

Sheet Metal Roof Covering:

Sheet metal roof covering is in widespread use throughout the Caspian Region. It can be purchased in local service centres but is cheaper in the main urban centres (eg. Rasht). A sheet 80x150 cm (#28 guage) costs 200 to 240 rials in Rasht (1978).

The roof pitch for sheet metal is approximately 25° . The sheets are nailed to flat battens. Each sheet overlaps the top of the sheet below it. The joining of two side by side sheets is formed with a standing seam (fig. a; see photograph).

Sheet metal will rust where it has not been properly galvanised, but this process has been improved in recent years. However, rusting does take place around nail holes, and can result in movement occurring. This leads to the loosening of the upstand joints between sheets. Joints and nail holes require tightening and repairing periodically to avoid rain penetration. Because the roof covering is light, it can also be loosened or completely removed by wind action. The roof framework needs to be strong to resist the suction effect of the wind and the fixing of the sheets to the timber needs to be secure.

A small two room house takes three to four days to cover with sheet metal, employing three men, one of whom is a specialist (halabzan). It costs 80 to 100 rials per sheet for laying, with an extra 250 to 300 rials per square metre for preparing and fixing the fascia and gutters (1978). The major difficulty in using sheet metal is in forming the upstand overlap joint between two sheets. Sheet metal is locally estimated (in the Fouman Plain) to last 20 to 25 years for number 28 guage; but in the Astara area, due to the high rainfall and wind, the lifespan is shorter than that of the

single lap tiles which are preferred in the Astara Region. In the Fouman area thatch is more economical although fashion is often a deciding factor in using sheet metal. Sheet metal is a poor insulator, and extremes of temperature are transferred to interior spaces. This renders the roof space unsuitable for food storage, a common practise. Because of the build up of heat in the roof space, ventilator outlets are always required on these roofs. The decoration on these ventilators and along the fascia boards is often the most notable feature of new houses. Local people also complain about the acoustic properties of sheet metal. During a rain-fall the noise can be considerable.

One of the earliest references to the use of sheet metal is made by Rabino (1906-12) who said that the governor of Gilan at that time has a two room house with a sheet metal roof. The house was used for formal occasions and no doubt gave prestige to the new roofing material and vice versa.

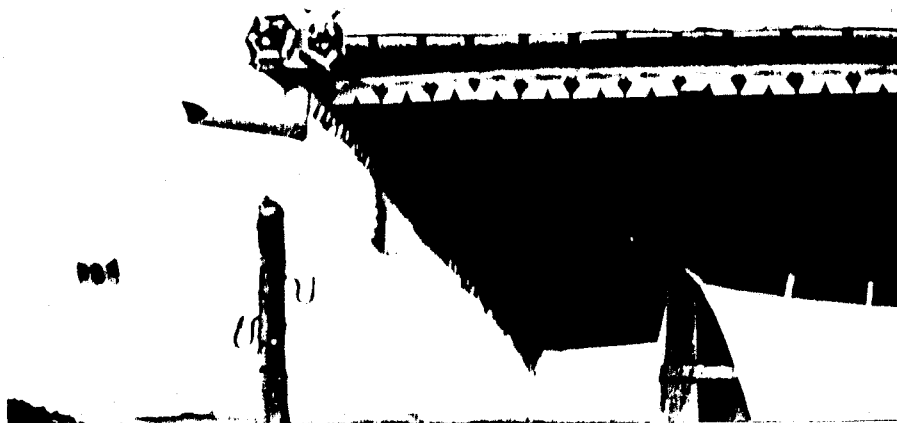
Sheet metal roofing
on a school near
Qaleh Rud Khan.



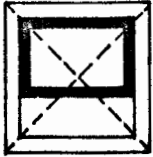
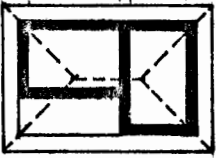
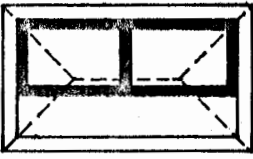
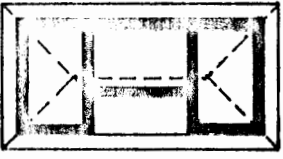
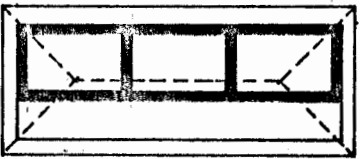
The edge of each
sheet is bent at
right angles to
form the upstand
joint between two
sheets.



