Course on Design of Steel Structures
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Lecture 57
Module 11
Design of Gantry Girder

Today we are going to discuss about the design steps to design a Gantry Girder, first we will go through the design steps which can be followed and then we will go through one example following those steps.

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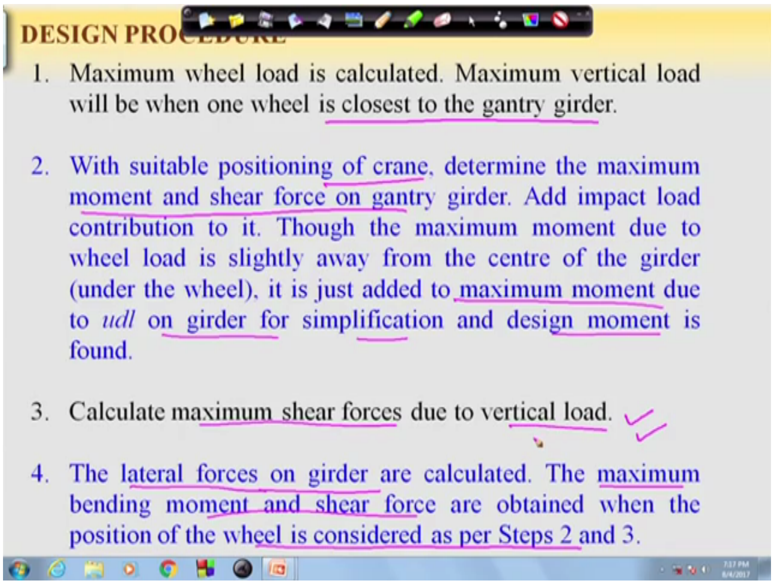

So step wise if we see first what we need to do is we need to calculate the maximum wheel load that maximum wheel load is coming how much and this maximum wheel load will be when the one wheel is closest to the gantry girder that means the wheel is moving along the crane girder so when the wheel load is closest to the gantry girder then the maximum effect on the girder will be. So that position we have to consider we have to take and then we have to find out what is the maximum reaction on the gantry girder is coming due to this wheel load and due to the crane load, right so that will be calculated first.

And then with suitable positioning of crane again crane is moving through gantry, so suitable positioning of the crane we can find out the maximum moment and shear force on the gantry girder.

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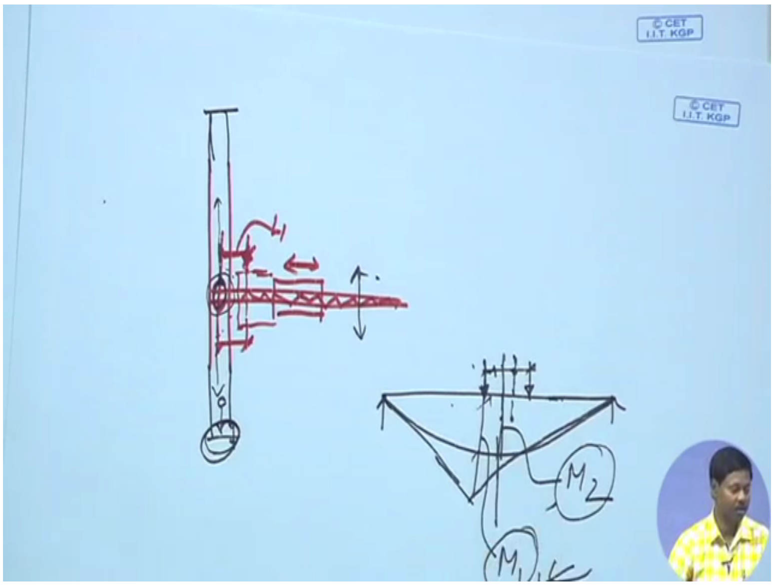

As I told that if I see here say suppose this is gantry girder and this is crane, right say this is crane. Now the crab is here so crab can move here in this direction, right. So except the clearance means excluding the clearance from the crab we can find out the maximum load that means when crab is in this position considering the minimum clearance then the load we can find out on the crane in at a certain position say I can say L1, okay.

So because of the position of the load at L1 from one end of the gantry position then what will be load on the gantry means reaction on the gantry girder that we can find out, okay. So this will be the maximum load coming on to the gantry. Then second case is again this gantry are say suppose from this to this is the gantry span. So now this crane are moving like this, so this load is moving towards this and towards this and when this load is at the support means one wheel load at the support and another wheel load at away from the another wheel then the maximum shear force can be obtained, right so maximum shear force will be obtained when one of the wheel is placed at the support.

