Bulk Material Transport and Handling Systems
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Lecture - 40
Off-Highway Trucks and Haul Roads (2)

Welcome back to our discussions on this transportation machinery for surface mines and though there are number of different machines will be introduced to you. But in the last class I introduced what are these off highway trucks that is the large capacity mining trucks or we say it says sometimes the other words used for this hauler you use as a dumper, dump truck. But basically, these are automobiles that are which has got its own power for its propelling and then it has got carrying.

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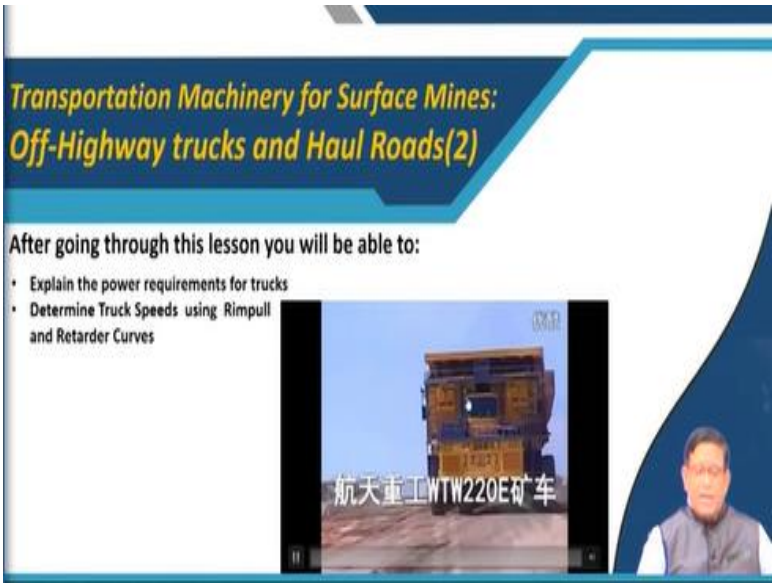

So, today we will be just describing how you will determine that what is the power requirement or when you want to know about what should be the required engine power. So, we will have to know that where this power gets consumed exactly what are the resistances it must overcome, the all the issues will not be covered in one class. But we will try to introduce you so that you can start constructing your knowledge by going through the relevant literature.

But here one thing only our objective of today's class is that you should be able to read the Rimpull curve or the retarder curves, which are given by the manufacturer when you are using a particular truck that you should know that that truck will be giving you how much

speed. So, selecting the speed from the Rimpull curve or retarder curve that a practical aspect I will be explaining today.

But at the same time, we will have to know that these truck exactly there are the Chinese trucks which is just for an example.

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You see that such truck when it is working in a mines. This figure is showing that your mining haul road it is not a very uneven road and then when they are working in conjunctions with your shovel that will be loading on to this truck you can see the working condition is very rough and tough. So, in that when such machines will have to work that is the dumper it is taking this load when that when the shovel is loading to the dumper it is getting a shock load on it.

At the same time that when this haul mass the total mass it will be accelerated. So, during the time that engine will be having a different type of load that is the characteristics of the engine will have to be determined so that it can provide that power. So, this is one of the very important things about knowing about this truck.

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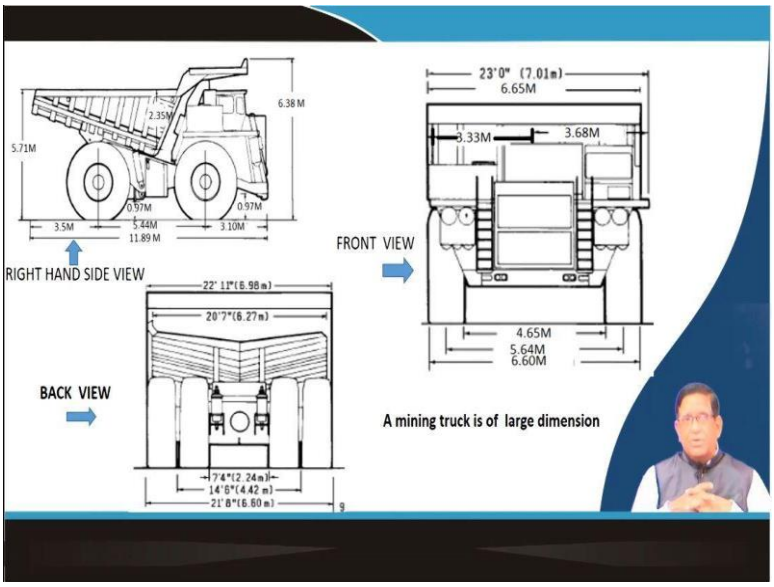

