Design of Steel Structures
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Module – 7
Gantry Girders and Plate Girders
Lecture - 3
Introduction to Plate girders - Part 1

Hello, today I am going to discuss about plate girders. In last 2 lectures we have very briefly discussed about gantry girders. Now, as you see that gantry girders is used in industrial building to move or to lift some heavy load from 1 place to another places for industrial purpose. Here we will see the plate girder is basically used in bridge like structures. Why plate girder is required? Because, the span of the bridge is generally become very high from the practical point of view and to carry the heavy load we need to have a bigger size.

Now, as you know the rolled steel I section is the most efficient to carry the bending moment to exchange the bending moment. For flexural action we have seen the I section will be the most efficient 1. But in the available market the rolled steel I section is available up to 600 depths. And as you know the major part of the bending moment flexural action is taking care by the flange and the shear force is taken care by the web of the section. So, we have to design the beam member in such a way that such type of means the bending moment and shear force are taken care by the section appropriately.

Now, if the load is becoming very high then we have to go for higher section. Higher sections mean maximum section available each 600 depth ISWB 600 right. Now, if … In fact, ISWB 600 has its own maximum bending moment carrying capacity and shear capacity. Now, in that case if we see that more load is required means more load is given in the beam then we need to increase the dimension of the section. So, how to increase?

We have seen we can use some plate additional plate in terms of flange, but in that case depth is not going increase as such. So, as depth is not going to increase as such. So, what is happening? That moment of inertia of the combined section will not be going to increase drastically. As well as for this the displacement criteria means displacement for long span will be high unless the moment of inertia becomes very high. So, to counter this type of problem we use generally plate girder.

Plate girder from name itself it it is understood that girder means beam and it is made from the plate. Means, the web of the section plate girder the web generally is used from the solid plate. And the flanges are made with either solid plate or some other rolled sections. Different types of sections are there we will see 1 by 1.

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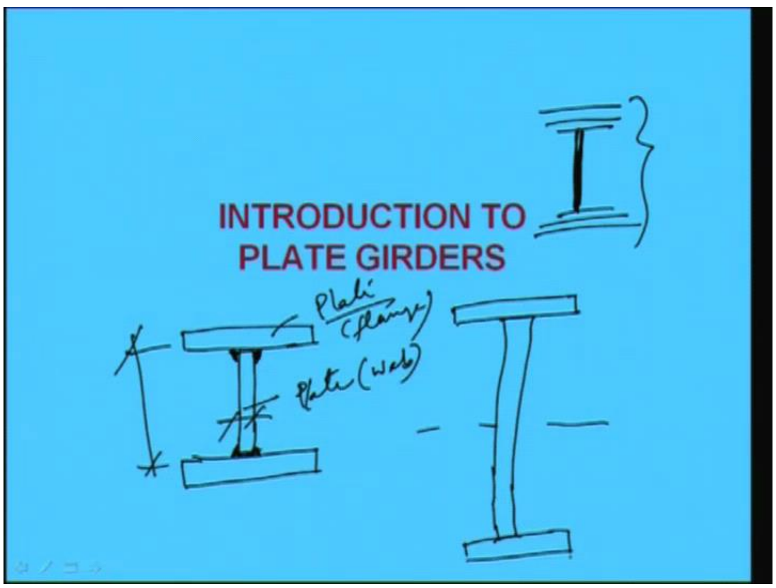

Say let us see 1 plate girder section. Say this is a solid plate which has been welded with another plate section the welding has been done here. Now, suppose we need say depth as say 1000 millimeter depth of web is required web depth is required 1000 millimeter to carry heavy load for a long span. Then what we can do? We can simply use higher section right. Say the plate as much as possible we can make and then we can make the flange.

So, in this case we will see the moment of inertia is becoming high and in this case the deflection will be coming very less those span is very high. Generally plate girder is used when the span length is more than 18 or 20 meter more than 18 or 20 approximately 18 or

20 meter right. So, this is called welded plate girder means it has been the joint has been made by the weld connections right. So, these are plate means these are plate this is also plate means both are plate this in web and this is in flange it has been used.

Now, as per the requirement the thickness web thickness of the plate can be decided the distance can be decided distance means depth of the plate can be decided. So, accordingly we can make. But in case of rolled section if we use say suppose this is 600 now we cannot increase. So, only what we can do we can provide some plate like this right. So, the depth overall depth is not going to increase as such, but if we can increase this portion by using some solid section plate then our purpose will be solved.

In fact, plate girder had many components which we need to know 1 by 1 for designing a complete plate girder. And to understand plate girder completely it will take many lectures many lectures should be require to understand properly for all the things. But, here we will restrict means where we will just give an small introduction to the plate girders what are the components are there. How the components dimensions are decided, how the joints has been made, how the economic sections are arrived? All these things we will discuss so that, the students can make at their own for further study.

Then as this course is a core course and is a preliminary course that is design of steel structure preliminary course 1. So, we are not go means we may we may not be means we cannot go further details because we have to cover many chapters from many aspects. Only the elementary design we have focused in throughout our lecture. So, here as a continuation of the beam chapter we are just introducing this plate girder very briefly.

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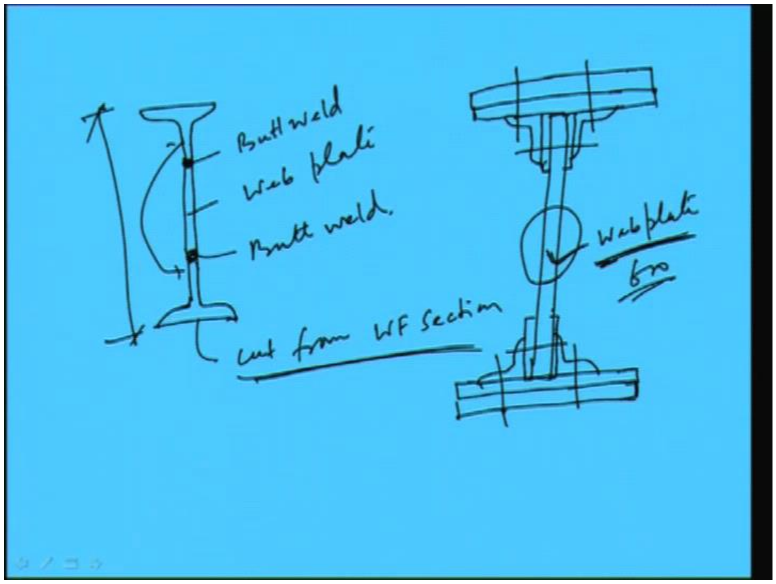

Now, let us see some other sort of plate girder. Say sometimes we use say 2 T section is may be T section here and another T section. Say this is your shear say this is say this is the T section welded here welded here and this is the web plate. Either directly 2 2 T sections can be joined or it can be joined through web plate. It depends on the how much depth we are requiring how much depth we are looking for.

Now, this is T section or cut from say wide flange section that is also possible from some wide flange section say I section or from some T section we can cut. Otherwise you can use some plate also. So, this is another type of plate girder we can use. Another commonly use plate girder I am going to show most commonly I should say that simply a plate is made. Then say we are providing here some packing material to or some plate to connect angle section then we are providing say plate here right.

So, similarly here also here we are providing angle section and then the another plate right. Now, if we need more means the if the moment is more than maybe, we may have to increase the thickness of the plate or … And thickness of the plate if it is restricted means if not available in the market the up to requirement then 2 plate can be provided. So, in this way 1 plate girder can be made. So, you see this web depth this can be increased like as our requirement. This is called web plate right.

So, this is not restricted where in built up section means in rolled steel section this is up to 600 it was this depth was up to 600. Now, we can go up to anything as per the requirement. Of course if we go up to anything other problems will come like buckling another thing will come. So, that we have to see from other points of view we have to see right. So, here we have to either may be bolted or riveted connections has to be done or welded connection whatever we want has to be done. So, plate girders are basically as we told there are 2 type of plate girders 1 is riveted plate girder another is welded plate girder. That is why design when we are going for design little difference we will get.

