Farm Machinery
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Lecture - 09
Laboratory class on traction and tire testing

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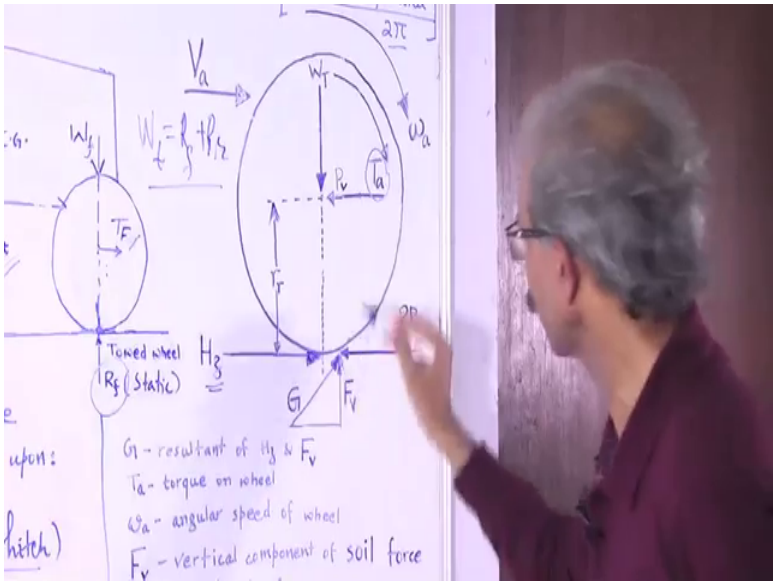

Dear student. So, far we have discussed about the different types of implements which are connected to the tractor. You have also seen the operation of these into the field and in the course of the lectures I have discussed about what are the forces which are coming on to the tractor with respect to the soil and its operation.

Now, we will like to clarify certain other things, you might have seen that we talked of the weight transfer in the class. I would like to explain more in details this juncture and also I would like to tell you that how we get maximum power from the tractor. Actually it is because of the tractor wheel whether we are talking of the front wheel or the rear wheels when in case of a front two wheel drive we are talking with respect to only the rear wheels when we talk of the front four wheel drive we talk of all the four wheel in which power is given

Now, let us have a look at what it is when the condition of the tractor is a simple static condition.

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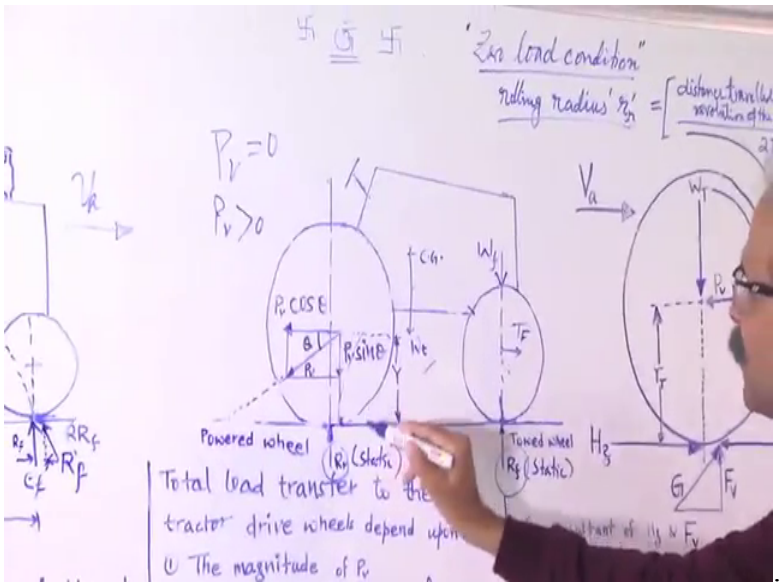

I have already explained this, but I would like to draw your attention at this point that in the static condition. We do have the C G weight of the tractor over here then the reaction of the front and reaction of the rear.

