Chapter -8

Roofs

A roof may e defined as the upper most part of the building provided as a structural covering, to protect the building from external weather exposure such as rain, sun, wind, etc. Basically, a roof consists of structural elements, which support roof coverings. The structural element may be trusses, beam, slabs, shells or domes. The roof coverings may be corrugated metal sheets, reinforced concrete slab, tiles, etc. Roof covering material is laid over network of frames. The availability of the materials and the climate of the place governs the particular type of roof. The roofs may be classified as follows:

Types of Roofs

The General types of roofs are

1. ***Pitched/slopping roofs***
2. ***Flat roofs***
3. ***Dome roofs***
4. ***Shell roofs.***

The selection of the type of roof depends upon the shape or plan of the building, climatic conditions of the area and type of constructional materials available. Pitched roofs have sloping top surface. They are suitable in those areas where rainfall/snowfall is very heavy. Buildings with limited width and simple shape can generally be covered satisfactorily by pitched roofs. Buildings irregular in plan, or with long spans, present awkward problems in the design of a pitched roof, involving numerous valleys, gutters and hips. Buildings of large area, such as factories, require internal gutters in the valleys when covered by a series of parallel- pitched roofs.

1. Sloping or Pitched Roof

Pitched roof is is a type of roof which slopes in one or more directions. It is the most common form of roof and is generally regarded as the cheapest alternative for covering a structure. Pitched roof is almost always constructed in wood or steel. The different shape can be provided to the pitched roofs. The various shapes, which can be given to roofs of this type, depend on the area covered, materials available, type of lighting and ventilation needed inside, available appliance etc. In pitched roofs a slope of less than l in 3 is generally not considered satisfactory from drainage point of view in areas of heavy snowfall, steeper slopes(1:1.5 or1:1) incidence of snow load on the roof

Forms of Pitched Roof

Sloping roofs are basically of the following forms:

Shed roof: It is the simplest type and slopes only in one direction .It is used for smaller span and is also known as lean to roof. At the upper ends, the rafters are nailed to the wooden wall plate, which may be of stone, brick or steel. At the lower end the rafters are notched and nailed to the wooden post plate.
Gable roof: It slopes in two directions and is commonly used. It is formed by a pair of inclined rafters with their upper ends nailed to a common ridge piece and their low ends. Notched and nailed to the wooden wall plates embedded in masonry on the top of the wall on either end. Gable roofs slope in two directions but there is a break is slope.
Hip roof: It slopes in four directions such that the end formed by intersection of slopes results in triangular and/ or trapezoidal form.
Butterfly roof: It slopes in two directions and intersects at the centre of the span and will have common drainage system.
Gambrel roof. This type of roof slopes in two directions but there is break in slopes.
Mansard roof. This type of roof slopes in all the four directions but there is break in slopes.
North light roof. This type of roof is commonly used in factories to admit sufficient light through the glass panels fixed on the steep sloping sides of the roof.
Pyramid roof: It is similar to hip roofs, slopes in four directions and the intersections of slopes make a pyramid

Important Elements and Terms of Pitched Roof

Some of the important elements of pitched roofs are:
Span: It is the clear distance between the supports of beam, roof truss, or an arch.
Rise: It is the vertical distance between the top of the ridge and the wall plate.
Pitch: It is the inclination of the sides of a roof to the horizontal or is expressed either in degrees or as ratio of rise to span.
Ridge: It is define as the apex line of the sloping roof. It is thus the apex of the angle formed by the termination of the inclined surfaces at the top of a slope.
Ridge piece: It is a horizontal member provided at the ridge line of a sloping roof.
Eaves: The lower edge of the inclined roof surface. From the lower edge (eaves) the rainwater from the roof surface drops down.
Hip: It is the ridge formed by the intersection of two sloping surfaces, where the exterior angle is greater than 180^0. It is the external angle of a pitched roof at which the roof slopes are turned down (Fig. 15.1).
Valley: It is a reverse of a hip. It is formed by the intersection of two roof surfaces, making an external angle less than 180^0. It is a depression or gutter formed by the inter-section of two slopes in a pitched roof.

Hipped end: It is the sloped triangular surface formed at the end of a roof.
Verge: The edge of a gable, running between the eaves and ridge, is known as a verge. It is the edge of sheets or tiles, projecting beyond the gable end.

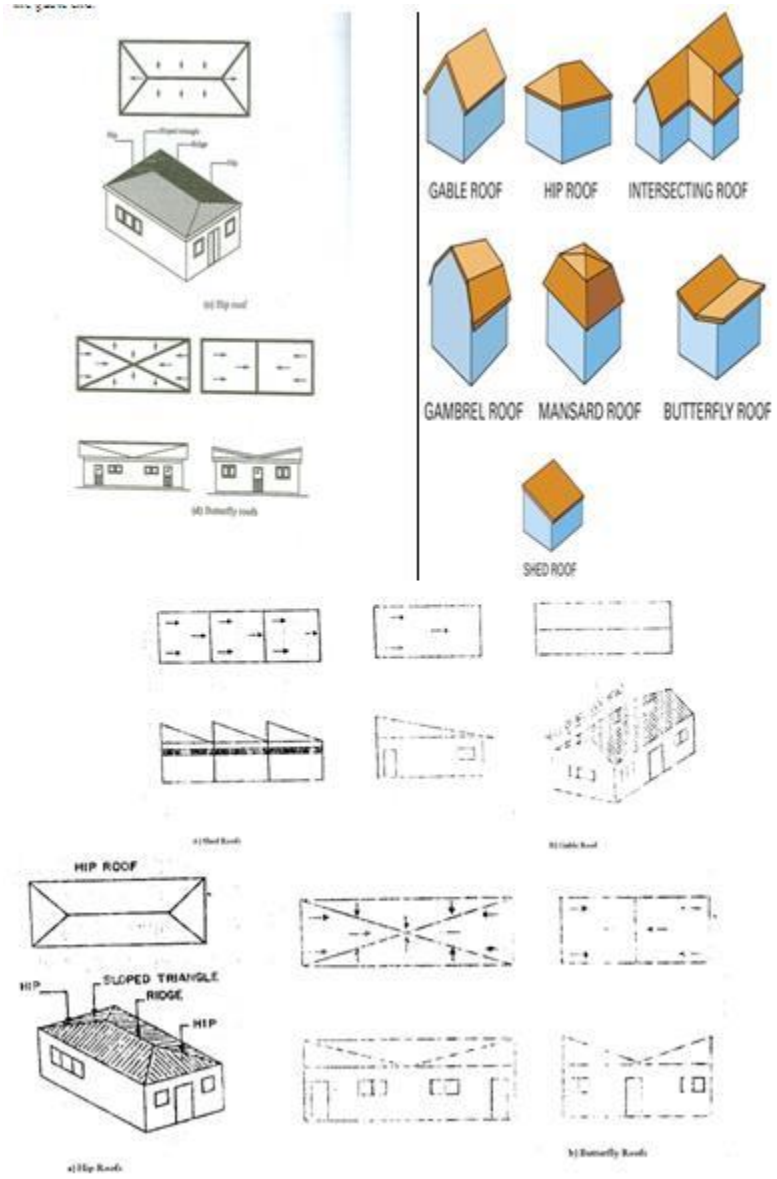


Fig. Types of Basic sloping roofs

Principal Rafter: The principal rafter carries the purlins which are notched to fit them. Each principal rafter is supported near its center, close below the purlin by a sturt tenoned into it.