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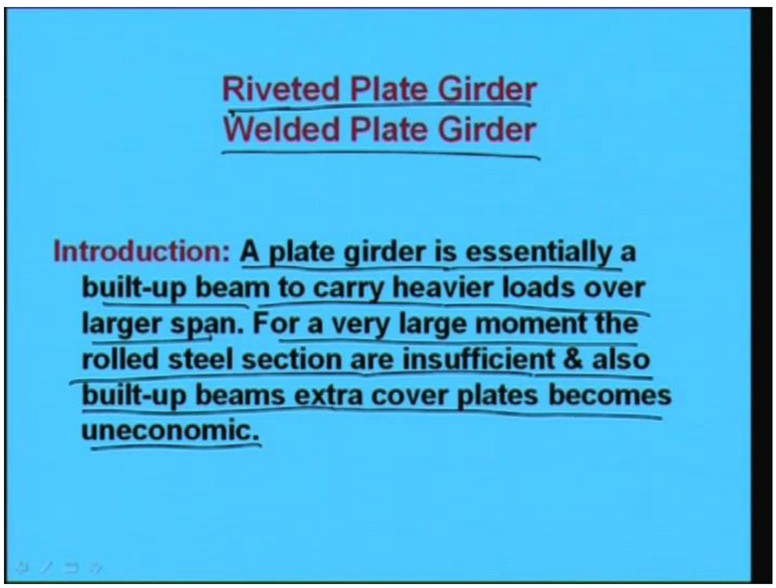

Now, as I told that 2 type of plate girders are there 1 is riveted plate girder another is welded plate girder. Say as I was telling that a plate girder is essentially a built up beam to carry heavier loads over larger span. For a very large moment the rolled steel section are insufficient. And also built up beams extra cover plates becomes uneconomic means built up beams with extra cover plates becomes uneconomic. Means, as depth is restricted we cannot go beyond section rate that is why it will be uneconomic.

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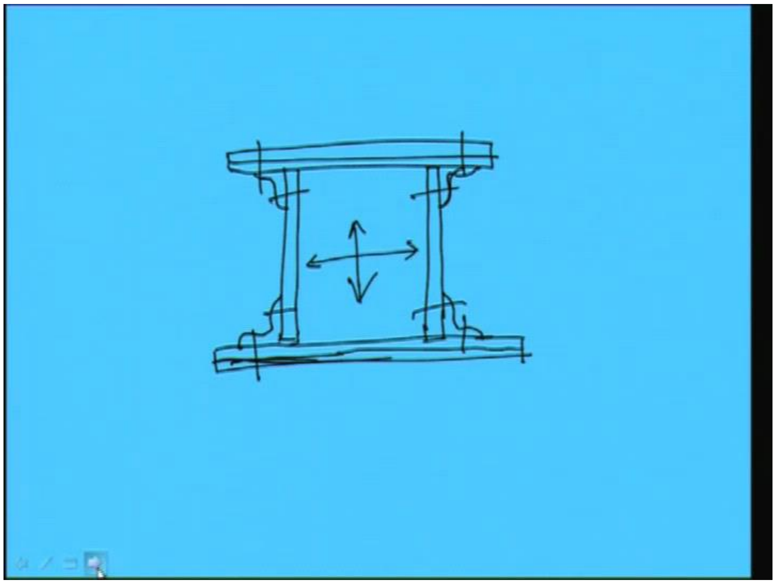

So, for that we are going to use such type of plate girders. Another plate girder which we use is say like this. So, this is a plate this is another plate means it depends how the moments are developing what are the loads are coming depends on all these aspects right. So, there is 2 plate we may provide because plate thickness are again you will not get like anything plate thickness has to be available. Then we can provide some angle for connections right. So, here we can make some bolted connections.

So, in this way also; that means, here what we are seeing that we can increase the depth as per the requirement we do not have any restriction and we can increase the width also as per the requirement. So, in this way we can make the plate girder to carry heavy load in case of dish structure because of practical problem we have to go for higher span length means more than twenty meter or so. So, for those types of problems we always face the means we always such type of plate girders means plate girder we are using right.

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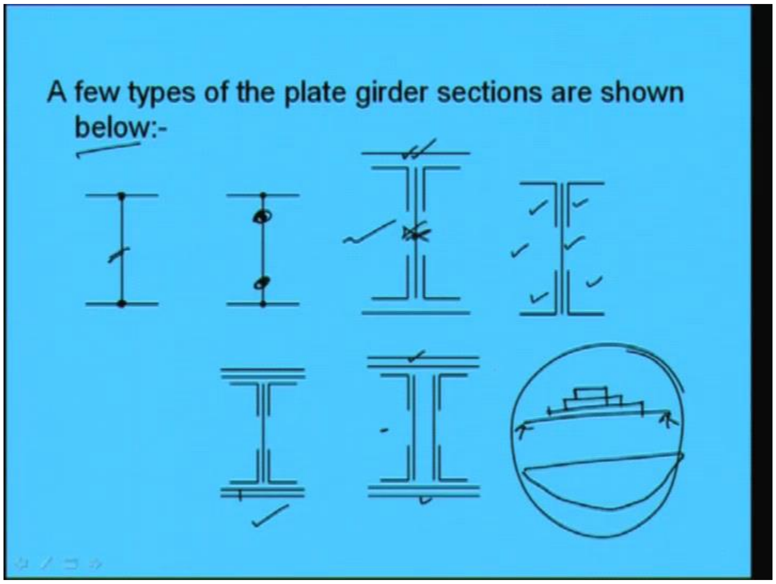

So, some other type of plate girders sections I have drawn here. Say 1 is I as I was telling that you can weld here just simply with the use of solid plate or like this also you can rivet it here means sorry you can weld it here with the use of Bart weld. This is another type of connections I have shown. This is another type of connection means without providing any plate just 4 angle along with 1 solid plate.

So, plate girders are not only consisting of solid plate, but also with the available rolled section. It is a combination of solid plate and available rolled sections also may happen. This is another type of plate girder what we use means 2 plates have been provided. This is another type right. So, these are the some type of plate girders I am showing.

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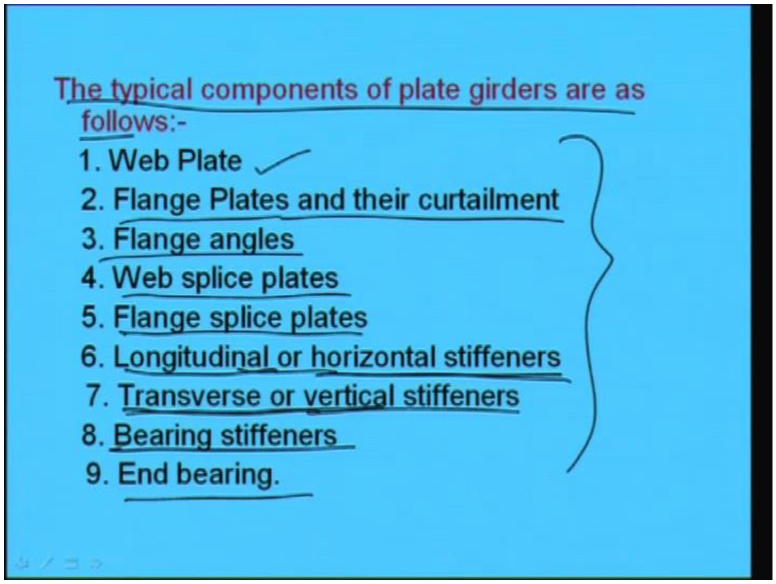

Now, let us see what are the components As I told that when we are going to design a plate girder we need to know before that the what are the components are in the plate girder and accordingly what are the codal provisions given and how to design those components 1 by 1. So, what the components we have that is. 1 is web plate right web plate means this 1 this is called web plate this 1 right. Then flange plates and their curtailments flange plates and their curtailments these are the flange pate right.

Now, curtailment will happen means as you know say suppose there is a long span with the bending moment. If bending moment is like this then the plate has to curtail means, maybe up to this distance we will provide some plate up to this distance. We will provide some extra plate up to this distance will some provide extra plate. Like this we will make the section economic at various places of the span right because of the nature of the bending moment. So, that has to be also decided.

Then flange angles flange angles as you have seen here angle we are providing. So, how to join it how to decide flange angles all these things. Web splice plates web splice plate. Then flange splice plate. Then longitudinal or horizontal stiffener, because of the large dimension we may have to provide stiffener. So, there is 2 type of stiffener; one is longitudinal another is horizontal stiffener. So, those things also have to be seen. Another is transverse or vertical stiffener.

One is longitudinal or horizontal stiffener another is transverse or vertical stiffener, then bearing stiffeners. And then end bearing or connections right. So, these are the things which we have to keep in our mind for designing a plate girder these are the typical components of the plate girder right.