Now, here I have just shown force P v here now in case of a static situation, we have this P v is equal to 0. So, when this is 0 what we get is we get simply W t which is equal to R f R r plus R f now. The moment we have this value when P v, P v is greater than 0 and it had some value what will happen? There will be change in this and in that case then the value this particular R r will not be acting. It will be acting at some other location. I will just give an examples see it will act at slightly angle at this point with respect to the rear wheel and at this point in case of the front wheel.

Now, coming back to this so, what will happen is the moment there is a change in this because of this P v is P v greater than 0 we will have a weight transfer. So, what is the amount of that weight transfer? Well before we go into the details I would like to tell you what are the factors on which these weight transfer depends. See it depends on the magnitude of P v that is the value of the P v which is there, then the distance height, height of reach at what point we have reached whether at this location or at this location. Which has been shown this is the height Y or this is the height Y here.

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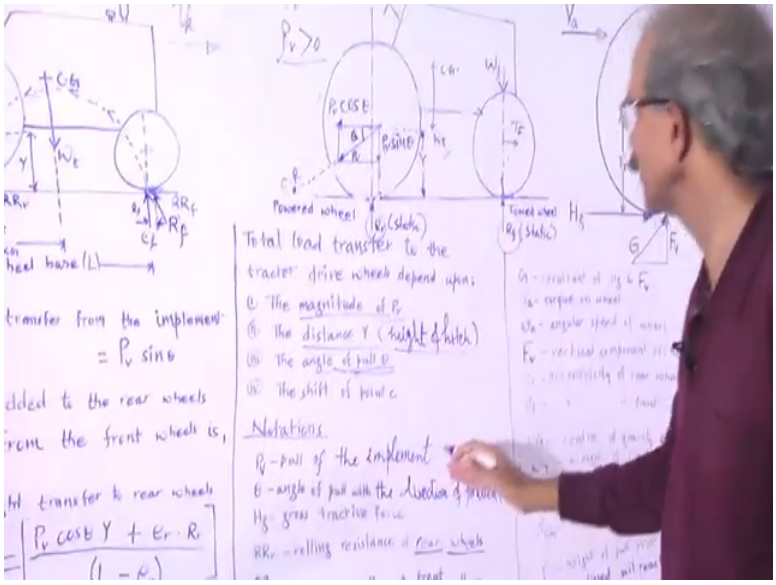

So, where we have reached is very important then the angle of pull or the angle at which it is hitched. Now we know that line of pull because line of pull is the line where if we consider somewhere here is the centre of resistance of the implement then this is the hitch point although in case of the three point linkage hitch this will go somewhere else, but I have told you in the class that this can come below the transmission somewhere below the transmission we actually we would like to assume here not the virtual hitch point

So, the line joining C R and the hitch point is the line of pull. So, at this line of pull if this is the force P v then the horizontal component of this which is P v cos theta will be the draft which we see and P v sine theta will act here at this point

Now so, it is very important that this angle is to be taken care off with respect to the implement and this will vary depending on the type of the implement which has been attached to this shift of point c of course, depending on the soil condition and depending at the speed of operation etcetera. This value this point c actually a point c is here as I showed here initially in case of the static this is c is not here c is not any other place, but it is exactly below the centre line of this, but the moment there will be a low transfer it will shift to this place which has been shown in this particular figure over here. So, this low transfer will depend on these.

Now, let us have some notations which I have given in this P v is the pull of the implement. Why we have written because the these all we are considering in the vertical

plane. So, P v talks of the pull of the implement in the vertical plane theta is the angle as I told you earlier and H g is the gross traction force. This H g force is shown over here in this diagram H g is the gross traction force because the moment P v is greater than 0. We will assume this condition of the tractor and not the static condition this becomes the dynamic condition here. This is the dynamic condition and that case this will come into play

Then RR r rolling resistance of the rear wheels we will see here rolling resistance of the rear wheel. Similarly rolling resistance of the front wheel then the rolling reaction of the force on the wheels see reaction force on the rear wheel this is the reaction force R on the rear wheel this is the reaction force on the front wheel. Which was in case of a static it was simply R f and R r which we have taken and I said that in case of a static situation we have simply W t is equal to R f plus R r this.

