3 multipurpose rooms, a kitchen and a verandah. An attic under the pitched roof is used for storage. The placement of the living areas between two insulated zones, ensures thermal comfort in the living areas. The kitchen and verandah are the two most commonly used covered areas. Most of the daytime activities spill out into the court while the rooms are only used at night for sleeping. The kitchen area is often used for sleeping where the soot layer keeps the insects away. Very little furniture is used and most activities are done on the floor. Houses have a number of niches, shelves and built-in cupboards for storage. All rooms of the house are lockable and openings are small and barred for security. Privacy is an important consideration, especially for women.

The main entry into the house is through an open court with a low boundary wall defining the plot boundary. The transitional areas include platforms in the courtyards, steps and the threshold. These are not only for arrival and departure but are used for the spill-
over of house activities into the court. Washing of vessels and cutting of vegetables is done in the court. The verandah is supported by pillars and often has a portion that is screened with a railing, providing for both privacy and participation.

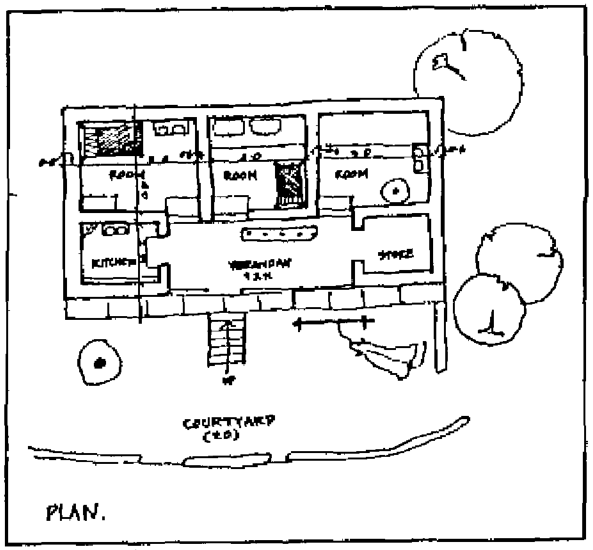


Fig 3.iv **PLAN OF A TYPICAL TWO STOREY HOUSE IN GARHWAL**

A survey of a few households in Tehri Gadhwal, was conducted as part of a larger project to prepare an action plan for rural housing in the country. This was undertaken in 1990 and 1991, well before the earthquake, but reflects some of the broad trends of lifestyle and housing practice in the area. A broad indication of space use is presented in Table (5). This is only indicative, a considerable variations exist in this area.

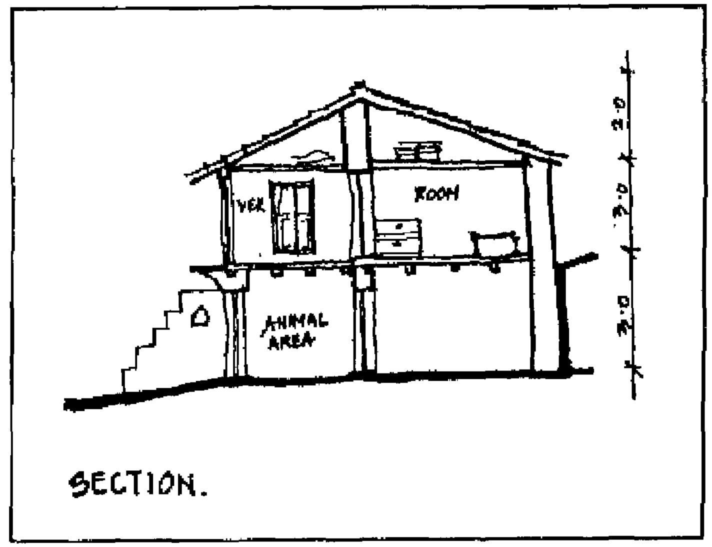


Fig 3.v **SECTION OF A TYPICAL TWO STOREY HOUSE IN GARHWAL**

The upper range of plot area was observed to have a similar range for both one storey (lower income) and two storey households as presented in Table (3.1). There is considerable difference at the lower end from 60 sq.m. for one-storey houses to 100 sq.m. for two-storey houses. The covered area of two storey houses (180 to 220 sq.m.) was found to be more than twice that of one-storey buildings (55 to 100 sq.m.).