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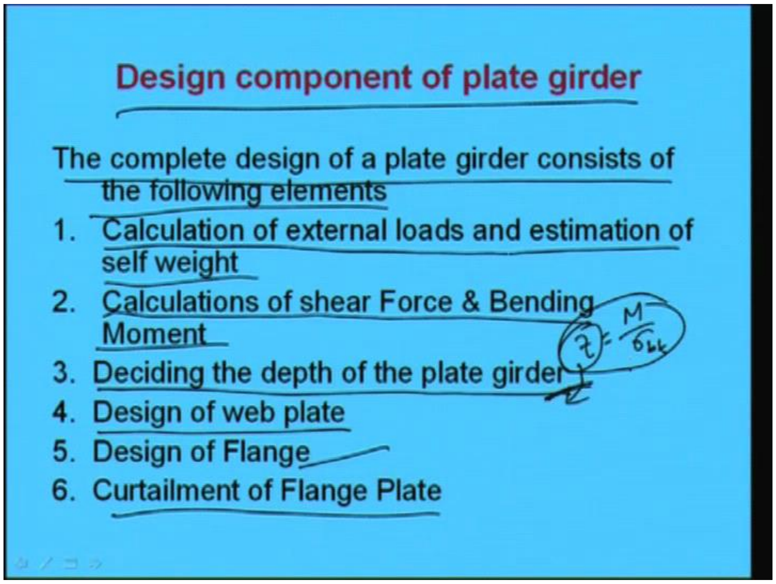

So, what are the things we have to design, what are the design components of the plate girder? 1 is the let us see what are the procedure means the complete design of a plate girder consist of the following elements. First is calculation of external loads and estimation of self weight. Calculation of external load that is easily we can calculate what are the external load is coming may be due to the moment due to other imposed load due to wind load due to earthquake load.

So, what are the loads are coming accordingly we can find out what are the external load is coming. Another thing is estimation of self weight self weight to start with its difficult we do not know what is the dimension of the plate girder. So, it is difficult to find out the self weight. So, we may have to assume some self weight from the experience of the designer they can find out some appropriate self weight. And then considering that self weight there be means design we will start and then with the actual 1 it has to be checked.

Then with those assumptions we will calculate shear force and bending moment shear force and bending moment on the plate girder; the deciding the depth of the plate girder. So, from that what we will do? Now, the moment when it is developed the bending moment when it is developed what we can do that the section modulus can be find out. Z is equal to sigma bc or sigma bt right. So, from there we can find out the depth of the plate girder right. Then design of web plate design of web plate and then design of flange and then curtailment of flange plate.

Even this depth also we may not find out from here means from displacement point of view what is the maximum displacement from that also we can find out. Some assumptions can also be considered right.

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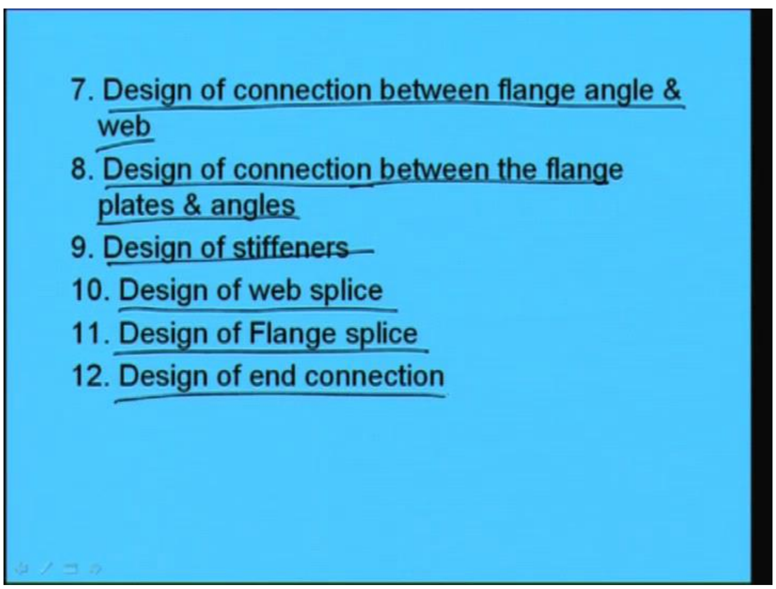

Next design of connection between: flange angle and web design of connection between flange angle and web; then design of connection between flange plates and angles as shown between flange plates and angles. Then design of stiffeners then we will go design of web splice then flange splice then design of end connection. So, there are 12 components which we have to design means 12 steps are there majorly 12 steps and in between means in 1 step also you will get many sub steps right. So, these are the means at a glance, we can say that these are the steps which we have to perform for the design of a complete plate girder right.

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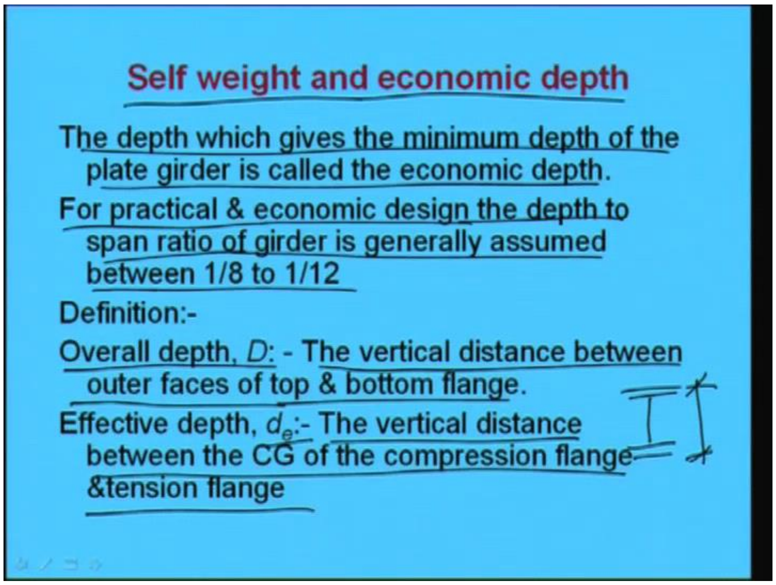

Now, how to calculate self weight and how to calculate economic depth let us see. We will means under some assumptions we will try to find out some economic depth. First is the depth which gives the minimum depth of the plate girder is called the economic depth. What is economic depth that which gives the minimum depth of the plate girder is called means with that the external load can be carried out by the plate girder with that depth right? For practical and economic design the depth to span ratio of girder is generally assumed between 1 8 to 1 twelfth.

So, what I was telling her that may be from here you can find out, but from practical point of view it is better to find out from this that 1 8 by 1 twelfth right. So, from this we can find out the girder depth in between some value 1 8 to 1 12. Now, before going to start let us know some term which we will use in later for deriving some expressions. One is overall depth which I am going to denote as capital D. Overall depth is the vertical distance between outer faces of top and bottom flange outer faces of top and bottom flange.

Say suppose this are there. So, from here to here extreme side's right. The vertical distance between outer faces of top and bottom planes and effective depth de is the vertical distance between the CG of the compression flange and CG of the tension flange. So, effective depth de can be found in this way that vertical distance between CG of the compression flange and CG of the tension plane that will be the effective depth de.

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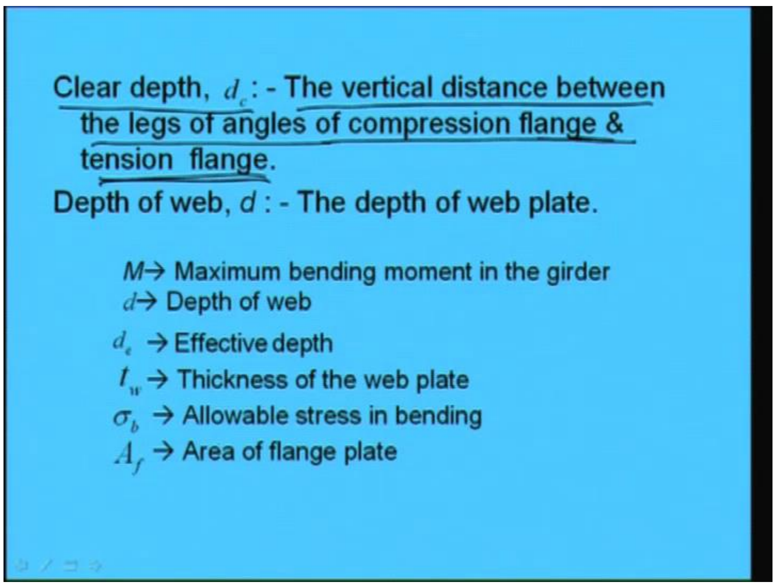

Then clear depth which is dc denoted as dc. The vertical distance between the legs of angles of compression flange and tension flange which is called dc. The vertical distance between the legs of angles of compression flange and tension flange I am showing I will show the figure then it will be clear.

