Load Bearing Walls:

Log Wall Construction

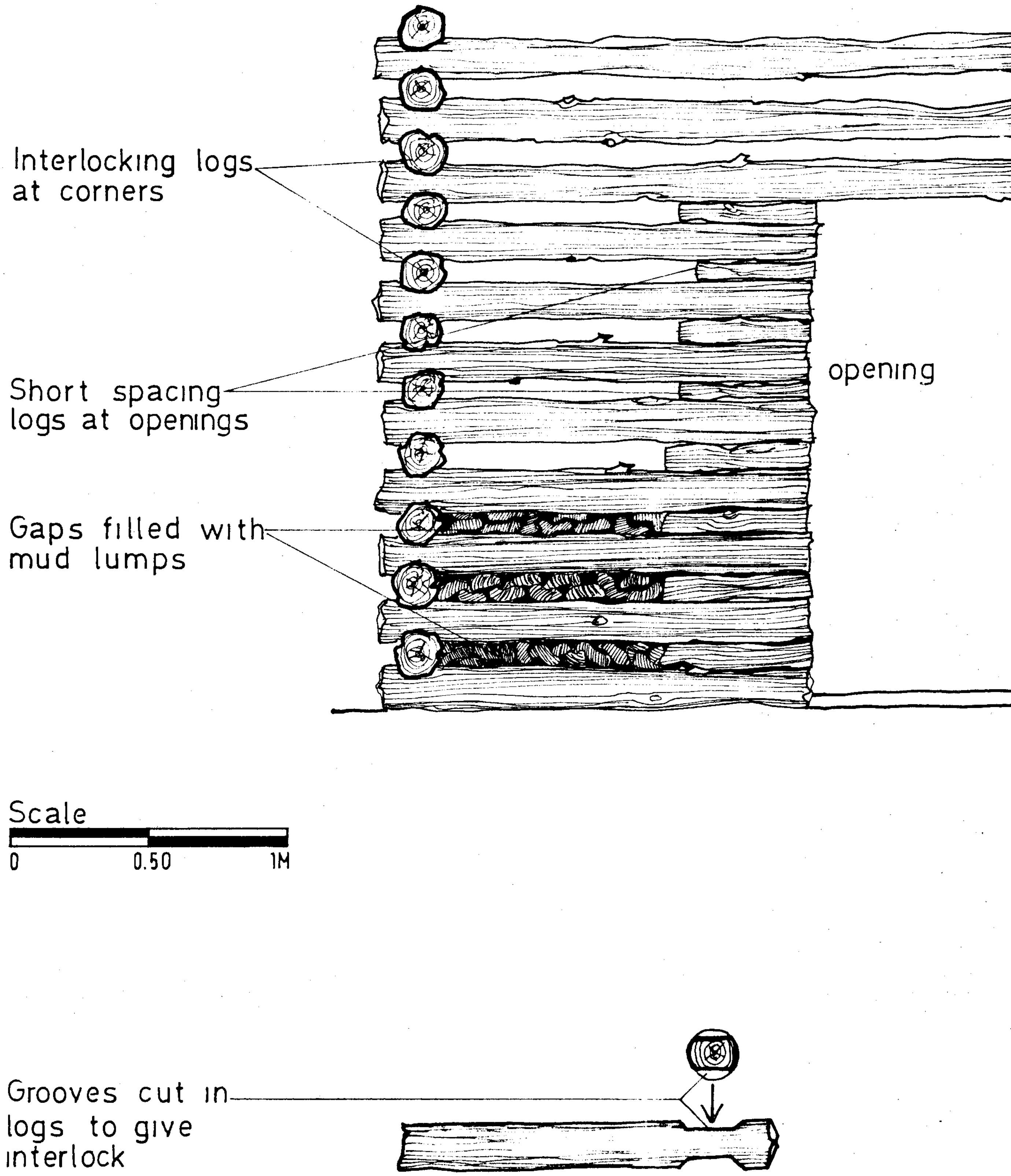
This is a system of walling in which logs are laid horizontally with interlocking corners when logs intersect.

At the point where a log overlaps, one or sometimes both of the upper and lower surfaces is slightly cut away to provide a groove for the next log overlapping it. Each log becomes firmly fixed in position by these notches. Where an opening is required, the gap between two horizontal logs is filled with a short (50 cm.) spacing log held in place by a vertical post. The gaps which remain between horizontal logs are filled with small rolls of mud. Occasionally a gap is left unfilled to provide additional light to the interior. Although in many of the poorer examples the walls have not been rendered outside, it is usual to finish off the interior and exterior surfaces with plaster.

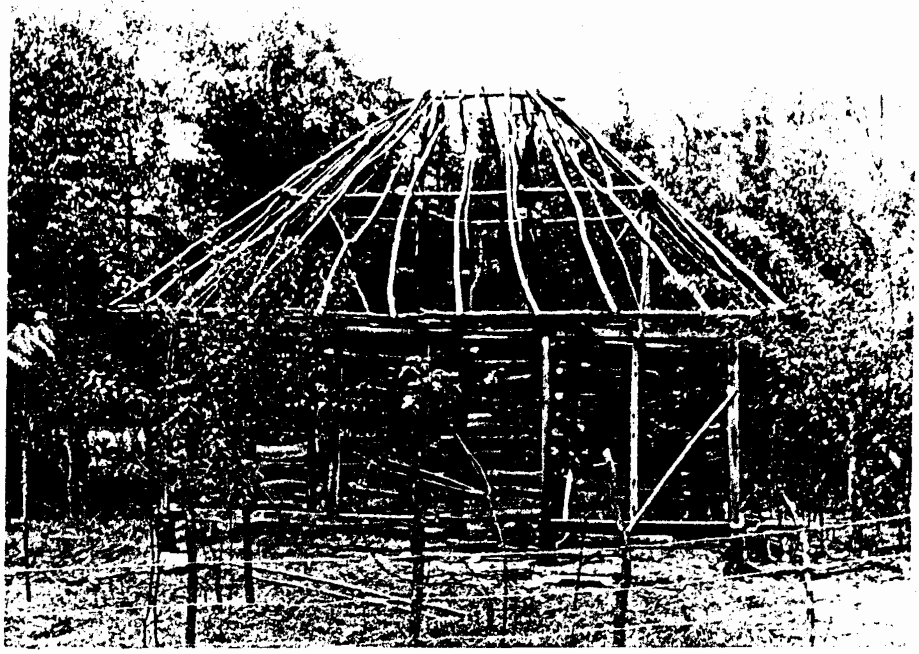
Previously for this type of walling trees could be cut from the forest. Control by the Forestry Department has restricted this and alternative walling methods are being used in almost all areas (see Coursed Stone and Timber Lath Walls).

Log walls can be extremely strong provided that the interlocking of logs has been properly done at the corners. However, where these structures are situated on a slope, the stone walls built below the logs to form either a level platform base or a complete lower storey, are often unstable. These walls are usually made of rubble stone with mud mortar and collapse easily. The recommendations for stone and brick walls apply in this case.

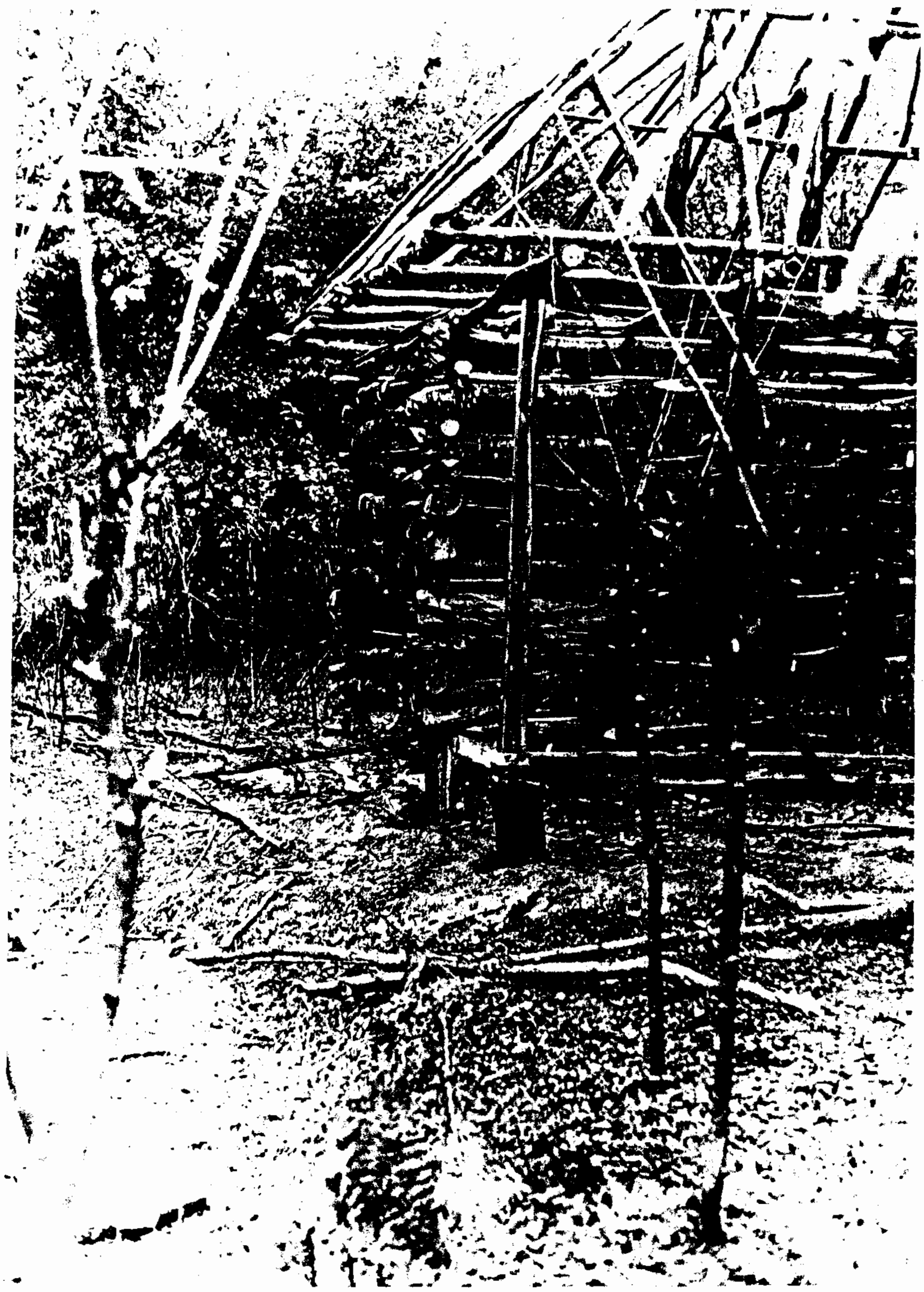
LOG WALL


Interlocking logs at corners
Short spacing logs at openings
opening
Gaps filled with mud lumps
Scale
0
0.50
1M
Grooves cut in logs to give interlock

Log wall house under construction south of Fouman.

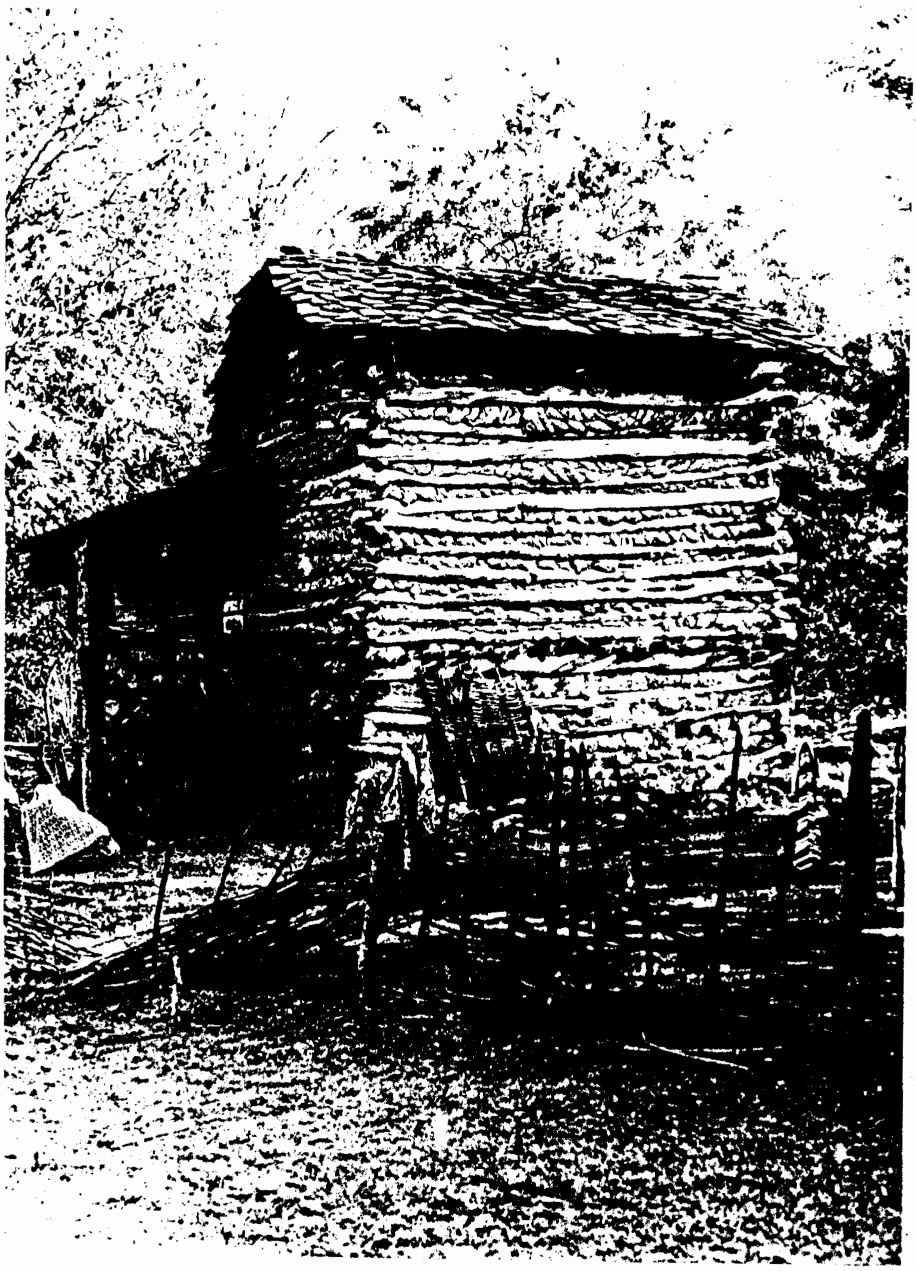


Interlocking corner detail of log wall house under construction.



Log walls are not always regular. The gaps between logs are filled with mud.

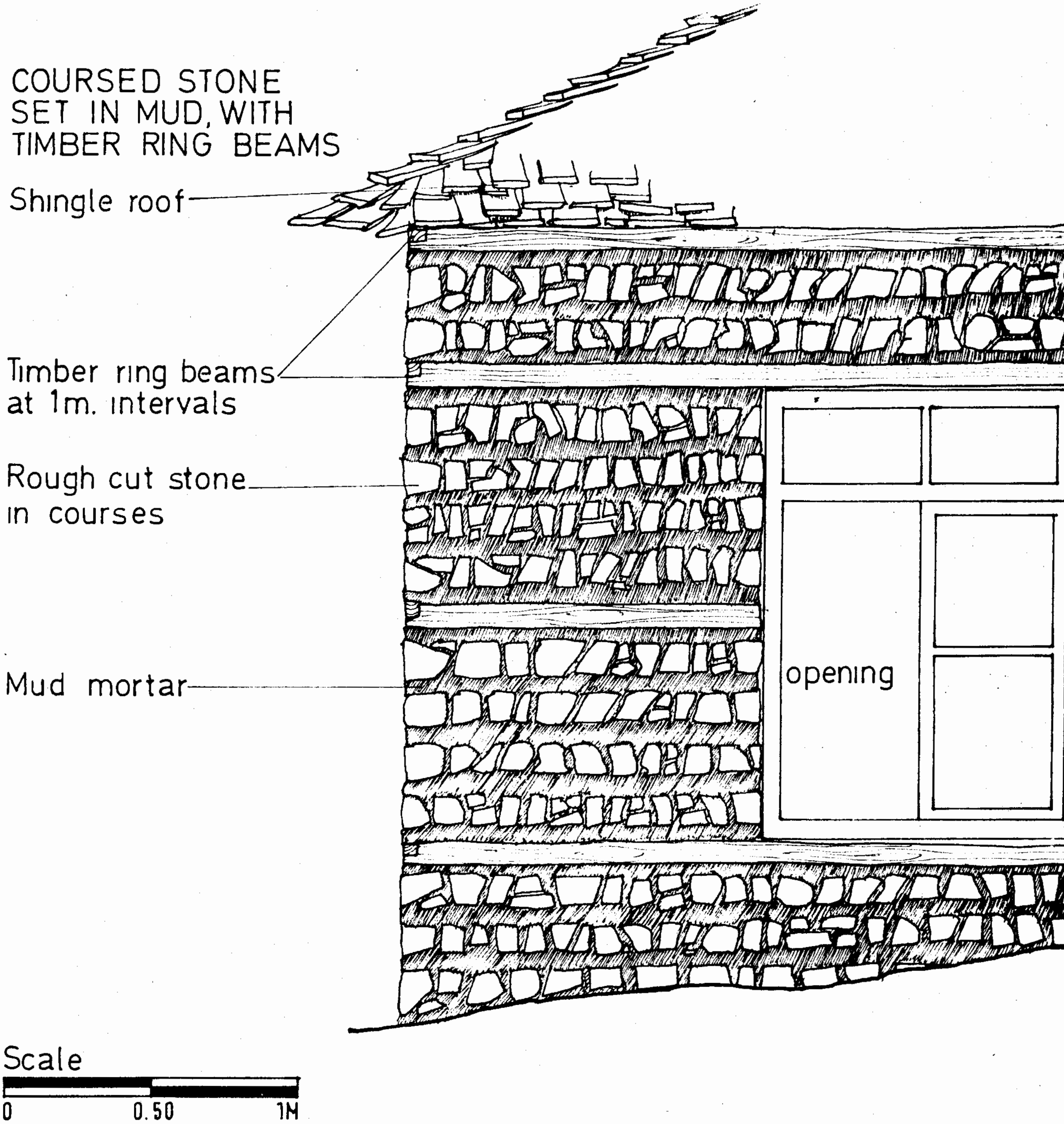
Careful interlocking of logs reduces the amount of mud packing required.



