Design of Steel Structures

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Module - 2
Connections
Lecture - 6
Bolted Connections

Hello. Today, we will be discussing about bolted connections. In last few lectures, we have discussed about welding connections and rivet connections. Bolted connections are basically almost similar to the riveted connections; I will go into details, but before I am going into details of the bolted connections, I would like to conclude the remaining part of the last lecture about the slot weld.

Now in case of slot welding, we have seen how to make the specification as per the codal provisions and why it is required that we have discussed. Now as we know that basically slot weld or plug weld will be required when the required welding is exceeding the type of weld which we have to provide there. Basically, if we want to provide more welding length with a specified area, then we may have to go for this slot weld or plug weld. And this is required because of high tensile strength; means tensile forces coming into picture in the member. That is why to adjust those loads, we have to go for this type of slot weld or plug weld.

Now I will go through one example through which we will be able to understand how to design a slot weld and what is the specification has to be maintained through the codal provisions and how we will adjust; all those things will be clear if we go through this example. Now let us see this example; I am going to work out this example. I hope if we understand step by step, then it will be easier for us to design a slot weld.

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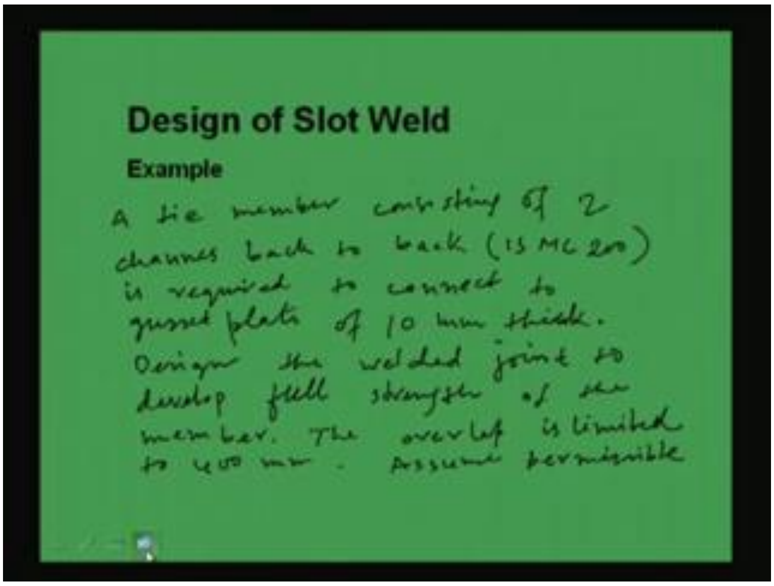

Say let us take an example of this say a tie member consisting of two channels back to back; this is ISMC 200. This channel is ISMC 200 is required to connect to gusset plate of, say 10 mm thick. Now design the welded joint to develop full strength of the member; that means we will make the connection in such a way that the maximum strength taken by the member will be also able to take by the joint through welding connections. Here the restriction is that the overlap length is limited to say 400 millimeter. Now let us assume the permissible stress in weld.

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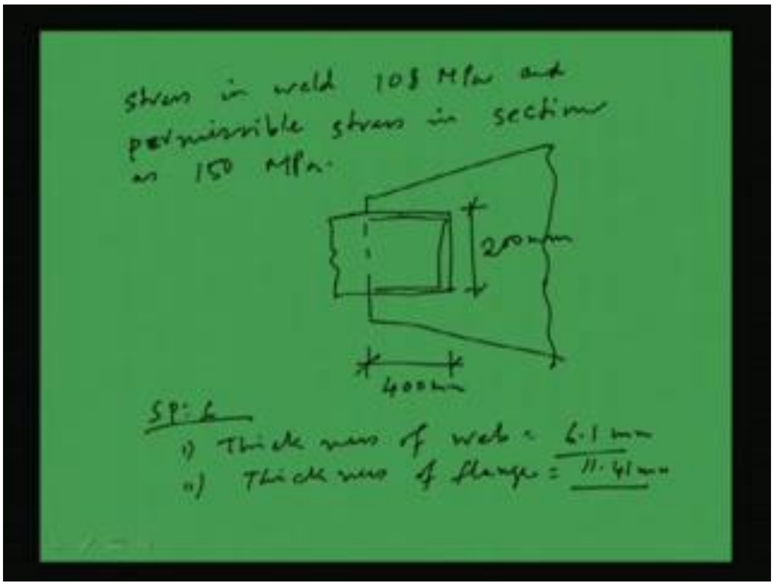

Stress in weld as 108 MPa and permissible stress in the section as, say 150 MPa. So, these are the data which has been given; now we have to design this. Design means we have to connect these members this channel sections though one gusset plate, so that the maximum load which can be carried by the channel section also can be carried by the connections. So, connections will look something like this; say this is the channel section, and, say this is the gusset plate it is given here.

So, the maximum overlap length is given restricted to 400 mm, and the size of the channel is ISMC 200. So, these are the things. So, we are having the length of welding will be maximum this area. That means 400 plus 400 plus 200 means 1000; 1000 mm length we will be getting for welding. Now from SP 6 in the codal provision, whatever the data which has been given for ISMC 200 is the thickness of the web that is given 6.1 mm. Then the thickness of flange, this is given as 11.41 millimeter. That means from SP 6 for the channel section of ISMC 200, the thickness has been given as 6.1 mm, and thickness of flange has been given as 11.41 mm.

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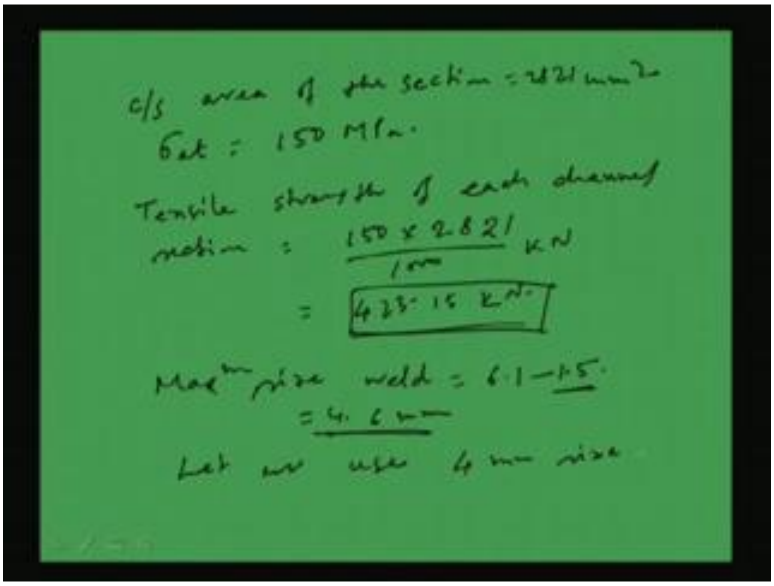

And the cross sectional area of the section is given as 2821 millimeter square. So, these are the given data which we have found from the SP 6. Now here the sigma AT value that is permissible stress in the section which has been given in the problem that is 150 MPa. So, the tensile strength now we calculate for the section. So, the tensile strength of each channel section will be the permissible stress into the area. Area was given in the code 2821 for this type of channel, and this is in Newton.

So, if we divide by thousand, it will be in KiloNewton. So, this is coming, say 423.15 KiloNewton. Now this load can be carried by the section. Now we have to design the weld in such a way that this much load also can be carried by the welding joint. So, now for joining the weld means for designing the weld for finding out the details of the weld, let us first assume some size of the weld. To assume the size of the weld, first we have to know what is the maximum size available in this case?

So, as per the codal provision maximum size of the weld will be the thickness of the thinner part of the section which is coming 6.1, because this is the thickness of the web of the section that is 6.1 mm. And maximum size will be 6.1 minus 1.5 mm means thickness of the thinner part minus 1.5 mm is the maximum weld size. So, here it is coming around 4.6 mm, right. Now minimum size we now 4 mm. So, as the maximum size is coming is 4.6 mm. So, let us use, say 4 mm size weld, right. So, the size of the weld has been fixed now. Now what we will do? Now we will find out the strength.