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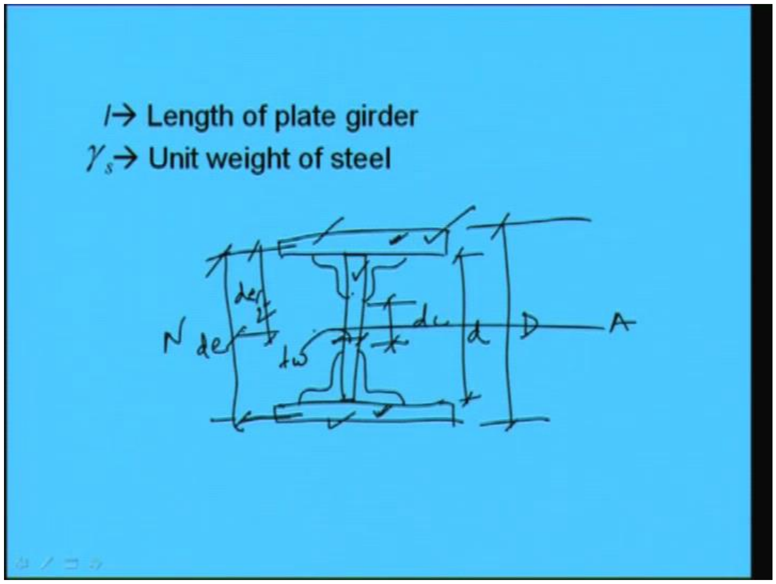

So, let me draw the figure first. That is say … So, these are the 2 means a simplest plate girder with having some angle to join each other right. So, D will be the overall depth as I was telling this is D right. And de will be the this 1 and this 1. CG of the compression flange and CG of the tension flange that 1 de. And dc will be this 1 clear distance right this is called dc right. And depth of web is simply the depth of web plate that will be d; that means, which 1 this will be from here to here this is called d right. So, this is called d.

So, and other terms like M will be denoting maximum bending moment in the girder and di as I told depth of web de is the effective depth tw is the thickness of the web plate. And sigma b is the allowable stress in bending and Af is denoted as area of flange plate. This will be required for a calculation that is why I am mentioning here right. Now, we will find out the moment of inertia of the whole section.

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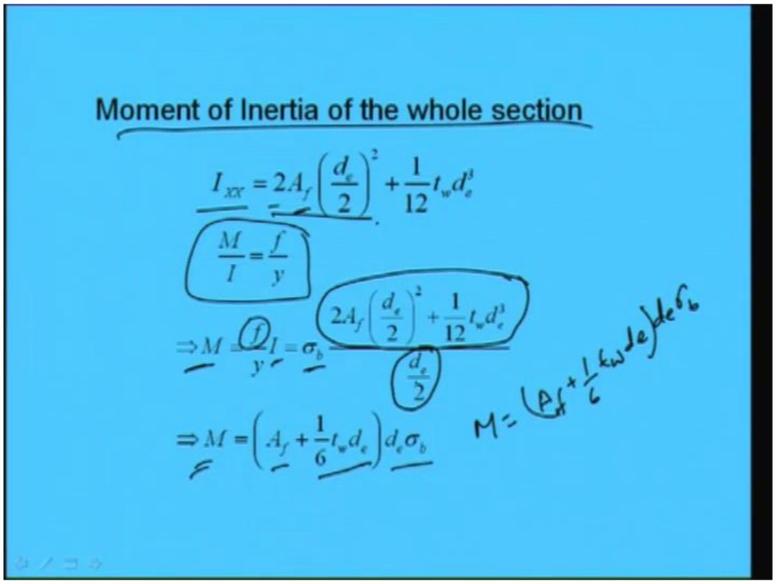

So, moment of inertia of the whole section how do we find out that will become. Ixx is equal to 2 into Af area of flange into de by 2 whole square right means Ar square square plus 1 by 12 into tw into de cube right. So, what we are going to get if we see here that moment of inertia Ixx will be where. So, if it is symmetric then like this neutral axis is here. So, Ixx will be first this area of flange area of flange. So, Af into r square r square means this is de by 2 right, this is this will be de by 2 this distance would be de by 2.

So, Af into de by 2 and in 2 and in top and bottom it is there. So, 2 into Af into de by 2 that is what it has written 2 into Af into de by 2 whole square Ar square. Then 1 by 12 tw into de cube right. Now, de is which 1 as you know de is this 1 right. So, 1 by twelve of tw tw is this 1 thickness of web. So, tw into d cube means moment of inertia due to flange and moment of inertia due to web. And this is approximately because the moment of inertia about its own axis we have not taken moment of inertia about its own axis own axis of the flange right.

Now, as we know the equation for developing stress due to bending can be written as M by I is equal to f by y. So, from this I can write M equal to f by y into I. And f is nothing, but the sigma b sigma b as I told that allowable stress in bending right. So, sigma b into I, I has been calculated here which has been written here. Af 2 Af into de by 2 whole square plus 1 by 12 tw into de cube by y y means de by 2. So, from this I can find out M is equal to if I take common de by 2 if I divide we will get finally, Af plus 1 by 6 into tw into de into de into sigma b. So, moment we are going to get this 1 Af plus 1 by 6 tw de into de sigma b right. So, in this way we can find out the moment. So, next what we will do?

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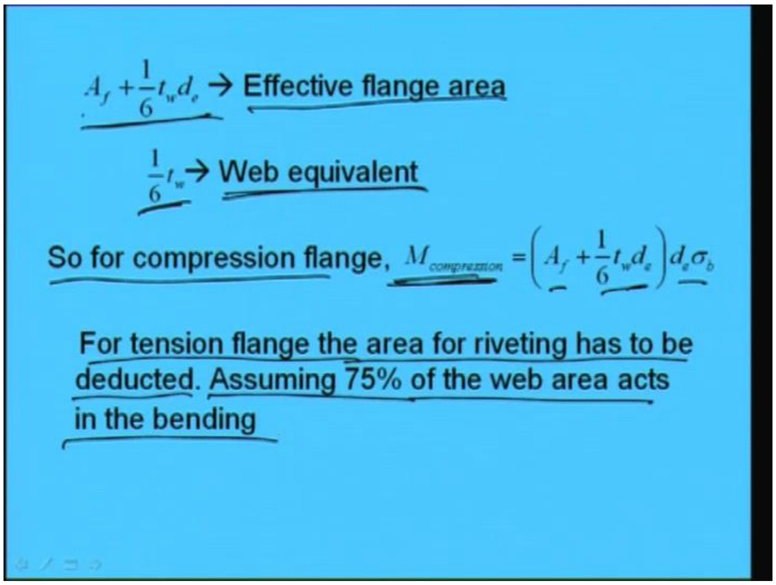

So, from this let us see that M is equal to something means this into this means sigma into z right. So, this can be written effective flange area and this can be written as web equivalent equivalent web, right. Af into 1 by 6 tw into de right Af plus 1 by 6 tw into de that is called effective flange area. And 1 by 6 tw can be called as web equivalent. So, for compression flange M will become Af into 1 by 6 tw de into de into sigma b. So, this is for compression flange.

Then for tension flange the area for riveting has to be deducted right because in tension flange area will be less because of the presence of rivet and because of presence of rivet there will hole. So, we have to deduct. So, net effective area will be less than the gross area. So, we are assuming 75 percent of the web area acts in bending. So, this is another assumption that 75 percent of the areas are going to act for bending, because of the presence of the hole.

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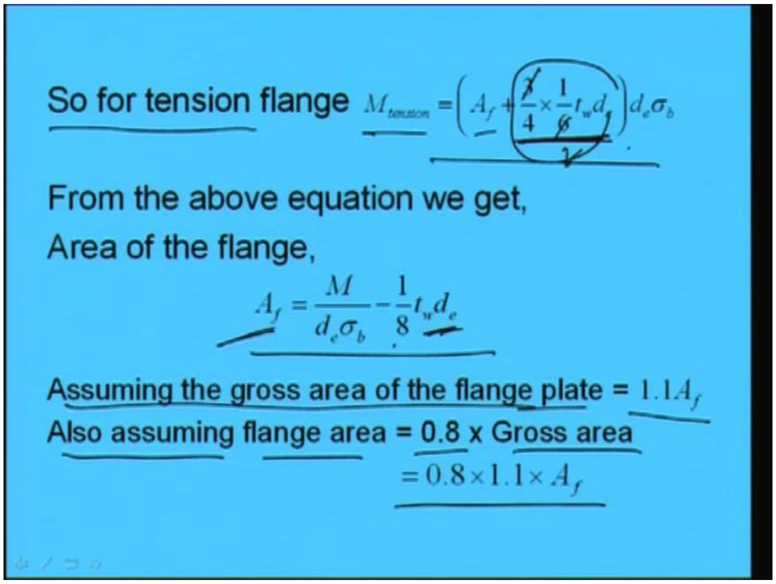

So, for tension flange this will be simply M tension is equal to Af into this is 3 4 means 75 percent you see 75 percent of the this. So, this will be the change means area is going to change little. So, from this equation we can get area of flange as Af is equal to we can find out M by de into sigma b minus 1 by 8 tw into de because this if we cross this will be tw de by 8. So, Af is becoming area of flange in area of tension flange. In fact, is M by de into sigma b minus 1 by 8 into tw into de.