Coursed Stone Set in Mud With Timber Ring Beams

This type of wall is predominantly found in the mountains, and is one of the methods of walling now used instead of log walls. Stones are laid in horizontal courses set in a mud mortar. At approximately 1 metre horizontal intervals, a timber ring beam is laid round the building. This is essential for achieving a strong wall, since the mud mortar has no adhesive quality with stones, and without reinforcement the wall would be unsafe especially in earthquakes or land movements. The walls are rendered inside and out, with a fresh coat of plaster applied annually to external surfaces to protect against weathering.

These walls would be much improved if a sand/lime mortar were used. The stones should also have proper bonding through the thickness of the wall and at corners. The depth required for an adhesive mortar should be much thinner than currently used with mud mortar. This will increase the quantity of stone needed in the wall; however most buildings with this type of wall are sited quite close to stone supplies, and the increase in strength offsets the extra effort required.

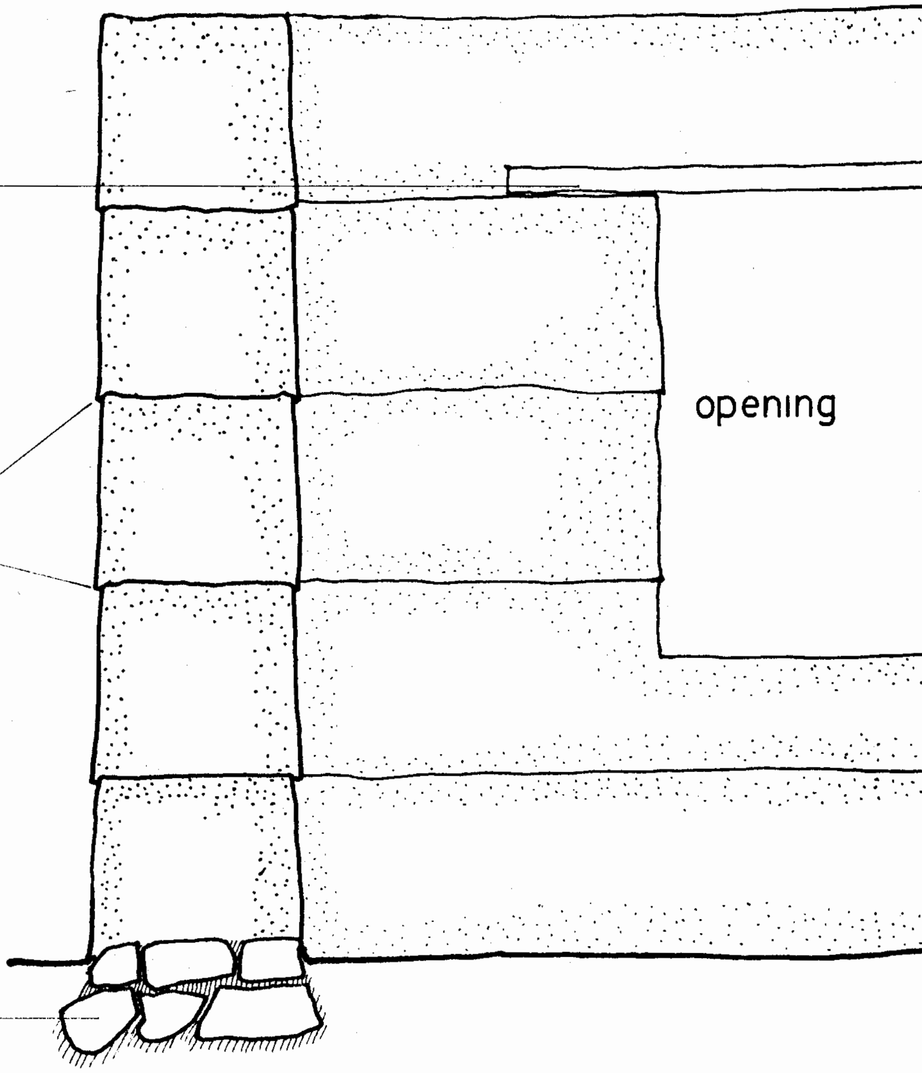

COURSED STONE
SET IN MUD, WITH
TIMBER RING BEAMS
Shingle roof
Timber ring beams
at 1m. intervals
Rough cut stone
in courses
Mud mortar
opening
Scale
0
0.50
1M

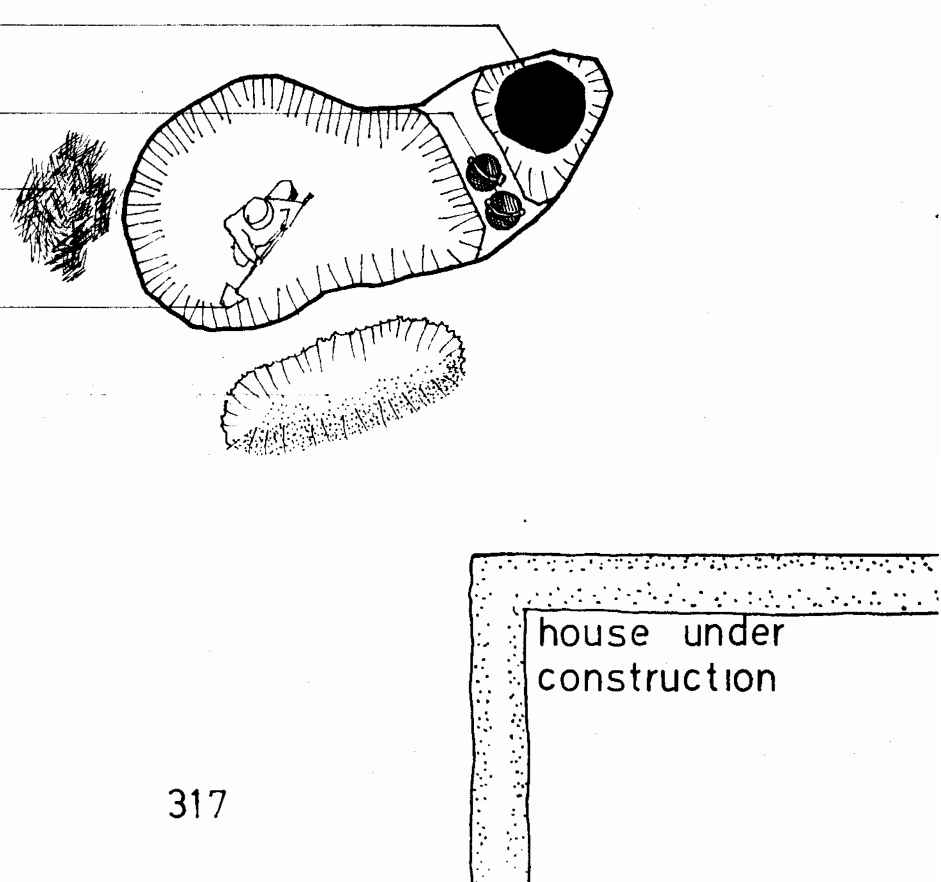
Chineh Walls (Packed Earth)

Such walls are found in both Mazandaran and Gilan. For this type of walling earth is moderately wetted and mixed with finely cut straw to produce a plastic mass that can easily be moulded. Mixing is usually done by kneading with bare feet. The mix is carried by hand in a lump or by spade or basket to the building site, normally immediately adjacent to the mixing area. The builder places the mix in lumps onto the wall, smoothing the sides on completion of each layer. The walls are usually 50 cm. or more wide. It is built up in stages 50 cm. high, with a drying period allowed between each stage. In most cases the base is wider than the top of the wall. Foundations are of stone laid in a mortar of mud, lime and water (shefteh) and are essential to preserve the wall from water damage and to give stability. Provided there is a stone footing, a chineh wall can last up to 100 years, but usually requires external rendering annually. A whitewash with lime render lasts up to two years. Chalk whitewash is used internally. Where contact with moisture occurs, chineh walls deteriorate rapidly. They are subject to damage by rats and other animals that burrow into the wall for nesting. A small quantity of lime in the base course of chineh walls normally deters rodents and insects. A well organised mixing area adjacent to the building site was noted in Sar-e-Marz (Mazandaran), with water supply, earth supply and mixing area arranged side by side in two pits, the smaller with a well, the larger for providing the earth and mixing. A straw supply is to one side, and the prepared mix is shovelled out to a pile beside the larger pit, ready to use. One drawback of this type of walling system is that large pits occur near to the house, which become unhealthy stagnant pools of water or rubbish tips.

Where a chineh wall is used around courtyards and has no additional load on top, horizontal movement perpendicular to the wall does not usually cause collapse. On the other hand,

CHINEH WALL
(Packed earth)

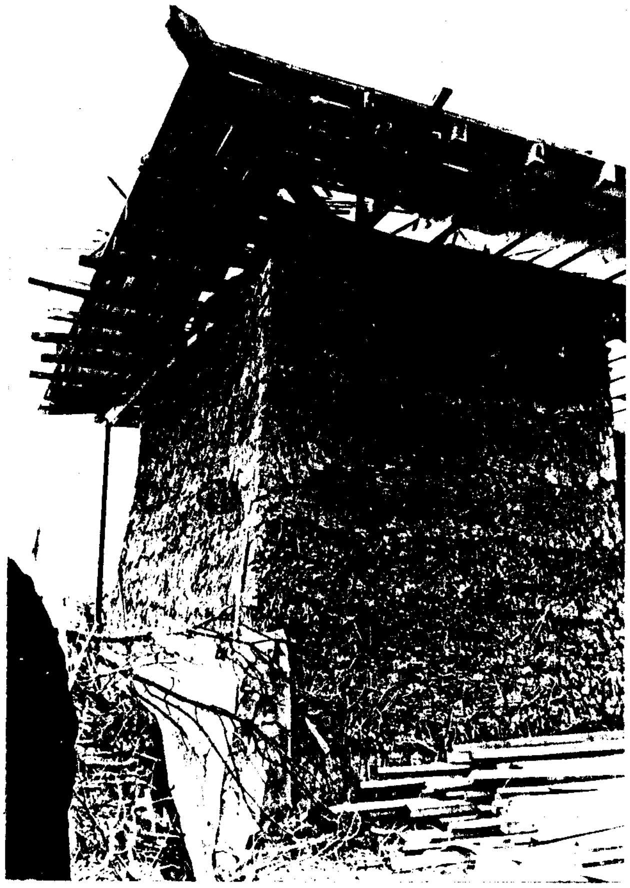




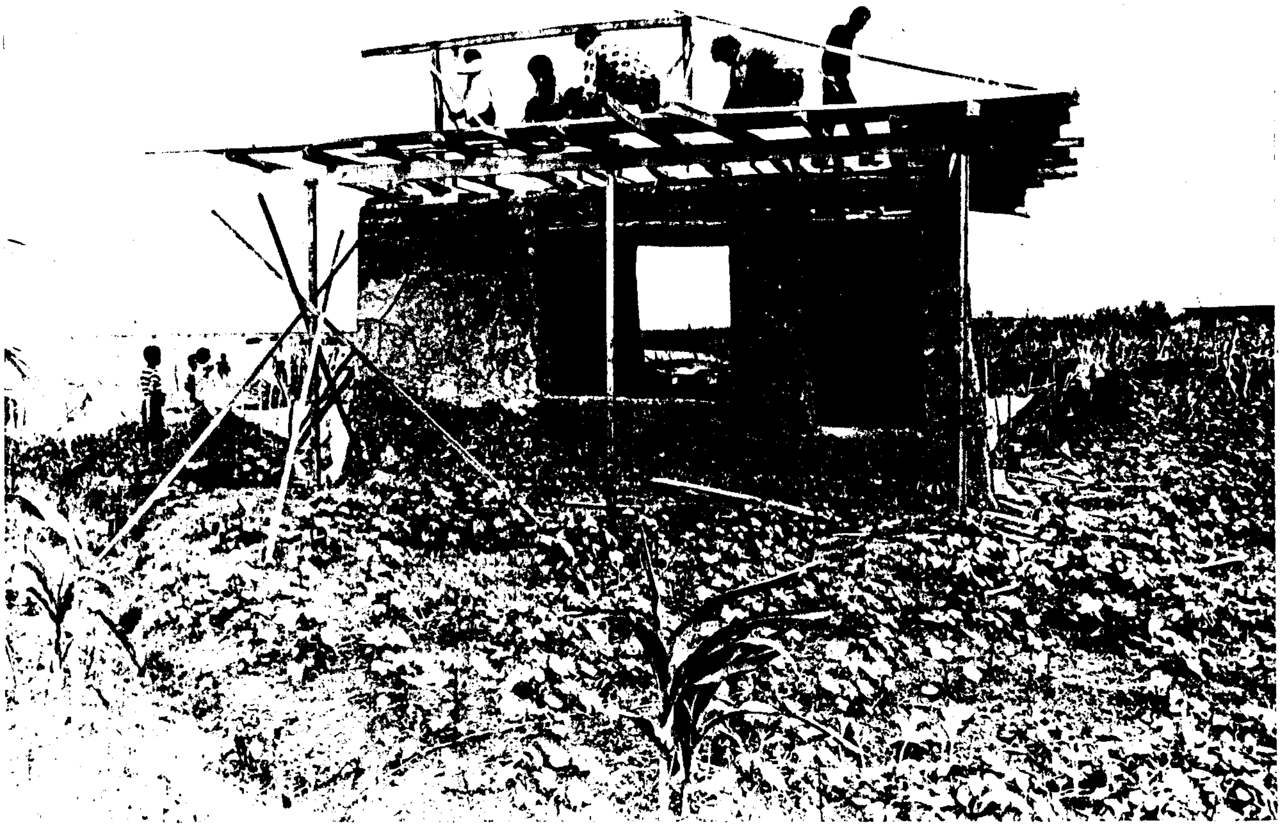
ORGANISATION OF MIXING AREA

where the wall is supporting a heavy roof, movement caused by an earthquake can result in the wall collapsing. When chineh walls are used in house building, it is essential to have a horizontal ring beam below the roof framework. In addition, vertical framing can at least help to support the roof in the event of wall collapse. A horizontal ring beam can also be introduced lower down the wall, particularly immediately above the top of openings. Windows and doors should be placed as far away as possible from corners and should all have deeply imbedded lintels at the same height. At the corners the 50 cm. layers of mud should either be bonded into each other, as in the overlap of bricks meeting at a corner, or built continuously without joints at corners.

House with packed earth walls under construction. The mixing pit for mud shows in the foreground.



Packed mud walls are laid in layers and can be seen in this unrendered wall.



A simple roof truss being built over a packed mud wall house (Sare Marz).

Mud Brick Walls

There are two types of mud brick wall found in the Caspian Region. First there is mud brick produced in a mould and then left to dry until ready for use. Two basic sizes were noted: 20x20x6 cm., the size commonly found in Iran; and a larger block approximately 30x15x15 cm. The second type is the hand cut mud brick. The production method involves spreading a layer of mud, slightly drier than used for moulding, over a prepared area of ground, to a layer of approximately 7 cm. This is then cut into brick sized units with a spade, providing a somewhat irregularly shaped unit with wedge shaped edges. This method is, according to the local builder in Fouman plain, better than mud brick made in a mould, since it is prepared with mud of a drier consistency and is used semi-dry on the wall, where it dries more easily in the humid conditions of the area. These bricks are often laid in a herring bone pattern, providing good vertical interlocked bonding.

All types are laid with mud mortar, which provides adhesion between bricks. No other mortar should be used. However, it is essential that proper bonding between bricks is employed, especially at corners and also through the width of the wall. Mud brick walls in Masouleh where there is a history of landslides, make use of horizontal ring beams at approximately one metre vertical intervals. This is a good practise and should be encouraged elsewhere.

All types of mud walling require rendering, usually annuall

Fired Brick

Fired brick is more common in the Sari Plain/Behshahr to Gorgan area and Turkomansara, than it is in Gilan, where it is used in towns and the Astara area. However the fired brick produced previously in the Rasht area is of poor quality and is damaged by weathering. Some of the fired brick found in Masouleh has been imported from Tehran. Kilns in the Behshahr area which previously produced tiles have now, where still functioning, changed to small scale brick production. There are a large number of brick kilns in that area.