Apart from the obvious difference of the number of floors, the lower caste and income families have one storey buildings. The living area in low income houses was slightly higher in fraction (60%) in comparison with two storey houses (50%). This was also because the lower income families had little or no cattle. A verandah on the first floor is an essential feature of a "*affluent*" Garhwali house and uses upto 25% of the living area. Most single storey houses did not have a verandah. The kitchen sizes in low-income houses were lower than others, but occupied a larger portion of the living area (15% vs. 10%). Cattle are an essential part of a Garhwali household and an important investment, hence the shock in the area at the large-scale death of cattle trapped under the collapsing houses. The area utilised for cattle, fodder and storage of agricultural produce and implements range from 35% of the covered area.

Table (3.1): SPACE UTILISATION IN SURVEYED BUILDINGS IN TEHRI GARHWAL(sq.m.)

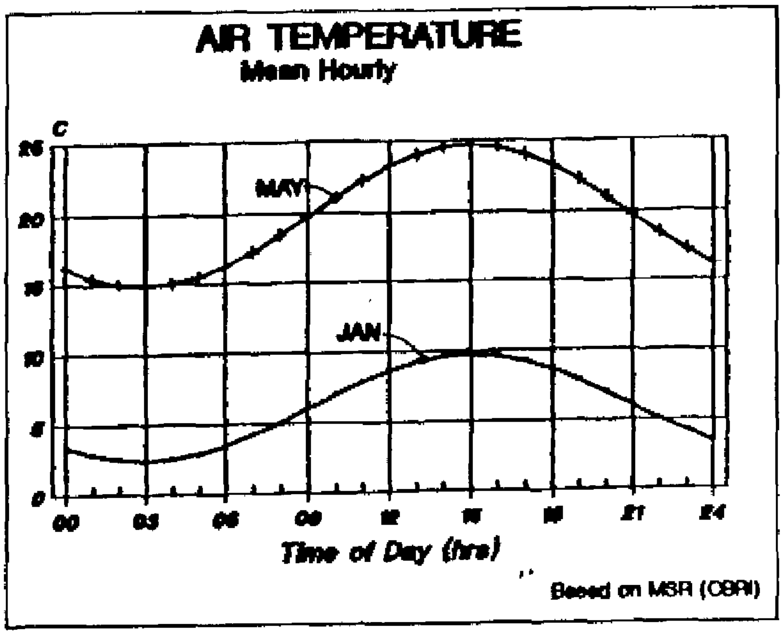
SPACE TYPE	1 Storey building	2 Storey building
Plot area	60 to 190	150 to 225
Covered area	55 to 100	180 to 220
Living area	35 to 60	80 to 110
Verandah	None	25 to 30 (25% of living area)
Kitchen	7 to 12 (20% of living area)	10 to 15 (10% of living area)
Animal area	20 to 60	80 to 110

Source: BMTPC, Technology Action Plan for Rural Housing

A traditional house is usually built in 7 to 8 months by specialised artisans who are paid in a mixture of cash and local produce. Family members usually participate in the construction effort along with men of the village.

CLIMATE AND BUILDING DESIGN IN GARHWAL

The climate of the Garhwal region is cold and humid. While actual climatic data is not available, the climate can be broadly derived from the climate of Mussorie and Mukteshwar (Table 3.2) with the solar radiation interpreted from first principles using latitude and estimated cloud cover. Likewise, hourly readings can be estimated by interpolation between the minima and maxima, the sinusoidal interpolation being as good (or as bad) as can be implemented in the absence of primary data. This provides a rough and ready guide to the climate and is given in two charts below. The wind speed and direction shall vary from site to site and is extremely unreliable. It can be seen from this data that the temperatures generally remain just above zero in the winter, but in the upper reaches the temperatures may definitely drop to about -5 °C. The values plotted are mean monthly values, and extreme values shall be definitely lower. It can also be seen that the highest summer temperatures are below 25 °C, and this means that there should be no heating discomfort. The humidity and wind speeds are generally high. Annual precipitation is high. Global radiation on the horizontal surface is around 1 kW/m².



