Traction Engineering
Professor Hifjur Raheman
Agricultural and Food Engineering Department.
Indian Institute of Technology, Kharagpur
Lecture No. 31
Performance comparison of track with wheel

Hi everyone, this is H Raheman from Agricultural and Food Engineering Department IIT, Kharagpur. I welcome you all to this NPTEL course on Traction Engineering. This is lecture 31, where I will try to discuss about performance of track and its comparison with wheel. Wheel and track, these are the two traction elements which are mostly used with the tractors.

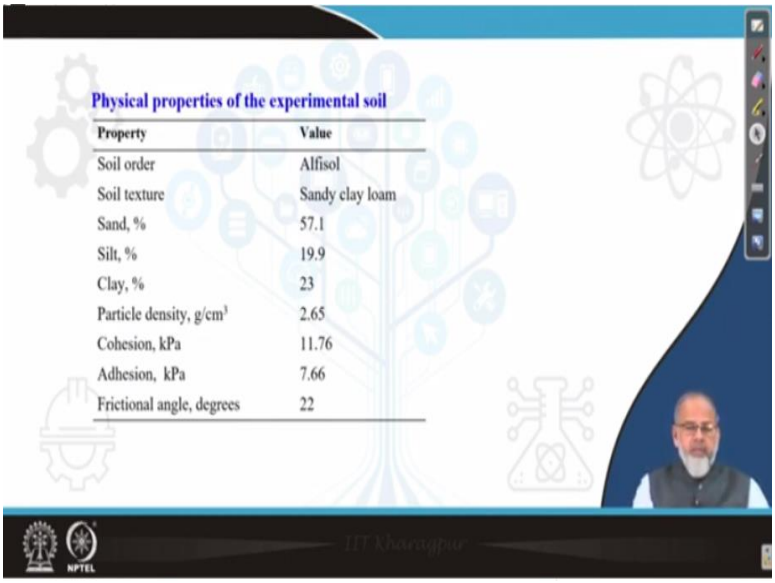
(Refer Slide Time: 1:00)

So, so you have to now compare which one will give you better performance. So, the performance comparison will be carried out based on tractive performance parameters like motion resistance, pull, net traction ratio, tractive efficiency and slip. So, these are the parameters based on which we will try to compare the performance of a track with wheel.

(Refer Slide Time: 1:30)

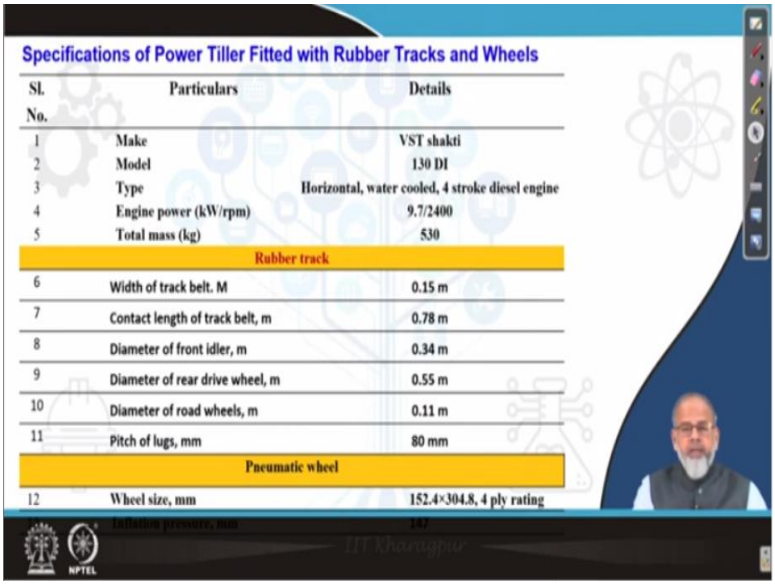
So, to carry out this kind of study, what we have done is, a power tiller is fitted with a track, rubber track and the power tiller is fitted with a normal wheel and their performance will be compared when they are operated under the same operating conditions.