Common Rafter: These are wooden members laid from the ridge to the eaves and parallel to the roof pitch. They are supported by purlin at their centre. Common rafters are bevelled at the upper end to abut against the ridge piece and nailed to it. They are inclined wooden members supporting the battens or purlines on which roof coverings rest. These are inclined members spaced regularly and laid from the ridge to the eves over the purlins.

Strut: It is a compression member in a roof truss which prevents sagging of the principal rafters. The strut should be almost immediately under the purlin.

Tie beam: It is a beam subjected to tensile stresses only and is used in a truss to hold the end or feet of the rafters to prevent them from spreading out.

Collar: It is a beam used in a truss about halfway up the rafters.

Purlin: A purlin is a beam running longitudinally from principal tp principal as support for the common rafter. Purlins are sometimes framed in between the principal rafters. The purlins are generally notched where they rest upon the principal rafters, so as to keep the latter rigidity apart. They are horizontal members placed over principal rafters to support common rafters (Fig. 15.2). They may be horizontal wooden or steel members, used to support common rafters of a roof when span is large. Purlins are supported on trusses or walls.

Eaves board or **Facia board:** It is a wooden plank or board fixed to the feet of the common rafters at the eaves. It is a board fixed along the eves joining the common rafters. It is usually 25mm thick and 20cm wide. The ends of lower most roof covering material rest upon it. The eaves gutter, if any can also be secured against it.

Battens: These are thin strips of wood, called scantlings, which are nailed to the rafters for laying roof material above. They are small sections of the timber which are fixed to the rafters for placing tiles/CIS on the sloping roof.

Truss: A roof truss is a framework, usually of triangles, designed to support the roof covering or ceiling over rooms. It is a framework of triangles and used to carry the load of roof covering materials and other members of the roof.

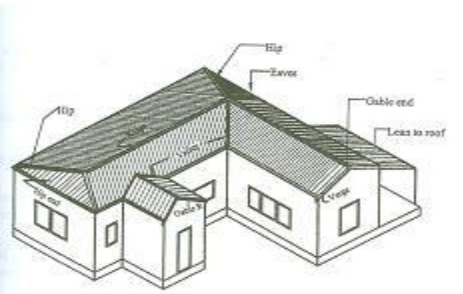
Gable. It is the triangular upper part of a wall formed at the end of a pitched roof.

Wall-plates. These are the members placed at the top of wall to receive the common rafters.

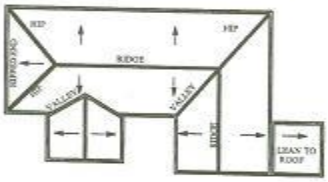
Cleats. They are small sections of steel or timber, fixed to the rafters of the truss to support purlins.

Hipped end. It is formed at the end of a roof in the shape of a sloped triangular surface (Fig. 15.1).

Template. It is a masonry block under the end of tie beam to distribute the load from the roof over a large area.



a) View of a building with basic sloping roofs and their elements



b) Elements of pitched roof

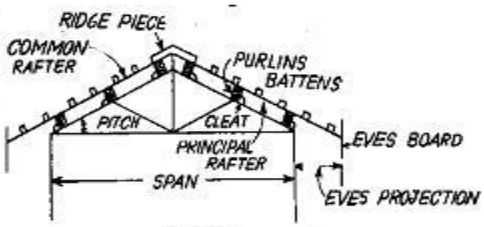


Fig. 15.2

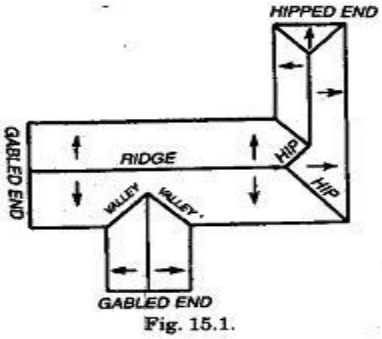


Fig. 15.1.

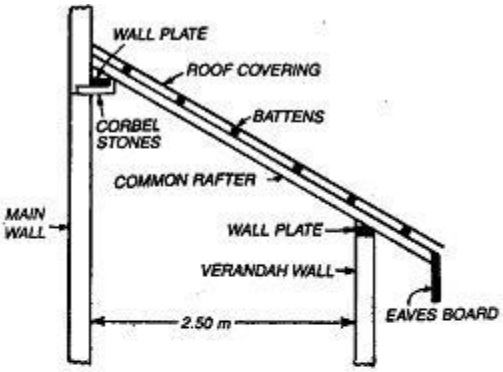


Fig. 15.3.

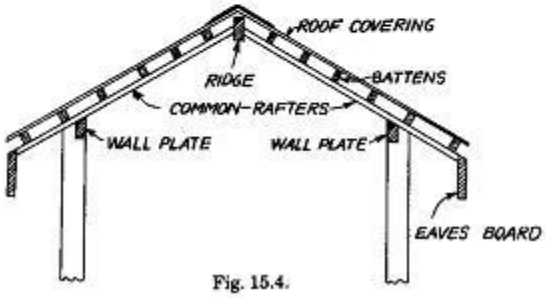


Fig. 15.4.

Fig Elements of Pitched roof

Pitched roofs are basically classified into three categories. ***Single roof***, ***Double or beam or purlin roofs*** and ***Triple-membered or Tramed or Trussed roofs.***

1. Single Roof

This roof consists of common rafters that are secured at the ridge and wall plates The various forms of this type are as follows:

Lean to roof: This is the simplest type of pitched roof and consists of rafters that slope in one direction only (Fig. 15.3). Generally, it is used to cover the veranda of a building and projects from the main wall of the building. At the upper ends, the rafters are fixed by nails to the wooden wall plates which are placed on corbel of the main wall. The lower ends of the rafters are notched and nailed to the wooden post plate. The post is of timber section which runs parallel to the wall and is supported on the intermediate columns or posts. Battens are placed and fixed over the rafters and it is finally covered by suitable roof covering materials. It is suitable for spans upto 2.5 metres and is generally used for sheds, out- houses attached to the main buildings, verandahs, etc.

Couple roof*:* It is formed by a pair of inclined rafters and their upper ends are nailed to a common ridge piece and their lower ends are notched and nailed to the wooden wall plates which are fixed at the top of the walls. The battens are fixed over the rafters suitably spaced. Over the battens the suitable roof covering material is fixed. This type of roof is suitable upto a span of 3.60 metres. (Fig. 15.4).

In this types of roof, each couple or pair of common rafters is made to slope upwards from the opposite walls and they are supported at the upper ends at the ridge piece or ridge board in the middle. The lower ends of the common rafters are fixed to the wall plates embedded in the masonry on the top of the walls.

Couple close roof: It is similar to a couple roof except that the legs of the common rafters are closed/joined by a horizontal tie known as tie beam as illustrated in the Fig. 15.5. This tie beam is connected at the feet of the common rafters to check their tendency of spreading out wards and hence save the walls from the danger of overturning. The tie may be a piece of wood or a steel rod in tension. Under normal loading conditions, this type of roof can be used for a maximum span of 4.5m. For increased spans or greater loads, the rafters have a tendency to sag in the middle To check this tendency, a couple-close roof is supported by a central vertical rod, known as king rod or king bolt between the ridge piece and the center of the tie beam.