Now, that as a dimensionally this truck you can see here it is only about on 122 tonne dump truck. It is having 6.38 meter there are even bigger and larger truck like that is height, the width you can see from the front it is ever 6.6 and in the back side when you see that there are

suspensions and the truck. So, you need to how this mining truck of large dimensions will have to be there.

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So, when we talk about this machine, that our basic thing is that what are the resistances it will have to overcome and then what is attractive effort how this vehicle will get accelerated, how that exactly the braking will be done how this machine will be controlled. So, maybe that regarding the accelerating breaking or stopping distances calculations and all maybe we will be covering in our another class. Today let us see first what are these resistances.

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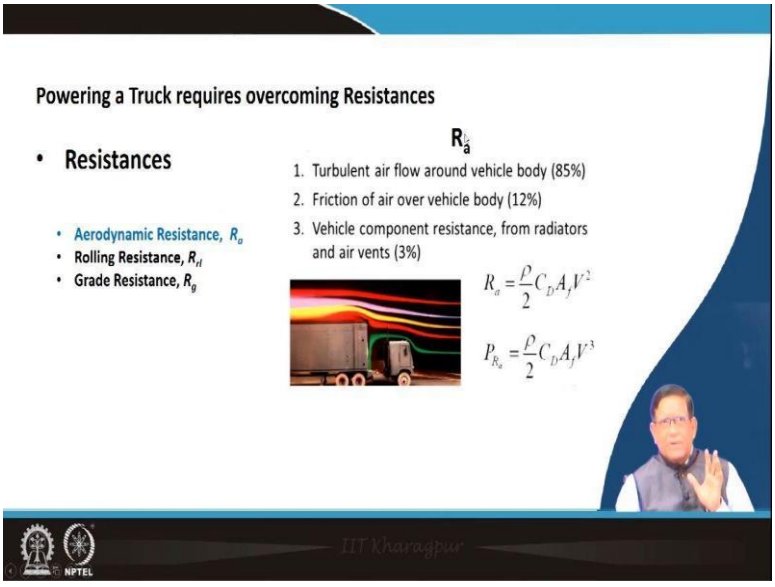

Now, you know that three types of resistances are very common when a that is it will have to be overcome and to overcome this resistances power will have to come from the engine. Now, these aerodynamic resistances it is the air resistance. Say for example you can see in

that figure that when the truck is moving the air will be giving a resistance to it that is why whether the tire has got a, mirrors it has got a front size.

That how the front portions what is the area of it which will be taking up these haul resistances. So, it depend exactly the turbulent air flow around the vehicle body this gives about more than 85% about the resistances. Then friction of the air over the haul vehicle body that comes about 12% and the vehicle component resistance from the radiators and the air vents.

And these other things there also this there about 3% like that this haul air resistance is contributing and that total air resistance are calculated there are this the mainly on these coefficients. And then your the velocity and the area and the density of that air which is going over there that affect this resistances.

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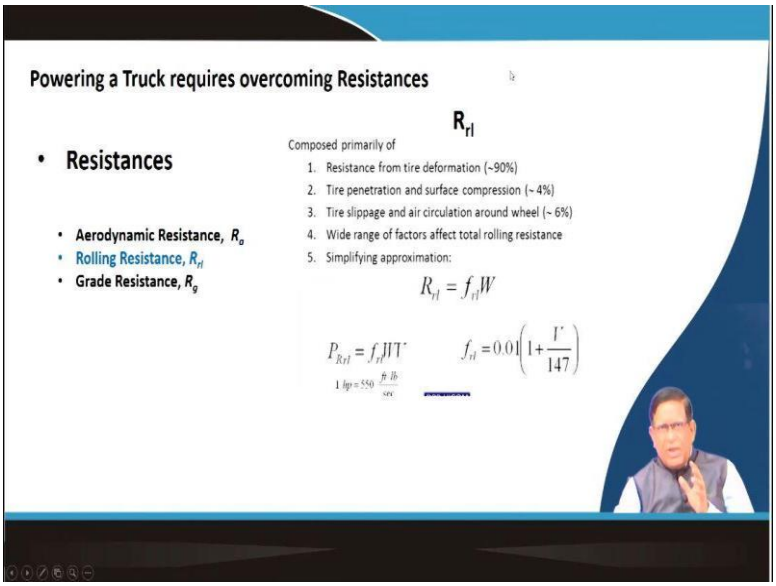

