Course on Design of Steel Structures
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Lecture 27
Module 6
Lug Angles

Hello today I am going to discuss about Lug Angle Lug Angle is an angle with short length which is required to shear the load of the main angle. Sometimes the main angle carries a huge amount of load and to make corrections of this type of angle section with the main member to transfer the load we need a large number of large number of bolt, so if we use a large number of bolt or large length of weld then the size of the gusset plate become very high and if size of the gusset plate become high material required for gusset plate will be large and it will be uneconomic.

So to reduce the size of the means length of the joint or the size of the joint to a certain amount sometimes we provide lug angles at the beginning of the joint to shear the load from angle means from main angle to the gusset plate. So basically lug angle is connected with the outstanding leg of the main angle and some percentage of load of lug angle of main angle is transfer to the lug angle and then that load again is connected means again is transferred to the gusset plate through another angle means leg of the lug angle, so this is how it happens.

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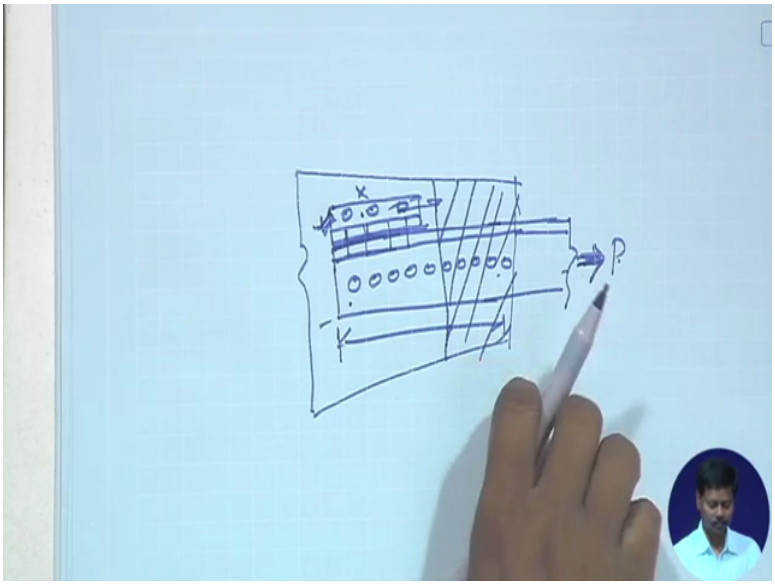

I can show a diagram say suppose a angle sections are connected with a gusset plate, right suppose this is an angle section. Now if this angle section carries a huge load huge load if it carries then I need lot of number of bolts and this is how it increases the length of the gusset plate say suppose this is the length of gusset. Now to save the material sometimes we may be able to reduce this length by putting an additional angle with the with connected with the main angle in this directions.

So suppose this is outstanding leg and if I put another angle say with small length then say suppose I am putting another leg then what I am doing I am trying to transfer certain load means I am trying to connect this angle this outstanding leg and transfer this certain load to this member which is called lug angle and then this is connected to this gusset plate and this main member is connected to this gusset plate.

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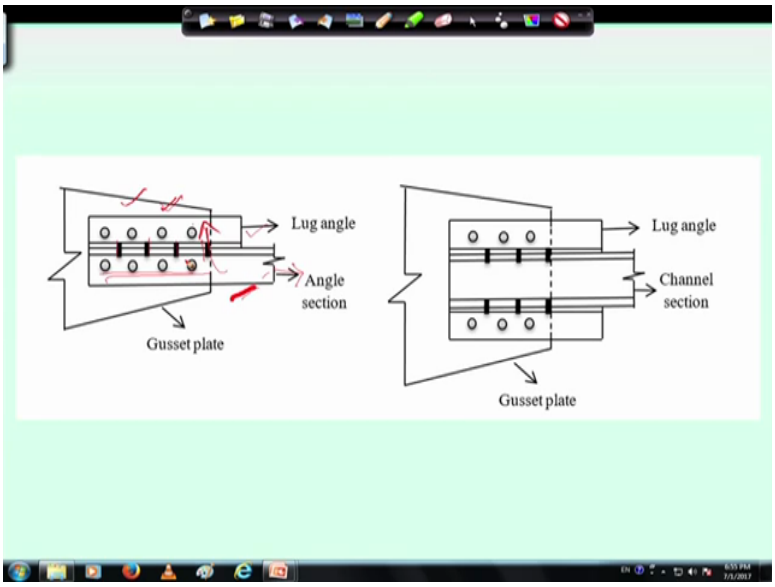

So if we see the picture here we can see that say for example this case this is an angle section this is the main angle. So this angle is connected with a short length of lug angle and it is connected by this bolt that is outstanding leg and this lug angle is also connected here, right that means with gusset plate. Therefore what is happening this angle section whatever load is taking as it is connected to lug angle and then connected to gusset plate so some percentage of load is going to be shear by this.