Bricks should be laid so as to have a proper bond through the thickness of the wall, along its length and at corners. As with elsewhere in Iran, this is not always properly done. Infil walls between vertical columns are often only one brick thick and are liable to fall down. Fired brick walls were observed with only a mud mortar in Turkomansara. There is no adhesion in such a wall and it will be easily damaged. The following mortars can be used:

Cement	Lime	Sand	Powdered Brick
1	1	6	-
1	2	9*	-
1	-	6	-
1	1	8	-
-	1	3	-
-	1	-	3

*Recommended for the Caspian Region

The chart shows considerable variation: different mixes will be preferable under different climatic conditions, different quality of materials used and different functions of the wall Availability of materials will also affect the choice of mortar. To illustrate this variation, lime sets better in a moist atmosphere, since the chemical reaction which lime goes through in setting requires the presence of water or water vapour. Mortar mixes should not be stronger than the brick itself. In general, mortars containing cement are less likely to cause failure.

A common fault in bricklaying is to attempt to save mortar by only applying it to horizontal joints. By properly filling the vertical joints as well, the strength of a wall can be increased by 20% to 25%. Bricks should always be thoroughly wet by submergence in a bucket of water before they are laid. This greatly helps adhesion between brick and mortar.

It is common practise in Iran to build up corners before infilling the wall. This is done to simplify the problems of lining up and levelling. However, this practise produces badly bonded and weak corners. Corners are critical stress areas in an earthquake and this practise should be discontinued. Brick courses should be laid continuously and wall building should progress evenly.

Concrete Block Walls

Hollow concrete blocks are produced in small yards all over the coastal area of the Caspian.

Production yards often employ only two men, using a simple block press. Distances for transporting the blocks to the building site are small and this walling system is popular in part because of its wide availability. The cost of blocks vary depending on the quantity of cement used. One bag of cement per forty blocks produces moderately strong blocks, selling at thirty rials each (1978). One bag of cement per seventy blocks produces a weak block selling at twenty-five rials each (1978). Because the latter are cheaper they are more commonly used. The cement proportion in these blocks is too low and a major criticism is that the blocks are of poor quality and deteriorate quickly.

Concrete block walls are only bonded longitudinally. Walls used in the Caspian are one block thick. Mortar is applied to face edges only and to one header face (e.g. the block adjacent to it). This does not produce a good moisture resistant wall, and rendering of exposed surfaces is essential.

Concrete walls are quick to build, taking about half the time required for a comparable fired brick wall. The jointing of blocks is, however, not very strong and it is extremely susceptible to ground movement, resulting particularly in failure at corners. Concrete columns have a poor slenderness ratio and are unstable. These hand made blocks (using a hand press) are only suitable for single storey buildings; for more than this machine made blocks are necessary, which have a greater compression strength. To improve the stability of the wall, vertical reinforcing bars can be used, with the hollow of the blocks filled in with mortar. This will, however, considerably increase the cost. The lack of quality control in both manufacture and building often results in poor quality walls. Damp proof courses should be used at the base of the wall to resist the penetration of moisture. On the other hand, it is locally believed that the well made blocks will last at least a hundred years. It is felt that this is an exaggeration and relects over confidence in new prestige materials.

Wall Renders-

All materials deteriorate to some extent with the passage of time; obviously some more rapidly than others. It is particularly important to ensure that this deterioration does not take place to the extent that the structure becomes unsafe.

The deterioration of materials can occur in several ways: by corrosion (as in the rusting of iron or steel, which is a chemical reaction and can reduce the strength of the material); by damage through impact and abrasion; and by the effects of the weather. The above are not an exclusive list, and in addition the deterioration of timber is discussed in the section on timber.

For the indigenous materials of the Caspian Region, the effects of the weather, notably rain, is most likely to cause damage to a building. In this context the walls are particularly vulnerable. In most areas of the Caspian a simple mud/straw render is used to protect the wall structure. Most of the indigenous wall systems contain mud, either as an infill (e.g., timber lathing and mud packing), a mortar (e.g. coarse stone with mud mortar), or as the principle wall material (e.g. mud brick walls). In all cases, a mud straw render will adhere well to the mud used in the wall, and while annual maintenance is required, such a render is cheap and simple to use. A cement render, which is necessary for a concrete block wall, will not adhere well to mud. In addition, cement renders, while not requiring such frequent maintenance, are expensive and place an additional load on the finances of the house owner. Hence the cheapness of the annually maintained mud-straw render may outweigh the advantages of the semi-maintenance free cement render, and in turn influence the type of wall used. It has also been noted that chineh (packed earth) walls can last for a hundred or more years, providing the render is in good condition.

A more water resistant render is provided by a coating of lime whitewash, and it is frequently used at the base of a wall to a height of one metre, to prevent damage from water splashing against the wall. Such damage can undermine the wall and cause it to collapse. The lime whitewash is also quite cheap and lasts better than a plain mud-straw render.

In the mountain settlements of Kodir and Masouleh, the external walls of houses have an additional coating of mud on top of the render. In the case of Masouleh, this coating is applied quite thinly but can last for three years. This mud coating differs from that which is used on the flat roofs. While both came from sites on the hillside opposite the town, this mud can be classified as a sandy-clay, and is yellow in colour (see soil test chart).

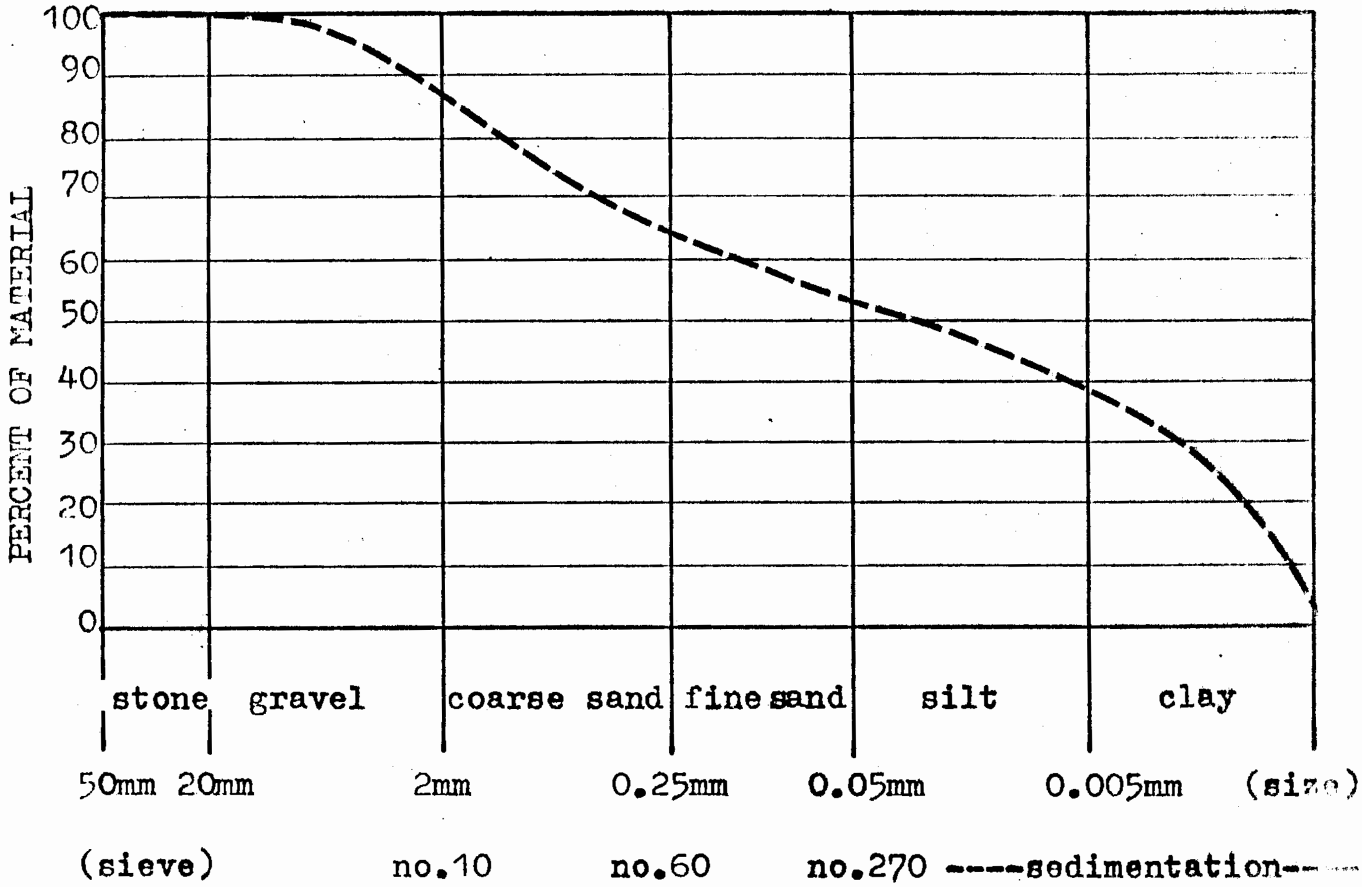
MECHANICAL ANALYSIS

LOCATION: Masouleh, Gilan, Iran

SITE: hillside, render soil

DATE: 24.10.78

Granulometric Chart

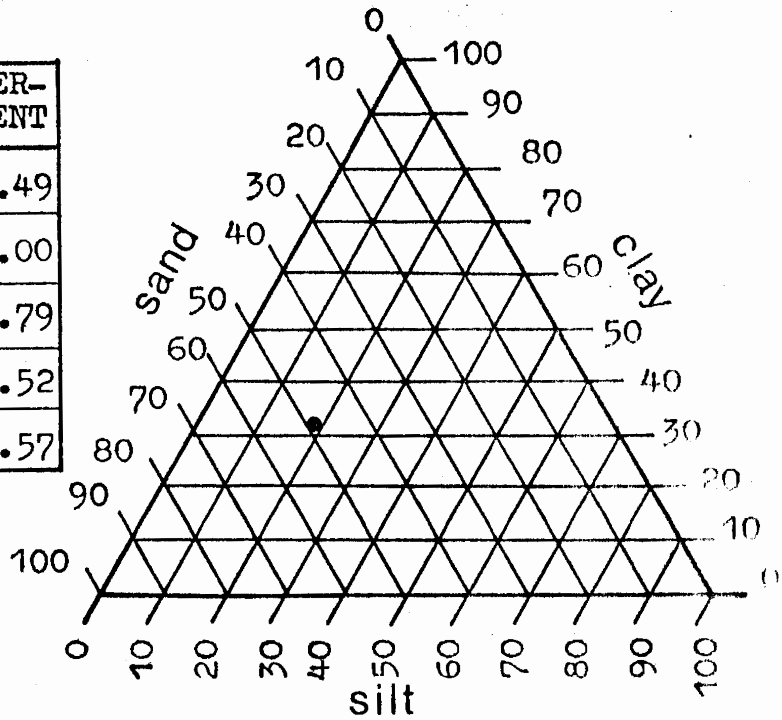


Particle Gradation

PARTICLE	mm SIZE	no. SIEVE	PER-CENT
Gravel	+2	10	24.49
Coarse Sand	+.25	60	16.00
Fine Sand	+.05	270	11.79
Silt	-.05	270	17.52
Clay	.005	sed.	29.57

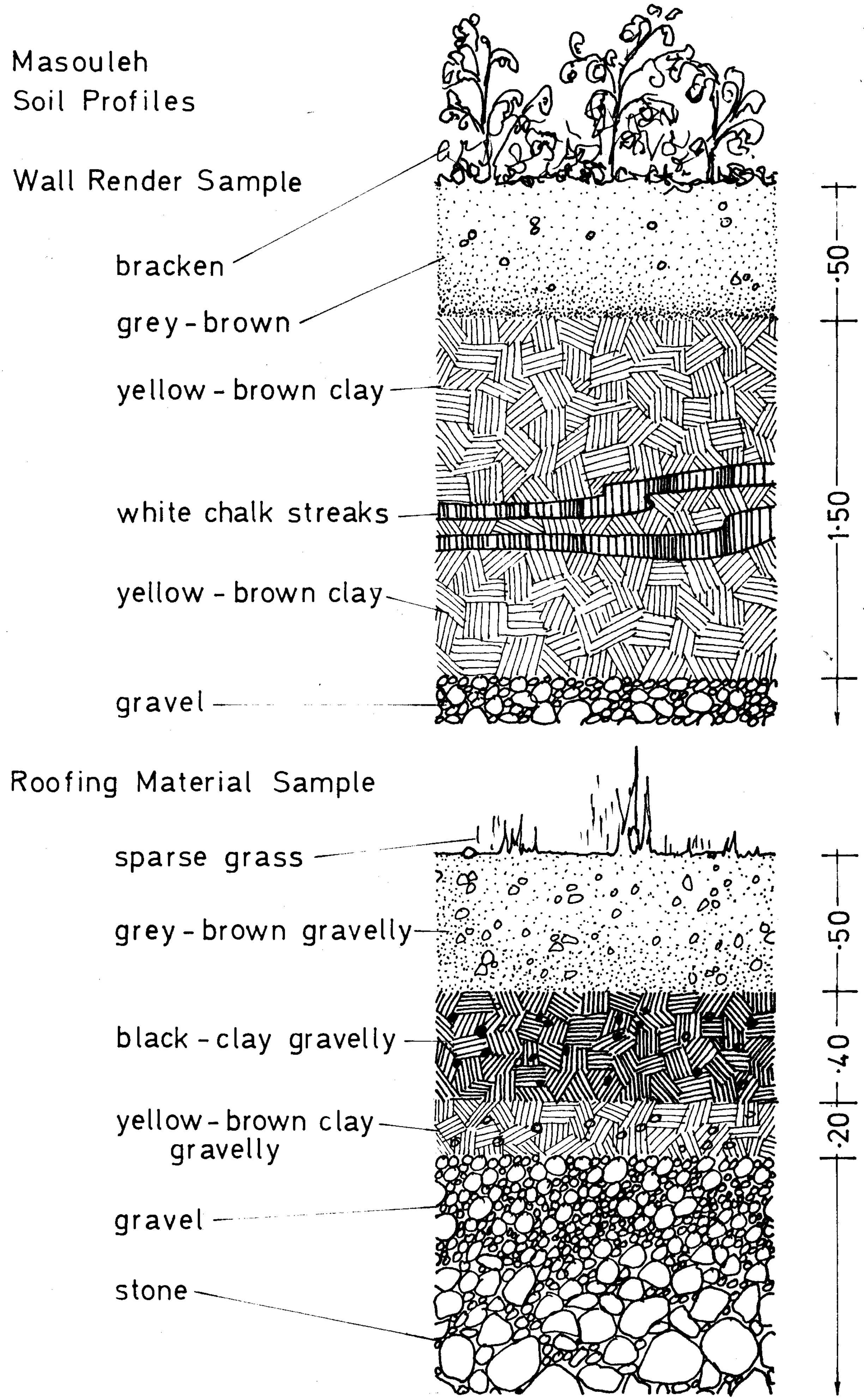
Soil Classification:

Sandy-Clay

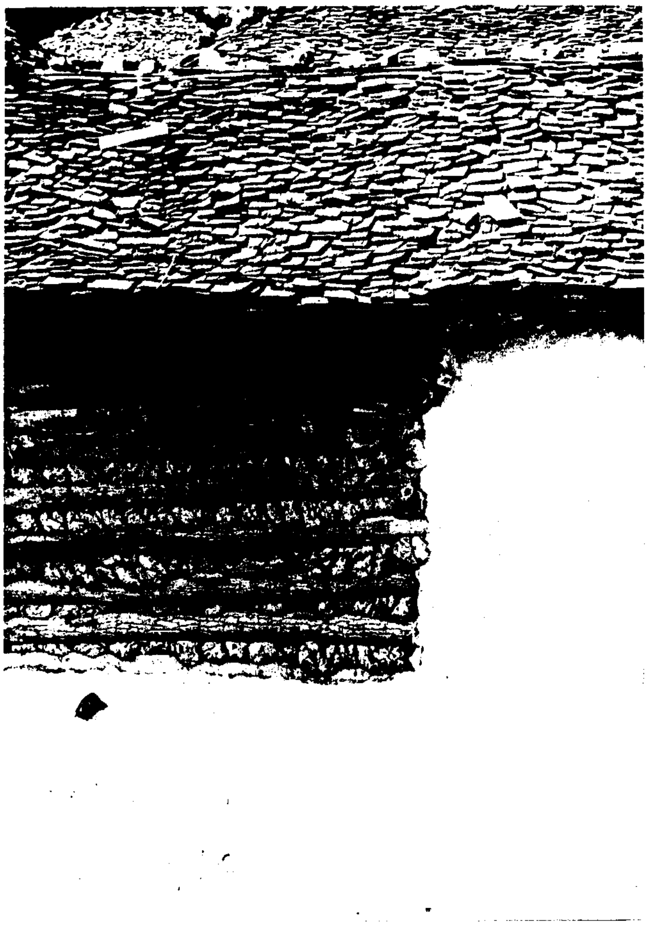


Classification Chart
(Gravel Eliminated)

Masouleh
Soil Profiles



Unrendered log walls are untidy and the mud packing can be washed away.



