

IV

TECHNOLOGY

Technology

Introduction:

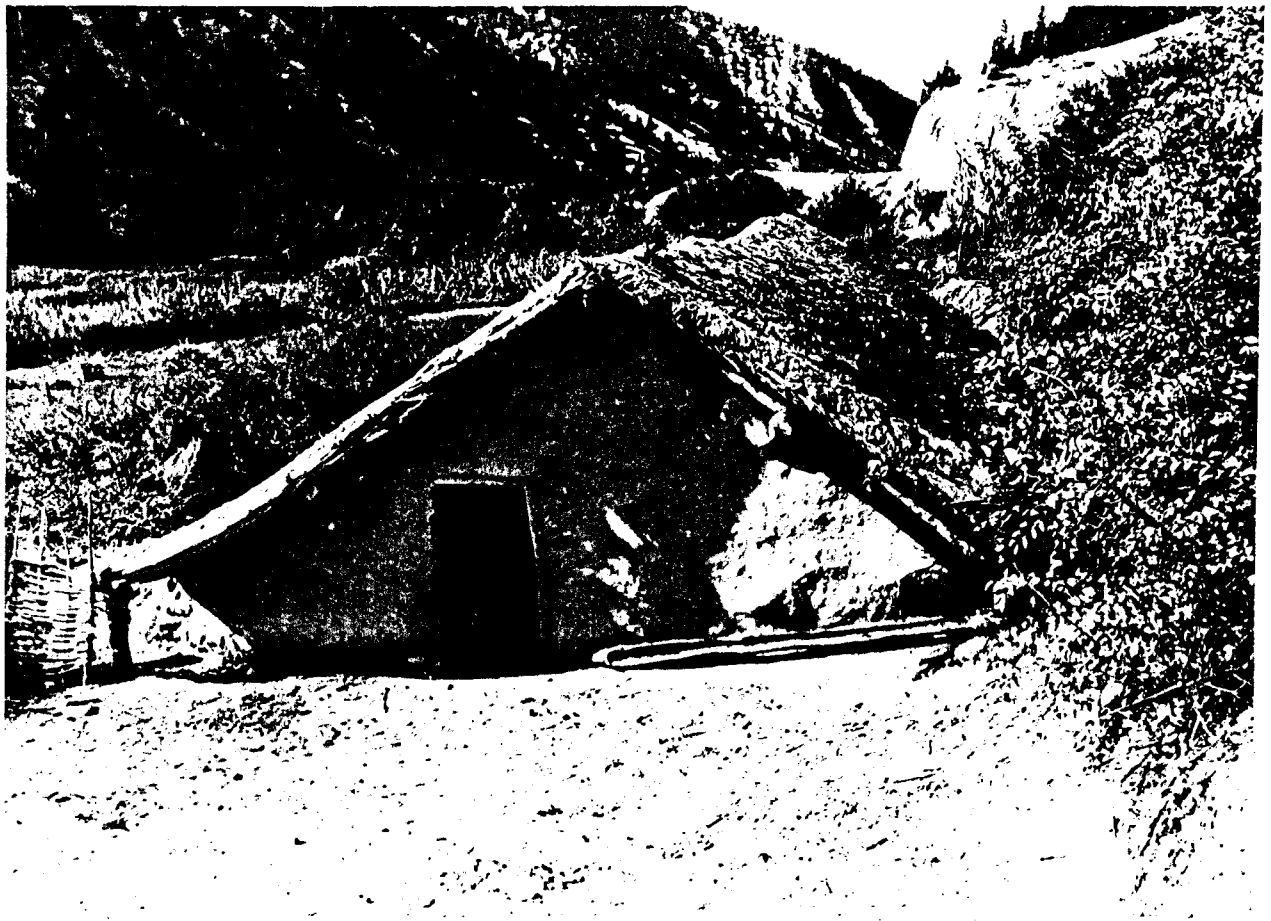
The particular topographical, environmental, and socio-cultural conditions of the Caspian Region have produced a range of building techniques unlike those found in the rest of Iran. The area is also noted for its high quality building.

The high rainfall demands that in most regions pitched roofs must be used, but this is also made possible by the large supplies of timber that have been available for building. Thus timber building technology and craftsmanship have reached a high degree of excellence in the area. On the other hand, some materials in common use elsewhere in Iran are less suitable here because of the climate: the problems of producing and maintaining moulded mud brick in an area with high rainfall and humidity limit its use. The system of steel beams and brick jack arches, common throughout Iran, is not suitable in the damp climate because of rusting. Proximity to the sea also causes deterioration to some materials through increased corrosion and damage from salts. Techniques have been modified to meet the specific needs of an area, as in the region west of Kojur. Here the normally flat, timber and mud roof, which is typical of the drier central and southern Alborz, is built as a double pitch roof at 25° as a response to a slightly higher rainfall. A pitched mud roof is extremely unusual, but has been noted also in Afghanistan.

Temperatures are not extreme in the Caspian Region. Therefore the need for insulation from severe heat or cold is less compared with, for example, the central plateau of Iran, where thick walls are important to moderate the harsh effects of the climate. In the coastal areas especially, thin walls are sufficient and the use of locally grown materials are suitable for this purpose.



Mud roofs, normally flat, are built with a pitch in this village, west of Kojur.



Broadly speaking, the coastal areas have houses with light weight frame construction, such as timber lath with mud packing, branches woven between vertical posts, or reed walls. In general, the mountain areas have houses with loadbearing walls, made of materials such as log, stone, mud brick, or packed mud (chineh). There is a transition area between the two which roughly coincides with the foothill areas, as in Astara and Behshahr districts where fired brick walls are used.

Regional variations in construction are most clearly reflected in the roof types of the Caspian Region, showing changes in climate and available materials. The available materials are in many cases closely linked to the occupation of the house owner, such as a rice cultivator producing his own thatch for roofing. The roof is perhaps the most important part of the house construction. Its upkeep and maintenance are essential to ensure the good condition of the walls and spaces below. On the plains of Gilan roofs usually have a low overhang on the north and west sides of the building to protect the more vulnerable walls from rain and snow.

There are three main indigenous roof coverings in the Caspian: shingles, thatch, and two types of clay tile. Flat roofs are also used in the drier areas (e.g. Kojur) along with Masouleh. Even within the use of one particular material such as thatch, the pitched angle of the roof varies according to changes in local climatic conditions.

Changes in the availability of materials (for example, the shortage of logs for walling due to restrictions by the Forestry Department and in some areas due to depletion of forests) have recently altered some of the methods of house building. Throughout the coastal region concrete block is becoming fashionable as a walling material. Sheet metal roofing is even more widespread and is replacing other roof

