Course on Design of Steel Structures
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Lecture 58
Module 12
Worked Out Example for Gantry Girder

Now I will go through one worked out example on gantry girder. So in last lecture we have discussed the design steps for the design of a gantry girder and I have given an example for for solution. So I hope many of you have done, now we will try to check the results means we will try to see whatever the actual results are coming and you try to correct or modify your results, okay. If you have done something wrong.

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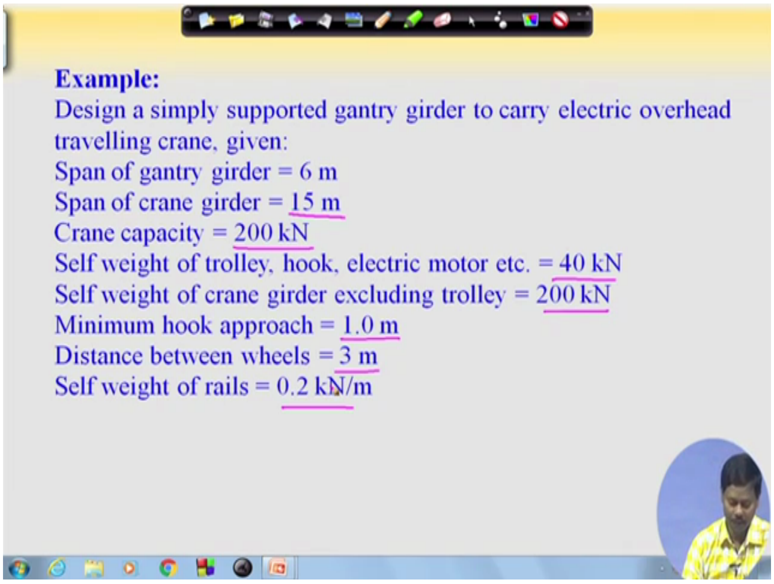

Now the example was this that is span of gantry girder was given as 6 meter, then it is simply supported gantry girder, span of crane girder was 15 meter, crane capacity was 200 kilonewton, self-weight of trolley, hook, electric motor etc is 40 kilonewton. Self-weight of crane girder excluding trolley 200 kilonewton and minimum hook approach is 1 meter and distance between wheels are 3 meter and self-weight of rails are 0.2 kilonewton per meter. So with this we will try to find out the section a suitable section.

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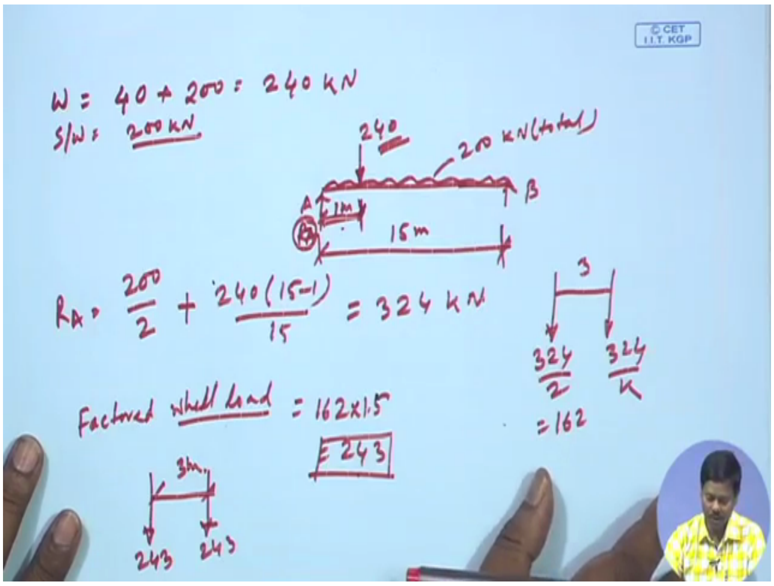

So first what we will do we know the maximum sorry weight of the trolley plus lifted load means w which is weight of trolley plus lifted load that is 40 plus load was 200 kilonewton, so 240 kilonewton and self-weight was 200 kilonewton total self-weight of the crane was 200 kilonewton and crane was 15 meter span, okay span length of crane was 15 meter. So the self-weight was distributed so total load which is 200 kilonewton is total, right and wheel load means the weight of trolley and lifted load etc was total 240 kilonewton, okay.