Therefore in place of shearing whole forces as it is shearing a percentage of load, so number of bolts required for this section will be less and therefore we can reduce the length. So if it is it shears in place of this I can provide upto this, so therefore I can reduce this length means I

can omit this length there by I can make economy to the connections. However sometimes it may not be possible because as we are providing extra angle, so some extra materials we are going to use here and also eccentricity may generate because of the connections. So it has certain disadvantages but sometimes we use.

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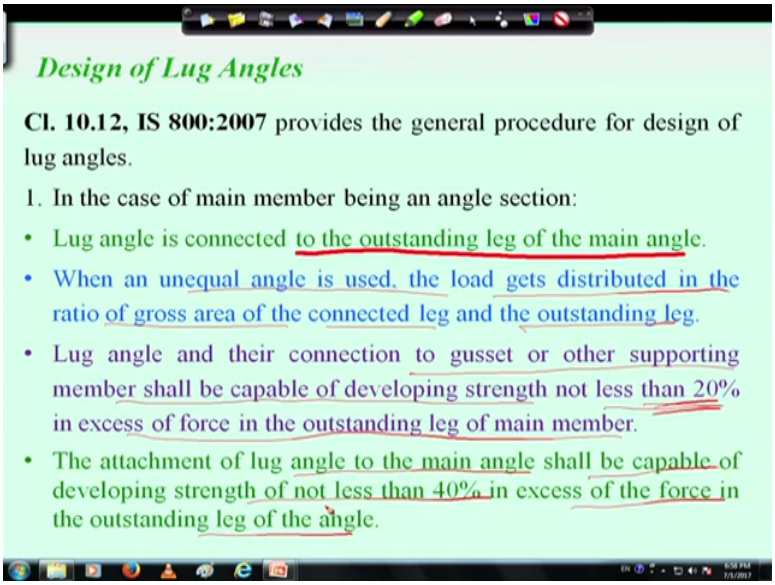

So before going to design I am going to provide the codal provisions once again I like to discuss the details about the lug angles like ok. In clause 10.12, in IS 800:2007 here it provides the general procedure for design of lug angle. So when we will be going for designing we have to keep in mind these codal provisions. It is two type one we can provide angle section, another is we can provide channel section. The main member may be angle or main member may be channel sections.

So if main member is angle section then it is told that lug angle is connected to the outstanding leg of the main angle, right. So as I told that lug angle will be connected to the outstanding leg of the main angle. Then when unequal angle is used the load gets distributed in the ratio of gross areas of connected leg to the outstanding leg.

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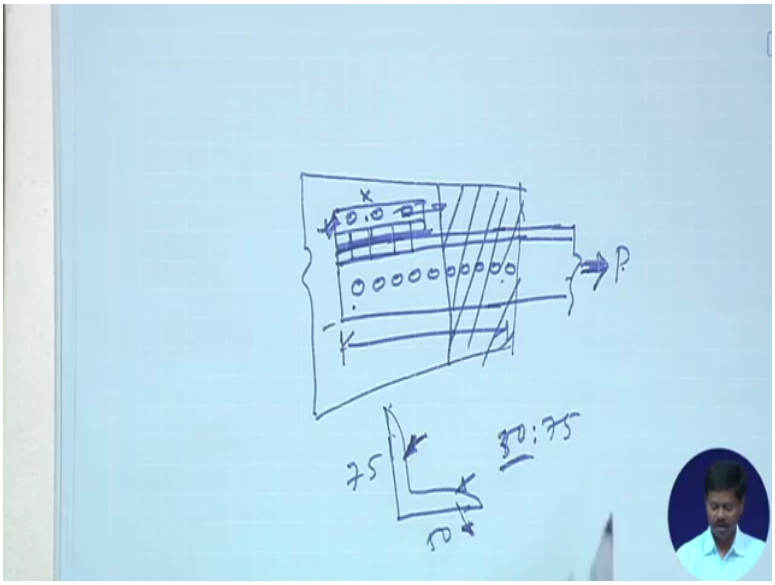

That means if an unequal sections are used say suppose this is 75 and this is 50, then load to this leg and load to this leg will be with the ratio of 50 is to 75. So less load will be shear by this angle and more load will be shear by this angle. So with this ratio it will be shear, this is what codal provisions says.

Then it says that lug angle and their connections to gusset or other supporting member shall be capable of developing strength not less than 20 percent in excess of force in outstanding leg of main members. So 20 percent minimum of 20 percent in excess of force in the outstanding leg that means whatever load is coming here whatever load is coming excess to that 20 percent more load has to be carried by this.

So when we are going to design a lug angle we have to take load whatever proportionality coming to that member that plus 20 percent of that we have to make. The attachment of lug angle to the main angle shall be capable of developing strength not less than 40 percent in excess of the force in outstanding leg angle, this also we have to keep in mind. So once it is 20 percent and another one is 40 percent shear has to be done.