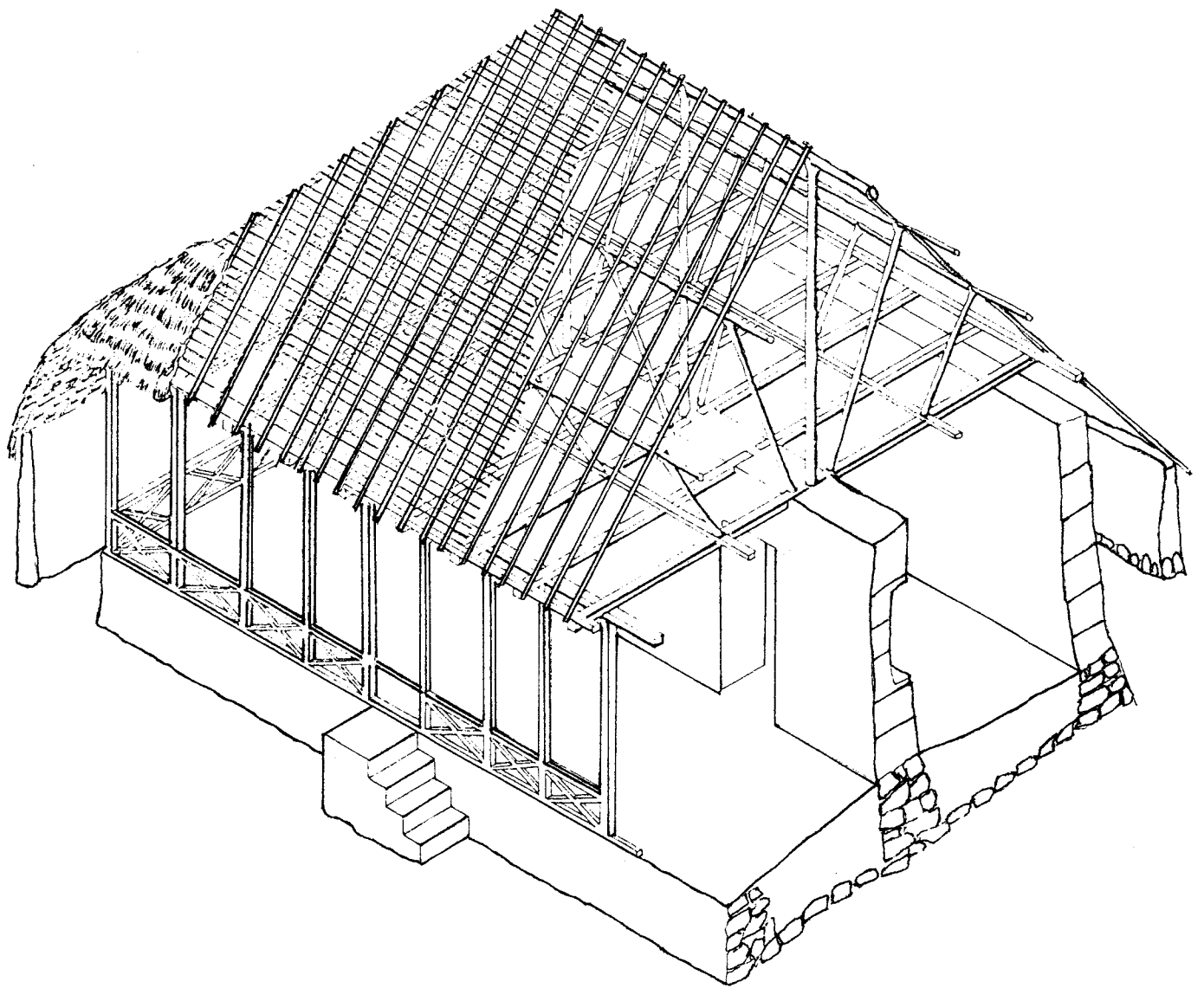
covering techniques in nearly all areas except for the Astara region. Both these materials have become popular because they are believed to be long lasting, maintenance free and prestigious. However, these materials have some disadvantages as well.

The benefits and disadvantages of each material are not always obvious. Thatching is usually a family or community cooperative effort, paid for in kind - lunch is provided by the house owner on each day worked and there is the knowledge that assistance will in turn be needed by others in the community. Sheet metal roofing is done by a specialist (halabzan) and must be paid for in cash. The economic capabilities of the house owner may not allow him to meet a heavy expense at one time. The thermal insulation of thatch or tile roofs is valuable in permitting the roof space to be used for food storage. This can not be done with sheet metal roofs, which transmit extremes of temperature to the interior.

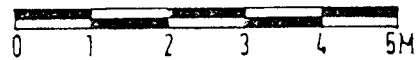
The indigenous building methods of the Caspian Region are in close harmony with the environmental and socioeconomic conditions of the area and any replacement materials or technologies should retain this relationship. Dr. M. Sotudeh in his book "From Astara to Astarabad", expresses his apprehension about the changes taking place in building technologies of the Caspian in the following quote:

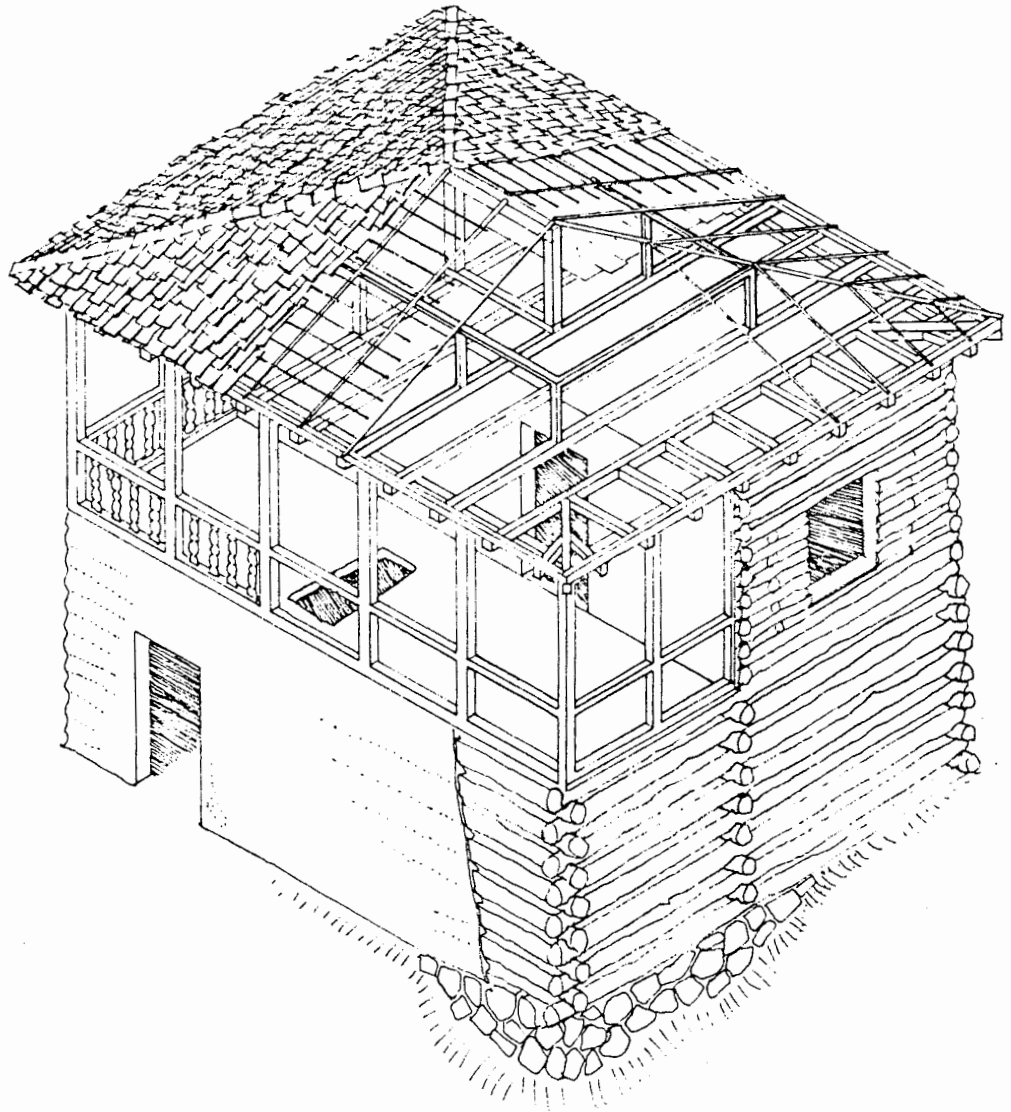
"Experienced builders used the readily available building materials of their time such as stone, brick, gypsum and lime (and timber) to create aesthetically appealing and durable buildings...In recent years reconstruction has come into vogue, so mosques and stable historic buildings are demolished and in their place buildings are constructed with concrete blocks and metal that display no delicacy or art, and the passage of time will show that they are not as durable."*

* M.Sotudeh, op.cit., pp.32-33.