(Refer Slide Time: 1:47)



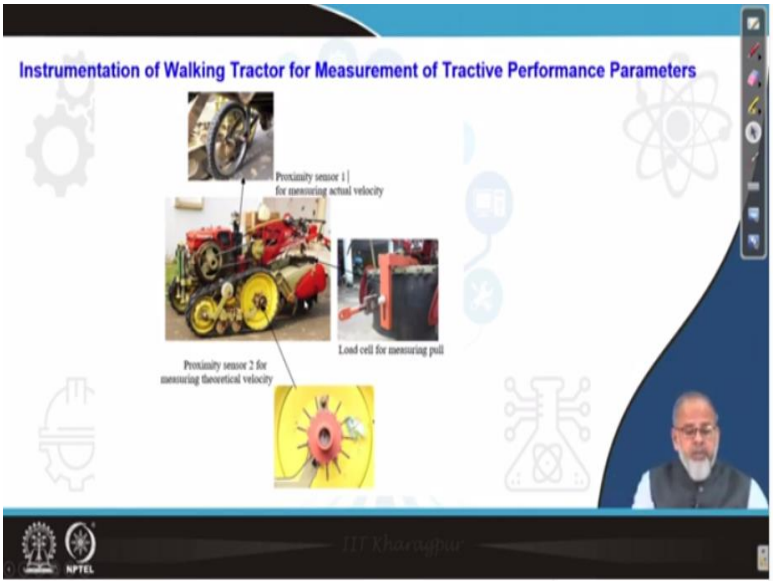
So, this is the soil condition where the soil is sandy clay loam, sand, silt and clay percentage are 57.1, 19-19.9 and 23 percent. Then particle density is 2.65 gram per centimeter cube and then cohesion is 11.76 kilo Pascal, adhesion is 7.66 kilo Pascal and the angle of internal friction that is around 22 degrees.

(Refer Slide Time: 2:19)



These are the specifications of the power tiller. One thing of which we try to maintain is the mass for both the conditions. Both the conditions means, the wheel as well as tracks should be same, so that we kept as 530 kg. Then this is a single cylinder engine, 4 stroke diesel engine. Width of the track is 0.15 meter, contact length is 0.78 meter, diameter of the idler wheel is 0.34 meter, diameter of the rear drive wheel is 0.55 meter and diameter of the road wheel is 0.11 meter. Then the lugs which are present in the track is similar to the lugs which are present in the wheel. And the wheel size is 152.4 by 304.8 and there is a 4 ply rating. And the inflation pressure maintain is 147 kilo Pascal.

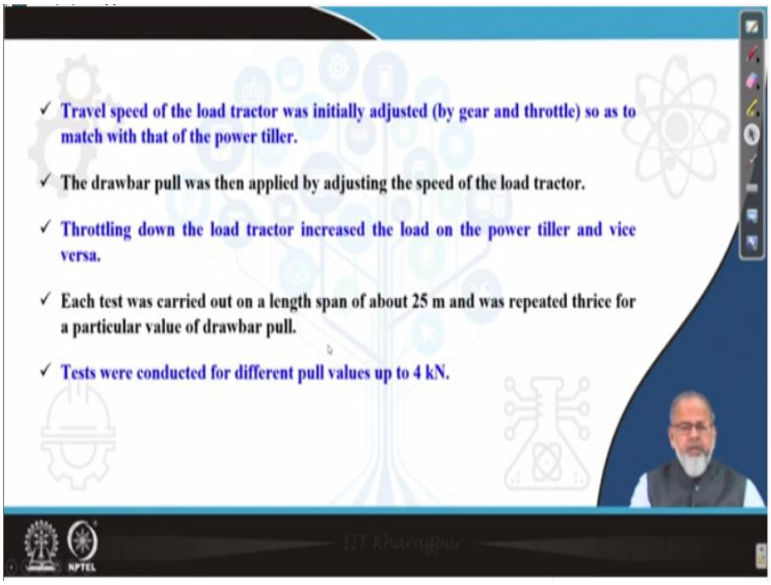
(Refer Slide Time: 3:15)



These are the instrumentation which are used to measure these performance parameters. The performance parameters include your wheel slip. For measuring wheel slip, you require theoretical speed as well as actual speed and both are measured with the help of proximity sensor. And, the proximity sensor is attached to the rear axle. So, that will give you velocity of theoretical velocity. And another proximity was attached to a towed wheel which is an extra wheel. So, that will give you the actual velocity. So, knowing the actual velocity and theoretical velocity, we can calculate slip.

