Design of Steel Structures
Dr. Damodar Maity
Department of Civil Engineering
Indian Institute of Technology, Guwahati

Module - 07
Gantry Girders and Plate Girders
Lecture - 01
Gantry Girders

Hello, today I will be focusing the lecture on some other topic, but related to the beam that is gantry girder. As we know, gantry girder from the name itself we understand the girder is a beam. So, it is a type of beam, and it is a type of beam where the span is laterally unsupported. So, when we are going to discuss about this gantry girder we will see that the gantry girder as it is laterally unsupported, so the bending stress due to compression has to calculate in that way.

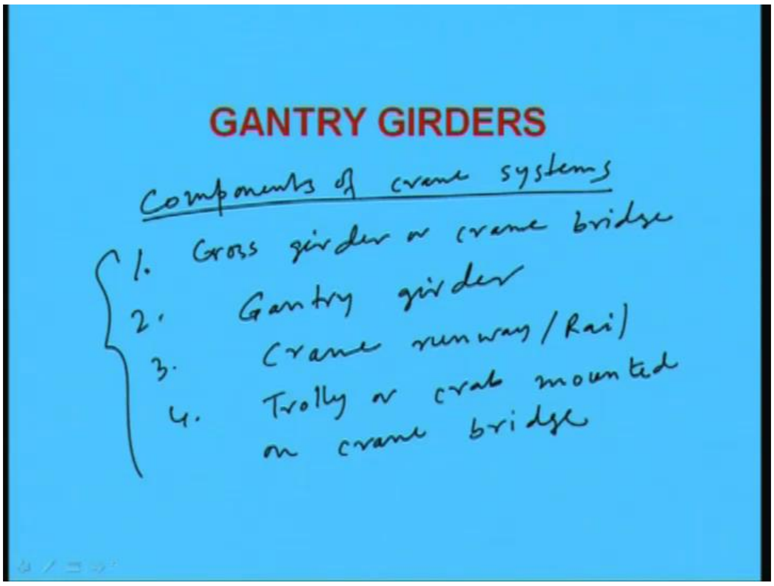
In fact, in our previous lectures we have shown the theory how to calculate the bending stress in compression for such type of beams, but gantry girder has additional thing that is, it is not a symmetrical beam. So, because of unsymmetry we have to find out the bending stress in compression through that formula which is, means, we cannot find out directly from the IS code. So, here we will demonstrate how to find out a, means, the bending stress in compression for unsupported length with unsymmetrical section.

Now, what is the use of gantry girders? Gantry girders are basically used for carrying the moving load; means, to carry a heavy load in industrial building we need to set up gantry girder along with the crane system; so, how to design and what are the aspects of design procedures, those things we will discuss. Here the difference you will get is that - one is the due to moving load; because of moving load what will be the maximum bending movement and shear force of the, on the gantry girder for a particular position of moving load.

So, as we know for different positions of moving load the bending moment and shear force on the gantry girder will be different. So, we have to find out the worst condition; that means, the position at which maximum bending moment will occur and the position at which maximum shear force will occur. And at that position what will be the maximum magnitude of bending moment and shear force; that we will calculate and on that basis we have to select the section and we have to check the stresses. So, in that way we have to do. This is the basic difference means in terms of calculation of load.

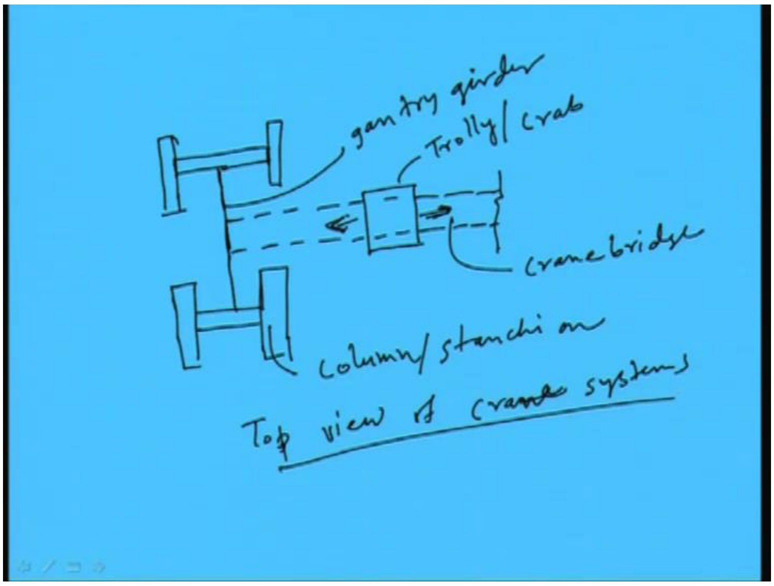
Another thing is as it is moving, so impact load will become; means, we have to add some load in terms of, mean, some additional load we have to add in terms of percentage of total load because of this moving load for impact. So, that also codal provision has been given for what type of load, how much additional load we will be providing, those things has been given in the code. So, what are the codal provisions has been given? Again, code has defined some deflection; how much deflection we can allow for this gantry girder? So, all these things we will be discussing in this lecture.

(Refer Slide Time: 04:37)



So, first let us see, what are the components are available in this crane system; say, components of crane system. So, if you see, one major component is the cross girder or crane bridge, you can say, which would be a truss like structure. Second is gantry girder which we will try to design today, gantry girder. Then, crane runway or this is called rail also. And, another component is trolly through which the load is passed, trolly or crab, to mounted on crane bridge. So, these are the major 4 components we have in a crane system.

(Refer Slide Time: 06:05)

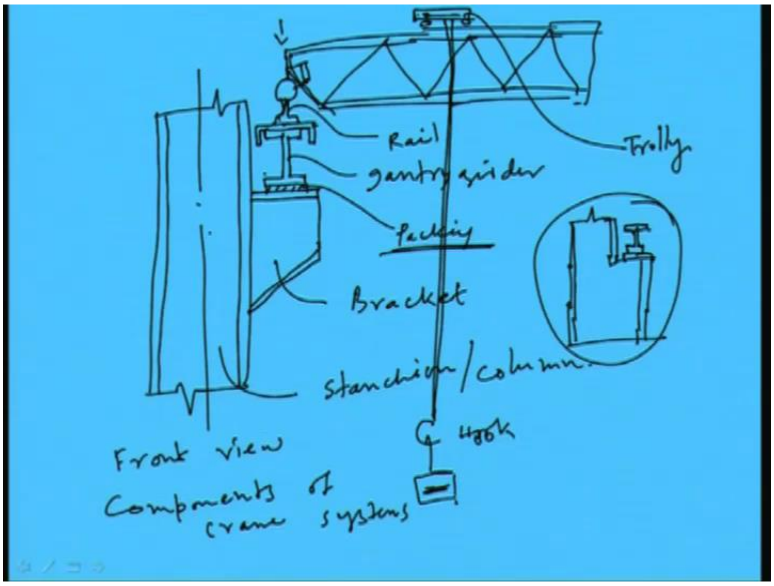


Now, if I draw the diagram then it will be clear, how it works. Say, first let me draw the top view of the crane system. Say, in top view from top if we see, we will see that there is 2 I sections are, means, 2 columns are there; maybe, this is I section or some built up section whatever it is. So, these are 2 I section on which the girder is placed, gantry girder is placed.

And on gantry girder, means, gantry girder, on gantry girder the crane bridge is there; means, Crane Bridge is supported on the gantry girder in one side, means, in both side, right. So, if I cut there. Now, this is what the trolly is going to move; this is trolly or we can say crab. This is column which support the gantry girder; column, or we can say stanchion.

And, this is the crane bridge through which this is going to move, this trolly is going to move. And, because of this moment we will see that the maximum, means bending moment and shear force is developing here and that we have to calculate. This is the gantry girder, right. So, this is the top view of crane systems. So, this is how it, arrangements are made like this.

(Refer Slide Time: 08:12)



Now, it will be much more clear, if I show the front view. Say, this is the column; this column maybe a single section or maybe a built up section, as per the requirement we have to make. Now, here some packing is provided, this is called packing. And, this is bracket on which the gantry girder is kept. This is stanchion or column, we can say. Now, this also we can make as a step column; by the use of step column also we can make it.