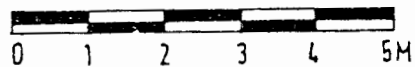


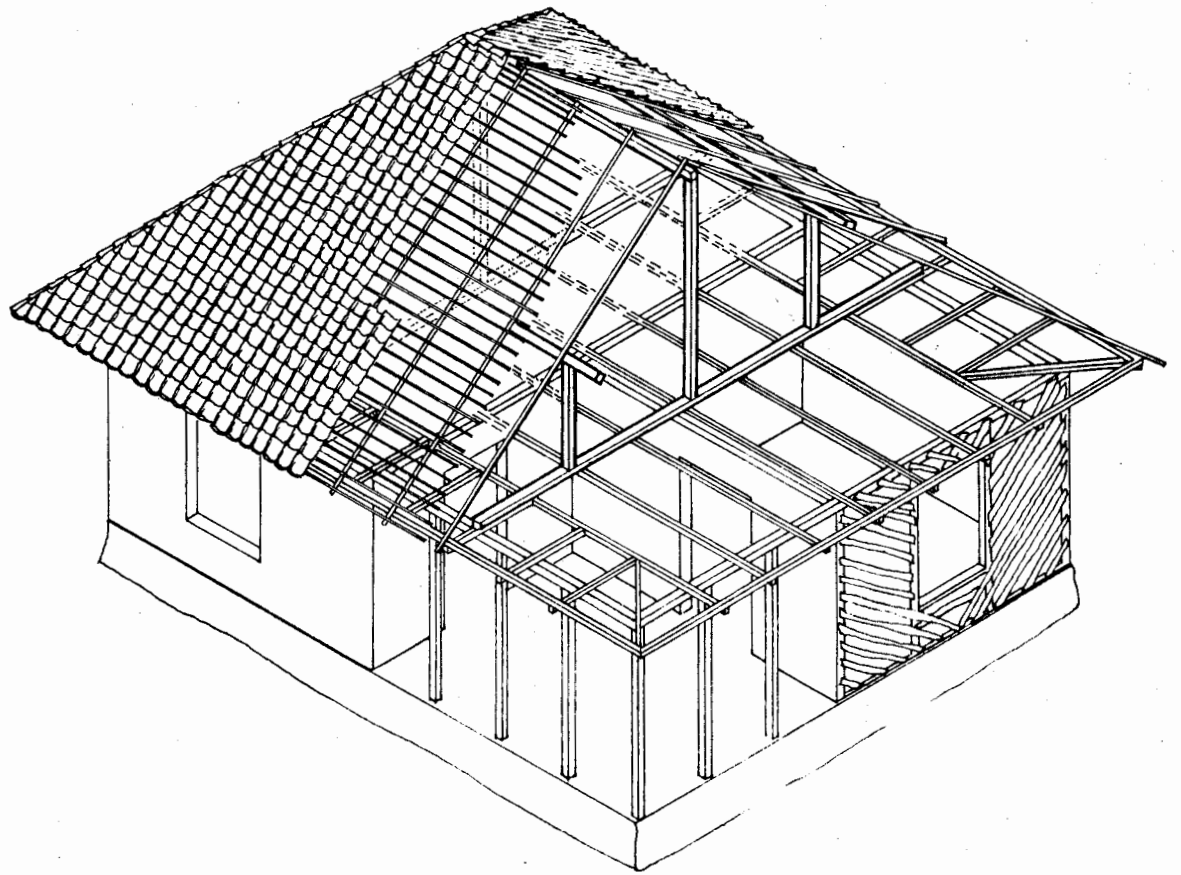
TIMBER TRUSS ROOF WITH RICE THATCH; CHINESE WALLS
Surveyed in Dogoor, Gilan.



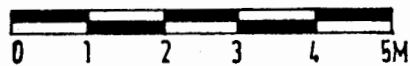


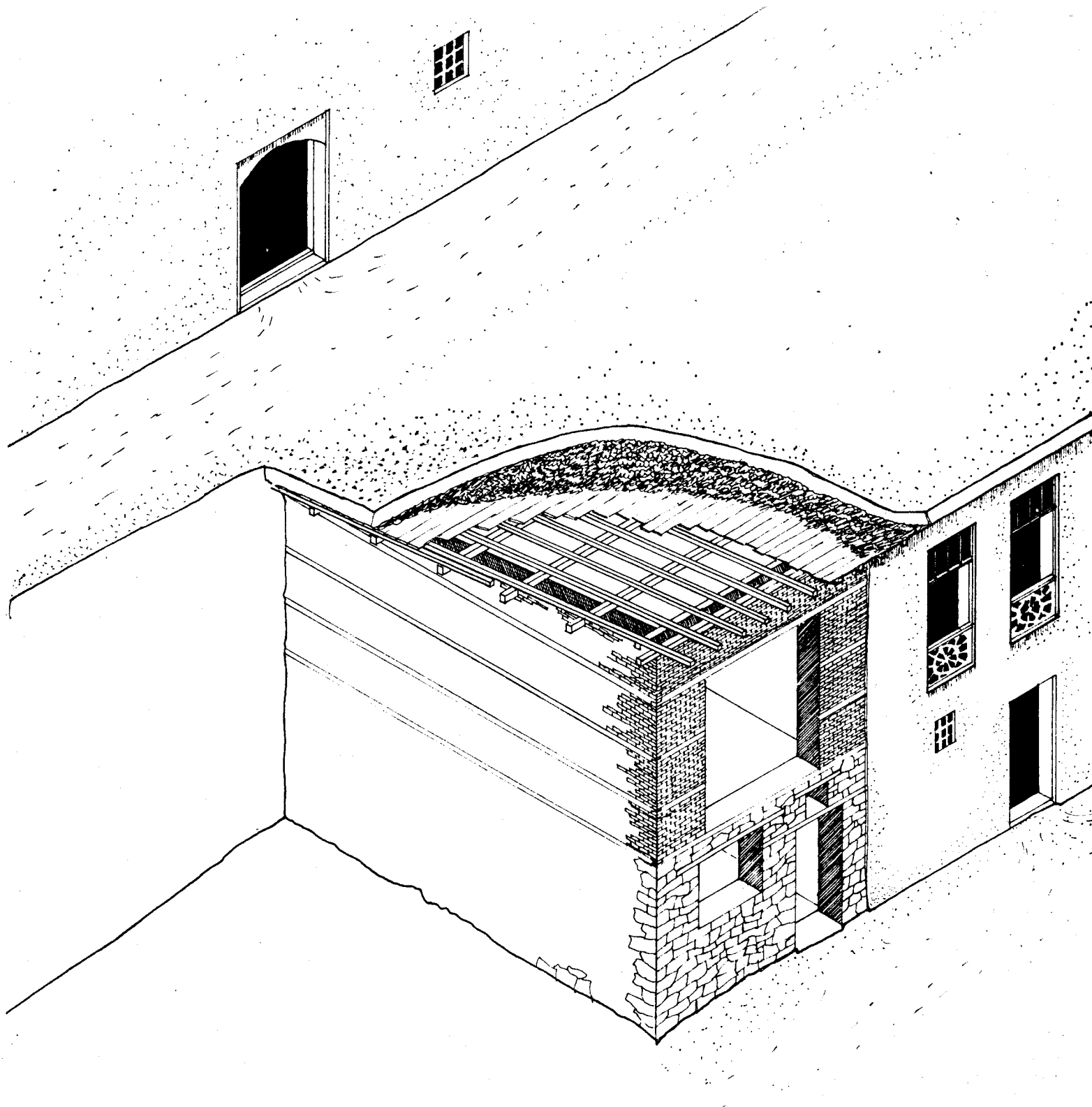
TIMBER TRUSS ROOF WITH SHINGLE COVERING;
INTERLOCKING LOG WALLS
Surveyed in Kodir, Mazandaran



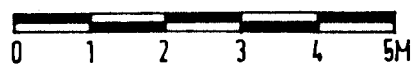


TIMBER TRUSS ROOF WITH ASTARA TILES;
TIMBER LATH AND MUD WALLS
Surveyed in Chubhar, Gilan.





TIMBER ROOF WITH MUD COVERING; MUD BRICK
UPPER WALLS WITH HORIZONTAL TIMBER REINFORCING
Surveyed in Masouleh, Gilan.



HOUSING AND MATERIALS

(figures in 1,000's)

Material	Gilan			Mazandaran		
	Rural	Urban	Total	Rural	Urban	Total
Reinforced Concrete	+	+	1	+	+	1
Stone and Iron	+	+	1	+	+	+
Stone and Wood	14	3	17	16	1	17
Kiln Dried Brick and Iron	+	2	2	2	5	7
Kiln Dried Brick and Wood	4	19	24	15	24	39
Wood	15	1	16	15	2	18
Sun Dried Brick and Wood	103	11	115	91	15	105
Sun Dried Brick and Mud	42	6	47	30	7	38
Straw	+	+	+	2	+	2
Other	48	5	52	56	4	60
Total	227	47	274	227	59	286

from Statistical Yearbook 1973; 1352 (Mar.1973-Mar.1974),
Plan and Budget Organisation, Statistics Centre of Iran,
published June 1976.

Loads on Structures

In order to propose structural improvements to builders in the Caspian Region, and introduce mechanisms for resisting exceptional forces such as earthquakes, a clear understanding of the structural behaviour of buildings and the forces that act upon them is essential. A building should be capable of resisting or modifying the effects of the environment according to the users' requirements. It must also be able to withstand all the forces to which it will be subjected in use. These can be divided into forces and loads which are inherent in the building (dead loads: the weight of the structure) and those which are imposed upon it by humans or the external environment (live loads: fixtures, snow, wind loads, and land movements as in landslides or earthquakes). The distribution of a building's weight, as well as the applied loads, through the structure, determines the shape, location and size of elements such as posts, beams and bearing walls. Many of these forces have a vertical action and accumulate from the top to the base of the structure so that the lower portions of a building must support a greater load than the upper portions. This is of primary importance when considering the foundations upon which the whole mass of the building will rest. The bearing capabilities of the soil below are equally important.

