Traction Engineering
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Lecture 23
Comparison of single tyre with dual tyres

Hi everyone, this is Professor H Rahman, from Agricultural and Food Engineering department IIT Kharagpur. I welcome you all to this NPTEL course on Traction engineering.

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This is lecture 23rd, where I will try to compare the performance of a single tyre with dual tyres.

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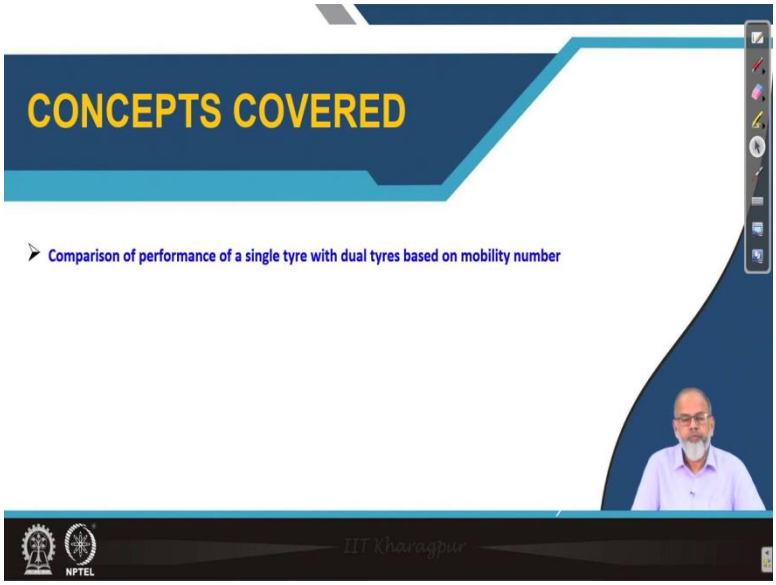

Means, the concept which will be covered is how to compare and on what basis you should compare. Should I go for comparing tractive efficiency or should we go for comparing coefficient of traction or should we go for comparing rolling resistance? So, we will discuss in detail. Usually rolling resistance, coefficient of traction both are dependent on a number called mobility number. If you are concentrating on Brixius equation, then there is a number called mobility number which combines both soil parameters, fuel parameters and the weight which is coming on the tyre.

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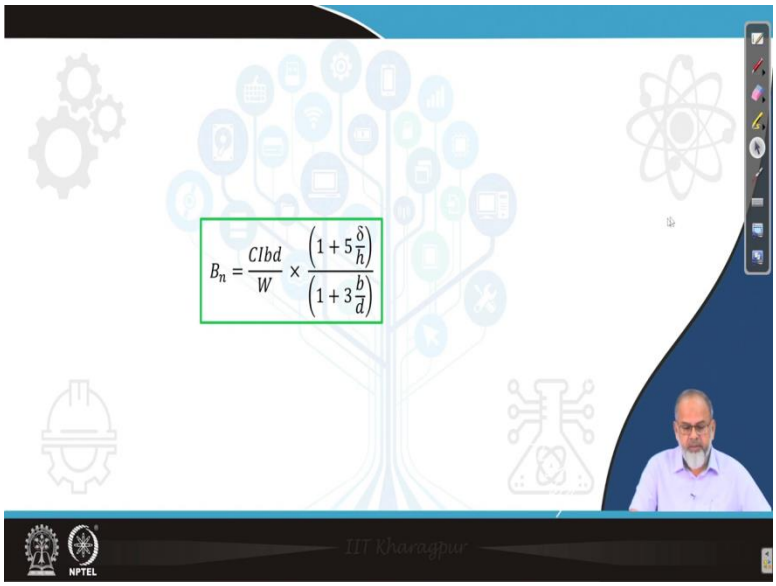

So, this is expressed as

$$B_n = \frac{CIbd}{W} \times \frac{\left(1 + 5\frac{\delta}{h}\right)}{\left(1 + 3\frac{b}{d}\right)}$$

Since rolling resistance is a function of mobility number, coefficient of traction is also a function of mobility number and of course, productive efficiency, which is the ratio of coefficient of traction to coefficient of gross traction, so, that is also a function of mobility number. Hence, instead of calculating rolling resistance or calculating coefficient of traction or calculating productive efficiency, what we have to do is simply we have to calculate the mobility number and then compare the mobility number of a single tyre with a dual tyre. So, that is good enough to indicate that which tyre is good or bad. That means, higher the mobility number better will be the performance. So, a tyre having higher mobility number will give you better performance.

