Farm Machinery
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Lecture – 23
Design of a Seeding Equipment : Part – III

Dear students, now we will discuss about the Design of Seeding Equipment Part-3 here. If I recall, we discussed in the previous design, we talked of the metering mechanism. As if I recall, I had told that in a seeding equipment what we have? We have the hopper, we have the seed metering unit, then the seed tubes, then the furrow openers and then the tube through which the seeds will fall.

Now, here in this section of the design, we will be talking of the furrow opener, the material of the furrow opener, the design of the furrow opener, the type of the shoe which is there And the forces which are coming onto these shoes and how to analyze these and how to design this, so that we can fit this. As well as if we know that the total size of the equipment will be a particular dimension, then we will also try to find out the frame on which these shanks or these furrow openers will be fitted.

So, what we will talk in this section is to there are two things to be talked of one we are talking of the tines or the shanks and the shoes, which are connected each which are there and then these are connected to the mainframe. Now, there will be they it depending upon the total number of such shanks or the furrow openers, the size of the frame will also be designed. So, we will start with first the shank or the shoes or the furrow openers.

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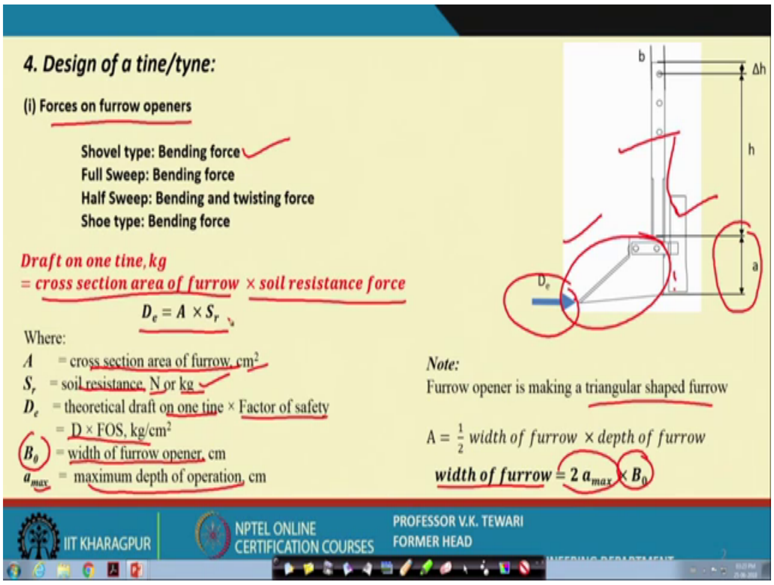

Well design of the tine, where many books and many locations you will find, we are talking of this as tines. But, then as if we are talking of tines, I had shown you earlier in a cultivator tine a double type of shovel type of tine. Here we are talking of the one, which will open the furrow and that is why the design is slightly different. You if you observe the design here, you can see here that this is the total frame over here and this is the portion which is of the shoe. This one is your seed tube, through which the tube comes and then the seed will fall here and the furrow is made.

Now, there are various dimensions of this particular tine. If I call, let me please permit me to call this as a tine, for the time being, just for the understanding part of it. So, this has a length a here, a height a here, a height h here, a delta h here, from the last point to the end of this. And they there is a location here, where we will see that the total draft which falls which is acting on this.

Now, what will happen, when the tine is moving into the soil, it will encounter these strength of the soil and try to open the furrow. And once the furrows are open the seed tube is carrying the seed and seed will fall. Now, the amount of load which comes on this, will determine what should be the size of this, what should be the dimensions of this. This is what we need to do, we will consider one at a time.

Now, let us see here, forces on furrow openers. Now, what are the different types of forces which come on to these furrow openers or the tines which we are talking of? The on the shovel the bending force, there will be a bending force coming into picture. Yes, it will try to bend because of the soil force, it will try to get, it will try to bend. Full sweep, then also there will be a bending; half sweep, now, these are the different types of furrow openers. Furrow openers could be of a shovel type, a full sweep type, a half sweep type, and shoe type.