So, then other things; that which you will be requiring is the rolling resistance. Rolling resistance is the resistance which is coming from the tire and road interactions. There are different ways of calculating determining that in the field but we have not done much of these experimental determinations many a times we take the rolling that frictional the resistance that rolling friction.

Rolling friction is taken that f rl from other data or some secondary data. But there is a need for our different types of haul roads we need to develop that resistance because, they if we know the rolling resistance and the W the vehicle weight then you can find out that what will

be these rolling resistances can be calculated very easily. That rolling resistance it is also contributed from the tire deformation.

Because as the tire the new tire and that old tire when their tire is having even a cart and all at that time this tire is a main component from where the tire trade how it is designed. Those things also a lot of this mechanical engineers do study that by how the trades of the tire will be there. You might have seen that in the trades there are lot of gap. Now in that gap when the tire will be moving over there that the gap will be exactly working as a pump.

And then the whatever the fluid or dust which will be coming over there that will be thrown out away this sides. So, that is why how the tire trade will be interacting with the road is another issue. But the resistance comes to that is a haul rolling resistance 90% contributions from there. Then, also when the tire will be penetrating that means if the ground is of your softer nature that ground bearing pressure is less.

It will be giving a penetration that will contribute to rolling resistance. Then also when the tire is that it will be moving if the rule the resistance is less on the road, then it will be started this air slipping that try and then. And there will be air circulation around the wheel when it slips, means around the wheel there will be air coming over there. Then wide range of factors that may affect the total rolling resistance.

Because, that what is the rain conditions what are the grain size of the what are the type of potholes on the road that there are many things over there. That frictional resistance how it will be determined that is exactly experimentally done some of this relationship is given in that f ps system. But we will be looking into things of this rolling resistance from the standard values which are exactly adopted as a standard practice from there you need to calculate.

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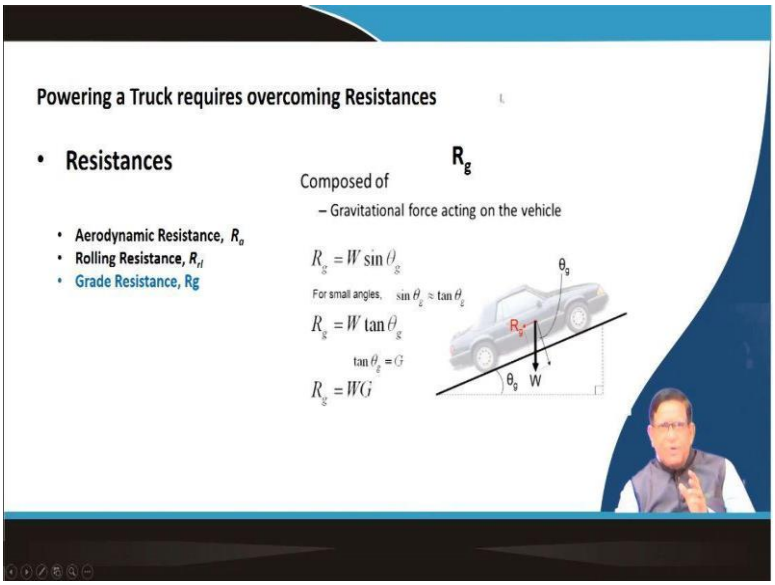

Then the third component is the grade resistance, you know when the vehicle is moving on a grade whether it is going up or going down that angle theta z here which is the angle of inclination depending on that this your W sin theta component will be coming. And as it is becoming a horizontal that component is going missing. And this is the way how exactly the grade resistance will activated.

The total resistance will be sum of all these resistances. Then the other concept which is necessary is a tractive effort.