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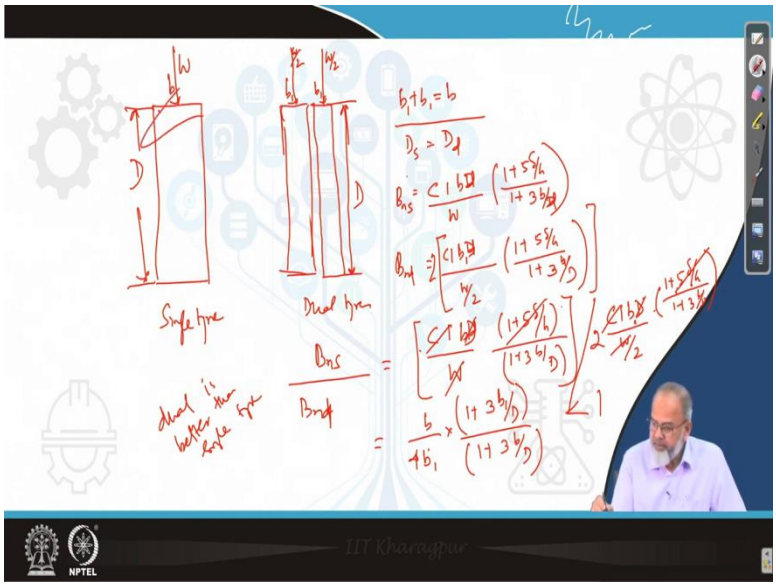

So, what I will do is, I will take an example in the sense I will take a single tyre and then I will take 2 tyres of same dimensions. That means if a single tyre if I took so, this is having width b, diameter D. I will take a dual tyre, so that means 2 tyres will be there. So obviously their dimension will change. So, this is b_1 this is b_1, so, summation of b_1+b_1 should be equal to b and diameter will remain same.

So, now I try to find it, find the mobility number. These are denoted a single tyre, this is dual tyres. Here we are maintaining the dimensions same that means, twice b_1 will be equal to b and diameter for single will be equal to diameter of dual. So, the weight which is coming in a single wheel tyre, if it is W so, here it will be W_1; W/2, W/2. That means W will be shared by the 2 tyres. So, only the weight will change. So now, for finding out the mobility number of a single tyre, so, that will be equal to

$$B_{ns} = \frac{CIbD}{W} \times \left(\frac{1 + 5\frac{\delta}{h}}{1 + 3\frac{b}{D}} \right)$$

Now, for mobility number of dual tyres, it will be,

b will be equal to twice b1 or we can say you can find out mobility number of 1 tyre then you multiplied with 2 that is also possible.

$$B_{nd} = 2 \times \left(\frac{CIb_1D}{W/2} \times \left(\frac{1 + 5\frac{\delta}{h}}{1 + 3\frac{b_1}{D}} \right) \right)$$

b1×D/d, 'd'which I have written in small, and that is capital D that is diameter, capital D. So,

So, now, if I want to find out which one is better, then I can take the ratio B_{ns} by B_{nd}. So, obviously,

$$\frac{B_{ns}}{B_{nd}} = \frac{\frac{CIbD}{W} \times \left(\frac{1 + 5\frac{\delta}{h}}{1 + 3\frac{b}{D}} \right)}{2 \times \left(\frac{CIb_1D}{W/2} \times \left(\frac{1 + 5\frac{\delta}{h}}{1 + 3\frac{b_1}{D}} \right) \right)}$$

So, now, if you simplify this one, so, this will cancel out now, this will be 4W. So, W, W will cancel out so, CI, CI will cancel out because we are operating in the same soil and D will also cancel out. so, what is remaining is

$$\frac{B_{ns}}{B_{nd}} = \frac{b}{4b_1} \times \frac{1 + 3\frac{b_1}{D}}{1 + 3\frac{b}{D}}$$

So, this ratio. If it is lesser than 1 that means, dual tyre is performing better than the single tyre. If this ratio is higher than 1, that means single tyre is performing better than a dual tyres. This is the case when the tyre dimensions are remaining same whatever dimensions we follow for single tyre, same dimensions we are following for dual tyres.