Now, what will what are the forces which come on to these, actually we find that the shovel type will have bending force, full sweep also will have bending force, half sweep also bending and twisting also, because it is half, then shoe type will have bending force. Now, this will be there. Now, question is what type of the one which you choose for your design, but each one of them are facing this type of force.

Now, what is the draft? Draft on one tine, if we consider this tine into picture here what is the amount of draft? What is the you can say, when we are talking of draft here, we are all talking of the horizontal force, which is actually acting on to these shoes at this location. So, this is nothing but the cross section area of the furrow and the soil resistance force. So, this is the force, which is happen, because this furrow opener is moving ahead and then creating a furrow.

So, it will take care of all these soil forces, which are encountering in the process, and total volume is because of the area of the furrow. So, area of the furrow and soil resistance force, this soil resistance force is in the kg here. So, you can say the soil resistance force kg or Newton, whatever you can say and cross section area is this. So, then what is the draft that you get? The draft is see cross section area is this much and soil resistance is this force.

So, the theoretical draft for on one tine using a factor of safety, we need to add a factor of safety always, because then see we design that the amount of force it should encounter is something like this. But, then we have to have a certain value of factor of safety, to see that the it does not fail in the process, because there could be situations, where it may encounter a heavy load. And in order to take care of that, we should have a fairly good amount of factor of safety connected together. So, this D, then is D into factor of safety.

B 0 is the width of furrow opener. Now, what is the width of furrow opener? Well, this is not shown here, in maybe in the earlier in the next one, we will be able to show. And a is the a is here is the maximum depth of operation, this is what it comes. This is the one, which is the depth operation. So, in this depth operation maximum a, maximum is the depth operation, which we are calling a, value a.

Now, width of the furrow opener, B 0 is the width. So, if we want to find out the width of the total furrow, then 2 a max into B 0, because it is nothing but the area under that when the shoe is moving. So, when this particular shoe or the sweep is moving inside, what is the total area? So it will be nothing but half base into altitude, it is just like a triangular shape, as it has been said here. So, the width of furrow is this. So, we get the draft on one, which is in kg is given by this here right.

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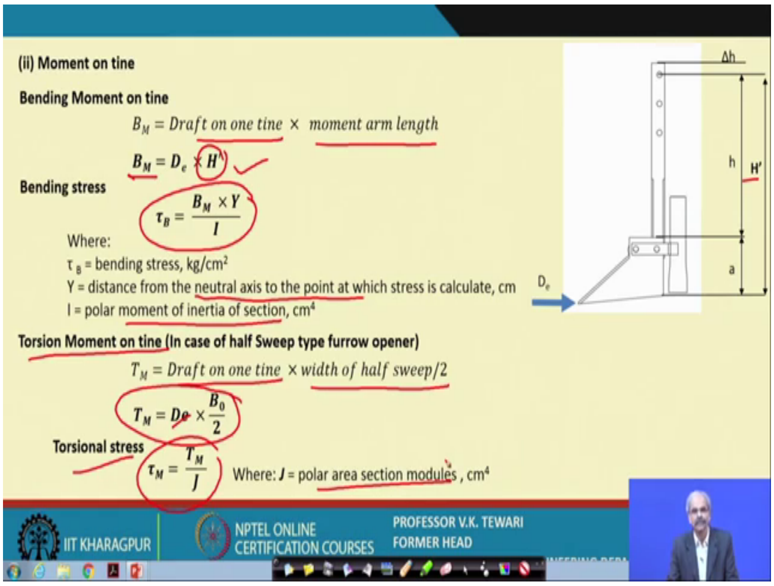

The moment on tine; now, what is the moment, which is coming on that? It will try to when you say bending moment, because it will try to bend, we have said the bending stresses will get it will try to bend. Now, what is the bend? Draft on one tine, draft on one tine into moment arm length, definitely this will give us the total value, we have which we have taken here H dash, which is h plus this a. So, this is H dash here. And D is the draft, which we had got earlier. So, the total bending B M is given by this.