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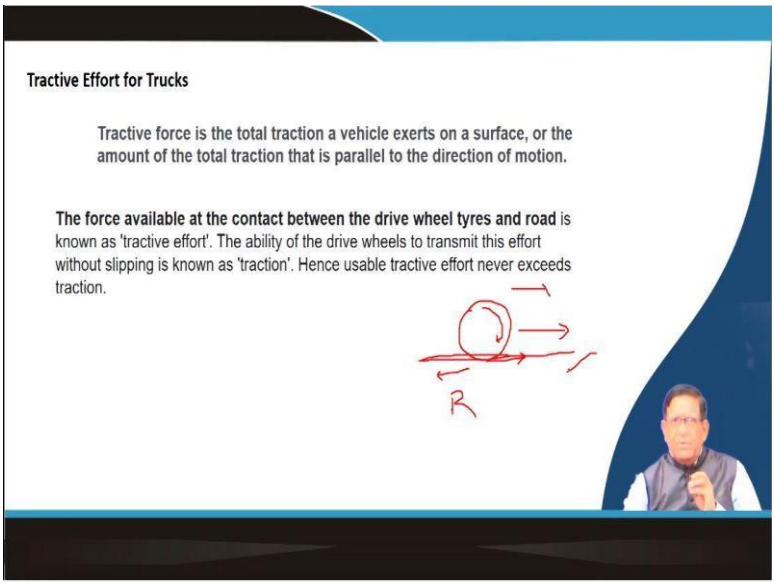

This is another very important thing that what is attractive effort for a truck or the attractive force is the total traction a vehicle exerts on a surface. That means when that engine is running at that time that your will which will rotate at that time how much exactly the vehicle

can be propelled, how much it can be tracked that is the amount of the total traction in is in the parallel to the direction of motion.

If it is going in addition along with that will be coming your different surface whatever the surface on which there the traction force is parallel to that. Now, the force available at the contact between the drive wheel and tires on road is known as the attractive effort. Basically, when you see here, that is your if you take this when any wheel will be here say for example when a wheel will be rotating over a surface over any surface that time exactly you are will rotating in this direction.

Now, if you are travelling in here there will be in these directions then there will be resistances coming over here. And then how much exactly the traction force you will be getting over here. Now, this is one of the very important things on any transportation equipment that how you are the attractive effort or the attractive force will be coming over here. The force available at the; contact between the wheel and the tire road.

That is the attractive effort how much exactly you will be able to pull in this at the point of contact of the point of contact here how much exactly you are going to get to overcome the resistances which is coming as a resistance that resistance will be overcome and then you will be getting an effort. The ability to drive a will to transmit this effort without slipping is the traction.

Now, the usable tractive effort it will never exceed the traction. This terminology should be clear in your mind. Now, that another thing is proceed to the next discussion is how will, you calculate the attractive effort.

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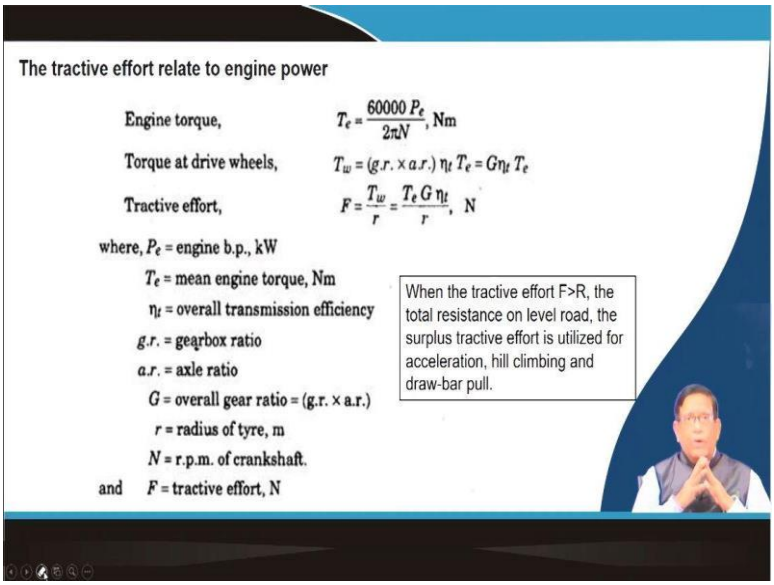

Because this is related to your engine power. That is how that engine will be used using that how the engine will be delivering the power to get the traction. So, you know that engine torque it is exactly what is the engine brake power given in kilowatt if it is P e and then your this the crankshaft of that engine crankshaft is giving a rotation of N rpm. Then this tractive engine torque you are finding it in newton meter as given in this equation.