It is very similar to the couple roof but the legs of the common rafters are joined by a tie beam as illustrated in the Fig. 15.5. The tie beam checks rafters from spreading out and, therefore, the overturning of the wall is prevented. The tie beams also serves the purpose of ceiling joists when false roofing is to be used. It can be used economically upto a span of 4.20 metres.

Collar beam roof*:* This is similar to the couple-close roof, except that the horizontal tie is now raised up form the feet the rafters to almost the middle of the rafters. This raising up of the tie beam checks the tendency of sagging due to further increase in span or excessive loading conditions. Collar beam roof is considered suitable for spans varying between 4 and 5.5m.

It is used for spans between 4 metres and 5.5 metres. A collar of the same width as the rafter is fixed to every pair of rafters and it is attached at a height of half to one third of the vertical height between the wall and the ridge. The collar is dovetailed with the rafter and the use of bolts can be done as an additional safety. It is desirable to place the collar as low as possible to provide maximum strength to the roof (Fig. 15.6)

Collar and tie roof. It is used when the roof span exceeds 5.5 metres. It is a combination of collar beam roof and couple close roof. The rafters are supported by purlins and the purlins rest at the ends on walls. A collar and struts are employed to support the purlins and rafters. Its use is recommended where purlins may be supported at the ends with reasonable economy (Fig. 15.7).

1. Double Roof

Purlins are introduced to support the common rafter at intermediate point. The purlins are used to tie the rafters together and act as intermediate support.

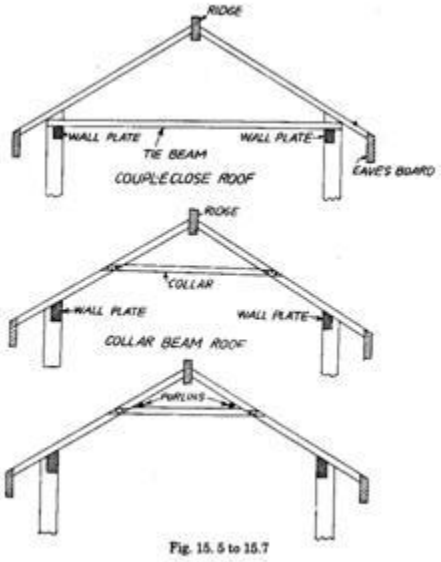


Fig. 15. 5 to 15.7

1. Trussed Roof

Trussed roofs are sloping roofs used when the span exceeds 5m. In other words for greater span than 5metres, when no intermediate supporting walls for the purlins are available, framed structures known as trusses are used. The spacing between trusses is guided by the load coming on the roof, material of the truss, span and the location of cross-walls, if any.

Generally they are spaced not more than 3m centre to centre. There are three elements in a trussed roof system:

A. Rafters which support the roofing materials,

B. Purlins to provide intermediate support to rafters, and

C. Trusses to provide support to the ends of purlins.

The trusses are connected to each other through purlins, which are placed at right angles to the sloped rafters and are secured to them through nails or cogged joints and cleats.

The various types of trusses include the following.

1. **King-post truss**
2. **Queen post truss**
3. **Mansard truss**
4. **Steel trusses**
5. **Composite Trusses**

King-post truss

In a king-post truss, the central vertical post, called as king post provides a support for the tie beam. The inclined members are known as struts are used to prevent the principal rafters from bending at the centre. A king-post truss can be used economically for spans 5 to 8 metres.

The joint between the king-post and the tie beam is ordinary mortice and tenon joint. An iron strap is also provided to strengthen the joint further. For joining principal rafters and the king-post, a tenon is cut in the principal rafter and the corresponding mortice into the head of the king-post. A bridle joint is provided to connect the principal rafter with the tie beam. Joints between the king-post and the strut are also mortice and tenon joint. A king-post truss with the details of different junctions is illustrated in Figs. 15.8 to 15.14.

Queen post truss

It can be used for spans 9 to 14 metres. It varies from the king-post truss in having two vertical members known as queen-posts. The heads of the queen-posts are put apart by a horizontal member known as straining beam. The head of the queen post is made wider to receive the principal rafter and the straining beam. The top end of the principal rafter and the end of the straining beam are tenoned into the widened head of the queen-post. A three way iron or mild steel strap is fixed to further strengthen the joint. The bottom end of the queen-post is tenoned into the tie beam and a steel stirrup strap is fixed by gibs and cotters to make the joint more strong. The tenon of the inclined strut is inserted into the splayed shoulder of the queen-post. The other joints in this truss are similar to that of king-post truss. Figs. 15.15 to 15.17 illustrate the various components of a queen-post truss.

Mansard truss

It is a combination of king-post and queen post truss. The upper portion has a shape of a king-post truss and the lower portion resembles to queen-post truss. The truss has two pitches. The upper pitch varies from 30^0 to 40^0 and the lower pitch varies from 60^0 to 70^0. This type of truss is economical in cost and in space and an extra room may be provided in the room. The construction of various joints is similar to that of the king-post and queen-post trusses. The Fig. 15.18 illustrates a mansard roof truss.

Steel trusses

The use of steel trusses become economical for spans greater than 12 metres. Various standard shapes and sizes or rolled steel are available for the fabrication of steel trusses. This type of truss is designed in a manner that members are either in compression or in tension, and bending stress is not allowed to develop in them. The size and type of the truss depends upon the roof slope, span, centre to centre distance of the trusses and the load coming over the roof. T-sections are best suited for use as principal rafters, whereas

angle iron or channel sections are used as struts. The tension members should preferably be of a flat or round section. The different members of the truss may be fabricated with two or more sections joined together. The members of a truss are joined by rivets or bolts or welding the plates known as gusset plates. The minimum spacing of the rivets should pot be less than 3 times the diameter of the rivet and the maximum spading is limited to 150 mm and 200 mm respectively in compression and tension members.

The minimum number of rivets to be used at any joint should not be less than two Gusset plates are designed for the forces coming at the junction but the least thickness should be adopted as 6 mm.

The ends of the trusses are placed on bed plates provided on the walls. The bed plate may be of stone or concrete. The ends of the truss are bolted down with Lewis or rag bolts which hold down the truss firmly. The small trusses are pre-fabricated in the workshop on the ground and then they are placed in the required positions.

The bigger trusses-are pre-fabricated in smaller parts and then they are erected to the required positions and fixed by gusset plates and riveting or welding, as the case may be. Figs. 15.20 to 15.31 illustrate the various types of steel trusses used for different spans.

Composite Trusses

Composite trusses are fabricated with timber and steel. Steel is used for tension members of the truss and the timber employed for compression members of the truss. Special fittings are used to connect the wooden members with steel members. A typical composite truss is illustrated in Fig. 15.32.