So, in this way I can find out the area of flange in tension. Now, assuming gross area of the flange plate as say 10 percent more right and assuming flange area as point 8 of gross area. So, finally, this will become point 8 into 1 point 1 into Af. So, this will become that much value.

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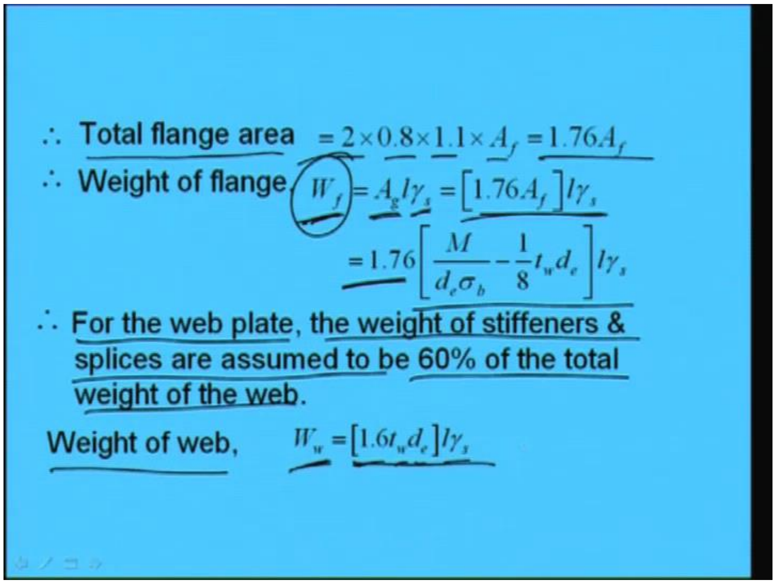

Then the total flange area will become then 2 into point 8 into 1 point 1 into Af which is becoming 1 point seven 6 Af. Now, weight of flange can be calculated Wf that will become Ag means gross area into l into gamma s where gamma s is the mass density of the steel right. So, Ag into l into gamma s l is the length. So, if we put the value of Ag then this will become this 1.76 Af into l into gamma s, right.

So, in this way Wf will become finally, this M by de into sigma b minus 1 by 8 tw into de into l into gamma s right. So, in this way we can find out the weight of the flange. So, Wf is found. For the web plate the weight of stiffeners and splices are assumed to be 60 percent of the total weight of the web. This is another assumption. So, all the assumptions are made on the basis of experience and basically this is an trial and error method. With these assumptions we have to start. And then next check when we will do we will do with the actual whatever we have adapted from that point of view we can check step by step right.

So, here weight of web will be Ww I am writing weight of flange is Wf and weight of web is Ww. So, this will become 1 point 6 into tw into de into l into gamma s right as 60 percent of the total web is going to be there. So, 1.6 into tw into de into l into gamma s right.

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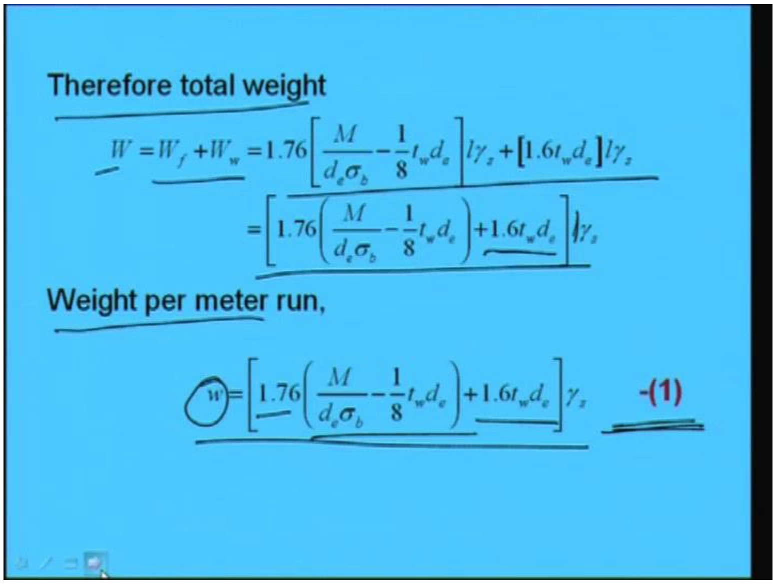

So, total weight W will become Wf plus Ww right. Total weight of the plate girder will become like this Wf plus Ww. And if we add Wf was this 1 1 point seven 6 into this. And Ww was 1 point 6 into this. So, if I add that this will become this. That is 1 point seven 6 into M by de sigma b minus 1 by 8 tw de into l into gamma s plus 1.6 tw into de into l into gamma s right. So, if we calculate this finally, the expression will be this that is 1.76 into M by de sigma b minus 1 by 8 tw de plus 1.6 tw de into l gamma s.

So, this is the value we are going to get right. Now, what we will do now weight per meter run right. Weight per meter run weight per meter run what will happen simply divide by l. So, this will be 1.76 into this M by de sigma b minus 1 by 8 tw de plus 1.6 tw de into gamma s. So, weight per meter run w we are going to get this say we are providing this as a equation number 1 which will be equal later.

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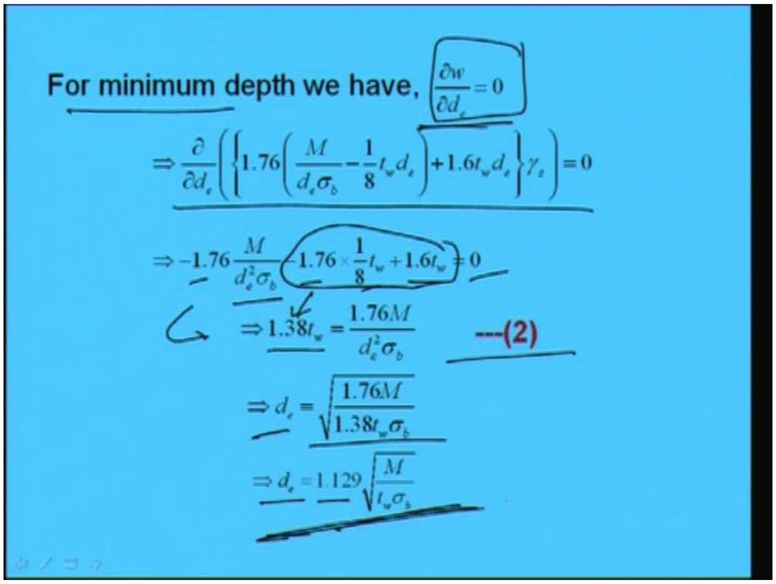

And for minimum depth we can say that del w del de is equal to 0 for minimum. For minimum we can use this expression. So, now if we make partial derivative of this term W in terms of del de then what will happen. Del de into this is equal to zero because del w del de equal to 0. So, now if we derive we will see that minus 1.76 into M by de square sigma b minus 1.76 into 1 by 8 tw plus 1.6 tw is equal to 0. And if you further simplify then we will get that 1.38 tw is equal to 1.76 M by de square into sigma b.

This will become 1.38 tw. So, this equation is denoted as equation number 2 and this should be also required that is why I am giving the … So, now from this equation I can find out de is equal to square root of 1.76 M by 1.38 tw into sigma b. De is equal to 1.76 M by 1.38 tw into sigma b. And so finally, de will become 1.129 into square root of M by tw into sigma b. So, the de is found effective depth what is that depth. The depth between CG of compression flange and CG of tension flange that de we are finding on the basis of minimum weight minimum weight we are making right.

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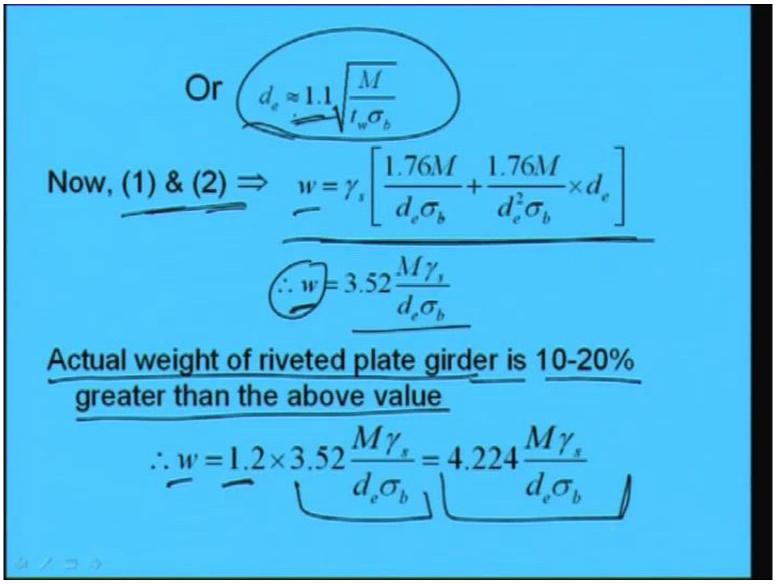

So, de can be find out approximately 1.1 into M by tw sigma b. This 1.129 we are making approximate as 1.1. Now, from equation 1 and 2; if we use this 2 equation, equation 2 is this 1 and equation 1 is this 1 right. So, using this 2 equation to replace the tw means this 1.38 tw what we will get sorry what we will get. We will get w is equal to this 1. So, from equation 1 and 2 you will find out w is equal to gamma s into 1.76 M by de into sigma b plus 1.76 M by de square into sigma b into de.