Similarly, when you find that say you are having this equation for getting the track engine torque. Now, that torque at the drive wheel that is more important and this will depend on the your gear ratio and axial ratio. The product of these two it is called your overall gear ratio and then efficiency of the transmission and that engine torque. So, this will give you what will be the torque at your wheel.

Now, then the tractive effort is depending on what is the radius of the tire that is that your you are having this torque. Torque is nothing but that force into the resistance so from there you can find out. So, if you break it up so this equation will give you attractive effort. So, sometimes when you do that whether distractive if your required tractive effort from the road conditions and all you calculate the resistances.

And if this is not coming and then your that engine power will be insufficient to draw that truck. So, this is a basic concept you should have when the attractive effort if it is greater than the total resistance on the level road the surplus tractive effort is utilized for acceleration. That is on a hill climbing and draw bar pull all that draw bar pull means if you are something with your driving you are at giving an articulated drum truck.

That is your when you are connecting the dumb body to the your the tractor part there whether how much pull how much exactly load it can pull that is the draw bar pull can be calculated.

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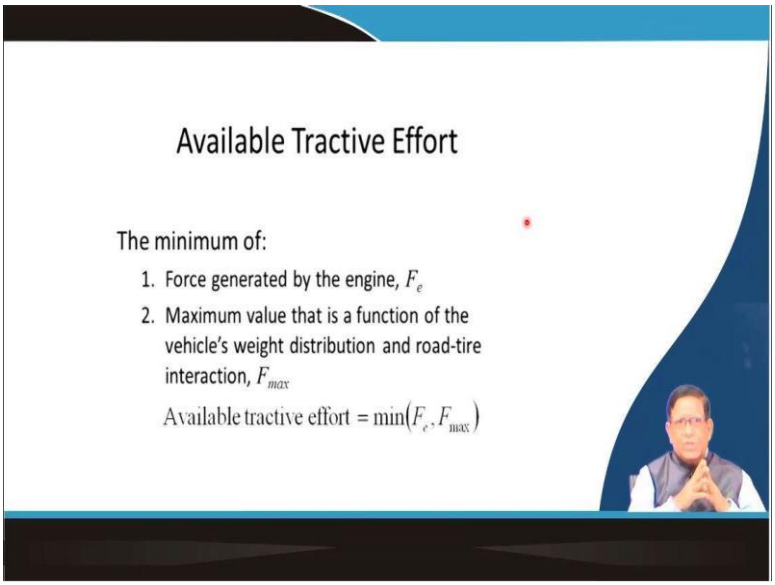

So, now if you see here that available tractive effort is how much. Now that if your force generated by the engine is known and the maximum value of is the function of the vehicle's weight distribution and the road tire interactions. These two that means your whatever the available minimum effort will be that minimum of these two whether the force generated by the engine is how much and then what is the maximum value of that function of the vehicle.

So, weight distribution on the road tire interactions, these two whatever is the minimum that will be your available attractive effort.

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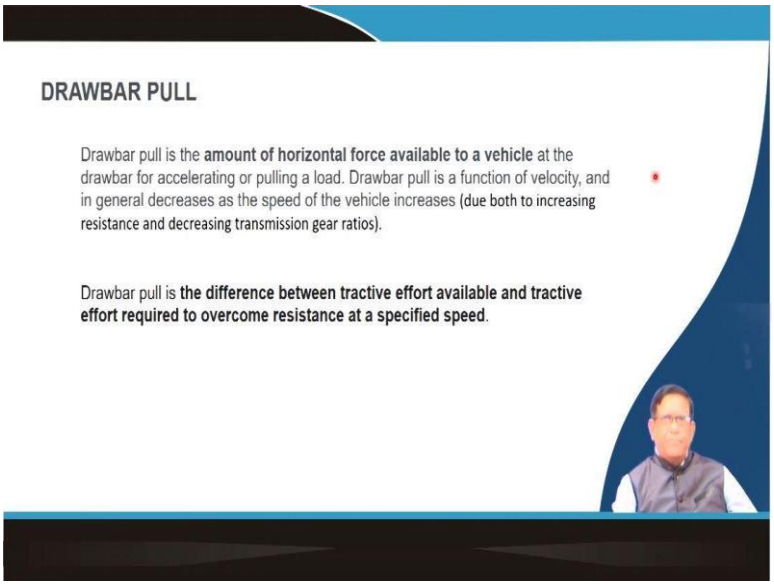