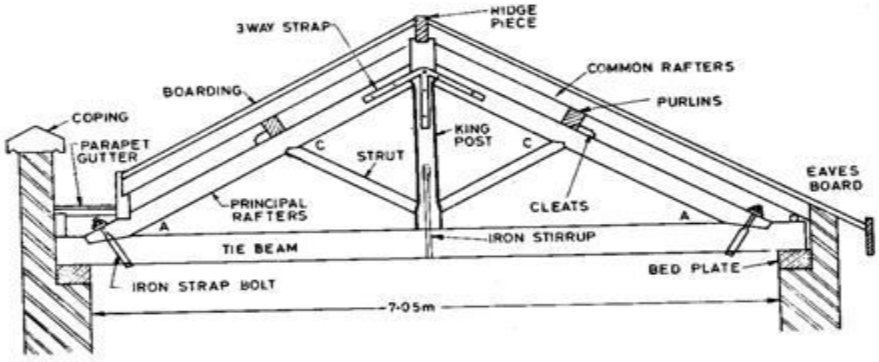


Fig. 15.8

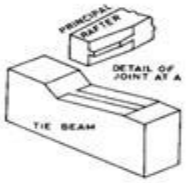


Fig. 15.9

Fig. 15.10

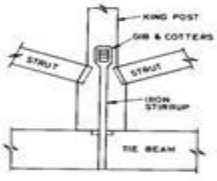


Fig. 15.12

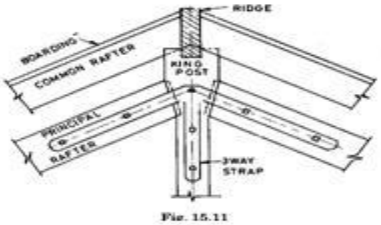


Fig. 15.11

Figs. 15.13

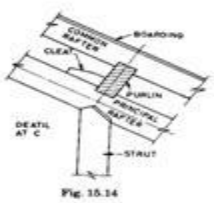


Fig. 15.14

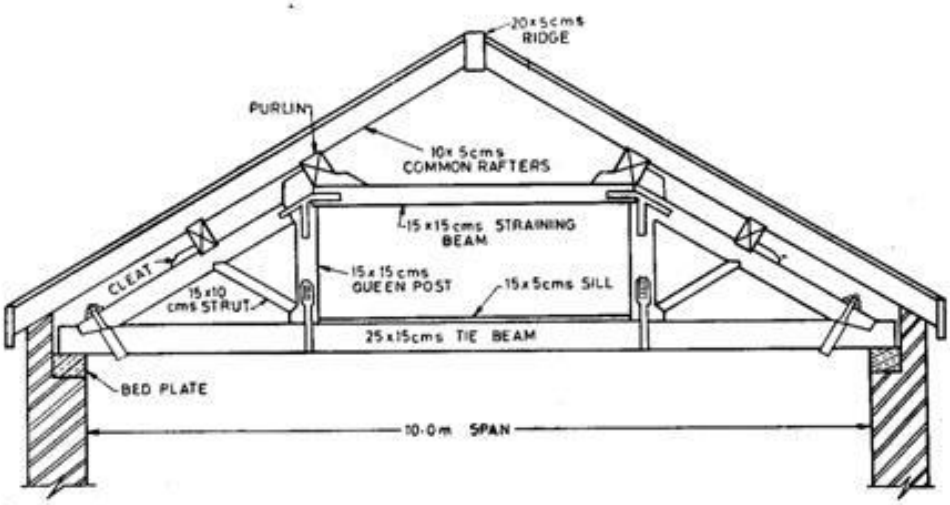
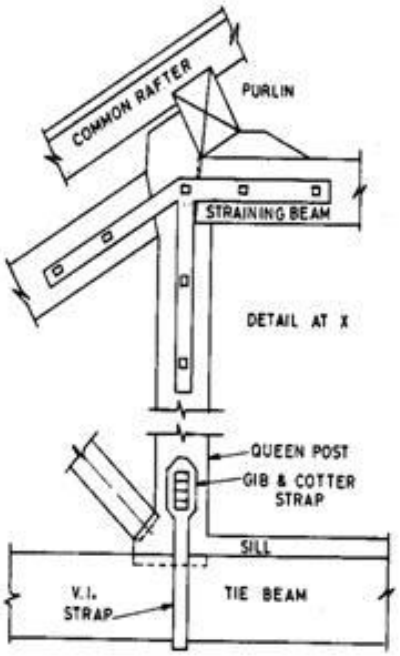


Fig. 15.15



Figs. 15.16 and 15.17

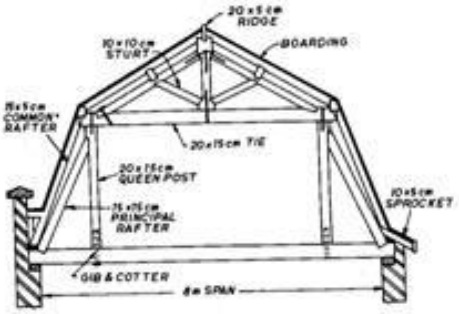
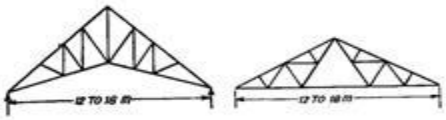


Fig. 15.18

Fig. 15.19

Figs. 15.20 to 15.22

Figs. 15.23 and 15.24



Figs. 15.25 and 15.26

Figs. 15.27 to 15.29

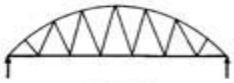


Fig. 15.30

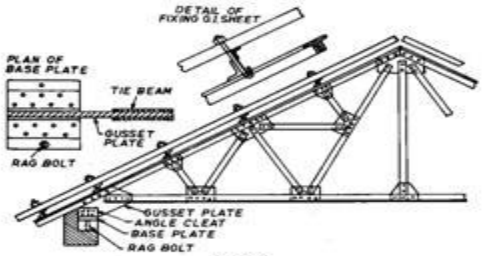


Fig. 15.31

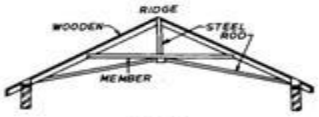


Fig. 15.32

Wooden Sloping Roof

Wooden pitched roof consists of a system of joists. Rafters and purlins arranged in the form of triangular shaped support known as truss. The lower ends of the rafter rest upon the wall plates and at their upper end they are connected to a common ridge piece.

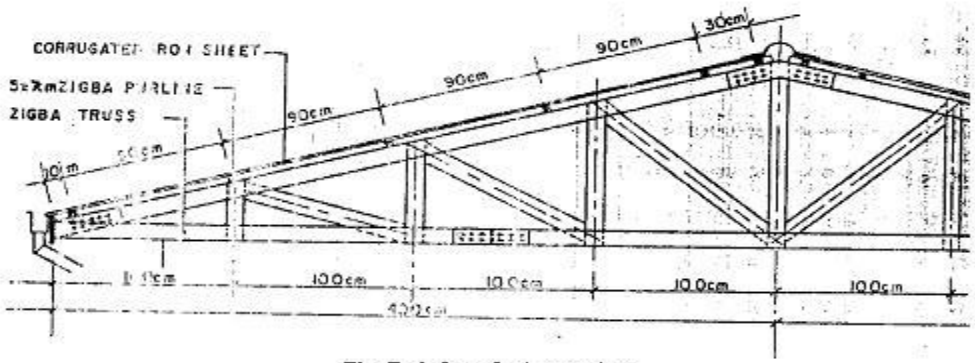


Fig: Typical woodentruss system

Steel sloping Roof

Steel sloping roofs are used for various necessity of the building. Steel roof trusses are mainly used for short and medium span buildings intended for industrial or recreational use. The inclination of the truss system depends on the amount of rain expected. A steel roof truss is a plane frame consisting of a series of rigid triangles composed of compression and tension members. The compression members are called rafters and struts and the tension members are termed ties.

