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

**Module - 6**
**Flexural Members**
**Lecture - 3**
# Design of Laterally Supported beams

Hello today we are going to focus our lecture on design of laterally supported beams in case of beam design we will see design philosophy are of 2 types: one is for laterally supported beams, another is for laterally unsupported beams right. So, today will focus our lecture on laterally supported beams. In fact, in last lecture mostly we have discussed about the design steps for laterally supported beams. Basic difference between laterally supported beams and laterally unsupported beams is that the stress due to bending in compression will be defined.

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In case of laterally supported beams the stress sigma bc will become say 0.66 fy which will be equal to sigma bt where, sigma bc is the stress due to bending in compression and sigma bt is the stress due to bending in tension. Whereas, in case of laterally unsupported beam what will happen? This sigma bc will not be 0.66 fy means it will have some other value which we will discuss in next class, not today that how to calculate.

But today we will be focusing on the laterally supported beam. And then, if we have time we will discuss about the buckling; web buckling because, as we know we are going to use beam sections as say I section, channel section, t section, like this. In those cases, web thickness is much less than the flange width, so thickness as thickness is less. So, we may have possible to buckling so that, buckling effect has also to be taken care while designing.

So, those things also we will discuss after discussing this design of lateral supported beams. Now, last day as we have told that the different steps of design procedure for laterally supported beams. Today we will just give an overview of the steps by 1 minute then; we will work out 1 example. And before that I like to introduce means already introduction is there regarding shear stress.

The average shear stress we know how to calculate. The shears stress as you know say important factor for design of beam section, we know shear stress is going to vary along the depth of the cross section. Now, how it varies little I have told last day, but I have not calculated how to calculate the shear stress exactly. That today I will give an insight of that and then; I will start the design procedures right and in fact, many things we know. So, I am trying to exclude those things there about the shear stress only, which we have not discussed in the class that portion only I will discuss today. That means, only the calculation of shear stress for a particular section over the depth of cross section.

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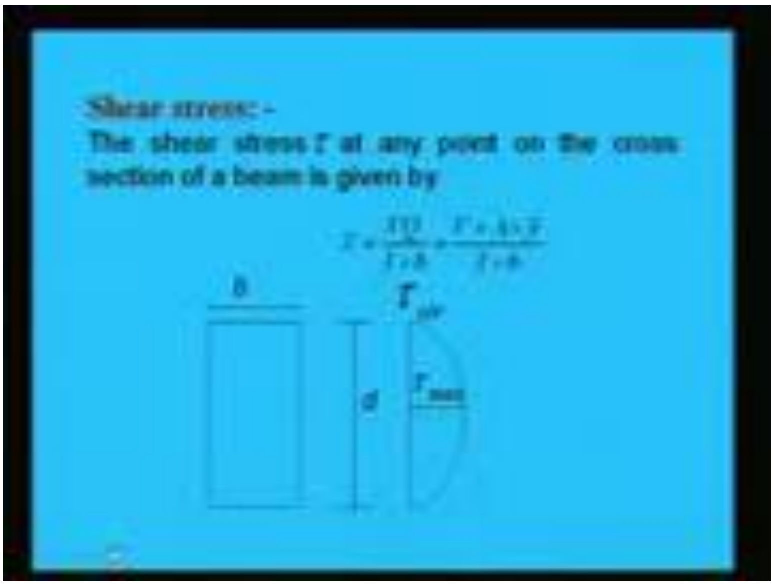

So, as we know the shear stress tau at any point on the cross section say tau can be given as VQ by I b, where these are shear force we know I is the moment of inertia and b is the width of the beam and a is the area from which the shear stress is going to calculate. Suppose, we are trying to find out say this is neutral axis is here; suppose we are trying to find to say shear stress at this point. So, area means the outer section of that portion area into y bar the right. So, in this way we can find out the value V into A y by I B. So, in this way we can calculate exact value.

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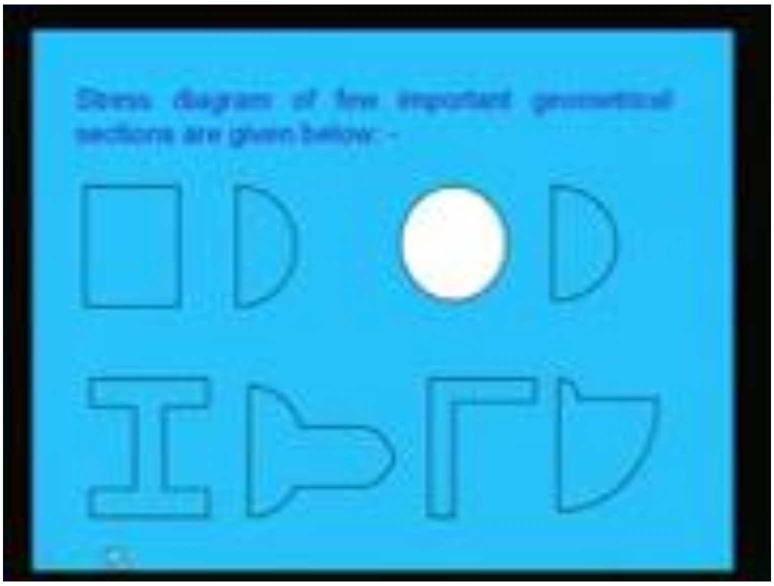


As we know yesterday we have seen that, the shear stress distribution along the depth of the cross section of a rectangular section will be like this parallel right. And in case of circular section also we will see it will act something like this, but the magnitude will be definitely will be different. And also in last class we have seen, there the sudden increase of the magnitude of the shear stress at this level right this is not in the same level we have made say at this level.

So, as the width of the width of the section is decreasing at the web. So, increasing the magnitude or shear stress because, this is VQ by Ib it is proportional means inversely proportional to the width of the section. Similarly, if we have say suppose L types of section or angle section this will the shear stress distribution will be something like this.

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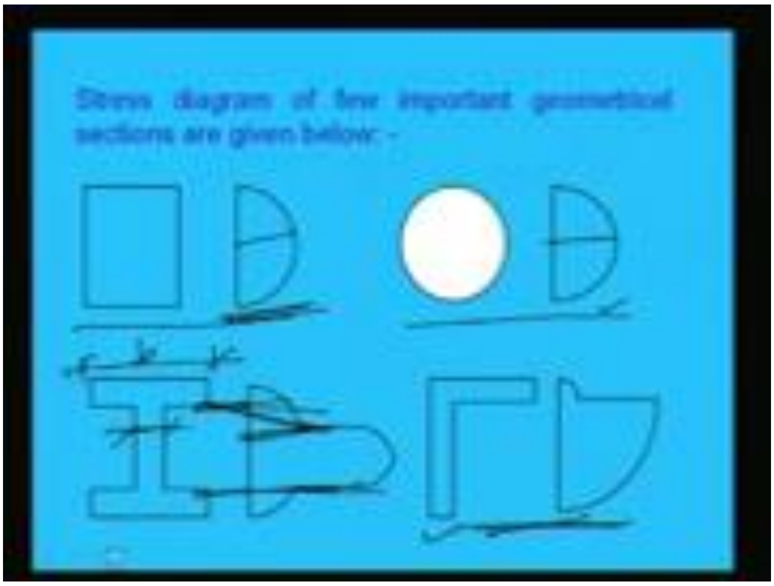


Now, how to calculate that we will focus here; we know that tau max what will be tau maximum V into A into y by I into b this will be the tau max say for rectangular section if we see right. So, if we put the value what will happen say V by I means 1 by 12 bd cube and then b and area; area means, here when we are going to find out the maximum shear stress.

So that means, area will be this portion that means, b into d by 2. So, b into d by 2 and y; y means this will be acting at a center from here. So, this will become d by 4 so into d by 4. Now, if we derive this expression we will get finally, something like this that 3 V by 2 bd where, the V is the width of the beam and d is the depth of the beam. So, that is how we can find out tau max value, not only tau max value at any point the shear stress can be find out through this. But problem will arise when we will consider the section at say t section or say I section I think, in that case the calculation will be little complicated.

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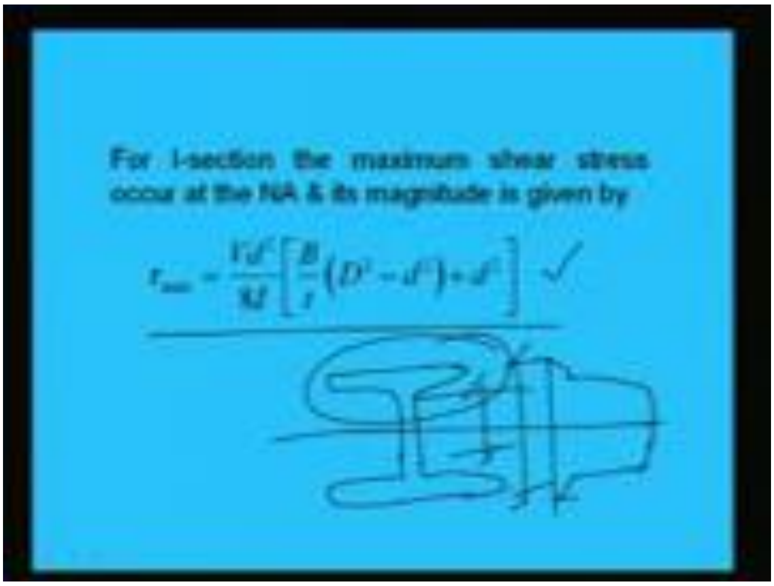


So, in that case if suppose we have I section, so what we have to do we have to find out where it will be. And as we know this is will be acting as means, maximum tau max will be if we see the diagram, so maximum tau max will be here. So, we have to in a similar way we have to find out right where, D is the total depth and d is this depth right. And we know other terms V d etcetera.