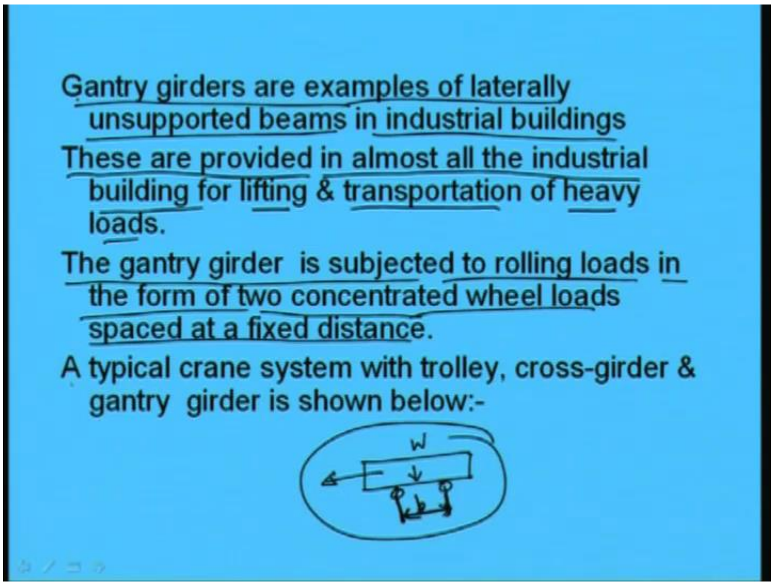
After this we are the gantry girder is generally placed, right; so, this is the gantry girder. And then, maybe channel section or some other section, as per the requirement we can provide. Then, we will provide the rail, right. This is called rail, and this is gantry girder. Now, the crane bridge be placed like this, is the crane bridge which will be a truss like system; means, these are kept like this.

And here, a trolly will be put, right; this is trolly, right. And, this will be made here like this, right. So, and from trolly if I see, means just I am giving a big one, just to show. Now, the load will be here; this is called hook where the load will be pressed means load will be moved, right. So, this is the front view, and means, to show the component of crane systems, right; this is the column.

So, this is how the gantry girder is placed, and this gantry girder we have to design, right. So, gantry girder is placed on column, means by the use of bracket; and it may be placed directly or with some packing with rail; it depends, what type of things we are going use. Then, the crane is made, means is kept on gantry girder. Now, when this load is going to move, when this trolly is going to move to carry the load, moving load, then the load is coming, means, here, and bending moment is coming. So, we have to find out what will be the maximum bending moment and maximum shear force or reaction at the gantry girder, so that we can design accordingly, right.

So, another, means this can be, this column can be also made like this, means some step column we can use also; say, this is like this, right. So, this is a step column. So, after this we can make some packing, and then we can make gantry girder, right. So, in this way also we can make; either we can use such type of column or we can use the bracket, so that gantry girder can be pressed.

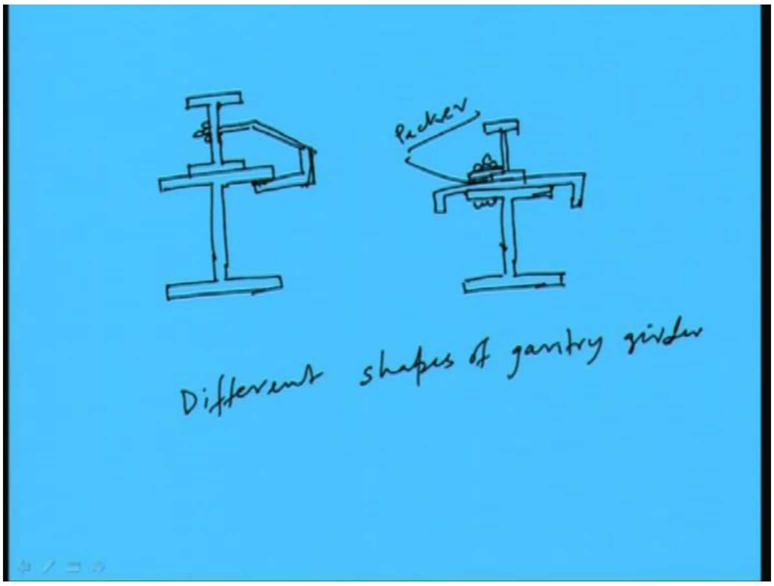
(Refer Slide Time: 13:19)



So, in short, what we can say that the gantry girders are examples of laterally unsupported beam in industrial buildings, right; laterally unsupported means only it is supported at the end by the 2 column. These are provided in almost all the industrial building for lifting and transportation of heavy loads. So, for lifting and transportation of heavy load this type of gantry girder are used.

The gantry girder is subjected to rolling loads in the form of 2 concentrate wheel loads spaced at a fixed distance. As we know, because of this, means wheel is going to move, so, means this trolly is going to move, right. So, the concentrate load whatever it is coming because of this, so, it is giving reaction at a fixed distance where this is called base of the, means base distance of the wheel which is called b, small b, you have to give it term as b. And, weight is w. So, w is if total weight w, then that is coming through this and this wheel load, right. So, in that way we will see 2 concentrated load at a fixed distance is coming into picture which has to be made.

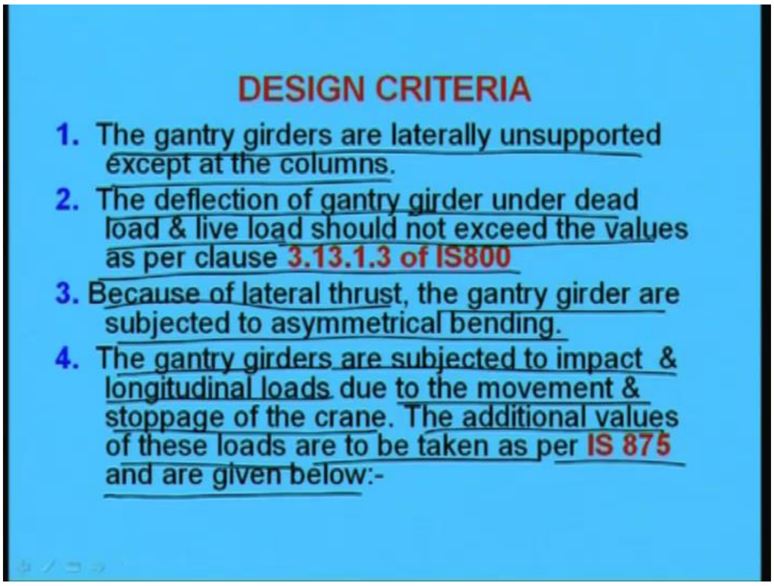
(Refer Slide Time: 15:00)



Now, a crane system with trolly, cross-girder, and gantry girder is shown already, right. Now, I will show some different shapes of gantry girder, how it looks like, right. Say, suppose, different shapes can be used as per the requirement; I am just showing 1 or 2. Say, this is one I section; we can use other sections also; we can use built up section also. Then, maybe we can make from here say, directly we are providing, right. If in this way we can, sorry, we can make connections. So, this is one type of gantry girder we use.

Another is with the use of channel. Say, this is an I section; then, we can use some channel, then we can put in the right section here, and then we can use some packers here, then we can tie it through this. So, this is packer. So, this has some, means different shapes of gantry girder. As I told that we can use other type of shapes also including the built up sections as per the requirement of the design.