Standard mild steel angles complying with the recommendations of the relevant standards, are usually employed as the structural members and these are connected together, where the centre line converge, with flat shaped plates called gussets.

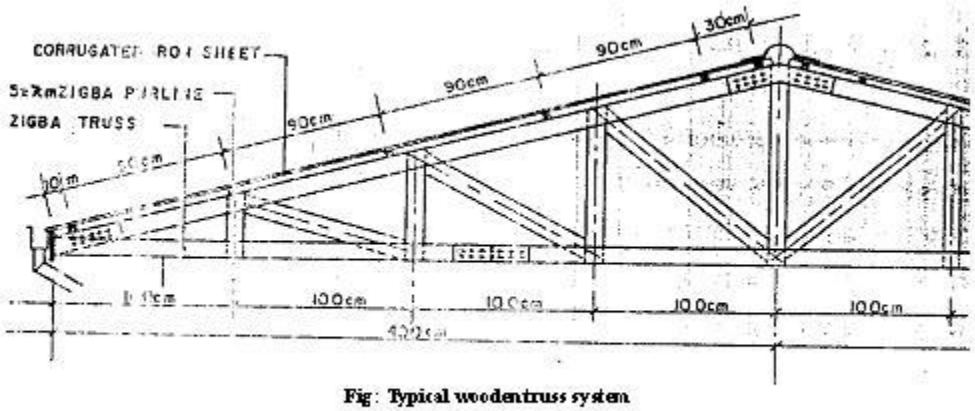


Fig: Typical woodentruss system

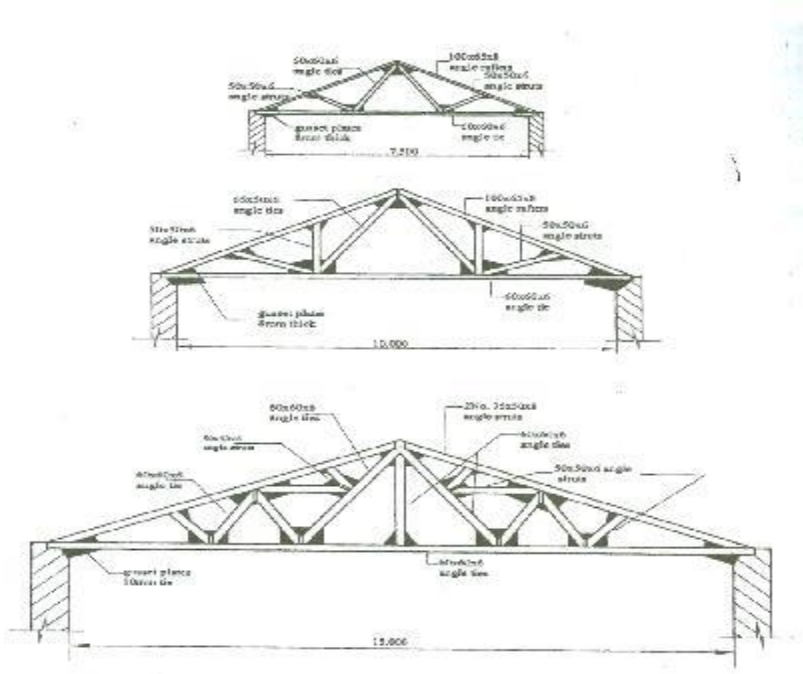


Fig. Typical Mild steel angle roof truss

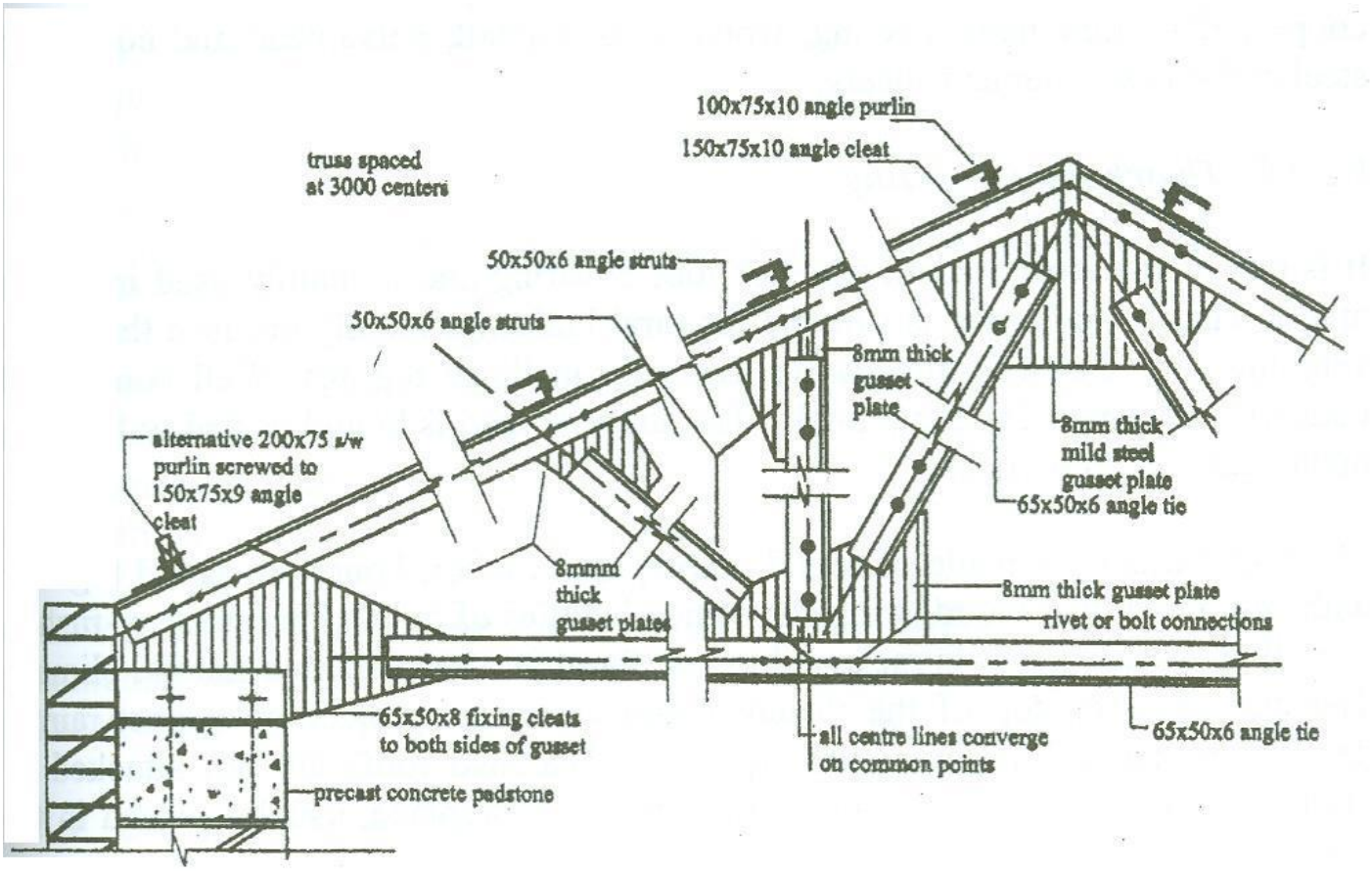


Fig .Typical parts of medium span mild-steel roof truss

The basic requirements for covering materials to steel- roof trusses are:

1. sufficient strength to support imposed wind and snow loadings,
2. resistance to the penetration of rain, wind and snow,
3. low self weight, so that supporting members of an economic size can be used,
4. reasonable standard of thermal insulation,
5. acceptable fire resistance,
6. Durable to reduce the maintenance required during the anticipated life of the roof.