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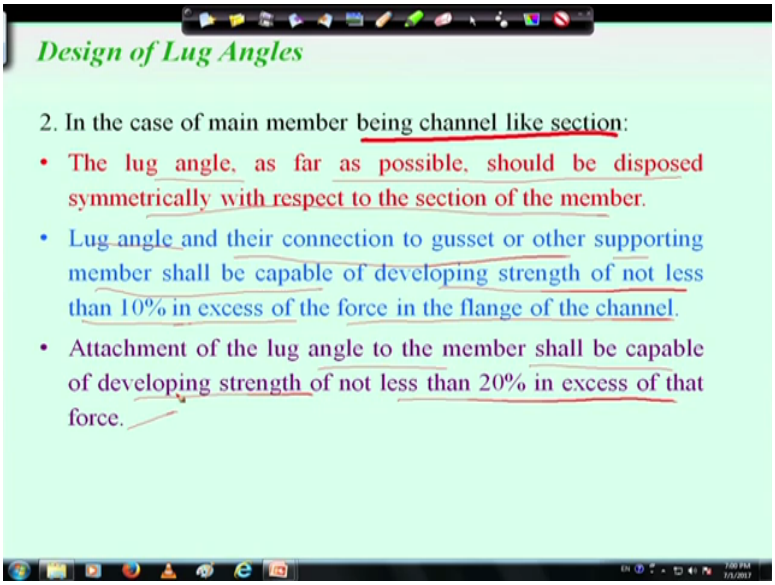

Then in case of main member being channel section, so earlier we have consider angle section main member, here we are considering main member as channel section if it is then we should remember that the lug angle, as far as possible should be disposed symmetrically with respect to the section of the member because in channel section channel section it shall be the symmetric. So lug angle should be provided at the top and bottom in a symmetric way.

Then lug angle and their connection to gusset or other supporting member shall be capable of developing strength of not more than not less than 10 percent excess of the force in flange of the channel. So whatever force coming to the flange 10 percent more than that has to be designed.

And similarly attachment of the lug angle to the members shall be capable of developing strength of not less than 20 percent in excess of that force. So this is what we have to keep in mind while designing the lug angle.

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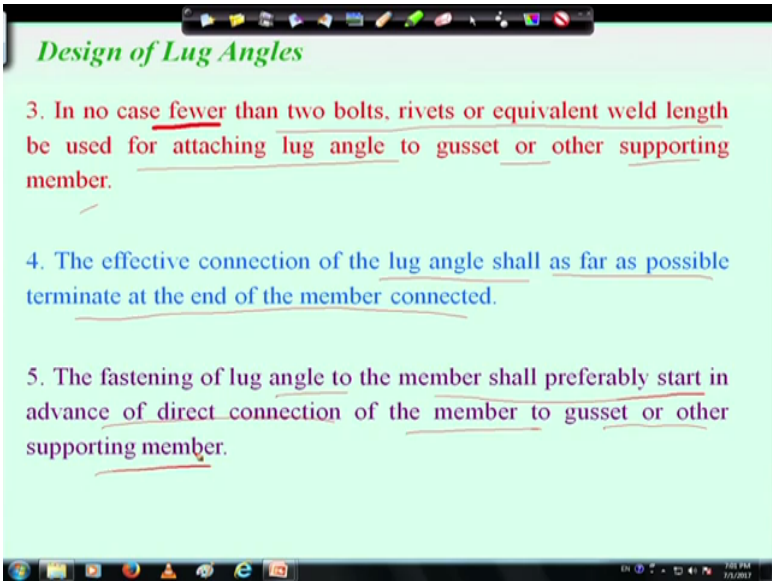

And then other few criterias we have to remember that is in no case fewer than two bolts, rivets or equivalent weld length be used for attaching lug angles to gusset plates or other supporting member. That means when we are attaching the member with the lug angle and lug angle with the gusset plate atleast two number of bolt or rivet has to be provided, right.

And the effective connections of the lug angles shall be as far as possible terminate at the end of the member connected. The fastening of lug angle to the member shall preferably start in advance of direct connection of member to gusset or other supporting members, so these things we have to keep in mind when we are going to design this lug angle, ok. So we can make it clear when we will go through design of a lug angle.

