Chapter -7

Stair case

Stairs are sets of steps leading from one floor to another and are provided in a building to afford a means of communication between the various floors. Steps arranged in series and placed in an enclosure is called staircase. It is the hall of a building in which the stairs are located. Stairs should be designed properly to provide proper ventilation and lighting. In public building it should be located near the main entrance and in residential building it should be placed carefully so as to provide easy access for all rooms and to maintain privacy at the same time.

Various materials such as bricks, stones, timber, steel, plain concrete, etc. are used for the construction of the stairs. Sometimes, marble, mosaic or checkered finish is provided. The selection of suitable materials for the stair construction is governed by the fund available, expected life of the building, availability of materials, external appearance and the expected fire resisting qualities.

The stairs should be located such that they serve the purpose for which they are provided. It needs careful planning and consideration of all probable factors. In case of fire or any other emergency the stairs are only means of communication. Generally, they are placed near the main entrance in the public buildings such as offices, schools, hospitals, etc. and in the residential buildings, they are provided in the centre to provide easy access to all the dwellers and maintain privacy at the same time.

Typical sections of a stair with its components are shown in and the common technical terms associated with the design and construction of stairs are discussed below.

a) ***Tread*** is the horizontal upper part of a step or member of a stair which is used to rest the foot while ascending or descending the stairs. The tread of public buildings must be wide enough to provide safe footing.

b) ***Going*** is the horizontal distance between the nosing or front edges of two consecutive steps/risers. It is usually 30m for public buildings so that it is wide enough to provide safe footings.

c) ***Riser*** is the vertical member of a stair. The vertical distance between two treads

d) ***Rise*** is the vertical distance between the upper surfaces of two consecutive steps. It is the vertical distance between surfaces of two consecutive steps. The rise of private buildings is about 15cm while a higher value can be used for public buildings.

e) ***Landing*** is a platform between two flights. A landing gives brief rest during the use of a staircase and facilitates in changing direction. When the landing extends to full width of staircase. It is termed as half spaced landing. It is known as quarter spaced landing when it extends only for half of the staircase width.

f) ***Flight*** is a series of continuous sets of steps between floors and/ or landing without intermediate landing.

g) ***Baluster*** is a vertical member placed between the stringer and hand rail to provide support to the hand rail The combined framework of hand rail and baluster is known as balustrade.

h) ***Strings*** or ***Stringer*** is a structural member which supports the steps and act as inclined beams.

i) ***Handrail*** is a rounded or moulded member of wood or metal fixed on the top of balusters.

j) ***Head room*** is the minimum clear vertical distance between the tread of a step and overhead structure.

k) ***Newel post*** is a vertical member which is placed at the ends of flights to connect the ends of strings and handrail.

l) ***Winders*** are tapering steps which are provided for changing the direction of a stair. They are angular or radiating steps and are provided to change the direction in the stairs.

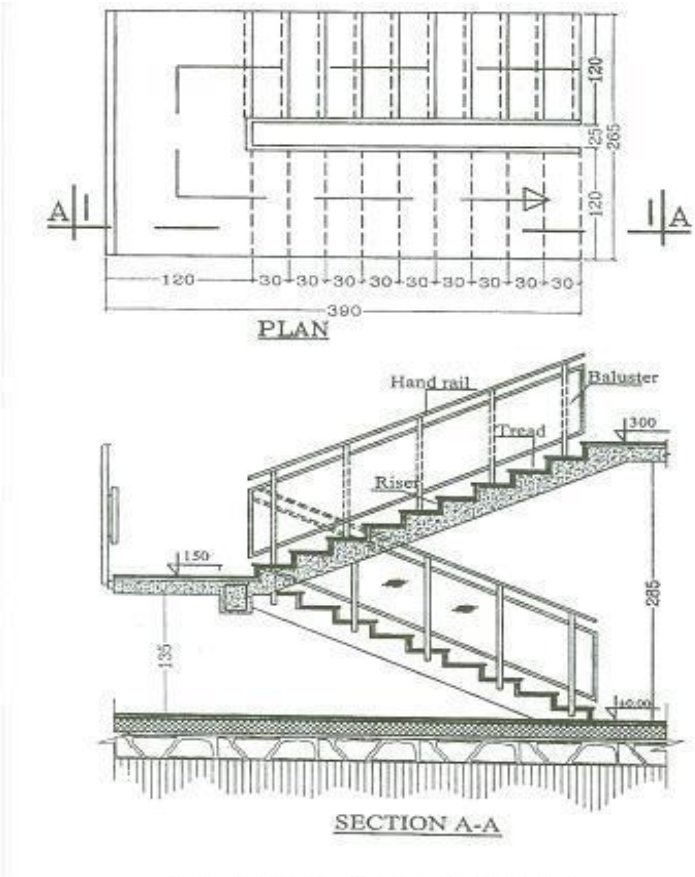


Fig.3.4 Typical Section of a staircase

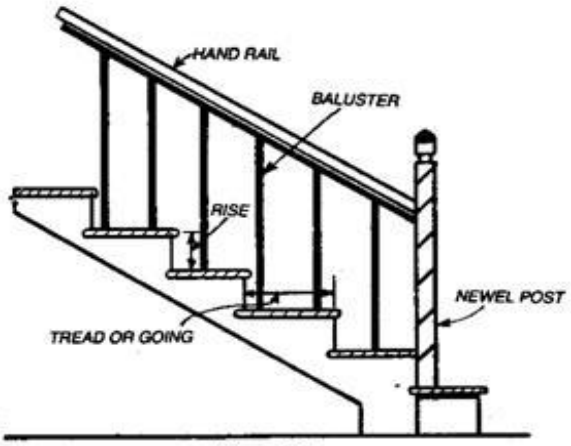


Fig. 14.1

The various types of stairs are classified as follows:

1. ***Straight flight stairs.***
2. ***Quarter turn stairs.***
3. ***Half turn stairs.***

(a) ***Dog-legged stairs.***

(b) ***Open Newel stairs.***

4. ***Three quarter turn stairs.,***
5. ***Circular or spiral stairs.***
6. ***Geometrical stairs***
7. ***Bifurcating stairs.***

Straight flight stair: In this type, stairs continue throughout their entire length in one direction only. This may consist of a single flight or a flight with one or two landings in between as shown in This type of stairs is constructed when long but narrow space is available to accommodate it (Fig. 14.2).

Quarter turn stair: is a stair type which changes the direction of the flight at right angles either to the left or to the right. At the quarter turn, there may either be quarter space landing or there may be winders, as shown in

When the direction of flight is to be changed by 90° quarter turn stairs are provided. This may be achieved either by introducing a quarter space landing or by providing winders at the junction (Figs. 14.3 to 14.5).

Half turn stair: is the one which has the direction of its flight reversed by 180^{o} as shown in. In other words, stairs changing its direction through 180^{0} are known as a half-turn stairs. It may be either dog-legged type or open newel type as illustrated in Figs. 14.6 and 14.7. In a dog-legged stairs, the flights are in opposite directions and no space is provided between the flights in plan. Whereas in an open newel stairs, there is well or opening between the flights and it may be used to accommodate a lift. Such types of stairs are useful where available space is enough (See also Fig. 14.9).

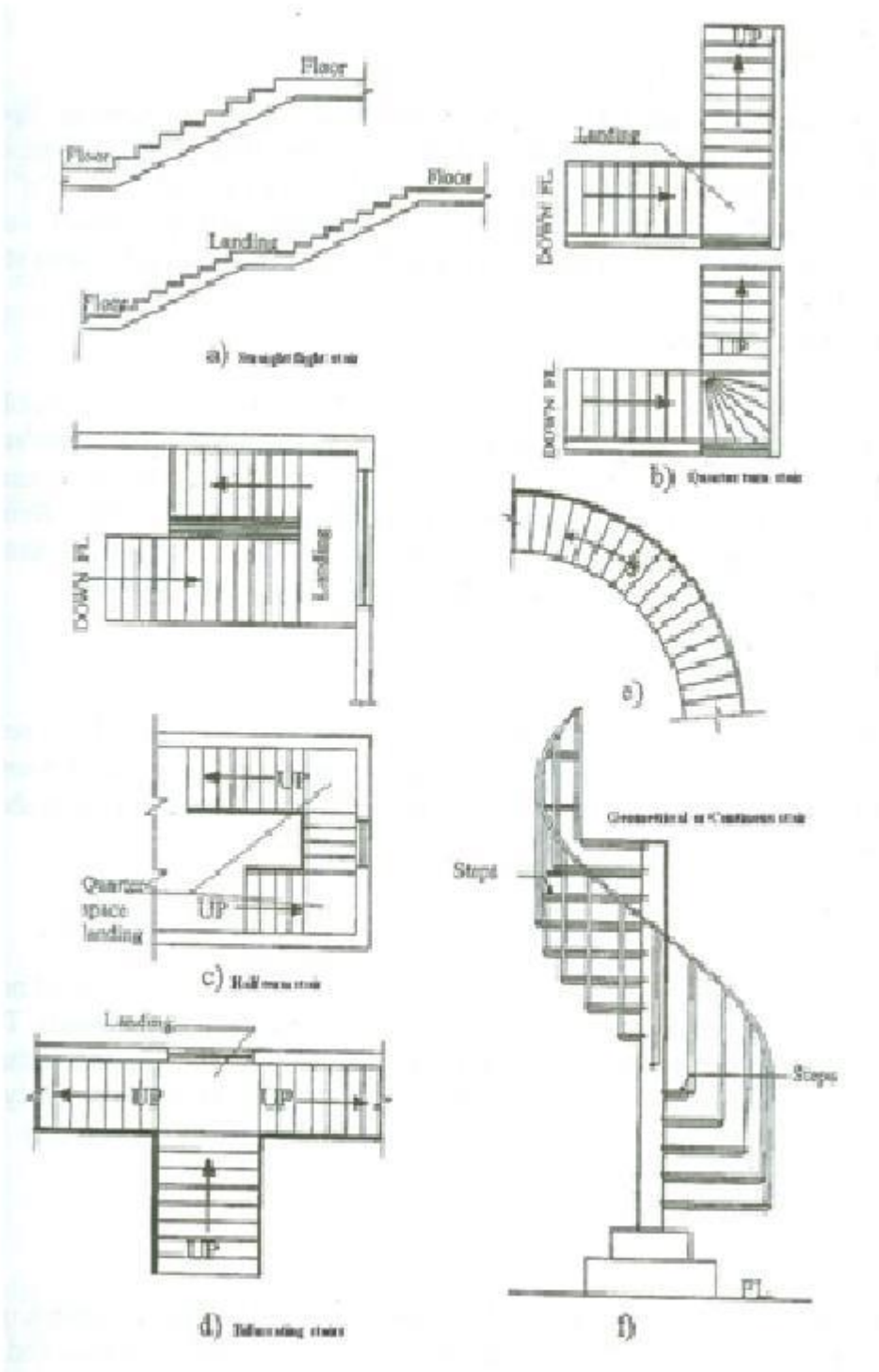
Three-Quarter Turn Stairs. Stair changing through 270^{0} are called as a three-quarter turn stairs as illustrated in Fig. 14.8. An open well is formed in such type of construction.