Buildings are also subjected to various loadings according to their use, which must be considered at the time of construction (e.g., where rice is stored in the roof space or attic, the ceiling joists must be capable of carrying this additional load). Walls which are load bearing (such as masonry walls) distribute the weight of the structure more evenly over a larger area of foundation. The walls themselves must have sufficient compressive strength to carry this load. Framed wall construction transfers the load of the structure down the supporting posts into point loads to

the foundations, concentrating the load of the building into small areas.- The infill walls between the framing are usually of light weight construction. The posts and foundation below must be capable of carrying this concentrated load.

Snow loading concerns the roof particularly, and the effect of different pitch on the amount of snow loading is dealt with in the analysis of roof trusses. However, the snow load will be transferred to the walls or posts supporting the roof as a vertical force. Snow can, however, be driven horizontally or upwards by the wind, and especially on tile roofs this should be considered.

Wind loading is especially a problem in locations subject to high winds, such as the coastal plain of the Caspian. The loads discussed so far apply forces directed toward the ground and can be taken by the compressive strength of the walls, posts, etc. Wind loads basically act horizontally to the building. Increasing wind velocities apply corresponding pressures to the walls, roof and structure. The magnitude of these pressures depend not only on the wind's velocity but also on the size of the geometrical form of the building, its orientation in the wind stream, and the friction effect on the surface of the building. Furthermore, wind not only exerts pressure on the windward side, but also considerable suction on the leeward side, and on the roof to a varying extent depending on the type of roof (see section on Roof Trusses). Wind can therefore exert an overturning effect, as in pushing an unrigid framework, and can also lift off lightweight cladding. In high winds whole buildings can be dislocated.

A landslide is a downhill movement of land on the slope of a hill or mountain, and can be caused by heavy rain, earthquakes and also by construction, mining and other alterations to the natural state of the land. The movement of soil

causes displacement of the foundations. In mild cases, although weakening the building, cracks in the walls, etc. may be the only visual signs. In severe cases the whole building may be carried away. Areas where there is a possibility of landslides occurring should be avoided for building.

Earthquakes

As with much of Iran, the Caspian region has a history of earthquakes, resulting in damage and destruction to property and loss of life. Perhaps of all the regions of Iran, the Caspian indigenous building employs some of the best earthquake resisting principles. This is certainly helped by the availability of timber for building. However, even timber buildings are damaged by earthquakes if proper precautions are not taken. In Japan where there is considerable experience in building with timber to resist earthquakes, damage is still recorded. In the Off-Tokachi earthquake of 1968 more than 4,000 wooden buildings totally or partially collapsed.*

The motion caused by an earthquake is complex. The effect upon a building depends upon many factors, such as the condition of the ground and the distance from the epicentre of the earthquake. Motion at the focus of the earthquake is normally vertical and is actually less damaging than the more horizontal movement that occurs away from the epicentre, which creates stress that can lead to collapse of the building. Stress is particularly known to concentrate at the corners of a building or at joints between building elements, and those areas need special attention.

The following are some simple guidelines to observe in building. It is important to provide a continuous framed or reinforced foundation, so that the building will move as a unified structure. The plan of the building should ideally be symmetrical.

* Shinzo Okamoto, Introduction to Earthquake Engineering, 1973, p.532.

rical and simple, to reduce conflicting corners, and to ensure as far as possible that each part of the building will behave in a similar way, and not transmit stress from, for example, a stronger part to a weaker. The height of the building should also be uniform, since different heights will have a different concentration of stress.

Structural framing should be firmly fixed to the foundation. Equally, the roof structure should be firmly fixed to the framing, and in every case ring beams should be incorporated at least at the junction between roof and walls.

Openings should be small, and positioned away from corners, preferably symmetrically.

With framed walls diagonal bracing should be used.

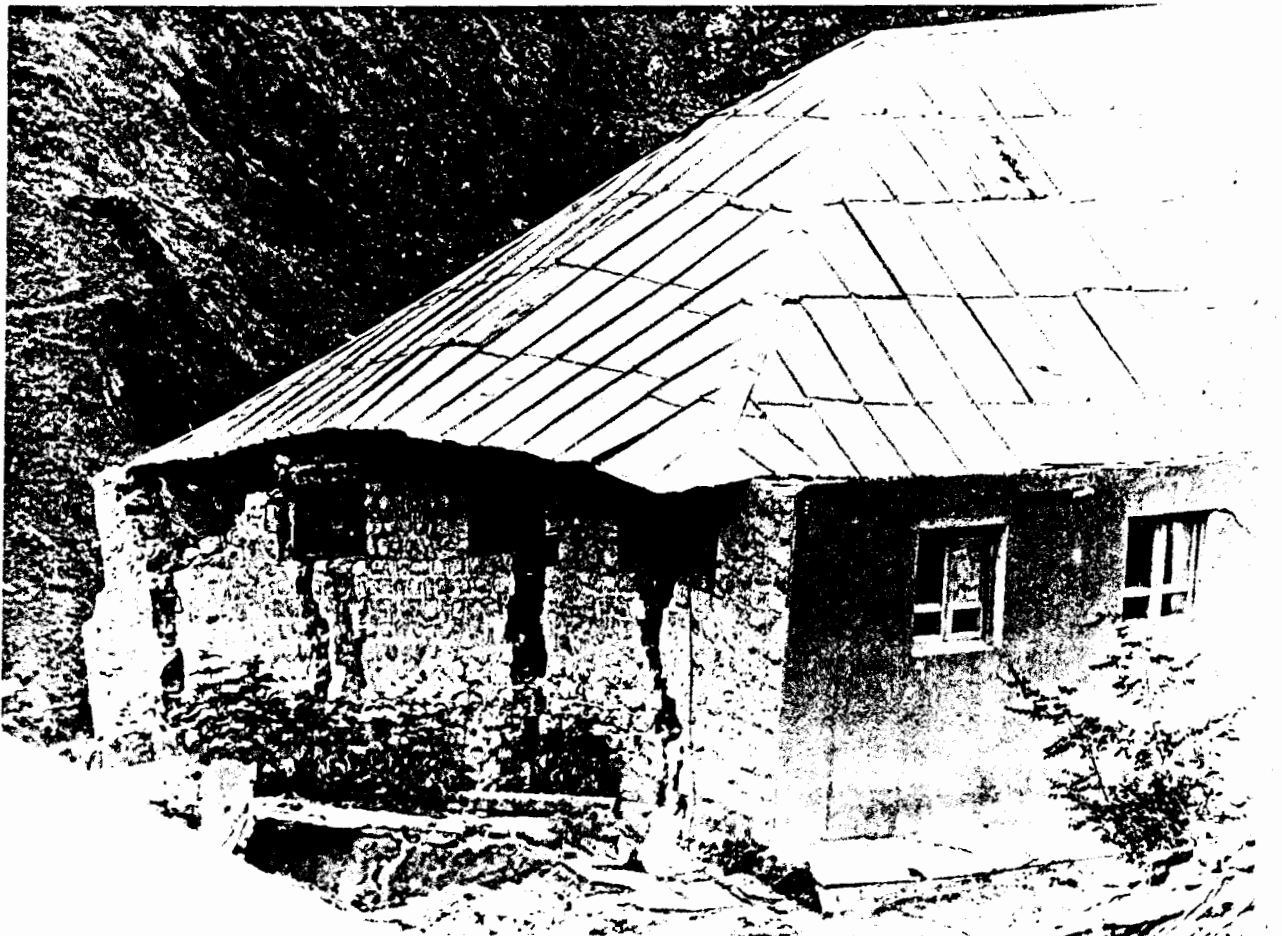
Where possible, foundations should be laid on solid ground. Soft ground can itself lead to failure of the building and in such locations correct foundations suited to soft strata should be used.

Finally, care and attention should be paid to the construction of every detail in the building, and to its upkeep. An extremely high proportion of building damage occurs because simple rules of good building were not followed. Reducing standards to reduce costs can be fatal.

Design for earthquake protection will be discussed in each technology section.

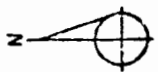






This house collapsed during a landslide. Diagonal bracing in the framing would have helped to resist collapse (Galand Rud).