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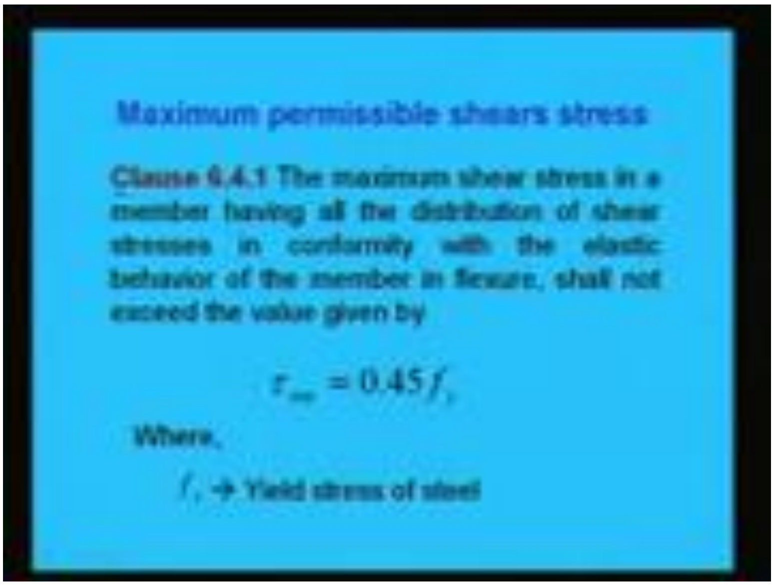


And we know the clausal provisions we have it has been given in the code at IS: 81984; the clause has defined that the maximum shear stress in a member having all the distribution of shear stress is in conformity with the elastic behavior of the member, in flexure, shall not exceed the value given by this. That means, maximum shear stress whatever we are calculating here; it should not exceed this value 0.45 fy where, fy is the yield stress of the steel.

So, tau vm the maximum allowable shear stress that will become 0.45 fy. And maximum shear stress we can calculate and accordingly we can check right.

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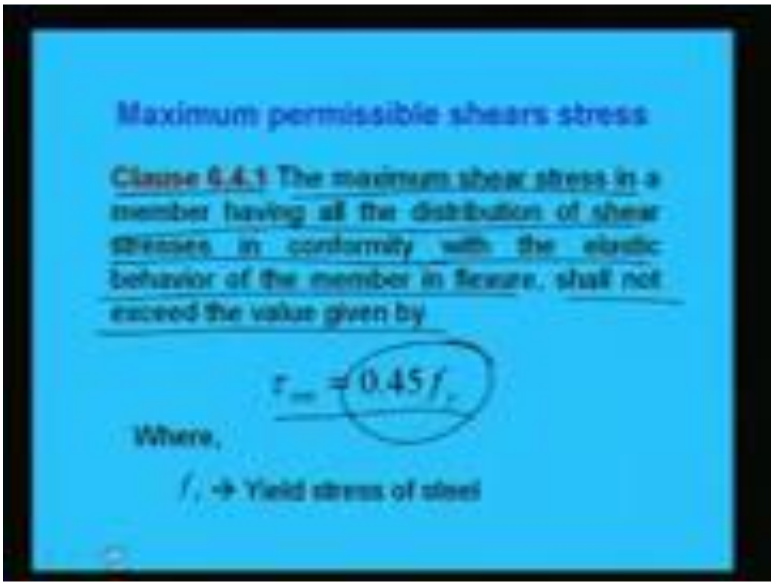


Again for un stiffened web of I and channel section the cross section of the web can be taken as this means, area of the web will be simply d into tw. Because, d is this 1 this is d and tw is this 1 thickness of the web. So, area of the web we can find out like this right where, tw is the thickness of the web and d is the depth of beam right. So, in this way we can find out the area of web which would be required.

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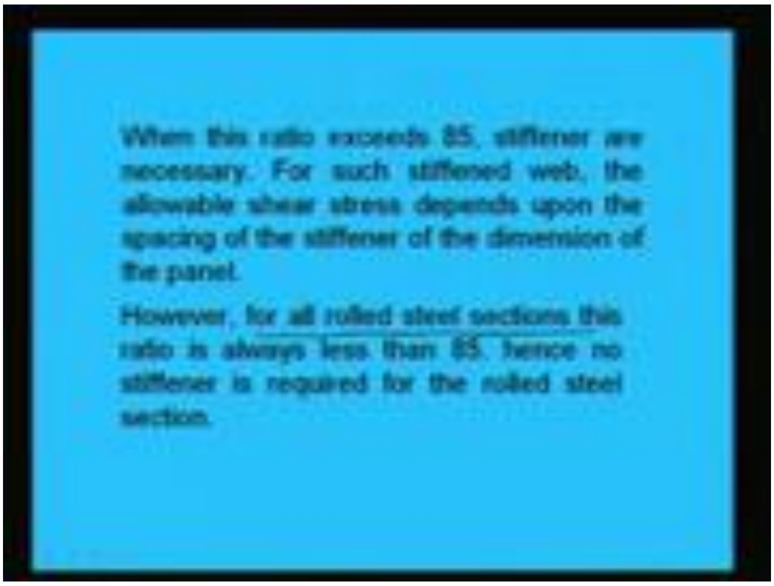


Now, the shear stress developed can be find out tau v is equal V by d into tw right. Now, this recommendation has been done by the code and this is valid only when the depth of the web does not exceed 85 times the thickness. Web depth is d if it is and web thickness is t then the ratio of web depth to web thickness should not mean, should be less than 85 or should not exceed 85 right. So, this recommendation we can use if d by tw is less than 85, for this case only we can use this recommendation.

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And it is also seen that the ratio does not exceed this 85, for all rolled steel sections this ratio is less than 85. We have standard steel section, rolled steel section, so here we have seen that all cases it does not exceed 85. So, for all rolled steel section we can use that formula that is this condition right. So, this condition we can use, but if for built-up section if we use then we have to go for calculation right. So, when the ratio exceeds 85, this stiffener is necessary.

In case of built-up section nearly it exceeds the ratio 85. So, in that case what we need? We need the stiffener. For such stiffened web, the allowable shear stress depends upon the spacing of the stiffener of the dimension of the panel. So, from that way we have to find out and all these things we will see case to case. And as the as you told that, for all steel rolled section the ratio is not exceeding 85, so we do not need to provide any stiffener for this rolled section.

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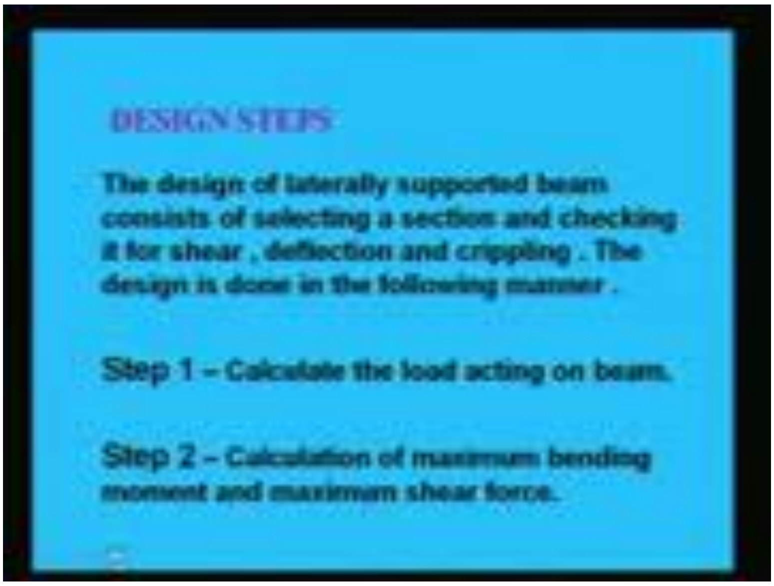


Now, the design steps which we have discussed in last lecture just I will give by 1 minute just to means refresh again, so that you can work out the example. What are the design steps was given earlier? As you know the first step was that calculate the load acting on the beam right. And this design step is for laterally supported beam right we are describing that the n steps, for other case will again make the other design steps.

In next step what we will do, that calculate calculation of maximum bending moment and maximum shear force. So, we will calculate the maximum bending moment and maximum shear force for that beam with taking consideration of the loading and they are boundary conditions. Accordingly we can find out what are the maximum bending moment and maximum shear force. Because, you have to check from the maximum bending moment point of view and maximum shear force point of view, so that the design section can carry the expected load.

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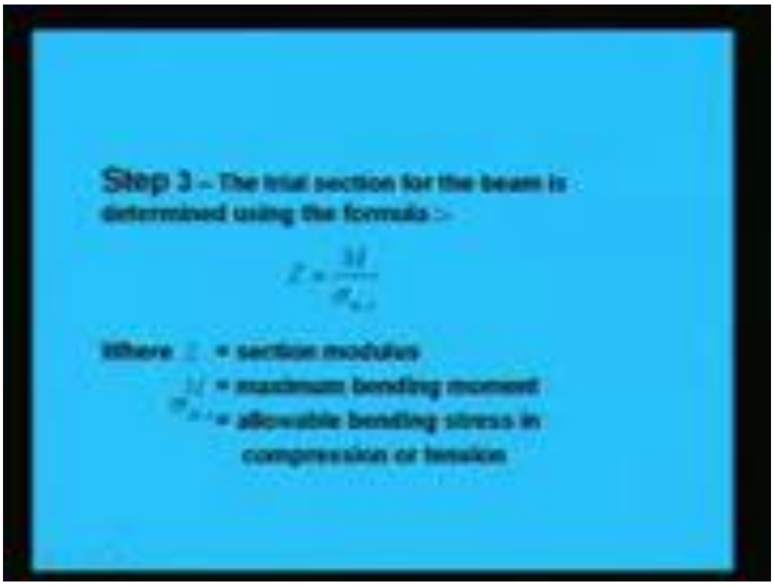


Next step is we will try to find out a trial section that we can find out from this equation. That is section modulus can be written as Z is equal to M by sigma bc or sigma bt and here as the beam is laterally supported. So, sigma bc and sigma bt we know these are equal and that is 0.66 fy right. So, we can find out maximum bending moment and the sigma bc or sigma bt then we can find out what is the modulus section modulus is required Z is nothing but the section modulus and M is the maximum bending moment. And sigma bc t is allowable bending stress in compression or in tension; so in this way we can find out.