Bifurcating stairs: are commonly used in public buildings at their entrance hell. The stair has a wider flight at the bottom, which bifurcates into two narrower flights, one turning to the left and the other to the right, at the landing as shown in

Such types of stairs are generally constructed in modern public buildings. There is a wide flight at the start and is provided into two narrow flights at the mid-landing. The two narrow flights begin from either side of the mid-landing (Fig. 14.10).

Geometrical or continuous stairs: In this type of stairs, the strings and handrails are continuous and are set out in accordance with geometrical principles. Continuous stairs do not normally have any landing and the may be of circular spiral or helical stairs This type of stairs may have any geometrical shape and there are no newel posts. Better skill is needed to construct geometrical stairs and it is weaker than open newel stairs.

Circular or Spiral Stairs. Circular stairs are generally provided at the rear of a building to give access for servicing at various floors. All the steps radiate from a newel post, in the form of winders. It may be constructed in stone, cast iron or R.C.C.



The following materials are used in the construction of Stairs:

1. Stone
2. Brick
3. Wood
4. R.C.C

5. Metal

The selection of materials for the construction of stairs depends upon the availability of materials, funds, desired life of the building, aesthetical importance and expected fire resisting quality. Be made either of timber, bricks, stones, mild steel, wrought iron or plain and reinforced concrete.

A combination of two or more of these materials may be used in the same stair.

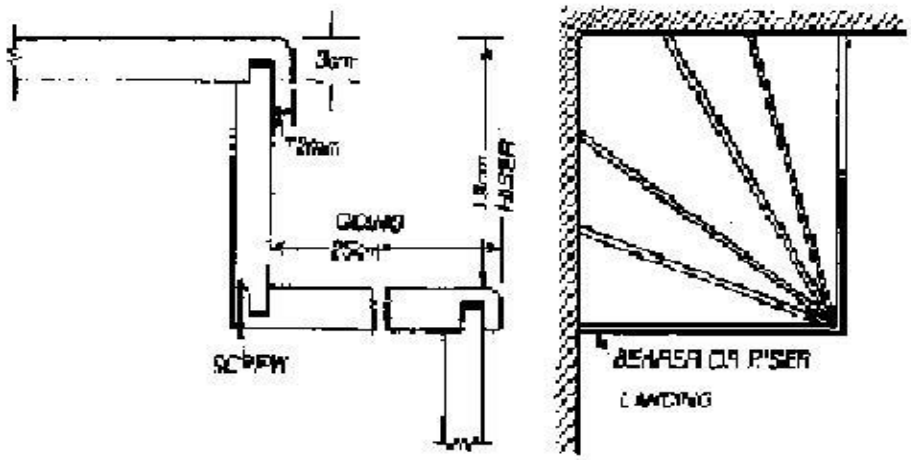
Stone Stairs

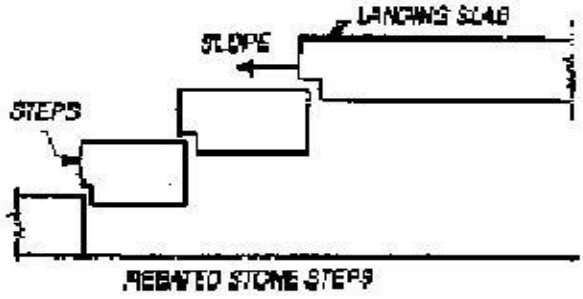
Stone stairs are strong and rigid and are widely used at the main entrance of public buildings. Stones for such stairs should be dressed and properly bounded to each other. Stone stairs are, however, very heavy and therefore difficult to transport. The stones employed in the construction of stairs should be hard, durable, weather resistant and fire resistant. Anyone of the following methods can be used for the construction of stone stairs (Figs. 14.11 to 14.15).

(a) ***Rectangular steps***. In case of a rectangular step, the lower edge of one step is supported on the top back edge of the other. Sometimes rebated or checked joints are used to strengthen the stepping. One side of the steps may rest on the main wall and the other side may rest on a drawfwall built for the purpose. The landings are built of stone slabs which are joggled to each other (Fig. 14.11).

*(b***) Spandril steps**. Spandril steps are approximately triangular in shape except at the ends which are' built into the wall. Splayed rebated joints are provided between each step and the splay is not less than 50 mm. The soffit exhibits a plain and better appearance. Greater headroom is obtained due to this fact.

(c) Built up steps. Thin sawn stone slabs are used as treads and risers and they are connected by dowels. They may be used as facing concrete or brick steps. The minimum thickness of the treads is about 50 mm when it is supported on ends only.