And this is possible to get say maximum reaction at A say RA this is point A, this is point B, so maximum reaction at point A if we want to get then we have to provide the wheel load as close as possible to A, right and we have seen that the minimum hook approach was 1 meter minimum hook approach was given 1 meter so 1 meter away from the gantry we can place the load, right. So this is the minimum to get the maximum reaction at A.

So maximum reaction at A we can find out one is due to this total load, so this will be RA will be total load 200 kilonewton that is udl load so 200 by 2 will be RA and this 240 kilonewton that will be 240 into 15 minus 1 by 15 because this is 1 meter, okay if we take moment about B point than I can find out RA value and this is coming 324 kilonewton, okay and this load is transferred to gantry girder through two wheels and wheel base is 3 meter away, okay.

So two wheels with 3 meter away it will be transferred, so each wheel will be carried 324 by 2 kilonewton, okay that means 162 kilonewton, okay. So load on gantry girder from each wheel will be 162 kilonewton and so factored load factored wheel load total will be 162 into 1.5, right so 243 kilonewton this is the load. So maximum effect on the gantry girder will be obtained due to the load of 243 kilonewton in each wheel, okay factored load so the wheel will be carrying a load of 243 kilonewton each at a distance of 3 meter, okay.

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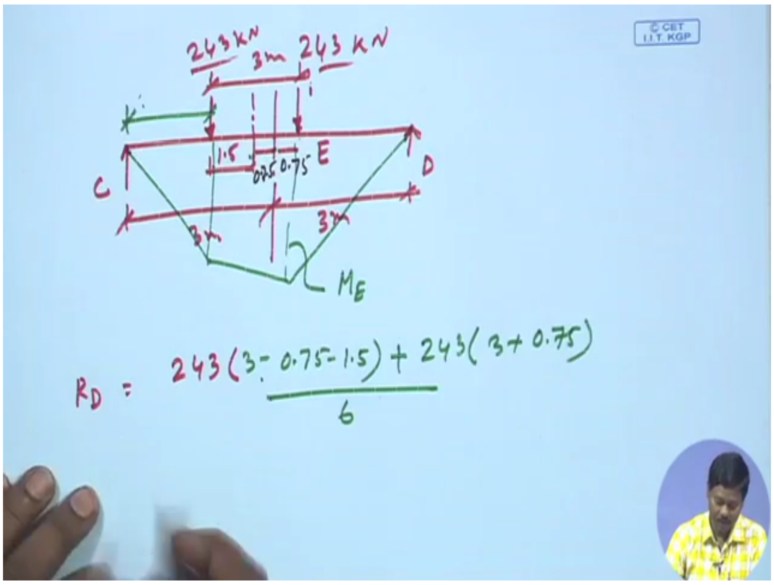

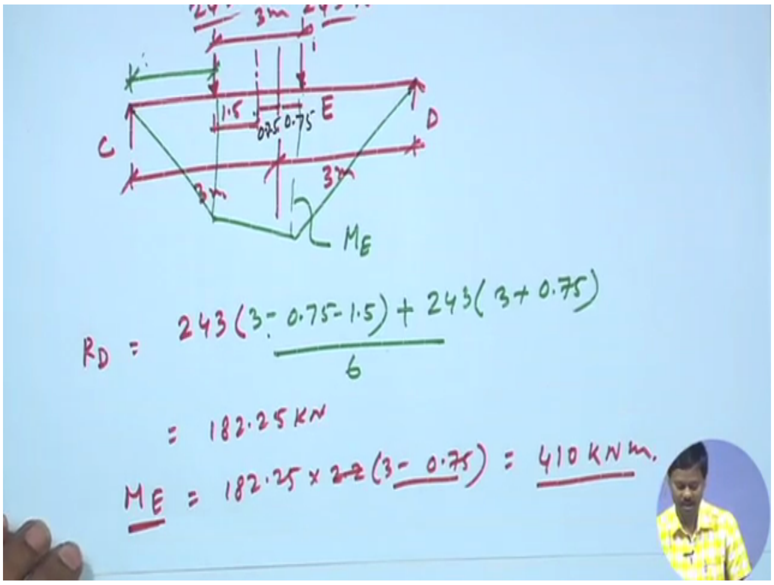

Now maximum moment due to moving loads occur under a wheel when the cg of wheel load and the wheel are equidistant from the centre of girder, okay. So that is possible if we have a position of the load in this way. Say suppose this is gantry girder say C and D the span of gantry girder was given 6 meter okay so this will be 3 meter, right and then I can consider say this is one wheel, okay and another wheel is say its cg is this another wheel is here, so this is 3 meter, right so this is 1.5 okay and now it is told that the centre should be equidistant from the cg of the wheel and one wheel okay.