A roof, which is nearly flat, with angles less than 10^0 to the horizontal, is known as flat roof. With the advent of very reliable waterproofing and heat insulating material, flat roof construction has replaced the pitched roofs in many types of constructions. Although flat roofs have high initial cost, they are extensively adopted even in places where rainfall is heavy.

It is becoming more popular with the introduction of suitable building material. It may be constructed in reinforced concrete, flat stone supported on rolled steel joists (RS.J.), bricks, concrete or tiled arches, etc.

This roof is provided with slight slope in one direction to drain off the rain water easily. The construction of flat roof is similar to the construction of floor except that the top surface is protected against rain water.

Drainage of flat roofs is one of the basic requirements. The rainwater should be drained- off from roof surface easily and quickly; otherwise it will lead to leakage. To achieve watertight roof surface, the selection of slopes and drain-outlets, depending upon the roofing materials and climatic conditions, should be done carefully.

Advantages of Flat Roof

1. The roof can be used as terrace for playing or for sleeping or for other domestic purposes.
2. The construction and maintenance of the flat roof is simpler.
3. It provides better architectural appearance to the building.
4. It is easier to make the flat roof fire resistant.
5. It possesses good insulating properties.
7. It avoids the need of false ceiling.
8. The construction work of upper floor can be readily taken up in case of flat roof, whereas in case of pitched roof, the entire roof has to be dismantled before the construction.
9. Pitched roof need much more area of roofing material than flat roofs.

Disadvantages of Flat Roofs

1. A flat roof cannot be used for long spans without using columns and beams.
2. In the areas of heavy rainfall, the flat roofs are not suitable.
3. Initial cost is more.
4. Due to greater variations in the temperature, sometimes cracks develop on the surface of the roof, which is difficult to repair
5. The speed of construction is slower than that of a pitched roof.
6. If proper slope is not provided on the roof to drain off the rain water, pockets of water are formed on the surface of the roof which leads to the leakage of the roof.

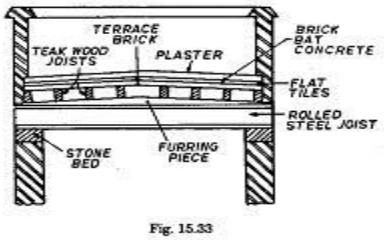


Fig. 15.33

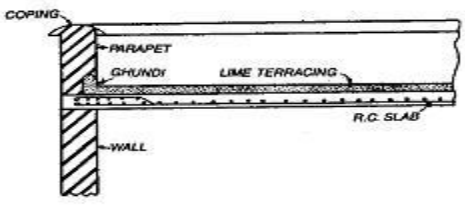


Fig. 15.34

A shell structure consists of relatively thin slab, which is curved in one or both direction and may be stiffened along its edges to maintain its curvature. Due to large floor spaces being covered uninterrupted by columns and for economical reasons, shell roof is becoming very popular for industry buildings, research labs, hangers and other large buildings. It has advantages of saving a lot of materials and appreciable reduction of dead weight, as the section needed is very thin. A shell concrete roofing, though similar in appearance to dome or vault , it is designed on quite different principles. It does not act structurally as an arch and setup no lateral pressure at its point of support; it is infact a bent or folded slab. It spans like a slab but gains additional strength from its shape. It is used for covering big structures.

Reinforced cement concrete shell roofs are becoming very popular these days. Very less quantity of materials are required to build up a shell' roof as compared to other conventional methods of roofing for the same span. The design of the shell is made as thin as practical requirements will allow such that the dead load is decreased and the shell acts as a membrane free from large bending stresses. Least quantity of materials is used to the maximum structural advantage.

Though consumption of materials are less, sometimes the cost of formworks makes the shell roofs quite expensive. It proves to be more costly when only a few similar units are to be constructed. Thin-shell roofs are economical when many identical units are to be built and the forms can be reused several times.

The forms are usually fabricated from timber battens lined with steel sheets or' plywood (Fig. 15.35). Sometimes plastic forms are also used to obtain special surface textures. The materials of formwork and the lining are selected in consideration of the number of reuses in a particular project. Economy may be achieved in two ways for the formworks. Firstly, by using movable formwork (Fig. 15.36), when the shell is to be cast is situ. Second way is to use the precast shells.

The cement concrete (1 : 2 : 4) used for casting shells should have stiff consistency. If it is very fluid, it will tend to slump down the steep slopes but if the concrete is too dry, proper compaction becomes difficult. Needle and form vibrators are used to compact the concrete with special attachments. A pneumatic hammer attached to a rod welded to plate may be used for compaction of the concrete. The reinforcement is properly tied on the sloping surface of t e shell. The shell should be properly cured for three weeks, otherwise it will develop many shrinkage cracks.

The sequence of removing centring is fixed by the designer at the time of shell design itself. The decentring sequence should be such that the shell is not subjected to concentrated or unsymmetrical loads for which it is not designed.

As the shells are very thin, some type of thermal insulation is provided either at the top of the shell or under the shell. Insulation boards, fiberous boards, light weight foam concrete block, etc. are used as insulating materials.

Advantages of Shell Roof Construction

1. 'The cost of shell-roof construction is less.
2. The maintenance cost is less. .
3. Reinforcement required is less, hence economy in steel.
4. The larger column free floor area is available for use.
5. Good ventilation is obtained.
6. Better appearance and good reflecting surfaces are obtained.

7. Greater head-room is available.
8. The construction of a shell roof can be carried out with reasonable speed if proper care is taken at the job.

Domes are a roof of semi-spherical or semi-elliptical shape. It is a special type of shell roof. The modern thin shell dome may be considered as an evolution of a structural form known and used by man from ancient ages. The dome over St. Paul at Rome was built in medieval period; show that in all the ages, the domical construction was favourite of the architects, since it is the most economical means of covering large column free areas.

Smooth-shell domes are constructed by brick, stone, concrete, or tile and ribbed domes may be built in steel, concrete or wood. A dome may be constructed with or without a "lantern".

The structure of the dome is such that within certain height and diameter ratios, very small thickness is required. They are used where architectural treatment is required such as monumental structures or where roofs have to be constructed on buildings circular in plan or hexagonal in plan. The method of construction is similar to that of shell roof described earlier in this chapter.

Fig. Shell and Dom roofs of EIC office building in A.A.