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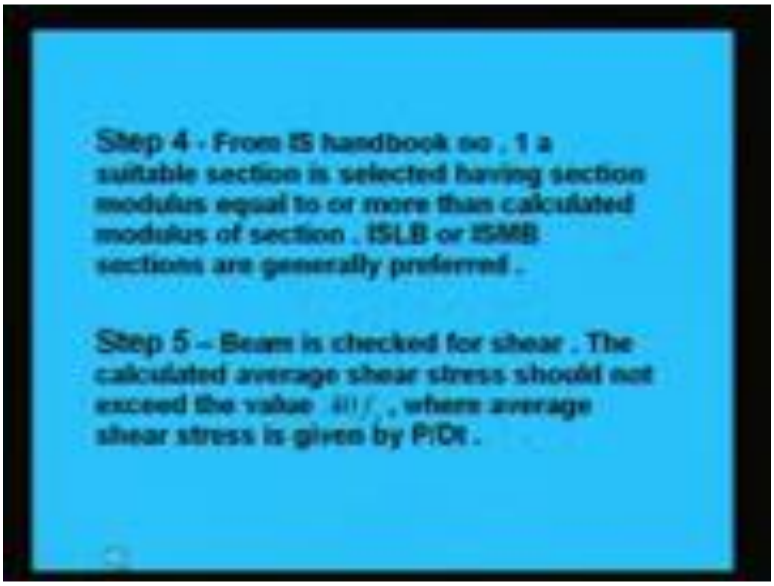


Next step what we will do we will go for check for shear right. Now, from IS handbook a suitable section we can find out having section modulus equal to or more than calculated modulus of section. ISLB or ISMB sections are generally preferred in practical case you will see mostly we use ISMB or ISLB section right. And so will try to find out a suitable section where modulus section modulus will be little higher than the required 1 right.

If it is little higher than the required 1 what will happen then, the developed stress in compression and in tension will be little less than the allowable 1 that means, it will be in safe. Next step what we will do, that beam will has to be checked against shear. The calculated average shear stress should not exceed the value 0.4 fy, where the average shear stress is given by P by Dt P or V we can write V by Dt, where V is the shear stress force right. So, from this we can find out the average shear stress which is should not exceed means, it should not greater than 0.4 fy right. So, that we have to check.

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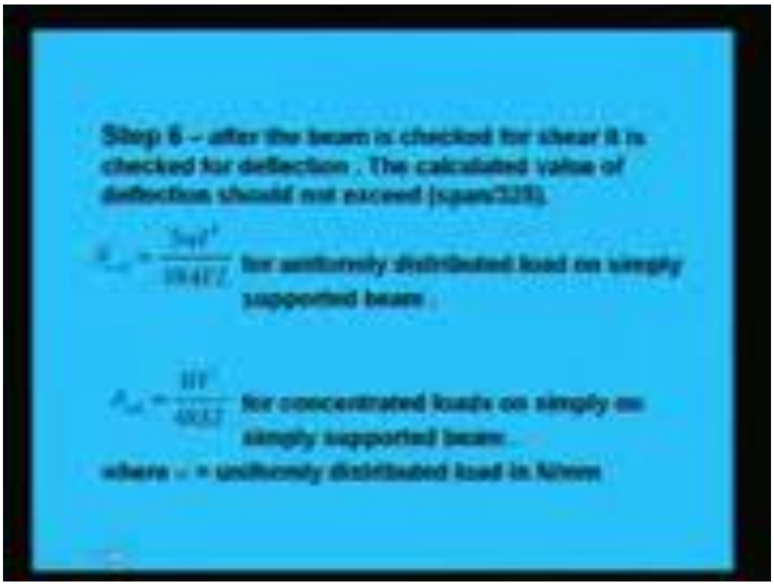


And next check is, the deflection check we have to see what are the deflection is coming due to that particular loading condition and that particular boundary condition. So, what is the maximum deflection for that case we will check, we will calculate and then we will check with the Codal provision. In Codal provision it has given that maximum allowable deflection is span by 325 right.

So, that we will check so that is what we have done that, after the beam is checked for shear it is checked for deflection. The calculate value of deflection should not exceed span by 325 right. Now calculate value we can find out say 2 cases we have sighted here; that1 is say if it uniformly distributed on a simply supported beam means, if it is like this say this is w and say this is l l and EI.

Then, we can find out that maximum deflection is phi by 384 w l to the power 4 by EI. So, in this way we can find out the maximum deflection. And similarly, for concentrated loads on simply supported beam what will happen concentrated load if we use on the simply supported beam at the mid span, then maximum deflection will come wl cube by 48EI where, w is the concentrated load.

Here remember this w is the uniformly distributed load; that means, load per will be taken or per unit length right. So, in this way we can find out the delta means deflection which is coming and we know what is the maximum deflection we allow as per the Codal provision, so that we have to check. If the calculate deflection or developed deflection each greater than the allowable deflection specified by the code, then we have to redesign the section. Otherwise, we can say that this is safe against deflection point of view.

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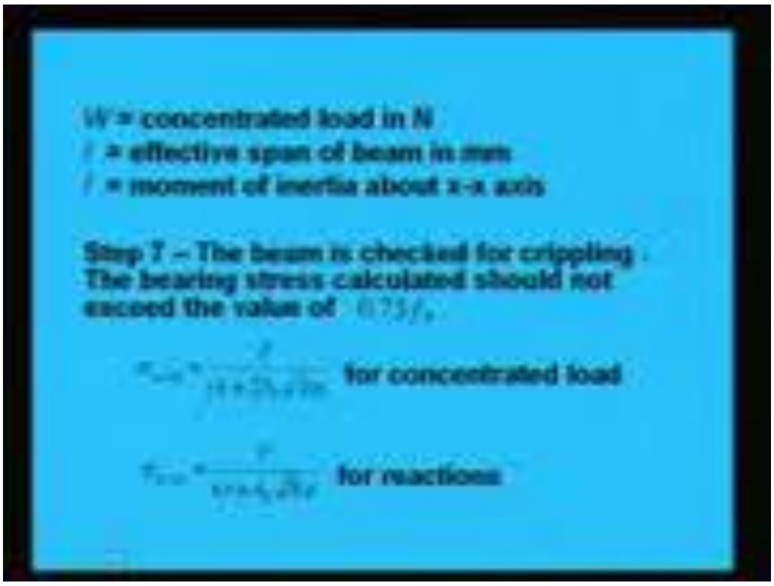


Next we will see that it should not be held against crippling in last day we have shown how crippling effects right. So, the beam is checked for crippling. The bearing stress calculated should not exceed the value of 0.75 fy. So, we know crippling where it is happened basically when the load is acting as a concentrated load at a particular section then, on that section on that portion the crippling effect may happen.

And at the support where suppose a support is there where the concentrated reaction will develop there also this crippling effect may happen. So, we have to check there whether this is exceeding the bearing stress or not say sigma P calculated that will be P by b plus 2h2 root 3 into t right for concentrated load. And for reactions this will be sigma P cal is equal to P by b plus h2 root 3 into t.

So, in this way we can find out the calculated bearing stress and we have to see whether it is exceeding this value or not the Codal provision where it is given that 0.75 fy. If it is below the exceeding means limiting value then fine otherwise, we have to go for some other sections.

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Now, the example we will sort out the last day, we have discussed means we had given the example for making at your own right. I hope most of you have already done this problem. So, now I will demonstrate the same thing and you can check with your workout example and you see whether it is matching or not right.

So, last day what we told that a simply supported steel joist with a 5 meter effective length right and carrying a uniformly distributed load of 50 kilo Newton per meter right including the self weight right. The beam is supported laterally throughout. Now, select a suitable section and check its safety. So supported laterally throughout means, sigma bc will become 0.66 fy or sigma bt also will become same. This is always this will be and sigma bc will be this 1 right. So, in this way means with this consideration we have to design, so first step what we will do?

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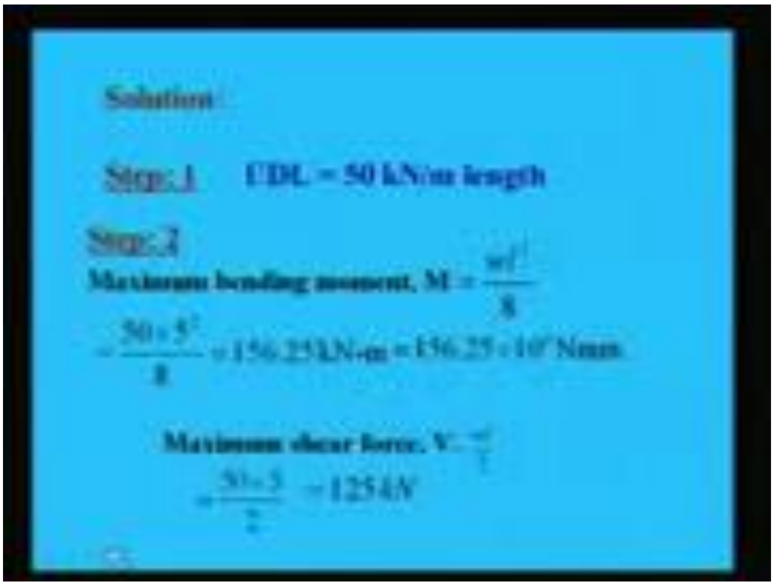


We will found out that what is the total load coming into the beam, and as it is told that total load is 50 kilo Newton per meter length including self weight, so we do not need to include any self weight. So, we can make UDL load as 50 kilo Newton per meter length as a load to calculate the design sections. Now, with this we can find out the maximum bending moment; maximum bending moment for simply supported beam what will it become M is equal to wl square by 8.