So this will be 1.5 by 2 and this will be 1.5 by 2 that means this will be 0.75 and this will be 0.75, right this is 3 meter, okay and we have 243 kilonewton, 243 kilonewton. Now if we place in such a way then we will get the maximum bending moment. So to get maximum bending moment so this I can make say this as point E, right so the maximum bending moment will occur in this position at E, right something like this so it will be maximum bending moment, right.

So to get maximum bending moment I have to find out the reaction at D so reaction at D RD I can find out if I take moment about C, so if I take moment about C I can find out say 243 into this distance this distance will be how much this distance will be 3 total 3 minus 0.75 minus 1.5, right. So 3 minus 0.75 minus 1.5 this will be this distance, right plus then another is 3 plus 0.75 243 into 3 plus 0.75, right divided by 6.

So doing this I can find out the value of RD as 182.25 kilonewton, so if the reaction at D is 182.25 kilonewton then moment at point E which is the maximum moment that will become 182.25 into 2.25 D because this is 3 minus 0.75 so 2.25 D, so this will become 410 kilonewton meter. So maximum bending moment we can find out as this okay.

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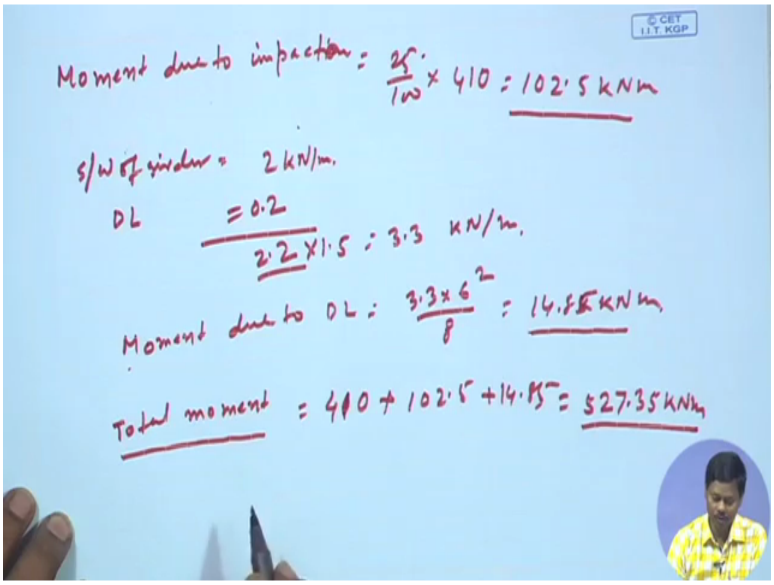

So once we get maximum bending moment we can find out moment due to impact also impact so due to impact additional 25 percent load will come into picture so 25 percent of this maximum bending moment that is coming 102.5 kilonewton meter, right. Now this is the bending moment because of this wheel. Now another is the self-weight of girder of girder we can assume so self-weight of girder let us assume 2 kilonewton per meter, okay because girder wheel also have some load and because of that we need to calculate the moment.

And dead load due to that rail was 0.2 so total load is 2.2 dead load due to self-weight and rail. So factored load will become 2.2 into 1.5 so 3.3 kilonewton per meter. So moment due to dead load I can find out due to this dead load I can find out say wl square by 8 maximum bending moment so 3.3 into 6 is the span length so 14.85 kilonewton, right. So one was the maximum bending moment due to the wheel load, another is the maximum bending moment due to self-weight and and rail weight, right. So this is 14.85 kilonewton, okay.

So we can find out now total moment so total moment total factored moment due to all vertical loads will be 410 we got vertical means moment due to vertical load 102.5 is the due to impact and 14.85 is due to self-weight, okay so this is coming 527.35 kilonewton meter, right. So total factored moment due to all vertical loads are coming this for which we need to design, okay. So for designing the girder the maximum bending moment on the girder has been calculated as 527.35 kilonewton meter.