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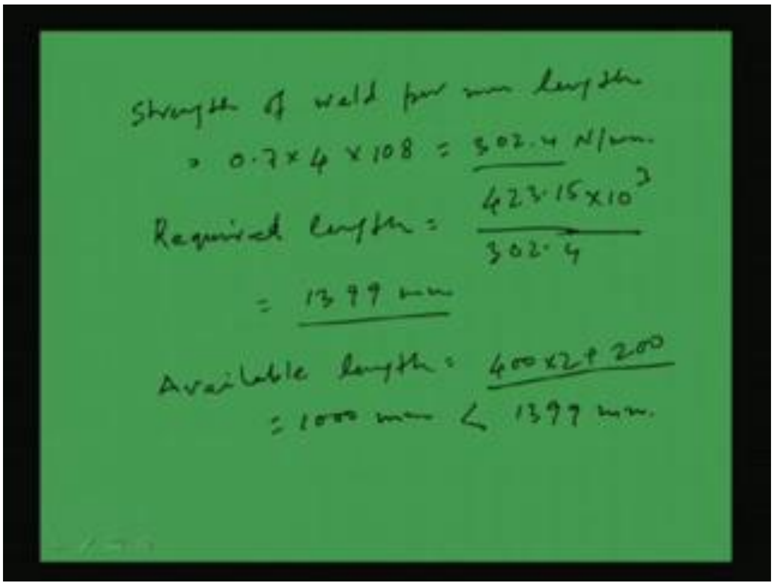

So, strength of weld per millimeter length can be found out. That will be now strength of weld how do we find out? Generally 0.7 into s is the throat thickness. So, 0.7 into the size of the weld is 4, and permissible stress in weld is considered as 108. So, this is coming 302.4 Newton per millimeter. So, we have to design the weld for the force of 423.15 KiloNewton.

Now per millimeter length, the strength of weld is coming 302.4 Newton. So, the required amount of length required length will be that 423.15 KiloNewton by 302.4 Newton per millimeter means this let us make Newton. So, this will become 1399 millimeter. So, length required to withstand this much load will be 1399 millimeter. Now overlap length is limited to 400 mm. So, available length what we are seeing? Here we will get available length this will be equal to 400 into 2 plus 200.

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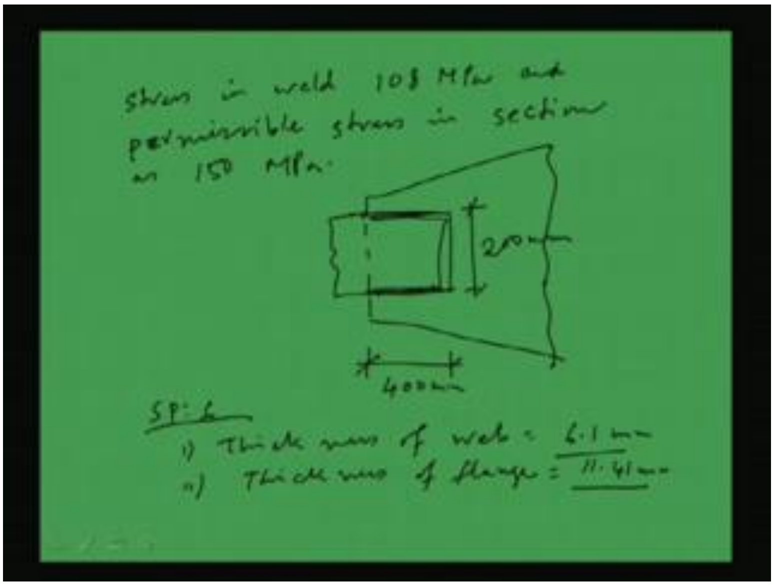

Because this is the available length; this length, this length, this is 400 into 2 plus this channel height. So, this length will be available which is coming 400 into 2 plus 200. This will become 1000 mm, right which is less than the required length 1399 mm. So, thus we need to provide an additional length of weld in terms of slot. So, what we will do?

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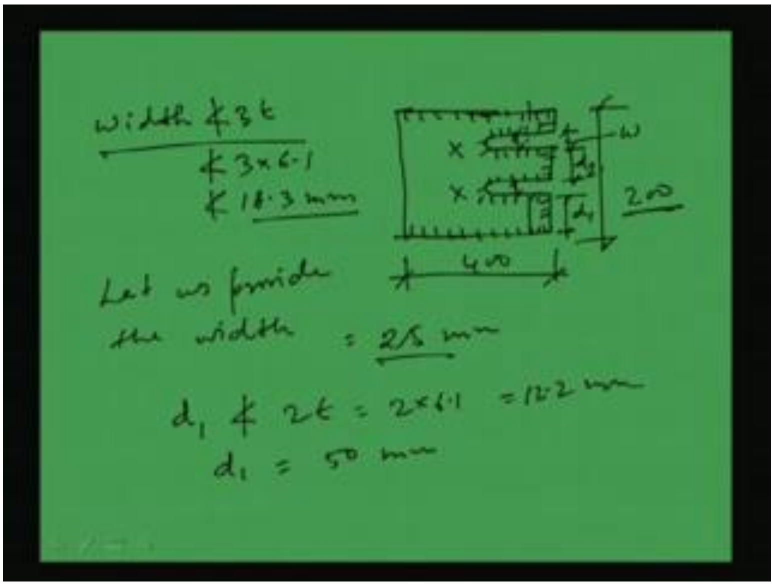

Now we have to find out the slot length and its distribution. That means slot length means we know that we are cutting though the plate up to some length and then we are distributing accordingly. Say, let us make like this, say this is the total over length length. So, this is 200 and, say this is 400. So, extra length we are providing through making some slot. So, this is the welding; this will be the welding area. So, in this way now we are going to provide some extra slot; in this way we will be going to provide, right.

Now if we see now that what will be this distance between two slots and what will be the width of the slot; that we have to find out. Now form the codal provision, we know that width will be this should not be less than 3 t. This is the codal provision as we have discussed in last lecture also where t is the thickness of the thinner part. So, width of the width means this one, say w. Width of the slot should not be less than 3 t; that means should not be less than 3 into t means this time 6.1. So, that is it should not be less than 18.3 mm. This is one restriction has been given.

So, let us provide the width of slot as, say 25 mm, okay, which is greater than 18.3; this is one. So, if this is 25 and if this is 25, then now I can find out this distance; this is, say d, right. So, now I can find out this distance, okay. Now we are considering that two slots we have provided. Let us assume that two slots we have provided. So, if we provide two slots, then width will be calculated in that way. So, again the edge distance which has been given by the code the edge distance this is say suppose d 1, let us make this is d 2.

Edge distance is d 1. This also should not be less than 2 t. That means 2 into 6.1; that means 12.2 mm. So, this distance should not be less than 12.2, okay. So, we can provide, say 50 mm, because the total is 200. So, we have to make it. So, let us provide d 1 is equal to 50 mm. Then what will happen? So, this is 25; this is 25, and this is 50; this is 50. So, I can find out d 2, right. So, now I can find out d 2.

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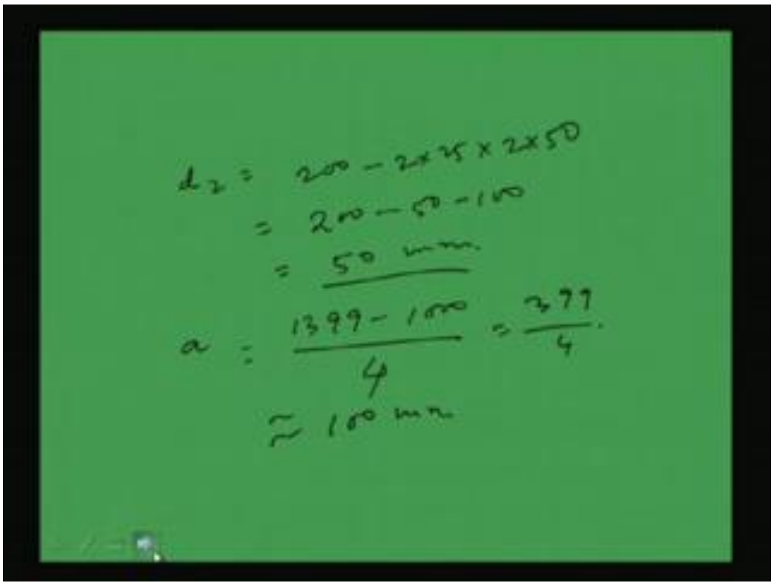

So, d 2 will be I can find out. D 2 will be 200 minus 2 into 25, and edge distance is 2 into 50. So, this will become d 2. So, that will be 200 minus 50 minus 100. So, this will become 50 mm. That means the distance will be 50 mm. So, in this way we can find out the details. What next will be the slot length? That means slot length also we have to find out.