And the other major component is the load, the pull which is applied, and the pull which is required to tow the tractor. So, those are measured with the help of a loadcell, which is shown in this figure. So, a loadcell and proximity sensor, the output data are stored in a computer through data acquisition system.

(Refer Slide Time: 4:25)



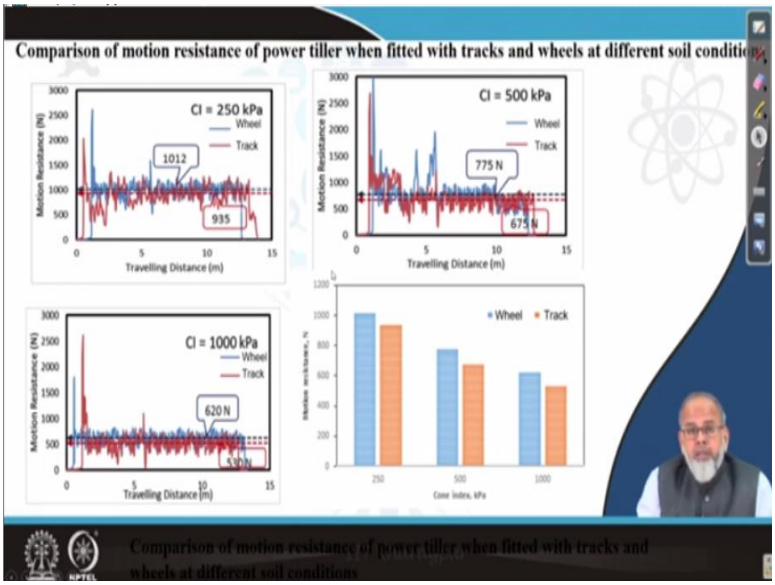
So, these are tested in the field. The procedure which is followed are, for the travel speed of the load tractor, initially, it was adjusted by gear and throttle so that it matches with that of the power tiller. Here, the tractor will be used as a pulling equipment we can say. And then the drawbar pull was applied by adjusting the speed of the tractor. So, power tiller, initially speeds are same for both the tractor as well as power tiller.

Later on, we tried to change the speed of the tractor because the power tiller, whether it is attached to a track or whether it is attached to a wheel that will be tested, so, that is why that to find out the pulling ability, we varied the pull of the, we varied the speed of the tractor, which is called the load tractor. Then by throttling down the load tractor, the load is increased on the power tiller and if you reduce the throttling further, speed will further reduce, that

means load will be increased. If you increase the speed of the tractor, then load will be decreased.

So, that is the way we tested the power tiller when it is fitted with tracks or wheel. And each test, whether it is fitted, whether the power tiller is fitted with track or whether it is fitted with wheel, this was carried out on the length of about 25 meter. It was a long span and it was repeated thrice so that whatever data we get, that will give you more or less an average experimental data with lesser experimental error. The test was conducted for different pull values up to 4 kilo Newton.

(Refer Slide Time: 6:25)



These are the outputs related to motion resistance. The blue line was for wheel and the red one is for track. These tests were carried out for three different soil conditions. One is, 250 kilo Pascal cone index that is soft soil, which is related to 250 kilo Pascal. Then there is a medium soil where the cone index is 500 kilo Pascal. There is a hard soil where the cone index is thousand kilo Pascal. In all these three conditions, what you can observe here is rolling resistance of a wheel is more than the rolling resistance of a track.