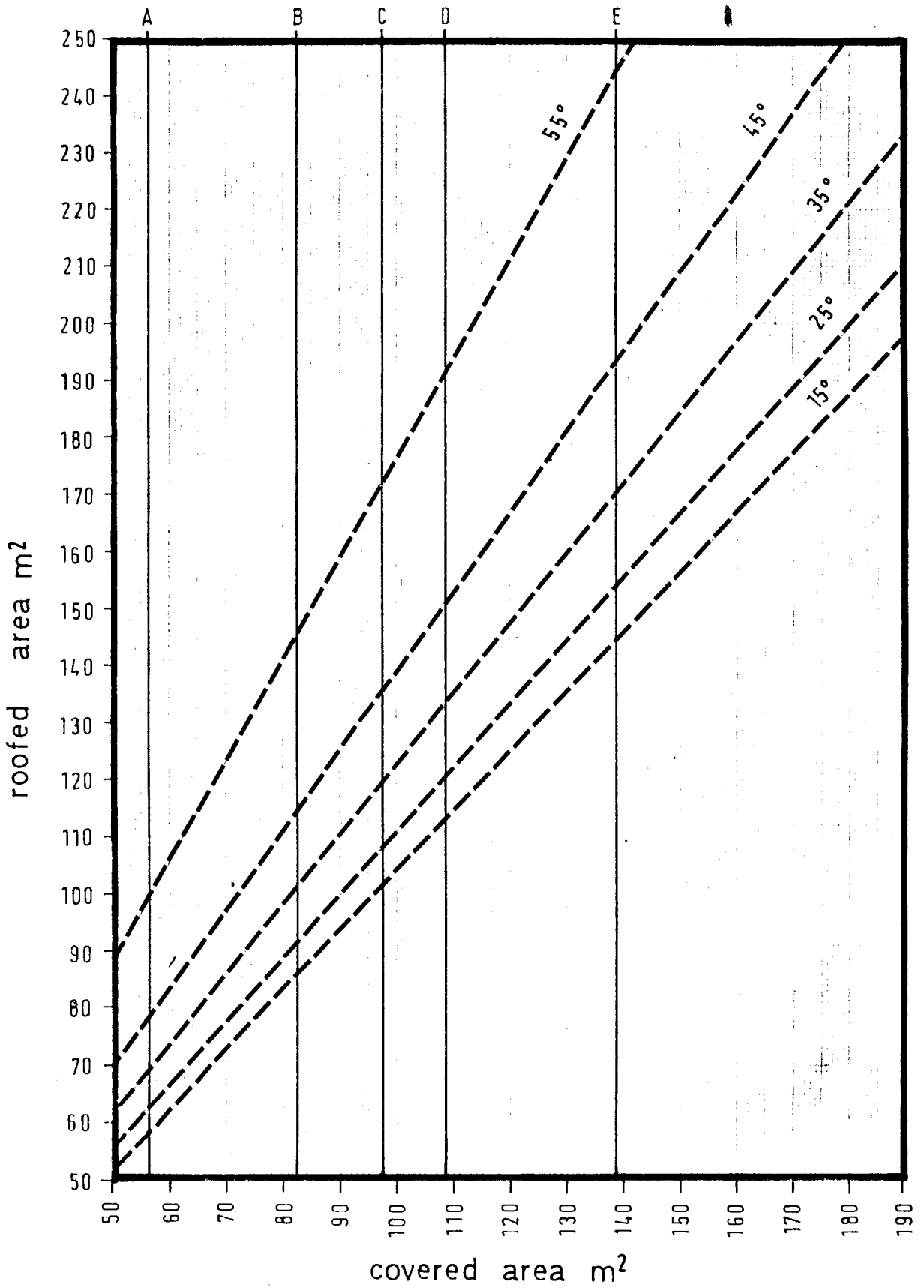
Metal work at the
eaves and drain-
pipes is usually
decorated and forms
a prominent feature
on newer houses.