That means the combined width will be equal to the width of the single tyre. So, if you look at the ratio here, obviously, we are dividing with a higher number in the denominator, so it will be always lesser than 1 this ratio is always less than 1 that means dual is better than dual tyres are better than single tyres if same dimensions as that of a single tyre is maintained for dual tyres. Now, the other extreme case is, when the dimensions are different somewhere somebody selects a 13.6-28 tyre and somebody wants to use dual tyres of different dimensions, may be diameter is less or the more. So, then we have to find out which diameter will give you better performance.

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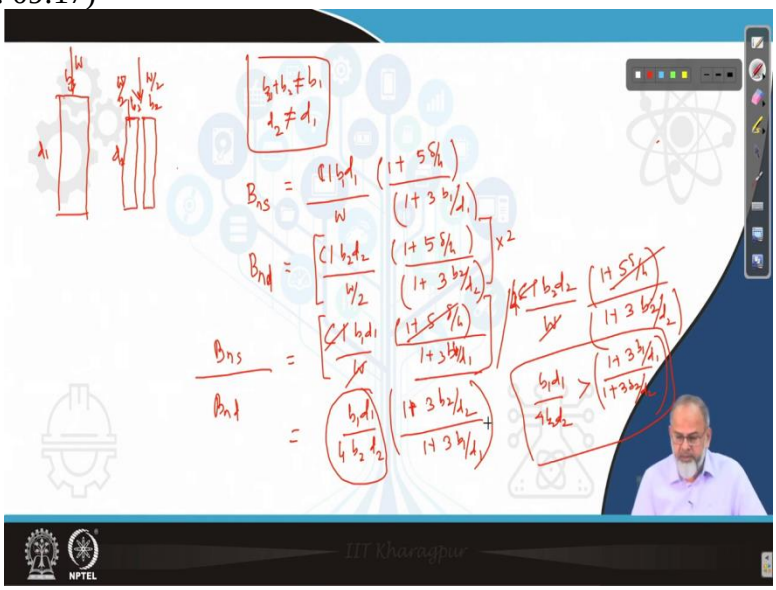

So again, we will try to draw a single tyre. So, this is having width b1, diameter d1, and duals will have some, I will take some smaller ones. So, this is, ‘d2, b2’. ‘b2, d2’ that means summation b2 plus b2 is not equal to b1 and d2 is not equal to d1. This is the condition. In the first case, we decided that twice b2 will be equal to b1 and D remain same, but in this case, we will decide in a different way.

Now again we will take the help of Brixius number. So, Brixius number, sorry mobility number, mobility number for single tyre will be equal to, mobility number of single tyre will be equal to

$$B_{ns} = \frac{CIb_1d_1}{W} \times \left(\frac{1 + 5\frac{\delta}{h}}{1 + 3\frac{b_1}{d_1}} \right)$$

Assuming that weights is acting same in both the tyres whether it is single whether it is dual, so, that means W by 2 will be shared by 1 tyre. Now, for dual tyre, mobility number will be

$$B_{nd} = 2 \times \left(\frac{CIb_2d_2}{W/2} \times \left(\frac{1 + 5\frac{\delta}{h}}{1 + 3\frac{b_2}{d_2}} \right) \right)$$

Now, if I want to find out the ratio B_{ns}/B_{nd}, then again, So, that means here it will become

$$\frac{B_{ns}}{B_{nd}} = \frac{\frac{CIb_1d_1}{W} \times \left(\frac{1 + 5\frac{\delta}{h}}{1 + 3\frac{b_1}{d_1}} \right)}{2 \times \left(\frac{CIb_2d_2}{W/2} \times \left(\frac{1 + 5\frac{\delta}{h}}{1 + 3\frac{b_2}{d_2}} \right) \right)}$$

