Design of structures – II

Lecture – 37

In the previous lecture we have seen in detail about the design of circular slabs that is we have seen the design and detailing of simply supported circular slab, fixed circular slab and partially fixed circular slab. In this we are going to start designing the staircase. Before start designing stair case we must know the components of staircase, the technical terms, type of staircases and how to provide the reinforcement detailing. In connection with the component of the staircase that is from this staircase

Components of Staircase

The first component is the step. The steps which are consist of two components one is the vertical component and the other one is horizontal components. The vertical component of the steps is normally called as riser and the horizontal component of the steps is called as tread. So here the vertical distance between the two steps is called as rise or it may be riser. Another component here it is over the post handrail or otherwise called as the baluster. Over the baluster we are going to providing certain base which is used for rising or climbing up of the staircase that is the material may be wooden or steel or aluminum or it may be stainless. And this portion is normally called as landing in the case of staircase if you have dark logger staircase this are all the steps and this is called as waist slab or normally it is called as flight. This horizontal component normally called as the tread and the vertical component here it is called as riser. And the distance between the two steps is normally called as riser and may be the tread otherwise called as going. Here the horizontal portion at the ground floor level is called as passage. And using the waist slab we are climbing up and we reach landing that is called as mid-landing. This mid-landing is the horizontal portion of the slab which is used to divide the vertical height of

the roof into two portions that is the two base slabs. Then using second waist slab or the flight we are reaching the landing at the first floor. This portion is called as landing at the first floor. In similar manner when you climbing up to reach the second floor that we called as climbing at second floor. So the portion at ground floor is normally called as passage. So there are all the certain components of the staircase we must know. So here in this portion it is called as the landing and here this is somewhat has stringer or carriage closed riser. Normally in the case of steps this edge of the step is normally rounded that is called as nosing of the steps. These are all the certain components of the staircase we must know before designing the staircase.

Technical terms:

These are the technical terms which we use in the case of the staircase that is here are some technical terms which are used in the connection with design of stairs,

a. Tread or Going: The horizontal upper portion of the steps is called as the tread or going. That is this is the steps and this portion i.e., horizontal component of the steps which is called as the tread or going.
b. Riser: The vertical portion of a step is called the riser.
c. Rise: the vertical distance between two consecutive treads is called as the rise.
d. Flight: A series of steps provided between two landings is called the flight.
e. Landing: A horizontal slab provided between two flights is called as the landing.
f. Waist: The least thickness of a stair slab is called the waist slab.
g. Soffit: The bottom surface of a stair slab is called the soffit.

h. Nosing: The intersection of the tread and the riser is known as the nosing of steps.
i. Headroom: the vertical distance from a line connecting the nosing of all tread and the soffit above.

This are all the certain technical terms we need to know before start designing the staircase.

Stairs and its types:

Now we will see the staircases and the different types of the staircases available. A stair is a series of steps arranged in such a manner as to connect different floors of a building. Stairs are designed to provide as easy and quick access to different floors. A staircase is an enclosure which contains the complete stairway. Normally staircases are giving to connect each and every floor in the building. Generally stairs are having different types they are,

- Straight stairs – straight stairs are normally provided in the case of residential building that is it is called as external staircase which is provided outside the building to reach each floors.
- Quarter turn stairs – it has only one turn which is used to reach the first floor that is called as the quarter turn stairs.
- Half turn stairs -
- Three quarter turn stairs
- Dog legged stairs
- Circular stairs
- Spiral stairs
- Curved stairs
- Geometric stairs
- Bifurcated stairs

This is the reinforcement detailing of the staircase and how to provide the reinforcement detailing for the staircase. And this is somewhat the arrangement of dog legged staircase. Here I am going to see in detail about the dog legged staircase. Here this portion of the staircase which is designed as the simply supported it is supported at its ends. So each and every flight of dog legged staircase is supported at the ends. Or it may be supported by providing beam near the waist slab. So here we are having the support and this two landing may be designed as the cantilever or it may be supported at the ends. This may be designed as the cantilever beam or the simply supported beam it is in order to save the space of the building. So here it is completely supported at its ends. In this it is supported near the staircase that is near the end of the waist slab. And the landings are designed as the cantilever and it can be extended beyond the beam which has been provided near the waist slab or it may be designed as simply supported and supported at the ends.

So here the reinforcement detailing in the waist slab the first flight of the waist slab that is dog legged staircase. If you design here it is supported at the ends. This is designed as the simply supported and due to deflection downward so here in order to resist this one this is the arrangement of reinforcement required for the slab. The bottom reinforcement has to be again bringing it to the top at near the support in the case of landing. And here the bottom reinforcement which is used to resist the tension at the bottom that has to be extended into the waist slab at the top. So here the slab is normally the transformation of the bending moment the slab and here it will be developed extension over the support that is at the top. To avoid those things we are providing the reinforcement at the bottom that bottom reinforcement has to be extended into the waist slab to resist the tension which is created near the bending of the slab at the top. In the case of the top reinforcement which has to be extended to the waist slab and it may be

provided at the top. Here also there is the tension at the bending of the slab that is created at the top. To resist this tension the reinforcement has to be extended into the waist slab and has to be provided at the top. So this is the arrangement of reinforcement and in order to keep this main reinforcement in a proper spacing the reinforcement which is provided in the transverse direction. That is transverse reinforcement is called as the distribution reinforcement. This is as in the case of simply supported slab and this is the arrangement of reinforcement required for the slab.