Similarly the maximum bending moment will be obtained when it is at towards the mid span and that we have shown earlier that if the cg of the wheel load and cg of the cg of the gantry span are center of both means center from the one end of the one end of the wheel then I can find out the maximum load that means let me tell one again once again that if this is a gantry span, if this is the center and if this is the load, right and so this will be the cg of this so it should be cg of these two.

So cg of these two load and mean one wheel load and cg of this should be equidistant from center of the gantry then the maximum bending moment can be achieved. So this is how we can find out the maximum bending moment. And then we can add the impact load contribution, right and certain percentage of load will be added due to impact. And the maximum moment due to wheel load is slightly away from the center of the girder it is just added to maximum moment due to udl on girder for simplification and design moment is found.

That means the maximum bending moment due to this udl load we can find out which will be at the center and maximum bending moment say for example this is here maximum bending moment for the position of the load at a certain point, so this is M1 and this maximum span is since represent 2, so we will simply add M1 plus M2 not at this position of for M2, so this slightly higher side we are considering for the simplified one, right. So in this way we can find out the maximum moment.

Then we can find out the maximum shear force due to this vertical load and shear force will be obtained maximum when one of the wheel is placed at the support of the gantry, right. Then we can find out the lateral forces on girder and lateral forces on girder can be calculated the way we have calculated means we have calculated the vertical load so certain percentage of forces will be consider as lateral forces and the maximum bending moment and shear force can be obtained when position of the wheel is considered as per steps 2 and 3 that means in step 2 and 3 we have calculated maximum bending moment and shear force due to vertical load.

So similar way we can find out maximum bending moment and shear force due to lateral load with similar positions, right so that can be also obtained.

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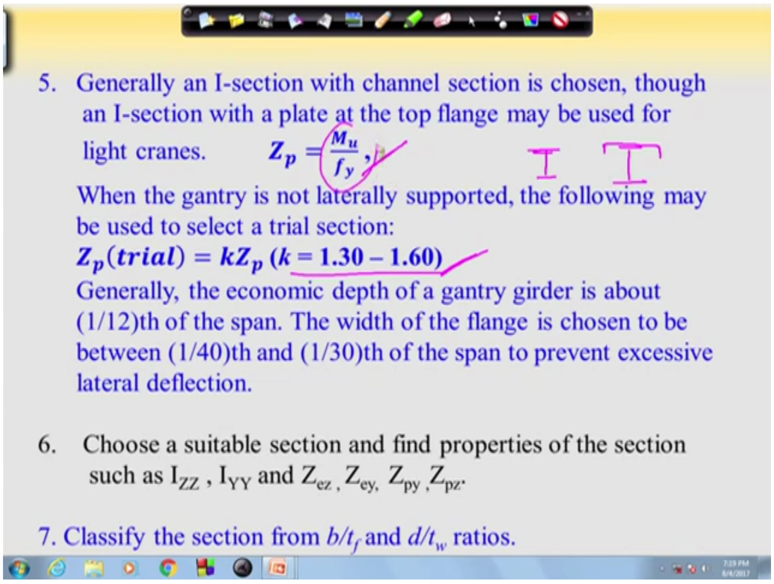

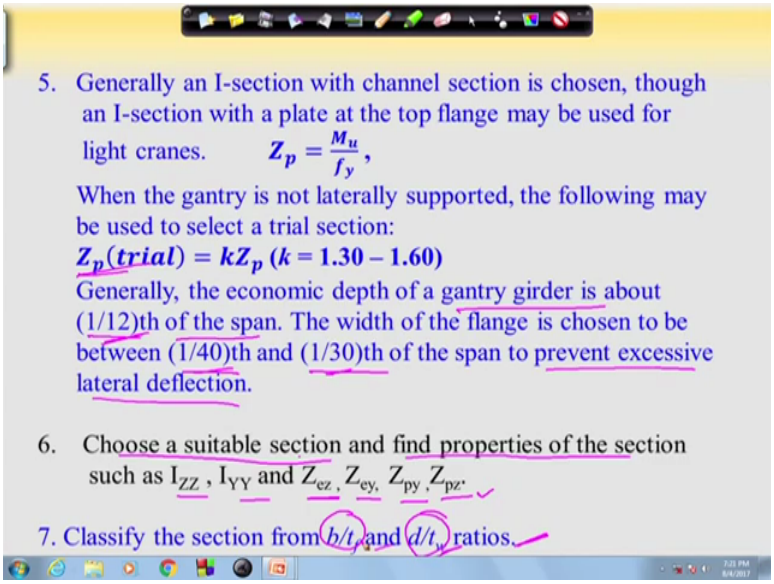

Then next step we can find out a section modulus, so generally we provide I sections and with channel section at top in general we provide however sometimes we provide I section with a plate at a top flange also for light cranes that means if cranes are light then we can provide a I section and at top a plate. However generally what we do we provide I section and at the top another channel section we generally provide for gantry girder design.