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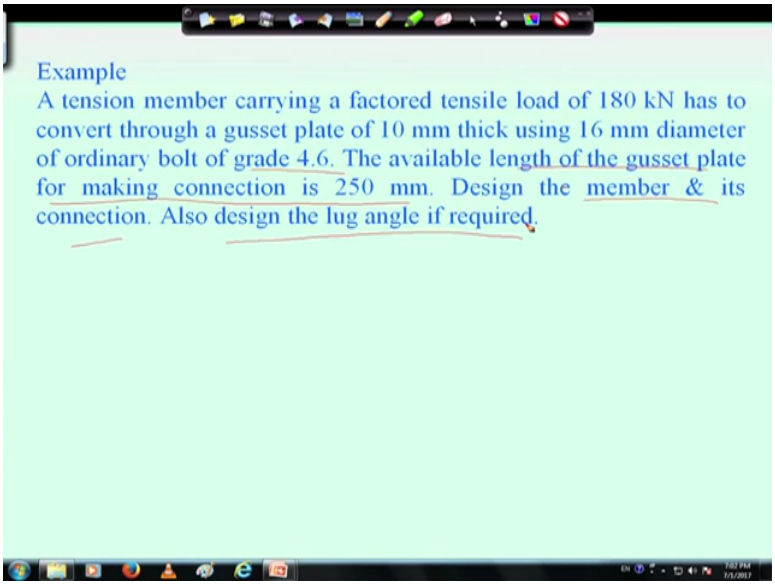

So here you see this is given that a tension member carrying a factor tensile load of 180 kilonewton has to convert through a gusset plate of 10 mm thick using 16 mm diameter of ordinary bolt of grade 4.6. The available length of the gusset plate for making connection is 250 millimetre. Design the member and its connection. Also design the lug angle if required. So here what we see the connection length is limited, so here connection length is limited to 250 mm available length is 250 mm.

That means if number of bolts are more and is not capable of accommodating in 250 millimetre length then we have to provide a lug angle, right.

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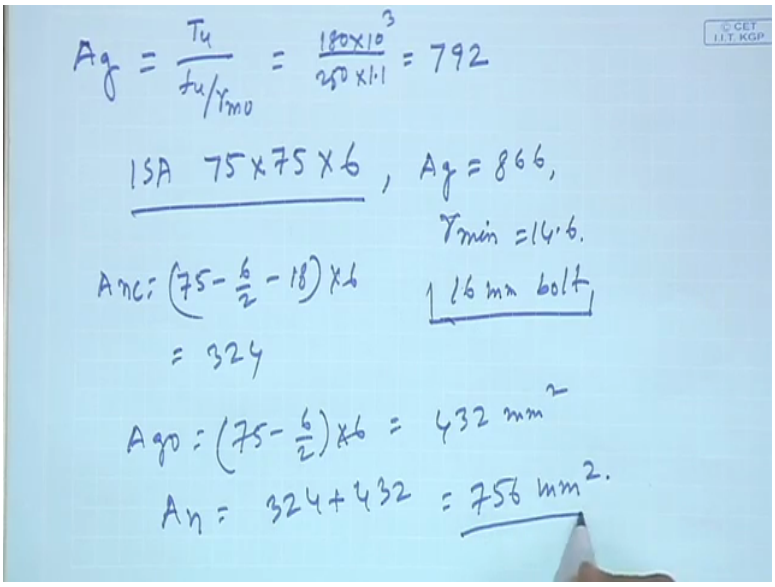

So we will see how to design these things, so first we will find out the gross area means Ag gross area required of the member we will first find out that is Tu by fy by gamma m0, that is 180 into 10 cube by 250 into 1.1, 792 millimetres. Now we can use a lug angle of say 75 by 75 sorry this is not lug angle this is the main angle ISA 75 by 75 by 6. Let us use an angle of 75 by 75 by 6 to carry this much load where its Ag the gross area will be 866, right and r minimum is given 14.6, right.

So if we use 16 mm diameter bolt, so it has been told to use 16 mm diameter bolt, so I can find out Anc value Anc will be 75 minus 6 by 2 minus 18 into 6, so this is coming 324 millimetre square. Similarly Ago value I will get 75 minus 6 by 2 into 6 is equal to 432 millimetre square. Therefore net area An I can find out 324 plus 432 that is 756 millimetre square. So net area of d member is coming 756 millimetre square.

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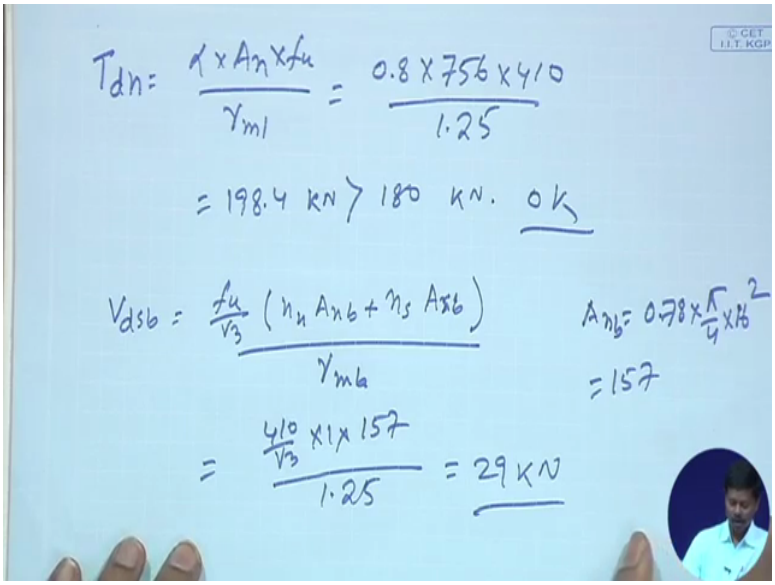