Now, what is the bending stress? So bending stress from general machine design formulae, you will be in a position to get this particular formula, which I need not to explain much into details, because all these you have undergone in different course elsewhere, where I is the polar moment of inertia of this section, which is considered.

And Y is the distance of the neutral axis for the point at which the stress is calculated well.

So, the torsion moment; now, what is the torsion moment on to the tine, it will try to twist this. So, what is the torsion, which comes? Draft on one tine into width of the sweep, so because it is at the it will act at the centerline of that and that is why, width of sweep by 2. So, this comes to be this value, where D is the draft on one tine and B 0 is the width, so B 0 by 2 here.

And so, at the torsional moment, then T M is given by T M by J or J is the polar area section modules. So, what we get in this design is important with respect to finding out how much is the what should be the strength, what should be the material of construction of this, that is why, we have considered each aspect of the bending and the twisting moments, which should come. Now, once we know about the bending moment the twisting moment, how do we go to an equivalent stress, which is coming under or equivalent moment or the equivalent total stress, which will come on to the particular shank. This particular item, when we consider both these aspects.

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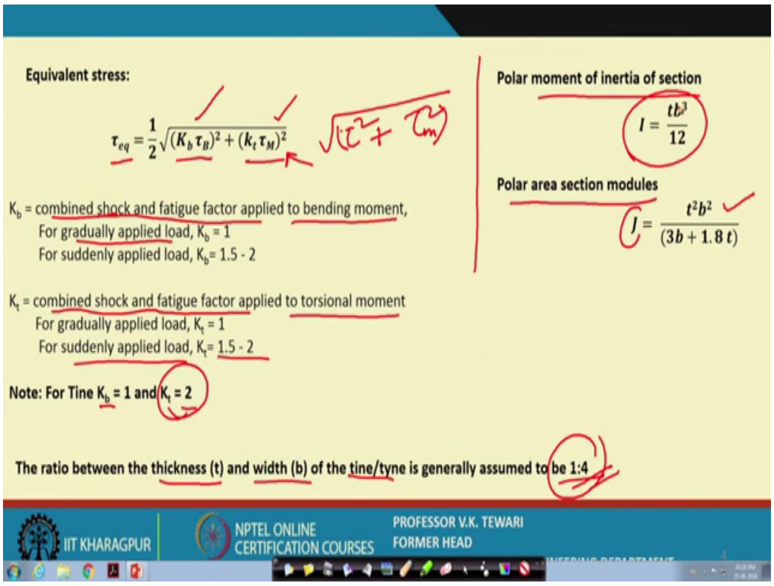

Well, so, then the equivalent. So, what we get equivalent over here is, we get the equivalent here, this and this; one is for bending, the other is for twisting moment. So bending and twisting moment now, if you go back to the machine design, you will find here, when we used to design these shafts, there are certain considerations which need to be looked into. For example, see the combined shock and fatigue factor also comes into picture, because sometimes the if the shaft is a stationary, there is one case when the shaft rotates, there is another case, you might have learned this in a machine design.

Now, taking a clue from there, then this equivalent stress is given by K b times bending and K t times the twisting moment here. What are these K b and K t? K b is the combined shock and fatigue factor applied to bending moment, then K t is the combined shock and fatigue factor applied to torsional moment. Now, these values generally when gradually applied load, when the load is applied gradually, K b is 1 and this K t is also 1 and that is why, you may find in many of the books that this is simply, in fact, instead of this, it will be simply like this that tau B square plus tau M square, that is all.

But, we have kept this, because we want you to have a clear idea about, what exactly is the load coming onto that. We can consider a cantilever beam and the situation is that to it is the shank is fitted to the frame, and this side is the force, which is connected which is acting on to that, where the soil forces. And that is why we wanted you that you must have a clear idea about the total stress, which comes on to the member.

And these K b and K t, in fact in sometimes when we are talking with respect to certain loads, and it is possible in some of these soils, it is possible that we may get certain loads are there. In that case, K t can be taken as 1.5 to 2. We can take for a safety purpose, let us take for safety purpose, we can say that K t can be taken as 2 here, and you can use this.