(Refer Slide Time: 17:29)

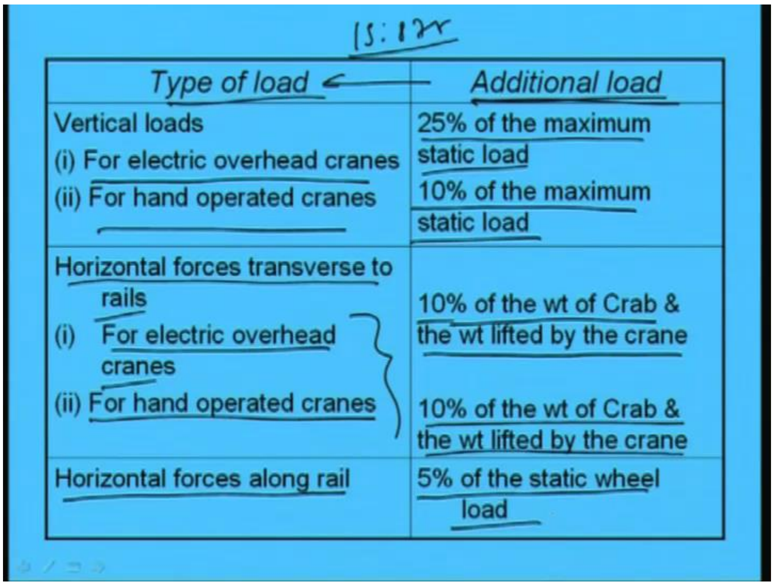


So, now I will go through some codal provisions which would be required for designing of gantry girders. So, what are the major criteria for designing a gantry girder? Let us discuss. First is, the gantry girders are laterally unsupported except at the column. So, this we have to remember, and then accordingly we can design the gantry girder. That means, the bending stress in compression will be different; it will not be equal to 0.66 fy. So, this is one thing we have to remember.

Another thing is, the deflection of gantry girder under dead load and live load should not exceed the values as per clause this – 3.13.1.3 of IS 800. In IS code, IS 800, 1964, sorry 1984, the deflection criteria have been given; means maximum deflection, how much it will be allowable for gantry girder, this has been specified there. So, that has to be followed.

Because of lateral thrust, the gantry girders are subjected to asymmetric bending. So, because of the presence of lateral thrust we have to design the gantry girder due to asymmetric bending. The gantry girders are subjected to impact and longitudinal loads due to the movement and stoppage of crane. The additional values of these loads are to be taken as per IS 875, and are given below.

(Refer Slide Time: 19:20)



Type of load	Additional load
Vertical loads (i) For electric overhead cranes (ii) For hand operated cranes	25% of the maximum static load 10% of the maximum static load
Horizontal forces transverse to rails (i) For electric overhead cranes (ii) For hand operated cranes	10% of the wt of Crab & the wt lifted by the crane 10% of the wt of Crab & the wt lifted by the crane
Horizontal forces along rail	5% of the static wheel load

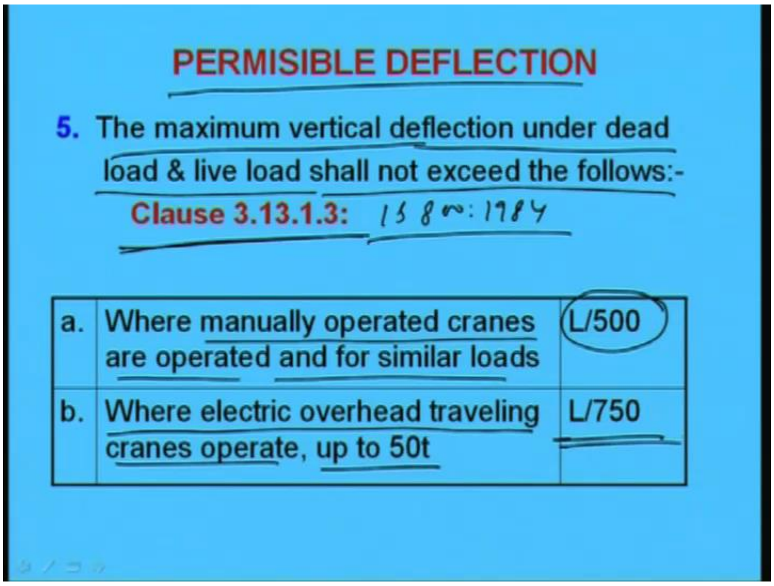
So, I am showing the additional load how to, means how much we should take for different case of crane. So, I will show which was given in IS 875, right. So, what are those? Here we have seen the table which is given in IS 875. So, type of load means additional load will be added which is depending on type of load.

One is vertical load. For vertical load if it is electric overhead cranes then we have to add 25 percent of the maximum static load. So, for electric overhead cranes 25 percent of the total static load has to be added; that means, total load would become 1.25 of the static load. And, for hand operated cranes, this additional load will be 10 percent of the maximum static load, for hand operated cranes, right.

And, for horizontal forces transverse to rails, if it happens, then for electric overhead it will be 10 percent; for electric overhead cranes this will become 10 percent of the weight of Crab and the weight lifted by the crane. So, horizontal forces transverse to rails for electric overhead cranes will be 10 percent of the weight of Crab and the weight lifted by the crane. So, this will be additional load.

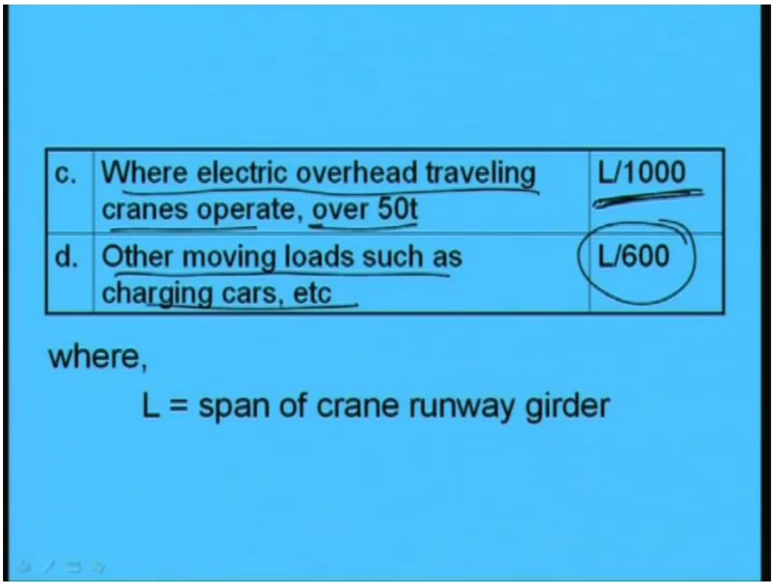
And, for hand operated cranes, this will be also 10 percent of the weight of the Crab and the weight lifted by the crane. So, for horizontal load this is same; that means, whether it is electric overhead cranes or hand operated cranes we will take 10 percent of the weight of the Crab and the weight lifted by the crane that we will take. And, horizontal forces along rail, for that we will add 5 percent of the static wheel load; 5 percent of the static wheel load will be added.

(Refer Slide Time: 21:28)



Now, permissible deflection, the maximum vertical deflection under dead load and live load shall not exceed the follows. This is given, as I was telling, that in clause 3.13.1.3 of IS 800: 1984. In this clause, it has been defined; that is maximum vertical deflection under dead load and live load, when manually operated cranes are used and for similar loads, the permissible deflection will be L by 500, it will just span, so L by 500 it will be. And, when electric overhead traveling cranes are operated and with having upto 50 tonne, this would be, this permissible deflection will be L by 750, right.

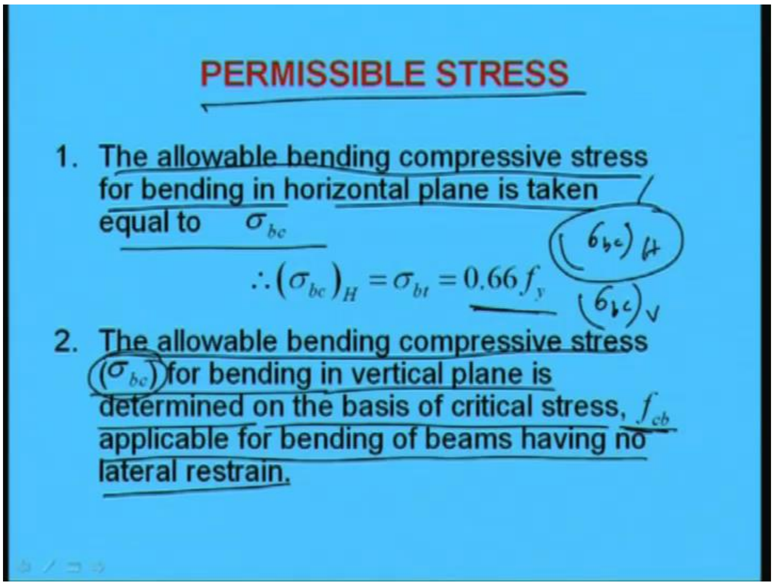
(Refer Slide Time: 22:32)



Other case let us see. Where electric overhead traveling cranes operated over 50 tonne, then the vertical deflection will be restricted to L by 1000. So, deflection we have to restrict less; means we, permissible deflection will be less, L by 1000. And, other moving loads such as charging cars, etcetera, in this case the permissible deflection will be L by 600, where L is the span of crane runway girder.