Section of log wall before rendering after repairs.

The interlocking corner detail on rendered log wall.

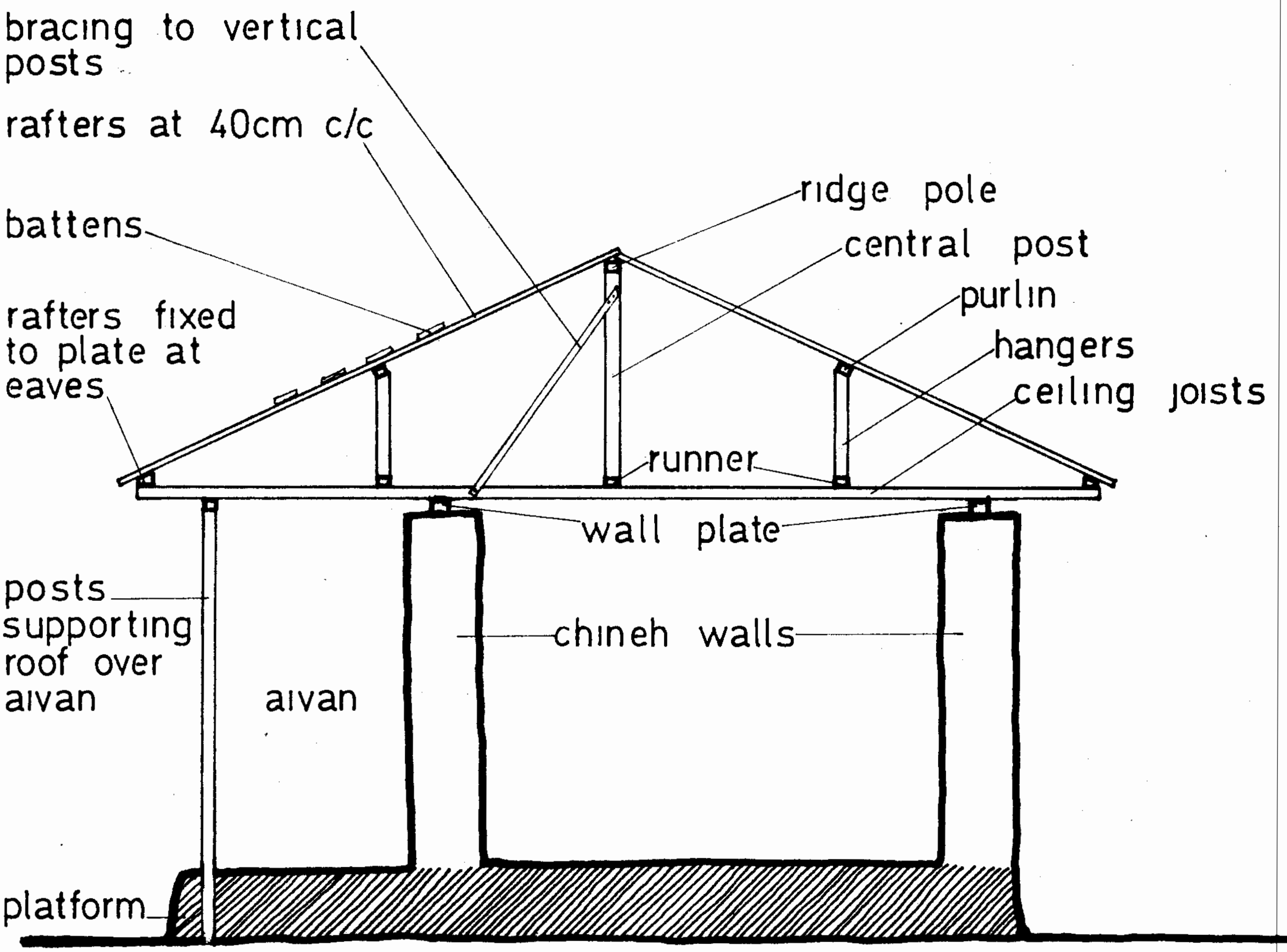
Women repairing the wall render on a Kodir house.

Roof Truss Frameworks:

Roof trusses can be divided into three main indigenous types within the Capsian Region. Subtle variations do occur, which are often the result of the differing skills of local builders and the requirements of different roof coverings.

The roof trusses have been divided here into the following:
A. Shallow pitch (25^{o}-35^{o})
B. Medium pitch (40^{o}-50^{o})
C. Steep pitch (55^{o})

A. The shallow truss type (25^{o}-35^{o}) is used with roof coverings of shingle, tile and sheet metal, although in each case the arrangement of the battens is different.
The roof truss has a vertical central post and hangers on either side, but no struts. The ceiling joists span between the walls and to the framing on the aivan. They rest on a wall plate fixed to the top of the wall. The overhang of the joists varies depending on the covering material and the area: it's between 50 cm. and 1 m. At the eaves is a plate, forming a ring beam round the building, to which the rafters are attached. At the centre of the truss section, and midway along each half, are runners resting on the ceiling joists. These in turn support the central posts and the hangers on either side. The latter are steadied by diagonal braces where necessary. At the top of the central posts the ridge pole is fixed. Purlins are similarly fixed to the top of the hangers. Rafters at approximately 40 cm. centres span from the ridge to the eaves. The fixing of the rafters to the purlins and ridge pole is done with string on simpler buildings; but nails are used where the standard of joinery is better and squared timbers have been used. Battens are either tied or nailed to the rafters. In the case of tile and shingle roofs, the battens are usually small in section (see tile and shingle roofing section), but where sheet metal is used as a covering,

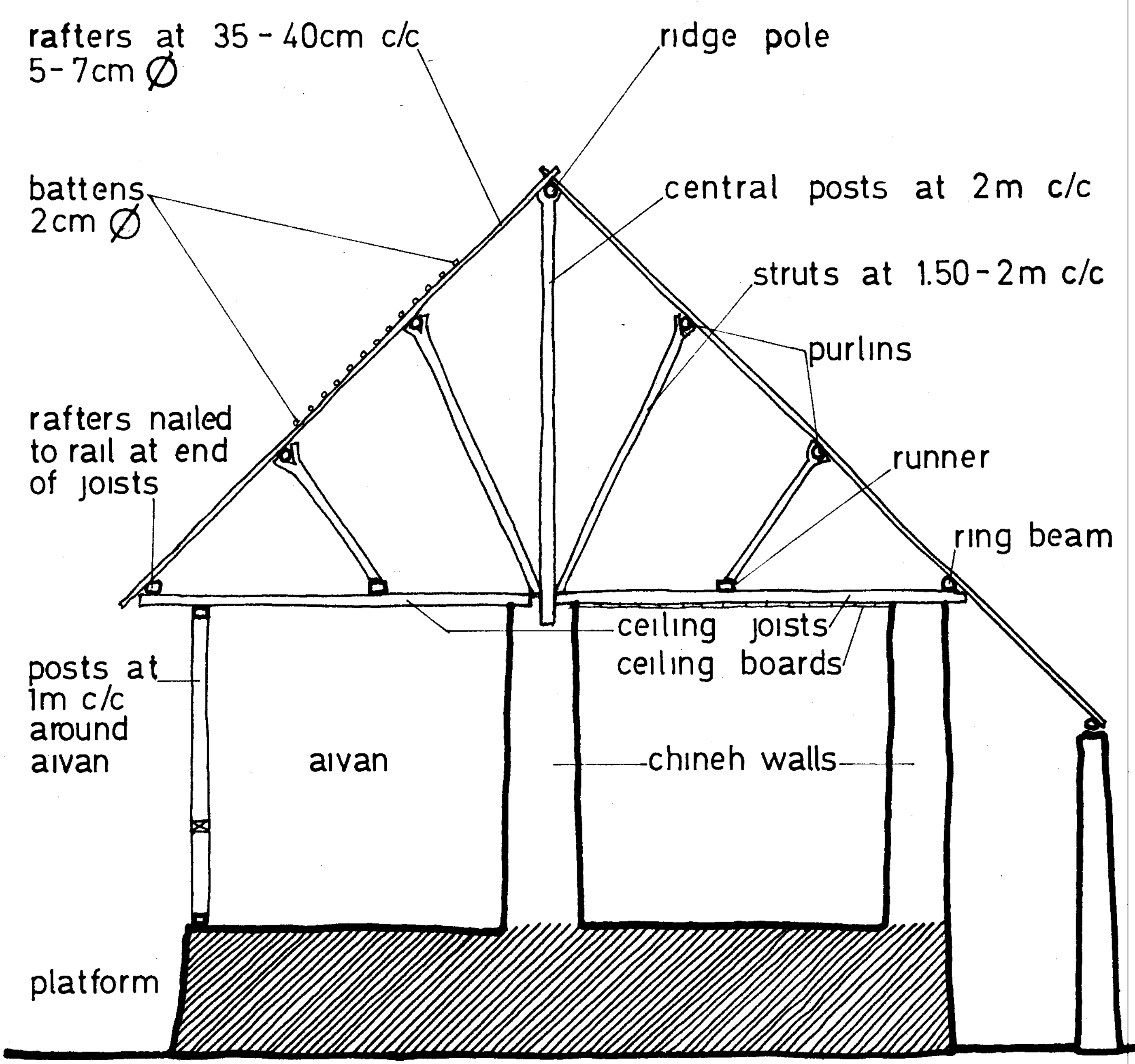


ROOF TRUSS **A** with vertical posts, used on low pitch roofs (25°-35°), with shingle, tile or sheet metal covering. Surveyed in Sar Marz, Mazandaran.

Scale
0 1 2M

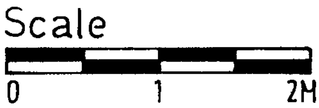
boards are nailed over the rafters to provide a flat surface for the sheet metal to lie on, and a fascia board is nailed to the rafters where they overhang at the eaves. This is covered by metal sheeting, usually with cut out decoration.

B. This is a roof truss with a single tier of struts used on medium pitch roofs (40^{o}-50^{o}). The covering is thatch, mostly of rice stems but sometimes with reed. Ceiling joists span between walls and the framing at the edge of the aivan. On the aivan side these ceiling joists project out 50 cm. beyond the front of the building. At the outer ends of these joists a rail is fixed, forming a ring beam around the building. The central post (as noted in the house of a local builder interviewed) is fixed into the top of the wall dividing the aivan from the rooms. It would be better if this post rested on a beam at the top of the wall, spreading the point load. These posts are at 2 m. centres and continue up to the ridge, where a ridge pole rests on a natural or artificial 'Y' bracket. Thin diagonal wooden braces are used to steady these vertical members where necessary. Round section timber rafters run from the ridge pole down to the eaves. In the Fouman area the rafters at the rear and one side (north and west sides) project down and beyond the walls, to stop about one metre out from the main building. At this point a wall, usually of reeds, connects the eaves to the ground. Rafters are spaced at 35-40 cm. centres. Purlins are attached with a string woven from rice stems, to the underside of the rafters at 1/3 and 2/3 intervals up the side of the roof. After the rafters are in position, struts are put in between the lower purlins and the runners (the runners rest on the ceiling joists) and between the upper purlin and the central wall (see section). These struts provide stiffening to the roof framework as well as resistance to any sag that may occur in the rafters. The battens are attached to the rafters with string. Their spacing depends upon the method of thatching being used (see section on thatching). This truss uses a minimum of sawn timber.



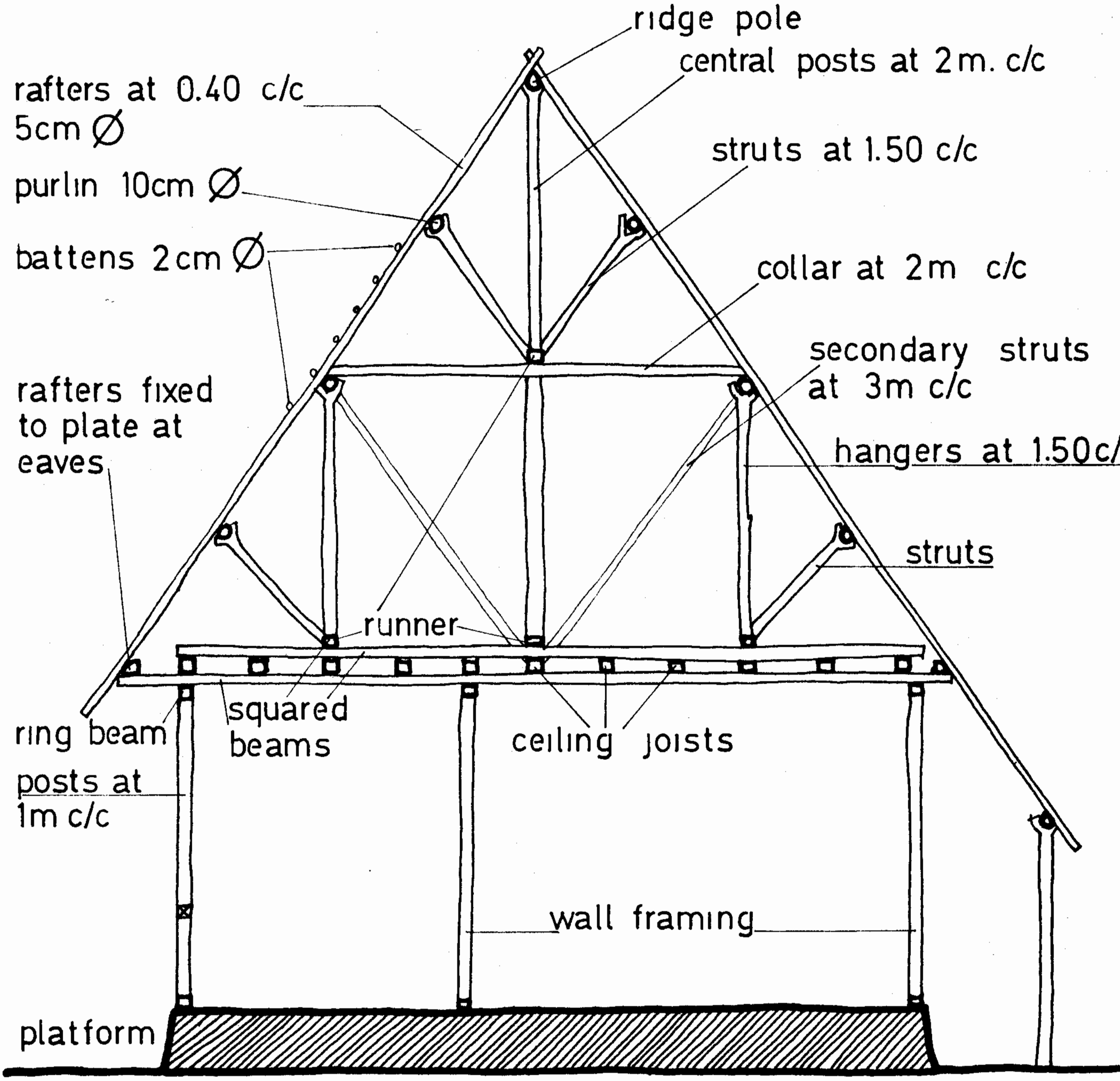
ROOF TRUSS with single tier of struts, used on medium pitch roofs (40° - 50°), with thatch covering. Surveyed in Dogoor, Gilan.

B

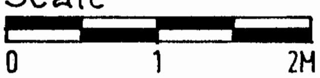


Because of the regular use of struts, the size of the rafters can be quite thin. Compared to a flat roof of similar span, the pitched roof makes economical use of thin poles which are cheaper and easier to obtain.