Now I can find out d value of Tdn, ok strength governed due to rapture. So Tdn I can find out as alpha into An into fu by gamma m1. So roughly I can find out if I assume that number of bolts should be 4 or more than that, then I can find out as like this. So this is becoming 198.4 kilonewton which is more than 180 kilonewton so it is ok, right. Now end connections I have to make so bolt value I have to find out Vdsb, so Vdsb if I find out that will be fu by root 3 into nn Anb ns Asb by gamma mb. Here Anb is equal to 0.78 into pi by 4 into d square 16 mm, right.

So this is coming 157, so if I put this value it will be I am assuming the shear plane to pass through root of the bolt, so Anb will be 157 that means ns will be 0, gamma mb is 1.25, so this is coming 29 kilonewton, right.

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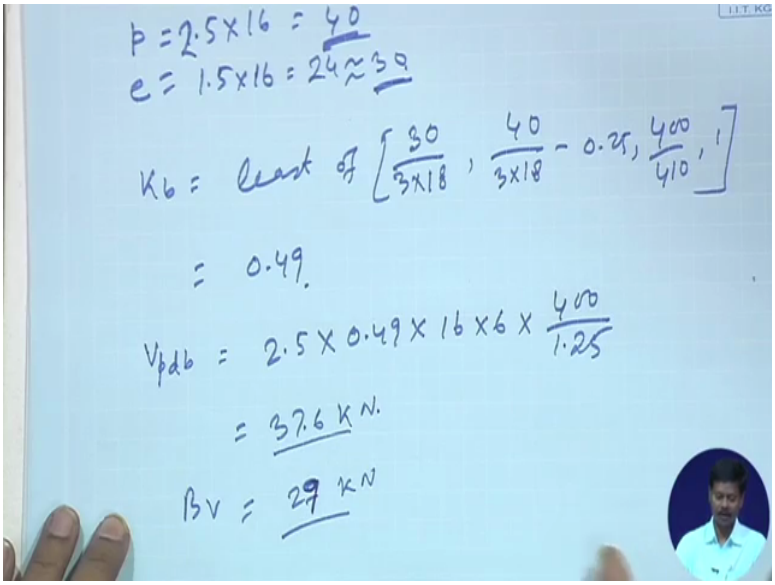

So now I have to find out the bearing value of the bolt to find out that I have to make edge distance and pitch distance, pitch distance I can make 2.5 into d so this is 40 and this is 1.5 into d this I can make this is coming 24 but I can take 30, right. So pitch as 40 if we consider and edge as 30 we consider then Kb I can find out as least of e by 3d0, that means 30 by 3 into d0, p by 3d0 minus 0.25 and then 400 by 410 and 1. So least of this is coming 0.49, right.

Now so bearing value I can find out Vpdb this value will be 2.5, Kb is 0.49, d is 16, t is 6 and fub is 400 by gamma mb. So if I calculate I can find out as 37.6 kilonewton, so bolt value will be lesser of this Vdsb and Vdpb that will be (27 kilonewton) 29 kilonewton, right.

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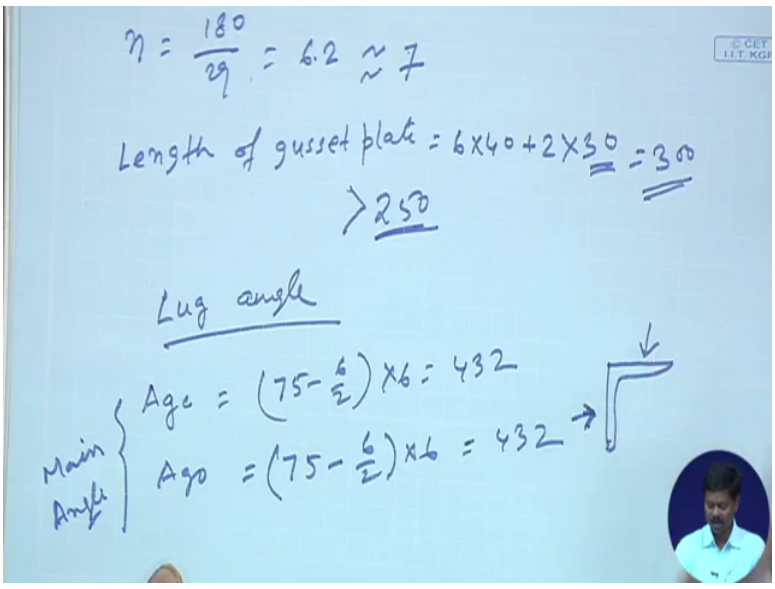