And the required plastic section modulus we can find out from this formula that is Zp is equal Mu by fy, Mu is the maximum factored bending moment due to vertical load, right so this is how I can find out the section modulus plastic section modulus, right. However this is true for laterally supported beam but if it is not laterally supported then we can increase to a certain factor, in case of laterally unsupported beam I have discussed earlier that we have to increase with a certain percentage of the Zp required so that the lateral torsional buckling effect can be taken into consideration, right.

So to take care the lateral torsional buckling effect we need to find out the some increased amount of Zp, right and as gantry girder is laterally unsupported beam so we have to increase this value after obtaining Zp, right. And for generally there is a guide line that to get the economic depth of a gantry girder generally depth are kept as 1 by 12th of the span, so gantry girder span we know so 1 by 12th will be the depth and width of flange will be chosen between 1 by 40th to 1 by 30th of the span to prevent excessive lateral deflection.

So we need to see apart from the Zp trial value we also have to keep in mind that to get an economic depth we should keep the depth around 1 by 12th of the span and we should keep flange width as 1 by 40 to 1 by 30 of the span. So keeping all this mind we will now choose a suitable section from the SP 6 okay and we can note down the relevant properties of the section such Izz, Iyy, elastic section modulus along Z, along Y, similarly plastic section modulus Zpy, Zpz Zpz is given in IS: 800-2007 however Zpy we have to calculate manually, right.

So apart from this like cross-sectional area and other things also we have to note down because it will be also required like another properties like what will be the overall depth, what will be the thickness of the web, thickness of the flange all these things should be required so all the relevant properties will be noted down.

Then once we choose a trial section now we will classify the section that what is the b by tf ratio and d by tw ratio and based on that whether section is plastic, compact, or semi compact that will be defined. So to define the to classify the section we need to know the d by tf ratio and d by tw ratio and from which we can find out the type of section, right.

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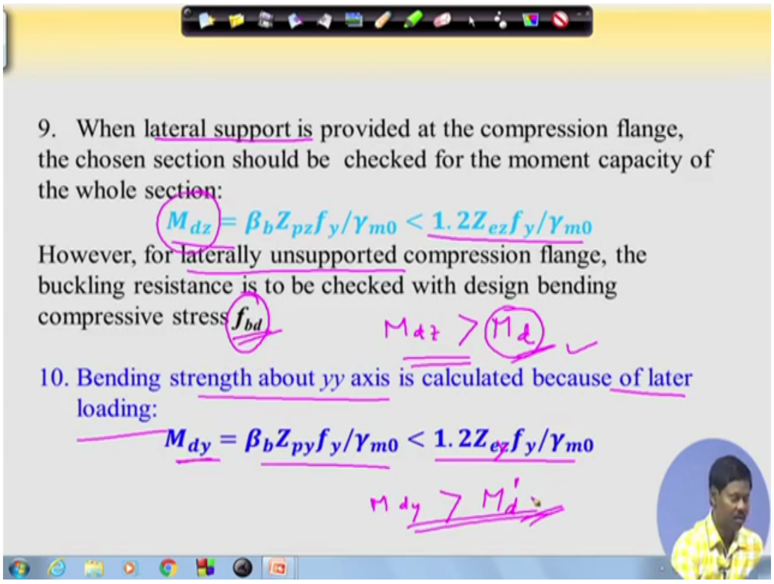

So after that we can find out the Mdz, right. So the lateral sorry the bending strength of the section or the moment capacity of the section. Now when the lateral support is provided if lateral support is provided at the compression flange, then we can find out the strength of the section bending strength of the section as Mdz is equal to beta b Zpz fy by gamma m0 and it has to be less than or equal to this 1.2 Zez fy by gamma m0, right however this is true for laterally supported beam but if its compression flange is laterally unsupported then the buckling resistance will be checked with the design bending compressive stress fbd that means considering the lateral torsional buckling effect we will find out the value of fbd design bending compressive stress, once we find out the design bending compressive stress fbd then we can find out the value of Mdz which will be lesser than the value obtained for laterally supported beam, right.