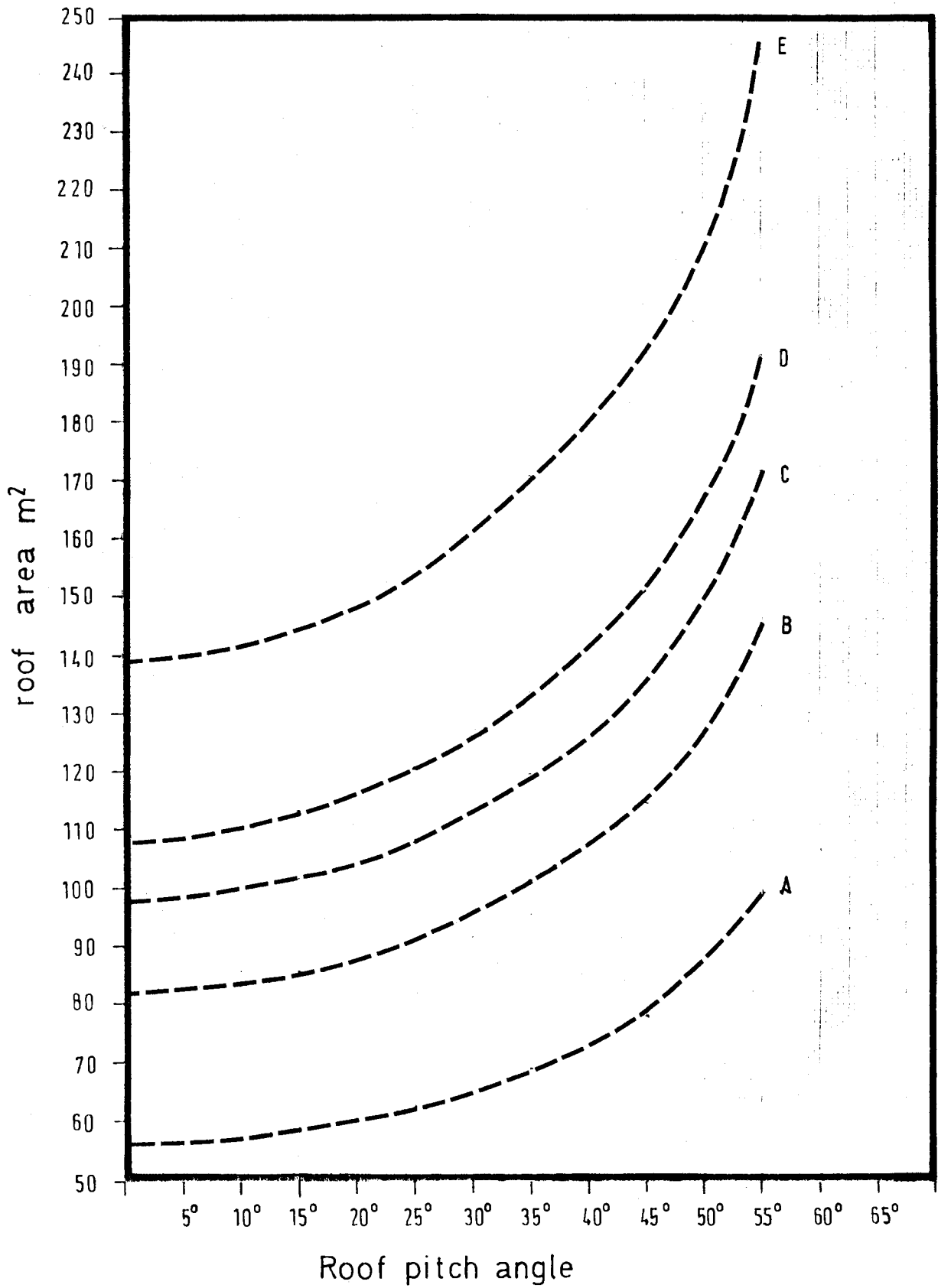
Roof Areas for Various
Unit Sizes and Roof Pitches

unit type	covered area sq.m.	15°	25°	35°	45°	55°
 A	56.25	58.50	62.25	69.00	78.00	99.00
 B	82.50	85.80	91.30	101.20	114.40	145.20
 C	97.50	101.40	107.90	119.60	135.20	171.60
 D	108.75	113.10	120.35	133.40	150.80	191.40
 E	138.75	144.30	153.55	170.20	192.40	244.20