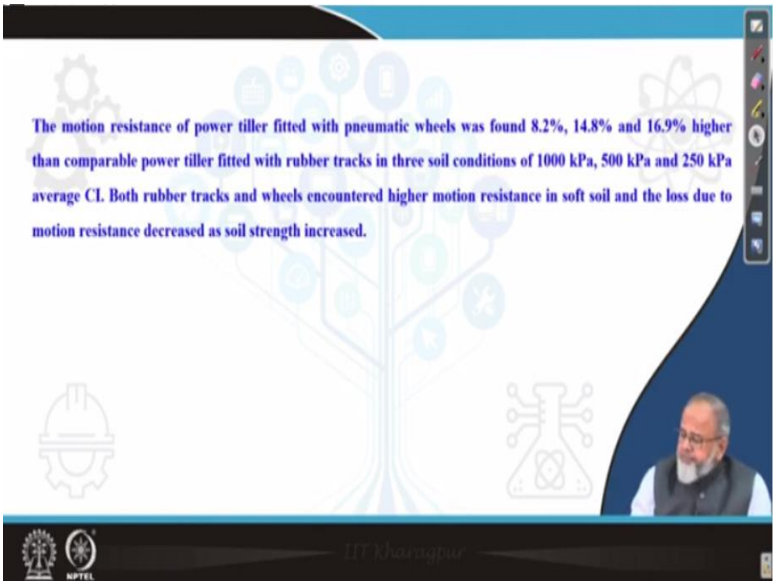
The reason is track has longer contact length, it has longer contact, it has higher contact area. So, obviously, the contact pressure is less. So, compaction is less. Hence, rolling resistance is less. So, that could be the reason why the rolling resistance of a track is lesser than the rolling resistance of a wheel.

Now if you look at the soil conditions, the soil conditions if you look at, then the harder soil gives you lesser rolling resistance. That means you are getting only 530 Newton. Whereas, in

soft soil, it is giving you 935 Newton. Same is the case with wheels, on hard soil is giving you 620 Newton and soft soil is giving you 1012 Newton. The reason is very simple. A soft soil means more compaction, so more rut formation. Hence, more power is required or more forces required to overcome that rut, to ride over that rut. So, that could be the reason.

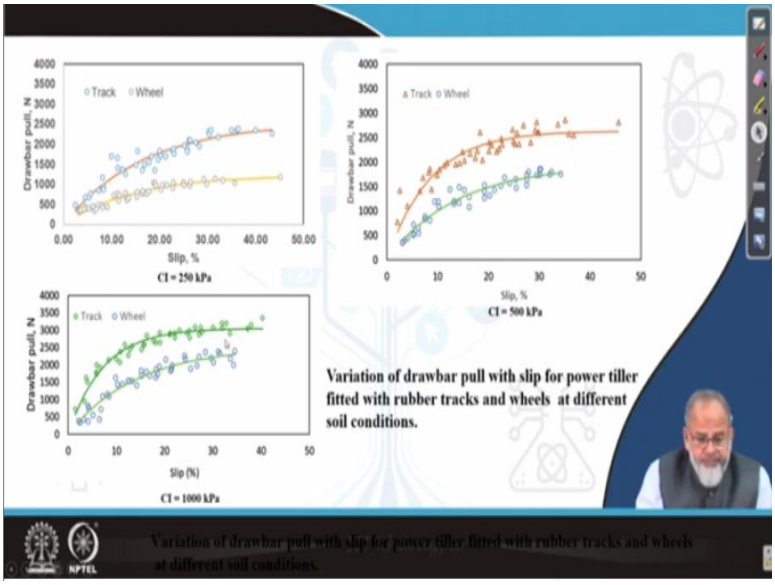
So, when you compare a different soil conditions, that means 250 kilo Pascal, 500 kilo Pascal, 1000 kilo Pascal, you can see always the tracks are better than wheel. That means track will require less power to overcome the rolling resistance and with increase in strength of soil, the cone index values are decreased, and the motion resistance values are decreased, whether it is a wheel, whether it is a track, for both the cases, rolling resistance values are decreased.

(Refer Slide Time: 9:18)



So, in summary, what we can say is, motion resistance of power tiller when it is fitted with pneumatic wheel, it was found 8.2 percent, 14.8 percent, and 16.9 percent higher than the comparable power tiller when fitted with the rubber tracks. So, in three soil conditions for example, 1000 kilo Pascal, 500 kilo Pascal and 250 kilo Pascal average cone index value, both rubber tracks and wheels encountered higher motion resistance in soft soil and the loss due to motion resistance decrease as the soil strength is increased.