Figs. 14.11 to 14.14

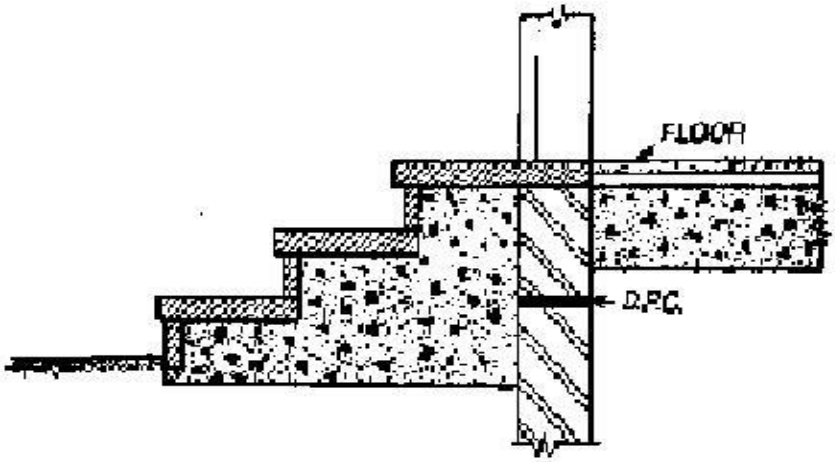


Fig. 14.15

Wooden stairs are light in weight and easy to construct, but they have very poor fire resistance and sound insulation. Wooden stairs are normally used for small size residential buildings. The timber to be used for the construction of stairs should be well treated before use. The greatest limitation of wooden stairs is that it catches fire easily, and in case of a fire, the occupants of upper floors will find no way to escape. If good quality of timber of proper thickness is used, it resists fire to a great extent and the occupants will have enough time to escape. The constructional details of wooden stairs may be briefly described as follows:

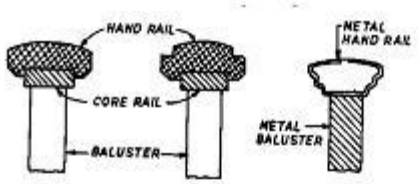
(a) Steps. The thickness of riser should not less than 25 mm. and that of the tread should not be less than 35 mm. The riser and the treads are joined together by tongue and grooved joints and the joints are also nailed or screwed. The nosing should not be allowed to project more than the thickness of the tread.

(b) Stringers. The outer ends of the steps are fixed into the stringers which are thicker than 50 mm. The outer stringers are either one piece or two pieces which are joined together by tongue and groove joint.

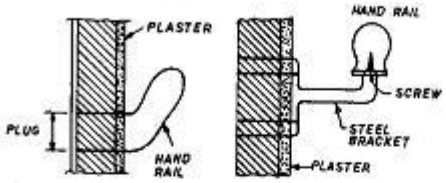
(c) Landings. These are constructed of tongued and grooved boarding on joists which is supported on the walls. In the construction of quarter-space landing, a timber joist known as "Pitching piece", is inserted in the wall at one end and housed with the newel at the other. for the construction of a half-space landing, wooden joist known as "trimmer" is placed across the full width of the staircase.

(d) Newels. The bottom newel is fixed with the floor and screwed or nailed suitably to a joist below. The central newel is also carried down to the floor level or below the floor level and fixed rigidly. The trimmer joist is attached to this newel. The tenons of the stringers are fitted into mortices made in the newels and are further secured by dowels or pins.

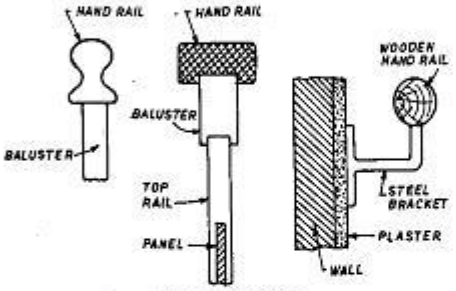
(e) Handrail. The handrail for the upper flight is fixed into the two newels by tenon and mortice joist. The handrail at the top landing is attached to the newel at one end and to a half newel at the other end which in turn is inserted into the wall. The upper end of the lower hand rail is intersected by the upper outer stringer (Figs. 14.21 to 14.28).