Now, there are other things say for example, we are interested to find the thickness and the width b, because the we would like to find out what is the thickness t, and taken a width of the time, these are important. Generally, these are assumed to be in the ratio of 1 is to 4. Now, one would like to know, why they are such. If you go back to the design machine design, you will find that the members, who which are under such loading of bending and moment bending and twisting moments, as well as the ratio of length total length to the diameter, there slenderness ratio.

So, considering these, you will find that these t and b are generally in the ratio of 1 is to 4. When certain other formulae I have written here, for your information, it is about the polar moment of inertia of the section, which is given as this, were t and b. And polar section area section modules which is J, which is given as this. Now, we are talking of these t and b over here, when we are thinking that what should be the diameter sorry what should be the thickness, and what should be the width of the members, which we are considering for the design.

So, we have seen that, we started with this shank, the portion of the shank, the portion of the shoe, then what are the forces which are acting when these soil is when the sweep is moving inside this. And then, we are talking with respect to what are the different types of twisting and bending moments come, and how we take an equivalent stress with respect to these two and try to find out the values of these, which will help us in actually finding out what should be the thickness of the material, what should the total length h and a, what we have shown earlier to you, and the thickness b.

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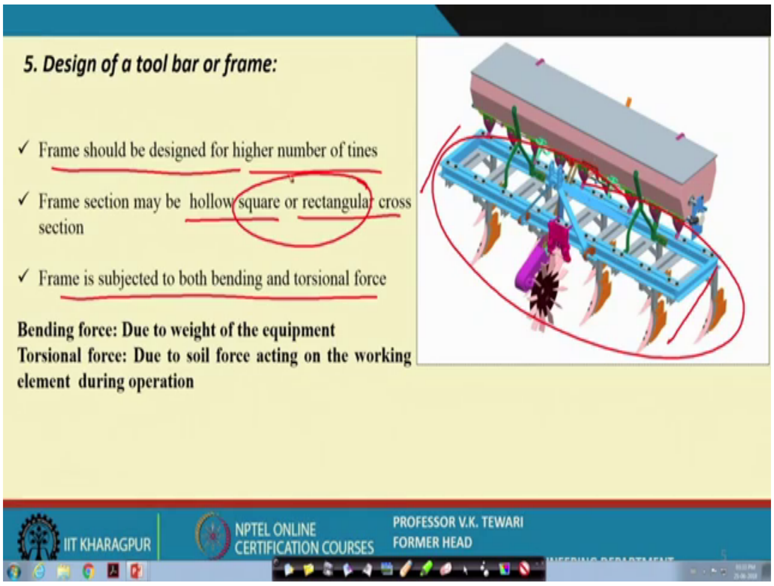

Now, the tool bar. This is see we just talked of the tines there, we have taken care of that what are the forces coming on to that, and what should be the values of the thickness and width. Now, where this will be fitted? As I said that these will be fitted on to the frame. So, what should be the size of the frame, what should the design of the frame, this is very important. So, the frame is shown over here, this is the frame here, which is shown to you.

Now, this is designed for number of tines, higher number of tines. Generally, which you might have seen by now that the tines, which we are talking with respect to either cultivator or we are talking of sea drills or these we talk with respect to say 7 tine cultivate, 5 tine cultivate, 9 tine cultivator like this. And accordingly, when we are talking of sea drills, accordingly we are talking same thing with respect to these as well. And therefore, if there are the number is says 7 and 4 are in the rear, and 3 are in front, then we will design for 4, because we will see that is the maximum value.

So, similarly that is what is written here, that the frame should be designed for a higher number of tines, which we are thinking that will be fitted onto that, because this also talks of the total. Because, you can see from here to here, it also talked to the total width of that, which will be actually trailed behind the tractor, I mean it will behind the tractor particularly when it is main operation, otherwise definitely these are mounted equipment. So, they will be in lifted form with a 3 point linkage design.