So, and R r is the rolling radius this is important I had also to discuss this in the class, but it is important to show you to tell you and to show also in the actual situation I will show you. Zero load condition see, rolling radius of the tractor wire is. In fact, when you have a zero load condition; that means there is no load on the wheel. So, there the distance travelled in one regulation if the wheel is travelled for one regulation then the total distance covered divide by twice pi under zero load condition is the definition of rolling radius. It is very important one must consider this in the analysis of the mechanics of this forces when we are considering a tractor wire implement combination.

V is represent in the speed of the forward travelled when we have talked of this here and we are talking of here when the moment is in this direction. Similarly, when we consider this is a towed wheel in the front of the tractor is a towed wheel in case of two wheel drive mind you. This is a towed wheel where we have this force only which is pulling it and then this is powdered wheel. In case of a powdered wheel these situation here that we have a torque which is acting weight of the implement is definitely acting here and this pull and same time that this gross tractor force and the soil reaction force G which is here. Now we can see the details of this particular G is the resultant force of H g and F v here T a is the torque which is onto the wheel then w omega is the angular speed of the wheel this is the angular speed of the wheel which has been shown over here.

P v is the vertical component of the soil force. This is the vertical component of the soil

force which is shown over here. Then E r and E f as I have told you, here E f and E r these are the eccentricities in the front and rear C G is centre of gravity of the tractor. In fact, tractor chess is that we call at both the locations which I have shown here as well as this location here. Weight of the tractor W t which is shown already L is the wheelbase. Well this is the distance which is known as wheelbase I have already explained in several locations, again I described here that this is the distance wheelbase. When we are talking with respect to the centre distance between the wheel and centre distance between the rear wheels so, centre to centre distance between the two wheels the front and rear is the wheelbase so, this is what is given here.

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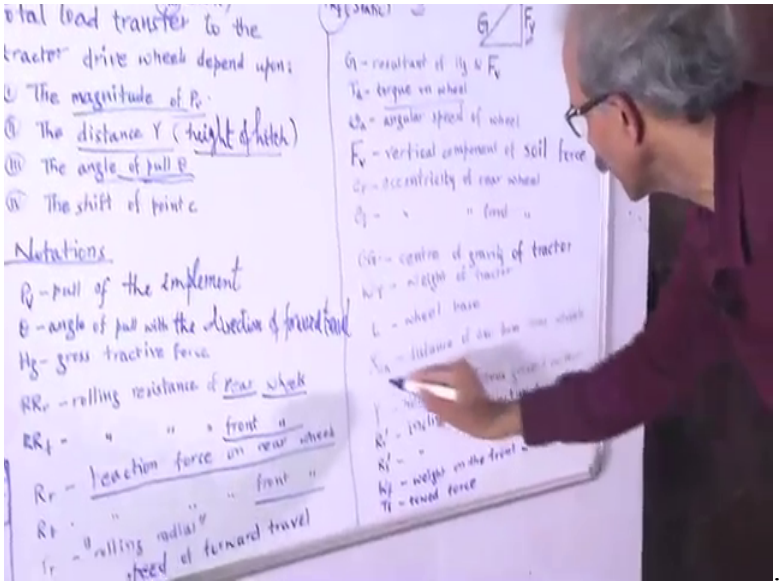

Wheelbase X C G is the distance of CG from the rear wheels this is the distance which we have got here X C G this X C G here which is the distance of CG from the centre of the rear wheel X C G is this then R r dash R f dash or. In fact, when we when we it goes into the soil definitely this R r will not be at the centre line of the wheel, but it will be at certain angle R r, R r dash in case of rear wheel and R f dash in case of front wheel. So, and that is why we get this eccentricities which I talked of earlier C f r front and C r for the rear wheel the weight of the front wheel where weight of the front definitely weight will be there whether weight of the front wheel or even weight come weight of the weight coming onto the into visual wheel which is described here.