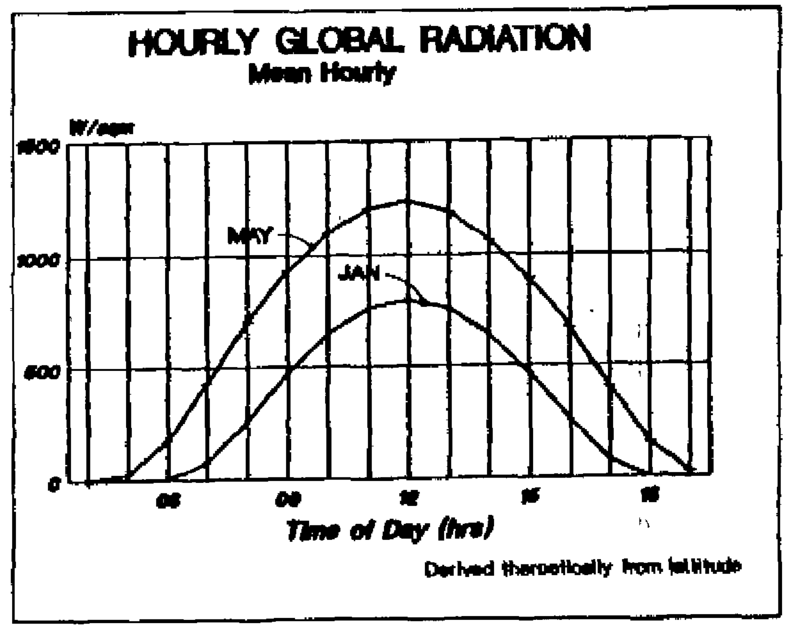
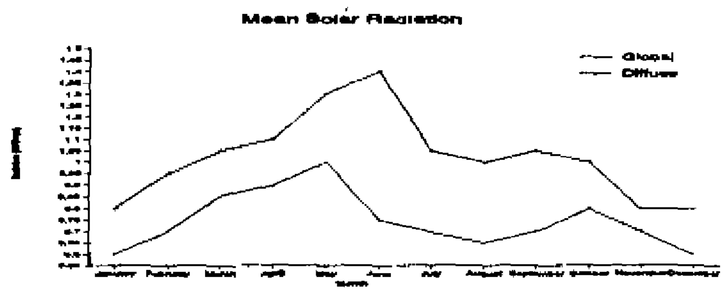
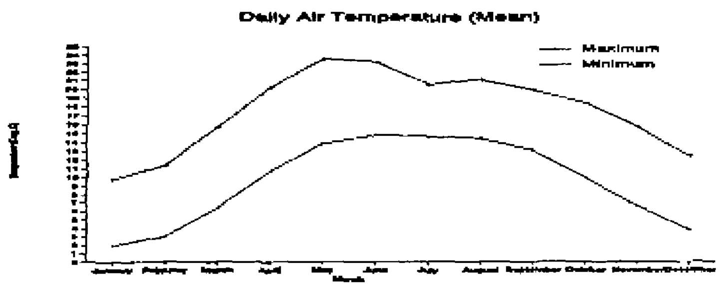
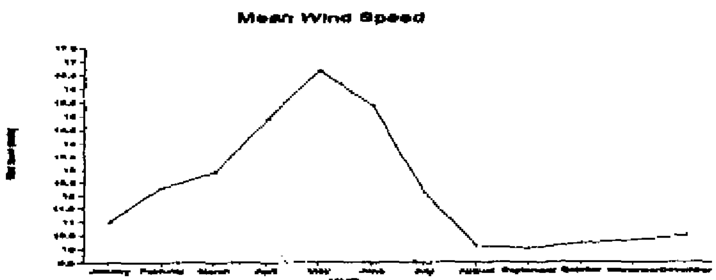


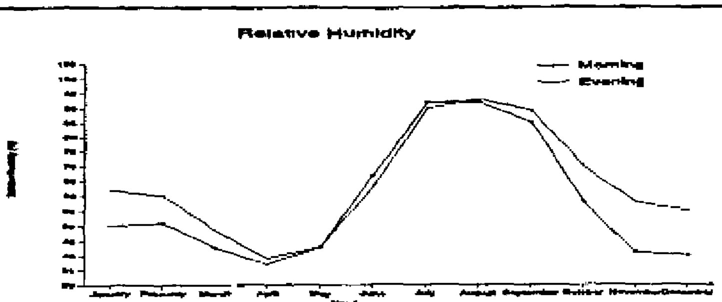
Table (3.2) CLIMATIC DATA OF STATIONS ADJOINING THE GARHWALREGION