So, here w is 50 kilo Newton per meter and length is 5. So, after calculating this we will get 156.25 kilo Newton meter or 156.25 into 10 to power 6 the Newton millimeter. So, maximum bending moment against which we have to design the section is now known. Next maximum shear force, we know for a simply supported beam maximum shear force will develop at the end at the support. So, that will become wl by 2 right, so w is this l is this. So, we can find out maximum shear force wl by 2 that is coming 125 kilo Newton.

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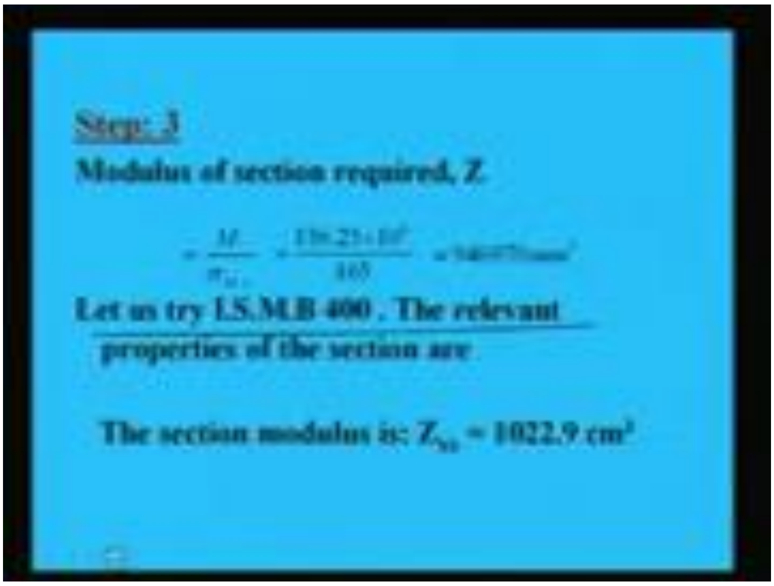


Now, in step 3 we will find out the required modulus of section, what is the required modulus of section? That will be M by sigma bc or sigma bt. And in this case we know for beam having lateral support, we know sigma bc will become sigma bt and that will be becoming 0.66 fy. So, if I find out the value of sigma bc as 0.66 fy; fy is 250 then it will come 165. And maximum moment we have already calculated as 156.25 into 10 to the power 6 Newton millimeter right.

So, from this equation we are going to get as the section modulus as 946970 millimeter cube or we can say 946.97 centimeter cube. So, with this we have to see what are the available sections, which we can use here, so with the SP: 6 we can find that an ISMB 400 section will be relevant to use here.

In case of ISMB 400 the section modulus is 1022.9 centimeter cube, which is little greater than the required Z required is 94697 right. So, we are providing the section or we are choosing a section, in such a way that the section modulus of the selected section will be little higher than the required section modulus. So, in this way we can find out the suitable section.

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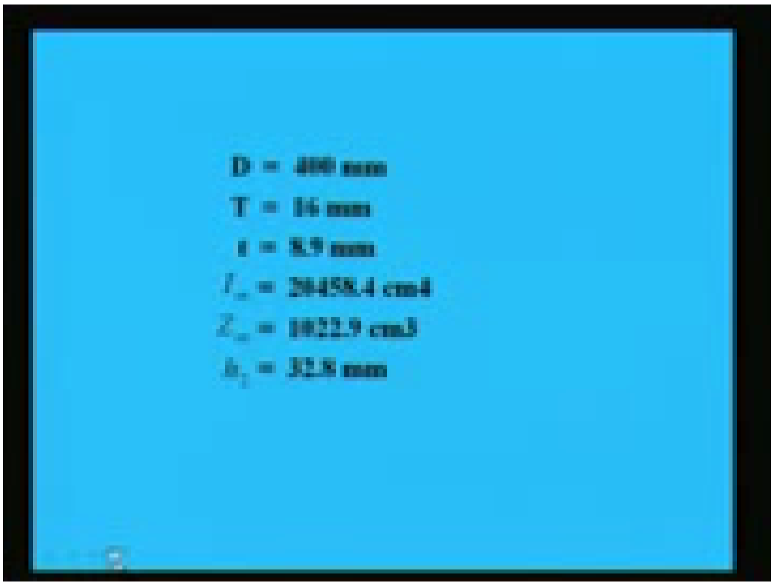


Now, for that section that ISMB 400 these are the relevant property which is required for calculating and checking other things right. Like D we know what is D, what is T in a I section D is the overall depth, so that is given 400. Now, T is the thickness of flange right and t is the thickness of web that is given 8.9 and thickness of flange is given 16. Similarly, Ixx means moment of inertia about xx direction that is given as 20458.4 centimeter.

Therefore, these already we have told that the section modulus each 1022.9 centimeter cube. And h2 which will be required the root from root 2 the distance that is 32.8 millimeter right. So, these are the required data which will be necessary for checking and calculating different parameters for final design right. Now, what we will do, so we are seeing that as we are providing section modulus little higher than the required. So, from bending moment of point of view this will be that means, the sigma c or sigma t that will be less than sigma bc or t sigma c or t right. So, that we can assure because z required is less than z provided is more, so definitely this will become.

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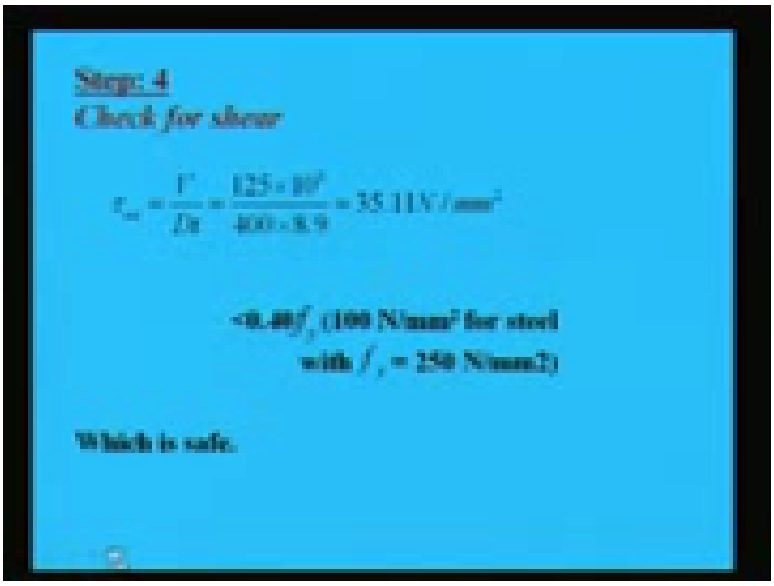


Next what we will do, next we will check for shear. Now, the average stress can be find out from this expression that is V by D into t where, maximum shear develops at the support which has been calculated as 125 kilo Newton. And this we are changing to Newton by multiplying 10 cube. So, V by Dt means 125 into 10 cube Newton by D is 400 and t is 8, so we can find out the value as 35.11 Newton per millimeter square right.

So, average shear stress is coming 35.11 Newton per millimeter square, which will be less than 0.4 fy right it should be less than 0.4 fy. Now, what is 0.4 fy value? 0.4 fy means 0.4 into 250 and this coming 100 Newton per millimeter square, so this is becoming less than 0.4 fy. The average shear stress developed as 35.11 Newton per millimeter square and the allowable shear stress is 100 Newton per millimeter square. So, it is quite safe, so the section is safe from shear force point of view next what we will do?

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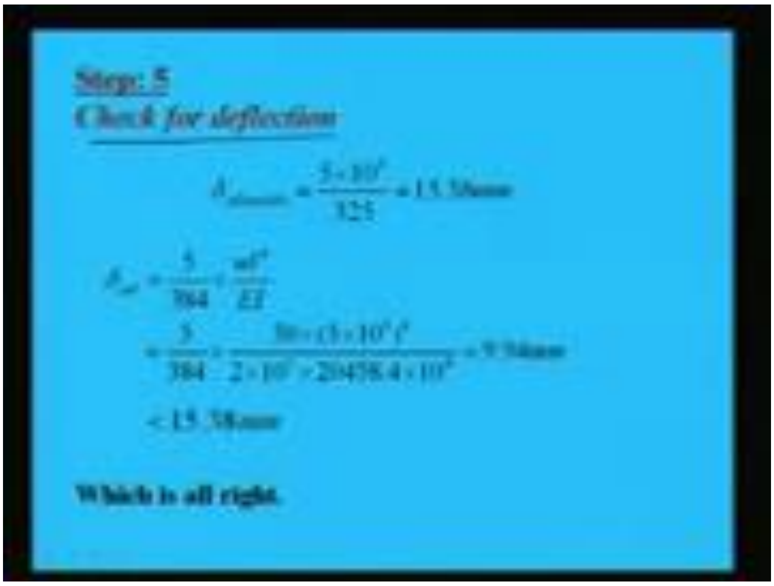


Next we will check for deflection, first we will find out the what is the allowable deflection as per the Codal provisions. Allowable deflections means, we know span by 325 now span is 5 meter, so 5 into 10 cube millimeter and 325 the coefficient. So, if we divide span by 325 we will get 15.38 millimeter this is the allowable deflection for this case.

Now, what is the deflection actually developing? That will be developing as 5 by 384 into wl to the power 4 by EI. Because, we know this beam is supported by means simply supported and carrying a UDL load right. So, for this case we know the coefficient is 5 by 384 right. So, if we put those values like 5 by 384 into w is 50 and this is l is 5 meter; that means, 5 into 10 cube millimeter and then E is 2 into 10 to the 5 Newton per millimeter square.