Towed force yes this is pulling force because when there is the this tire the front one case

of a two wheel drive is a towed force simple force there is no torque we have also discussed you may recall that I have discussed about the different types of tires for example, the towed wheel I have discussed about a self profiled wheel I have to discuss about a powered wheel braked wheel etcetera we have discussed and I have shown you the instances as well as I have given example of where they are.

So, when we are talking of this weight transfer as I said I will come back to this; that means, we have weight transfer from the front because the moment P v is equal to 0. What happens that this R f starts decreasing. Now when R f is starts decreasing; that means, there will be a or there may not be a physical change, but definitely this there will be load or there will be a transfer of load from this side to this side; that means, from the front of the tire tractor to the rear and this value is given by if you take moment about this point then the value is given by this is the dynamic weight transferred to rear wheel this is the one which is from the front wheel.

So, in case of this is the amount which is transferred from the front wheel to the rear wheel by this dotted line. We have just show you just an idea that how this takes place physically it does not takes place mind you keep always remember that there is a no physical change, but yes actually it takes place and you see it how because when the tractor gets over turn the you will know the definitely it has happened lot of load is here and this has happened.

So, on that count we would like to tell you what is this weight transfer. So, the dynamic weight transfers of the rear on to the rear wheel to the rear wheel is this amount P cos theta into y which is this. When you take moment about this point this equation comes so, E r into R r and L minus R, because L is the total distance and minus this; because we have taken moment of this point here minus f.

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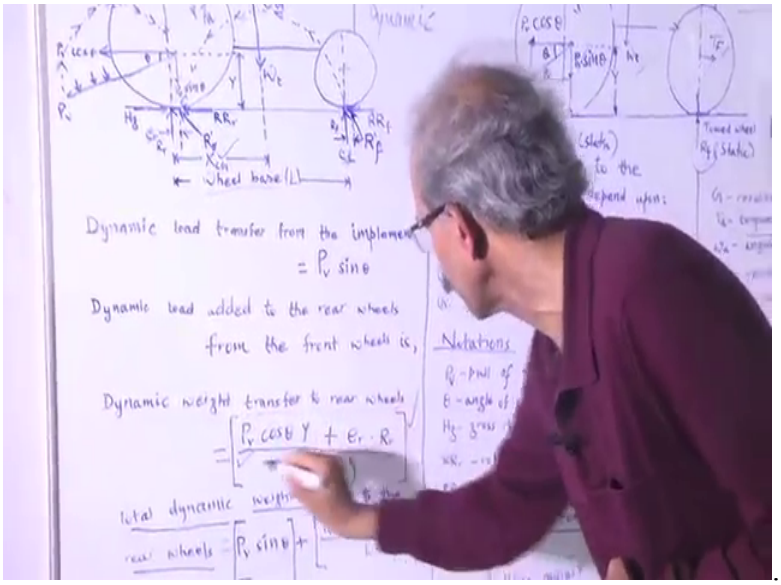

So, total dynamic weight transfer to the rear wheel is then P v sin theta because this is if P v is the force which is acting this line as I showed here also that P v cos theta is the draft which is acting in the horizontal direction and the P v sine theta acting downwards. Now this is the force which is because of the implement because of the implement is connected here. So, the total force will then come about this which is because of the front wheels and which is because of the implement. So dynamic weight transfer to the wheel to the rear wheels this is because of the front wheels and this is because of the implements. So, P v sin theta because of the implements. So, because of the implement this and this and add together we get the direct total weight transfer.

Now, this is very important to understand because ultimately the tractors this tire in case of a two wheel drive or in case of four wheel drive is the one which gives us the total pulling ability of the tractor. Now let us have a look at the tire what are those features of the tire which actually make this pulling ability enough or pulling ability capacity of this p and many tractor manufacturers have manufacture different types of tires and those tires with different types of their features which we will see in to the tire actually now and on the basis of which they also try to see that what a particular what type of tire what specification of a particular tire will be fitted for a 60 horsepower tractor or a 75 horsepower tractor or a given tractor. So, let us have a look at the tires.