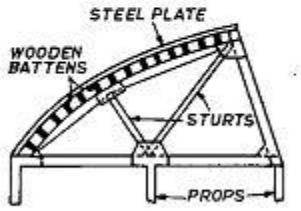


Fig. 15.35

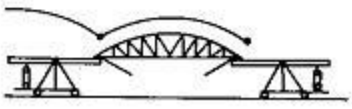


Fig. 15.36

Roof Covering

Roof covering material is provided to protect the surface of the roof structure. It also prevents heat, moisture, rain-water, etc. to enter into the building. It is not supposed to carry any structural load. The structural loads are directly taken by the roof. However, the roof covering must be strong enough to carry some occasional light loads. There are various types of roof covering .materials available for use under varying conditions.

The following are the various factors which need considerations in selecting a roof covering for a building:

(1) Climate of the locality
(2) Type of the building
(3) Initial cost (4) Maintenance
(5) Durability
(6) Resistance to fire
(7) Heat insulation
(10) Weight of the roof covering
(8) Appearance

1. Climate of the Locality. The selection of roof covering material depends upon the geographical position of the place and prevailing climate throughout the year. Wooden shingles may be suitable for dry places whereas they may prove very unsuitable for wet places. Corrugated G.I. sheet are not suitable for very hot places.

2. Type of the Building. The roof covering material must be selected to match the building and type of roof structure over it.

3. Initial Cost. The cost consideration is after all most important factor for guiding the selection of roof covering material. The initial cost varies from place to place and it also depends on the time. Clay tiles are cheaper at places where good brick-earth is available with facilities of making good tiles. State roofing or wooden shingles will prove cheaper in hilly areas. At the time of considering the initial cost of roof covering materials, the additional cost due to the supporting members should be also considered.

4. Maintenance. The cost of maintenance is an important consideration at the time of deciding the type of roof covering material. Wooden shingles and tiles require less maintenance than that of thatch roof covering.

5. Durability. The economy of the roof covering material depends upon the durability of the material. It is governed by many factors and varies from place to place. Under normal prevailing conditions slate, tiles, etc. have longer life. Asbestos cement sheets or wooden shingles have medium life. Thatch roof covering has very limited life.

6. Resistance to fire. Fire-resistant property of roof covering material should be also considered. Clay tile, metal sheet or slates are more fire resistance as compared to thatch roof covering.

7. Heat Insulation. The rooms of the building will be heated, if heat is allowed to be transmitted through the roof covering. This may be undesirable in tropical countries.

Clay tile or thatch provides sufficient protection against thermal effects. Corrugated metal roof covering has low resistance against heat. Asbestos cement sheets, unless used in double layers, have got a very low resistance to the transmission of heat. R.C.C. shell roof has also low resistance against heat,

8. Appearance. Appearance of the roof covering material is an important consideration from the architectural point of view . Clay tiles or shingles impart good appearance in some cases. Cement tiles are satisfactory for industrial buildings. Asbestos cement coverings do not look attractive unless some special treatment is made.

9. Type of Construction. To provide a particular type of roofcovering material, some special type of supporting structures may be required.

10. Weight of the Roof Covering. Heavier roof covering materials required stronger supporting structure. This increases the cost on the whole. Clay tiles and slates are the heavier types of the roof coverings whereas asbestos cement roof covering are lighter. The metal sheet roof coverings are very light in weight.

Roof Coverings for Sloping Roof

As described above, roof coving is a material, which gives a protective surface to the roofing structure. The function of the covering is only to prevent ingress or egress of heat and moisture into the building. It does not withstand structural loads, which are directly taken by the roofing elements. It is only to take loads to the extent over which it is supported on the roof members. There are various types of coverings depending on the character of the building, the type of roofing structure, local conditions, cost, etc. The major roof covering materials include thatch, lead copper, zinc, aluminium sheeting, wood, tiles, asphalt, galvanized and corrugated steel and asbestos cement sheets.

Thatch Roof Covering

It is one of the most ancient types of roof covering material and is mainly used in village areas. Thatch roof cover is suitable for rural buildings mainly because the cost is very low and thatch is abundantly available in those regions. Well constructed thatch roof is about 15-25cm thick in order to check the penetration of rain water.Thatch is of either straw or reed. The straw or reed is bound or tied to the layer underneath by grass ropes. It is very light roof covering material but it catches fire easily. A bed of matting is prepared over a timber truss to receive the thatch. Generally the slope is kept as 45° for easy drainage of rain water. Thatch is also attacked by worms, insects, etc. and birds try to nest in them. Hence sometimes they are also treated for making them worm proof. Sodium-bicarbonate, copper-sulphate or other chemicals are used for this purpose.

Galvanized Corrugated Iron/Steel sheet

Galvanized Corrugated Iron Sheets. Galvanized sheets are widely used though its appearance is not very good. It is very durable, light and fire proof. It is usually manufactured in sheets which are corrugated or bent in a series of parallel depressions from end to end. The object of corrugation is to provide strength to the thin iron sheet. This means that the sheet is made more resistant to bending stresses lengthwise These corrugations also help in draining the water from top of the roof. The purpose of galvanising the iron sheet with zinc is to protect it from rusting in wet weather. One of the drawbacks with such type of material is that it transmits heat and cold to a great extent.

The placing and fixing of corrugated iron sheets is very simple. The sheets are fixed to purlins which are supported on 2 to 2.5 metres. The sheets are nailed to these timber members with galvanised nails or screws. The washers are used to make the joint watertight. Each sheet is fixed with one screw in the central corrugation and one at each end. The screws are always placed on the top of the ridge to prevent infiltration

of water. The screws are not driven until the adjacent sheet has been lapped over the first. About 75 to 150 mm lap should be provided at the ends of the sheet. For restricting the heat flow from such roof covering, tiles can be placed over this type of covering.
The gauges indicate the thickness, for instance SWG 24 has 0.549mm; SWG 26has 0.457mm; SWG 28 has 0.376mm; SWG has SWG 30 has 0.315mm, SWG 32 has 0.274mm and SWG 35 has 0.200mm thickness.

Generally it is required that a sheet should be strong enough to carry without buckling, the load of a full grown man. A roof of corrugated iron consists of mainly separate sheets fixed so that water is prevented from penetrating through, between and under the sheets. One sheet should overlap the other both laterally and longitudinally.
The lateral over lap (or side lap) is usually 11/2 corrugations. For temporary buildings, or for places with very little rain, ½ corrugation overlap may be sufficient. The length of longitudinal overlap depends on the pitch of the roof (side slope) and the wind force as well as on the exactness in laying the sheets. The greater the pitch, the less overlap is required. The roofing sheets are fixed to the purlins by means of nails, which should be rust resisting just as the sheets. Since different qualities of galvanized nails exist it is always important to choose the best quality. The amount of nails to be used per sheet varies. It should however, not be less than 4 nails at the bottom and top parts of the sheet and 3 nails in the middle. The most common practice otherwise is one nail per every second corrugation at the top and bottom parts and one for every fourth corrugation at the middle parts of the sheet.
In Ethiopia, galvanized corrugated sheets should comply with the recommendation of the relevant Ethiopian standard, which specifies the size, number of corrugations and the quality of zinc coating or galvanizing.

Corrugated Asbestos cement Sheets

Corrugated asbestos cement sheets were frequently used as the major covering material for mainly steel roof structures, It was made from cement and about 15% asbestos fibres together with a controlled amount of water. The sheets made out of these materials are light, cheap, impervious, and durable and fire resisting. It does not necessarily require any protective paint and cannot ne eaten by vermin.
Nowadays, however, concern with the health risk attached to the manufacture and use of asbestos- based products has led to the development and production of alternative fibre-based materials.