And this is millimeter cube that section modulus 20458.4 into 10 to the power 4 millimeter cube. And this is all are where I am changing to Newton and millimeter to keep in same unit. So, w UDL was 50 kilo Newton per meter so that has to change to Newton per millimeter, so 50 into 10 cube Newton by meter means 10 cube millimeter so Newton per millimeter.

So, that is finally coming right, so that is what we have put 50 Newton per millimeter. So, in this way we can find out the deflection which is coming due to the certain boundary conditions and the load, which is coming 9.94 millimeter. So, deflection with the load is coming 9.94 millimeter and allowable deflection is given 15.38 millimeter. So, calculated deflection or developed deflection is less than the allowable deflection. That means, from deflection point of view the chosen section is all right because; the allowable deflection is higher than the developed deflection, so we can go for next step.

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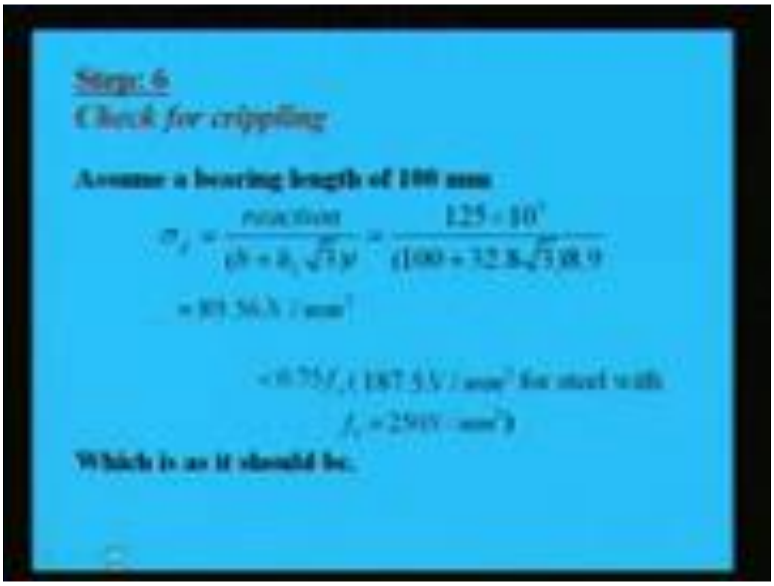


Next step is what, Next step is check for crippling whether the chosen sections are safe against crippling or not. What we will do in case of crippling? We know in this case as this is a simply supported beam with an UDL, so there is no as concentrated load. So crippling only will happen at the support because, there is no concentrated load existing on the beam due to external load; only as a reaction force the crippling will happen right.

So, for that we know the formula we have derived earlier that is reaction by b plus h2 root 3 into t. Reaction means, we know what is the reaction it is coming right which is 125 kilo Newton. So, 125 kilo Newton by b plus h2 into root 3 into t; b we are assuming the bearing length as say 100 mm minimum bearing length. So, let us assume the bearing length as 100 mm.

Then and from the IS handbook that is SP: 6 we can find out for ISMB 400 the h2 is 32.8 mm. And root 3 into t; t is the thickness of the web which is given 8.9. So, if we calculate this value we will get the sigma P value as 89.56 Newton per millimeter square right. Now, as per the closed Codal provision it has to be less than 0.75 fy and as fy is that means, 0.75 fy means 0.75 into fy is 250 right, so this is becoming 187.5.

So, this is the allowable stress in bearing and developed stress in bearing is 89, which is less than the allowable 1; that means this is also safe right. So, in this way we can check the assumed sections say step by step and then finalize the section for a particular beam.

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So, next we will go for web buckling so far we have discussed about the design aspects of a beam which is laterally supported. Now, before going to start design aspects of laterally unsupported beam let us, discuss little about web buckling why web buckling happens. Because, the type of section which we are going to use in case of steel structure means in case of beam is generally I section or channel section or t section like this.

Where the thickness of web is much much less than height of the web; depth of the web because, if we see the I section what you will see? This is a say suppose this is an I section now this is the depth of the web and this is the thickness. Now, when a concentrated load coming into picture or a heavy load coming into picture then what will happen? This portion may buckle which is called Web Buckling.

So, we have to take care this web buckling effect also when going for design of beam section using such rolled steel section, we have to check for weight buckling also right. So, the web in a rolled steel section behaves like column when placed under concentrated load. Because, it behaves like a column right the web is quite thin and is therefore, therefore, subjected to buckling.

The buckling of the column web is influenced by the restraints provided for the flanges right.

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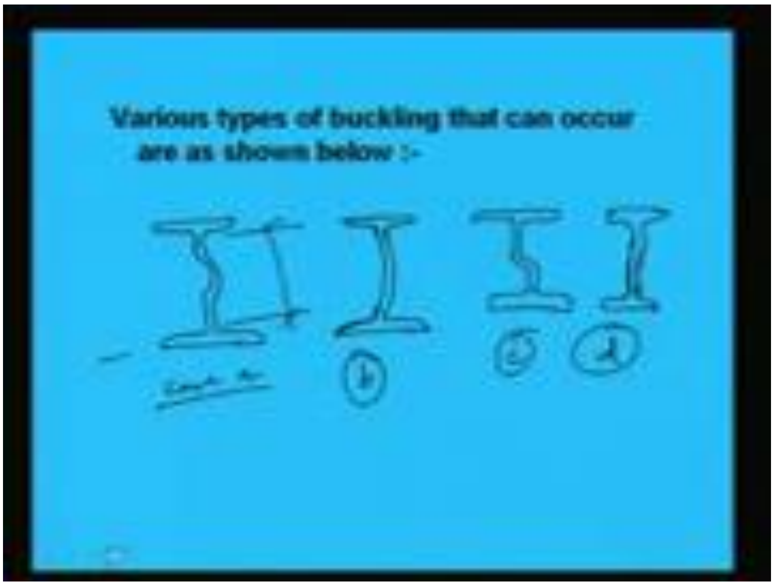


Now, what are the types of web buckling? Let us see. Say this 1 case where the web may buckle like this say this is case a right. Another case is say it may buckle something like this right this is b, then another is say first it will go then start buckling, another is first it will start buckling right, so this is c and this is d. So, what happens and how we will calculate the effective depth of the buckling effective depth we have to calculate what is the effective depth?

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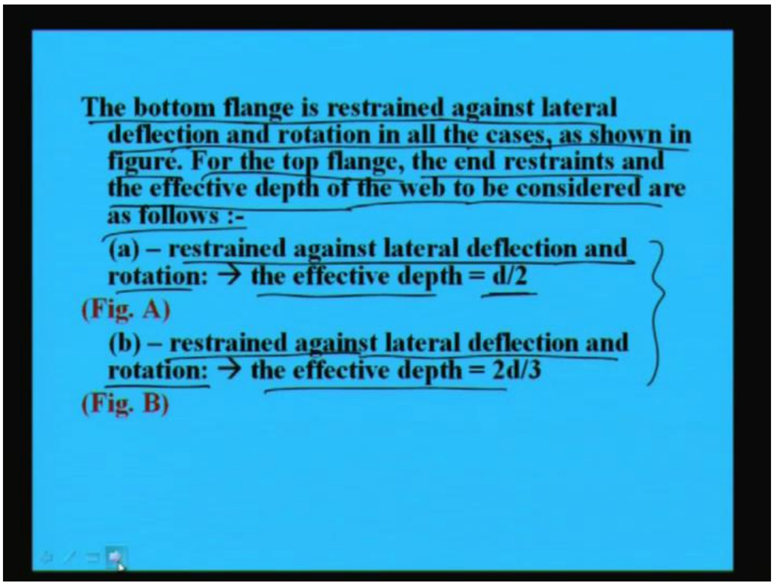


So, what are the cases happening? That first we will assume that, the bottom flange is restraint against lateral deflection and rotation in all the cases as shown in the figure. So, for the top flange, the end restraints and the effective depth of the web to be considered are as follows. So, for top flange for different cases the effective depth will be different. Like if it is restraint against lateral deflection and rotation; that means, if the top flange is restraint against lateral deflection and rotation.

Then, the effective depth can be written as d by 2 this is when this case is coming right. Next when restrained against lateral deflection and rotation. The top flange when it is restrained again lateral deflection and rotation the effective depth will become 2d by 3, right.

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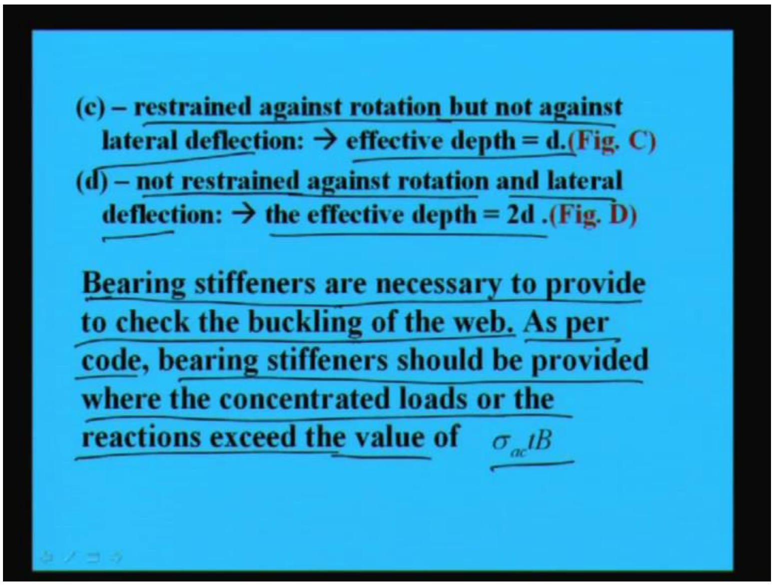


Again when restrained against rotation, but not against lateral deflection we can find out effective depth as d; and when not restrained against rotation and lateral deflection the effective depth the 2d. So, for various cases the effective depth has to be considered in fact, this depth how to calculate all these things are given in the Codal provisions right. Now, bearing stiffness are required for this, bearing stiffness are necessary to provide to check the buckling of the web.