Relationship Between Covered Area
and Roof Area for Various Pitch Angles
for Standard Caspian 'Hipped' Type Roof

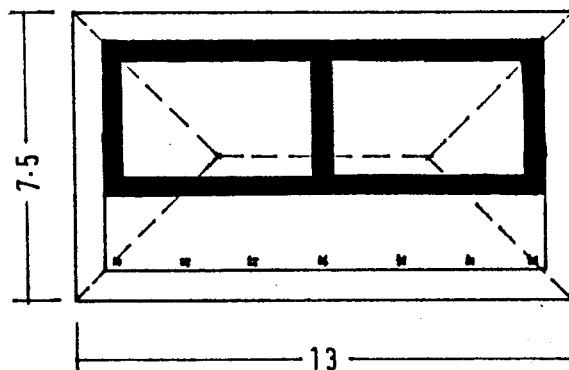


Relationship Between Roof Pitch Angle and Roof Area for Various Roof Sizes



Notes on 'Roofing Materials Comparative Costs Chart'

- *1 The price of one labourer's work in one day (which at the time of the research was 600 Rls.) is taken as the basic unit of cost, and all costing figures given in the table are fractions and multiples of this unit. Since the prices of local materials in the Caspian area include a large labour component in production, this appears to be an appropriate unit. The labour unit maintains its comparative value over time as prices change.
- *2 The unit of construction is taken to be a standard two room house with a front 'aivan' covering a built area of 97.4m. The pitch of the roof varies according to the different roof covering material used and thus the surface area of the roof to be covered also varies.



On comparing Costs:

The costs should be regarded in connection with the lifespan of the material, although in rebuilding the roof after its period of lifespan some materials may be salvaged in certain cases and the cost of the new roof is not necessarily as high as the original roof. Also it should be noted that low income groups find it economically easier to invest a small capital in a relatively short term structure than a large sum in a longer lasting building. Thus a relatively small initial capital outlay with periodic inputs for maintenance is more geared to a rural family's economy.

ROOFING MATERIALS: COMPARATIVE COSTS

name of material	Rice Thatch	Reed Thatch	Shingles	Rasht Tiles	Astara Tiles	Sheet Metal
local name	Koloush	Lee	Lat/Takhteh	Sofal	Sofal	Halab
cost* ¹ of material/m ² Roof Surface Area	0.075	0.155	0.333	0.378	0.450	0.413
cost* ¹ of construction/m ² Roof Surface Area	0.133	0.133	0.050	0.165	0.050	0.166
total cost* ¹ /m ² Roof Surface Area	0.208	0.288	0.383	0.543	0.500	0.579
pitch of roof ⁰	55°	55°	25°	25°	35°	25°
surface area of roof m ²	170	170	110	110	120	110
cost* ¹ of material/unit of construction	12.5	26.	37.5	41.	54.	45.5
construction cost of unit* ²	22.5	22.5	5.5	16.5	6.	18.5
total cost of unit * ²	35.	48.5	43.	57.5	60.	64.
lifespan yrs.	8-12	15	15-20	25-30	25	20-25
maintenance requirements	thatch renewed in parts of roof. Ridge rope tightened & replaced when rotted.	ridge rope tightened every yr. & renewed when rotted.	shingles turned over every 5 years.	lower tiles moved to the surface after 15	-	joints loosened by wind are tightened. Rusted holes are fixed