Now, this concept, as I said that drawbar pull whenever you talk of a dozer whenever you talk of a this scraper whenever you are talking of a tractor whenever you are talking of any this your towed vehicle the drawbar pull is the amount of horizontal force available to a vehicle at the drawbar that where it is getting connected for accelerating or pulling the load. So, all your side discharge dump trucks your the that your rear your bottom distance dump truck.

If it is an articulated drum truck you are adding that thing that that drawbar pull will be very, very important which is a function of the velocity. And generally, this drawbar pull it will decrease as the speed of the vehicle increases because when you are getting more energy for accelerating it or increasing this one then the other side your that available for pulling it will be less.

So, that means when you are having a very heavy load at that time you will not be able to give a very high acceleration to get to a higher speed. That is a general basic concept. So, drawbar pull is the difference between the attractive effort available and tractive effort required to overcome the resistance at a specified speed. So, once you have got these concepts clear then you can do some numericals over here.

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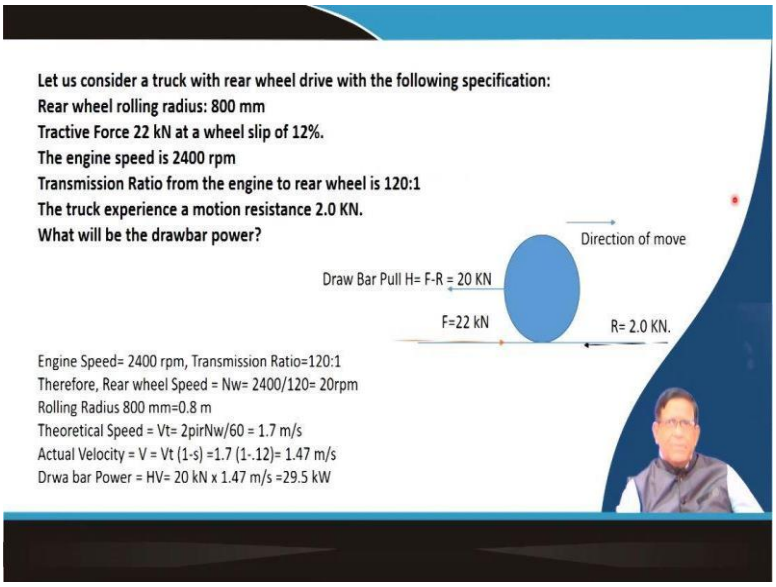

Say let us consider one truck with a rear wheel drive which the following specifications. A rear wheel rolling resist radius it is say 800 millimetre, that is your the radiate rolling resistant from here this radius is 800 millimetre and the tractive force is 22 or we say I thought that this is 22 kilo newton it is your because this direction it is moving in this direction. So, that is your tractive force is giving 22 kilo newton.

And a will slip this wheel is slipping here at a 12% slip. Now, the engine is capable of rotating at a 2400 rpm and the transmission ratio that is your total gear ratio is say 120 is to 1. Now the truck experiences a motion a resistance of 2 kilo newton, that is a motion resistance in rolling resistance road resistance all this thing is 20 kilo newton. Now, what will be the drawbar power that how much power will have to be given by the engine here.

Now, one thing is very simple drawbar pull which will be the difference of these forces. It is a vector force by the same they did they are both in the horizontal parallel to the road. So, their differences will give you the drawbar pull. Now, from this drawbar pull how will you get the drawbar power? As you know that engine speed is given your 2400 rpm and the transmission ratio is given.

So, what will be the rear wheel speed? That if you divide by the that ratio that means it will be rotating that is if the engine is rotating at 2400 rpm, at least rear wheel will start rotating at 20 rpm. When this rolling resistance is radius is your 800 millimetres. So, therefore you can find out that what will be the theoretical speed? Theoretical speed will be coming as your 2 pi

r N by 60 that formula you apply 2 pi r N by 60 is your 1.7 meter per second here for this given data.