Because, to the restrict the buckling of the web we need to provide some bearing stiffness. Now as per code, bearing stiffness should be provided where the concentrated loads or the reactions exceed the value of this sigma ac into t into B. Where sigma ac is the allowable compressive stress in that section, t is the thickness and B is the web right.

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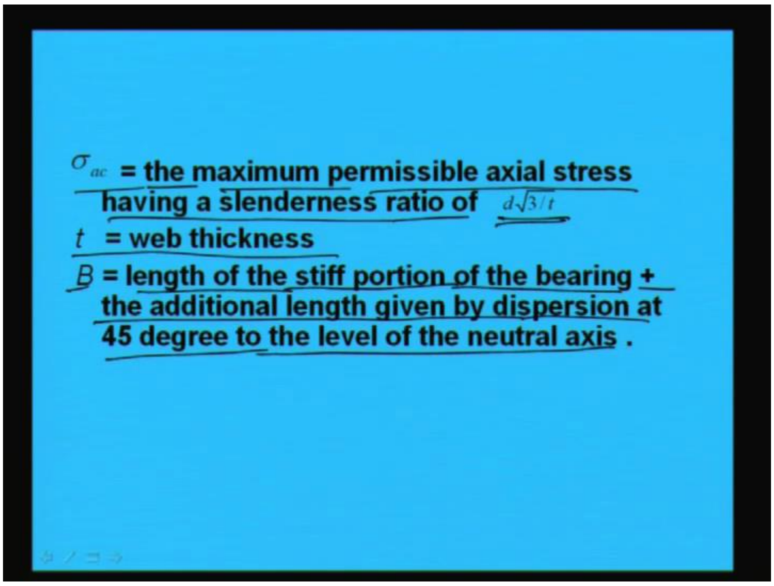


So, sigma ac this is the maximum permissible axial stress having a slenderness ratio of d ()) root 3 by t. How it is coming, I will derive later D root 3 by t where, t is the web thickness and B what is B; B is the length of the stiff portion of the bearing plus the additional length given by dispersion at 45 degree to the level of the neutral axis, these things when I will derived will be clear.

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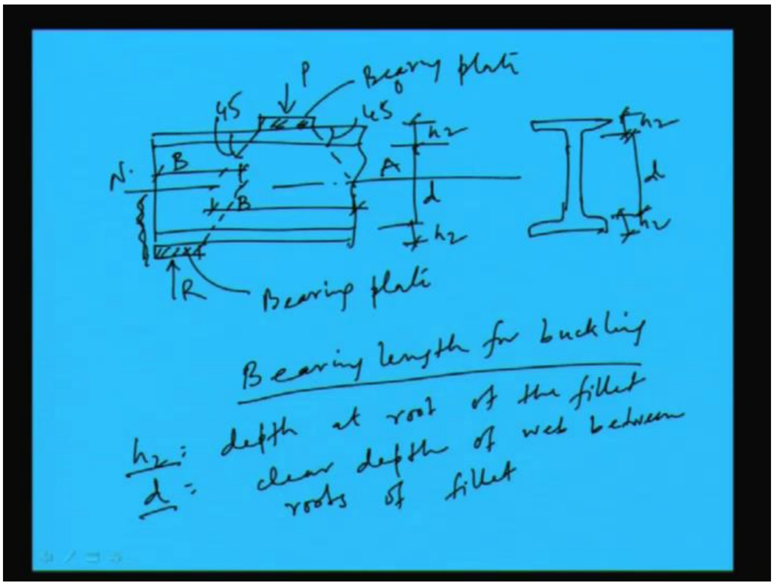


So, this is the plate now P is concentrated load is say acting here right with P. Now, as per the assumptions what we will do that will be dispersed at 45 degree angle right. So, the value of B will become this 1 B right, so this is B. Again if at the support what will B value of B at the support due to reaction, so we are assuming that this also it is acting up to this, so this will be the B.

So, the magnitude of the B will differ for concentrated load at the section and for reaction. Because, at the support there is no scope to disperse the load in this portion right this is the neutral axis. And this 45 degree angle it will disperse in 45 degree angle right. Now, this is called h2 this is d and this is again h2 right the section will be like this if I section we are providing.

So, we can the section will be like this which is this is h2 and this is d this is bearing plate, this is also bearing plate right. So, this is how it disperse the load, so we can calculate the bearing length for buckling can be calculated right. Here h2 is what h2 is depth at root of the fillet and d is the clear depth of web between of fillet right. So, we know h two we know d for a particular section. So, what we will do now we can find out the effective depth of the web and effective length, first we will find out effective length.

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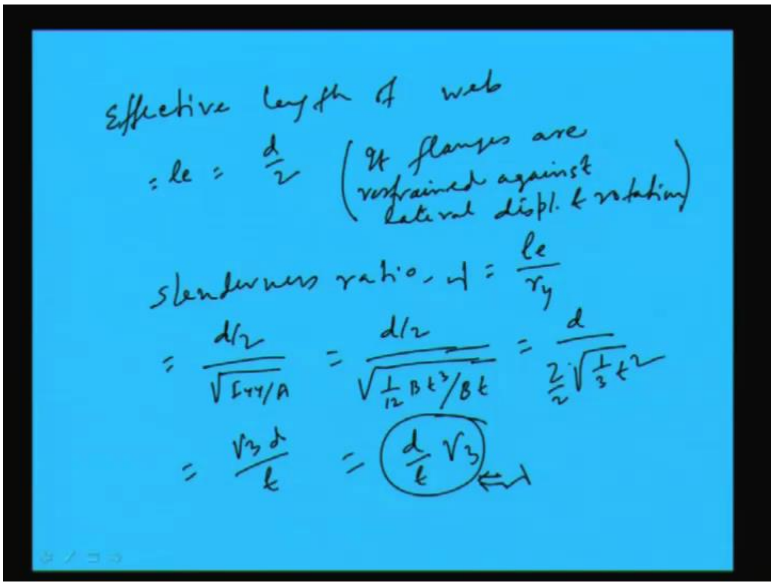


So, effective web this will become say if I say le this will become d by 2 in case when if flanges are against lateral displacement and rotation right. So, slenderness ratio lambda will become l by r le by ry So, this will become le means, d by 2 and ry is Iyy by A we can write, so d by 2 by Iyy will become in this case 1 by 12 B t cube right and A will be B into t for this web.

So, if we calculate this value what will happen this will become finally, that D by 2 into 2 by 2 it will come 1 by 3 right and t square, so this will become so 1 by root 3 means root 3 d by t. So, this is becoming basically d by t into root 3. So, slenderness ratio is lambda will become d by t root 3. So, why we are going to calculate the sigma is c value for d root 3 by t I think now it is clear.

The sigma ac, which is the maximum permissible value because, we have to see what is the slenderness ratio of that section because, the section is acting as a compression member. So, as a column member we can say, so as a column member when we are going to consider or compression member when we are going to consider. We have to find out the allowable compressive load on the basis of type of steel and slenderness ratio.

So, slenderness ratio we have to find out across the depth right and then we can find out the allowable compressive load. The moment we can find out the allowable compressive load then, we can find out the allowable load which can be taken care by the section itself.

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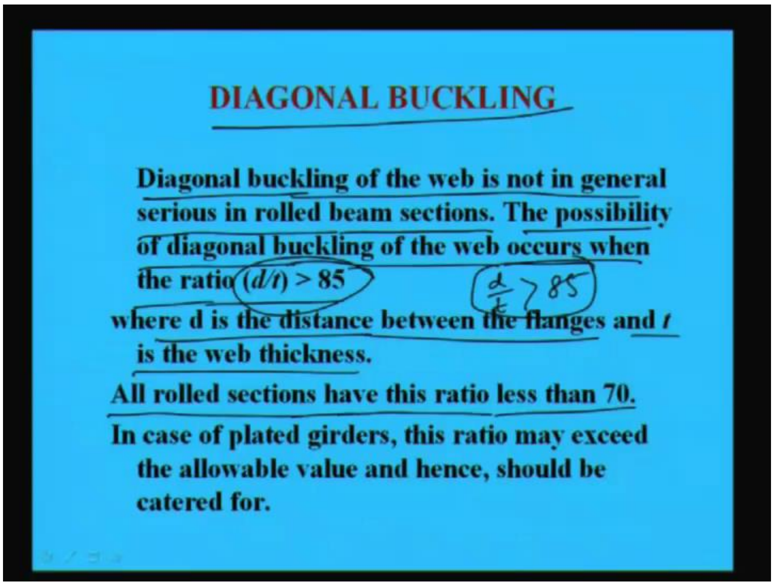


Now, another type of buckling we will discuss which is called Diagonal Buckling right. Diagonal buckling of the web is not in general serious in rolled beam sections right. In case of rolled beam section generally we do not design against diagonal buckling because, it will automatically satisfy why I am telling. The possibility of diagonal buckling of the web occurs when the ratio d by t becomes greater than 85.

So that means, the ratio d by t greater than 85 right, where d is the distance between the flanges and t is the web thickness. So, if it is becoming more than 85 d by t ratio then only this diagonal buckling may occur right. So, all but in practice what do we see that all real sections have this ratio less than 70.

For all rolled steel section the ratio of d by t generally become less than 70 that is why we do not need to check against diagonal buckling. But when we will be going for design of a beam using built-up section in that case chances of occurrence will be there, so in that case we must check for diagonal buckling.