Now, frame is subject to both bending and torsional(yes, definitely. Generally, the section of these frames are hollow or square or rectangular cross section. Well, we have seen then needless to explain over here that with respect to the designs. We find that hollow, square or rectangular cross sections are still giving us a fairly strong frame, and that is why, we pick up any one of this.

Now, we how the bending force is come? Well, it has already we see, bending forces is coming because of the weight of the equipment. And then, the torsional forces are coming because of the soil forces total soil forces, which are coming into all the tines, which are there, all the shoes, which are there, while the whole implement is going, say it is a say, we are talking of the 7 tine or 9 tine, so you will find that all the 9 tines are moving in this soil and at a certain depth operation. We are maintaining a certain depth operation, while we are want the seed to be shown. And therefore, the torsional forces are coming from there.

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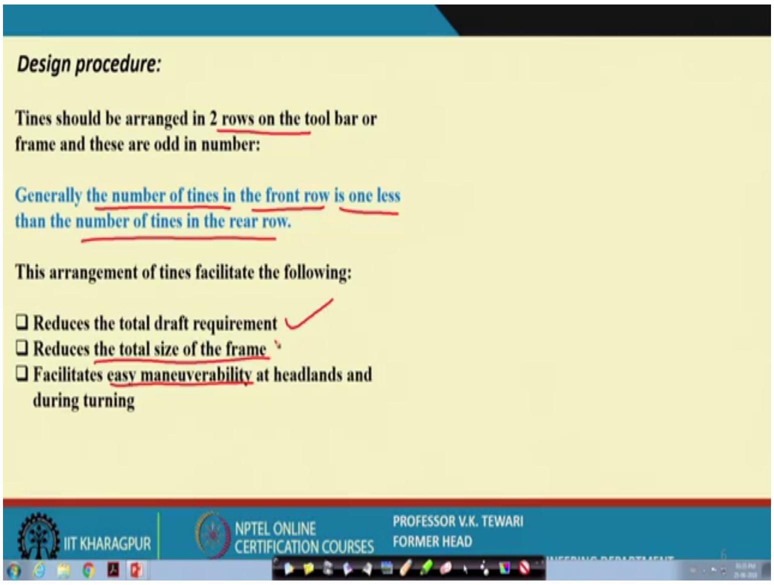

What is the procedure here? Well, as I said earlier that if you have the number of tines and in the power in the cultivator or in sea drills and all, so generally we like to put them in 2 rows on the toolbar, because they then you will be in a position to cover this, with the it has certain advantages. Generally, the number of tines in the front row is one less than the number of tines in the rear one. Yes, you might have seen this.

Now advantage here, what does it do? It has certain purpose behind this, reduces the total draft requirement. Yes, it reduces the total draft requirement, instead of having longer one. Then facilitates easy maneuverability, it facilitates easy maneuverability a head at headlands and during turning; true, and also reduces the total size of the frame, because then if you have all 9 or 13 or 7, I mean one row, then you find the total width has increased.

So, in the from aesthetic point of view also, you can think of from the maneuverability point of view, and most very important importantly is the headland management, because you lose lot of tine, and hence you your field efficiency will come down. So, therefore, it is very important what where they should be kept. So, it is said that, these are generally on the toolbar, they should be kept say one less than the rear one. Say if you are talking of a 7 tine, then 3 will be in the front, and 4 will be behind like this, so we.