**WALL MATERIALS:
COMPARATIVE COSTS**

name of material	Packed Mud	Timber lath & Mud Packing	Mud Brick	Concrete Block	Fired Brick
local name	Chine	Ajor Paiee or Arreh Kasma	Khesht	Sangblook	Ajor
wall thickness cm.	50-60	20	40	20	20
cost of material per unit Area*1	labour cost in preparing mud	timber, cutting & transport 41	34	blocks & mortar 73	76
construction cost ² per unit Area*1	65	26	41	34	41
total cost per unit Area*1	65	67	75	107	117
lifespan	80 yrs.+ if protected from moisture	50 yrs.	80 yrs.+ if protected from moisture	100 yrs.+ depending on cement/sand ratio	100 yrs.+ depending on quality of brick
maintenance requirements	white-wash with lime plaster every 2 yrs.	plastering exposed surfaces	white-wash with lime plaster every 2 years	-	-

1*unit surface Area of wall is taken as 100m².

2*unit of cost is in ratio to the wage of a building worker.

The Properties of Timber

An understanding of the properties of timber is an essential step towards the improvement of timber construction technology. Wherever it has been available, timber has been used as a structural material from the earliest times.*¹ Before the advent of steel and iron for building, timber was the logical choice as a spanning material, as well as for a wide range of other uses, including whole buildings. However little was actually known about the real behaviour of timber and its strength. Unnecessarily large timbers were used in some cases and inadequate ones in others. When it was introduced steel was assumed to be stronger and was often used for elements where timber would have performed better and more economically. Tests have shown in a comparison of rolled steel joists ("I" beams) and timber pole beams of the same weight, that greater loads can be carried by a short length of steel joists but over long lengths the timber pole will carry much more.*² Timber can also bear large loads for a short period of time and is particularly suitable under short term loading conditions, as in roof construction which is subject to intermittent wind loads. Timber performs extremely well when used in situations which would require elastic stability - eg. the ability to bend and return to its original shape after the force has been removed. Furthermore, contrary to what is often believed, timber behaves well when exposed to fire, and steel beams will fail sooner than timber beams of a similar weight when exposed to heat and flame.*³

In many areas of the Caspian stocks of timber have been depleted due to indiscriminate felling. On the other hand, unlike inorganic materials (eg. steel) timber is a replenishable material and, provided replanting takes place, its

1* Traces of neolithic timber buildings around 8000 B.C.

2* H.E. Desch, Timber: Its Structure & Properties, 1974, p. 1.

3* Alan Everett, Mitchell's Bldg.Const.: Materials, 1972, p. 1.

use can be encouraged. Ecologically, such a policy is more preferable to the present use of non replenishable materials.

Timber is used as a predominant building material throughout the Caspian Region. However, the unrestricted felling of trees in the forests has been controlled by the Forestry Department over the last few years and this has limited the use of timber in some areas which previously relied heavily upon local forest resources for fuel and building construction. New materials, such as steel, concrete block and sheet metal roof coverings, have also been introduced and are altering some of the traditional methods of building. Nevertheless, timber remains the major construction material of the area. In the forests the timber is mostly hardwood. Oak, beech, maple, elm, alder and mulberry are the most common and are all used in building.* In addition, trees are grown within individual plots of land surrounding houses, notably poplar. These provide necessary protection to houses against rain and wind, and also supply some of the timber for building in the plains.

* H. Sotudch, op.cit., pp. 37-45.

Seasoning

Seasoning is the process of drying timber under suitable conditions after a tree has been cut. The object of seasoning is to reduce the moisture content in the wood, which has the effect of reducing the movement (expansion, contraction and warping) likely to take place after the timber has been used (see moisture content in wood). Seasoning also serves to reduce the weight of timber while increasing most of its strength properties. Moreover, most wood rotting and all sap-stain fungi can grow in timber only if the moisture content is above 20%.* Therefore by seasoning the timber after felling, decay can be stopped or prevented. Subsequent infection after seasoning can occur but there are many insects which only cause damage while the wood is green.