So, in this way, the deflection means maximum permissible deflection can be found from the code. And, when we are going to calculate the actual deflection we have to check whether the actual deflection is exceeding the permissible deflection as per code or not. If it is exceeding then we have to redesign. So, in this way we have to check. This is one factor which we have to remember for designing of gantry girder.

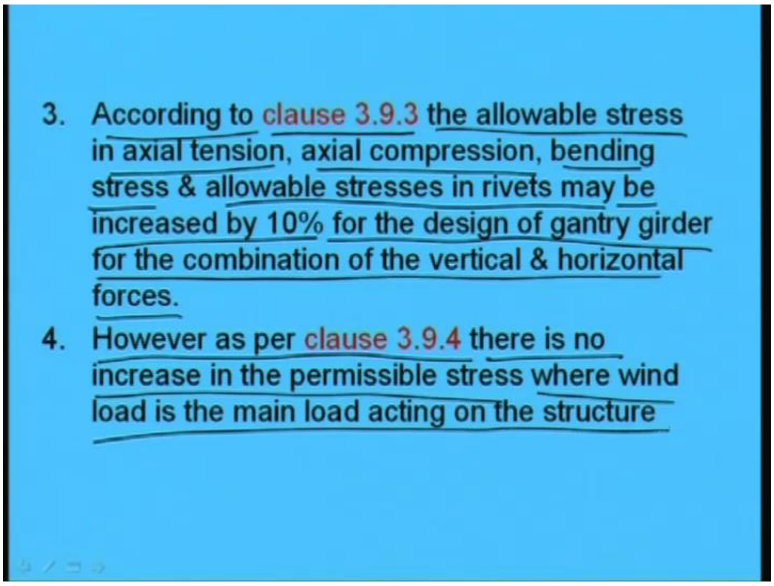
(Refer Slide Time: 23:42)



Now, another aspect is the stress criteria, permissible stress; what will be the permissible stresses for different cases, let us see. So, as we know, the allowable bending compressive stress for bending in horizontal plane will be taken sigma b c is equal to 0.66 f y. So, when horizontal load is taken, means, and because of horizontal load the bending moment is developing and the stress is developing, in that case sigma b c will become simply 0.66 f y, that is equal to sigma b t also. So, sigma b t and sigma b c will be 0.66 f y when the load is in horizontal direction; that means, the bending moment when it is developing due to the horizontal load. So, in that case, we will take permissible bending stress in compression and in tension equal to 0.66 f y, right.

Now, allowable bending compressive stress for bending in vertical plane is determined on the basis of critical stress, f c b, so the, because it is unsupported. So, in that way we have to calculate; applicable for bending of beams having no lateral restrain. So, this sigma b c; one is sigma b c, H means horizontal, and another is sigma b c v. So, this is ok; this is we can take 0.66 f y. But for this, the permissible bending stress in compression due to vertical load, that has to be calculated through the formula which we have shown earlier.

(Refer Slide Time: 25:35)

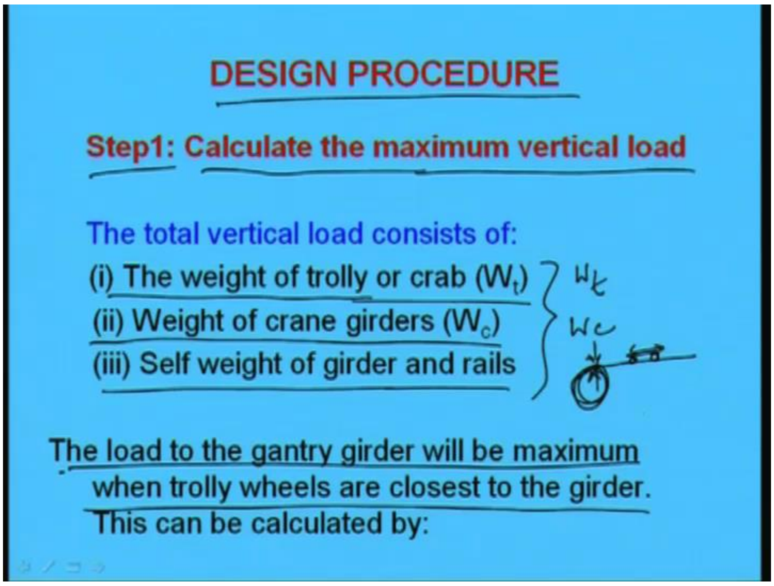


Now, according to clause 3.9.3 the allowable stress in axial tension, axial compression, bending stress and allowable stresses in rivet maybe increased by 10 percent for the design of gantry girder for the combination of the vertical and horizontal forces. That means, when we are combining the vertical and horizontal forces, means when we are combining the stresses due to vertical and horizontal forces in that case the allowable stresses will be simply 10 percent more.

That means, whatever the allowable stresses we are going to calculate we have, that we will increase 10 percent more when we are combining the horizontal and vertical load for calculating stresses; that means, stresses due to horizontal load and stress due to vertical load, that stress maybe tensile, compression or axial tension, whatever maybe. So, when we are summing up these stresses, similar stresses, due to vertical load and due to horizontal load, then the permissible load, when we are going to check permissible, stress will be 10 percent more than the allowable stress whatever we calculate.

Next is, in clause 3.9.4, in next clause it is told that there is no increase in the permissible stress where wind load is the main load acting on the structure. So, when wind load will play major role, in that case we will not increase the permissible stress by 10 percent. So, in that case permissible stress will be same as we have calculated earlier, means actually. So, there is no scope of increasing in case of wind load when it is playing the major role. So, these are the aspects we which we have to remember.

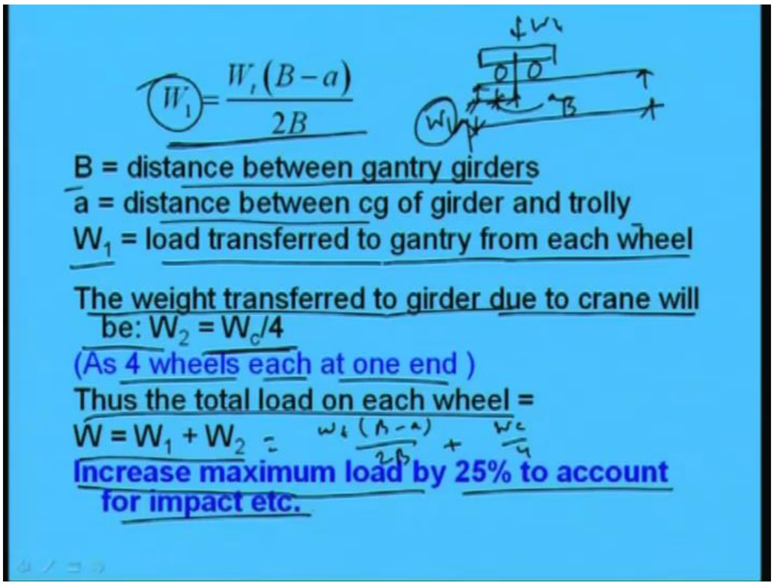
(Refer Slide Time: 27:47)



Now, I will discuss about the design procedures. So, in step 1, what we will do, that calculate the maximum vertical load. Vertical load means, what are the vertical loads? One is weight of trolly or crab, then the weight of crane girder, and then self weight of girder and rails. These are the 3 loads, majorly it is coming as vertical load. Weight of trolly which we are giving name as Wt; weight of crane girder Wc; and self weight of girder and rails.

And, the load to the gantry girder will be maximum when trolly wheels are closest to the girder because when this trolly is moving like this, so, when this will be in this position means closest position, then the maximum reaction force will happen here. So, maximum load on gantry girder wheel be when it will be the, when trolly will be at the closest position, means trolly wheel will be closest position, right.