So Mdz we will find out and this Mdz value has to be greater than the factored moment due to vertical load, right Md. If it is okay then fine, if it is not okay then what we need to do we need to increase the section size so that the bending strength of the section is sufficiently more than the factored bending moment, right so this is how we have to check, right.

Now if this is not okay that means if Mdz is less than Md sorry if Mdz is greater than Md means if it is okay then what we will do we will go to next step that means we will go to step 10 where we will find out in a similar fashion the bending strength about y-y axis because of lateral loading because we have lateral loading and because of lateral loading the bending moment is going to be calculated and for that we will find out what is the bending strength about y-y axis.

So Mdy we can calculate from this formula beta b Zpy fy by gamma m0 and it has to be less than 1.2 Zey into fy by gamma m0, right and this Mdy also that means the developed this also has to be less than Md dash Md dash is the maximum bending moment due to lateral load so that has to be checked. If it is not satisfying then again we have to increase the section size and if it is going to satisfy this formula this criteria then we will go for next step.

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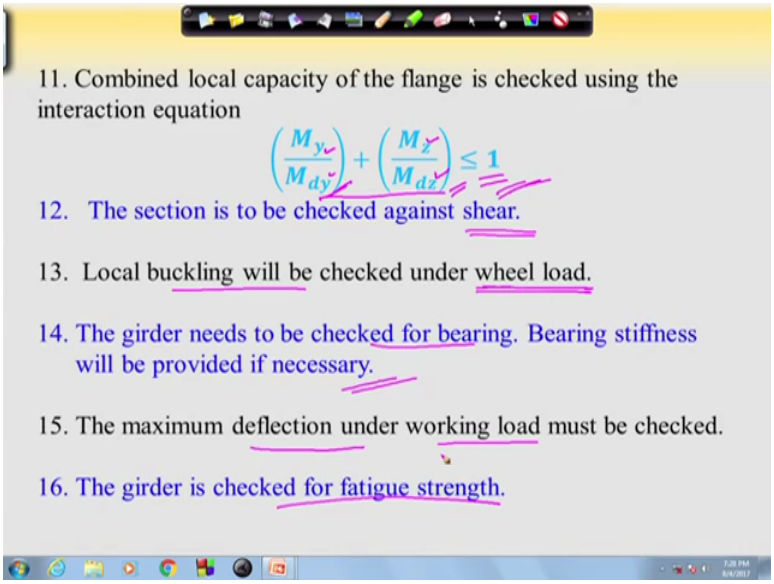

Next step will be the combined local capacity which will be calculated and will be checked using the interaction equation, so there we can see that My by Mdy plus Mz by Mdz should be less than or equal to 1, right so this we need to check that is combined local capacity of the flange using the interaction equation.

Now sometimes we will see that My is less than Mdy and Mz is less than Mdz however the combination of these two is not less than or equal to 1 so that may be possible. So in such cases again we have to redo that means again we have to go back to the earlier steps to calculate means to increase the section size and to redesign recalculate the the design strength of the design bending strength, right.

So what we will see if the from the interaction equation if this condition is satisfied then we can go to the next step, step 12 where we need to check against shear generally against shear it does not fail but in any case if it fails again we have to increase the section size or we have to take certain measurement so that it does not fail against shear, right.

Then again we will go for local buckling checked, so local buckling will be will happen under wheel load right. So we have to check the local buckling and if it is going to fail then we have to provide some additional stiffener to (())(16:53) this local buckling or we have to provide certain bearing or means different measurements can be done or we can increase the section size.

Then against bearing will checked, right so bearing stiffness will be provided if necessary. So crippling may come into picture for that we have to provide certain means sufficient bearing length so that the crippling does not occur so all these checks are required and also we have to check the maximum deflection under working load, okay. So from serviceability point of view also we need to check that the maximum deflection is under working load means under the limiting deflection, right. So and limiting deflection we can find from table 6.

Then in step 16 we will check for fatigue strength so all these steps has to be carried out for designing of a gantry girder, right. So these are the 16 steps difficult to remember but if we try to understand conceptually then we can we can do the things and may be some steps we can do means means suppose step step 12 can be done after step 13 or step 14 like this it is also possible, okay.

So basically what we will do we will try to find out first the maximum load coming on to the girder because of the position of the trolley on the crane. So maximum load effect we will consider after that we will try to position the load on the gantry in such a way that maximum shear force and maximum bending moment can be achieved. So once we calculate the maximum bending moment and maximum shear force then we can go to calculation of the plastic section modulus required, right.