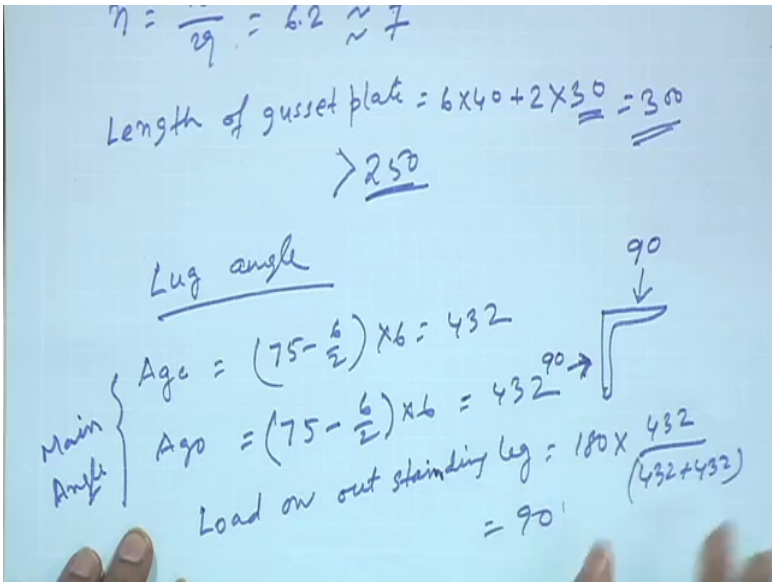

So if bolt value is 29 kilonewton then number of bolts required will be 180 divided by 29, is 6.2 so it is coming 7. So 7 number of bolts are required, right if 7 number of bolts are required then the length of gusset plate will be length of gusset plate that we have to find out, so this will become 6 into 40 because pitch distance is 40 plus 2 into 30 edge distance is 30, so this is become 300 and that is greater than 250 because available length is 250 mm, therefore so we need 300 mm length of gusset plate however available length of gusset plate is 250, so we can provide lug angle means we have to provide lug angle to accommodate this, ok.

So if we provide lug angle then gross area of the connected leg will be 75 minus 6 by 2 into 6, 432 and gross area of the outstanding leg of the lug angle of the main angle will be 75 minus 6 by 2 into 6, this is for main angle, ok so this is coming 432. Now see what we could see here that if the angle is like this, so area of this length leg and area of this leg is same, right gross area of this two leg is same, right.

So load on outstanding angle will be outstanding leg, so load on outstanding leg of main angle outstanding leg of main angle will be 180 into the shearing will be 432 by 432 plus 432, right so it will be 90 that means in this leg it will be shear by 90, in this leg it will be shear by 90. So 90 kilonewton each will come to both the leg of the main angle.

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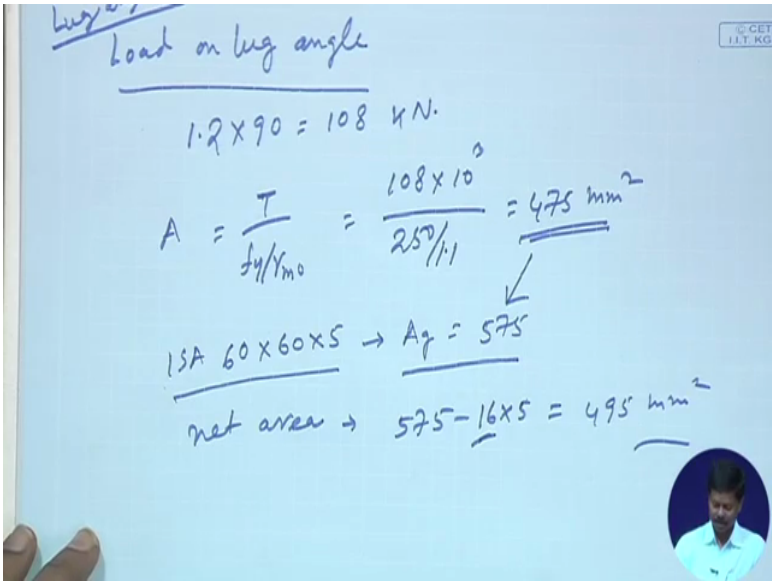

So load on lug angle will be 20 percent more as per the codal provision, load on lug angle will be 20 percent more. So this will be 1.2 into 90, so that is 108 kilonewton that means net area required for lug angle, now for lug angle we will try to find out the section size. So net area required will be means area required will be T by fy by gamma m0, that means T is here 108 kilonewton I am making it (())(23:06) newton, then 250 by 1.1 that will be 475 millimetre square. So net area required is 475 millimetre square.