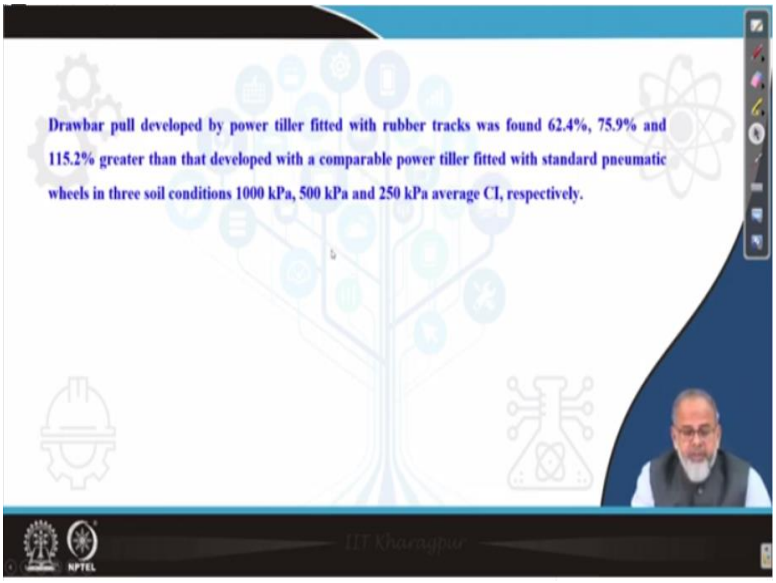
(Refer Slide Time: 10:13)



The next parameter is your drawbar pull. How much pull a track or wheel can develop at different values of slip, starting from let us say 3 percent to 45 percent. Again, these are carried out for three different soil conditions. One is drawbar pull, one is the soft soil, which is 250 kilo Pascal. The other one is medium soil, which is 500 kilo Pascal. The third one is hard soil, which is 1000 kilo Pascal.

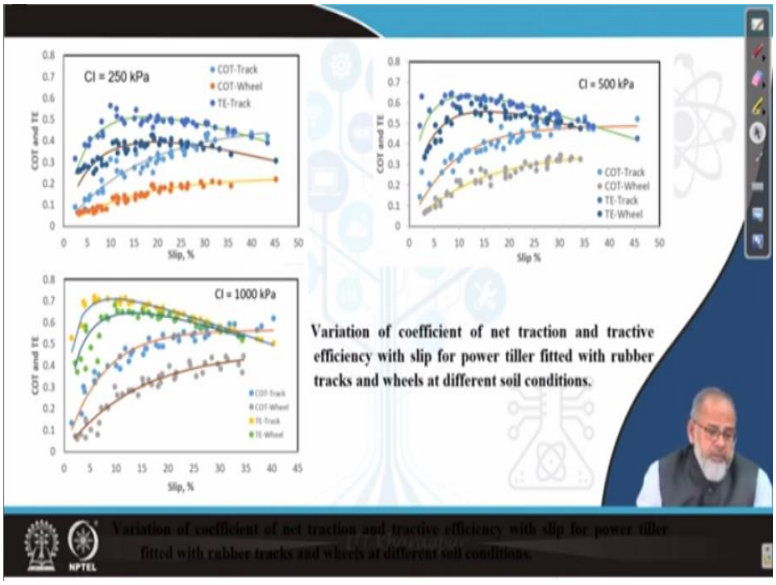
So, if you look at these curves, whether it is a wheel, whether it is a track, both the tracks and wheels are giving you similar output. Similar output in the sense, the nature of output is same. It is first increasing at a faster rate, and then it is slowing down. Same is the case with track. And same trend is followed in different soil conditions. However, if you look at the two graphs, there is a difference, difference in the pull which is developed. The track is developing much more power or much more pull as compared to your wheel. And these differences decrease with increase in soil strength.

(Refer Slide Time: 11:57)



So, in brief, the drawbar pull which is developed by the power tiller when it is fitted with rubber tracks, it was 62.4 percent, 75.9 percent and 115.2 percent greater than the developed than that pull which is developed by the power tiller when fitted with the standard pneumatic wheels in three soil conditions. So, much gain was there in case of soft soil, 250 kilo Pascal, we are getting a gain of 115.2 percent, more than a 100 percent. Whereas, in hard soil, we are only getting 62.4 percent. So, softer the soil, better with the pulling ability for a track as compared to wheels.