So, if I simplify further, so, since they are operating in the same soil condition, when you try to compare and assuming that the δ/h ratio is remaining same for both the cases then this can be simplified as

$$\frac{B_{ns}}{B_{nd}} = \frac{b_1d_1}{4b_2d_2} \times \frac{1 + 3\frac{b_2}{d_2}}{1 + 3\frac{b_1}{d_1}}$$

If you want that Bns should be greater than bnd, that means mobility number of a tyre 1 is to be greater than the mobility number of dual tyres then be this component this ratio

$$\frac{b_1d_1}{4b_2d_2} > \frac{1 + 3\frac{b_1}{d_1}}{1 + 3\frac{b_2}{d_2}}$$

If this condition is satisfied then single will be better than the dual tyre. If this is not satisfied, that means

$$\frac{b_1d_1}{4b_2d_2} < \frac{1 + 3\frac{b_1}{d_1}}{1 + 3\frac{b_2}{d_2}}$$

then the duals are better than this single tyre. If duals are better, or if you want the dual tyres should behave and perform in a better way, then what should be the diameter for a given section width? So, to do that exercise, I will show you an example, where it will be clear how to find out the diameter which is required to make the dual tyres performance better than the single tyre.

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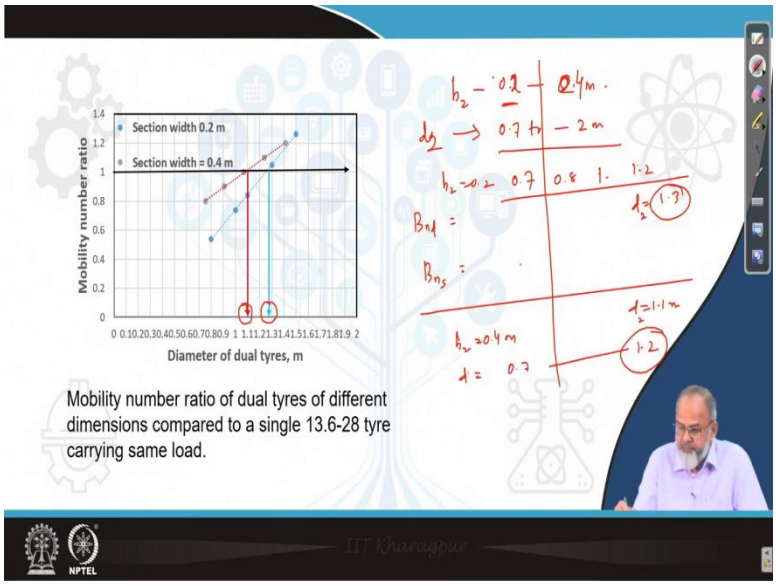

Now I am taking the mobility number ratio on the y axis then I vary the diameter of dual tyres starting from that means the b2 value, b2 value I vary from 0.1 to 2, these are in meters. Now, section width I have taken initially say 0.2 suppose, initially it have taken 0.2, then corresponding to this I tried to find out for different diameters. Section width I have varied from 0.2 to 0.4, 2 section width I have taken and diameter d2 I have varied from say 0.7 meter to 2 meter.

So, initially I took b2 as 0.2 Then I tried to change the value of d2 and found out what is the bn dual. Now take the ratio from the single. The derivations which I derived for single tyre, so, if the ratio whatever I found, I try to plot it for different values of diameter for a section width of 0.2, I varied 0.8, 1, 1.2 like that, then I tried to plot it. So, this is for section width 0.2 meter. Similar exercise I carried out for b2 is equal to 0.4 meter. So, and then I varied the diameter from 0.7 to 1.2 and then I got this line.

So, if duals had to be equal to single tyres, then the ratio is 1. So, there is a minimum thing. So, I draw a horizontal line here, so, wherever it does the 2 graphs, 1 is for 0.4 meters, the other one is for 0.2 meter. So, there I draw 2 verticals to touch the x axis. That means, it will indicate what should be the minimum diameter required so that the dual will behave like a single tyre. That means, performance of dual tyres will be equal to the single tyre. So, what I observed here is, for a section width of 0.4 meter the diameter is around 1.1 meter and for a section width of 0.2 meter the diameter is around 1.3. So, diameter should be around 1.3. So, this is the minimum diameter so, you have to have a diameter more than this then only the dual will perform better than the

single wheel. So, this is how we will, we are going to decide the dimensions of dual tyres, if we are interested to replace the single tyres.