So, from this finally, we will get the expression w is equal to this 1 that is 3.52 M gamma s by de into sigma b M gamma s by de into sigma b right. So, actual weight of riveted plate girder is ten to 20 percent greater than the above value. So, weight we are finding out. Now, if we use riveted plate girder because of the presence of the rivet we are increasing ten to 20 percent of the weight right. So, if we increase that. So, w will become what 1.2 of that 1 w. So, 1.2 into 3.52 into M gamma s by de into sigma b. And if we multiply finally, we will get this equation that is 4.224 into M gamma s by de into sigma b. So, in this way we can find out the w the weight.

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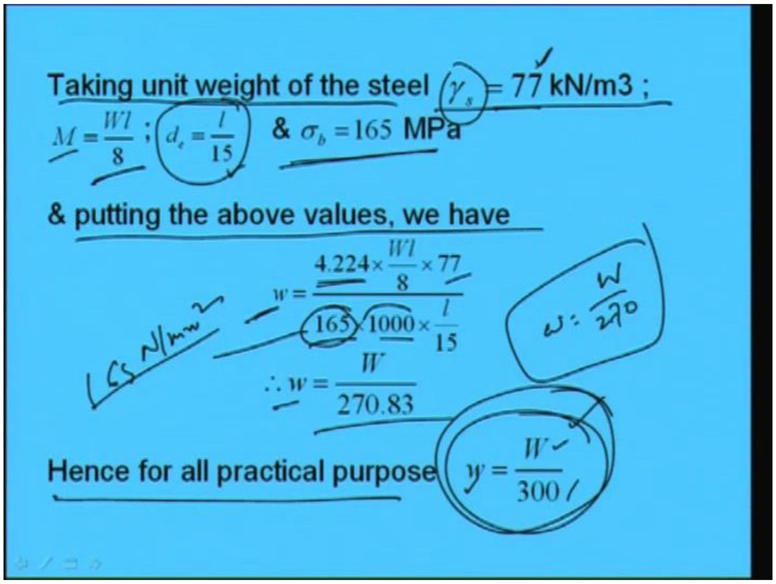

Now, taking unit weight of the steel as 77 kilo Newton per meter cube, now we are putting some values some standard values. If we put, what will be the w value? Let us see, so taking unit weight of the steel as 77 kilo Newton per meter cube. As you know steel weight is around like this 7 7 0 0 right; so 77 kilo Newton per meter cube or 7 7 0 0 kg per meter cube and assuming the de as l by 15. As we told that the span to depth ratio has to be limited within some range right. So, we are assuming this as de is equal to l by 15 and we are considering sigma b as 165. Assuming that fy 250 we are going to use right.

So, and M is equal to what will be that is Wl by 8 where W is the total weight. Or small w l square by 8 right. So, putting the above values we can find out w from the earlier equation. W we have here 4.224 into this. So, on this if you put the value we can find out this. 4.224 into M value we are getting say Wl by 8 into 77 into sigma b into l by 15. Now, all we are making kilo Newton per meter cube. So, this is 165 Newton per millimeter square.

So, if we make kilo Newton per meter square we will be we will have to multiply 1000 to make in same unit. So, we are getting w is equal to capital W by 270.8. And so what we are seeing therefore, practical purpose we can start with as this w is equal to W by 300 right. So, self weight in this way we can find out right. W is equal W by 300 with the with such type of expression we can start. Or we can start with w is equal to say W by 270 which will be little conservative side right.

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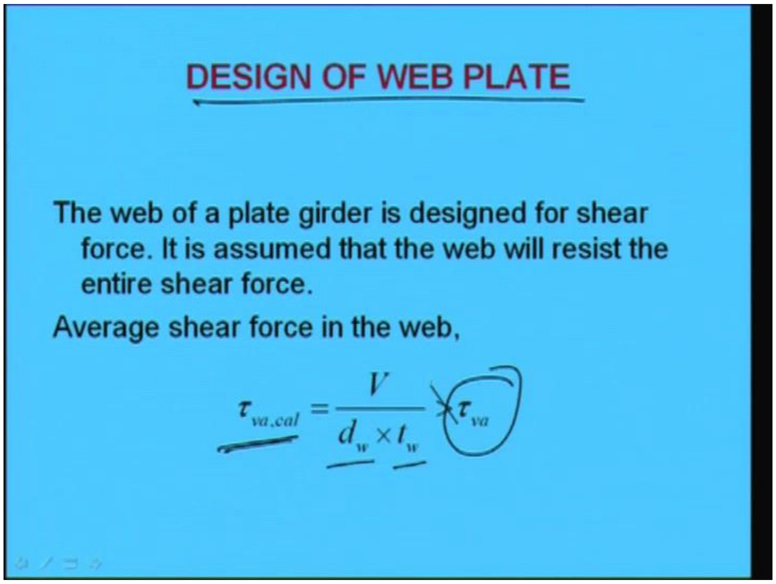

Next we will see the design of weight plate. So, economic depth we could find out economic size and its weight how to find out we have found. Now, let us see how to design the web plate. As we know web is taking mainly shear. So, web plate will be designed on the basis of shear. So, shear force what is the maximum shear force is going to develop that we will see first. Then accordingly we will check whether the shear stress developed is exceeding the permissible stress or not.

So, average shear stress as we know that will be V by dw into tw where dw is the depth of the web web plate and tw is the thickness of the web plate right. And V is the maximum shear force developed at the section and it should be less than tau va the permissible shear stress. The tau va means point 4 fy is it not so...

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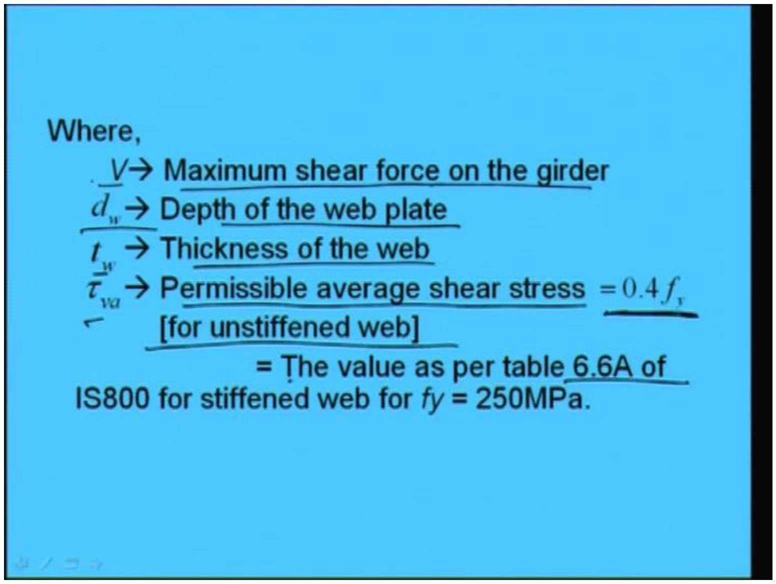

So, that has to be less than point 4 fy. Tau va is permissible average shear stress that will be 0.4 fy for unstiffened web. But for stiffened web these value has to be taken from table 6.6 A of IS 800. In table 6 point 6 A of IS 800 the value has been given. So, from that we have to take the tau va value the permissible average shear stress. And for unstiffened we can take simply point 4 fy right. As I told V is equal to maximum shear force on the girder maximum shear force and dw is the depth of the web plate tw is the thickness of the web plate, right.