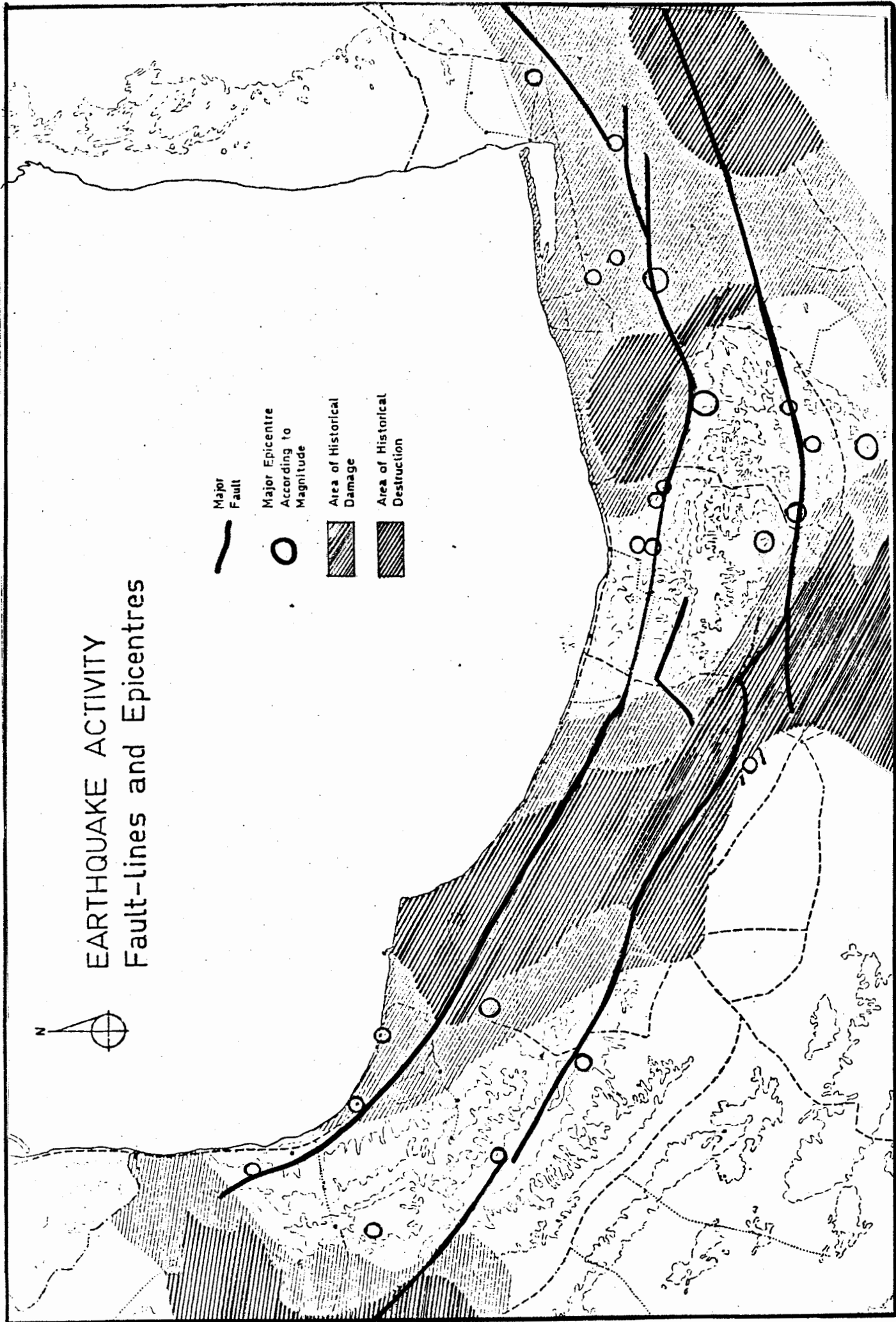


Weakness at openings is clearly shown in the damage caused by a land movement.

EARTHQUAKE ACTIVITY Fault-lines and Epicentres



-  Major Fault
-  Major Epicentre According to Magnitude
-  Area of Historical Damage
-  Area of Historical Destruction



Foundations:

Foundations are in many cases insubstantial, but where care has been taken at least a shallow bed of stones is used. Footings sunk below ground level usually only reach down 50cm. and are set in a mortar of lime and mud (shefteh). This is common in the mountains but less so on the coastal plains where stone is not so easily available.

There should be a solid foundation with stones laid in mortar (lime/clay mortar is cheap and sets very hard, but should only be used below ground level). Ideally, foundations should go down to a proper load bearing strata. A layer of sand between the bearing strata and the foundation can help to isolate the building from ground movement.

Platforms:

Houses on the coastal plain, to protect the building from possible flooding and the penetration of ground water, are largely built on platforms. They vary in height from 0.50 m. to 1.50 m., depending on the location (see Typology). Changes in availability of materials for platform construction in recent years have not notably changed the basic pattern.

Platforms can be divided into three major types.

A. Noted particularly where houses have a framed wall construction. The vertical framing of the walls is sunk into the ground. The platform is 80 to 100 cm. high. A horizontal timber member, joined to the vertical posts along the upper edges of the platform, forms a frame and the whole base is filled in with packed earth giving the platform an earthen floor.

A variation of this type of platform has no solid infill but is floored over with timber joists and floor boards, with a mud finishing layer. The sides of the platform, between the framing, are filled with mud and stones. This type of platform, although protecting the structure above against rising damp from the ground, uses a considerable amount of timber and has been restricted by limits placed on the free felling of trees in the forests. Additionally, the lifespan of such a structure will be reduced by the decay of timber in contact with the damp ground, and preservatives must be used to resist this. Much of the strength of this type of platform and the structure above, relies upon having good joints and proper embedding of the posts in the ground.

Many of the platforms in newer framed houses now use a concrete block retaining wall, supporting the framework above, with a packed earth infill. This method is similar to type

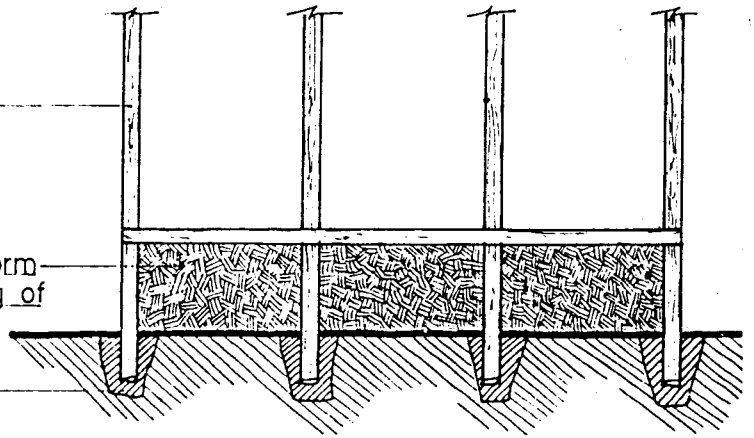
PLATFORMS

A

Framing

Packed earth platform
built within framing of
building

Lime/mud mortar

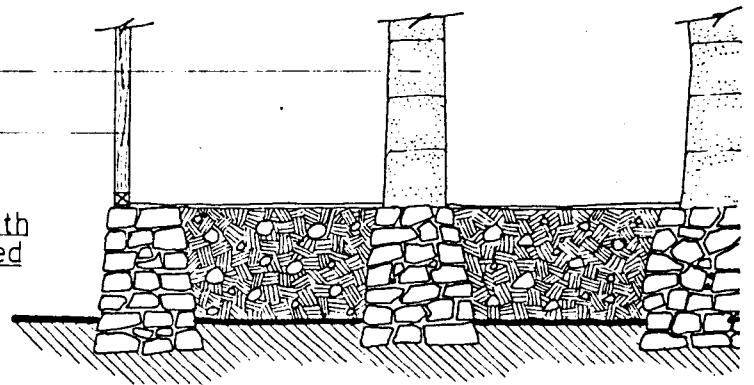


B

Chineh walls

Post at front of
aivan

Solid platform with
stone piers, packed
earth and rubble
infill.