Figs. 14.21 to 14.23



Figs. 14.24 to 14.25



Figs. 14.26 to 14.28

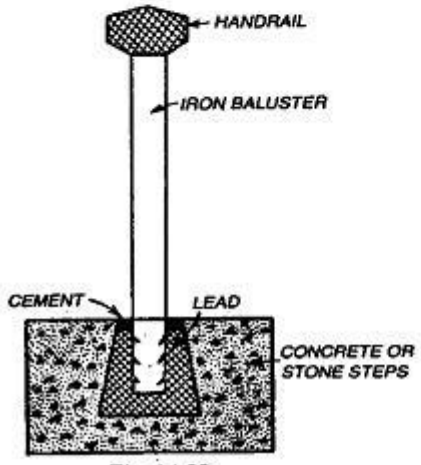
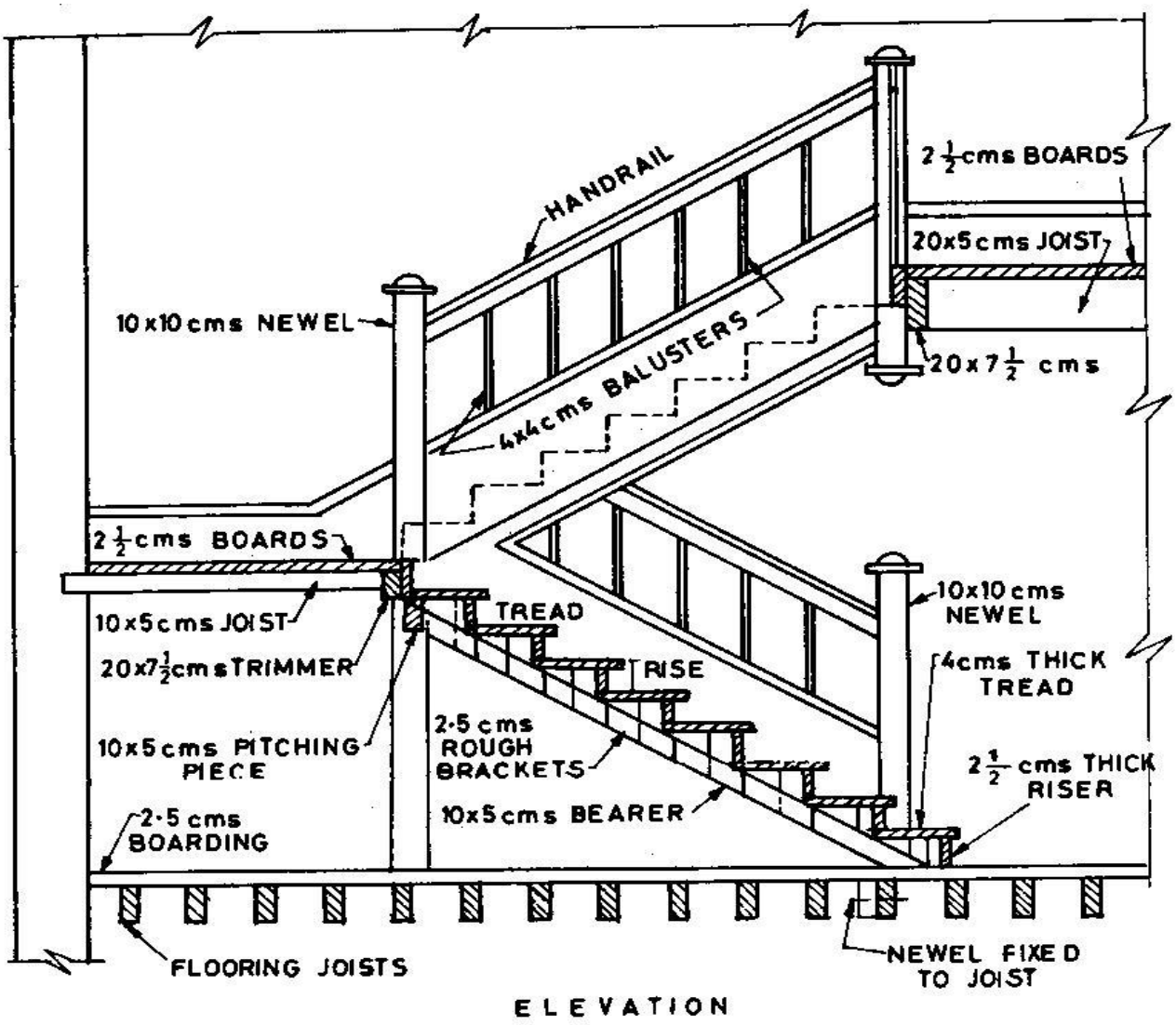
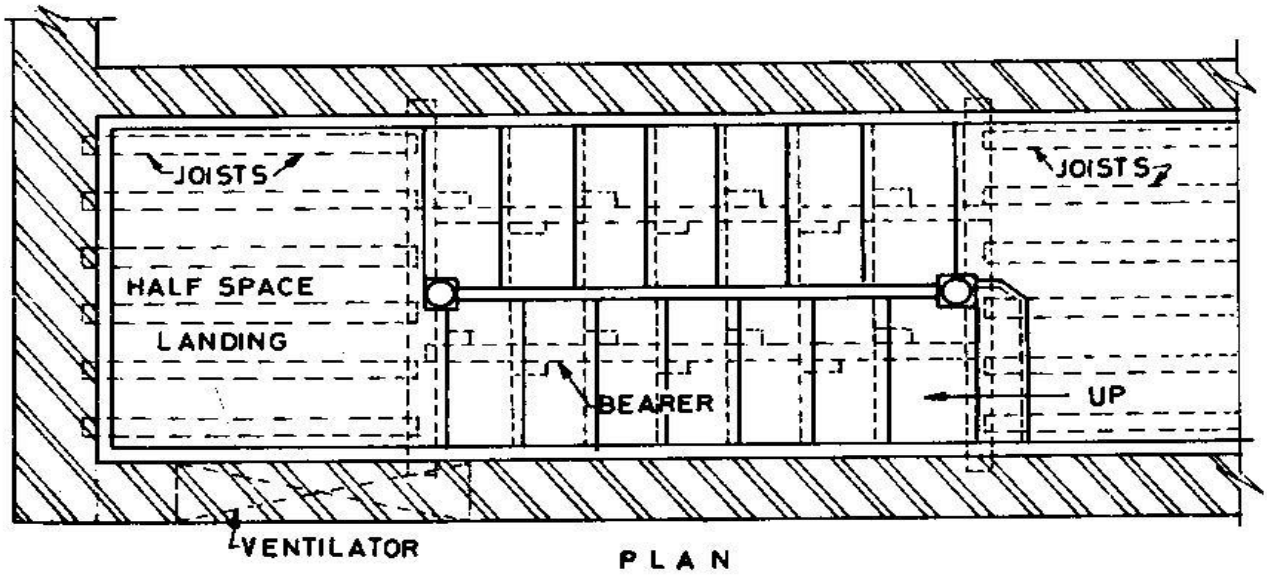


Fig. 14.29

(j) *Balusters.* The minimum width of square balusters is 50 mm and spaced 100 mm apart. They are fixed into the handrails and stringers. Sometimes balusters are fitted into a continuous groove formed into the handrails and the groove is latter filled up. Metallic balusters are also used at certain places (Fig. 14.29).