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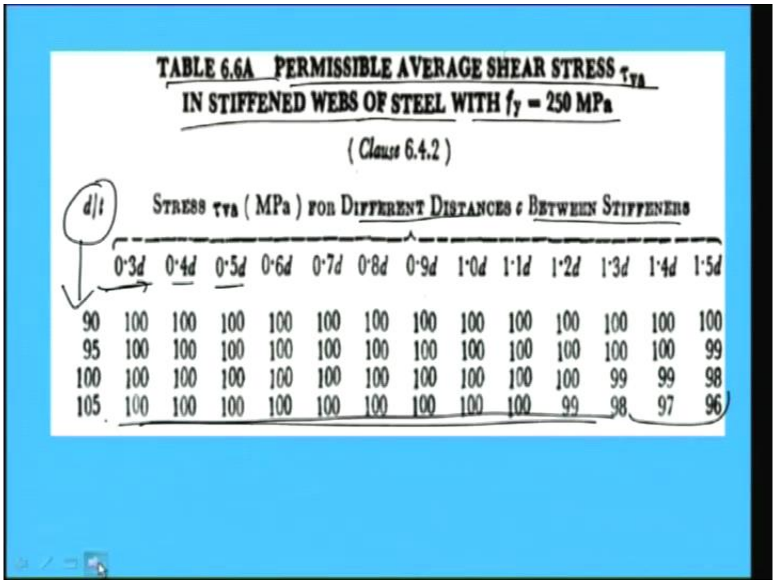

TABLE 6.6A PERMISSIBLE AVERAGE SHEAR STRESS τ_{va} IN STIFFENED WEBS OF STEEL WITH f_y = 250 MPa

(Clause 6.4.2)

d/t	Stress τ_{va} (MPa) for Different Distances c Between Stiffeners												
	0·3d	0·4d	0·5d	0·6d	0·7d	0·8d	0·9d	1·0d	1·1d	1·2d	1·3d	1·4d	1·5d
90	100	100	100	100	100	100	100	100	100	100	100	100	100
95	100	100	100	100	100	100	100	100	100	100	100	100	99
100	100	100	100	100	100	100	100	100	100	100	99	99	98
105	100	100	100	100	100	100	100	100	100	99	98	97	96

Now, this table 6.6 A I just took from the IS 800 1994 to show you it is giving like this you see permissible average shear stress tau va in stiffened webs of steel with fy 250. For 250 it has given right. So, here you will see d by t ratio is given and for different depth for different distance between stiffeners if it is point 3 d 0.4 d 0.5 d like this it is gone. So, the permissible shear stress will be defined like this. You see here almost 100 100 100 100, but here you will get some changes, right. Whole table I am not able to show here because it is a big table which will not be visible through power point. So, I have just shown a means a part of this, right.

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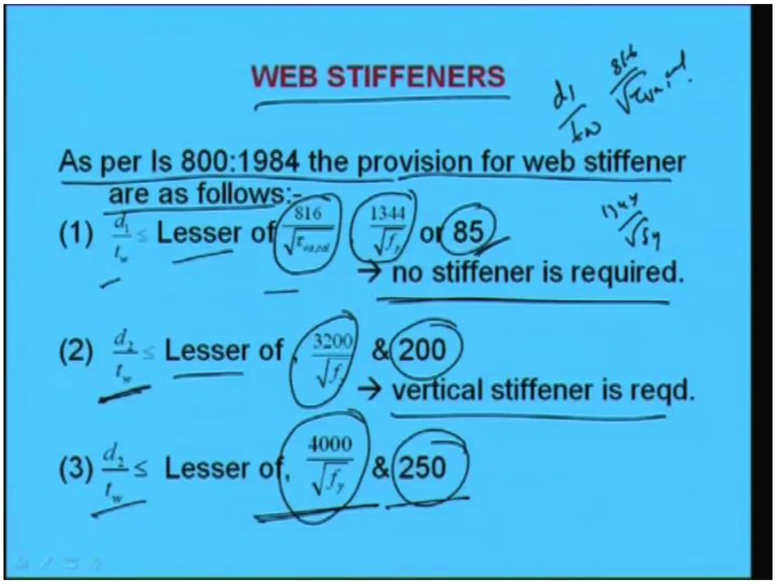

Now, we will see the web stiffeners web stiffeners. Now, in case of web stiffener sudden polar provisions are given like as per IS 800 1994 the provisions for web stiffeners are as follows that also we have to remember when we are going to provide web stiffeners. The IS code IS 800 1994 has specified explicitly. That is if d 1 by tw is lesser of 8 1 6 by tau va cal root of tau va calculated or 1344 by root over fy or 85 then no stiffener is required right.

So, what we will do we will find out d 1 by tw value right. And we will see whether it is less than 8 1 6 by tau va calculated whether it is less than 1344 by root over fy and of course, whether it is less than 85 or not. If so then there is no stiffener is required. Again we will see otherwise you have to provide stiffener if any of that is greater than d 1 by tw you have to provide stiffener. Another is dw by d d 2 by tw. If d 2 by tw is lesser of 3 2 0 0 by root over fy and 200, then we need to provide vertical stiffener.

So, when d 2 by tw is lesser of 3 2 0 0 by root over fy or 200 then vertical stiffener has to be provided. And if dw d 2 by tw is lesser of 4000 by root over fy and 250. If d 2 by 2 is lesser of 4000 by root over fy and 250 then...

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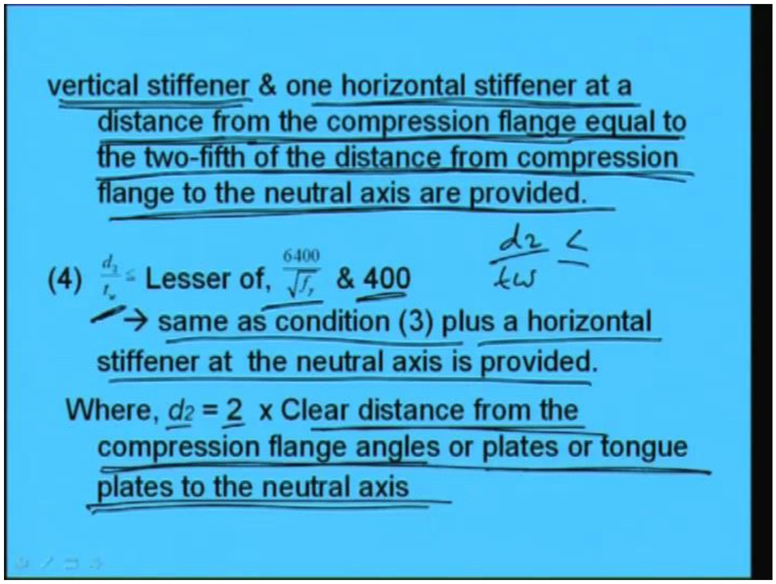

Vertical stiffener and 1 horizontal stiffener at a distance from the compression flange equal to the 2 fifth of the distance compression flange to the neutral axis are provided remember. Of course it is given in the code you can have a look that is vertical stiffener and 1 horizontal stiffener at a distance. From the compression flange equal to the 2 fifth of distance from compression flange to the neutral axis are provided right.

Other aspect is if d 2 by tw is lesser of 6400 by root over fy and 400 d 2 by tw is lesser of 6400 by root over fy and 4 400 then this will be same as condition 3 plus a horizontal stiffener at the neutral axis is provided. So, in condition 3 whatever it is given that has to provided along with a horizontal stiffener at the neutral axis along with a horizontal stiffener at the neutral axis that has to be also provided. Now, what is d 2 d 2 is 2 into clear distance from the compression flange angles or plates or tongue plates to the neutral axis right. D 2 is the 2 into clear distance from the compression flange angles or plates or tongue plates to the neutral axis.

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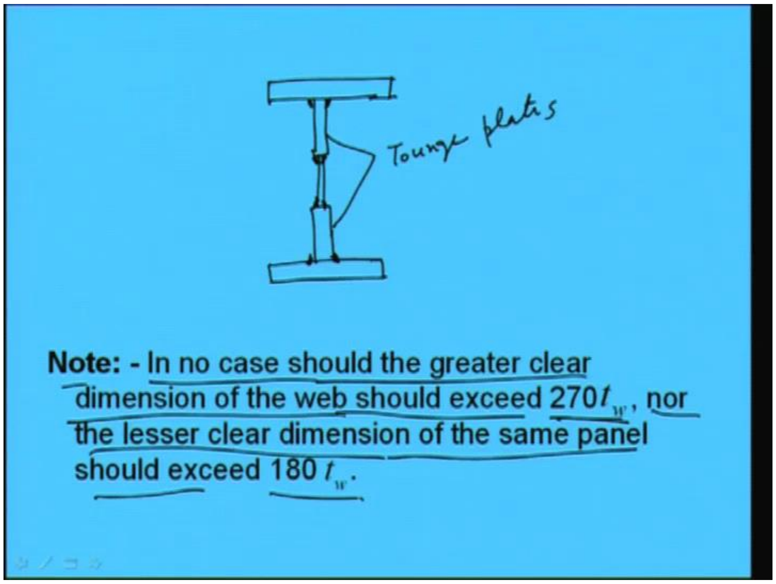

Let me draw then it will be clear. So, if this will look like this. So, this is 1 means in another 1 is here then again flange and these are welded right. Here also it is welded this is called tongue plates right. So, this is called tongue plates right. Note in no case should the greater clear dimension of the web should exceed 270 tw 270 into tw. Nor the lesser clear dimension of the same panel should exceed 180 tw. These also we have to keep in mind right.