Air seasoning relies on the absorption of moisture from the timber into the surrounding air. Air that has become saturated is replaced by fresh air through the process of its movement through and away from the stack. The relative humidity of the atmosphere and its temperature are all important in the seasoning process: the lower the relative humidity of the air the better will it be able to take up moisture from the surface of a piece of wood, and conversely, wood in contact with saturated air cannot dry out at all. Alternatively, and of importance in the Caspian Region, high temperatures can aid the drying power of the atmosphere, although its relative humidity is high. At temperatures between 25° to 30°C. comparatively high relative humidities, eg. 70 to 80%, still leave the air with appreciable drying powers. This is because the amount of moisture that air at 30°C. requires in raising its relative humidity 1% is so much greater than the amount involved in raising the relative humidity by 1% at 15°C. Hence it is possible to air dry timbers in hot humid conditions to almost as low moisture

H.E. Desch, op.cit., p.255.

contents as those achieved in temperate regions, and often in less time.*

In the Caspian Region very little proper seasoning of timber occurs. Timber is commonly stored in the open, usually in contact with the ground, and exposed to both sun and rain. This allows damp to penetrate into the timber from the ground and to cause fungal decay. Furthermore, air will not be able to move freely across all the surfaces of the timber, which is the most effective part of the drying out process; and exposure to direct sunshine can cause the outer surfaces to dry out too quickly with the result that the surface of the timber will crack and split. In cases of rainfall (common in the Caspian) the whole drying out process is negated. Proper seasoning of wood aims at making the best use of air movement, and the warming effect of the sun on the atmosphere. Protection from rainfall and direct sunshine is essential.

In point form, the following principles should be observed.

- a) The timber should be covered by a roof. Sheet metal and roofing material should be avoided since it will heat up in the sun and cause uneven drying of the timber under the shelter. Thatch, shingles or tile are better. The insulating properties of a thatch roof are extremely good.
- b) The floor upon which the timber is to be stacked should be of a material which will not hold moisture and can be kept clean. A concrete floor is best, but a well rammed earth floor, protected from flooding (eg. raised above the surrounding ground level) is adequate. The floor should be kept clean, since scraps of wood lying on it can become diseased and then contaminate the stored wood above.
- c) Timber should be raised off the ground on blocks, laid at right angles to the runs of timber. Concrete blocks are ideal, being inorganic; but properly seasoned and

H.E. Desch, op.cit., p.202.

preserved wood blocks can be used in the absence of anything else. Sufficient concrete block for this purpose should be easy to obtain in nearly all parts of the Caspian area. The height of these blocks should be 20 to 30 cm. if a concrete floor is used; 45 cm. if an earth floor is used.

- d) The overall dimensions of the stack should not be more than 4 metres wide and 5 metres high. In practise, the height will probably be less than this, since handling of timber will be difficult if the stack is full. If these maximum dimensions are not observed, the stack will be too large to ensure rapid and even drying, and stagnant air can be trapped in the centre of the stack with a resulting risk of fungi growth.
- e) Each piece of timber should be separated from its neighbours above, below and on both sides. Vertical separation is achieved by the use of small, well seasoned battens of wood. The dimensions of these battens should technically vary according to the season in which the stack is built and to the type and size of wood being seasoned. However, as a rough guide, little will be achieved by having battens thicker than 5 cm., and to do so would be uneconomical. On average, 2.5 to 3.5 cm. would be satisfactory. Thinner than this can slow down the seasoning process, which is advantageous in cases where the timber is prone to splitting. The essential point is that air should be able to circulate through the stack freely so that moisture laden air will be removed and replaced by fresh air able to absorb moisture. The average spacing of these battens should be one metre, more frequent for timber liable to warp, and less frequent for thicker planks.
- f) The stacking of timber should occur as soon after sawing as possible. A delay in doing so can allow fungal decay to start.

g) The ends of the timber should be covered to reduce rapid loss of moisture along the grain, which can cause end splitting. Various methods are suitable, but a cheap and simple solution is to coat the end with a clay/dung mixture which is reasonably effective and easily obtained.

The above can at best serve as basic guidelines for the seasoning of timber. Given the number of small timber workshops scattered through the region, it would probably be unrealistic to expect more than this to be carried out.

Kiln drying of timber would probably be impractical and uneconomical for small-scale local treatment of construction grade timber. It requires an elaborate shed construction, fuel for heating, careful quality control and supervision. In other areas of Iran solar energy can be used, but with the high incidence of cloudy days in the Caspian this would be inefficient. Timber used in construction work may not merit kiln drying, a process which is more suited to timber to be employed in joinery or cabinet work.