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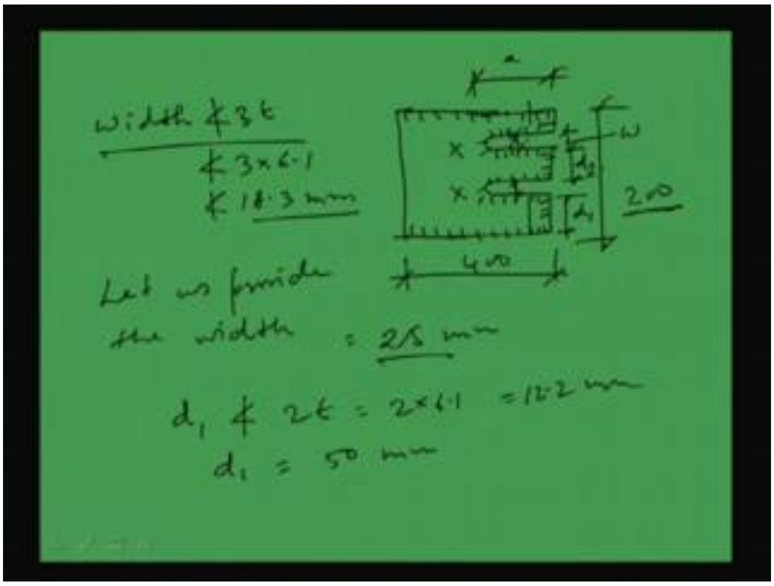

Say, let us assume this slot length as a. If this is the slot length, then I can find the value of a. So, how do I find out? So, this can be found out, say a will become 1399 minus 1000 by 4 a because. So, this length if it is a; so, a plus a plus a plus a; that means this 4 a. So, 4 a will be equal to the rest length that is 399. So, 399 by 4 that will become 100 mm; so, the length of the slot will become 100 mm. So, in this way I can find out.

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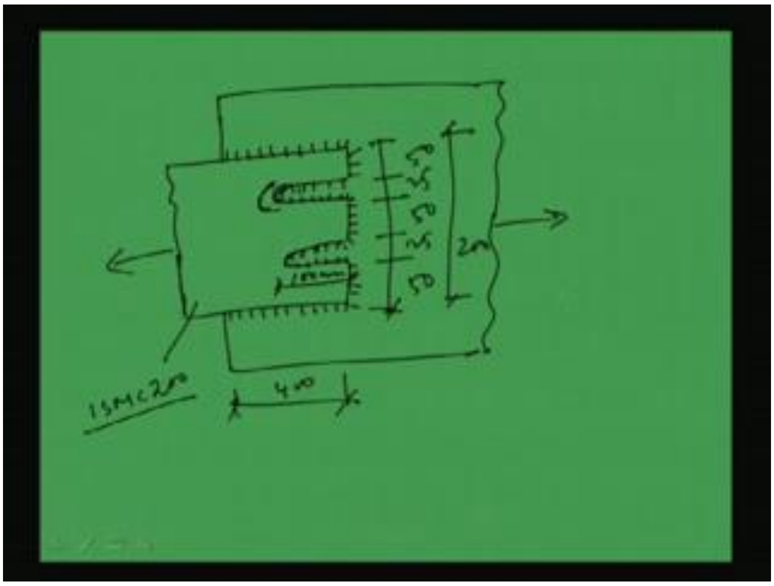

So, now if I draw the welding joint, it will look like this. Say, this is the channel. Now this is one slot weld we are providing. Then again another slot weld we are going to provide here, then like this. Now this is the gusset plate which has been joined. Now this is ISMC 200. So, if I go for welding, welding will be like this. So, remember that this portion will be circular means in a circular way we have to make it. So, welding will be in this way, right.

Now if we see the specification, this is 400 which is the lap length. Now this we are going to find this is 50; this is 25, 50, 25, 50 which is coming 200 total; that means this is total 200 mm. This is how we will distribute and this length will become 100 mm which is got from the solution. So, this will be the details of the slot weld how we have designed. So, to find out the maximum load carrying capacity which can be carried by the plate means this ISMC section as well as by the welding joint.

So, to withstand that load, we have to design the welding joint in this way with the use of system slot weld. So, the slot weld slot weld details have been given here, how we have made the details that I have shown. So, in this way we can make it.

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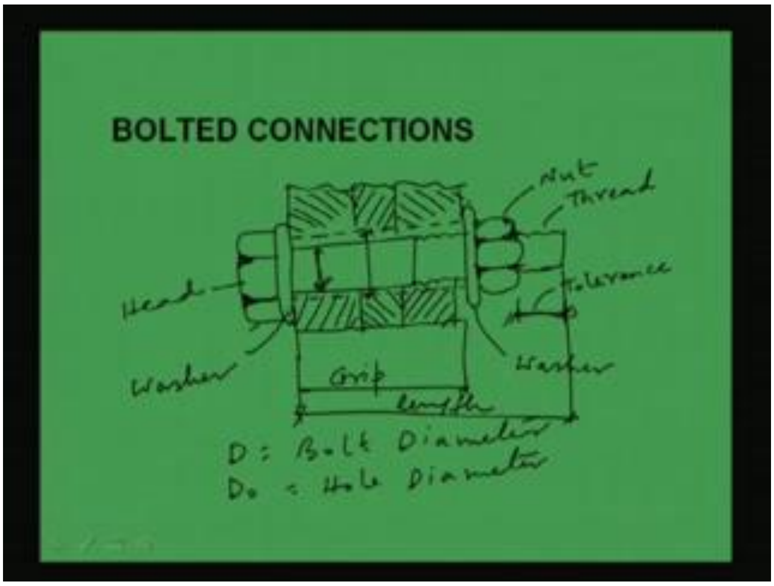

Now we will discuss about details of the bolted connections; bolted connection as we are telling that this is almost similar to the riveted connections. Only difference is the calculation of the strength which has been calculated by the use of nominal diameter in case of bolted connections. And in case of riveted connection, we know we have to calculate the gross diameter where 1.5 or 2 millimeter extra due to hole has been added. So, design and analysis will be almost same in case of riveted connections; little difference is there that we will discus.

And also we will see what are the advantages of bolted connections over the other connections, and what are the disadvantages? So, in terms of that, one can choose the designer can choose which type of connection he will have to make for a particular construction of the structural frame. So, first before going to details, let us see how it look like. What is the bolt? What it its terms different notations? So, let us first see all these things, then we will discuss the codal provisions and what are the types of bolt, then we will see how to design it, right.

So, now first let us see what are the notations we used in a bolt and how it look like. Say, first let us draw a bolt and its details. Say, this is called basically washer; we will come details later. So, this is how it will look here, and this portion is called basically nut, and this will go in and this is called thread. This is thread, and this distance is called tolerance. So, all these dimensions of a typical bolt are given in the codal provision means in terms of table it has been given, what will be the head diameter? What will be thread? What will be the tolerance? All these have been given in the code.

Now this length is called grip, and this is called bolt diameter, say d is equal to bolt diameter, and this total diameter is the, say D 0 hole diameter, right. Now other part is something like this. So, this is called head of the bolt, and this is already I told washer and say plates are, say one plates are given here; say another plates are here, another plates are here. So, different plates are to be in general connected through this bolt. So, these are the plate. Three plates are connected through the bolt connection, right.

So, this diameter is called bolt diameter, and this is the diameter of hole. Hole diameter is little more than bolt diameter, and this length is called tolerance. This is basically thread, and this part is call nut, and this is the head of the bolt. And this distance basically is called grip, and these are washer. These are washer to tighten the plates properly, and length will be from this to this. This will be the length. So, these dimensions are standard dimension.

So, for a particular diameter of the bolt, all other details are standard has been given in the code. Diameter to diameter means size of bolt is varying, and because of varying diameter of the bolt, size of other parameters will be going to be changed.