(Refer Slide Time: 29:13)

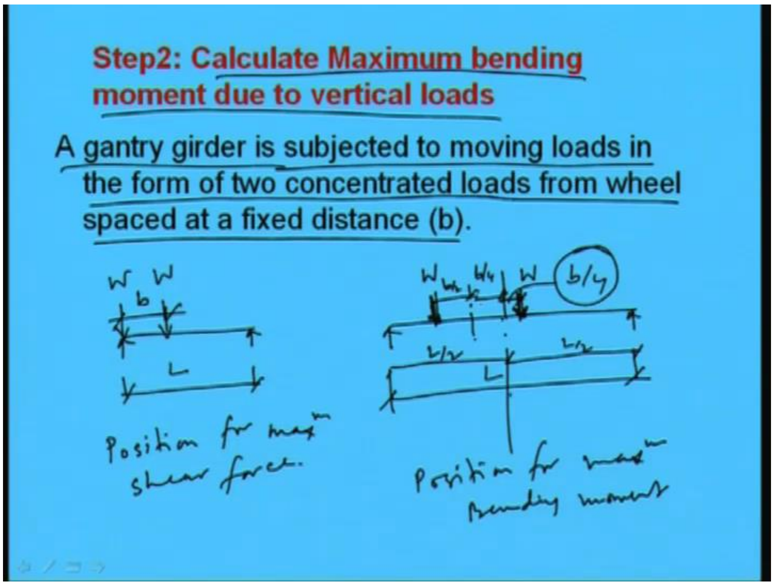


So, the load transferred to the gantry girder can be calculated from the formula, that is, Wt into B minus a by 2 B, where B is the distance between gantry girder. Say, suppose, there is one gantry girder here, another gantry girder here; so, this is B, right. Now, if trolly is like this; means, if it is provided like this, then this will be a; a is the distance between cg of girder and trolly. And, W 1 is the load transferred to gantry from each wheel.

So, this is, a, we can say; and W 1 which is the load transferred to gantry from each wheel. This is Wt. So, the W 1, what is means in terms of reaction, what is coming, that. So, load transfer to gantry from each wheel W 1 can be found from here; Wt into B minus a by B into half because of 2 side it is, right.

Now, the weight transferred to girder due to crane if we say W 2, that will become Wc by 4 because 4 wheels, each at one end. So, it will be divided by 4. So, Wc by 4; W 2 will become W c by 4. So, the total load on each wheel will become W is equal to W 1 plus W 2. So, total vertical load can be found in this way, W 1 plus W 2; that means, W 1 is Wt into B minus a by 2 B, and W 2 is W c by 4. So, from this expression we can find out the total load on each wheel. Next, what we will do? Increase maximum load by 25 percent to account for impact load. So, 25 percent or some other percentage also as per the codal provisions we have to increase. Generally, we used to increase 25 percent, most of the cases it as this, like this.

(Refer Slide Time: 32:02)

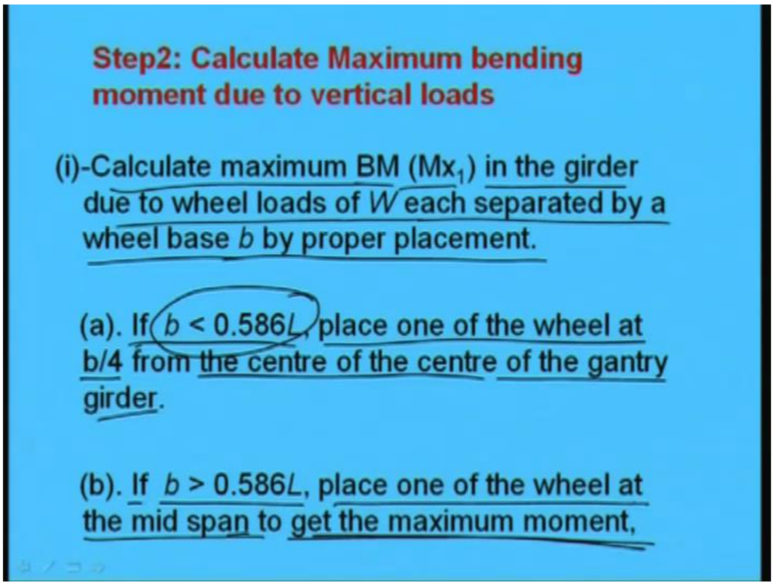


Next, calculate maximum bending moment due to vertical load. A gantry girder is subjected to moving loads in the form of 2 concentrated loads from wheel spaced at a fixed distance b. So, maximum shear, how it will develop? If we see that if this is the gantry girder, means 2 gantry girders are here with a span of say, L. Then, one wheel, if it is placed here, another wheel if it is placed here, so, theoretically, if it is like this then we can find out the maximum shear force. So, this we can say position for maximum shear force.

And, for maximum bending moment, how do we find out? Say, if this is the span length L, then we know, from theory of structure you must have seen, that if this is the center distance, means L by 2, this is L by 2, right. Then, the load has to be placed in such a way that it should be, means if this is W, if this is W, means the cg of the wheel load, means cg of the 2 concentrated load and cg of the wheel load will be here, right. So, this will be b by 2.

So, cg of the center will be at the mid position of the cg of the wheel; that means, if this is b by 2, then this will become b by 4, and this will become b by 4. So, in this way the maximum moment will develop; position for maximum bending moment. So, where the maximum bending moment is happening? If the position is something like this; that means if the fix, means if the wheels are spaced at a distance of b, then from cg of the span to one wheel load distance should be b by 4, right. So, in this way we can find out the maximum bending moment.

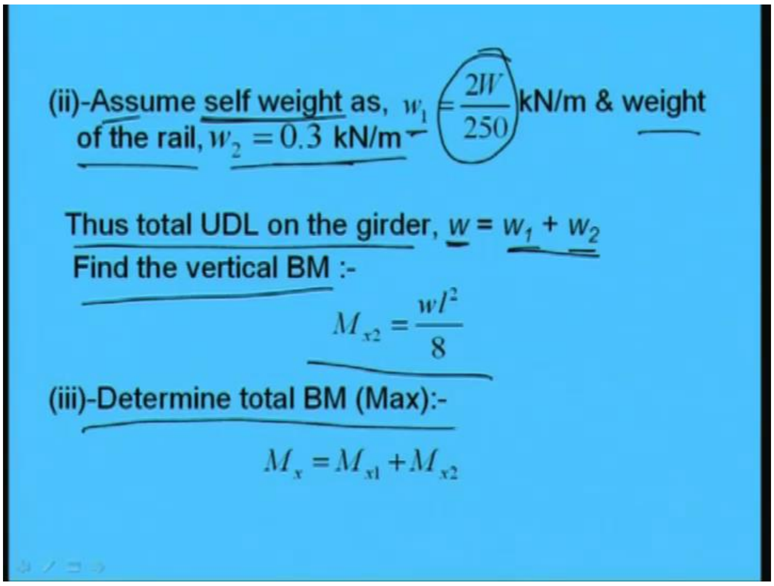
(Refer Slide Time: 34:58)



So, when we are calculating the maximum moment, what we will do? That calculate maximum bending moment say, M x 1 in the girder due to wheel load of W each separated by a wheel base b by proper placement. Now, if, we will see that if b is less than 0.568 L; b means this wheel base length, right. If b is less than 0.586 L, place one of the wheel at b by 4 from the center of the gantry girder. So, place here, b by 4, from b by 4, the center of the gantry girder one load has to be placed, right, if b is less than 0.586 L.

And, if b is greater than 0.586 L, place one of the wheel at the mid span to get the maximum moment. If b is 0.586 L, that you can calculate at your own from theory of, means from the knowledge of theory of structure; you know that how the maximum moment develops if two concentrate load moves right from influence law diagram you must have seen.