H.E. Desch, *ibid*; gives a more detailed explanation and is a valuable reference.

Preservation of Timber

The use of preservatives on timber for domestic constructional use is in little evidence in the Caspian Region. Some preservation takes place for railway sleepers and the Forestry Department use bitumen to preserve fence posts.

An incidental preservation of timber in roofing occurs in many rural houses where chimneys are not used. Smoke from cooking fires passes out through gaps in the roof. Both the roof framework and the covering are coated with soot, which acts as a preservative against insects and damp.

Timber is liable to attack or damage caused by

a) Fire

b) Insects and Fungi.

a) Although timber is commonly thought to be a weak material against fire, it is, as mentioned earlier, more resistant than a steel member of the same strength. Timber is a flammable material, but as it burns a layer of charcoal forms on the outside surface and retards the burning process in the interior of the wood. Oxygen cannot reach the centre and so combustion does not take place. Therefore timber members take more time to complete failure and thus give greater security in fire than do steel members which bend and collapse in the heat of the fire. The burning rate for timber is given at 1mm/minute at 900 to 1200°C. However, where timber members are used in a structural framework, only a small reduction in strength may be sufficient to cause failure. Equally, since in many houses the roof members are held together with staves the joints will fail and the structure collapses. Organic materials for roofing, notable thatch, will ignite easily and in falling will set fire to the rest of the structure.

Practical efforts should be made to provide readily available fire retardant/proofing solutions. In this context, most marketed products will be too expensive, and recommendations concerning them will be impractical if they cannot be used in a rural situation. Research needs to be done in this area. The benefits of fire proofing have in many cases been shown to be greater than simply reducing risk of fire. The life-span of combustible materials can be increased and the consumption of raw materials decreased. Many fire retardant processes also provide protection against insect attack.

A fire retardant treatment developed by the Central Building Research Institute in India*¹ with particular reference to thatch, string and the roof framework, makes use of a mixture of 95.95% Fertiliser Grade Diammonium Sulphate and 0.05% Sodium Fluoride with an additional 14% water added to this mixture. Application is by soaking for ten to twelve hours. According to the Institute, the treatment is "simple, cheap and effective". Its major drawback is that rain will, over a period of time, reduce its effectiveness. It is suggested that a water repellent coating be applied to exposed surfaces. The Central Building Research Institute in India recommend a mixture of Zinc Oxide 15%, Mica Powder 15%, Talc Powder 15%, Chlorowax (containing not less than CI 40%) 30%, Polyvinyl Acetate Emulsion 25%, and a spirit in a quantity adequate to yield a consistency suitable for spraying or brushing.

Another mixture proposed by the British Standards Institute uses: to make 4.55 litres - 50.8 kg. Sodium Silicate, 45.4 kg. water, 68.kg. Kaolin. This is more effective in sheltered conditions than it is in exposed conditions.*²

1* Dr.J.P.Jain, M.Chandra, R.P.Kulshrestha, Technical Note: Fire Retardant Treatment of Thatch, C.B.R.I., 1976.

2* H.E. Desch, op.cit.287.

b) Resistance to fungi and insects -

Low moisture content plays a major role in increasing the resistance of wood to fungi. The moisture content should be below 20%. Temperatures above 30°C. and below 0°C. destroy fungi that attack timber. For protection against insects, timber should be coated with insecticide fluid, especially in the joints and cracks.*²

For externally exposed timber and members in contact with the ground preservatives should be used to guard against fungi and insects. Creosote, a tar distillate, is one of the most effective preservatives. Creosote is often mixed with diesel oil, which can reduce the overall cost. Effectiveness decreases with increased percentage of diesel oil, but it can also reduce splitting in the wood.*¹ A cheaper method is to use a mixture of paraffin ("naft") and used engine sump oil. This does not last as long as creosote but is cheap and easily obtained. It is especially important to protect timber where it is buried or in contact with the ground.

1 H.E. Desch, op.cit., p.292.

2 Development Workshop, Traditional Iranian Timber Flat Roofs, p.41.