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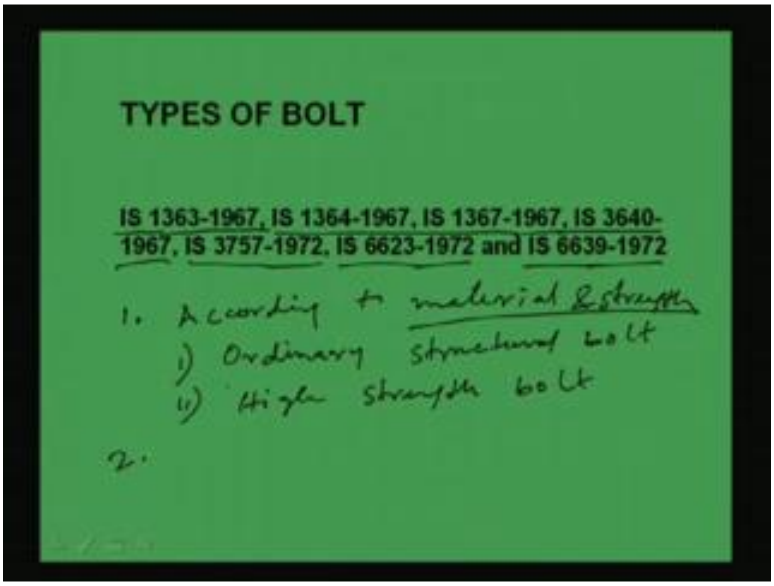

Now types of bolt. So, we will be seeing, now what are the types of bolt we used to provide in the connections? So, these details of types of bolts are given in this code; in many codes it has been given like IS 1363-1967, IS 1363-1967, IS 1367-1967, then IS 3640-1967, IS 3757-1972, IS 6623-1972, and IS 6639-1972. Different type of bolts, their configuration and their material characteristics and other details has been given in these codes. So, for details we have to refer the codes where the standard things are given.

Now type of bolt can be divided in different ways. One is according to the material and their strength. So, bolt can be classified according to material and strength. So, as per this one can classify that ordinary structural bolt. One is ordinary structural bolt and another is high strength steel bolt. So, in this way one can classify the bolt as per the material and their strength. One is ordinary structural bolt and another is high strength steel bolt.

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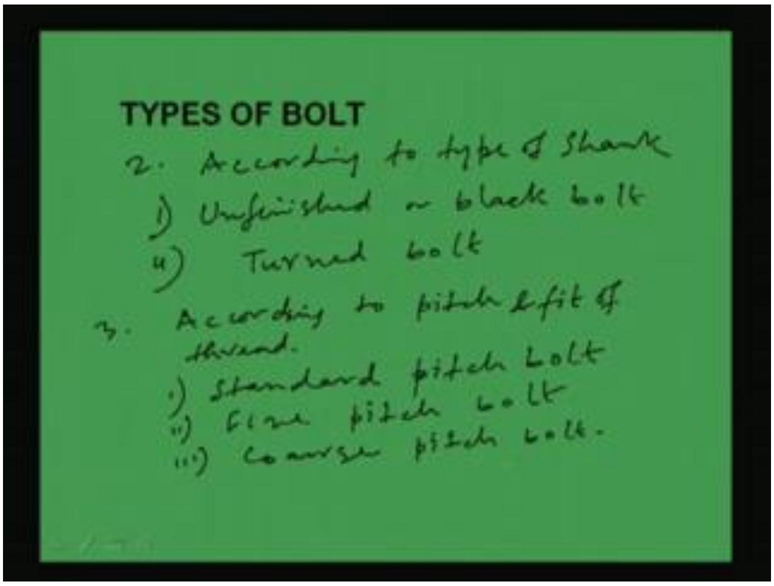

In another way also, one can classify that is according to type of shank. In this way also one can divide the bolt in two types. One is unfinished or black bolt, another is turned bolt. So, in this you also one can classify the bolts. Another way of classification is according to pitch and fit of thread. That is one is standard pitch bolt, another is fine pitch bolt, another is course pitch bolt. So, in this way also one can classify the bolt that is standard pitch bolt, fine pitch bolt and course pitch bolt.

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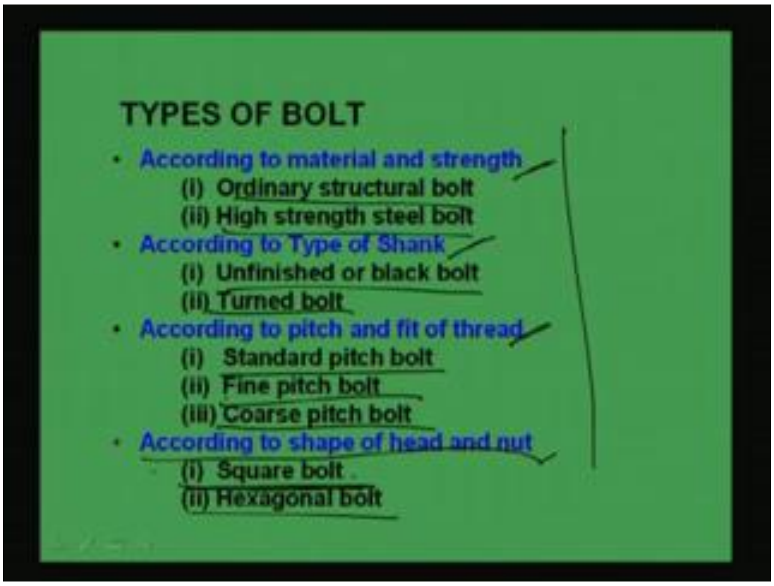

Another way of classification is according to the shape of thread and nut; that also can be classified which is called square bolt and hexagonal bolt. So, what we are seeing here that types of bolt can be categorized as per their different parameter like according to material and strength according to shank type, according to the pitch and fit of thread, and according to shape of head and nut. So, in case of material and strength, one can classify the bolt into ordinary structural bolt and then high strength steel bolt.

And according to type of shank, it is unfinished or black bolt and turned bolt. And according to pitch and fit of thread, one can make it as a standard pitch bolt or fine pitch bolt or course pitch bolt. Another way of classification is according to shape of head and nut; shape of head and nut means what is the shape of the head and nut. So, if it is square the shape is square, then it is called square bolt. If it is hexagonal, then it is called hexagonal means shape of the head is either square or hexagonal and nut also. So, in that way also one can classify.

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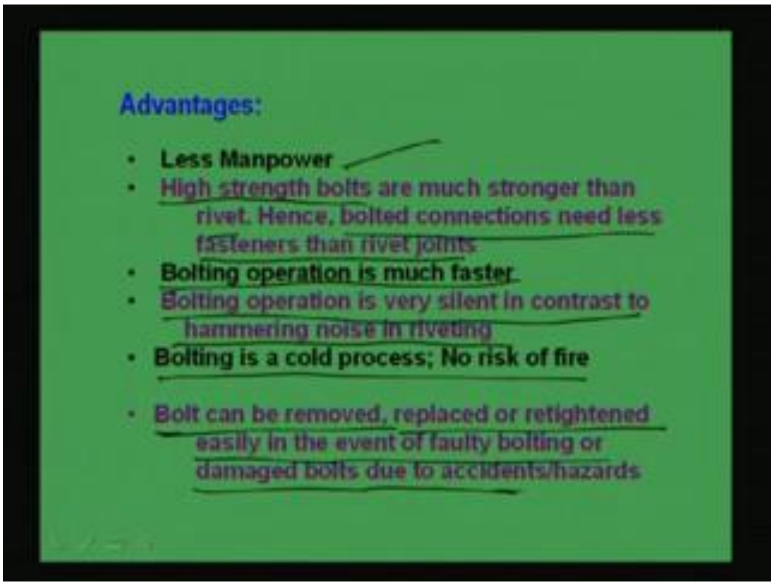

Now let us come to advantage and disadvantages of bolting. Now what are the advantages? The major advantage in bolt connection is one that is less manpower. Because manpower will be very less, because if you have the bolt along with the nut, then one can tighten the plates at this side very quickly, and there will be no requirement of other things like heating or like some hammering; nothing will be required, just you can tighten.

So, less manpower is the major factor in terms of advantages of the bolting connections. Another is high strength bolts means this high strength bolts are available and which are much stronger than rivet, okay. So, bolted connections needs less fastener than the rivet joints; that means because of high strength bolts, the number of fasteners will be less compared to the rivet joints. So, this is another advantage. And another advantage is bolting operation is much faster. So, very quickly one can join two members through the bolting operation which is very fast we can make.