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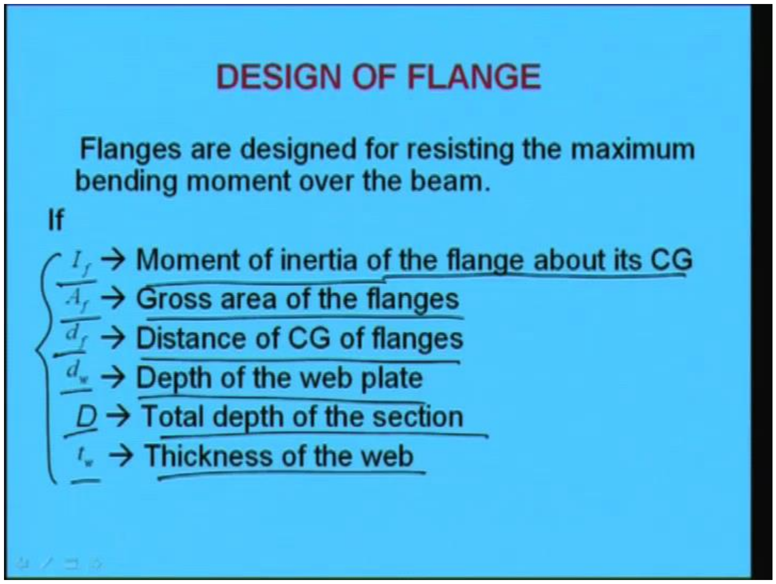

Now, we will go for design of flange. So, flange as we know flanges are you means flanges are designed for resisting the moment flexural action right. So, now let us before going to mathematical expression, let us know the whatever term I am going to use here say. If moment of inertia of the flange about its CG If right and Af is the gross area of the flange. Similarly, df is the distance of CG of the flange distance of the CG of flanges. And dw is depth of the web. D is the total depth of the section. And tw is the thickness of web right.

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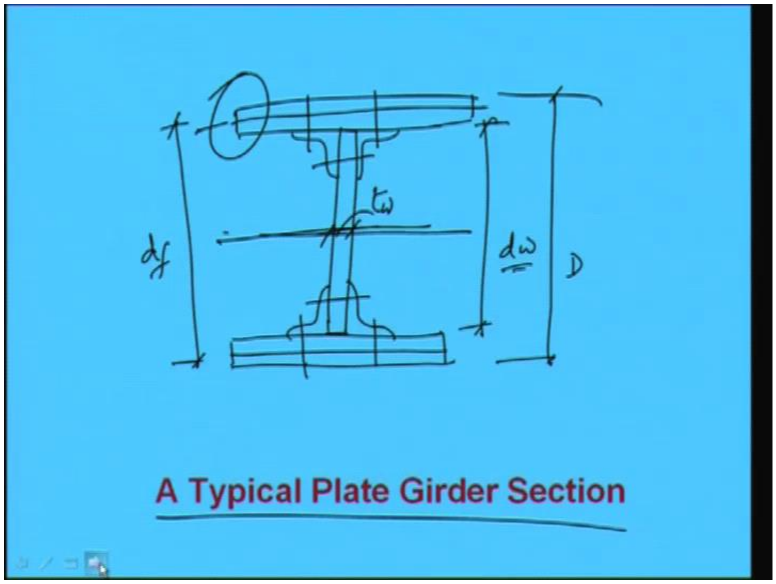

Let me draw then we will start the calculation. Say this is a typical plate girder I am going to draw with having said 2 plate similarly here and it has been connected through riveted by the use of angle right. So, what is dw this is dw depth of web. And overall depth is D right. And what is df df is earlier I made use as de this is df right. And here we can provide some rivet. Say a typical plate girder section I am showing here.

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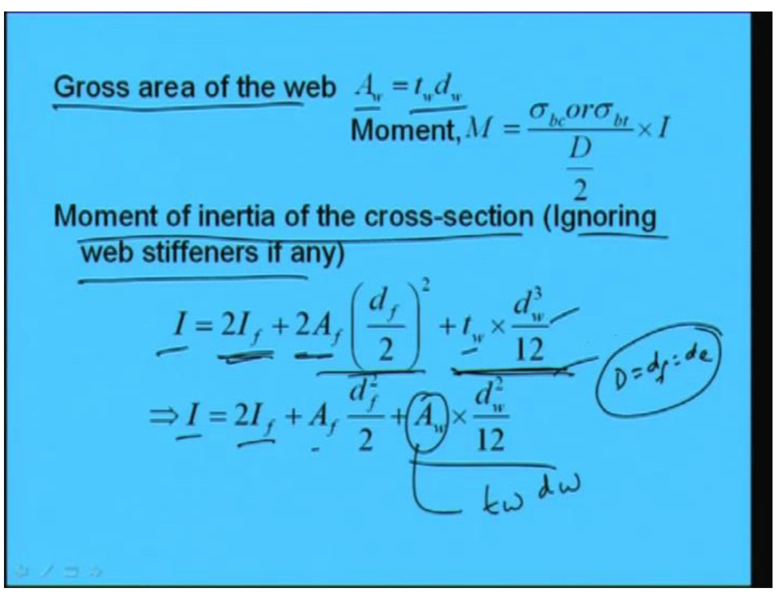

So, now if we find out the gross area of the web we will see that Aw will become tw into tw. Tw is this 1 thickness of web tw into dw right which is gross area of web Aw and moment will be sigma bc or sigma bt into I by D by 2 right. So, moment of inertia of the cross section ignoring the web stiffeners, if web stiffeners are there we can find out that I will be equal to 2 into If 2 into… If means if is the moment of inertia of the flange 1 flange.

So, there is 2 flanges that is why 2 into If plus 2 into Af into df by 2 whole square. If I take moment of inertia what will happen? 2 into If means area of moment of inertia of the flange at its own deduction means, then Ar square 2 Af into r means df by 2 whole square plus this is the moment of inertia because of the web cube by 12.That is tw dw cube by twelve right. So, I can be written as 2 If plus Af into df square by 2 plus Af into Aw into dw square by 12, because this Aw has been made tw into dw right.

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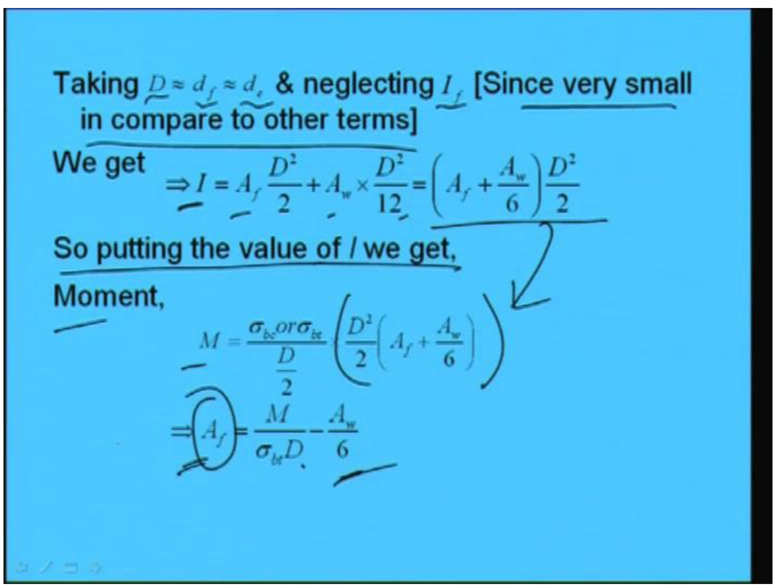

So, we can find out if we assume that D is equal to almost df is equal to almost de. And neglecting if in compared to other terms, since it is very small then what we can find out here. You see df means de is equal to df is equal to de means all are most similar because which is de and dw and df are means compared to the total value of D the difference is very less. So, we can ignore those things means ignore means we can take equal. So, if we take equal I will become Af into D square by 2 plus Aw into D square by 2 l plus D square by 12.

So, if I make that will become Af plus Aw by 6 into D square by 2. Now, putting the value of I we can get the moment as M is equal to sigma bc or sigma bt by D by 2 into I where I the value D square by 2 into Af plus Aw by 6, right. So, from this expression I can find out Af is equal to M by sigma bt into D minus Aw by 6. So, from this expression I can find out the Af area of flange. So, this is the way to find out area of flange of the plate girder. So, what we have seen that different components are there. So, step by step we have to find out the dimension for a load given. So, today I like to conclude here because you do not have time. In next class, we will precede the rest of the plate girder.