Design of a Dog Legged Staircase

Now I am going to design the dog legged staircase. So we have seen so far the components of the staircase as well as the technical terms which are used in the staircase and the reinforcement detailing of the flight of the staircase. Now we are going to design the dog legged staircase.

The service stair of an office building is to be located in a staircase hall measuring 3000mm x 5000mm. The vertical height of floor is 3500mm and thickness of slab is 125mm. The stair is supported on 230mm thick walls. Use M20 and Fe415 as materials. Live load on slab is 3kN/m^2. Draw the cross section of staircase showing reinforcement details.

Solution:

Before designing the thickness of the dog legged stair case first we must know the components of the staircase that is components of the staircases. We need to find the thickness of the steps and we need to finalize the horizontal length of the waist slab and we need to finalize the width of mid-landing as well as the bases. After finalizing the dimension of every component of the staircases we can start designing and start finding out the load acting on the slab and we can start finding out the bending moment. Then using the bending moment we are going to find the thickness of the

slab at the reinforcement required. Finally we are going to draw the reinforcement detailing of the dog legged staircase. So here these are all the designs required for the dog legged staircase.

a. Fixing of dimensions of components
b. Effective span of slab
c. Loads on waist slab
d. Loads on landing slab
e. Loading diagram
f. Bending moment
g. Effective thickness of slab
h. Main steel reinforcement
i. Distribution steel
j. Check for deflection
k. Reinforcement detailing

So here the clear size of the building is 3000mm x 5000mm and this is the wall on all four sides. Here this is the passage and this portion is called as mid-landing and this portion is called as the passage at the ground floor. This portion is called as the well portion which is used to divide the whole portion of the slab into two way slab. And this is the first step, second step, third step and fourth step and the other steps are indicated by dotted lines. And this is dog legged staircase that is in the staircase consist of two flights to reach every floor. So here how to draw the cross section of the staircase is that this are all the supports and this is the thickness of the wall. Now here this mid-landing which is support on the passage and here we are having landing at the first floor which is supported on this wall. And here this is the mid-landing which is supported on this wall and this is the landing of the wall which is supported on the beam at the first floor.

First we are going to assume the tread and size of riser and we are going to have and here we are going to determine the components of the staircase. The size of the room is 3000 x 5000mm. First assume the thickness of riser as 150mm and the maximum thickness of the riser should not exceed 150mm. So here I am going to find out the number of steps. The height of floor is 3500mm and thickness of slab at first floor is 125mm so total height of floor including the slab thickness is 3625mm. Now we need to find out the height of thickness of one flight which is 3625/2 that is equal to 1812.5mm. Now we need to find the number of steps for each flight so we have already assumed the thickness of the riser is 150mm hence it will be 1812.5/150 which is equal to 12.08 numbers. Here we can't fix this value of 12.08 numbers so we need to keep either 13 number or 11 numbers. Here I am going to keep this as 11 numbers or I can provide 12 numbers of steps for each flights.

Now we need to find the horizontal length of the section that is in this case it is easy to find the horizontal length of the waist slab. Once we determine the horizontal length of the waist slab we can easily find the width of the passage as well as the width of mid-landing. In order to find the horizontal length of this waist slab we must know the horizontal components of the steps. So here also I am going to assume the horizontal component of the tread as 275mm. Before that I want to find out the exact thickness of the riser. So we have assumed the thickness of the riser as 150mm then we have found the number of steps as 12.08. So the exact thickness of the riser is 1812.5/12 which is equal to 151.04mm it is very near to 150mm and it is very easy to climb up. Next assume the thickness of tread which is 275mm. So the horizontal length of waist slab is we have fixed 12 numbers that is 12 x 275 which is equal to 3300mm. So this is the horizontal length of the waist slab and the remaining length it is the length of the staircase slab room is (5000-3300) which is equal to 1700mm. This 1700mm has to

be utilized for the passage. Next fix the width of mid-landing as 900mm and the remaining length has to be fixed for the passage that is equal to 800mm. So here we have fixed the components of the staircase.

Summary:

In this lecture we have seen the components of the staircase that is we have started discussing about the design a staircase. Before designing staircase we must know the components of staircases that we have discussed. And what are the technical thickness used in the case of staircase and the different case of staircase we have seen along with the figures. And also we have seen how to provide the reinforcement required for each and every flight of the staircase. And also we have started to design the problem in which we have found how to find out the components of the staircase. Once we find out the components of the staircase we can start designing the staircase completely along with the reinforcement details.

Questions:

- Give the different types of staircase with neat sketches.
- Explain the behavior of a flight of staircase with the reinforcement detailing.
- Explain the components of staircase.

References:

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