Then bolting operation is very silent in contrast to hammering noise in riveting. That means in case of riveting, noise occurs due to hammering, but in case of bolting, this is very silent. So, this is another advantage you can say. Another advantage is that it is a cold process no risk of fire. In case of welding, risk of fires is there. So, as bolting is a cold process. So, this is an another advantage we can think, and the another important advantage is that bolt can be removed, replaced or retightened easily in the event of faulty bolting or damaged bolts due the accidents or hazards.

This is very important that bolting connections can be removed or replaced or retightened as per the requirement, and this can be done very easily compared to welding connection and riveting connections, because those connections are permanent in nature. But in case of bolting connections, we can change very quickly; we can replace the bolt very quickly. So, this is another major advantage. So, apart from advantage, we have to know what are the disadvantage because, otherwise, if all the advantages are there, then why we will go for welding connection or riveting connection.

So, let us see what are the disadvantages? So, disadvantage is that bolted connections have lesser strength in axial tension; this is important. Lesser strength in axial tension as the net area at the route of the thread thickness, threads is less. So, strength is less in case of axial tension because of the route of the tread thickness is less; net area at the root of the thread is less; this is one.

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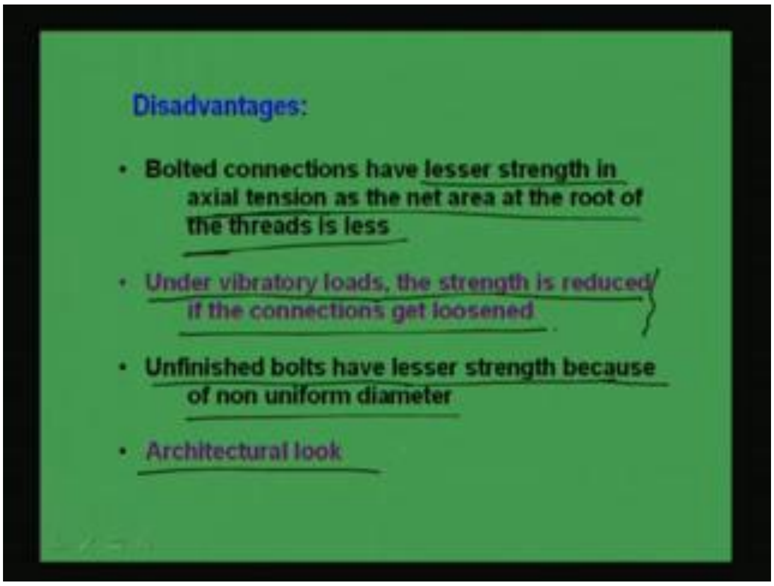

Another is which is very, very important that is under vibratory loads, the strength is reduced if the connections get loosened because of vibration the strength may reduce, because of vibration it will go to loosen the connection. So, for that the strength will be going to lose. So, this is important. In case of vibration, generally we used to avoid the bolting connection because of this; chances of loosening will be there unless it is tightened properly.

Another is unfinished bolts have lesser strength because of non-uniform diameter; unfinished bolts have lesser strength because of non-uniform diameter. Another important advantage is the architectural load from the aesthetics point of view, where the aesthetics requirements are there, then welding connections should be better, because in case of bolting connection, some extra mass, extra items are looked from the outside. So, to avoid that one can go for welding connection.

So, from aesthetic point of view, one can means find the disadvantage of using bolted connections. So, with this advantages and disadvantages, one can decide which connections we must go, whether bolting connection, whether riveting connection or welding connection, because three of the connections have their own advantages and disadvantages. As per the requirement at the site, as per the requirement of the design and as per the requirement of the structural type, we have to decide the designer has to decide what type of connections we will go, and accordingly he has to make it.

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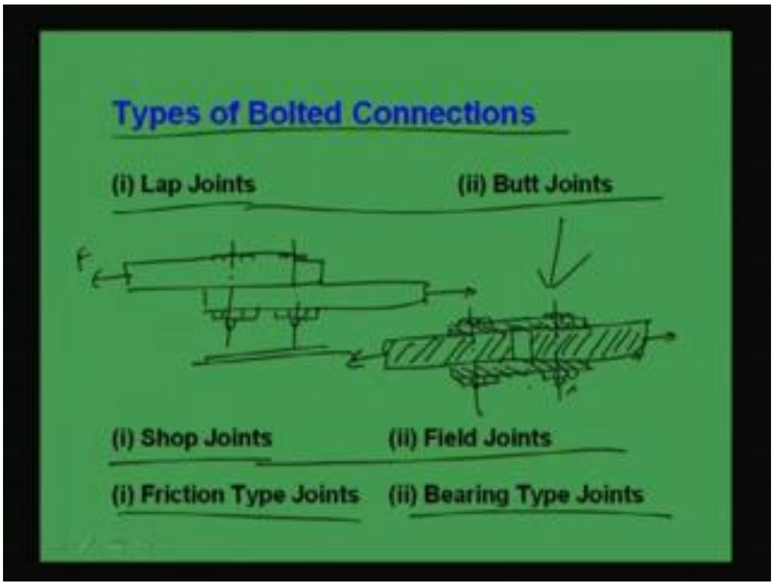

Earlier we have decided type of bolt. Now let us discuss about type of bolted connections. Now what is the type of connections through bolting we used to use. So, one is that we can connect as a lap joint or as a butt joint. This is one important connections, which through bolting we used to do. How it looks like in case of lap joint or butt joint let us see. In case of lap joint say two plates are left and, say force is acting like this.

So, bolt will be looking like this, and this is the thread. So, in this way one can see. So, this is called lap joint. In case of butt joint, basically two extra covers are used to give. So, this is one plate. This is the two plates which have been connected through butt. So, if we provide some bolting here, then it will look like this and here if we provide another bolt. So, this is called this is one plate. This is another plate which has been connected through butt, okay.

So, butt joint will be looking like this. Those two plates are joined through this extra plate, and bolting has been done here; two bolt per joint because of minimum bolt is required for this butt joint. Two bolt will be required minimum for the butt joint, and here one bolt is minimum and two also we can provide. As per the design requirement, we have to decide the number. Another type of bolt connections can be classified through whether it is shop joint or field joint.

Another is from the analysis we will see again that friction type joint or bearing type joint. If it is bearing type joint, then calculations will be accordingly. If it is friction type of joint, then its calculation will be accordingly, because way of action of the bolt will be different.

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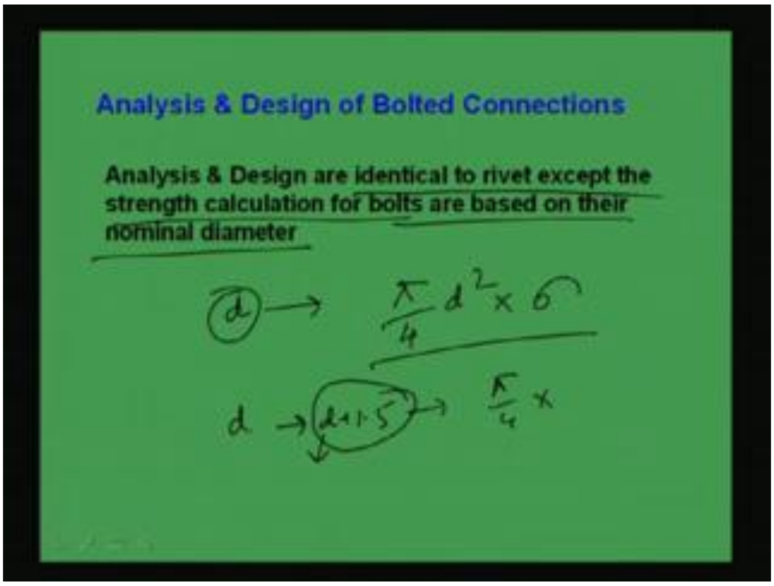

Now let us go to the analysis and design of bolted connections. So, as we told that analysis and design are identical to rivet except the strength calculation for bolts which are based on their nominal diameter. In case of bolt, we know the nominal diameter; what are the nominal diameter of the bolt? So, from that we can find out the strength, because the stress we know permissible stress in a particular bolt with a particular type of material. We know what is the permissible stress?