MUKTESWAR

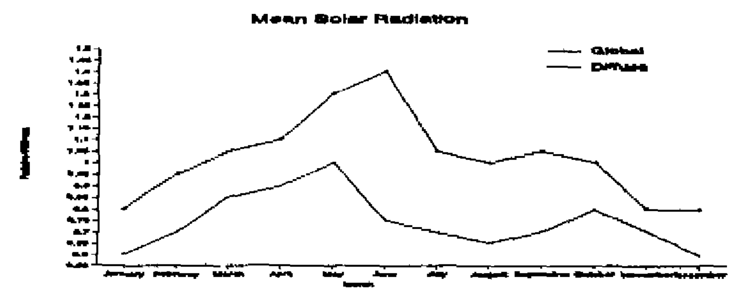


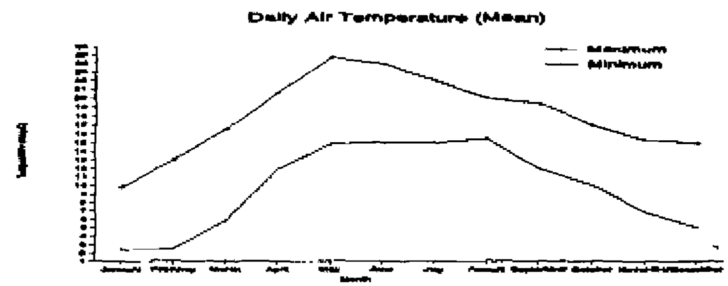


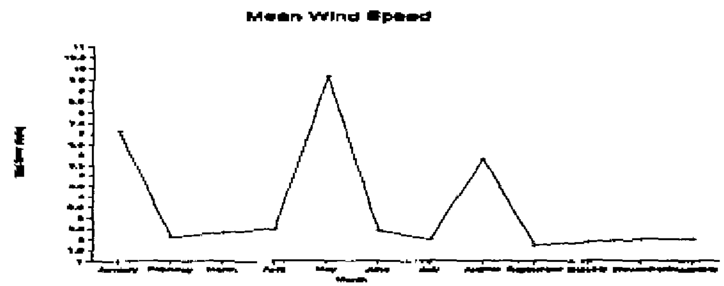


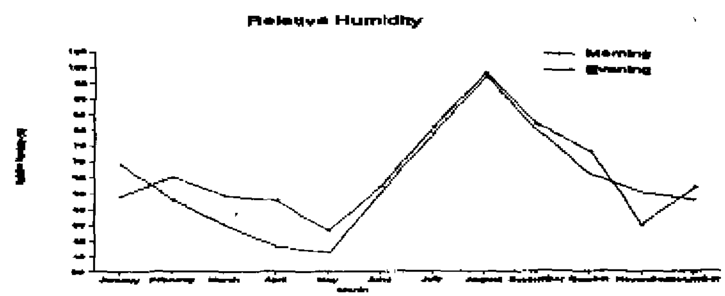


MUSSORIE









Source :CBRI, Climatic and Solar Data for India

Permanent buildings that are currently being built in Garhwal fall into three categories:

- o Heavy weight, with walls made of earth, stone, bricks and roofs of slate and earth, RCC
- o Light weight, with walls made of timber, steel sheets and roofs of timber, steel sheets, or bhusa and
- o Hybrid, with a heavy weight lower storey and light weight upper storey.

In principle, the five areas that will affect thermal performance of buildings in the region are:

Increasing external heat gain

Increasing external heat gain is best accomplished by capturing the sun through glass. However, a southward orientation is necessary to accomplish this gain. South facing verandahs could be glazed over if possible to make excellent sun spaces. In certain instances, south facing walls of bedrooms can also be coloured black and glazed over, this will perform as a modified trombe wall and provide heat well into the night (though traditional bedrooms were not in the south, this has changed Ladakh with the increased use of glass). Wherever possible, south windows and sky light are desirable, especially if they can also have an internal blind, or heavy curtain. On a sunny day, very high heating potential exists with the use of glass and or mass walls.

Increasing internal heat gain

Internal heat gain can be maximised by continuing the practice of keeping animals within the house and keeping the kitchen in a location where it is surrounded by other habitable rooms. Compact overall planning is also a great advantage in this case.

Reducing infiltration losses

Infiltration losses can be reduced considerably by the provision of an air-lock entry to buildings wherever possible. For example, entry could be effected through a glazed verandah. In addition, all joints should be well made and weather stripped using timber, mud, bhusa, plastic, or rubber. This feature alone could raise internal temperatures by 3°C or more at night.