So the simplest way of calculating this is, you do not have to compare the rolling resistance or you do not have to compare the coefficient of traction or you do not have to compare the tractive efficiency. All these 3 parameters, they are strongly dependent on mobility number, if you are using brixius equation for evaluating its performance. Hence, instead of calculating all those values, we just compare the mobility number that is sufficient to compare the performance.

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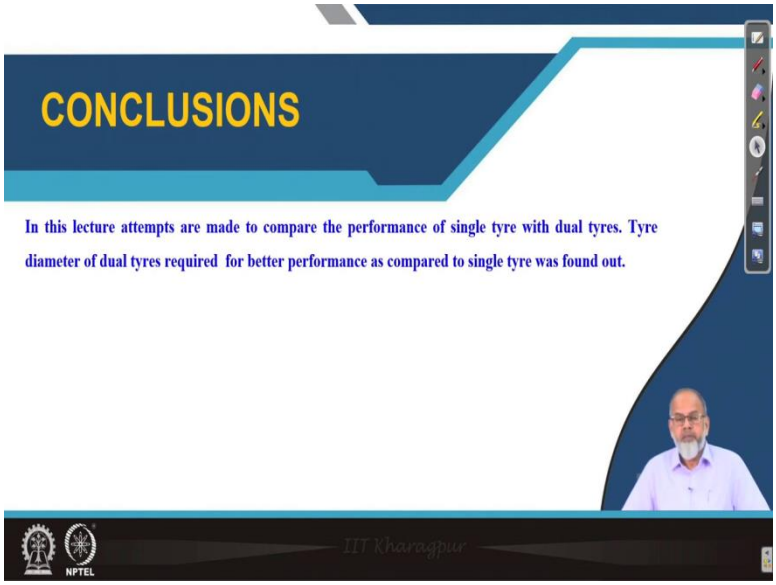

Briefly, I tried to compare the performance of single tyre with dual tyres when they are of same dimension. That means the diameter or width of single tyre is equal to diameter and width of dual tyres then I varied the diameter and width of dual tyres. They are not same as single tyres, so for both the cases I have given the expressions. Then the second thing I tried to find out what should be the minimum diameter if you are changing a single tyre to dual tyres. So, for different sections width, I have found out I have plotted and that gives you an idea how to compare the performance of a dual tyre with a single tyre.

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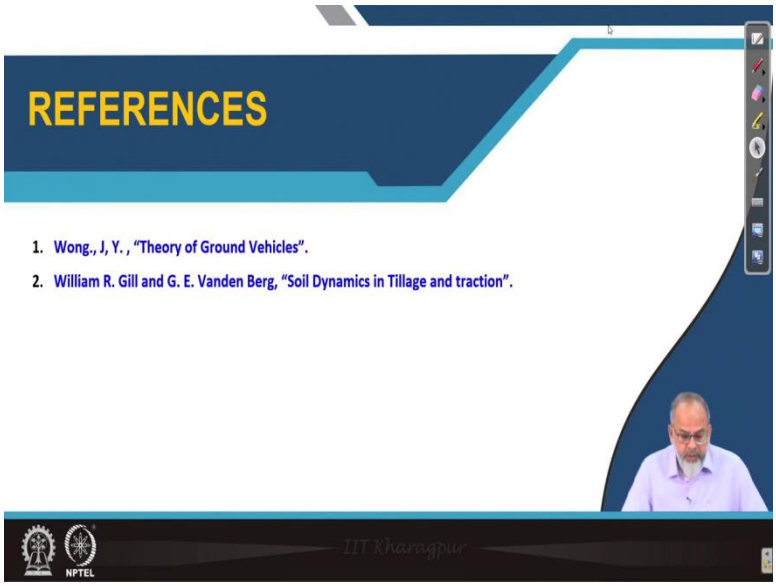

So, you can refer to some of these books that will help you further to calculate this performance. Thank you.