C. A roof truss, unusual for having two tiers of struts, is used on steep pitched roofs (55^{0}). The covering is thatch, either of rice stems or reeds. In constructing this type of roof the framing of the walls is first capped by a ring beam, over which horizontal squared beams are laid at approximately one metre centres. These beams carry the smaller ceiling joists and plates at the eaves. Another set of squared beams are laid over the ceiling joists. This strong platform supports the runners to which struts, hangers and the central posts are attached (see drawing). For the remaining truss round members are used. Hangers at 1.50 m. centres connect from the runners to purlins half way up the side of the roof. Thin wooden braces are used to steady these vertical members where necessary. Purlins on each side of the roof at this level are connected by a collar supported centrally by a central post. Over the centre of the collar is another runner, in turn carrying the upper half of the central posts. At the ridge is a horizontal pole (the ridge pole) on which rest the rafters, at 40 cm. centres, coming up from the eaves on either side. When the rafters have been put in place, additional purlins are added under the rafters at 1/4 and 3/4 distances up the side of the roof. Between these purlins and the runners below, diagonal struts are placed, spaced at 1.50 m. centres. The bracing effect of these struts provides stiffness and rigidity to the rafters and framework in general. Additional secondary struts are placed at 3 m. centres between the purlins half way up the side of the roof and the runner below the central post. Purlins, rafters and battens are all attached with string. Nails are used at the foot of the struts and hangers. Battens are laid horizontally on the rafters. Their spacing varies depending on the type and method of



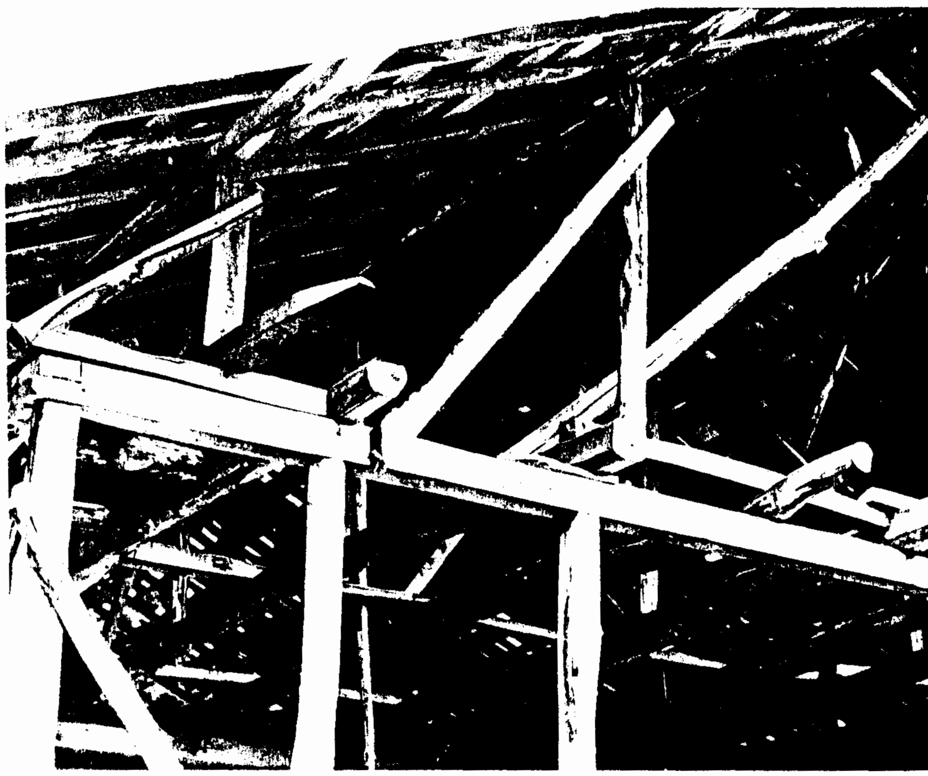
ROOF TRUSS **C** with two tiers of struts, used on steep pitched roofs (55°), with thatch covering. Surveyed in Shijan, Gilan.

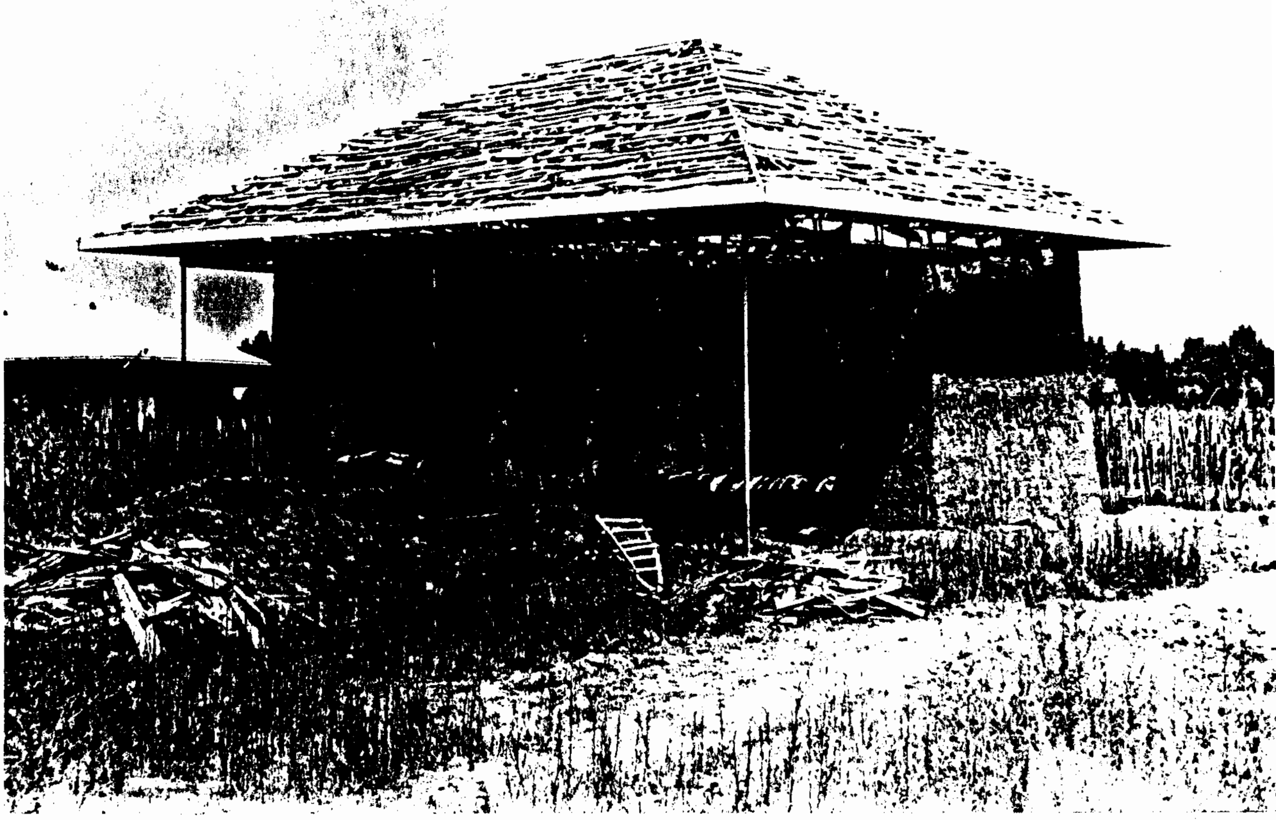


thatching. Reed thatch has battens spaced at 20 cm. centres. For rice thatch the spacing can vary, depending on the method of fixing used (see section on rice thatching process). Particularly through the use of the double tier of struts, this truss makes use of relatively small poles to provide a large roof area.

Detail of truss framework for a sheet metal roof (Qaleh Rud Khan). The central supporting post is seen in the middle.

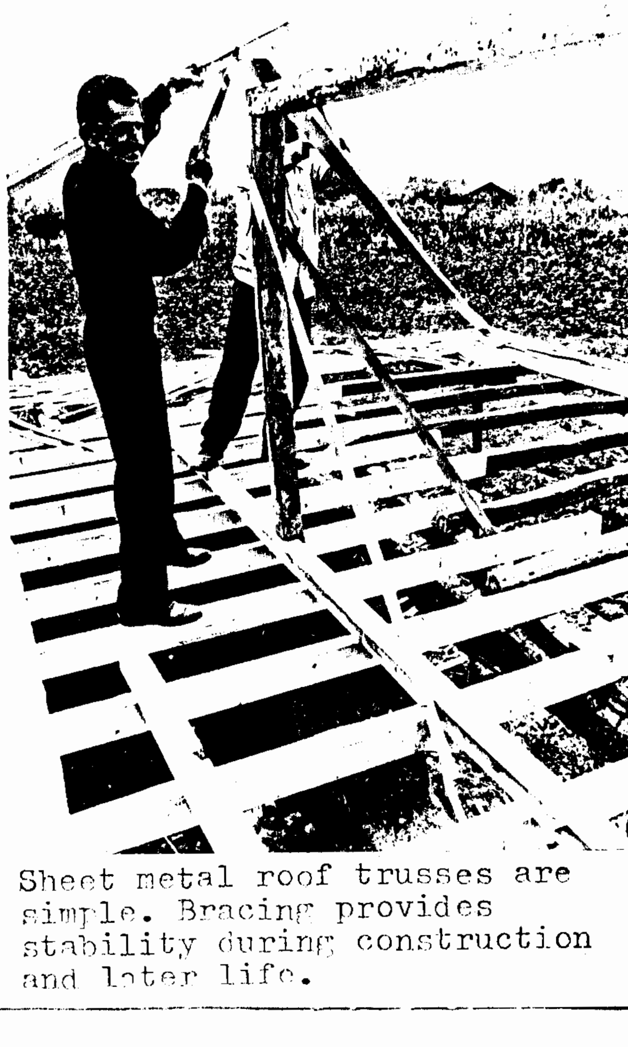
Diagonal bracing is used within the roof framework to provide rigidity.





Boarding covers the roof framework, ready for a sheet metal covering.

Ceiling joists support the roof framework.



Sheet metal roof trusses are simple. Bracing provides stability during construction and later life.

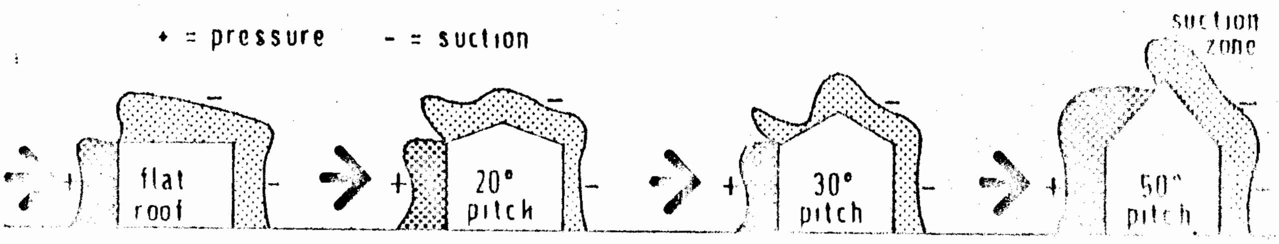
Analysis of Roof Trusses

With many traditional building methods, the builder makes use of his empirical knowledge accumulated and passed down through generations of experimentation, based on trial and error. The result is often extremely accurate. But to understand the behaviour and requirements of a roof framework, it is helpful to take an analytical approach. This can assist in locating areas needing improvement.

In the calculation of loads applied to a roof truss, various factors are taken into consideration. The <u>dead load</u> of the roof consists of the roof covering (thatch, shingle, etc.) and structural members (rafters, purlins, posts and fixings). The <u>live loads</u> of the roof are the changeable loads (snow, windload, maintenance workers, etc.). The sum of these two allow one to calculate how strong the roof must be, and how heavy, which in its turn affects how much load the walls and foundations will have to carry.

These loads vary according to the degree of pitch on the roof. Snow load decreases with increase in pitch. For example, for a roof at 25^{o}, if the snow load was calculated at $1.4KN/M^2$, the equivalent for a roof at 50^{o} pitch would be only $.4KN/M^2$ - slightly less than 1/3. It is usually necessary to design for the worst condition possible. In the cases of snow load, this is not the product worked out from the average amount of snow over a period of time, but the likelihood of the amount of snow that will collect on the roof during heaviest snowfall.

For a constant wind velocity, wind load increases according to pitch. Additionally, wind will exert pressure on some parts of the roof and suction on others. Higher suction and pressure occur at the edges of the roof. Steeper



The effect of wind on buildings

pitches suffer less from this effect than do lower pitch and flat roofs, where suction on the windward side and edge can be considerable. On lightweight, shallow pitched roofs (e.g. sheet metal cladding at 25°) considerable care should be taken that the roof is not damaged by this effect. Sheeting can be stripped off in high gusts of wind. In consideration of this, the lighter roof covering does not necessarily reproduce benefits in lightness of supporting structure, since the framing must be capable of withstanding these additional pressures. A tile roof, provided it is securely fixed to the battens and cemented at the ridge and eaves (as in Astara tile), can assist in stabilising the roof structure by its added weight, counteracting the suction effect of the wind. In short, the economy in structure provided by using a lightweight roof covering is limited.

To assist also in counteracting the effect of wind, most rural houses in the Caspian Region are protected by shelter belts of trees (see micro-climate and the house).

The roof framework itself must be able to resist both the dead and live loads.

The roof trusses used in the Caspian Region are nearly all variations of the conventional strutted purlin roof. This is an economical form of roof when there is a central partition to support the framework along its length. By making use of purlins which provide support to the rafters, the effective span of the rafters is reduced and they can consequently be formed from smaller members than would have been necessary in the absence of purlins. Individual timber members can be considerably thinner than those used in a flat roof of similar span.

However, most of the members in the trusses shown are in compression (fig. a). Those members must be strong enough to carry the loads applied on them without deflection or failure. Equally, the point loads, as at the base of the central posts, must be effectively transferred to the structure below. It has been noted in Truss B that the central post was placed directly into the top of the chinch wall. Although this detail is not universal in the area, it is worth illustrating as a particularly weak point. The post can sink down into the mass of the wall. It should be restrained by a plate along the top of the wall, which would spread the point load over a larger area. In the event of this central post moving downwards, the joints at the eaves will come under greater tension and are also likely to fail.

Another area of weakness commonly occurs at the foot of the struts. These members are in compression, carrying the load from the purlin and rafters above. The nature of this problem can best be illustrated by a simple triangle (fig.a). Sides A and B are in compression, carrying the load of the roof, A being the rafter and B the strut. C, the ceiling joist acting as a tie bar, must act to restrain this downward and hence outward movement. The joists at E and F are in tension when no blocking is provided to resist the compression of A or B; in the event of failure this would allow, for example, B the strut to move outwards. It was commonly observed that this joint was formed by simply nailing the foot of the strut to the runner or joist below as in fig.b, at an oblique angle. This is likely to be insufficient to restrain its movement. A method must be used that will provide a counteracting force to this potential movement, e.g. provide a compression joint. In considering this, and in the context of other joints within the roof frame, it must be remembered that the dead load and the snow load apply a predominantly downward force, which put