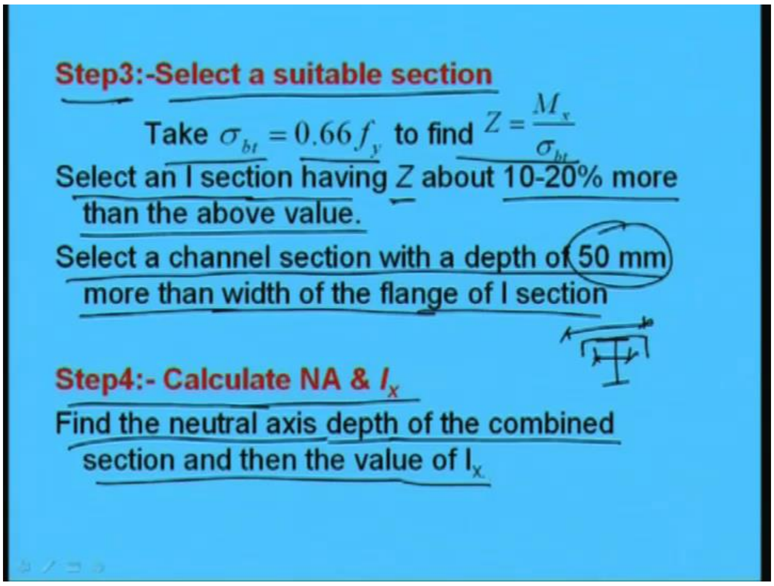
(Refer Slide Time: 36:18)



Now, another load is the self weight. And here, you may assume the self weight as w 1 is equal to 2 W by 250 kilo Newton per meter, and weight of the role rail say, maybe 0.3 kilo Newton per meter. These are some standard you can value, you can use; 2 W by 250 kilo Newton per meter, and w 2 as 0.3 kilo Newton per meter for the weight of the rail, right.

So, the total UDL will be, how much? The w if we denote, will be w 1 plus w 2, right. So, total UDL will be this one. And, total moment, vertical moment, bending moment will become w l square by 8; that is at the middle, at the center of the span the maximum bending moment will occur, that is w l square by 8, right. Then, we will find out the total bending moment, M x is equal to M x 1 plus M x 2; M x 1 due to the here for this one, and M x 2 due to the self weight and other thing. So, finally, we can find out in this way the maximum bending moment.

(Refer Slide Time: 37:56)



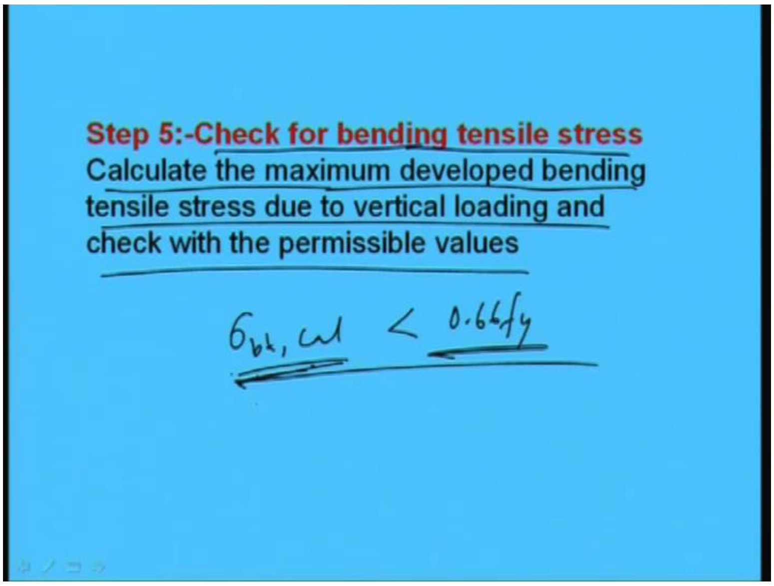
Next what we will do? Next step 3; in step 3 we will select a suitable section. So, how to select? To start with, we will find, means we will consider the permissible bending stress as 0.66 f y; that means, we will consider sigma b t, then we may increase little high to b in safer side because we do not know what will be the value of sigma b c, right.

So, take sigma b t is equal to 0.66 f y, then we can find out Z, section modulus which will be M x by sigma b t. Then, we can select an I section or some other sections also you can select, having Z about 10 to 20 percent more than the above value. In fact, we can use 2 channel section also, or as per the requirement we can use some built up section also. I am not going into complicated one, I am not going; just for the sake of simplicity let us assume the I section on the basis of which we will design the gantry girder, right.

Now, select a channel section with a depth of 50 mm more than width of flange of I section, why? Because, if I section is there, then if you provide a channel section, it has to be, means this depth has to be more than the flange of I section. So, around 50 mm more it has to be. So, we will select the channel section in such a way that the channel section depth will be at least 50 mm more than the width of the flange of the I section, just to accommodate it, right.

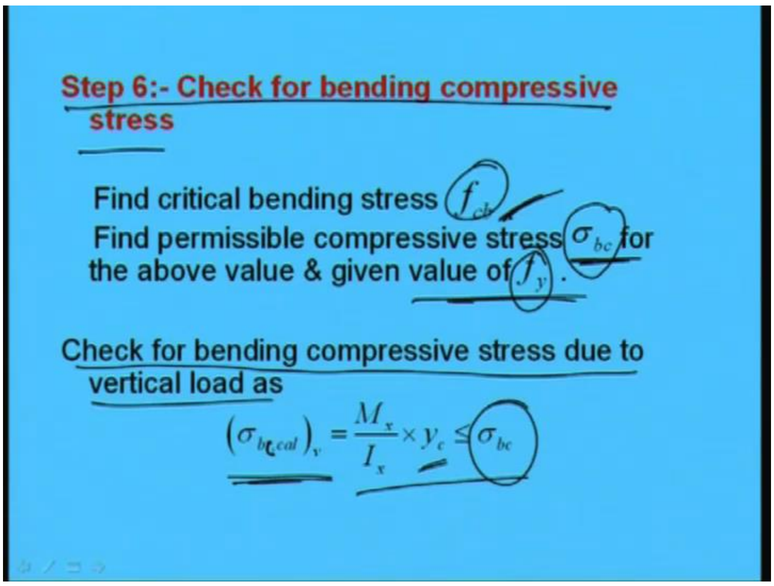
Now, we will calculate in step 4, the neutral axis and the moment of inertia of the combined section, right. Find the neutral axis depth of the combined section and then the value of I x. So, in step 4, what we will do? We will find out the neutral axis depth of the combined section and then the moment of inertia about x direction of the combined section.

(Refer Slide Time: 40:28)



Then, in step 5, what we will do? Check for bending tensile stress; so, we will calculate the maximum developed bending tensile stress due to vertical loading and check with the permissible values. So, sigma b t, calculated has to be less than; sigma b t means 0.66 f y, right. So, for vertical loading, we have to check whether the maximum stresses developed due to bending moment in, mean maximum tensile stresses which should be less than 0.66 f y; so, that we have to check for the combined section.

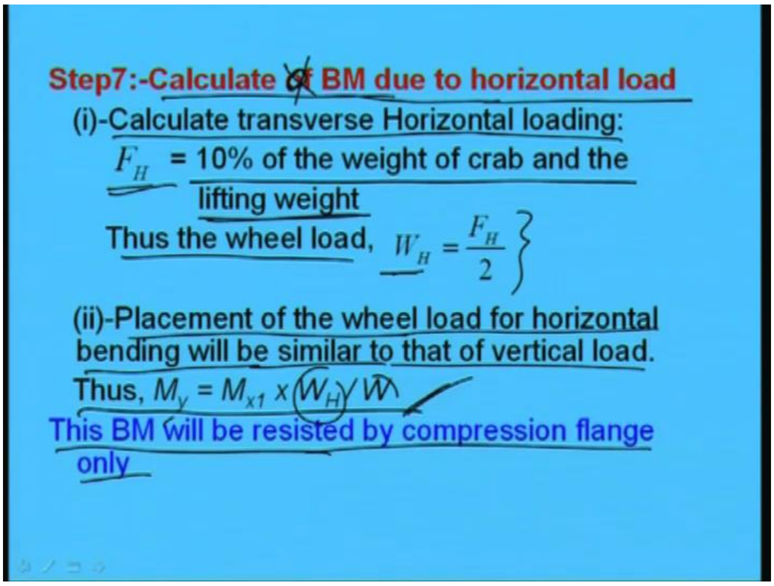
(Refer Slide Time: 41:17)



Next what we will do? Next, we will check for bending compressive stress; tensile stress is over, now we will check for the compressive stress due to bending. So, for this what we will do? We will first find out the critical bending stress f c b, the formula is given in the IS code, IS 800: 1984. So, from that we can find out f c b. Then, we will find the permissible compressive stress sigma b c for the above value, and given value of f y. So, sigma b c can be found from f c b and f y, from this we can find out, right.