So, as per the permissible stress we can find out the strength as pi by 4 d square into the stress. Now in case of rivet what we used to do? That d becomes basically d plus 1.5, where d is the nominal diameter and d plus 1.5 will be the gross diameter, and accordingly we used to calculate the stress. So, these are the difference between bolted connections and riveted connection. Of course, the allowable stress in bolt and allowable stress in rivet is also different which are given in the code.

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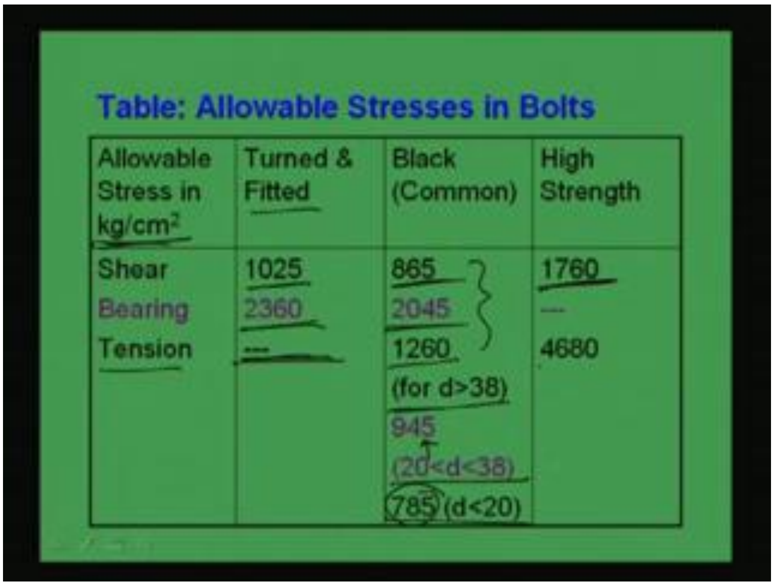

Table: Allowable Stresses in Bolts

Allowable Stress in kg/cm^2	Turned & Fitted	Black (Common)	High Strength
Shear	1025	865	1760
Bearing	2360	2045	---
Tension	---	1260 (for d>38) 945 (20<d<38) 785 (d<20)	4680

And earlier we have discussed we have shown what are the stresses for different type of rivets which are given in the code. Here I am showing in the table that what are the allowable stresses for different type of bolt and for different type of stress; like for turned and fitted bolt, the shear stress is 1025, and permissible shear stress for black common type bolt is 865. This is in kg per centimeter square. And for high strength bolt, the shear stress will be 1760 kg per centimeter square.

Similarly, for bearing stress the turned and fitted bolt will have this 2360 kg per centimeter square. And for black common type bolts, the bearing stress will be 2045 kg per centimeter square. Similarly, in case of tension, the black common bolt has 1260kg per centimeter square allowable stress whereas in case of tension, turned and fitted bolt does not has any contribution. Similarly, we can see that this stress the allowable stresses is if the diameter of bolt is greater than 38 mm.

But if the diameter of bolt is in between 20 to 38, then the stress will be 845; stress means the tensile stress. And if diameter is less than 20 mm, then the tensile stress in the black common type bolt will be 785 kg per centimeter square. So, these are given in the code from which we can find out and while designing we have to use this data for finding out the strength of a bolt.

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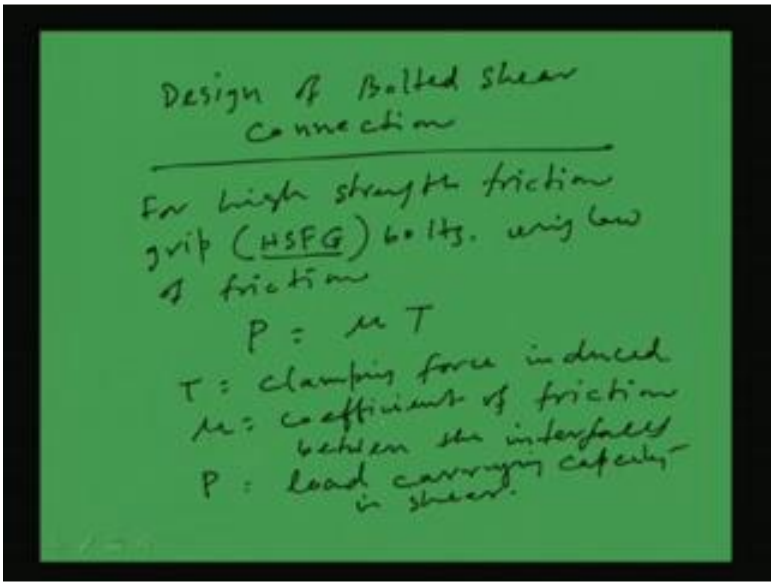

Now, say let us discuss about the design of bolted shear connection, how to find out the stress of the bolt and how to design it. Now for high strengths friction grip bolt, now onwards we will tell that HSFG high strength friction grip bolt using law of friction, we can write P is equal to mu into T. So, using law of friction, one can write P is equal to mu into T for high strength friction bolt, where T is the clamping force induced.

Then mu is the coefficient of friction between the interfaces. Interfaces means interface of plate, and p is the load carrying capacity of the joint in shear. So, t is the clamping force induced, and mu is the coefficient of friction between the interfaces, and P is the load carrying capacity in shear in the joint. So, in this way the P will become mu into t.

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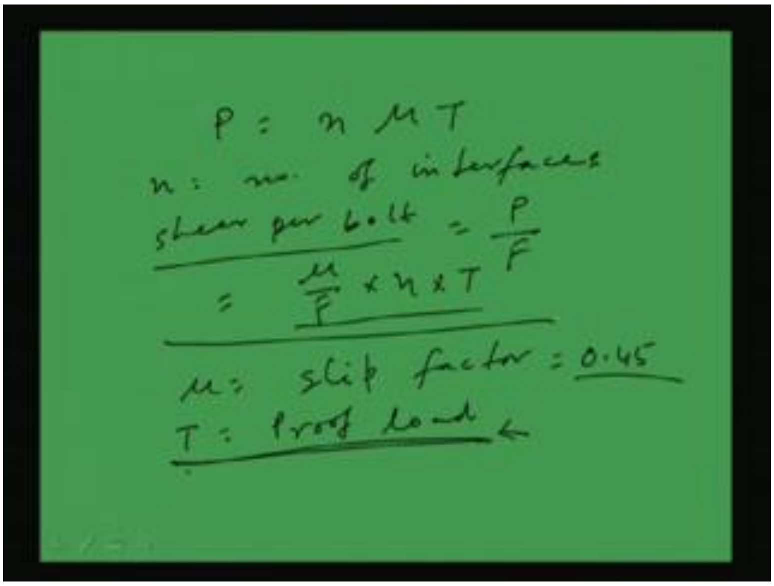

Now if there are n number of interfaces, then P can be made as n into mu into t, where n is equal to number of interfaces, okay. So, if I use a factor of, say T, then shear per bolt will become P by F, where F is the factor of safety. So, this I can write mu by F into n into T, right. So, shear per bolt can be made as mu by F into n into T, where mu is generally called as coefficient of friction, which is also called slip factor, which is taken as 0.45; in case of steel connections, we use to take slip factor as 0.45; mu is equal to 0.45.

Then T is basically proof load; T is called basically proof load. So, this will be the maximum permissible load in the bolt which is specified in the code. So, this can be found out the from the code means T is the proof load. Now for a particular diameter of bolt and for a particular type of bolt, this strength has been given in the code that par says 22 mm diameter of bolt, what is the strength that has been given by the code which is called proof load that is T. So, from these formulas we can find out, and we can find out the number of bolts required to carry a particular amount of load. So, this will be clear if we go through one example.