ELEVATION



PLAN

Fig. 14.18

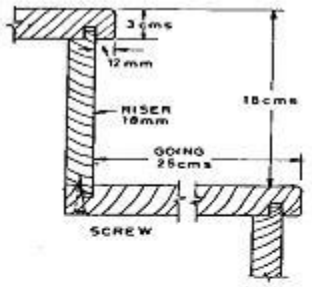


Fig. 14.19

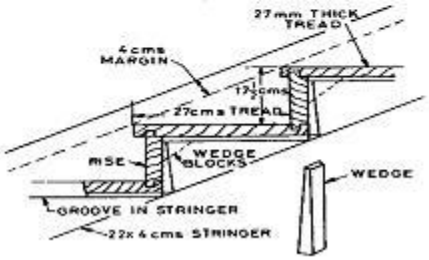


Fig. 14.20

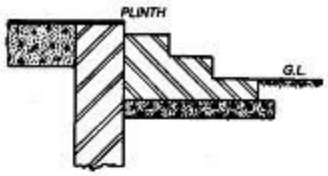


Fig. 14.16

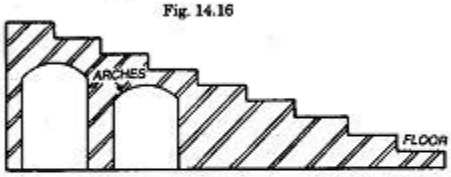


Fig. 14.17

Brick Stairs

Similar to stone stairs, brick stairs are used at the entrance of a building special quality of bricks should be used for the construction of stairs. Brick steps may be plastered or pointed at all the joints. If properly made, brick stairs are durable, have good aesthetic value, but requires frequent maintenance.

The advantages and disadvantages of each type of stair has to be evaluated based on their weight, fire resistance, sound insulation, aesthetic merit, freedom of design, ease of transportation and cost.

Now-a-days they are rarely used except at entrance steps. The treads and risers are normally constructed equal to 1and 1/2 lengths of bricks and height of two layers of bricks respectively. A brick stair may be built of solid masonry or arches may be provided in the lower portion. When arches are provided to total masonry work is reduced and cupboards, etc. may be made in this hollow space. The surface of the stair may be given any suitable type of floor finish (Figs. 14.16 and 14.17).

Metal Stairs

Metal stairs are mainly used as emergency exits. Metal stairs make lot of noise and can be built in a smaller area. Spiral stairs are mainly made of metal. They are normally manufactured in a workshop and fixed on site, which makes it faster and will be functional immediately. The metal used for stair has to be properly treated for possible corrosion, where specially exposed to external adverse weather condition.

Steel and cast iron stairs are adopted where fire-proof construction is needed, such as, in factories, workshops, etc. The following points may be noted for metal stairs.

(a) Channel section is generally used to act as stringers.

(b) The treads are of steel checkered plate. Sometimes, tread and riser are in one unit only but they may be in separate units also.

(c) Treads and risers are supported on angles which are in turn supported on the stringers.

(d) Sometimes risers may not be used at all.
(e) In metal stairs, metal balusters with pipe handrails are used. (j) The spiral stair of the cast iron has a cast-iron newel placed in the centre around which cast iron steps are attached. Figs. 14.34 and 14.35 illustrate the various details of the metal stairs.

Concrete Stairs

Reinforced concrete stairs are most widely used for residential, public and industrial buildings. They are strong, durable, can take any desired shape and have shape and have good fire resisting capacity. In addition, it is less noisy, it can be kept clean and it may have more attracting appearance if suitable finishes are used. Reinforced concrete stair can be cast in situ or prefabricated. Stairs spanning transversely and stairs spanning longitudinally are the main two types of concrete stairs.

In general R.C.C. Stairs are commonly used in all types of constructions. They can resist wear and fire better than any other material and can be casted to the desired shape. The advantages of the reinforced cement concrete stair are as follows:

(a) It can resist fire in a better way.
(b) Movement over it produces less noise.
(c) It can be cast into any desired geometrical shape.
(d) More headroom is available at thinner sections.
(e) Attractive appearance can be obtained if Imitable finishes are used.
(f) It can be maintained clean.
(g) Maintenance cost is less.

Construction of R.C.C. Stairs

In case of smaller buildings, a combination of plain concrete and reinforced cement concrete may also be used economically. In such types of stair, the stringers are constructed of RC.C. beams, the top slope being cut in a shape to suit the risers and the treads. The treads are constructed of precast plain concrete slabs and the risers are small, precast concrete blocks. One end of the stringers rests on the base and the other rests on the wall. A precast concrete slab is used as landing.

The handrails may be made of timber and the balusters of steel pipes. Fig. 14.30 illustrates an example of such stair.

RC.C. stairs can be constructed in anyone of the following types:

(i) RC.C. steps are fixed in the wall and they act as cantilever.

The reinforcement is provided at the top of each tread and nominal reinforcement is placed at the bottom of the riser (Fig. 14.31).