(Refer Slide Time: 12:50)

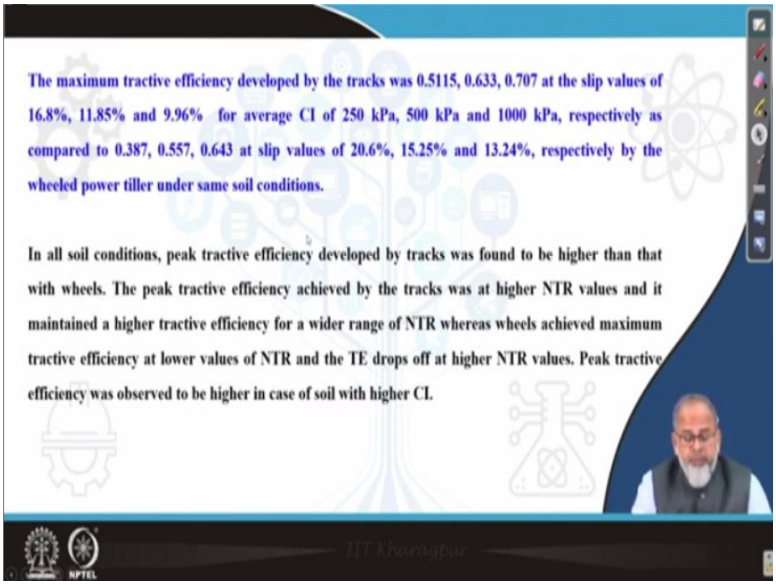


Next is the coefficient of traction and tractive efficiency for both wheels as well as track. This has been plotted for different soil conditions. One is 250 kilo Pascal, 500 kilo Pascal, 1000

kilo Pascal. In 250 kilo Pascal, the COT value maximum is reaching initial, it is increasing, then it is going slowly. The rate of increase is reduced and it is slowly becoming or nearly constant. This orange colour and this, these are the two for COT that means pull divided by weight.

Whereas, these two curve, the upper two curve, they are meant for tractive efficiency. The top, top curve is for track, tractive efficiency of track, whereas, the lower one is the tractive efficiency of wheel. Similar trend has been observed for 500 kilo Pascal as well as 1000 kilo Pascal. That the maximum tractive efficiency which you got is 0.7, 0.71 like that in case of track. And this is possible in case of hard soil. Whereas in case of wheel, it is only 0.62 like that. That means 62 percent is the efficiency in hard soil.

(Refer Slide Time: 14:35)



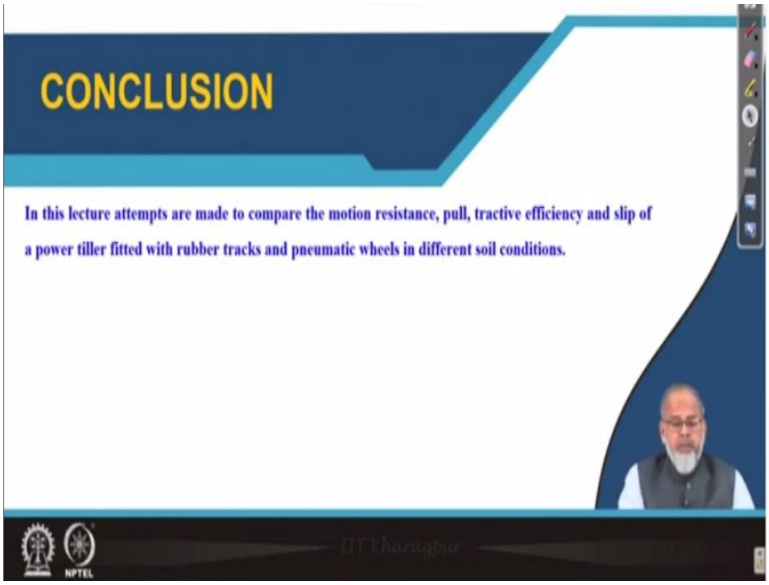
So, in summary, what you can say, the maximum tractive efficiency which is developed by track was 51.15 percent, 63.3 percent and 70.7 percent at the slip values of 16.8 percent, 11.85 percent and 9.96 percent for average CI that is cone index of 250 kilo Pascal, 500 kilo Pascal and 1000 kilo Pascal, respectively. And as compared to wheel, this was only 38.7 percent, 55.7 percent and 64.3 percent. And the corresponding slips are 20.6 percent, 15.25 percent and 13.24 percent.