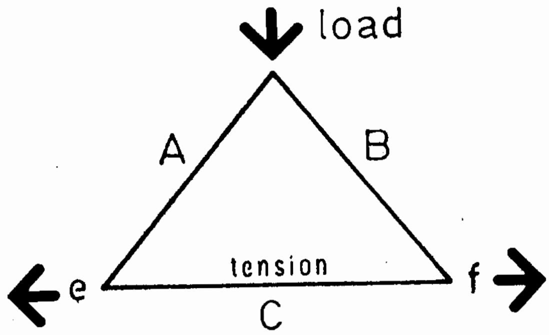


fig. a

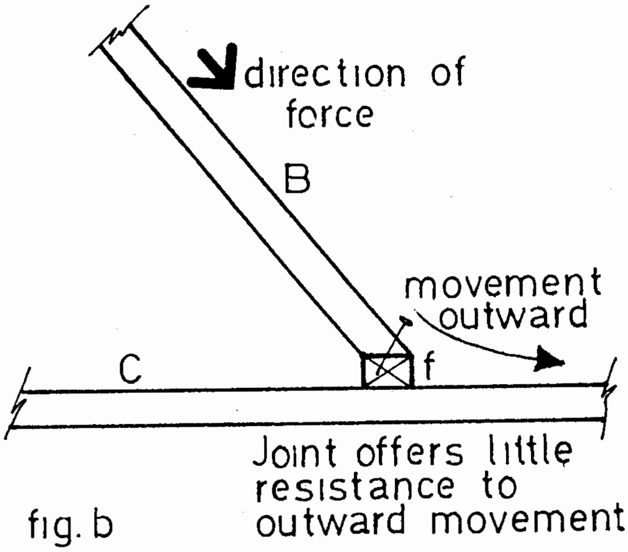


fig. b

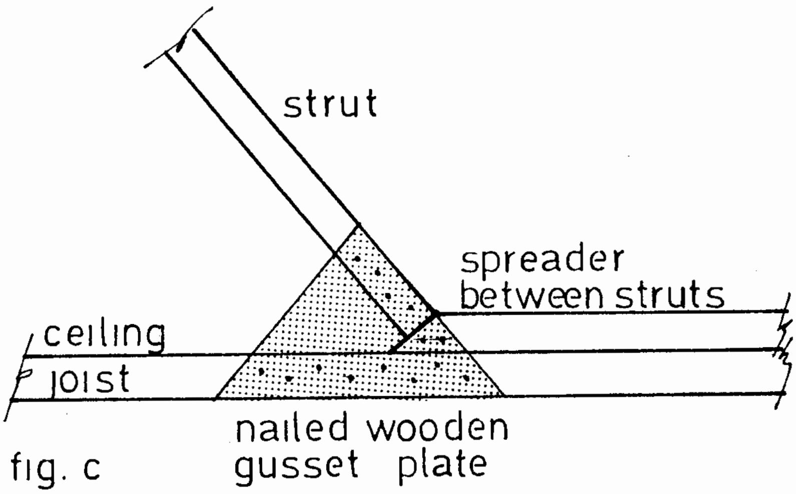


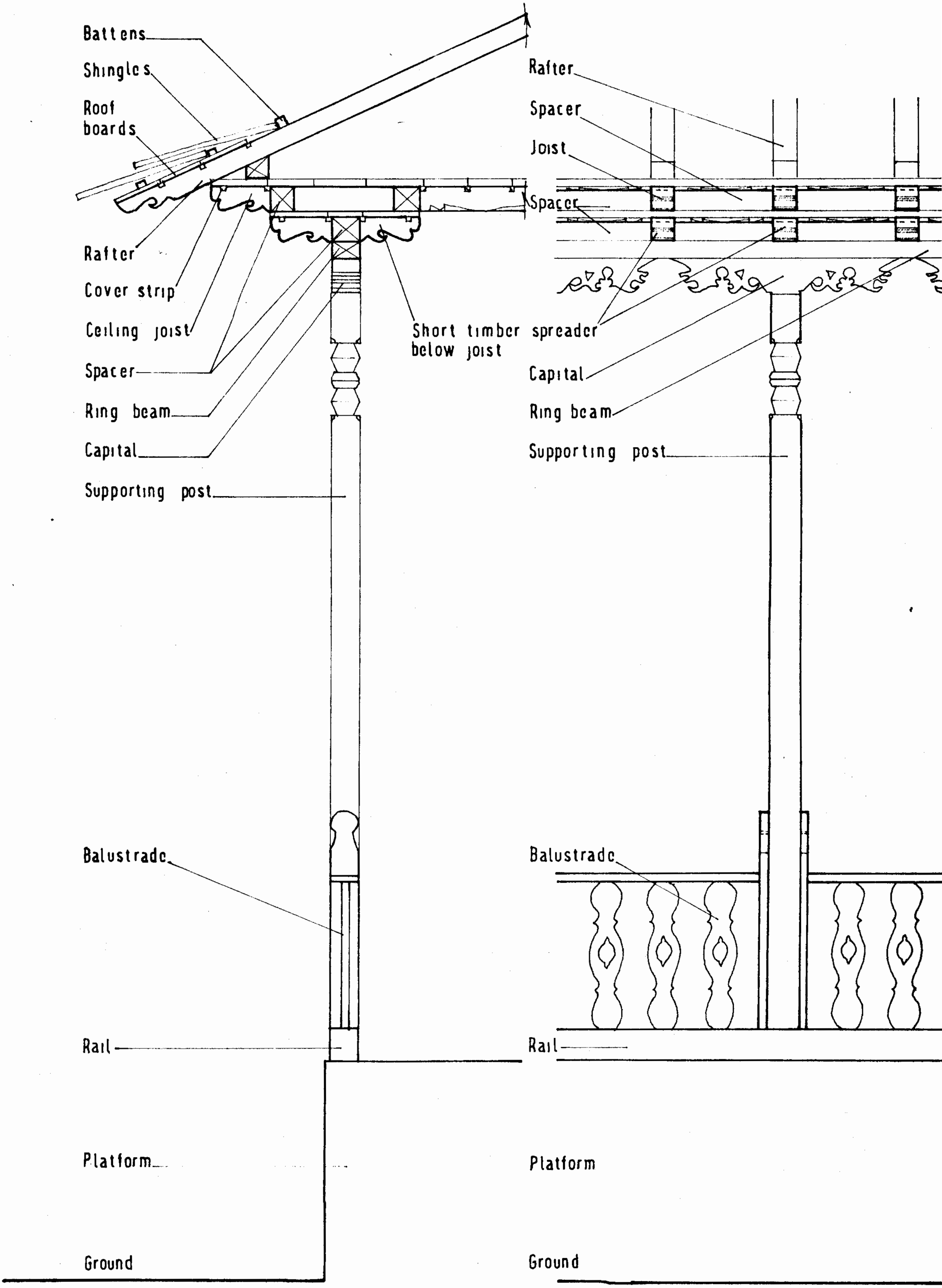
fig. c

members such as the strut mentioned above in compression. However wind loading exerts different forces: suction, which can lift the structure, and an overturning effect caused by pressure on one side of the roof. Both these can alter the stresses in the framework - joints normally in compression can be reversed and be in tension. This effect will furthermore be intermittent, so that joints and members will be potentially in compression at one time and tension at another. In effect, a joint is likely to be shaken at any time by a force contrary to the one it is already subject to. This situation is vastly exaggerated in an earthquake.

Rigid joints as illustrated above should have proper blocking against which the member can push. This ideally could be provided by a spreader connecting from the foot of the strut at one side to the foot of the strut on the other side (fig.c). The member upon which it rests should have its connecting surface at a right angle to the forces against it, and preferably some form of gusset connector should be used to link the strut to the joist, providing resistance to tension occuring when suction is applied to the roof surface (fig. c). In the shallow pitch roofs hangers are used which transfer the load vertically down onto the ceiling joists. This provides a more stable connection - the two members being at right angles to each other. Many joints used in the roof structure are simply bound tightly together with rope. This rope in most cases is made from locally available materials - rice stems, reeds, split wood (used in thin strips). Tight lashing of two poles provides an adequate joint, and in addition allows the members some movement. The joint is more in harmony with the inherent movement of both timber itself and the whole roof structure, and does not fail when this movement occurs. On the other hand, such lashings deteriorate quite rapidly and need to be maintained or replaced periodically. It should be noted that the strength of the joint dictates how strong the whole framework will be (stress is concentrated at these points).

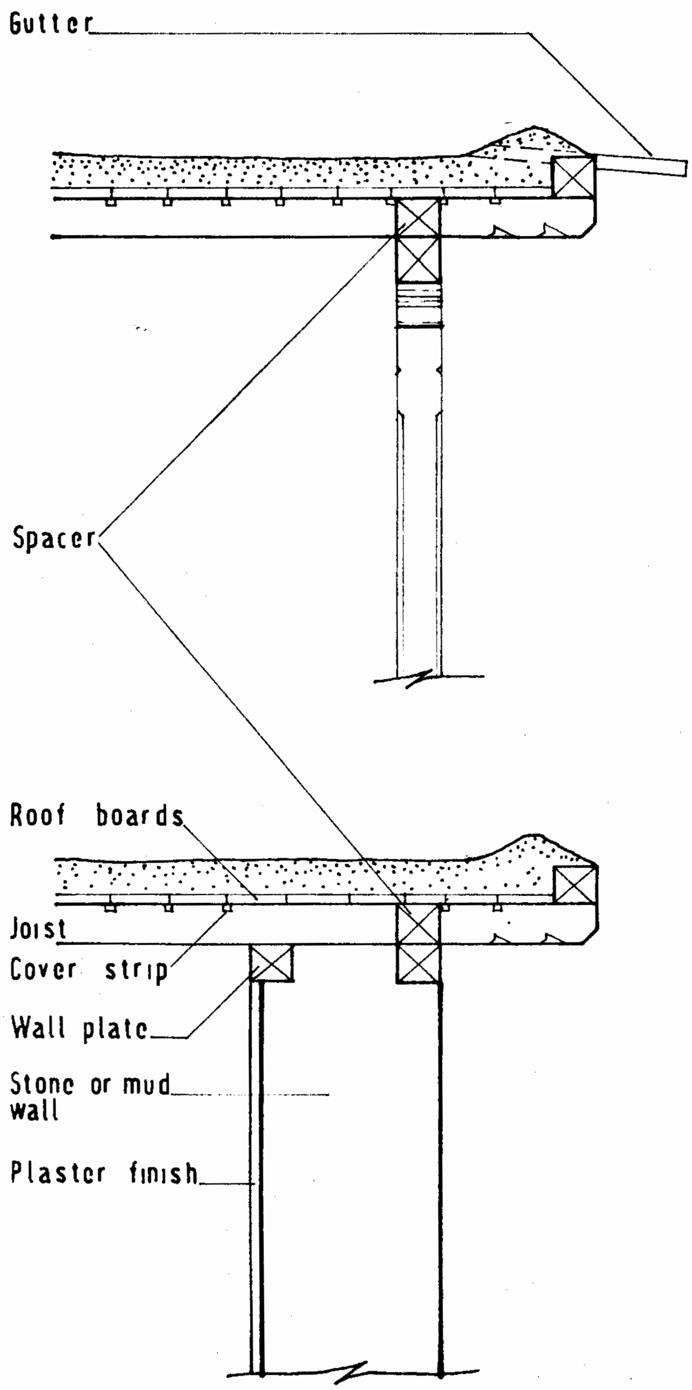
Vertical members in the truss should also be provided with lateral bracing, particularly to resist unusual forces (e.g. not the expected dead and live loads) such as occur in earthquakes. This bracing has been noted in many of the roof frameworks, but should be universal.

The problems of connecting members together in the roof framework apply particularly when untrimmed poles are used. More sophisticated connections are possible when squared timber is used. As an example of joinery, the standard at Kodir and Kojur is excellent. However, it is worth stressing again that joints between members in all parts of the building are extremely important and should be made with care.

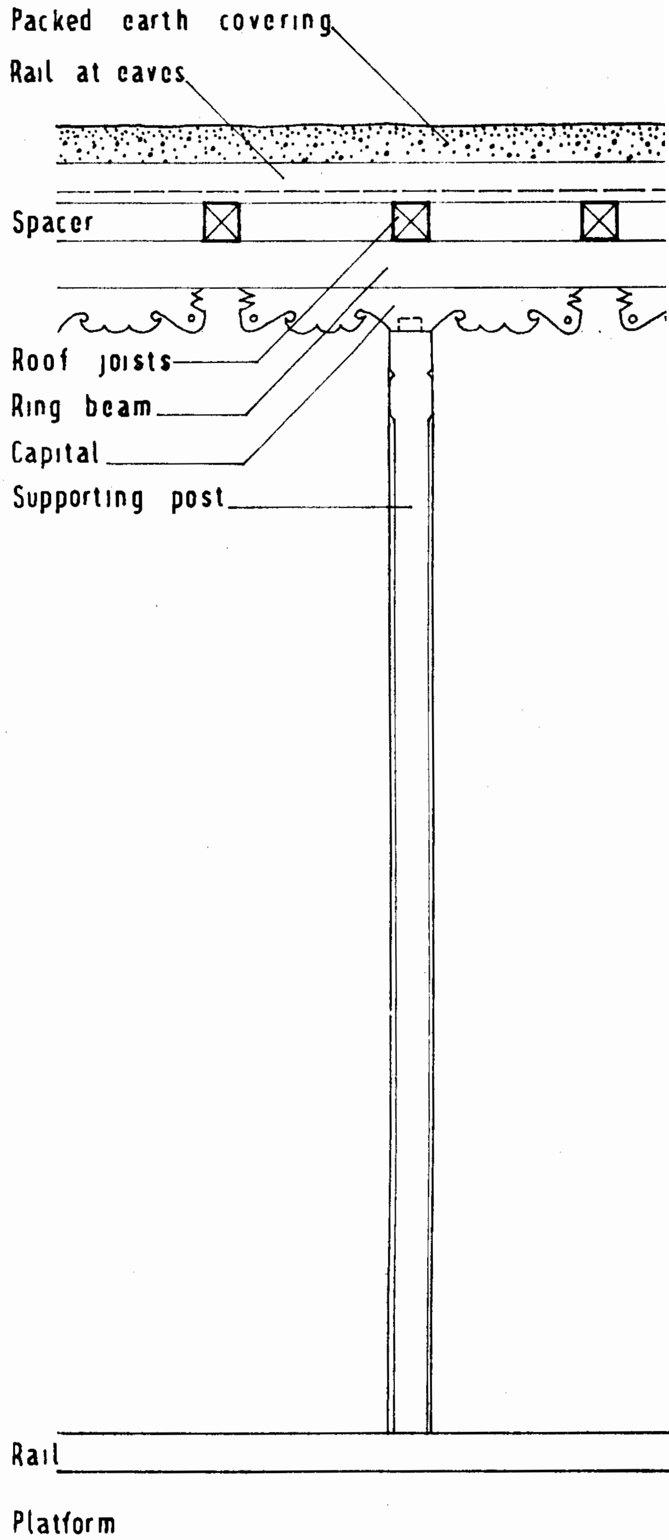


PITCHED ROOF EAVES DETAIL. Surveyed in Kodir, Mazandaran.

Scale



SECTIONS

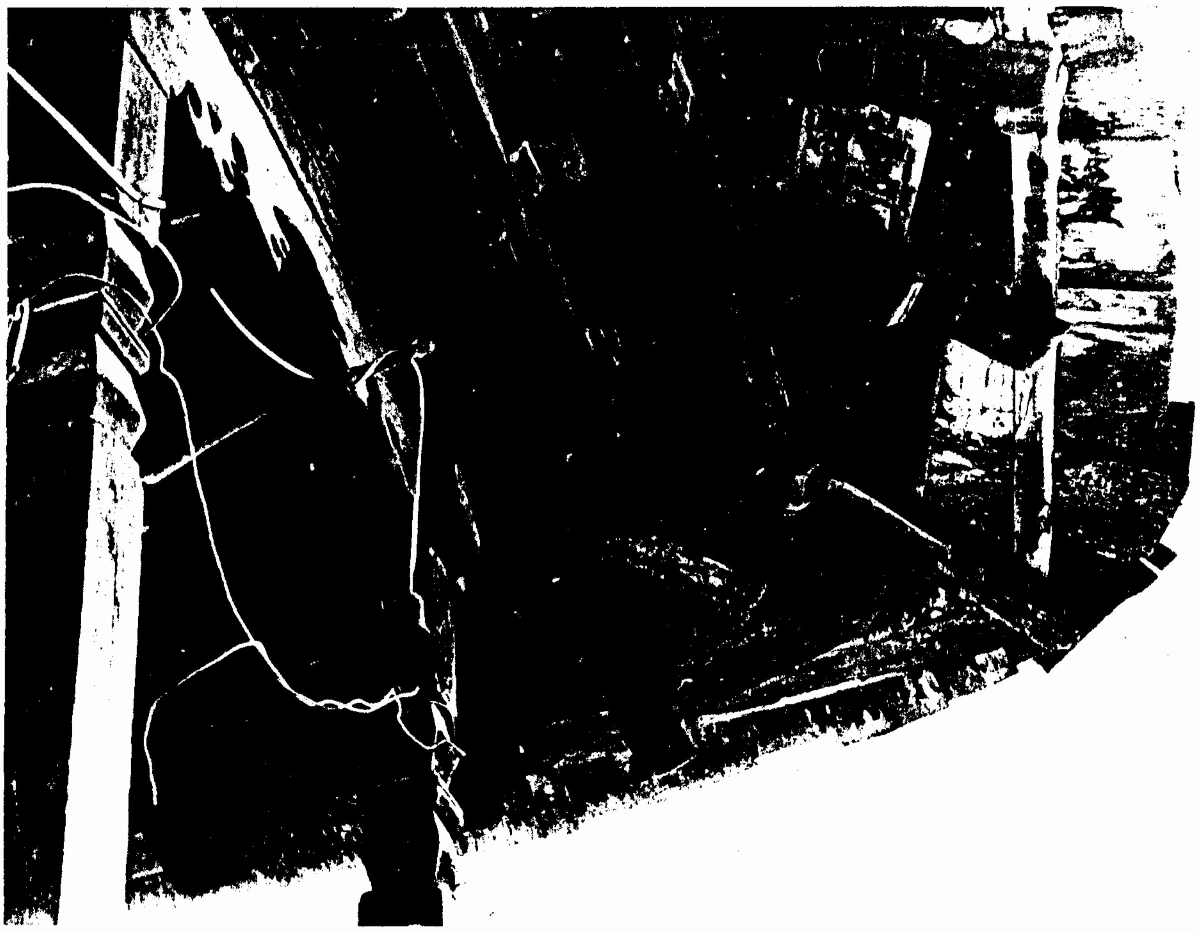


ELEVATION

FLAT ROOF EAVES DETAILS. Surveyed in Kojur, Mazandaran.

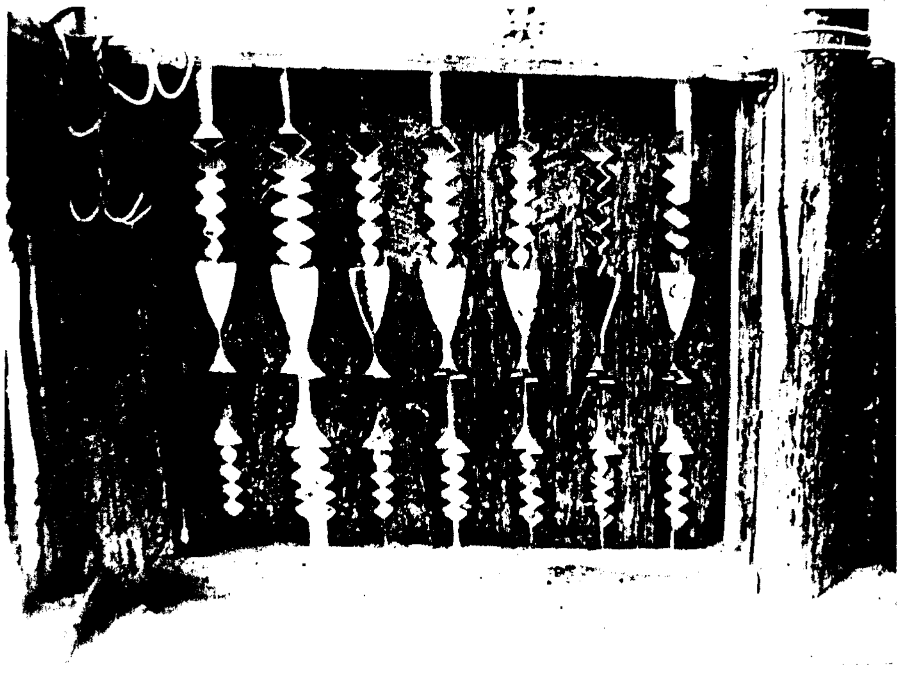
Scale
0 0.50 1M

Detail of joinery at the eaves of the Khan's house in Kodir.