So, then what will be the actual velocity? Actual velocity will not be this much because we have said that here is a 12% slip. So, because of the slip certain rpm will get lost over here. So, you subtract that so you are getting the speed that whatever that at with that load and with that pull it can run at a velocity of 1.47 meter per second. So, that means the drawbar pull is nothing but that with that newton force it is moving at this much speed.

So, we are getting the drawbar power is 29.5 kilowatt. Now, whatever your this engine rating was there if it is less than that then the engine will not be able to give you this. So, that is how we just check whether a specifications given by a manufacturer whether it will be able to take our that will be suitable or not. So, such type of calculations you may have to do when you are working in field.

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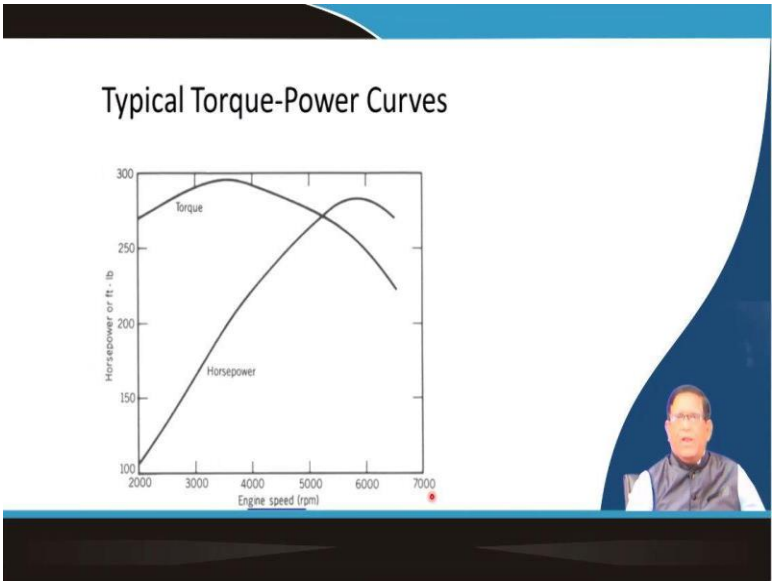

Now, then typically the torque power curve is given. Say if you are putting the engine power horsepower in this and then engine speed you will find that power curve is given like that and the available torque curve is given like that. So, this is your one of the optimal point so that means you can operate in the zone very easily.

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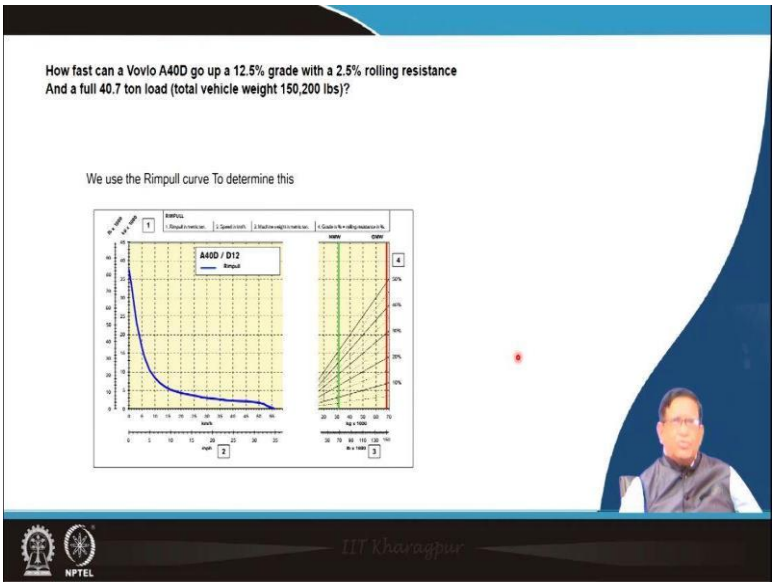

So, then the other things which you need to know. Suppose here I am showing you one curve it is called your Rimpull curve. All the manufacturer they give that is for their machines they do experimentally determine and they provide this their Rimpull curves. That means how much exactly that pull or the force will be available when the car will be moving at different speeds. So, in this one you can see the speed is given and in this here the your pull is given.