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Well as I told you with the about the tire now look this is tractor tire rear. You have a look at this mark which is given on to that. This is inside the specification of this particular tire 13.6 into 28. Now this means 13.6 as I have already explained in the class as well as in the field that this talks of the section height or the section width many a times, we take same section height and section width same which is 13.6 in inches mind you and the 28 is the rim diameter 28 inches in the rim diameter.

Now, when if you want to find out the diameter of the wheel then we will have this 28 plus 13.6 plus 13.6 this we have been taking as a thumb rule. We ignore that up to a 20 percent delta by H which I have told you the section height. So, on that count we can take under normal pressure of delta by h is equal to 0.2 we can say that the diameter of the tire will be 28 inches plus 13.6 inches plus 13.6 inches.

Now, in some of the tractor tires there is a well a R is written can I write? R is written along with this now you the movement you see this you must know that this is a radial tire of course, I have explained to you that what is the difference between radial tire and a bias tire, but from outside if you want to understand you must just look for this number R which will talk that this is radial tire.

Now, what are the important features which actually help this particular field to generate so, much of traction it are these factors.

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These are the self cleaning lugs because when it goes into the soil the soil must also come out otherwise this will be filled up with soil and then this will not be in a position to pull. In fact, it will start slipping which I have talked of in the in course of my lecture itself.

So, we will just see these lugs are of different types in different tractors it is a based on the manufacturer what the manufacturer wants I will also show you different lugs and their sizes, but let us have a look at this particular one the total length of this is this is the length of this then the width of this and the depth is or height of the lug is this we can have a look at this value what exactly we mean by this I will show you.

So, if we just put this. So, this is the height it this is the height of the. So, this is the height of the lug. Now this height the length and the various features which are there or the actual designs of the tractor manufacturers and they claim their tractors ability or the wheels ability on the basis of this and lot of work has been done on the lug design, lug shape, features and the capability etcetera.

Now, we would like to tell you how we are in a position to tell what is the capacity of a particular tire, how much load it can take and to which particular tractor a given size of tire could be fitted for this we have a facility developed at the IIT Kharagpur. We call traction laboratory in this tractor laboratory we have a 80 feet wheel I will show you the wheel here.

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Well. So, as I said we have developed a facility in IIT Kharagpur which we call as a traction laboratory and say 80 feet traction laboratory total length in which we can have any type of soil. In fact, we have tested soils are or sandy soils which we have been brought we have brought from Rajasthan and in fact, you can test and you can keep any type of soil here measure the strength of the soil.

We have also developed the facility for measuring the strength of the soil. We can prepare the soil the way we want and then, we can test the capacity of a particular tractor tire in to this and this has been long work which we are doing for a long time and we have tested several hundreds of tractor tires manufactured by different companies.

Well we will not go in to details of those, but definitely I will tell you the procedure and in which way and what parameters we actually measure which way it helps us in actually deciding because as an engineer you would definitely like to know what is the capacity and which type of tire to be fitted to which type of or what size of the tractor. So, for that we have the bin I can show you the more details or all we have facility for the measurement of the speed we have facility for measurement of torque, we have facility for measurement of the sink age, we have facility for measuring the soil strength depending upon and then all these are automated. And directly when the tractor tire is being tested you can measure the pull also and then everything is recorded in the computer cell which is there and we can find out the values at any moment of time

So, I will discuss and show you the details of this facility here for the knowledge and

then we will talk of some more details of how the loads are carried by the wheels, but before I take you there I would also like to show you the different types of tires and their sizes of the lugs it will be of importance to you can have this information because this is not a any secret information as an engineer you must have a look at it.