Fibre Cement Profiled sheets

Fibre cement sheets are made by combining natural and synthetic non-toxic fibres and fillers with Portland cement and unlike asbestos cement sheets which are rolled to form the required profile, these sheets are pressed over templates. The finished product has a natural gray colour but sheets with factory applied surface coatings are available.

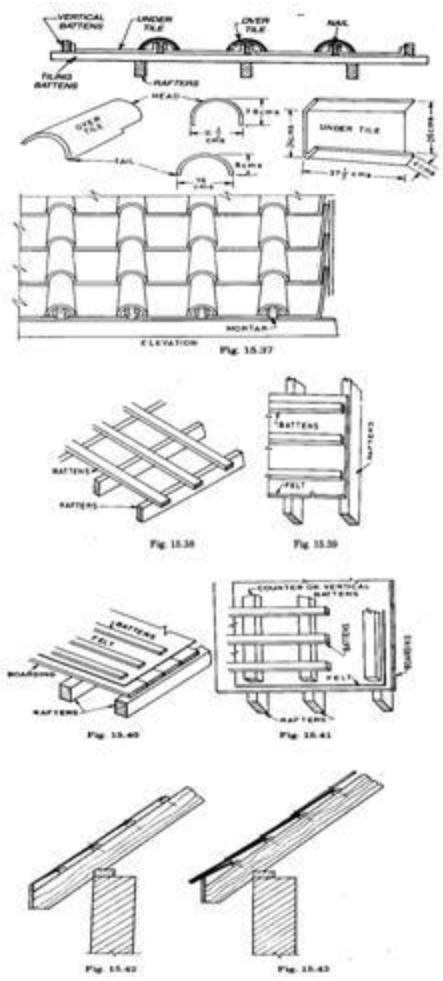
Aluminium sheeting

This form of roof covering is available in a corrugated or troughed profile. The sheets are normally made from an aluminium-manganese alloy resulting in a non-corrosive, non-combustible lightweight sheet (2.4-5kg/m^2)

Clay Tiles

These tiles are made from good clay and well burnt to make them quite strong and durable. They are suitable for villages and towns both. Various colours can be imparted to the tiles. They are very suitable for residential houses. They are non-conductors of heat and help to prevent extreme changes of temperature within building.

However, there are some disadvantages of clay tiles also. Since tiles are heavy and smaller in sizes, they require more laps which increase the total weight of the roof covering to an appreciable extent. The supporting structures are closely spaced and thus increase the total weight considerably.



Common Types of Flat Roof Coverings

Reinforced Concrete Flat Roof

Reinforced concrete flat roof is becoming very popular in construction of roofs for modern buildings. Concrete is weak in tension and to overcome this, steel, which is strong in tension, is introduced to form a composite material, and hence reinforced concrete member is equally strong both in compression and tension.

Similar to the construction of concrete floor slabs, the following steps are considered to be important in the construction of reinforced concrete roof slabs.

1. a well designed formwork and false work is required to support its own weight and the superimposed loads,
2. the reinforcement is then placed in position on the interior surface which has been finished first with a thin coat of oil,
3. the concrete is then poured around the reinforcement and for the required thickness of the slab,
4. the fresh concrete is properly compacted, finished taking into consideration the drainage pattern of the roof system and cured,
5. After the concrete has sufficiently hardened, the formwork is removed and the upper and under surfaces of the slab are treated as desired.

Asphalt Flat Roof

Mastic asphalt provides an ideal covering material especially where foot traffic is required. Mastic asphalt consists of an aggregate with a bituminous binder, which is cast into blocks ready for reheating on site. The blocks are then heated to a temperature of over 200^0C and are then transported in a liquid state in buckets for application to the roof deck by hand spreading. Once the melted asphalt has been removed from the source of heat, it will cool and solidify rapidly. Therefore, the distance between the cauldron and the point of application should be kept to a mini mum.

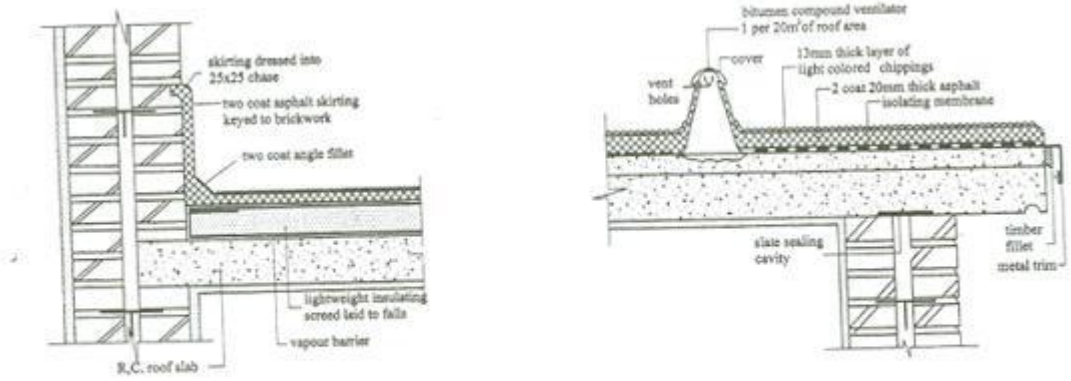


Fig. Reinforced concrete flat roof with mastic asphalt roof covering

Lead-Covered Flat Roof

It is understood that lead as a building material has been used extensively for over 5000 years and is obtained from the mineral galena of which Australia, Canada, Mexico and the USA are the main producers. It is a durable and dense material of low strength but is very malleable and can be worked cold into complicated shapes without fracture. The raw materials are mined, refined to a high degree of purity and the cast into bars or pigs which can be used to produce lead sheet, pipe and extruded products.

Copper-Covered Flat Roof

Copper, like lead has been used as a building material for many centuries. It is a dense material, which is highly ductile and malleable and can be cold worked into the required shape or profile. The metal hardens

with cold working but its original dead soft temper can be restored by the application of heat with a blowlamp or oxyacetylene torch and quenching with water or by natural air-cooling. If the dead soft temper is not maintained, the hardened copper will be difficult to work and may fracture. On exposure to the atmosphere, copper forms on its upper surface a natural protective film or patina, which varies in colour from green to black, making the copper beneath virtually inert.

Rolled copper is used for flat roof coverings. Rolled copper is available in three forms:

Sheet: flat material of exact length, over 0.15mm up to and including 10.0mm thick and over 450mm in width
Strip: material over 0.15mm up to and including 10.0mm thick and any width, and generally not cut to length. It is usually supplied in coils but can be obtained flat or folded.
Foil: material 0.15mm thick and under, of any width supplied flat or in a coil. Because of its thickness foil has no practical application in the context of roof covering.

Choice of Roof Covering!
In the selection of a suitable roof covering, the following factors need to be seriously considered: initial cost; maintenance; slope of the roof; durability; resistance to fire; weight of the roof covering; type of constructions; appearance (aesthetic value) and hat insulation.
Asbestos-cement sheet, unless used in double layers, has got a very low resistance to the transmission of heat and similar is the case with corrugated metal roofing. Clay tile or thatch roof gives adequate protection against thermal effects. Whereas thatched roof has go the least fire resistance.

Assignment 8

Sketch and describe different elements of truss.