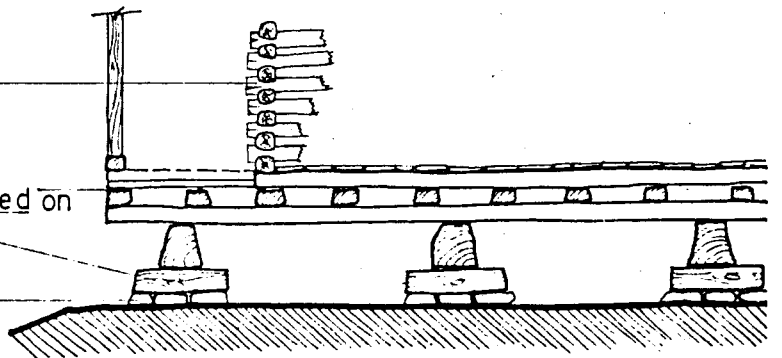


C

Log walls

Raised timber
platform, supported on
wooden blocks

Stone plinth



Scale



'B' (below), with similar drawbacks on rigidity of the super-structure since the framing posts above the blocks do not continue down into the ground.

B. Platforms on houses which are of solid loadbearing wall type, are made of stone piers below the walls and columns. The spaces between are filled in with packed earth and rubble. In some cases where stone is not readily available, the whole platform is made of packed earth and rubble, although the quality of such platforms is inferior to those with stone piers. However, lower platforms up to 50 cm. are often of this type. Where timber framing is used, the vertical posts should be carried on down into the ground to provide rigidity to the overall structure, especially in the event of earth movement, e.g. landslide or earthquake.

C. Probably the most notable of the platforms are those found in the Kuchesfahan/Langarud area - the Delta of the Sefid Rud, where the land is damp and subject to flooding. Timber platforms raised 1 to 1.50 m. above the ground level are employed. These are supported upon a series of wooden blocks resting on a bed of stones. The number of blocks in a pile vary depending on the height of the platform. In many cases there is a low (50 cm.) mound of earth and rubble raising the whole structure slightly above the surrounding ground level.

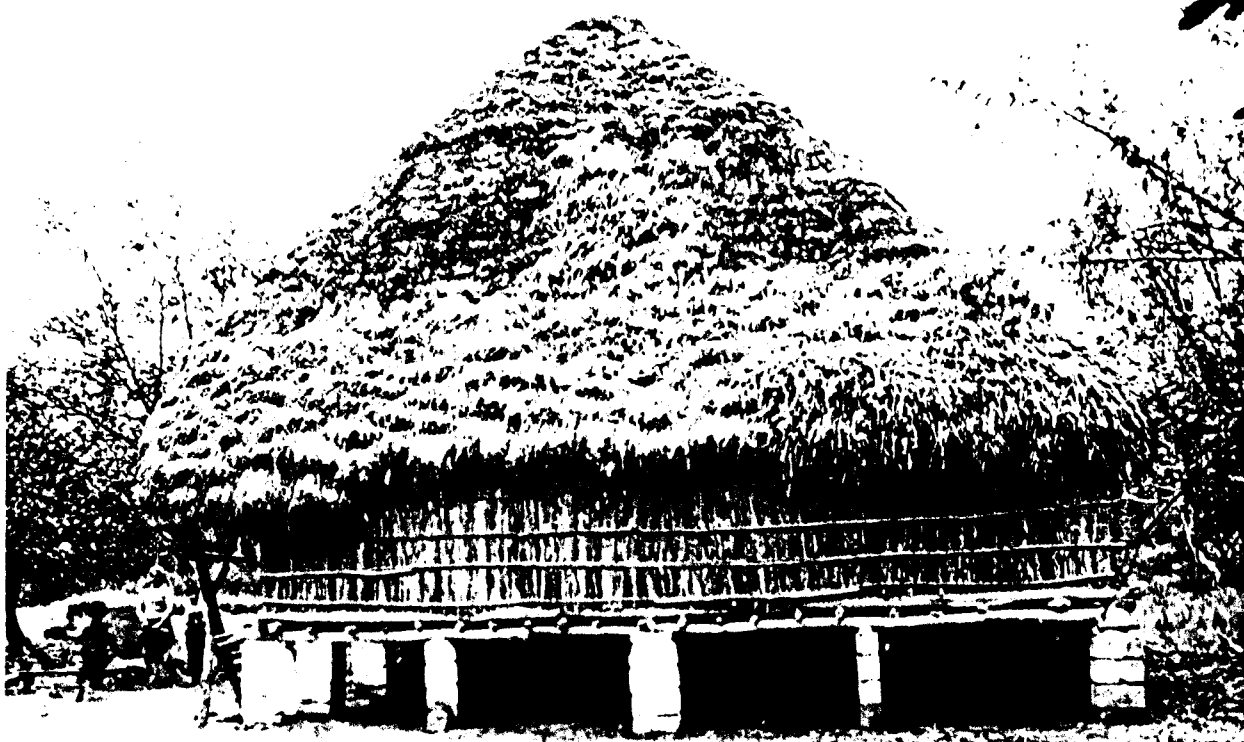
Since the blocks are used in a horizontal position, the grain of the wood does not come into contact with ground dampness and hence moisture is not transmitted to the structure above. If vertical posts were to be used they would be more susceptible to damage by damp rot.

These platforms, provided they allow for restricted play, are good in preventing the overall collapse of the structure in the event of ground movement. Newer rural houses in this

area are still built raised off the ground, but they are supported on columns of concrete blocks which are much more likely to collapse in the event of an earthquake. Unless reinforcement is used, such columns have little flexural rigidity.



Solid platform used for houses situated on damp ground (Sari plain).



Houses where river floods are likely are built up on stilts to allow water to flow underneath (Safidrud Delta).

Framed Walling:

Wood frame buildings are particularly common on the coastal plain of the Caspian Region. Although there are various types of framed walling, most are noted for their resistance to horizontal forces induced by high winds, landslides and earthquakes. These walls are also lightweight and cheap.

However, frame buildings are generally low in rigidity at joints, and there are examples in which collapses have taken place with joints acting as hinges. To resist this, the use of diagonal bracing is most important since it triangulates the structure. Some excellent examples have been recorded, notably in the area around Sari (see house 12.2 Chajkam). Where bracing must act in either compression or tension, depending on the direction of the forces applied, the joint between the brace and, respectively, the vertical member and the horizontal member (forming a triangle) must be capable of withstanding both these forces. For example, a brace bolted to a vertical post will allow for both tension or compression. Bolted joints are recommended. Traditional pinned mortice and tenon joints used in some of the buildings in the Caspian are also excellent but require good workmanship. The collapse where no bracing is used is clearly illustrated by damage done to houses in Galandrud during a landslip. Joints can also fail due to vibrations, and simple nailing is generally insufficient.

In the case of semi-rigid infill panels between framing, resistance to horizontal forces is greater where diagonal bracing is used. In every case horizontal framing should be built in as well, especially as ground level and eaves.

Walls made of timber lath and mud packing ("arreh kasma" or "ajor paiee")

This type of wall is non loadbearing; the roof is supported by a timber framework. The space between the structural framework is filled in with horizontal and diagonal rough sawn boards. These boards are nailed to the inside and outside of the framework at approximately 25 cm. centres. Vertical posts are at 80 cm. to 1 m. centres. The wood work is usually done by a carpenter. Wood for the lathing is now mostly cut by mechanical saw, but laths split by axe are used as well and are stronger* , as the split follows the direction of the grain. The space between the internal and external lathing is filled in with a mud and fine cut straw mixture packed in by hand. The finished wall is rendered with mud plaster, providing an overall thickness of 15 to 20 cm. surface to surface. The diagonal lathing will offer resistance to horizontal movement, provided that the fixing of the lathing to the horizontal and vertical framework has been sufficiently strong. Where one nail is used at each end of a lath this is probably insufficient. However, not all cases of this type of wall have diagonal lathing. Many cases were observed where on both inner and outer surfaces the lathing was horizontal. This is inferior to the diagonal lathing.

For a small two room house it takes two days to do the frames and lathing, and five days to put in the mud and plaster. This type of wall will last for up to fifty years, requires little maintenance except for the upkeep of the wall render, and is cheap to build.

This method of walling is still in widespread use, even where older roofing systems have been discarded in favour of sheet metal roofs. In Lasht Neshah/ Kouchesfahan area people interviewed said that timber lath and packed mud

* John S. Scott, A Dictionary of Building, 1969. p.488.

walls had been in widespread use for 20 to 30 years whereas previously log walls were the main wall type. Today however concrete block is becoming increasingly the vogue.