Then, what we will do? Check for bending compressive stress due to vertical load; so, sigma b c cal; vertical load will become this one, M x by I x into y c, where y c is the distance from neutral axis to the compressive, means extreme compressive flange, and it should become less than or equal to sigma b c which has been calculated here. So, in this way we will check for bending compressive stress.

(Refer Slide Time: 42:30)

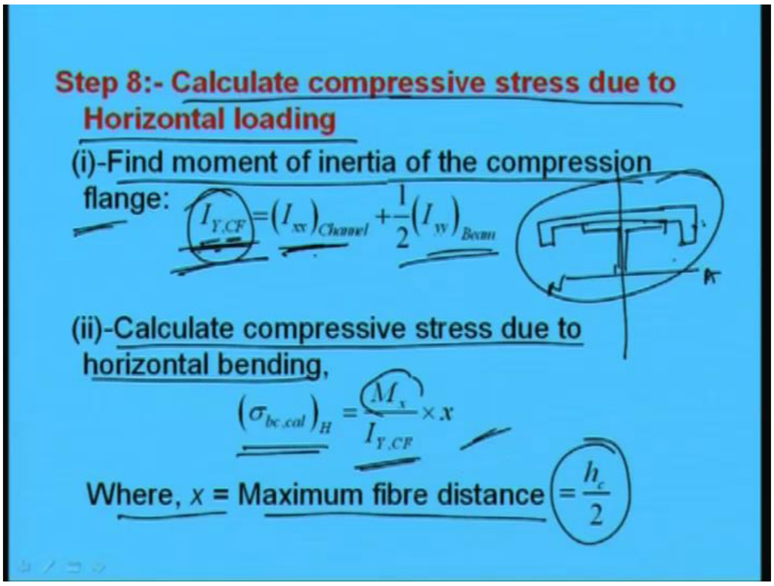


Next, step 7; in step 7, what we will do? We will calculate the bending moment due to horizontal load. So, for vertical load we have already calculated and we have checked; it is ok. Now, we will calculate the bending moment due to horizontal load. So, calculate transverse horizontal load as per the codal provision. Now, so, F H will become 10 percent of the weight of the crab and the lifting weight. And therefore, the wheel load will become W H will become FH by 2, wheel load will become F H by 2.

And now, placement of the wheel load for horizontal bending will be similar to that of vertical load. So, placement of the wheel load, where we will place? Similar to that where we have placed for vertical load because for this also the maximum bending moment will be developed, and that same position maximum shear force also will be developed, same position where the maximum shear force due to vertical load has developed.

So, from that we can find out simply this, M y is equal to M x 1 into W H by W because simply we can directly interpolate; M y will become M x 1, and M x 1 has developed due to this W, so, due to WH how much it will develop, we can find out from this ratio. So, this bending moment will be resisted by compression flange only. This bending moment developed due to horizontal load, and therefore, this stress has to be resisted by the compression flange only.

(Refer Slide Time: 44:39)

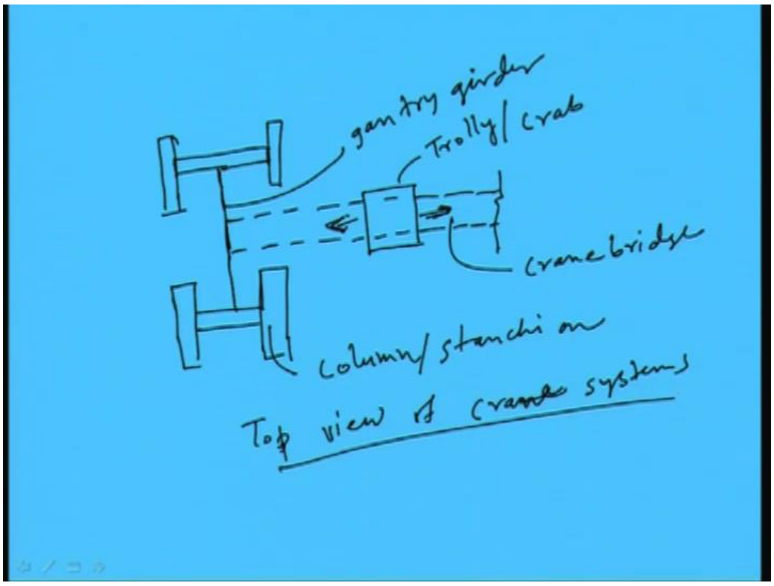


So, what we will do? We will calculate compressive stress due to horizontal loading in the compression flange. So, what we will do? First we will find out moment of inertia of the compression flange. That means, suppose this is the I section and this is the neutral axis depth, so, here we have one another channel section, area provided here, right. So, now this will be the compression flange.

So, and I Y of compression flange will become I x x of channel because I y y means here. So, this will become for this channel I x x plus I y y beam, half of that. So, in this way we can find out the moment of inertia of the compressive flange of channel section. Then, we will calculate compressive stress due to horizontal bending; that is sigma b c cal H, we are denoting as sigma b c calculated due to horizontal loading, sigma b c cal H. So, sigma b c cal H will become M x by I Y C F into x; I Y C F means this one, right.

So, in this way we can find out the compressive stress due to horizontal load. Now, x is the maximum fibre distance that will become h c by 2.

(Refer Slide Time: 46:35)

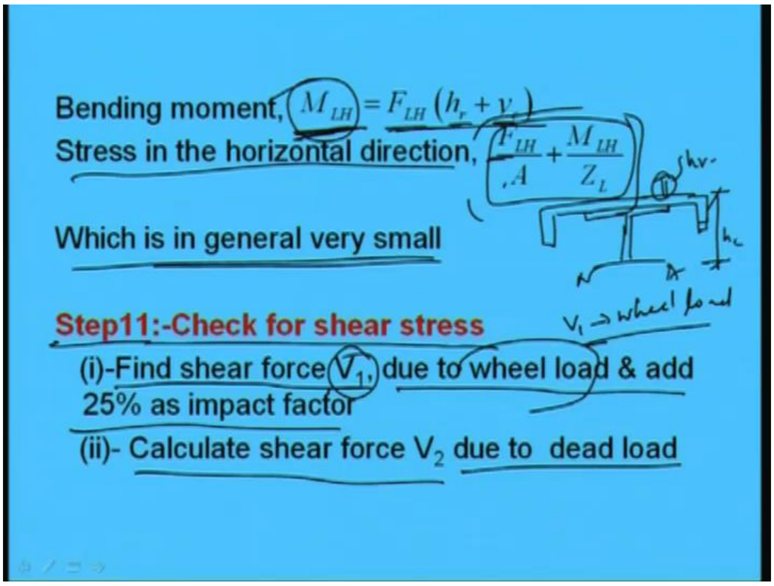


Next, check for maximum bending stress. So, check for maximum bending stress means we will check for the combined, means combined means, combined load of horizontal and vertical. So, we have calculated already these, sigma b c cal vertical and sigma b c cal horizontal. So, if we sum up, it has to be less than 1.1 of sigma b c, as codal provision has told that the permissible stress can be increased 10 percent more in case of combination of horizontal and vertical load.

So, the stress developed due to vertical load and horizontal load has been summed up, then has been checked which should be less than 1.1 of sigma b c; that means, 10 percent extra of sigma b c; and this sigma b c has been calculated in step 6, right.

And, in step 10, what we will do? Calculate stress due to longitudinal force. So, here what we will do? We will find out the horizontal longitudinal force along the rail which we have denoted as F L h; and h for codal provision it will be 5 percent of the total wheel load; total wheel load means 2 W.

(Refer Slide Time: 48:37)



And if the height of the rail is denoted h r, then we can find out the bending moment M L H as F L H into h r plus y c. F L H, what is F L H? F L H, we have told that horizontal longitudinal force. Now, because of this horizontal longitudinal force bending moment will develop which has been denoted as M L H, horizontal longitudinal moment. So, horizontal longitudinal moment will become F L H into h r plus y c, where h r is the height of the rail; and y c, what is y c? Y c is the distance between the neutral axis to the compressive flange.