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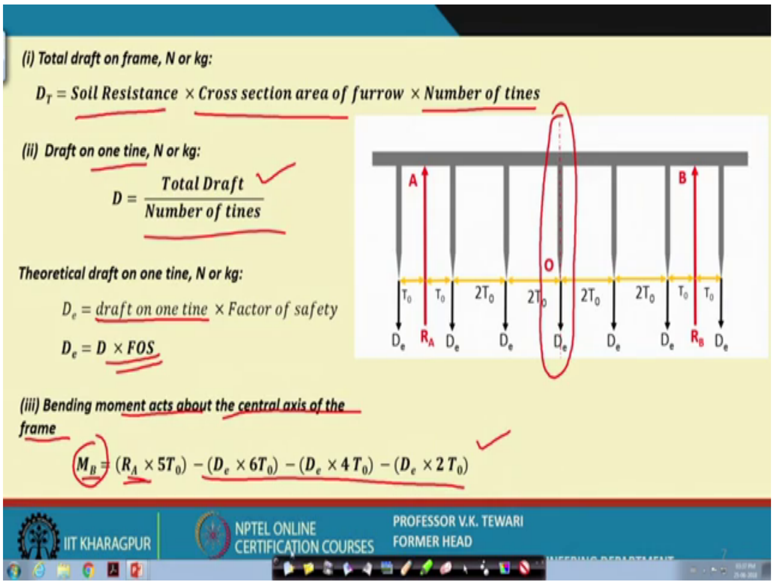

So, now on the frame, then you see here total draft on the frame, what is the total draft or total force, which is acting on the frame here? We can see that we can see here that all the tines 1, 2, 3, 4, 5, 6, 7, these are given here. Now, we are talking of a central line. Now, you can see that this is the one which we are looking over the centerline. So, the total draft is soil resistance into cross section area of the furrow into the number of tines. Yes, this is what is the total draft.

Now, draft on one tine. What is the draft on one tine? Total draft divided by the number of tines. Yes, very simple as that if you know the total, you can find out. Then the draft on one tine is we have already found out with this for a certain factor of safety, we found out earlier D e.

Now, what is the bending moment acting about the central axis of the frame? Yes, bending moment acts about the central axis of the frame. So, what is this? If you take moment about this point here, what you are getting? Then the bending moment M B is even R A, where R A is this here. So, with respect to this, you will find that 5 T 0. You can find 2 plus 2 4 plus 1 5, so 5 T 0 here. And accordingly, D e and T 0 D e, T 0, these will be acting in the other direction, because this is acting in this direction, and these are acting in the other direction. So, total bending moment acts about the central axis of the frame, and is given as M B is equal to this minus this. This is very simple. If you simple work out, you can get the values. So, you are in a position to get the bending moment about the central axis given here of the frame.

So, now we have understood that what will be the frame. Next point comes into picture as what will be the material frame. We have talked of the cross section of the frame, and we said that hollow or generally hollow either a square cross section or rectangular cross section etcetera. And now, we are talking of the total the draft which comes on to this or the force and the moment, which is coming on to the bending moment. Now, let us go ahead and see what are the other forces which come into play.

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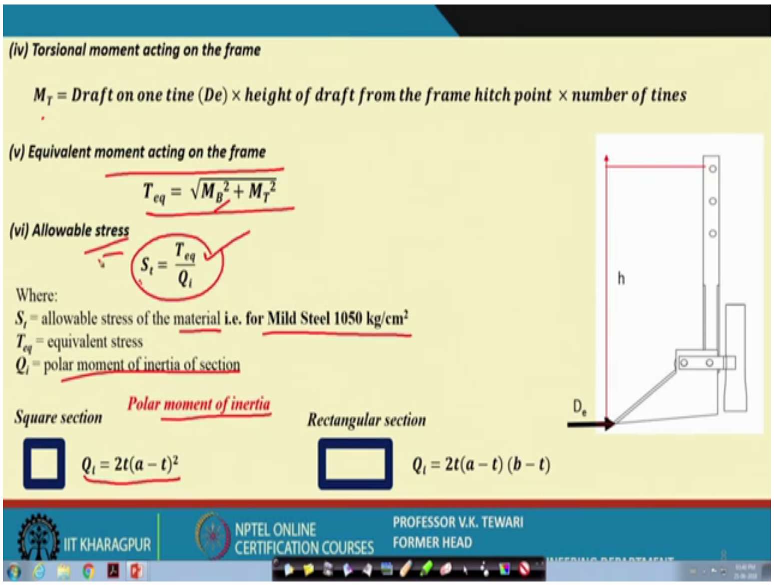

Yes. So, like the same this is the when in bending comes on to these shoes, and twisting comes on to the shoes, these are connected to the frame. So, those will be definitely transmitted to the frame as well. And therefore, we can say that the equivalent moment acting on the frame is simply this. We have we have put this M B square and M T square we are talking of bending and torsional.