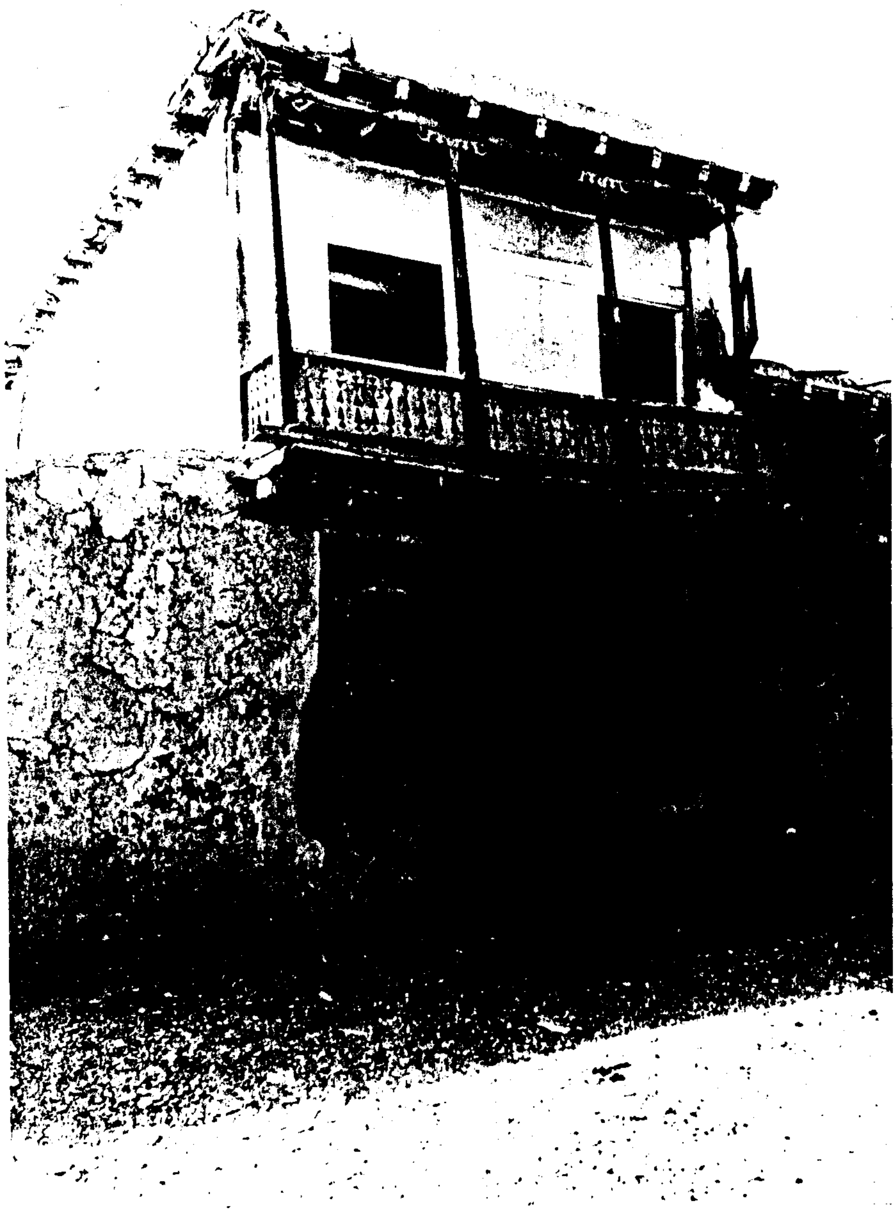


Eaves detail at the corner of the roof. Shingles can be seen projecting out beyond the roof framework.

Timber detailing in Kodir is of extremely high quality. Capital and eaves detail of Khan's house.



Balustrade detail.



House front in Kojur with carved wood balustrade, capitals and eaves.

Detail of carved capitals. Kojur.

Thatch:

There are two types of thatching material in the Caspian Region: reed thatch and rice thatch. Where it is available, reed thatch is preferred to rice thatch since the rice stems can be used for animal fodder and for making handicrafts such as mats and baskets. Reed thatch also lasts almost twice as long as rice thatch and is less susceptible to attack by rats and mice. However, with the reclamation of marshland and the channelling of irrigation water in concrete pipes the availability of reed has been reduced, and rice thatch is in more widespread use. This type of thatch occurs primarily in the rice growing plains of Gilan between the marshes and the foothills.

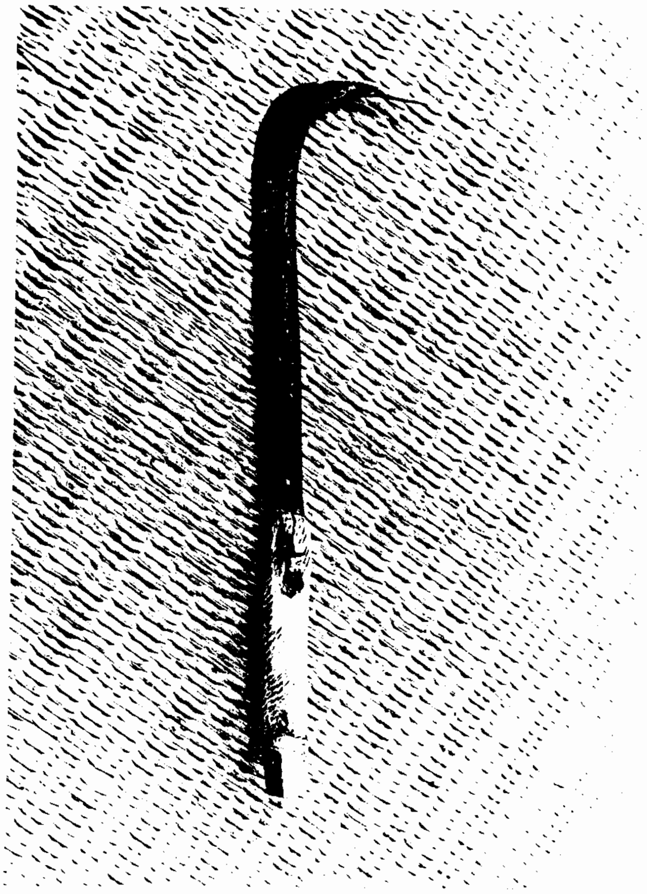
There are two methods of rice stem thatching. In both cases, after the harvesting the rice is removed from the stem by beating with a large wooden mallet. The stems are collected in large bundles either for home use or for sale (200 to 300 rials per 50 bundles). A one hectare field produces about 480 of these bundles. Large bundles are divided into half kilo sheaves for use in thatching (kuloosh).

A $100m^2$ house with a 55° roof pitch and a $170m^2$ surface area takes about two days to cover, employing six men: two men involved in transporting and preparing the bundles, one in throwing bundles to the men on the roof, two in fanning the bundles out and one man in fixing the bundles. Annual maintenance consists primarily of tightening the ropes holding down the thatch on the ridge, with new rope used if necessary. Although a rice thatch roof lasts about seven years and even up to twelve years where a large quantity of bundles has been used to provide a thick thatch, replacement is an ongoing process; each year old bundles are removed and new added, so that it is not necessary to replace the whole roof at one time.

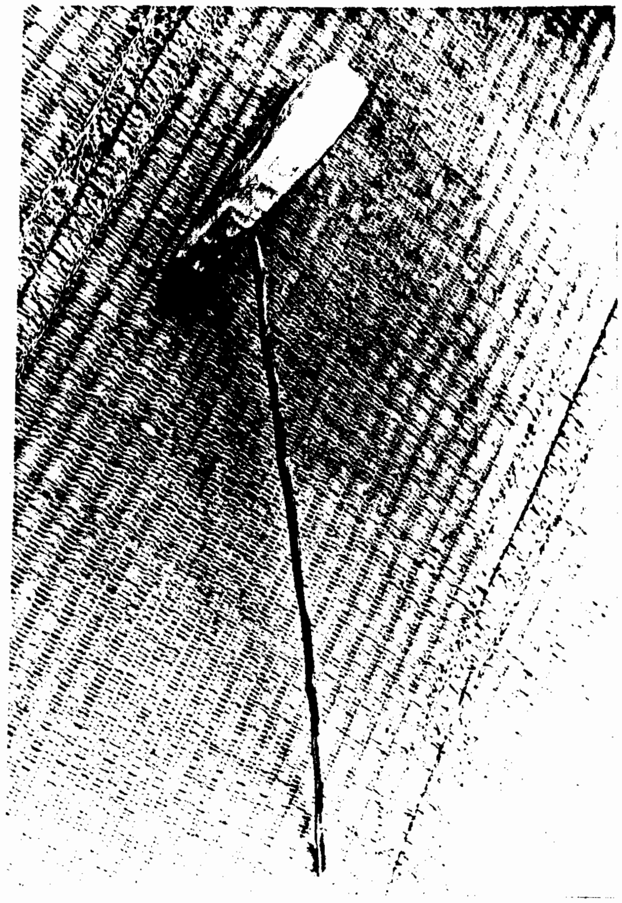
There are a number of problems with rice thatch roofs, fire being the most serious. Suggestions for fire retardant processes are made in the section on preservation of timber. The thatch also harbours insects (especially bees), rats which destroy the rice stems, and snakes which, according to the local people, do no harm and eat the rats. Older roofs, in addition, become dirty, and during high winds and rain dirt and particles of rice straw fall into the rooms below. High winds, common during the autumn, can damage the roof. Protection against this is provided by the trees which surround nearly every house and act as wind breaks.

On the other hand, since most people in the areas with rice thatch grow their own rice, much of the thatch required for annual maintenance is free. While the upkeep of such roofs require some attention and labour each year, the capital cost of such roofing is low. Furthermore, thatch provides good insulation against extremes of temperature since still air is trapped within and behind the thatch, and air itself is a poor conductor of heat or cold. This allows the roof space to be used for food storage, which was pointed out by local people interviewed as being an advantage over the use of sheet metal roofing.

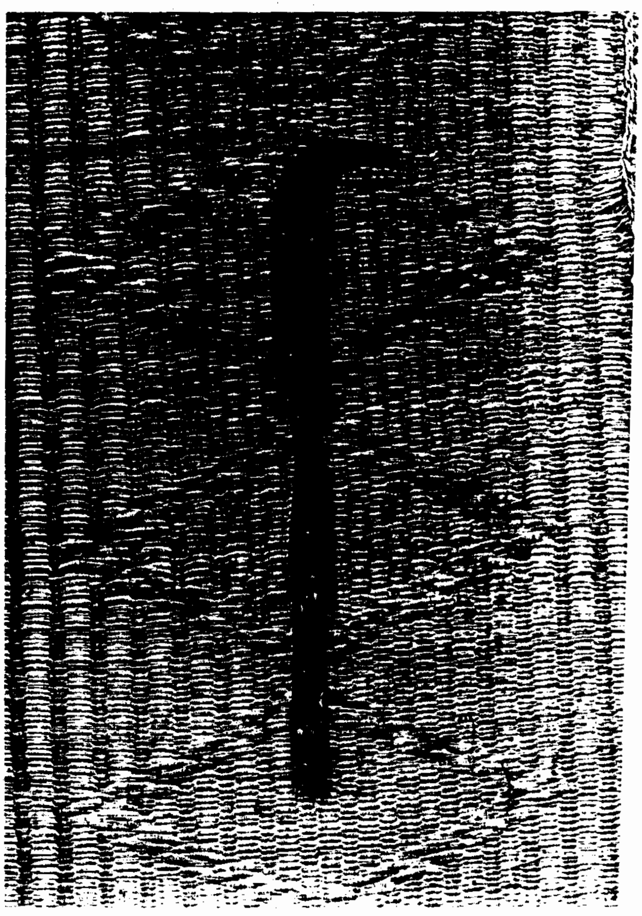
Many people desire to change from the use of thatch to sheet metal, which, while involving a greater capital cost, requires less maintenance.

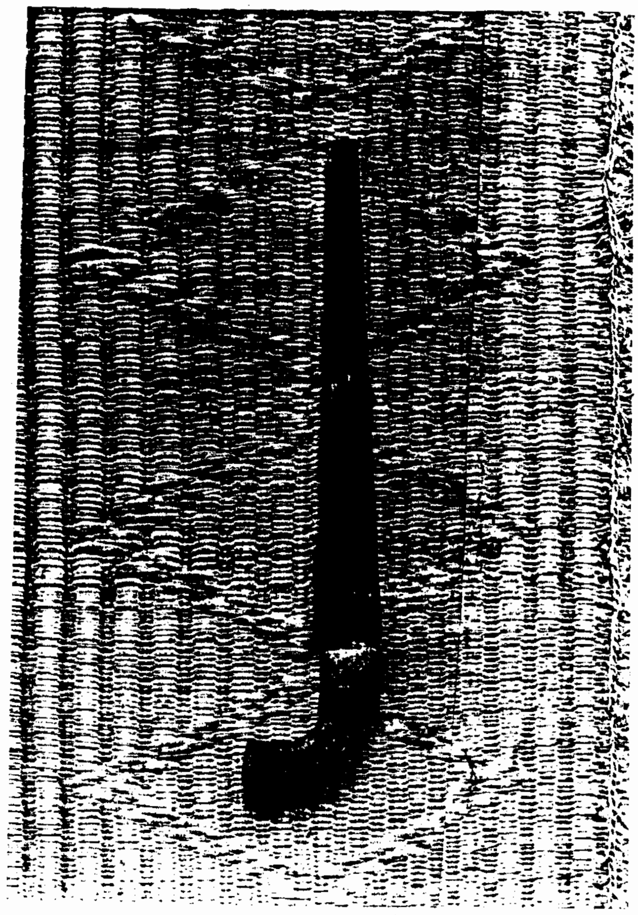


Above and below: billhooks for cutting branches and rice.



Mallet for removing ricefrom stems.





Hand saw

Rice thatch held between two battens (Sumesara/Dogoor area)

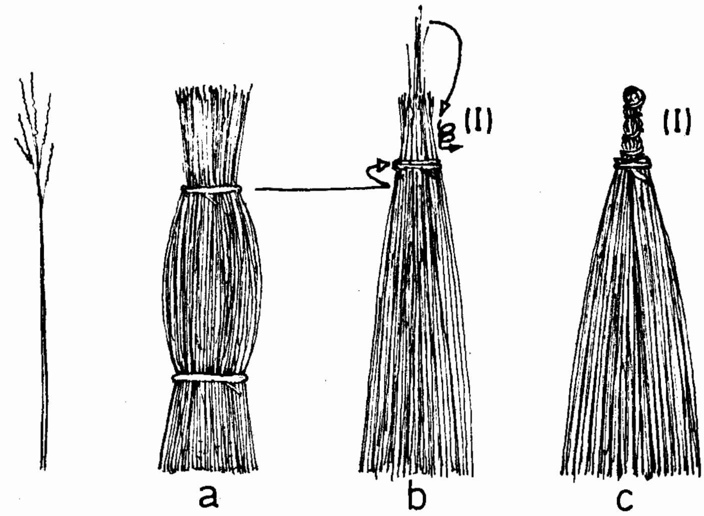
Rice stems are bundled into sheaves weighing approximately half a kilo. These sheaves are bound top and bottom with string, also made from rice stems (fig. a).

To prepare the sheaf for use in thatching, the string near the top is moved slightly nearer to the end and tightened. A handful of stems are pulled out beyond the end of the sheaf, and are then pulled down and wound tightly round the top of the sheaf (fig. b & c). The sheaf is then thrown to the roofer who unties the lower binding string, fans out the stems and pushes the bound top between the battens on the roof (fig. d). The battens are at 15 cm. centres. The distance between bundles along a batten is on average 30 cm. The bundles below are spaced in between the bundles on the batten above (fig. e).

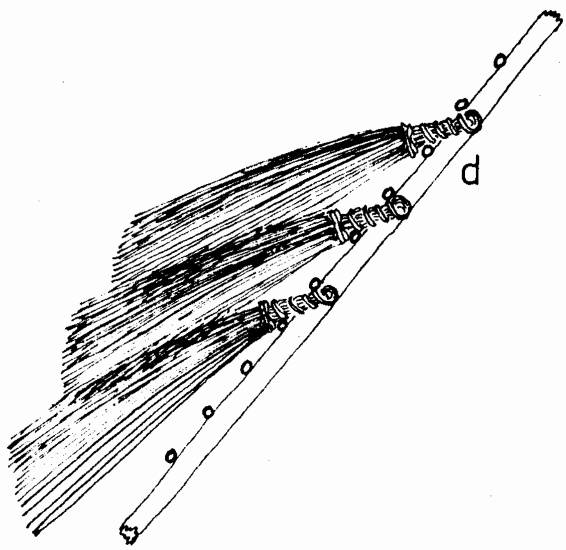
At the ridge, the thatch is held in position by string laced over from one side of the roof to the other and attached to poles pushed through horizontally below the ridge. This rope must be tightened annually and replaced when necessary to ensure the good condition of the roof. If the rope is loose, the high winds can remove the thatch.