(ii) R.C.C. Steps span between the two stringers or wall and a stringer. The stringers function as inclined RC.C. beams rest at the top and the bottom of the landing. The steps act as slabs.

(iii) Each flight is designed as an inclined slab and the reinforcement is provided parallel to the slope of the flight. The landings may be designed with the flight slab as a continuous member or the flights are supported on the beams at the ends (Figs. 14.32 and 14.33).

Reinforced concrete stairs may be either precast or cast-in-situ.

To improve the appearance, RC.C. stairs are sometimes covered with terrazzo finish or marble tiles or glazed tiles. Metallic strips or angles are fixed at the nosing to protect against knocking off or development or cracks in the nosing. Fig. 14.30 illustrates the RC.C. stairs.

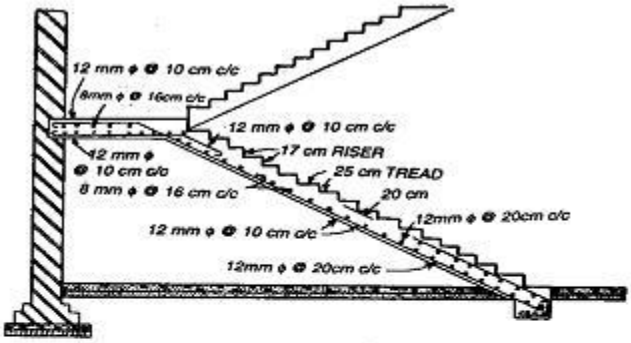


Fig. 14.30

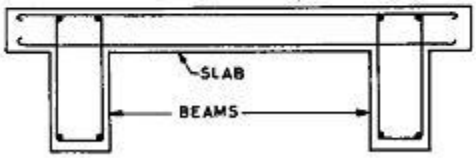


Fig. 14.33
Fig. Concrete or RCC Stairs

The building regulation requires the following:

1. A stair should be constructed of sound material and workmanship,
2. Its ascent should be relatively easy. Stairs for public buildings should have a pitch of 38^0 and for private buildings & the pitch should not be more than 42^0,
3. All risers and treads should be of uniform height and width, respectively, to avoid accidents,
4. The stair case must be adequately lit specially at turns,
5. The maximum number of steps in a flight is preferably 12 but should not be more than 15,
6. To ensure quick exit in case of emergency, the stair should be wide enough, especially in public buildings. A narrow stair may make it impossible to convey large furniture upstairs,
7. Adequate headroom of at least 2m should be available,
8. The width of landing should not be less than the width of stair,

The draft National Building code of Ethiopia (NBCE, 1995 E.C.(2003)) Provides important information regarding stair dimensions, width of stairs, length of stairs, ramps, handrail etc.

General Requirements of a Good Staircase

The following are the general requirements of a good staircase:

1. Location. It should be centrally located such that it is easily accessible from the various rooms of the building. Sufficient light and proper ventilation should be made available in the staircase for easy and safe communication between the various floors.

2. Length of Flight. Generally, the number of steps in a flight is restricted to a maximum of twelve and a minimum of three for easy and comfortable ascent or descent on a staircase.

3. Headroom. Headroom is never provided less than 2.15 m.

4. ***Stair Width.*** The width of stair depends upon the purpose and importance of the building. It is considerably more in public building where the number of person using it, is too many. In residential buildings, it may be kept about one metre only.

5. Pitch of Stairs. The longer flights should have smaller pitch. Generally, the maximum and the minimum pitch should be 40° and 25° respectively in any stairs.

6. Landing. The minimum width of landing should be equal to the width of the stairs.

7. Winders. The use of winders in staircase should be avoided.They are expensive in the construction as well as dangerous for the users. They should be provided at the lower end of flight, when their use becomes essential.

8. Balustrade. Balustrade must be provided in the open well stairs to avoid the danger of accidents.

9. Steps. In a staircase, all the steps should have uniform rise and tread. The rise and tread should be such selected that it will ensure comfortable ascent or descent on stairs.

The following rules are used as a guideline to obtain satisfactory proportion of steps in a stair:

(a) Tread in cm + 2 x Rise in cm = 60 to 62.5

(b) Tread in cm x Rise in cm = 400 to 500 sq. cm

(c) Tread in cm + Rise in cm = 42.5 to 45cm

Step Proportions

It is very essential that the design of the steps should be carefully worked out so as not to make the steps either too wide or too short. Furthermore, the rise should not be excessive which otherwise would cause inconvenience to the user.

The following rules may be generally followed:

a) I. Rise+ Tread>40 and <45cm

II. 2 Rise +Tread >58 and<63cm

III. Rise x Tread> 400 and<500cm^2

b) For large buildings a Rise<18cm and Tread>27cm is satisfactory. For ordinary buildings slightly greater rise and slightly less tread is permitted. However, Rise> 20cm and Tread<22cm should not be used,

c) Width of stairs should be adequate for the number of people who are expected to use them. A stairs width of 0.8-1m is recommended for residential buildings while 1.5m wide stair for public buildings is considered essential,

d) The slope of the stairs should never be grater than 400 and not less than 200 to prevent under exertion or wastage of space,

e) All the Risers and Treads should be of uniform dimensions,

f) The stairs should be well lighted specially at turns,

g) Generally, the number of steps in a flight should not be>12,

h) Sufficient head room should be provided for people to move up and down stairs without knocking their heads. The clear height should not be less than 2m (2.10m recommended).

i) Handrails- For public buildings the minimum height for hand rail is 90cm from the floor for horizontal hand rails 80cm for racking handrails measured vertically from the nosing.