Allowable stress is given by this here, these are all taken in fact you must know that these are all taken from the standard machine design books here. So, for any this thing, you can refer over there. So, the allowable stress of the material, we generally use mild steel is 1050 kg per centimeter square here. And Q is polar moment of inertia of the section. Therefore, the allowable stress S t is given by T e q by Q i, so with respect to the frame over here. And now, what is the detail dimensions of the frame? Now, the when we are talking of the section, we are talking as I said earlier that we can have either a hollow section, whether it is a square section or rectangular section.

If you have a square section that what you get? Q i, the polar moment of inertia you get like this, where a is the side, and t is the thickness of the material. Similarly, if you get rectangular, so a and b are the two sides that of the rectangle, and t is the thickness. So, a minus t, b minus t and accordingly you can get the total area of the polar moment of inertia of this particular section which you require and then you can get the allowable stress here. So, you are in a position to get the total design of the frame; total design of the frame.

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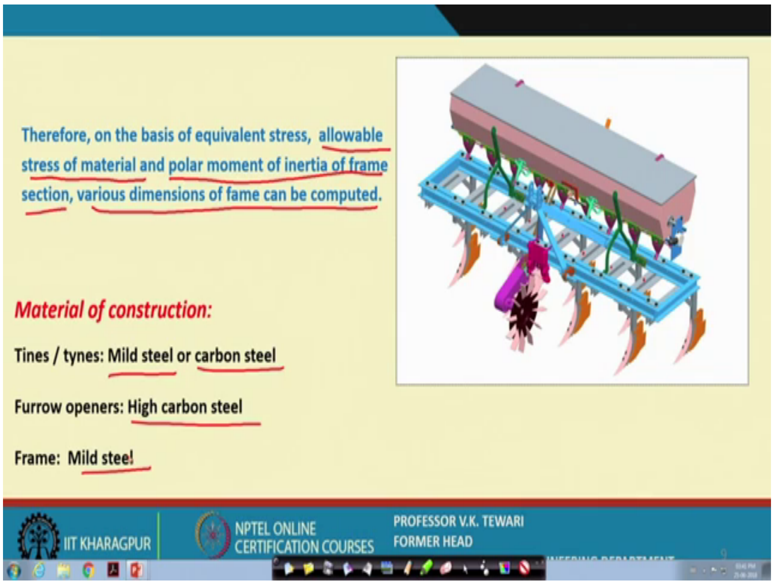

Well, therefore, on the basis of the equivalent stress well, allowable stress of material and polar moment of inertia of the frame section various dimensions of the frame can be computed. Yes, as we discussed there it is possible to find that what should be the dimension of this, what are the in between in fact we the what are these which should be also taken care of, if it is a rigid one of it or it is a spring tine one that those things also come into picture. But we are not talking of that at this point of time. Let us assume that once you select a frame or you get a frame, you will be in a position to get these things.

What is the material of construction? Well, what are the different materials of construction? We discussed all designs right from the beginning. And we find that the tines mild steel or carbon steel because they need to remain strong there. Then furrow openers high carbon steel they can because there scouring will take place, and they will be all with the soil. So, the idea is that they should be lasting for a longer duration of time; otherwise then you will have to change quite often.

And this will warrant cost on the part of the farmer. And the frame is mild steel frame. So, these are the general material of construction for such a frame. So, we have what we have discussed is we have discussed about the tines, we have discussed about the shoes, we have discussed about their designs, we have discussed the forces acting on that furrow openers, then we have talked of the different frame on which it has to be there. And the arrangement of this whether it will be the front or rear, why front less than the rear ones, and then what should be that width etcetera and then ultimately how do we find out the dimensions of the frame. So, this is what we discussed in this section of the design of the equipment.

Thank you.