Say, if I draw here say, suppose this is neutral axis, I am not drawing whole thing; and this is the I section which is placed another channel section. So, this will become, let, so, y c will become this one. And then, height of the rail is there; this is h r and this is h c. Therefore, the moment in horizontal longitudinal direction will become this one.

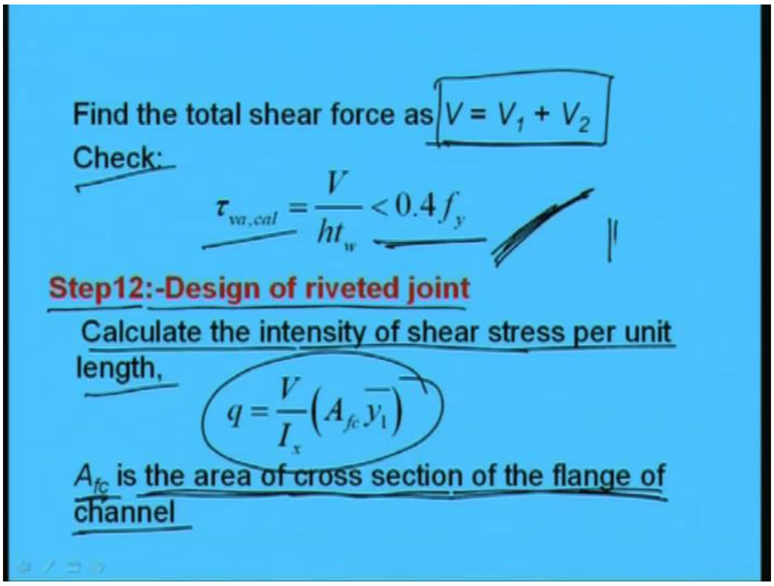
And then, stress in the horizontal direction will become the summation of these 2- F L H by A, this is direct stress; and then, M L H by Z L, right; F L H by A plus M L H by Z L. And it will be seen that this is very small; in general, it will become very small because F L H is very small because 5 percent only we are going to take. So, because of that very small load, so, M L H will be also small and F L H also will be small. And, when we are going to find out the stress, we will see, finally the stress will become very small. However, we have to check.

Now, we will go for step 11 that is check for shear stress. So far we have checked for bending stress means, stresses coming due to bending, stresses in terms of tensile stress and in terms of compressive stress, developed due to bending. And bending, again developed due to horizontal and also due to vertical load. Major force is coming due to vertical load, and horizontal load is coming due to some percentage, some percentage is coming horizontal thrust, again horizontal thrust.

So, for that we have checked; means, we have checked individually for the vertical load, and we have checked combinedly for the vertical load and horizontal load. So, those things we are doing, we have done. Now, all the, means all sort of check in terms of bending stress has been done, now we will go for the shear stress.

So, what will do? We will find shear force V 1, due to wheel load and we will add say, 25 percent as impact factor. As per the codal provision, we have to add some percentage of load for impact factor as we have done in case of moment also. So, we can find out shear V 1, this is because of wheel load. So, V 1 is coming because of wheel load. And, shear force V 2 is coming due to dead load; dead load means dead load due to rail and others; self weight is there. So, 2 type of shear force is coming, in fact we have seen in case of moment also 2 type of moment is coming due to wheel load and due to dead load which includes self weight.

(Refer Slide Time: 53:17)



So, now the total shear force will become V 1 plus V 2. So, finally, the total shear force we can find out as V 1 plus V 2. Remember, when we are going to calculate this V 1, we have to see that when the maximum shear force will develop. The maximum shear force as we know, theoretically, when one of the wheel will be placed at the support then it will be maximum.

So, we have to see from practical point of view, at what place it is the closest means wheel will be closest because wheel will be like this. So, when we are going to, say we calculate the shear force, say suppose here the gantry girder is there. So, what will be, so, this will be the minimum distance we have to leave. So, this position will be the, sorry, this will come here.

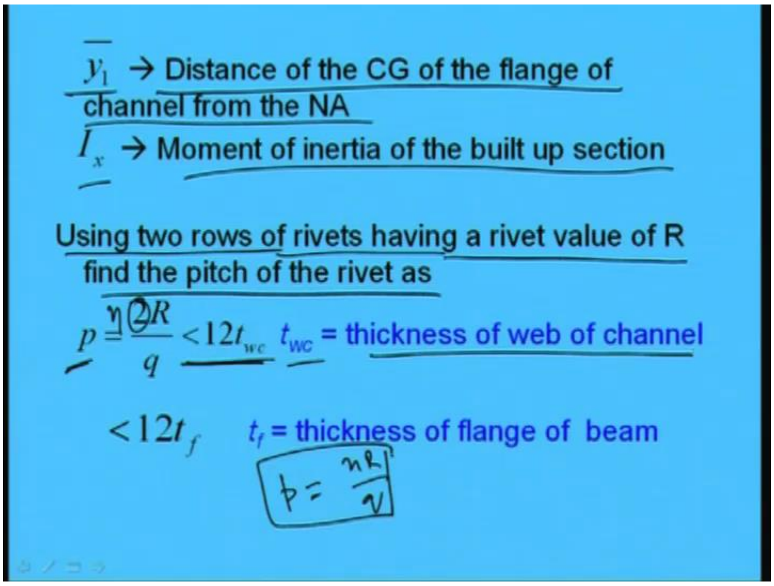
So, in that way, wherever the wheel is placed that would be. That means it will be like this, say if I redraw, it will be like this; say, this is gantry and something like this. So, in this way we have to see. And, we will see if it can come here, fine; means, maximum load where it is coming, means closest distance from gantry we have proceed. So, in this way we can find out V 1 and V 2, and then total shear force V.

Now, check for this tau v cal, means shear stress developed, that will become V by h into t w; t w is the thickness of web, h is the total height means the height of the girder; and it has to be less than 0.4 f y as per the codal provision; as we know, every shear stress has to be less than 0.4 f y, right; we have learned earlier lectures; in earlier lectures we have learned, right. So, this has to check.

Now, if it is not ok, then again we have to redesign; redesign means we have to increase the section and we have to start from the step 1 itself, or step 2, step 3 itself; means, have to find out all the details, then we have to find out the maximum bending moment due to vertical load, maximum bending moment due to horizontal load, then combination of that, then again this. So, whole steps we have to again make it, right.

Then next step is; so, if it is ok, what we will do? We will go for design of riveted joint. So, we will go for riveted joint means joint. Say, in case of riveted joint, what we will do? We will calculate the intensity of shear stress per unit length. That will become this, q is equal to V by I x into, A f c into y 1 bar; q is the intensity of shear stress per unit length, and V is the shear force, and A f c is the area of cross section of the flange of channel, remember. That means when I section is there, we know for channel we are going to provide, so the area of the flange of the channel. So, A f c in this way we can find out.

(Refer Slide Time: 57:48)



Now, what is y 1 bar? That is distance of the CG of the flange of channel from neutral axis. And, I x is the moment of inertia of the built up section means combined section. So, in this way we can find out the value of q, where q is the intensity of shear stress per unit length. So, the moment we get the value of q we can find out the rivet means rivet details.

Say, if we use 2 rows of rivets having a rivet value of R, then you can find out the pitch of the rivet from this formula: p is equal to 2 R by q, where R is the rivet value. And, if n number of rivets are, means n number of rows are provided then we can write, n R by q; p will become n R by q, let us make generalized, when n number of rows of rivets are used with a rivet value of R. And, this has to be less than 12 t w c, where t w c is thickness of web of channel.

So, pitch p has to be checked that whether it is less than 12 t w c or not. Also, it has to be checked through this, that twelve t f, where t f is the thickness of flange of beam. So, it has, the pitch has to be less than 12 t w c, and it has to be t f. So, in this way we can find out the pitch of the rivet. So, in this way, step by step, we can design a gantry girder. In next class, we will go through one workout example following these steps. So, with this I like to conclude today’s lecture on gantry girder.

Thank you very much.