TIMBER LATH AND PACKED MUD WALL

Vertical framing

Horizontal laths internally

Diagonal laths externally

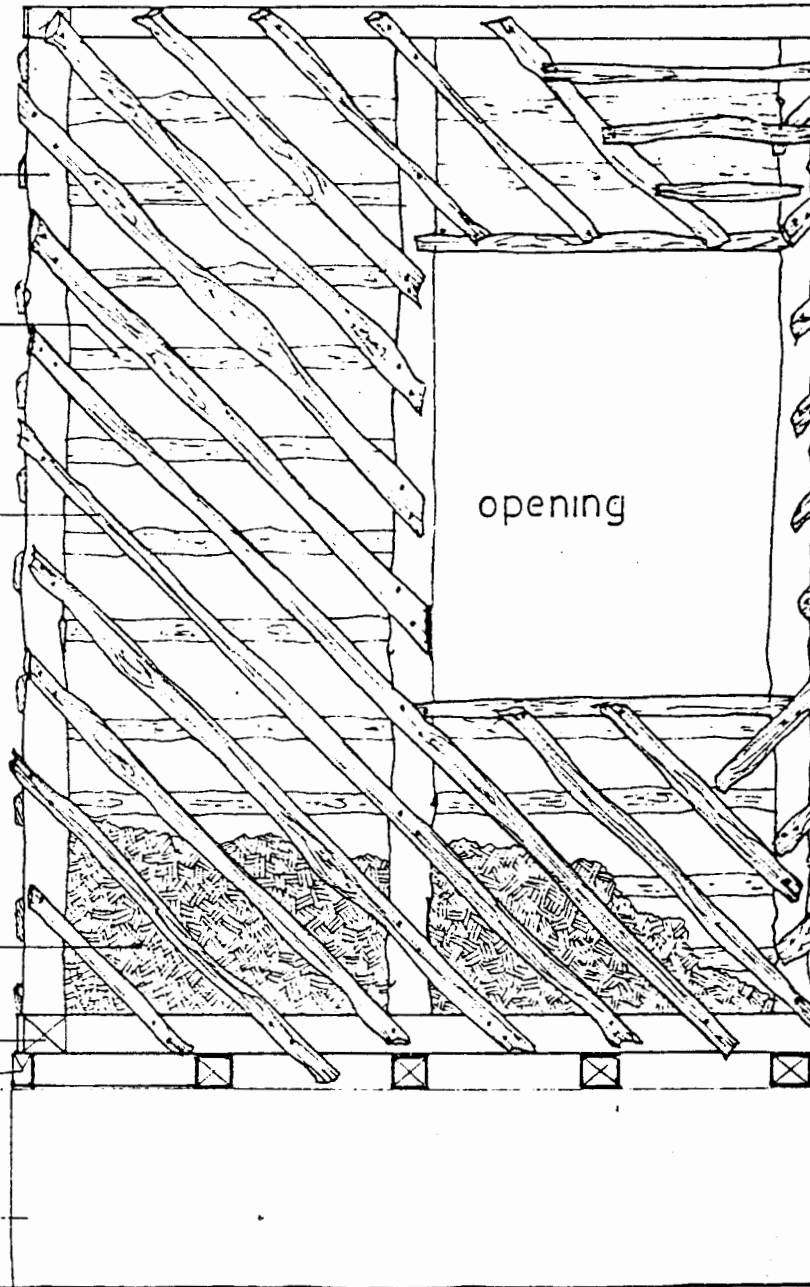
Packed mud and straw infill

Horizontal framing

Floor joists

Platform

ELEVATION

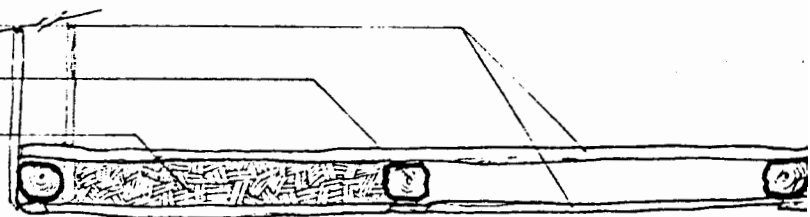


Laths

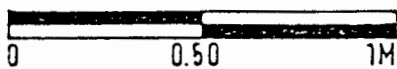
Framing

Mud packing

PLAN



Scale





Walls made of timber lath and mud packing. These walls have either diagonal lathing (above) or horizontal lathing (below).



Woven walls*

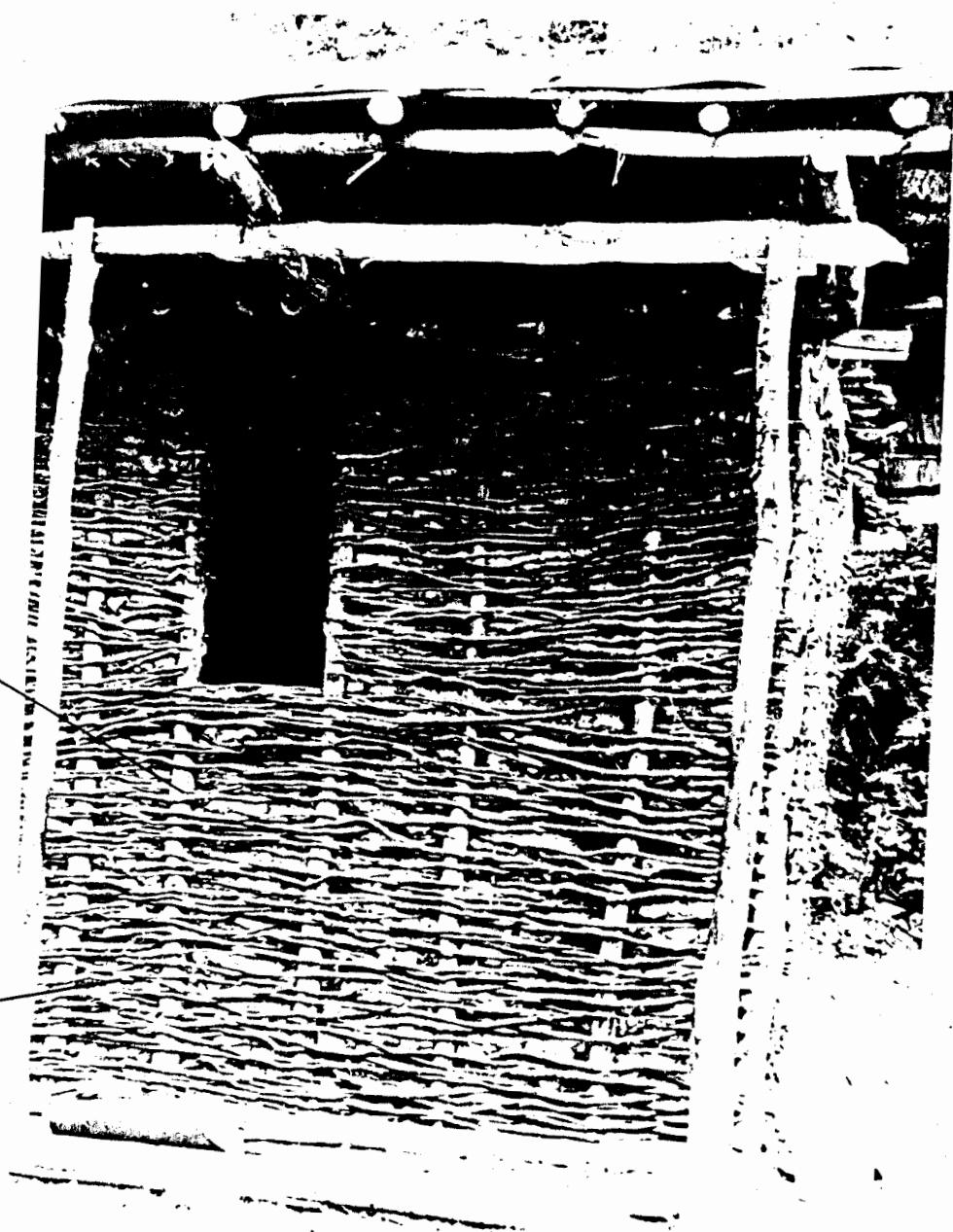
A system similar to the timber lath and packed mud walls, found close to the foothills, provides a cheaper but thinner wall. Vertical posts spaced at 50 cm. centres provide a framework between which thin branches are woven. When used in houses, the wall is plastered inside and out with a mud straw mix, wet enough to be squeezed through the gaps between horizontal branches. The same system, but without plaster, is used for fencing, and for walls of outbuildings and charcoal storage huts where air circulation is beneficial. Structurally, the more compactly the branches have been woven the stronger the wall is. The mud plaster provides protection against fire.

* known in England as wattle and daub.

Woven walls

Vertical framing

Horizontal woven
branches



Reed walling

This type of wall is found both in Gilan and Mazandaran in areas close to the marshes and the coast.