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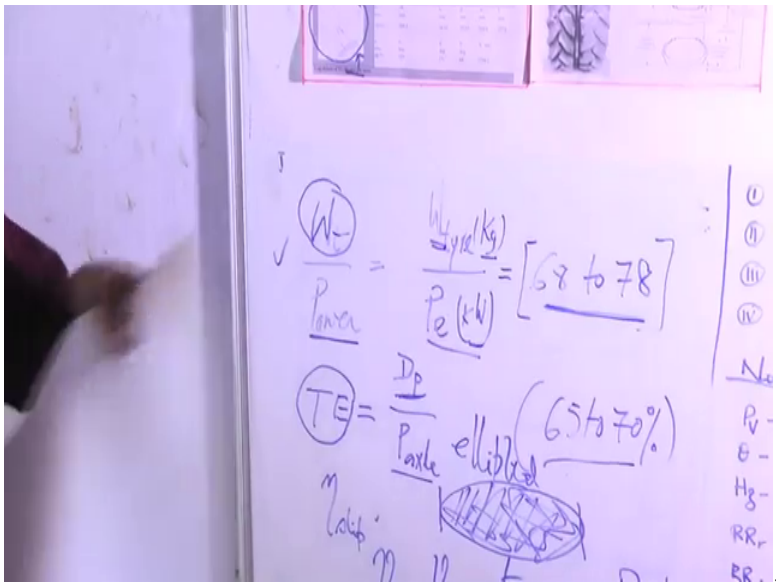

As I explained there about the lugs now have a look at the values of these lugs it is particular design of different types. We have shown you here different types of tires manufactured by different tractor tire manufacturers. We may not tell you about that, but we definitely want to impress upon you that have a look at the designs of this lugs have a look at the designs. These lugs which are given over here some of them are tires bias ply some of them are radial tires.

Now, what are the details of these of these lugs see a bias ply tire will have these details. Where radial ply will have these details and these are the important parameters which helps the tire to have higher and higher grip on to the soil. Now it is a different question that what will happen in which type of soil which needs to be investigated and lot of work has been going on in this aspect, but then manufacturers would always like to know what is the capability of my tire where this tire or this tire or any tire what is the capability of this.

So, by a thumb rule what we do if this is the total weight of individual tire here and the power; that means power of the engine if you know the power of the engine and we want

to know what is the capacity of our tire of the manufacturers tire. Then by a simple rule weight power ratio this is the weight of the tire and this is the engine if designated in kg this defined in kilowatt. So, the value if this value for somewhere between 68 to 78t we can find that yes the tire can be used.

But then there is definitely requirement of what is the actual print of this tire when it goes into the soil and that is more important and for that we need to find out the tractive efficiency of this that particular tire with this with the different types of lugs which we had. So, tractive efficiency this is given as drawbar power by axle power P axle means the tractors axle power

Now, this value varying to 65 to 70 percent we need to look into if the value of tractive efficiency comes somewhere. Here, we may see that yes the tractor is a tractor tire is in a position to fitted to a given tractor size; that means, the horsepower of that, but then for testing under the conditions which, I said on the traction conditions in under vary soil conditions vary compaction conditions in the soil which I will show in the actual working.

What we need is we need to know what is the actual velocity of the wheel when it moves, what is the theoretical velocity of the wheel when it moves and how much is the torque that is being applied onto the wheel when there is a certain weight on that what is the torque which comes when it is being pulled through a certain pull way pull force.

So, with these parameters we need to measure these under the laboratory conditions and on the basis of that we will know what is the print because we will then be in a position to find out for example, if I get some space here I will show you the general this could be the general print of a tire maybe that I will show you what exactly the print of a tire.

But then this is generally we have found that this is a elliptical in shape I have also told you in the class I can show you a detailed one which we have tested maybe if I show here. This is what exactly is that that this is the entire print of an actual tire we will not disclose the other details, but I can tell you that.