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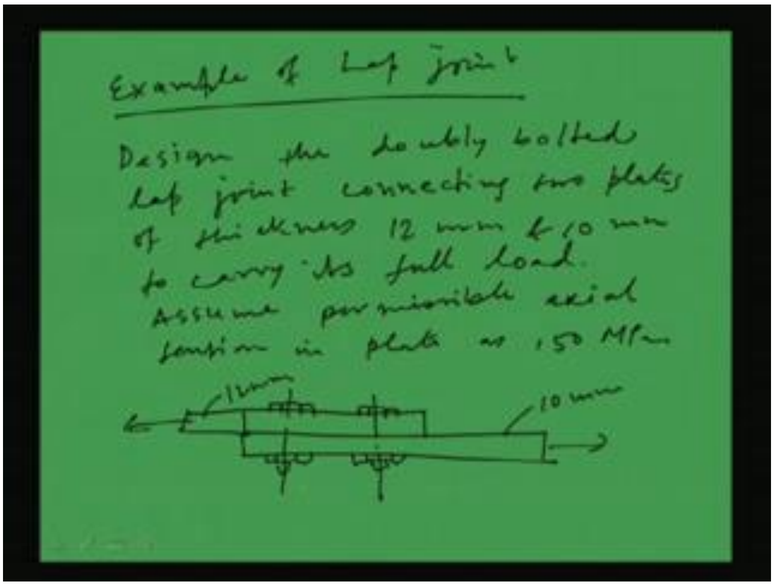

Say, first let us carry out one example of lap joint. Design the doubly bolted lap joint connecting two plates of thickness 12 mm and 10 mm to carry its full load. Assume permissible axial tension in plate as 150 mm. So, this will basically look like this that one plate. This is another plate. Say, bolting will be here, and this is another bolt. So, this is, say 10 mm thickness, and, say this is 12 mm thickness. So, this has to be found out the details of the bolting diameter and the pitch length.

So, now what we have to do is that first we have to find out the load carrying capacity of the plate. Plate means again we have two types of plates means two thickness. We have one is 10 mm thickness plate; another is 12 mm thickness plate. So, we have to go for the thinner plate thickness.

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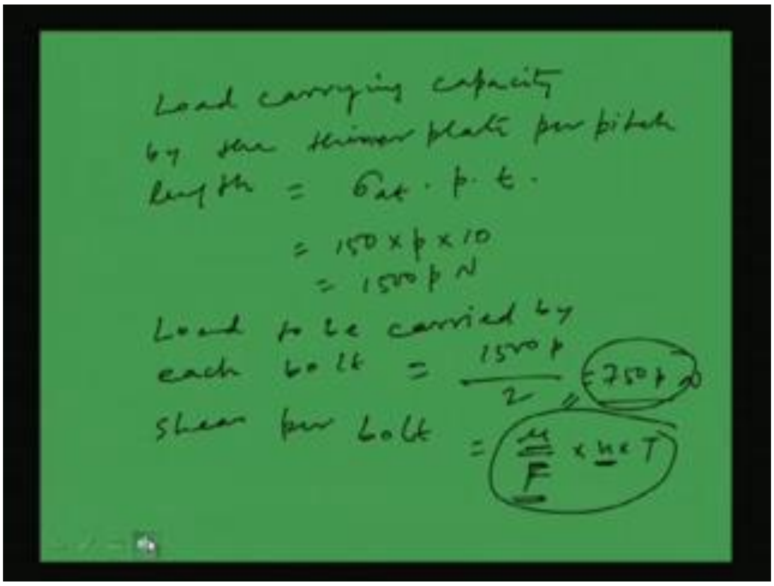

So, the load carrying capacity by the thinner plate per pitch length will be sigma AT into p into t. So, as in the question it is given that assume that permissible axial tension in plate as 150 MPa. So, I can find out the load carrying capacity as 150 into p into t is 10 mm thinner plate thickness. So, this is becoming 1500 p Newton. Now load to be carried by each bolt will be half of this because we have doubly bolted lap joint.

So, load to be carried by each bolt will be half of this 1500 p by 2, so 750 p. This is will be again Newton and shear per bolt will be as we have seen the equation that is mu by f into n into t. So, shear per bolt will be mu by f into n into t, where n is the number of interfaces and f is the factor of safety. Mu is the slip factor. So, to make optimum design, this two will become equal.

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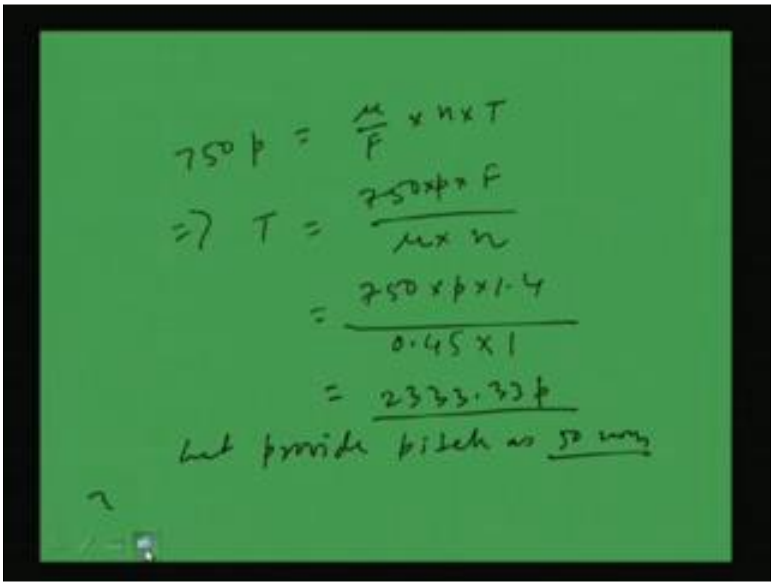

That means 750 p will become mu by f into n into t. So, from this I can find out the proof load t is equal to 750 into p into f by mu into n. So, this will become 750 into p into. Now factor of safety generally we use to consider as 1.4 in this case. So, 1.4 and mu we know for steel this is around 0.5 we generally used to consider. And n is the number of interface; in this case number of interfaces is 1. Number of interface means this is the interface. So, there are two plates. So, one interface will be. So, this will become. So, from this we can find out this is as 2333.33 p. So, the proof load t is becoming this one. Now we have to assume some pitch. So, let us provide pitch of as say 50 mm.

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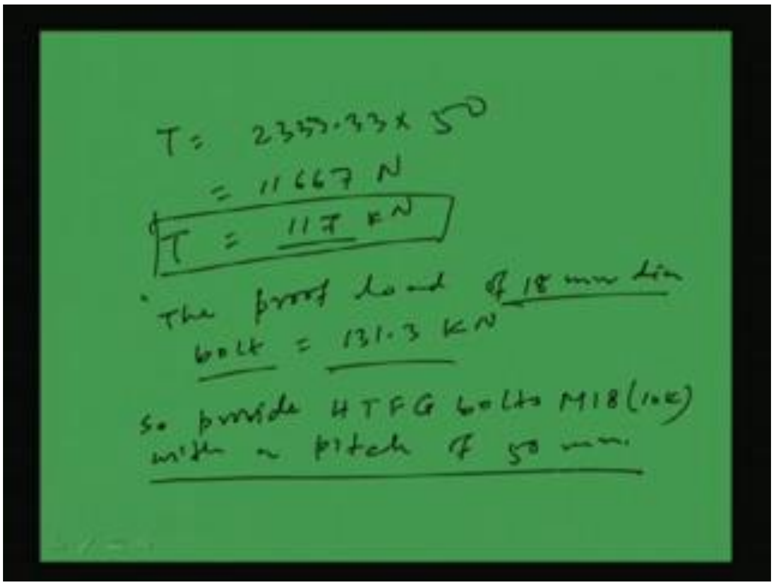

So, if pitch is 50 mm, then we can find out t as 2333.33 into 50. So, this will become 11667 Newton. So, this will become 117 KiloNewton. So, the proof load is becoming 117 KiloNewton. Now we have to find out this load which can be carried by the particular bolt. So, from the code we have to see that which diameter and what type of material bolt is taking more than this load. So, from the code in the table it is given the proof load of 188 mm diameter bolt 10 K bolt is taking as 131.3 KiloNewton.

So, what we see? That 18 mm bolt diameter can carry 131.3 KiloNewton load, whereas our proof load is coming 117. So, if we provide 18 mm diameter bolt, then it can carry. So, we can provide we can say that. So, provide high tensile friction grip bolt that is M 18, this is 10 K with a pitch of 50 mm. So, we can provide this. Now this is not the end of the design because we have to find out other details like what are the edge distance and other things we have to know.