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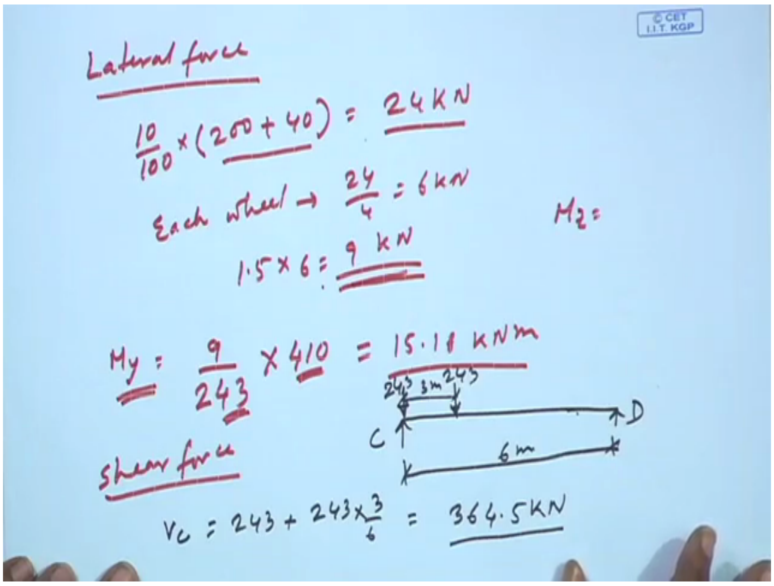

Now also we can find out maximum moment due to lateral force lateral force maximum moment due to lateral force. So horizontal force transferred to rail was considered as 10 percent of the load, right. So 10 percent of the wheel load wheel load means basically 200 was the lifted load plus trolley load etc was 40 so 24 kilonewton maximum moment due to sorry horizontal force can be calculated as 10 percent of the total load that is 200 plus 40, 240, right and this load is distributed over four wheel, okay.

So on each wheel load will be 24 by 4 is equal to 6 kilonewton and factored horizontal force on each wheel will be 1.5 into 6 so 9 kilonewton. So lateral force on each wheel will be 9 kilonewton, okay and because of this lateral force on each wheel I need to know what will be the bending moment and which will be about y-y axis so My we have to find out. Now this My is basically maximum bending moment in gantry girder in which the position of load is same as earlier, right.

So in earlier case we can find the value Mu or Mz, right which was we found earlier, right. So here similarly we can find out the maximum bending moment about y-y addiction with similar proportional okay so if we make proportional then we can find out 9 was the each wheel load and earlier it was vertical load was 243 into maximum moment developed under 243 was 410 if you go back to earlier slide you can see that 243 is the wheel load and because of that moment was developed 410 so with similar proportion I can find out the maximum bending moment about y-y direction as 15.18 kilonewton meter, right.

Now again once bending moment is over we can find out the shear force, right and shear force we can find out if positions are make like this that is if one of the wheel is placed at the support that means we can provide a load here and another load here this 243 and this is 243 with a distance of 3 meter because wheel base is 3 meter, okay. So with this position I can find out now the maximum shear so if this is C and this is D then I can find out the maximum shear VC as 243 plus 243 into 3 by 6 so 364.5 kilonewton will be the maximum shear force coming on the support, okay with this position.

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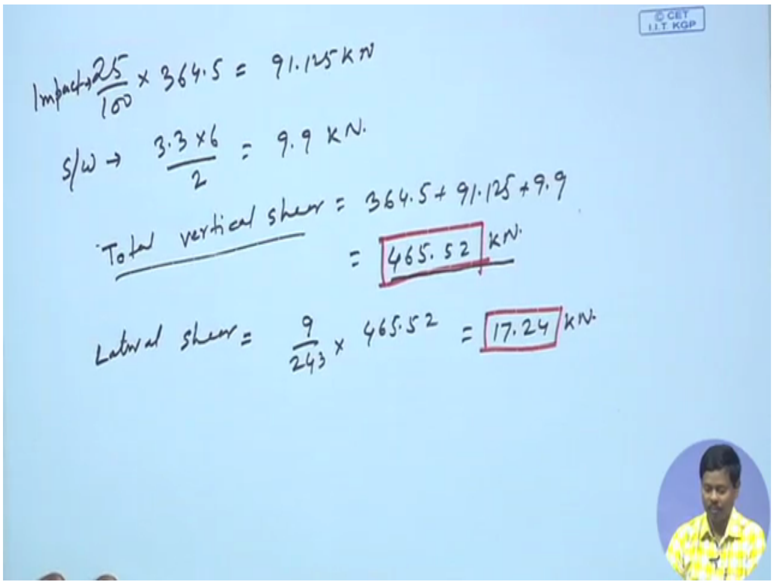