RICE THATCH HELD BETWEEN TWO BATTENS (Dogoor)

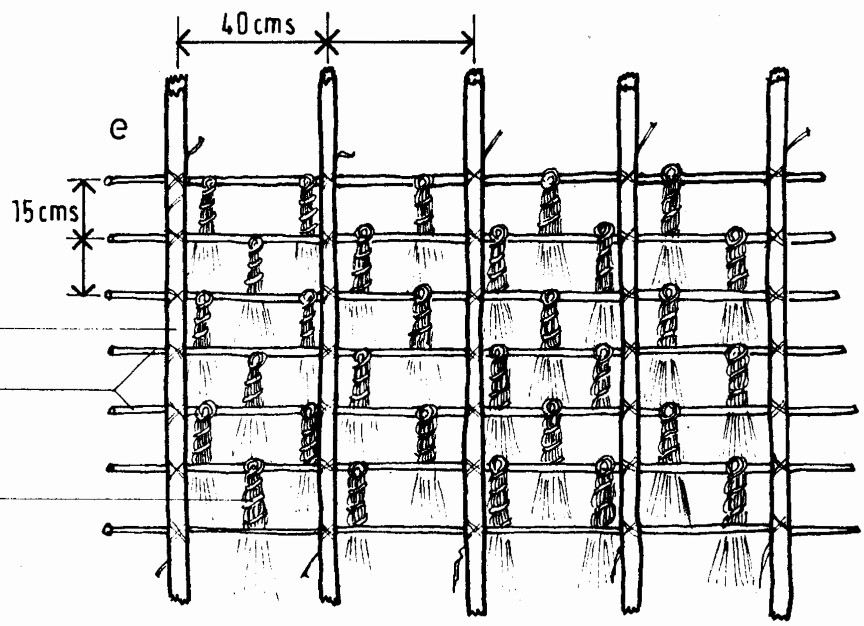
Sheaves of rice stems
a. bundle as stored
b. preparation of bundle for thatching; stems pulled out and bound round top of bundle (1)
c. bundle ready for use

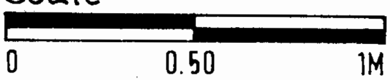


d. bound tops pushed between battens



e. spacing of bundles

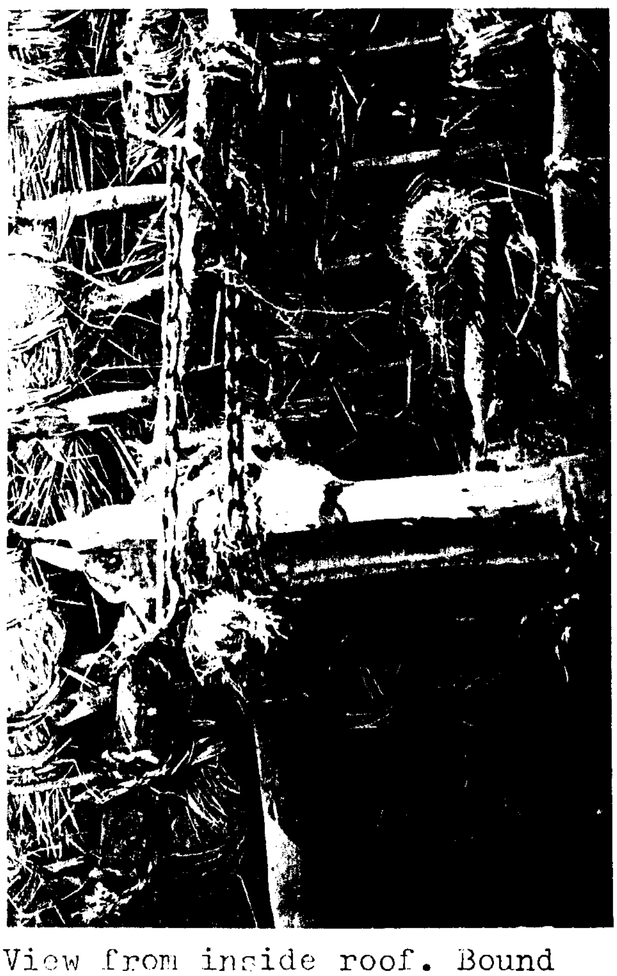




Above: a handful of rice stems are pulled out above the top of the bundle.

Projecting stems are pulled down and bound round top of bundle.

Bundle ready to be passed to roofer.



View from inside roof. Bound tops of bundle projecting between battens.

Detail of the bound tops of rice thatch bundles, with supporting battens.

Overhanging eaves at west end of thatch roof.

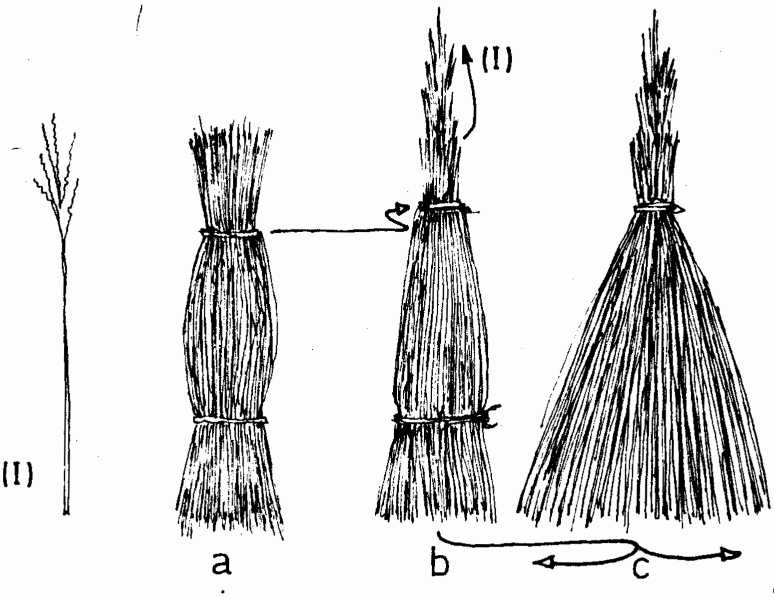
Roof timbers bound with string.

Rice thatch tied to battens (Shanderman)

Rice stems are bundled into sheaves weighing approximately half a kilo, all lying with their top at the same end, and bound near each end with rope also made from rice stems (a). Before being passed to the workers on the roof, the top binding string is moved up slightly towards the end and tightened. A handful of stems are pulled out 30 cm. beyond the edge of the sheaf (b). The sheaf is thrown to the roofer who unties the binding string at the lower end and fans out the stems (c). At the top end the stems that extend beyond the top of the main bundle are tied round the battens on the roof (d). These battens are spaced at 30 cm.

The method for securing thatch at the ridge is the same as that used on the "Dogoor" method of thatching.

RICE THATCH TIED TO BATTENS (Shanderman)

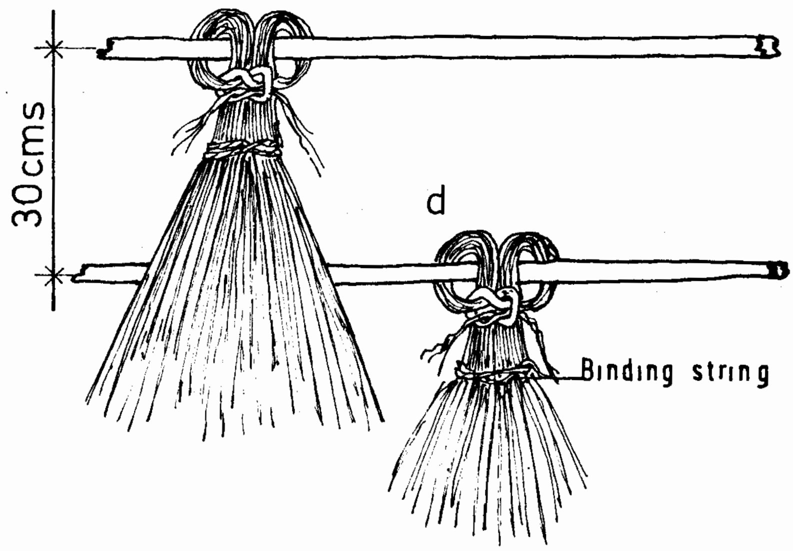


Sheaves of rice stems

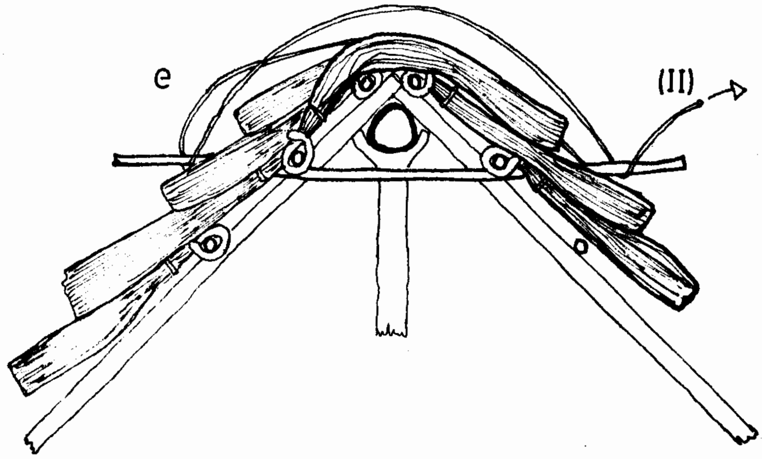
a. bundle as transported

b. bundle as thrown to roofer; stems pulled out for tying to battens (I)

c. bottom binding string removed; stems fanned out



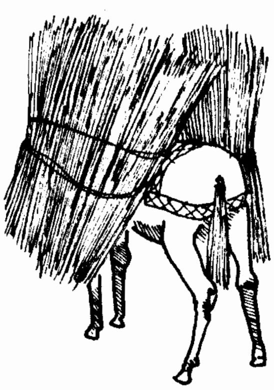
d. tying of bundles to battens



e. fixing at ridge with string laced over thatch (II)

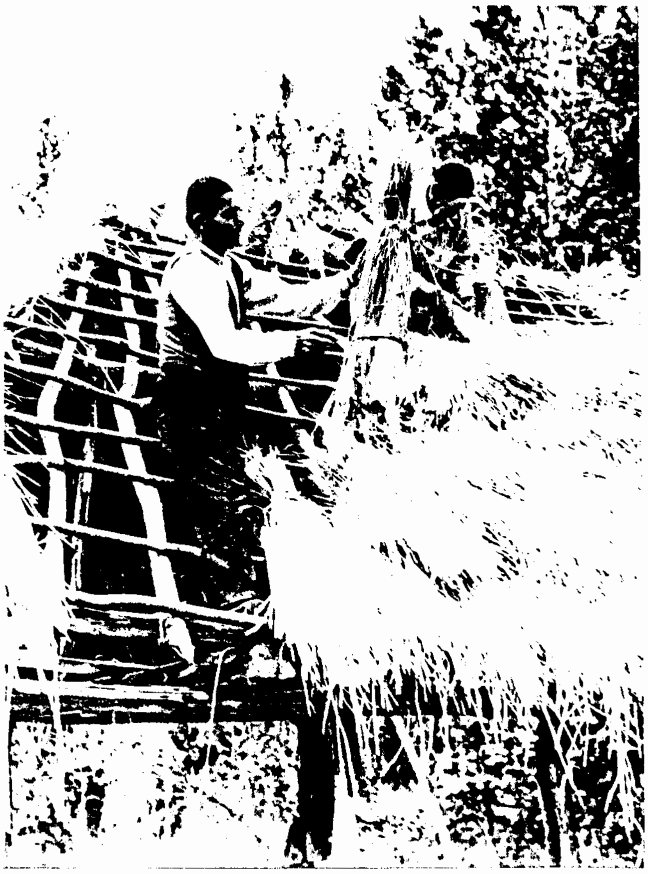
Scale for a, b, c & e.

0 0.50 1M



Transport

Rice stem thatch in the Shanderman area is tied to battens. These photographs show the process, looking up from the underside of the roof.



Rice thatch bundle being received by the roofer.

The stems are fanned out in position.

New thatched house with packed mud walls.

Reed thatch (Shijan)

Reeds are bundled together into sheaves and tied near the top and bottom (fig. a). Prior to being used on a roof, the top binding string is moved up slightly towards the end of the sheaf and tightened. A handful of reeds is pulled out roughly 30 cm. beyond the top, and pulled down and wound round the top 20 to 25 cm. of the main sheaf (figs. b & c). The sheaf is passed to the roofer, who places it on the horizontal battens of the roof so that the top binder is just above the batten. The bound end of the sheaf is then pulled down behind the batten and tucked in front of the lower batten 20 cm. below (fig. d). The ridge is bound over with rope, attached to poles pushed horizontally through the roof just below the ridge. At the eaves, the lowest layer of thatch is of rice stems which, being shorter than the reed, are covered on the outside by the layer of reed thatch immediately above.

Near the marshland north of Sari reed thatch roofs have horizontal bamboos placed over the thatch, tied through the thatch to the inner framework with string. These battens serve to hold the thatch tightly in place (fig. e).

Reeds take four to five days to dry after cutting before they can be used. A two room house takes three to four days to thatch, with five to six workers. The organisation of labour is the same as it is for rice thatch.

Reed thatch lasts about fifteen years but replacement is an ongoing process.

Reclamation of marshland in Mazandaran has reduced the supply of raw material, and nearly all new buildings are roofed with sheet metal.

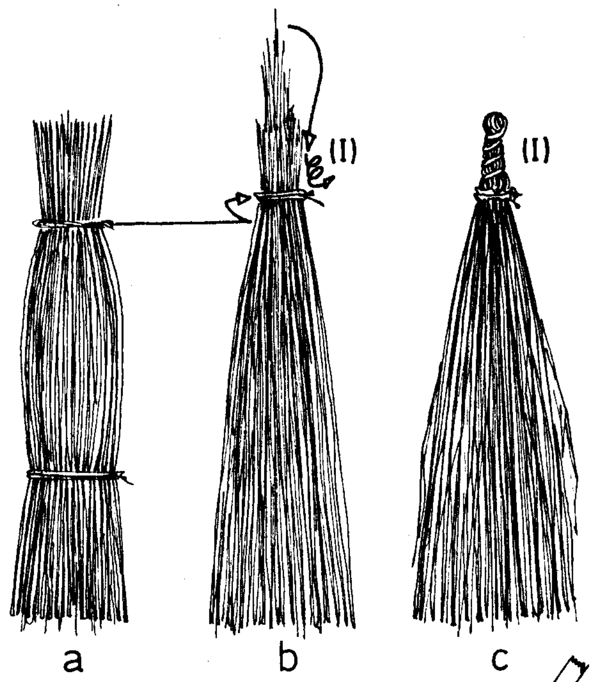
REED THATCH
(Shijan)

Sheaves of reed stems

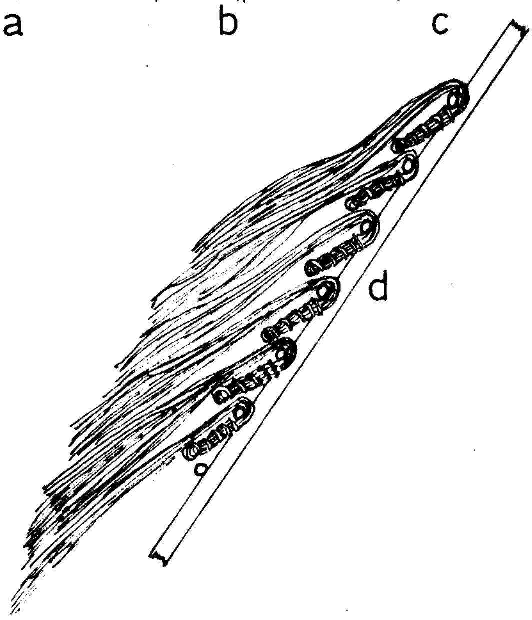
a. bundle prior to use on roof

b. preparation of bundle for thatching; stems pulled out and bound round top of bundle (I)

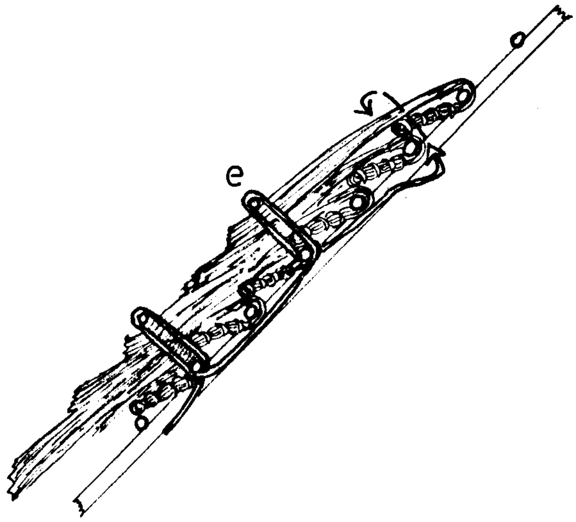
c. bundle ready for use



d. bound top pulled over batten and tucked in above batten below



In Mazandaran, additional battens over thatch (e) are tied through to main battens



Scale

0 1 2M

Reed thatch has the disadvantages of fire risk, insects and dust, but is less subject to attack by mice and rats than rice thatch.

Reed thatch can be used on lower pitch roofs than rice thatch, and although this is not the case in Gilan, pitches are considerably lower in Mazandaran where the rainfall is lower. Methods are suggested in the section on preservation of timber which are also applicable to reed thatch for reducing the fire risk and insect attack.

Internal detail of reed thatch showing bundles pulled over battens and tucked behind batten below.

A house with reed thatching and reed walls. Zebar Kenar.

Reed thatched
roof on a house
in Shijan.

Internal detail of reed
thatch roof.

Detail of framework at the
corner of the roof.