That means, at lesser slip values, we are getting more tractive efficiency in case of track. Whereas, in case of wheel, the tractive efficiency, obtained in soft, medium and hard soil, they are lower than the tractive efficiency which are obtained with the tracks and the slip at which the tractive efficiency were obtained for wheels is around 20.6 percent, 15.25 percent and 30.24 percent.

In all soil conditions, the peak tractive efficiency developed by tracks was found to be higher than that with wheels. And the other important thing is the peak tractive efficiency, which is achieved by the tracks was at higher NTR values. That means higher pull to weight ratio values and it maintain a higher tractive efficiency for a wider range of NTR values. Whereas, wheels achieved the peak tractive efficiency at lower values of NTR and the tractive efficiency drops off at higher NTR values.

And peak tractive efficiency was observed to be higher in case of soil with higher CI, whether it is fitted, whether the power tiller is fitted with tracks or whether it is fitted with wheels. So, we are getting tractive efficiency. If you look at this figure, we are getting tractive efficiency for a wider range of slip. That means this maximum from here to here if you, so corresponding to that, the pull to weight ratio is quite large in the sense from 0.2 to 0.34 like that. So, for a wider range of NTR, you are getting maximum tractive efficiency. So, that is a plus point in case of power tiller when it is fitted with tracks.

(Refer Slide Time: 17:46)



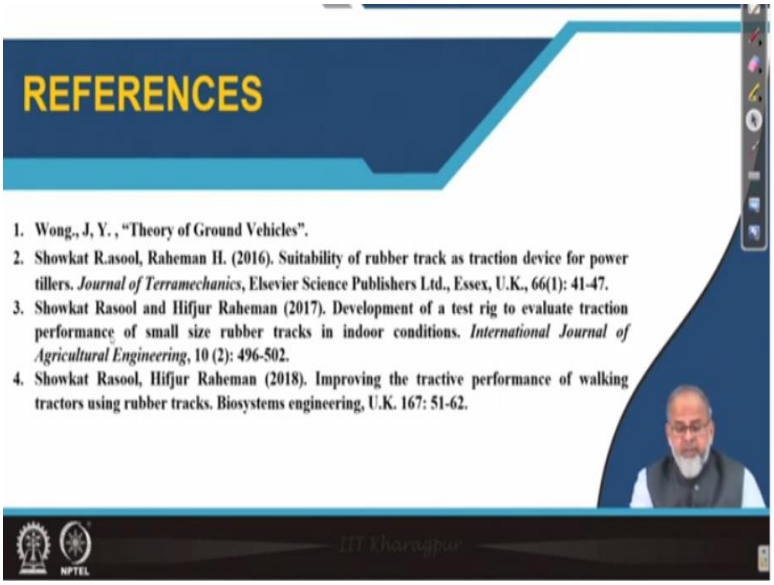
So, in this lecture, attempts are made to compare the motion resistance, the pull, the tractive efficiency and at for slip values you are getting the maximum tractive efficiency when the power tiller is fitted with the track, track or when it is fitted with the wheel, has have been discussed and their compared for three different soil conditions. So, from there we try, what we conclude is, is the track, which is giving you better performance, performance in terms of rolling resistance, in terms of tractive efficiency, in terms of coefficient of traction.

The main reason is why the tracks are behaving, are performing better than the wheels is the contact area. Higher the contact area for the same load, the ground pressure is less, hence less

compaction and some less rolling resistance. Hence, the thrust which is developed that will consume only lesser amount of power to overcome the rolling resistance. Hence, more power of the pull is available.

Whereas, in case of wheel, the contact area is lower as compared to tracks and the ground pressure is more, hence, more compaction, hence more rolling resistance. And the tractive effort or the thrust which is developed by the wheels are lesser than the tracks. Hence, net pull available is lesser than the net pull available with tracks.

(Refer Slide Time: 19:36)



This has been discussed on the basis of some experimental data which were carried out by these three last three papers which can be taken as reference. Thank you.