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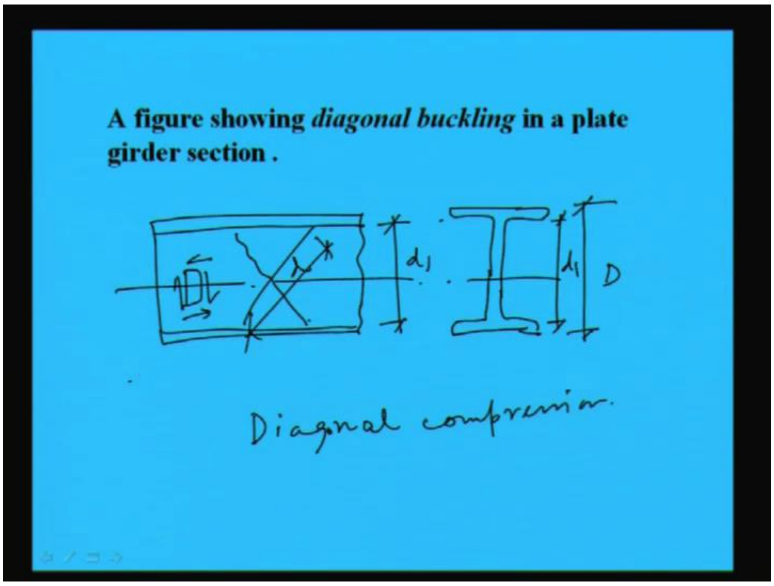


Now, let us see how diagonal buckling happens, say a plate is here right say I section plate now, if this is neutral axis depth and if this is the section right. Now, this is D and what is d1? This distance is called d1 that means, this 1 this is called d1. And this will act as a diagonal compression right. Now, it will be something like this right now the things may develop in this way diagonally right and this will be d. So, diagonal buckling can happen in this way and it will be in 45 degree angle.

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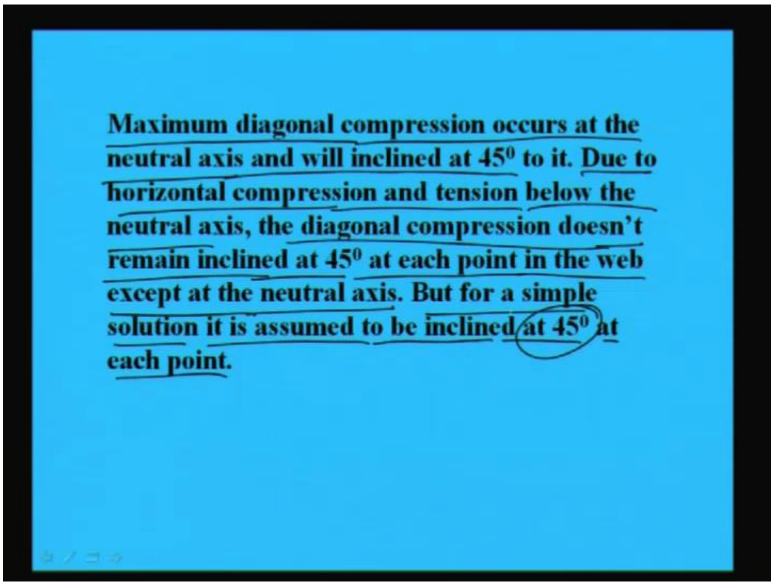


The maximum diagonal compression occurs at the neutral axis and will inclined at 45 degree to it. Due to horizontal compression and tension below the neutral axis, the diagonal compression does not remain inclined at 45 degree at each point in the web except at the neutral axis. But for a simple solution it is assumed to be inclined at 45 degree at each point. So, while calculating this we will assume that the inclination is 45 degree at each point this the thing which we will consider right.

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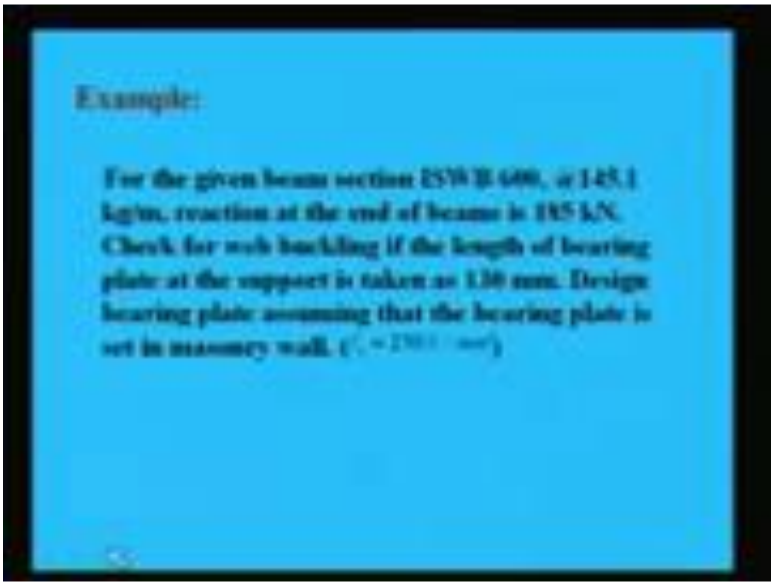

Now, we will go through 1 example to see how we can check the buckling effect right. The example is say, we are using ISWB 600, and this section we are going to use ISWB 600, at 145.1 kg per meter and reaction is 185 kilo Newton reaction at the end of beam is 185 kilo Newton right and section is ISWB 600. Now, check for web buckling if the length of bearing plate at the support is taken as 130 mm right so bearing length has been taken as 130 mm. Now, design bearing plate assuming that the bearing plate is set in a masonry wall it has been set in masonry wall and use fy as 250. So, these are the data which has been given.

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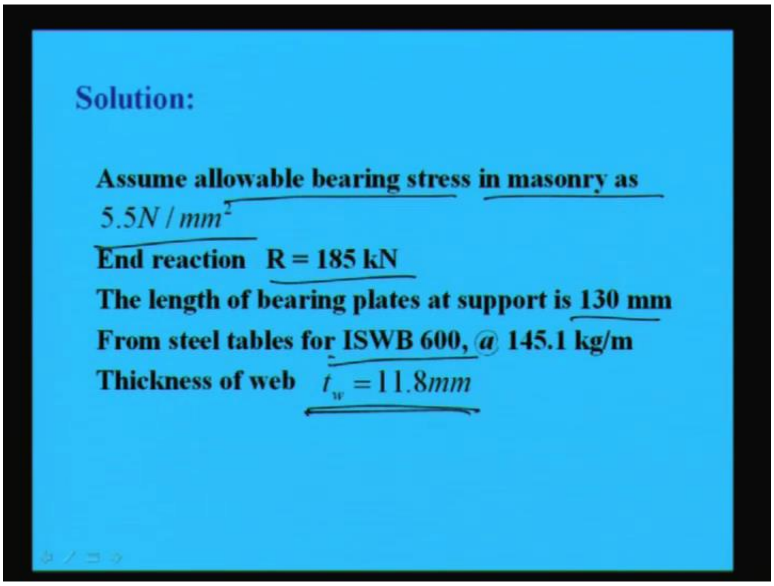


So, what we will do in case of masonry the bearing stress allowable bearing stress can be considered as 5.5 Newton per millimeter square. And as we know the end reaction is 185 kilo Newton and bearing 130 millimeter and for steel table means for ISWB 600 from steel table we can find out the thickness of the web as 11.8 millimeter. These are the things which are given for the section.

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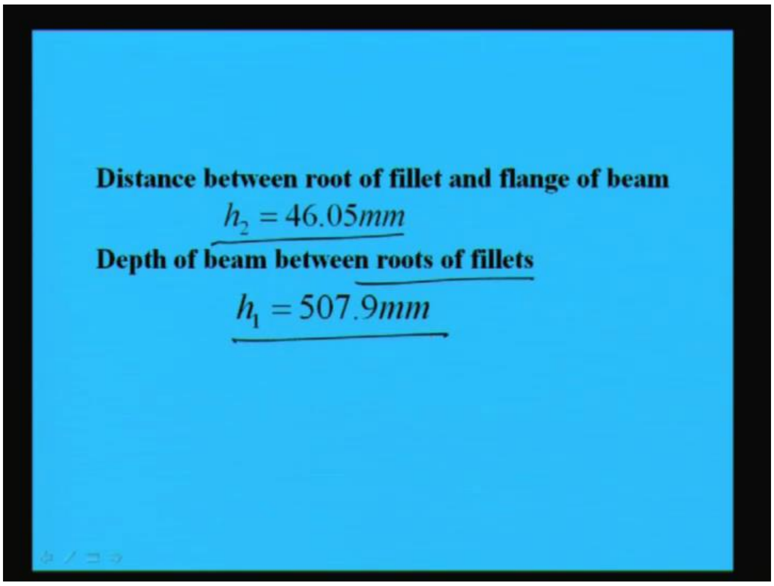


Now, this also is given at the code that is distance between root of fillet and flange that is h2 46.05. And depth of beam between roots of fillet h1 is given as 507.9 millimeter right.