So we can select a suitable size of the lug angle say if we look into the SP 6, we can find out as size of 60 by 60 by 5 of Indian Standard Angle, where the Ag value is given 575, we are taking little higher site of this because the net area will be little less, ok. So Ag we are considering this, that means the net area available will be net area of the lug angle available will be 575 minus 16 into 5 because bolt hole will be bolt diameter is 16, so that will be 495 millimetre square, right which is more than the 475 millimetre square.

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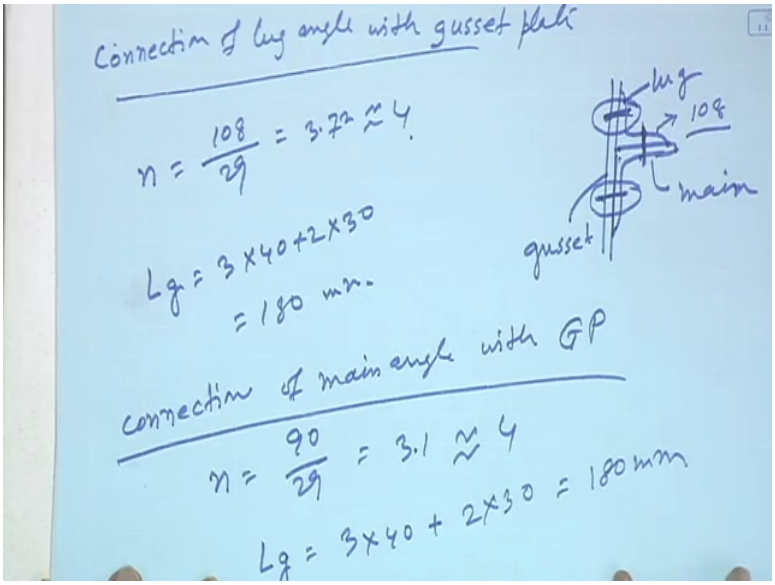

Now we will do the connection between lug angle and gusset plate because if we see if this is a gusset plate and if this is if we consider this as lug angle and if we consider this as main angle, right. So main angle is connected to the gusset plate main angle is connected to the lug angle, main angle is connected to the gusset plate and lug angle is connected to the (()) (24:46) these three things we have to see, right.

So first we will see the connection of lug angle with gusset plate with gusset plate. Now we see connection of lug angle with gusset plate, this is lug angle if I consider, this is main and this is gusset plate, right. So now if I want to connect here I know the force on lug angle is 108, right so number of bolts required in this connection means connection between lug angle and gusset plate will be 108 by 29 is the bolt value, so this is coming 3.72 that means 4 and length of gusset plate will be length of gusset plate I can find out that will be 3 into 40 plus 2 into 30, which is coming 180 so it is lesser than the available length, right.

So this is one, second we can see connection of main angle with gusset plate main angle with gusset plate, right GP for gusset plate. So the load on connected leg is 90 kilonewton, so we can consider number of bolts required for this will be 90 divided by 29 will be 3.1, so this is 4 that means length will be so length of gusset plate for this will be 3 into 40 plus 2 into 30 that means in this case also it is coming 180 millimetre, right.

So here we are using 4 number of bolts, here also using 4 number of bolts, this is how we are doing.

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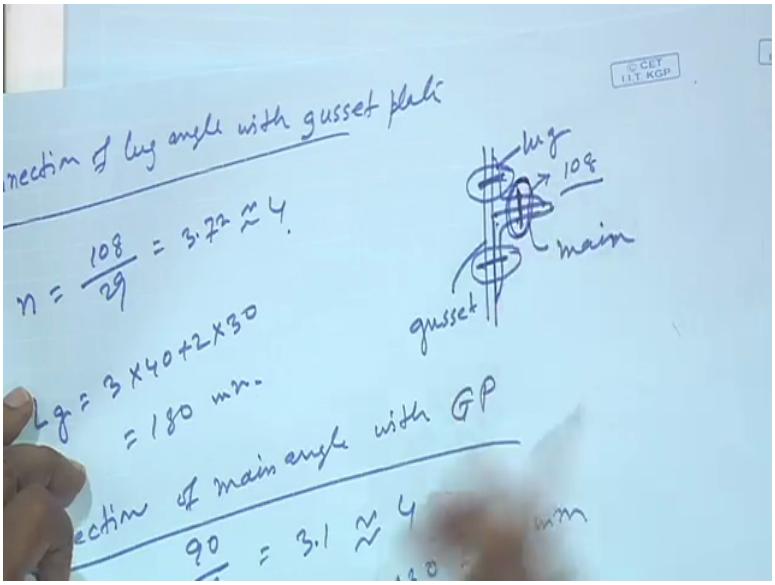

Now connection of lug angle to main angle, that means this one connection of lug angle to main angle, this how many number of bolts are required that we have to again see.