So I need to design the gantry girder against this maximum bending moment and maximum shear force and also I need to find out this shear force due to impact, okay. So vertical shear due to impact will be 25 percent of the earlier shear force that is 364.5 so this will be 91.125 kilonewton and vertical shear due to self-weight this is impact and due to self-weight it will be wl by 2, 3.3 was the load per unit length 9.9 okay so total vertical shear I can now find out total vertical shear will be how much that is earlier we got 364.5 plus due to impact we got 91.125 plus 9.9 is the due to self-weight so total is coming 465.52 kilonewton, okay. So total vertical shear we got this for which the girder has to be designed.

And lateral shear will be lateral shear we can find out lateral shear will be simply if I make proportional that is 9 by 243 into 465.52 so by proportioning we can find out the lateral shear that is 17.24 kilonewton, okay. So we have to design because of this vertical shear and because of lateral shear and similarly vertical means moment about z-z axis and about y-y axis, okay.

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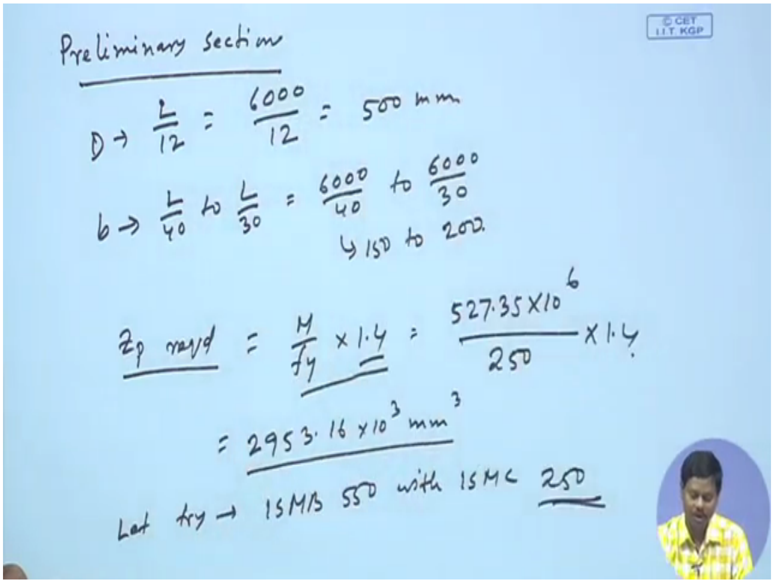

Now we have to find out a preliminary section against this. So preliminary section how do we find out to arrive a preliminary section what we can do first we we can find out minimum economic depth as L by 12, so some approximate depth we can arrive as 500 millimetre. Similarly L by 40 to L by 30 that means 6000 by 40 to 6000 by 30, okay 6000 40 means 150 to 200, okay.

So this will be the depth and this will be the width of the flange, okay and Zp required Zp required we can find out, right Zp required will be M by fy and say 40 percent we can increase 1.4 times we have seen that it can be 1.3 to 1.6 whatever we feel to start with we can increase 40 percent, so that will be M the bending moment maximum bending moment due to vertical load we got 527.35 kilonewton meter, fy is 250 into 1.4, right so we can find out as 2953.16 into 10 cube millimetre cube. So the required plastic section modulus Zp we can find out as this, okay. So we can try with ISMB 550 with ISMC 250 on compression flange at the top, okay.