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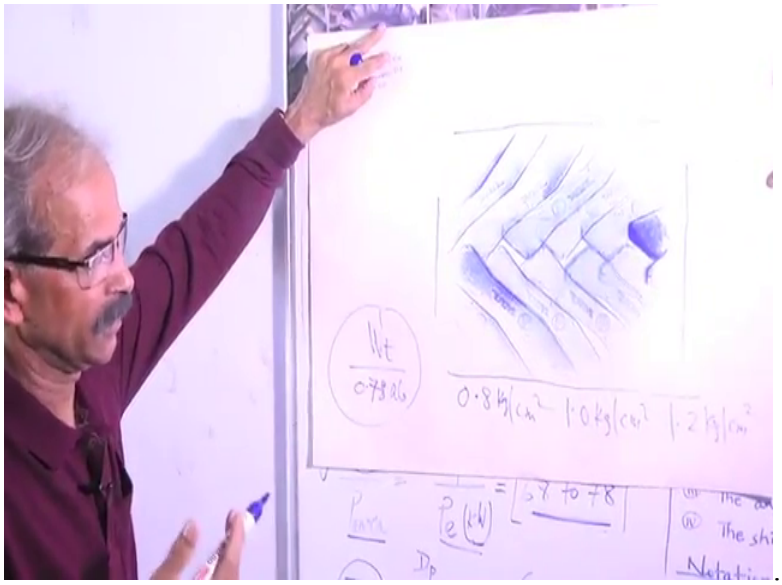

So, this is what it is you can see the print which comes and generally we measure this distance here as well as this distance and we find that generally this is elliptical in shape as I told earlier. So, if you want to find out the total load this divided by 0.78 ab. So, this is the total pressure which is there on to this.

Now, this there is an important factor when we do this exercises definitely we must do at varying pressures of the tires. Generally, we start from say and we give in the rear one say certain pressure of say it start from 0.8 kg per centimetre square to 1.0 kg per centimetre square or 1.2 kg per centimetre square.

Now, these are important parameter which we follow and then measure all these values to decide whether a particular tire is good and how much is the capability of that particular tire to be fitted in a if it is fitted in a certain capacity of tractor

Let us have a look at the test facility which is there.

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So, you can see that have a look at various types of tires which have come from various manufacturers and the facility is unique as I said now I would like my students who have been involved for long time in testing of this to explain more details about each and every component.

As described by the sir that we have to measure tractive efficiency and bias of the parameters to calculate the performance of tire for calculating the actual speed we are using a proximity sensor by this proximity sensor.

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We calculate the actual speed of this setup and for calculating a towed cut speed we are

mounting one more proximity sensor on the axle of this shaft by which we calculate the towed cut speed of this with this setup and by knowing the actual and towed cut speed we have to we have to come the ho w much the shape is coming and the other parameter for calculate the tractive efficiency. For calculating the torque we are using a torque sensor this is the torque sensor.

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By which we come to know the how much torque is coming from this motor to this setup for calculating the amount of pull we are using this ring transducer. By this we come to know how much pull is coming on this setup.

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As my friend explained you about the ring transducer to measure the pull now for measuring the tractive efficiency and slip that at which slip maximum tractive efficiency is achieved for that we applied the known load or known pull on the tractor tires.

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For that we use the brake drum type dynamometer. This dynamometer used applied the known pull on the tire. This is the device with the help of this we applied the known load and we measure the what is the tractive efficiency and slip at the corresponding load.

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Well as far explained by professor V K Tewari and my friends about the soil traction laboratory of IIT Kharagpur I am going to explain you about the processing trolley by the help of this processing trolley we are preparing the soil. We are preparing the soil of different a strength level for preparation of soil by the this processing trolley consist of rotavator.

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Rotavator, leveller, cultivator, and roller by the help of this rotavator we are tearing out the soil and by the help of this leveller we are levelling the soil inside this soil wheel and

by the help of this roller we are compacting the soil at different compaction level. And the to know the compaction level of soil we have made an instrumentation on this soil wheel soil wheel by the help of cone penetrometer we are measuring the a strength of soil.

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This cone penetrometer is assisted with s type load cell. There is a potentiometer by the help of this potentiometer we are measuring the penetration depth of soil.

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Thank you.