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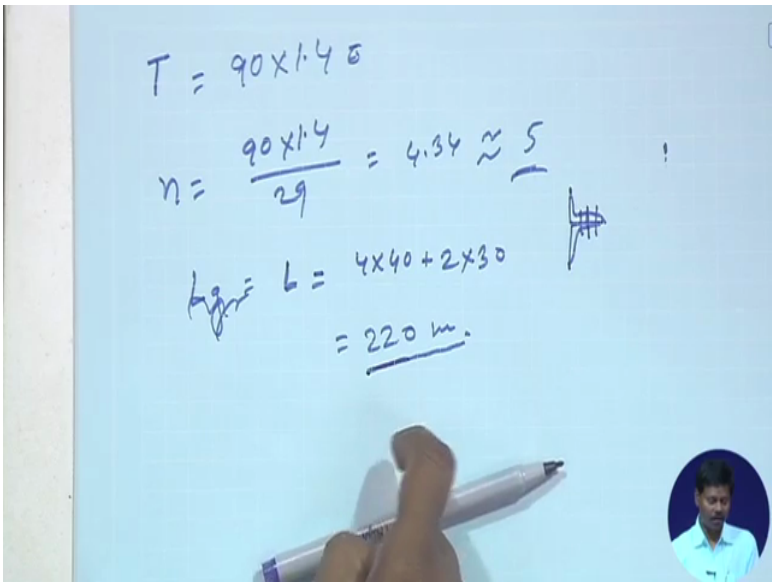

So here connection of lug angle to just one minute. Here the T value the load shear by this angle will be 40 percent excess to the load actually carrying, load was 90 so 40 percent excess, so that means 1.4 into 90. So number of bolt required will be 90 into 1.4 by 29, so this is coming 4.34 which is equal to 5. That means length of gusset plate here it will be require length of gusset plate rather we should say length of the length of the lug angle and main angle length of the lug angle and main angle because this is one angle which is connected with another angle, so this in between this.

So this if we find out it will be 4 into 40 plus 2 into 30 because 5 number of bolts are there so this is coming 220 mm, right. So this is how we can find out length of the main angle or the lug angle atleast should have 220 mm, right.

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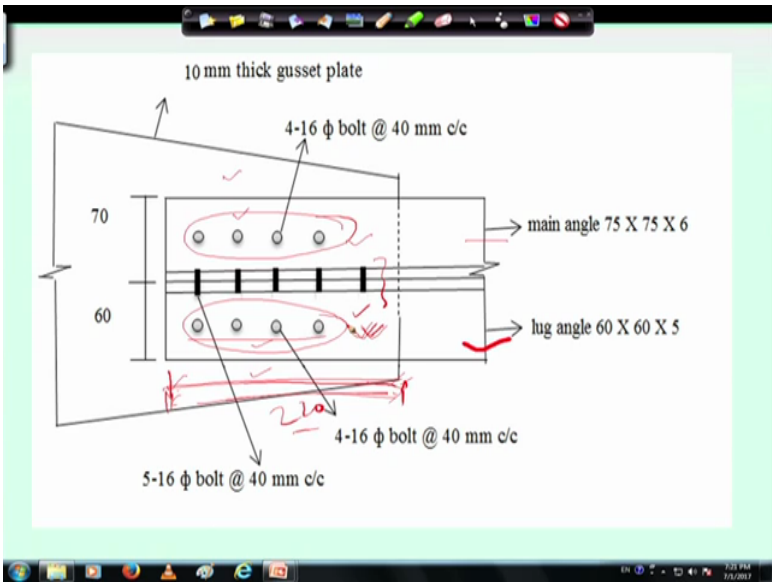

Now if we see in the diagram we can see as like this this is how it will look. So it will be like this say this is the lug angle and this is main angle now number of bolts required to connect the gusset plate and main angle will be 4 which we got and number of bolts required to connect gusset plate with the lug angle that will be also required 4 and number of bolt required to connect main angle with lug angle these connections will be 5 and total distance are coming maximum distance are coming this distance are coming maximum 220 and available distance is 250, right.

Available or allowable distance of the gusset plate was 250 and here we are getting 220 maximum, right and the distribution can be done in this way with its minimum pitch and minimum edge distance this is how one can do, ok.

So here what we can see that though we are going to reduce the length of the gusset plate length of the gusset plate in place of the higher length we are going to reduce but extra angle which is lug angle has been introduced. So material cost due to this introduction of lug angle has to be here also, therefore it is not always economic but sometimes because of architectural requirement or some other requirement we cannot go beyond the certain length in a particular case.

So in such case we may have to go for introduction of lug angle. However always it is better to provide means if the length is less require means allowable length or available length of the joint is less or if the tensile force is quite high then suggestion is that better to use bigger size of the bolt means larger diameter of bolt or use the higher site of angle section, so that means it can be accommodated in that itself, ok. So this is what about the lug angle, thank you.