Reducing fluctuations of temperature by providing mass

Permanent buildings in the region were generally massive, and this helps reduce fluctuations of internal temperature. But in order to make them more earthquake resistant some people will build light-weight or hybrid buildings. In such cases, it is important to try and provide some internal mass (such as one or two thick cross walls). If not possible, then such lightweight rooms should ideally be reserved for day use. If this too is not possible, insulation shall be necessary for thermal comfort as described below.

Reducing heat losses by insulation

While it is desirable to use insulation in the form of quilts, cavities, thermocole, woodwool, rockwool, glass wool, etc. on all buildings, it is highly recommended for new light-weight constructions. If possible, all buildings could be given some degree of earth berming, sheltering, or cover. The only exception where permanent insulation is not desirable are blackened or glazed south walls. To summarise, the features desirable in permanent buildings in Garhwal are:

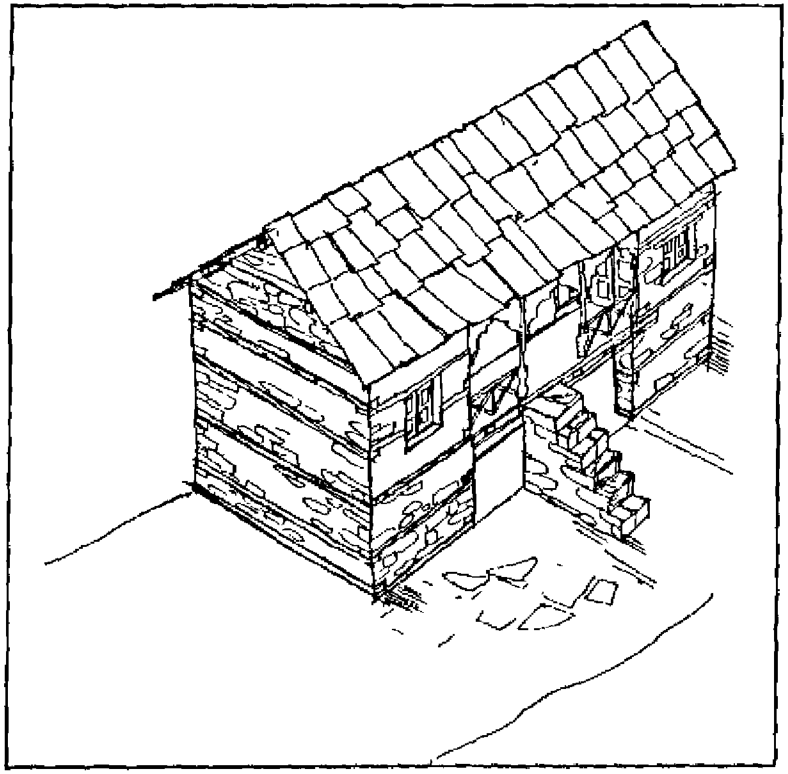
For heavy weight houses or heavy-weight parts of hybrid houses:

1. Reduce infiltration loss (most important)
2. Increase solar heat gain (important, and will result in direct fuel savings)
3. Increase internal heat gain (as far as possible)
4. Provide insulation on walls other than South and on roofs (as much as possible)

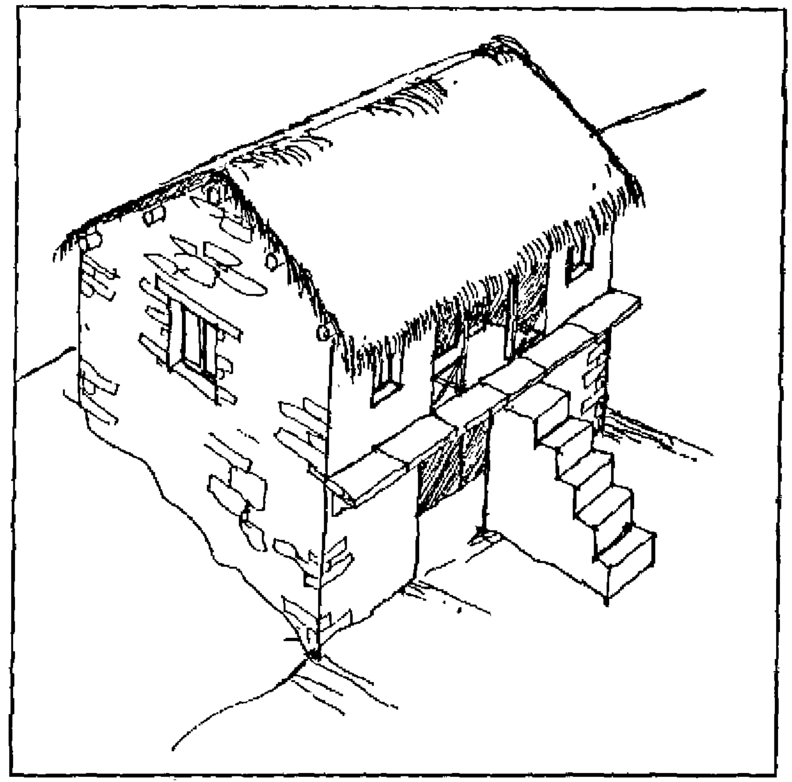
For light-weight houses or light-weight parts of hybrid houses:

1. Increase internal heat gain (essential at night)
2. Provide insulation (essential)
3. Increase solar heat gain (necessary)
4. Reduce infiltration loss (important)
5. Provide thermal mass (if possible).

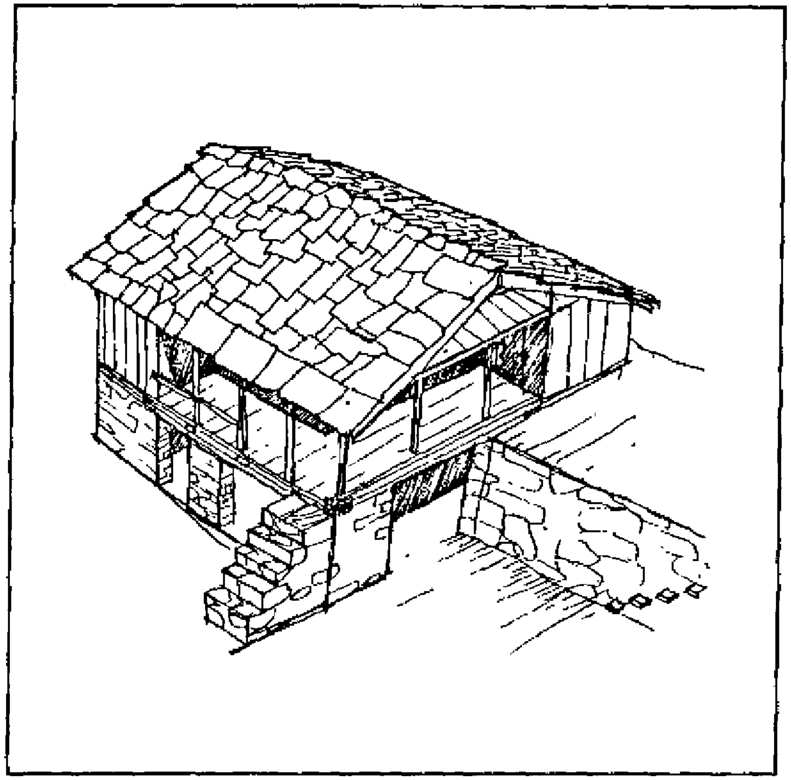
PREDOMINANT HOUSE TYPES IN THE REGION



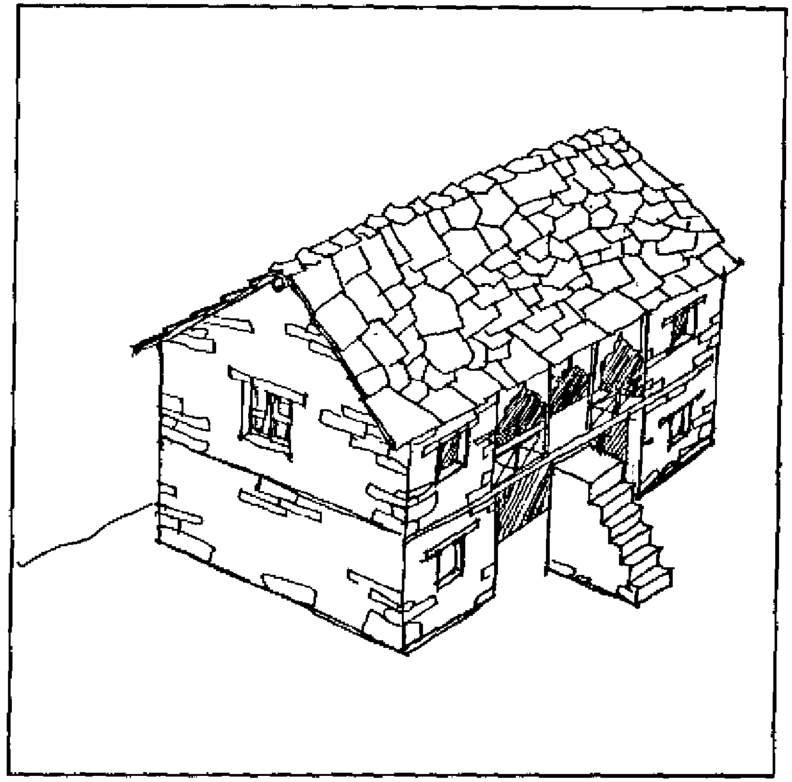
A traditional two-storeyed house in the upper elevations with a Timber plank roof on walls of Stone (random rubble in mud-mortar or dry-stone) masonry. The walls are reinforced in the horizontal and sometimes vertical direction by timber bands. These bands and the light roof mass have resulted in a low level of damage to these houses. The openings are small and well framed and the verandah on the upper floor brings the afternoon sun into this house.



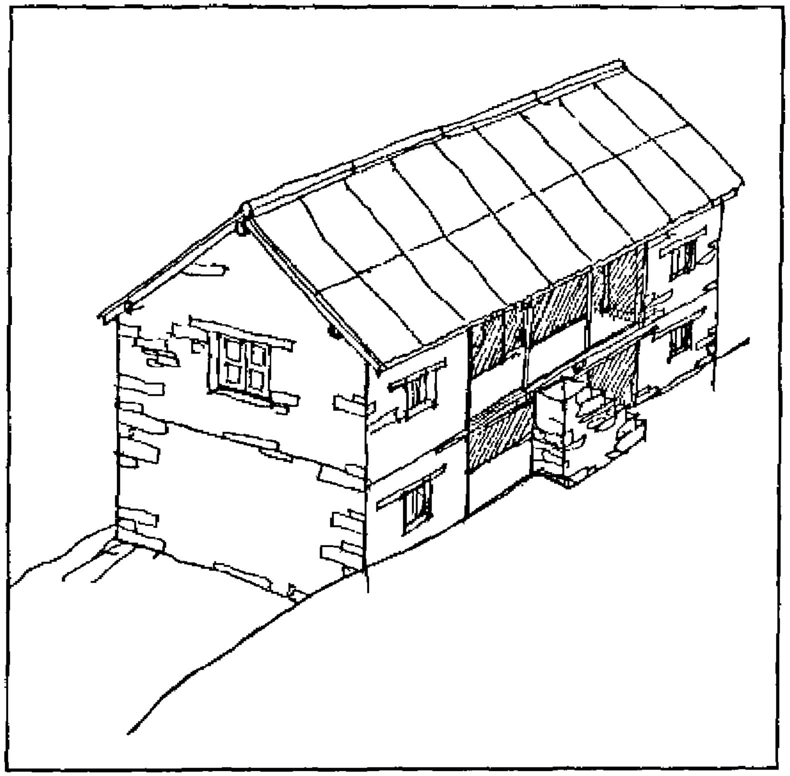
A traditional house belonging to a poor family with a Thatch and timber plank roof on Stone masonry walls in mud mortar. The cattle are penned in rooms on the lower floor. Their body heat, warms the rooms on the upper floor through the timber intermediate floor. The damage in such houses was limited because of the comparatively low mass of the roof but corner cracking and wall failures were fairly common.



One form of the traditional Slate roofed house with the upper floor clad in timber planks. The lower storey walls are in random rubble Stone masonry. The verandah extends around the corner of the building to take advantage of the sun. The cattle and agricultural produce are stored on the ground floor below the timber intermediate floor. These buildings have suffered damage to masonry leading to partial or complete collapse of the roof.