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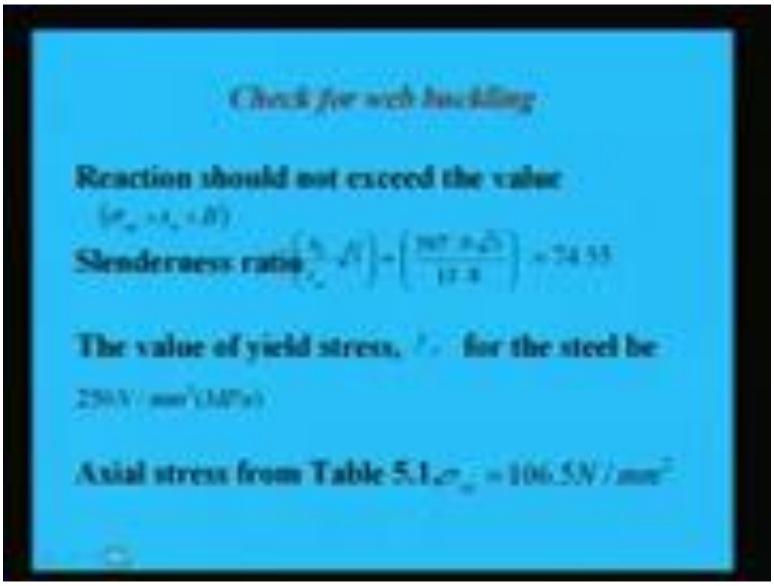


Now, we will go for check of web buckling right. So, we know first reaction should not exceed this value sigma ac into tw into B right. And, so we have to calculate what is the limiting reaction right, sigma ac into tw into B, now to find out tw is given B is given we can find out. Now, to find out sigma ac we have to know the slenderness ratio; Slenderness ratio is h1 by tw into root 3 which we have calculated earlier.

We have derived and we have seen right. If we put this value we will get the slenderness ratio as 74.55 right because, h1 is 507.9 and tw is 11.8. Now, the fy value we know 250, so from table 5.1 of IS: 81984 corresponding to fy and slenderness ratio we can find out the value sigma ac, which is coming 106.5 Newton per millimeter square right. We can find out from table 5.1 the value of sigma ac.

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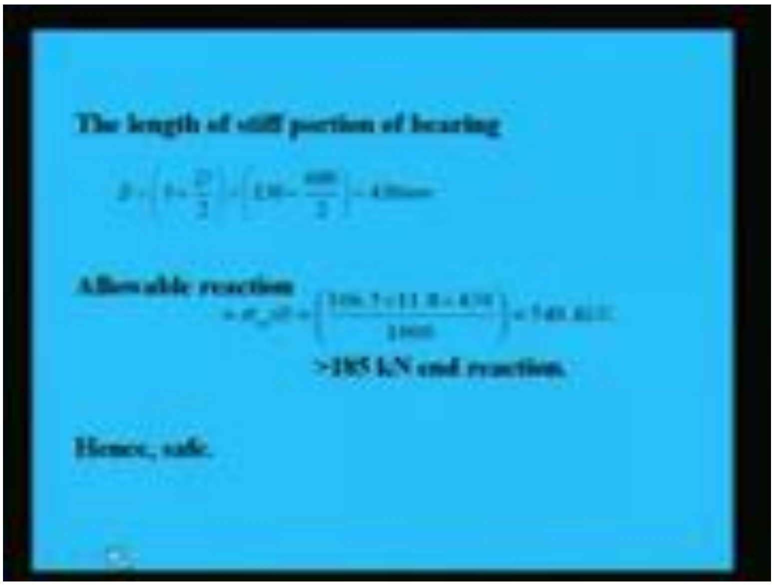


Then, what we will do we can find out the length of stiff portion of bearing. So, that will become B plus D by 2 because this is 45 degree angle dispersion this is b right. If this is the bearing plate then with 45 degree angle dispersion it will be, so b plus D by 2. And at the support only so , in this position it will not be here only it will be right.

So, this b and as this is D by 2 because of 45 degree angle, so b plus D by 2 and B is given 130 and D is given 600, so b we can find out 430 mm. Now, allowable reaction can be find out allowable reaction sigma ac into t into B. So, if we put the value sigma ac as 106.5 t as 11.8 and B as calculated 430 and dividing by 1000 to make it kilo Newton. It is coming 540.4 kilo Newton. And our end reaction is 185 kilo Newton which was given right. So, allowable reaction is 540.4 kilo Newton and end reaction is 185 kilo Newton. So, the means design is safe whatever section we have given that is safe against the buckling.

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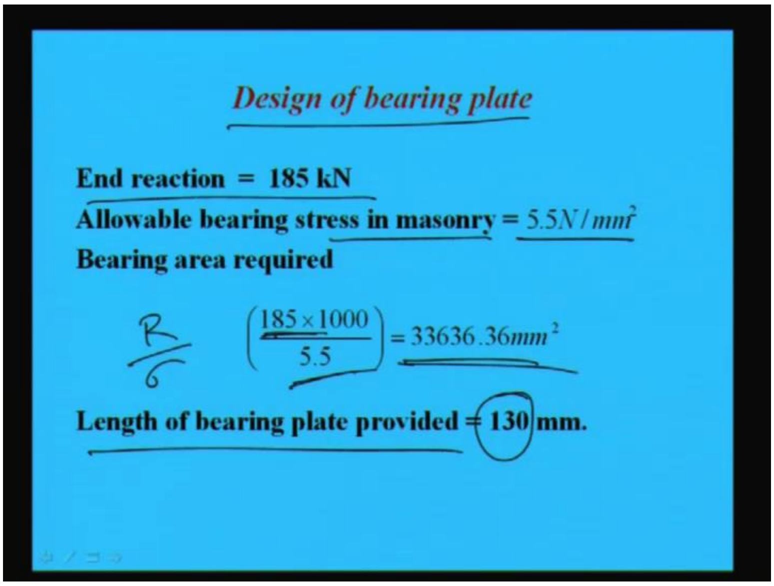


Now, what else we will do we will design the bearing plate. For designing bearing plate we know, the end reaction is given 185 and the bearing stress in masonry has been assumed as 5.5. So, bearing area will be required as R by sigma, so R is reaction force 185 kilo Newton and the stress 5.5 bearing stress allowable bearing, so this is the area is required. Now, length of bearing provided is 130 mm.

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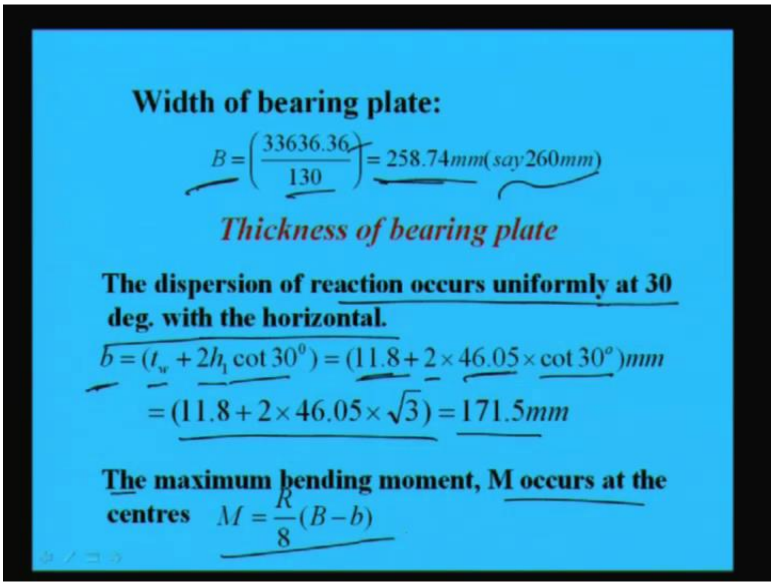


So, now we can find out width, so width will be the total area by 130, so this is coming 258 say we can use 260 right. Now, the dispersion of reaction occurs uniformly at 30 degree with the horizontal. So, we can find out this b value which will be tw plus 2 h1 cot 30; the value of tw is 11.8 plus 2 into h1 is 46.05 cot 30. So, if we put those values we can find out the value b as 171.5 millimeter. And the maximum bending moment occurs which will be at the center which will become M is equal to R by 8 into B minus b.

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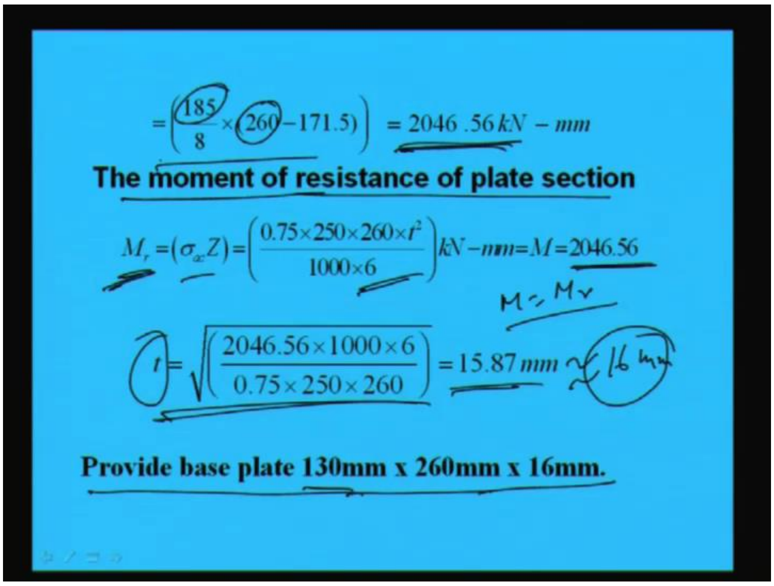


So, if you put those values R is 185 B is 260 which has been calculated. So, if we put those value R by b into 8 into B minus b we will get 2046.56 kilo Newton millimeter. And the moment of resistance of the plate is can be calculated that is sigma ac into z So, that value if we put we will get this means, and then we can equal with this.

So, Mr will be equal to M, so from this I can find out the thickness of the plate. So, thickness of the plate is coming 15.87; that means, we can use 16 mm right. So, how we are going to find out thickness that making M is equal Mr from this 2 equation we can find out the value of t. So, t we are finding as 16, so all the values we found. So, we can say that provide the base plate as 130 mm by 260 mm by 60 mm these are the value which we get. So, in this way we can find out a suitable plate dimension right. So, with this today's lecture I like to conclude and tomorrow we will discuss about the design aspects of unsupported beam.

Thank you very much.