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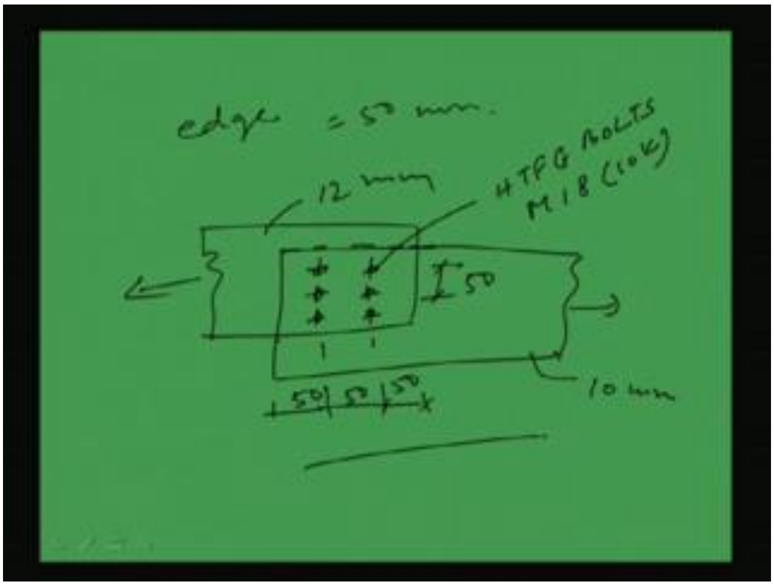

So, let us assume the edge distance as 50 mm also. So, then if we draw the diagram, it will look like this. Say this is one; say this is another one plate; say this is 12 mm; this is 10 mm. Now per pitch we have found. So, only thing we have to find out the distance; that means this distance is 50. This edge also we are taking 50. This is also we are taking 50, and here also we are taking, say gauge distance as 50. So, this is how the design will be and we can write that HTFG bolt M 18 10 K. So, in this way we can draw the thing means diagram will be looking like this.

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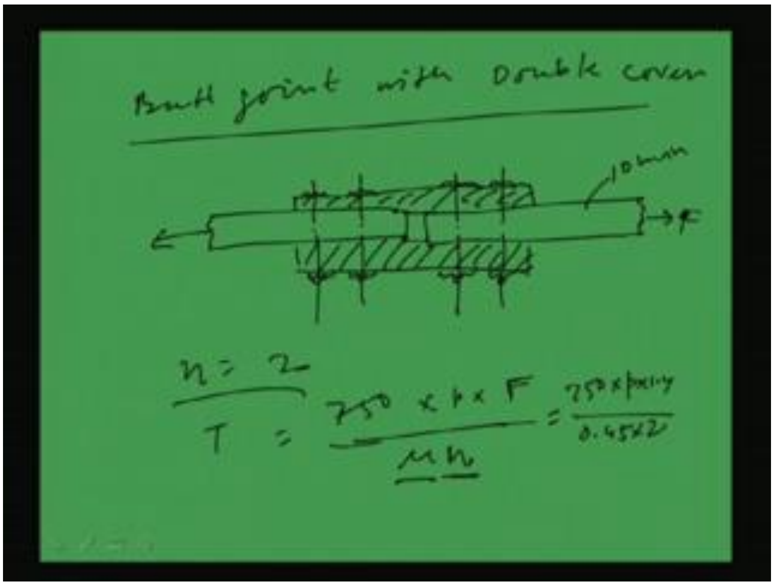

Now let us design the same plate considering butt joint with double cover, right. Now in case of butt joint, what will happen? So, it will look like this. Let us assume the plate thickness of two plate is same, right. Say, one cover is given here, another cover is given here and say two bolt is given per plate. It is a thread. So, this is one plate covered by the butt. Another plate here and these are the main plate.

So, here let us see what are the difference in this case. Here difference is that the number of interface is two; this is one. So, if number of interface is two, then the equation t is equal to mu means that 750 into P into f by mu n whatever we got in earlier case. So, in this case this n is going to change. So, this will become 750 into p into 1.4 by 0.45 into 2. So, in this case t will become accordingly, right. Another thing is. So, let us assume this plate is also 10, mm and this plate also is 10 mm. In this way let us make it, okay.

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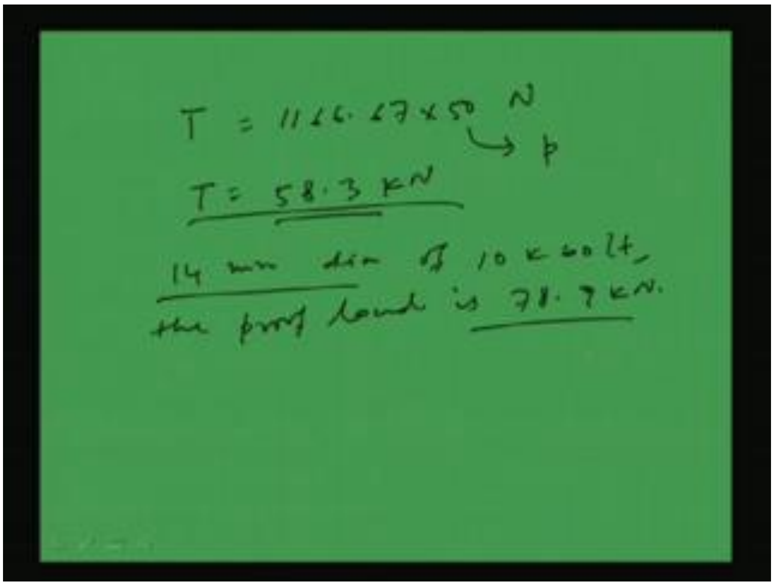

So, from this calculation we can find out t as 1166.67 into 50 Newton assuming the pitch as 50 mm. Means the same problem we are doing considering all other things same, except the plate thickness we are making same that is 10 mm, and the number of interface in case of butt joint will become 2. So, t is becoming from this as 58.3 KiloNewton. So, t is becoming this.

Now from the code we can find out that if we use 14 mm diameter of 10 K bolt, then for this the proof load is 78.9 KiloNewton, right. So, we need 58.3 KiloNewton to carry by the bolt, and if we use 14 mm diameter of 10 k bolt, then it can carry 78.9 KiloNewton, okay. So, we can do same thing using this diameter of bolt. So, if we draw the plate, this will look something like this.

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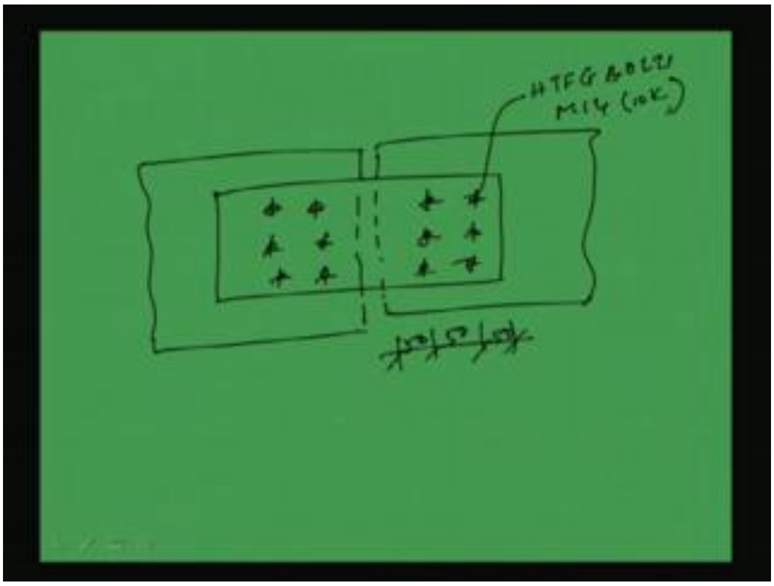

Say, this is one plate. Another plate is this. Now we have bolt, right. Now the pitch length and edge distance let us make same because we have considering accordingly. So, this we can make like this and this bolt will be HTFG bolt in 1410 K, okay. So, in this way we can draw the diagram. So, with this I think it will be clear to all that the bolting design and analysis is very easy, because it is almost similar to the riveted joint; only difference is that the nominal diameter is considered in case of bolt joint and in case of riveted joint, we used to consider the gross diameter which is nominal diameter plus the hole means extra addition diameter which is kept, right.

Now in this few lectures, we have seen that different type of connection can be used according to their advantage and disadvantage and according to the requirement of the site, the engineer can decide what type of joint they will go, and they can design accordingly. So, with this I like to conclude today’s lecture. In next lecture, we will discuss about the eccentric joint.

Thank you.