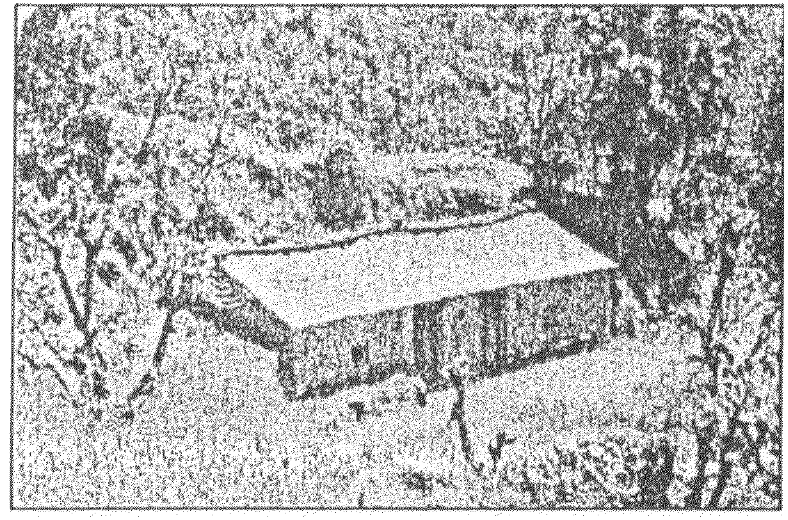


The most common form of traditional house with a Slate cladding on timber plank and beam roof with random rubble stone walls (most after in mud mortar). The intermediate floor is in timber. The upper floor has a verandah which usually faces South. The openings are small and centrally placed. These buildings were extensively damged in the earthquake because of their heavy roof load, lack of roof trusses, wall plate and failure of masonry: corner, gable and long walls.

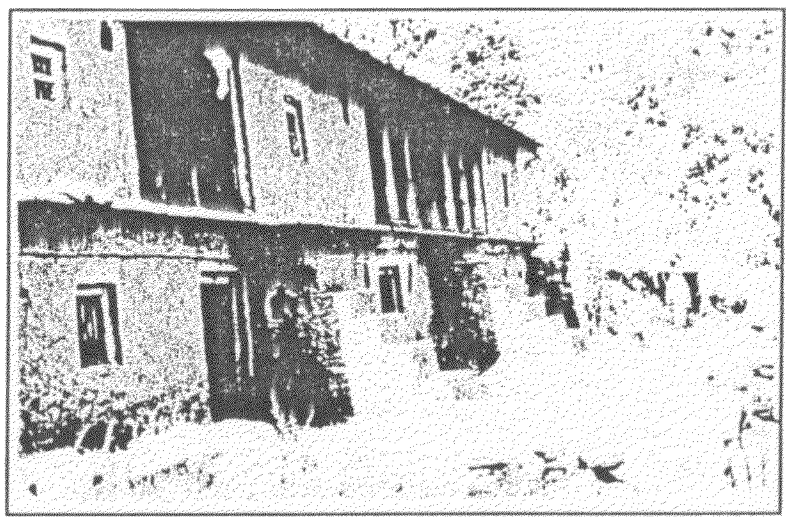


A corrugated galvanised iron (CGI) sheet house of two storeys. The walls are usually built in random rubble Stone masonry in mud or occassionally cement mortar. The roof load is light but a number of these houses have been damged because of masonry wall failure. This is the preferred house of the future, for a large section of the population, if only they could afford it. The release of CGI sheets as part of the relief package will tilt the balance in the favour of its use as a major roof cladding material.

A typical single storey South facing rural house of the region. The foundation and walls are in large random rubble in mud mortar (45 cm. thick). the house has two rooms of approximately (5 m. x 3.3 m.): one for the cattle and the other for the family. Each is accessed by a wooden door and has a small barred window for ventilation. The roof is constructed of uncut slate stones placed on a layer of earth on timber planks and unsawn timber rafters. The walls are plastered with earth and coloured with "*geru*"and whitewash. The rear and side-walls of the house abut the hillside.



A SINGLE-STOREYED HOUSE WITH SLATE ROOF AND STONE RANDOM RUBBLE WALLS



TRADITIONALTWO-STOREYEDHOUSE WITH SLATE ROOF AND STONE RANDOM RUBBLE MASONRY

A traditional two storeyed house, with rooms on the ground floor for cattle, fodder and storage. The wall are of Stone random rubble in mud mortar, the intermediate floor is in "*chir*"timber and the roof is built in Timber and Slate. Note the roof overhang (more at higher elevations), small openings and the verandah on the upper floor. This house is over 90 years old.