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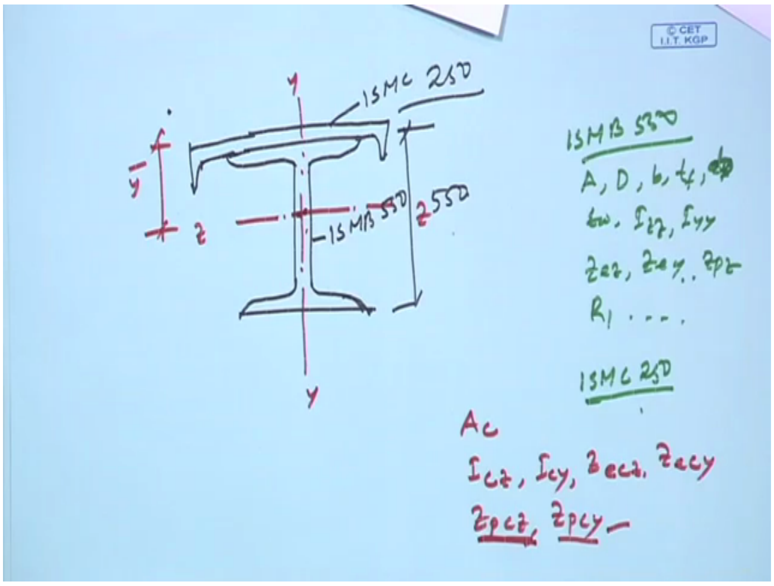

So with this we can find out the arrangement like this say an I section, right this overall depth is 550, this is ISMB 550, okay and top of that we have one ISMC 250 ISMC 250, right. So with this configuration we can now check the design that means what we could see here that a composite section comprising of an ISMB 550 and ISMC 250 where ISMC 250 is placed at the top of the I section in this manner and then now I know all the relevant properties of ISMB 550 ISMB 550 from SP 6, say area, depth, b, tf, df sorry tf, tw like this I can Izz, Iyy, Zez, Zey and also I can find out other properties like Zpz, right so R1 the root radius all these things I can find out.

Similarly for ISMC 250 I can find out all the relevant properties. Now once I find out all the relevant properties now I have to find out the combined sectional properties, okay. So from this what I need to do because I need to find out the design bending strength about z-z axis, about y-y axis, right this is y and this is z. So to find out I need to find out what will be the combined area say AC, okay I need to find out what is the combined moment of inertia about z, combined moment of inertia about y, I have to find out.

So this is a Tds job means I am not going into detail of the calculation I am just telling what we need to do and you go through one example in the book from which you can find out also in the power point I will give this example, okay. So now you see so first what I need to do I need to find out what is the neutral axis depth say neutral axis depth of the section. So after finding out I need to find out what is the Iz z of the combined section, Iy of the combined section, then z of the combined section means z means Zez, Zey of the combined section I have to find out.

Similarly the plastic section modulus okay so plastic section modulus how to calculate that also we have demonstrated earlier so using those things I have to find out. So once I get all these properties say Zecz, Zecy, then Zpcz, Zpcy plastic section modulus of the plastic section modulus of the combined section about z-z, about y-y so all these properties we need to calculate once we calculate all these properties then what we will do we will find out the design bending strength of the combined section design bending strength of the combined section about z-z axis, about y-y axis.

And that has to be more than the maximum bending moment which we have calculated earlier z-z axis and about y-y axis. If it is not more than we have to increase the section size and then we have to repeat again and if it is more than we can go ahead once it is done then we will find out the effect due to biaxial bending that means interaction formula has to be checked and then again we have to see whether it is okay or not once it is done then again we will go for shear that means the design shear strength of the section is sufficient to withstand the shear force whatever coming in the section in both the axis that we will do.

After that we will check for crippling, buckling and fatigue and then again we will check for reflection under working load. So all these checks has to be done, all these checks has to be performed if it satisfies then the final section means finally the section can be chosen whatever we have considered, okay so in this basis one can design a gantry girder. So I hope in these three lectures I could give an idea about the design of a gantry girder basically design of a gantry girder is nothing but design of an laterally unsupported beam under biaxial moment.

And for that we need to know what are the different type of load are coming both vertically and laterally and what is the impact load coming due to vertical load and what is the total load and where the wheel should be positioned so that the maximum effect can be achieved so that maximum bending moment and maximum shear force can be calculated against which the design will be run, okay.

So this is all about the gantry girder, if you go through some example given in the book then it will be much more clear because by these three lectures means 1 and half hours it is quite difficult to finish a chapter this is basically a chapter in most of the books you will get in a chapter form which I have covered in beam design, okay thank you.