Planning of Stairs

The dimension of the staircase hall and the floor height is generally known prior to the stair planning. The number of treads and risers may be determined as follows:

(a) Placing of first and last risers are decided depending upon the locations of doors, windows, verandah, etc.

(b) A convenient size of tread and riser is assumed.

(c) Number of risers is computed from the following formula

$$No\ of\ Riser = \frac{Total\ Height\ of\ Floor}{Height\ of\ Riser}$$

(d) No. of treads = Number of rises-1

The suitable type of stair is selected to accommodate the required number of risers and treads in the available space of the staircase hall with provision of intermediate landings at suitable places.

The stair of a residential building is to be provided in a staircase hall of size 3 m x5 m. If the vertical distance between the floors is 3.30 m. Plan a suitable stair for the building.

Solution

A dog-legged stair may be suitable provided in the given space. The width of the stair may be assumed as 1.4 m and the same width may be provided to the landing between the two flights.

Assuming two flights,

$$The\ height\ of\ each\ of\ flight = \frac{3.20}{2} = 1.65m$$

$$\text{Assuming 15 cm riser, } No.\ of\ risers\ required = \frac{165}{15} = 11$$

Number of trades, T= Number of Risers, R-1=11-1=10

It is proposed to keep the width of the tread as 25 cm.

Therefore, space occupied by 10 treads = 25 x 10 = 250 cm.

Space left at the entrance = 5 - (1.4 + 2.5) = 1.l0m= 110 cm.

The planning of the stair is shown in Fig. 14.36.

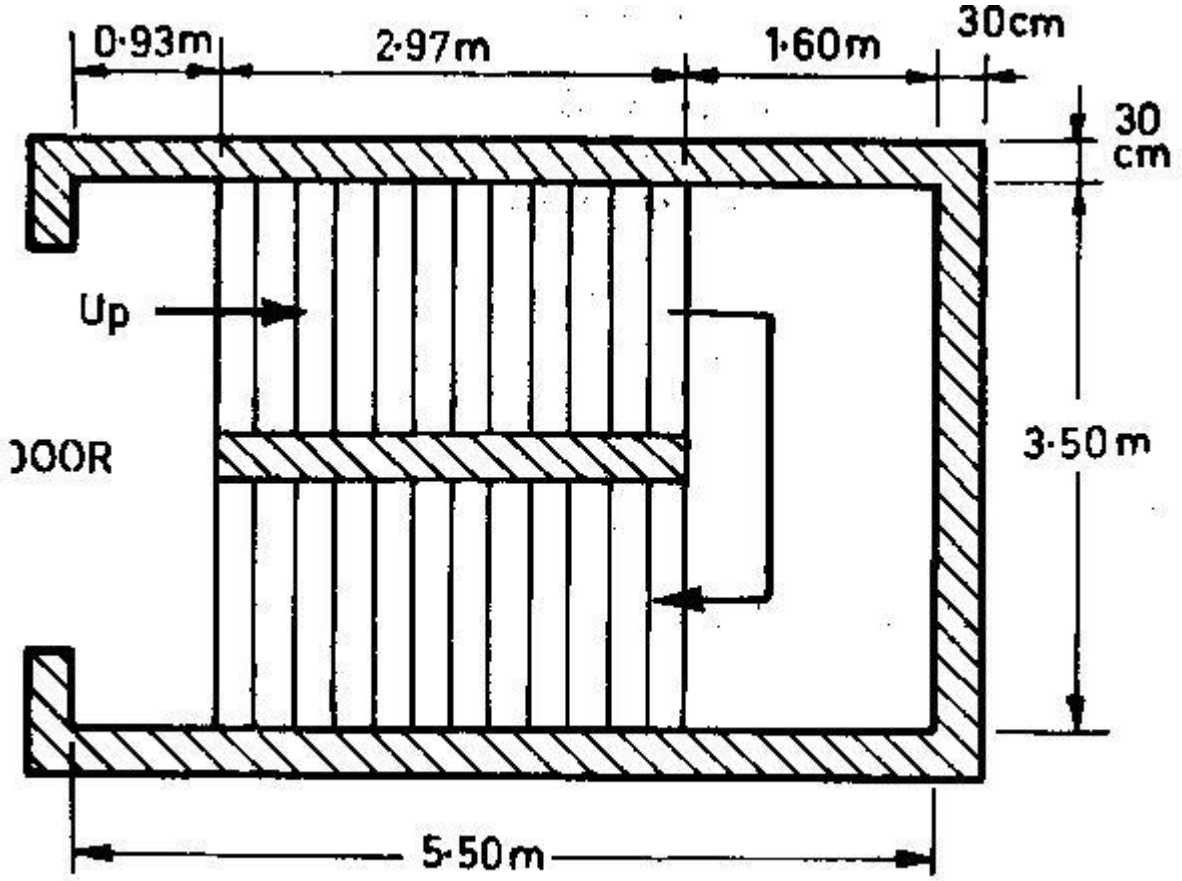


Fig. 14.36

Assignment 7

The stair of a residential building is to be provided in a staircase hall of size 3 m x5 m. If the vertical distance between the floors is 3 m. Plan a suitable stair for the building. Show the drawing plan briefly.