So from the maximum bending moment we can find out required plastic section modulus and then this this can be found considering the section as laterally supported and as the gantry girder is typical example of laterally unsupported beam therefore next step is to increase certain amount of plastic section modulus to account for the lateral torsional buckling effect. So whatever Zp required we are getting the plastic section modulus whatever we are getting we will increase say 30 to 60 percent so that the lateral torsional buckling are taken care.

So after increasing we can find out a suitable section size from SP 6 and also we need to remember for economic design the certain depths from span by some ratio we have to consider that means that is d by 12 sorry L by 12 is equal to d d should be around L by 12 and the b the width of the flange should be around L by 40 to L by 30, so we have to keep in mind those aspects also.

So keeping all these aspects we will find out a suitable section then we will go for checking of different aspects, checking of different aspects means first we will check for bending strength bending strength along means along z-z axis, so what is the bending strength about z-z axis we are getting and it should be more than the factored bending moment about z-z axis.

Similarly we have to check bending strength about y-y axis due to lateral load and that also has to be checked the bending strength about y-y axis what is the development. So if the strength is higher than the developed one then fine otherwise what we need to do is to increase the section size. So once this is done major work is done, then what we can do we can check for shear, check for deflection, check for buckling, check for crippling and check for fatigue.

So and in every cases if this check is not satisfying then what we need to do we need to go for increase for the section size or certain other measurements like increase of the bearing length also another option to take care the crippling effect, or to take care the buckling effect, right. So so these are the steps we have to perform another thing I forgot to mention that as this is a biaxial bending case so we have to check the interaction formula also after checking the individual moment about both the axis the moments moment carrying capacity about both the axis are greater than the developed moment in about both the axis if it is so also it may fail due to interaction formula, right.

So due to biaxial bending also we have to check that is Md by Mdz plus Md by sorry Mz by Mdz plus My by Mdy less than or equal to 1 this also has to be checked, right. So all these things has to be taken care.

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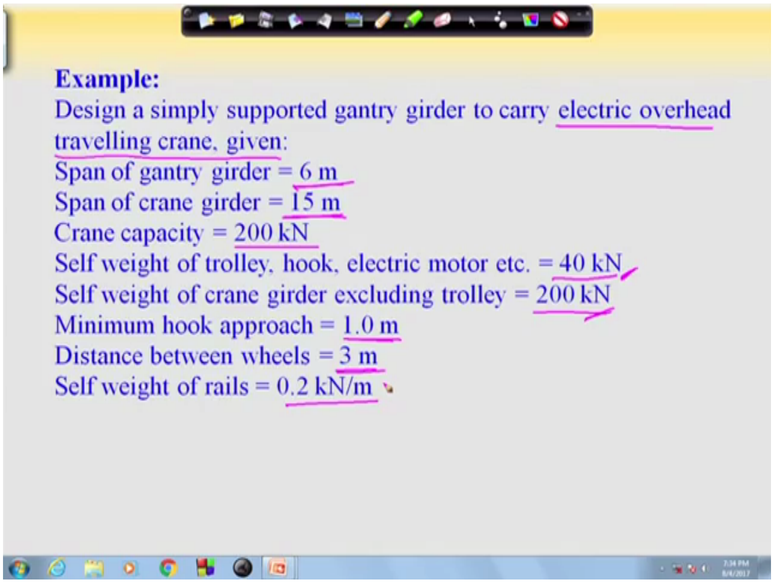

Next we will go through one example following these steps. Example is this that is we need to design a simply supported gantry girder to carry an electric overhead travelling crane where the span of gantry girder is 6 meter gantry girder span is 6 meter and span of crane girder is 15 meter, crane capacity is given 200 kilonewton, self-weight of trolley, hook, electric motor etc everything includes is coming around 40 kilonewton and self-weight of crane girder excluding trolley is 200 kilonewton. So one is self-weight of trolley who electric motor which are moveable is 40 kilonewton and self-weight of crane girder is (20 kilo) 200 kilonewton.

And minimum hook approach is 1 meter minimum hook approach and distance between wheels is 3 meter and self-weight of rail is 0.2 kilonewton per meter. So these are the data which are provided now we need to design a gantry girder, right. So I will suggest that whatever design steps we have followed following this let us try to calculate the load what are the loads are coming we will calculate and then we will try to find out the maximum bending moment and maximum shear force. So I will suggest you to do first before going to next lecture, with this example first try to find out the maximum bending moment and maximum shear force on the gantry girder basis on which we will be going to design, okay in next lecture we will discuss this, thank you.