Vertical posts, spaced 1.50 to 2 metres apart, both support the roof framework and provide the fixing for the infill panels made up in the form of reed mats. The reeds stand vertically. At roughly 50 cm. intervals above each other, horizontal battens (bamboo or thin wooden poles) are placed both inside and outside the reed screen. String is passed through from one batten to the other so as to tightly sandwich the reeds between them. In houses, these walls are plastered on the inside and in most cases outside as well. On less important buildings - shelters for cattle or chickens - the plastering is sometimes omitted altogether or just applied to the inside surface. These reed walls are also commonly used on the north and west sides of houses where the roof overhangs beyond the structural walls of the house, providing a covered space about 1 to 1½ metres wide round the two sides of the house. The reed wall fills up the gap between the low eaves and the ground.

A number of examples have been noted where diagonal cross bracing was used to stabilise these walls.

REED WALL

Thatch roof

Wooden framework
supporting walls
and roof

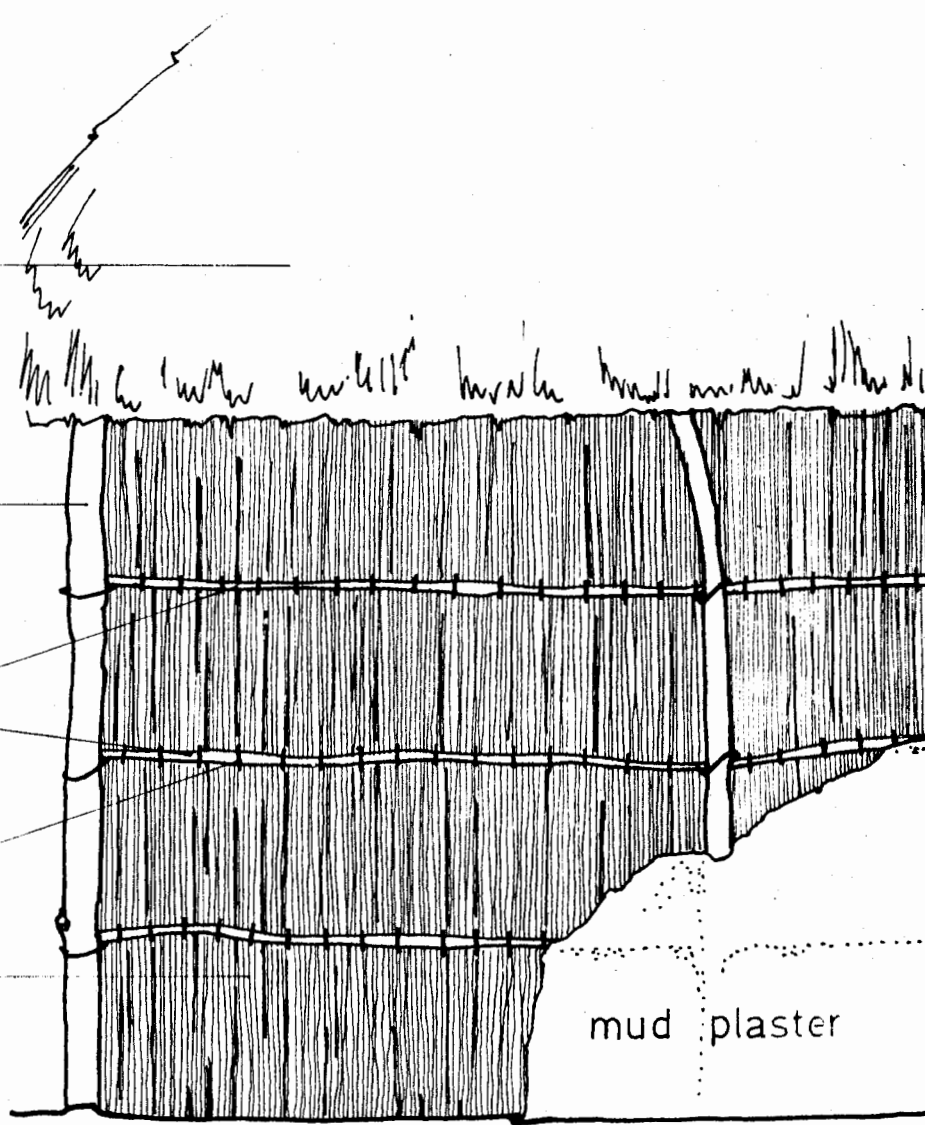
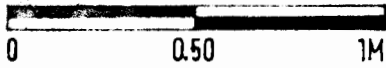
Battens inside
and out, providing
stiffening to reed
panel

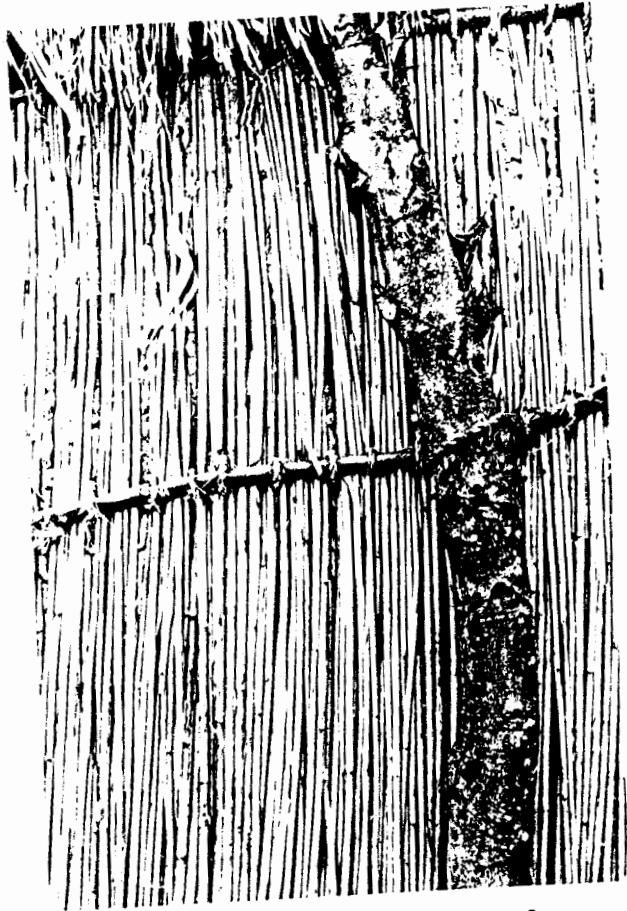
String binding

Reeds

mud plaster

Scale





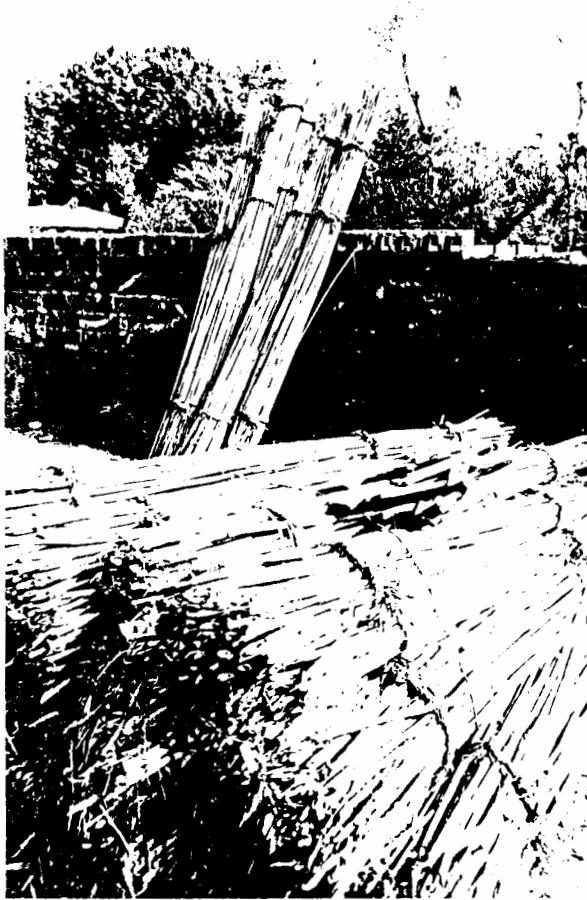
Reed wall with horizontal bracing.



Detail of reed wall. Mud plaster is visible between the reeds.



Reed wall supported between two concrete block columns (Shijan).



Reeds bundled before use in walls.



Reeds growing at the edge of the marshes.



Cutbuilding with reed walls and thatch.