Now, one thing is there in that curve in a your Rimpull curve, you will be given that that different unit normally nowadays they will get both the units you may have in fps and also in SI unit. And there this given at the different resistances that is your road resistances at different percent what will be there. And our say for this graph we will be using that to answer a question like how fast can a Volvo this truck Volvo truck go up a 12.5% grade.

You are having a haul road with 12.5% grade resistance with a 2.5% rolling resistance and a full load of 40.7-ton load when the vehicle weight is given over there that they have got its own weight then there is the your net weight this is your tarot weight. So, and under these conditions how will you determine the speed.

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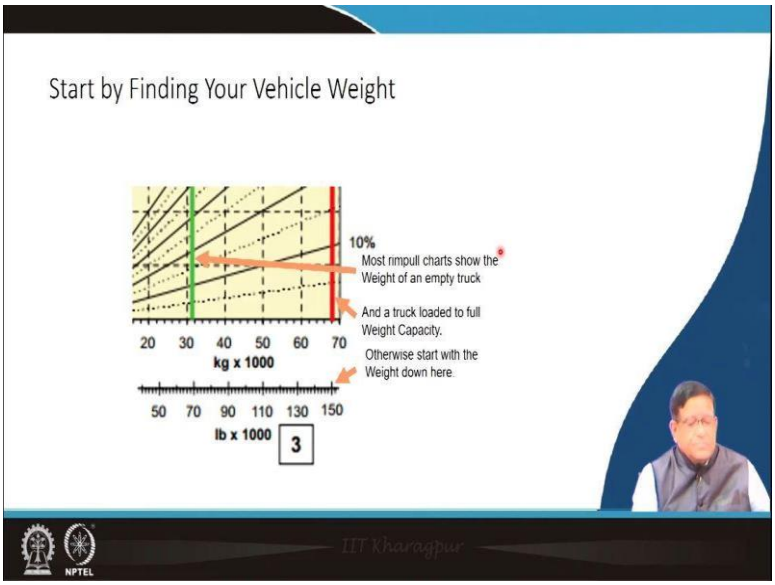

So, first what will have to do, what is your vehicle weight you need to find out. Now and then what exactly the for a particular vehicle when you get a Rimpull diagram, there will be one green line and one red line. This green line it will show that your Rimpull shows the weight of an empty truck this is this will give the weight of an empty truck that is here at 30 ton. And then when it is a full loaded because it is a 40-ton truck that means this is a 70 ton is the full load.

So, in that graph Rimpull diagram you will find out that exactly if you give more weight over here this will be going beyond. So, first you find out that and if you want to find out if you are going to have only 60 ton.

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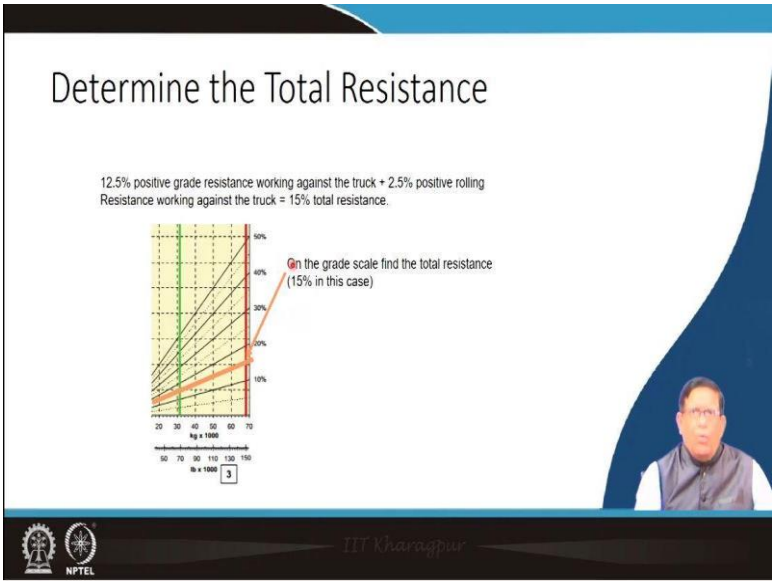

Now, how you determine the total resistance? Now for this 12.5% positive grade resistance working against a truck and this your rolling resistance is given the total resistance you can sum it up that will be your 15. So, you now go over here in this you find out that which curve which distance so here it is your 15% resistance. So, that means this is the your total grade resistance you will be taking up.

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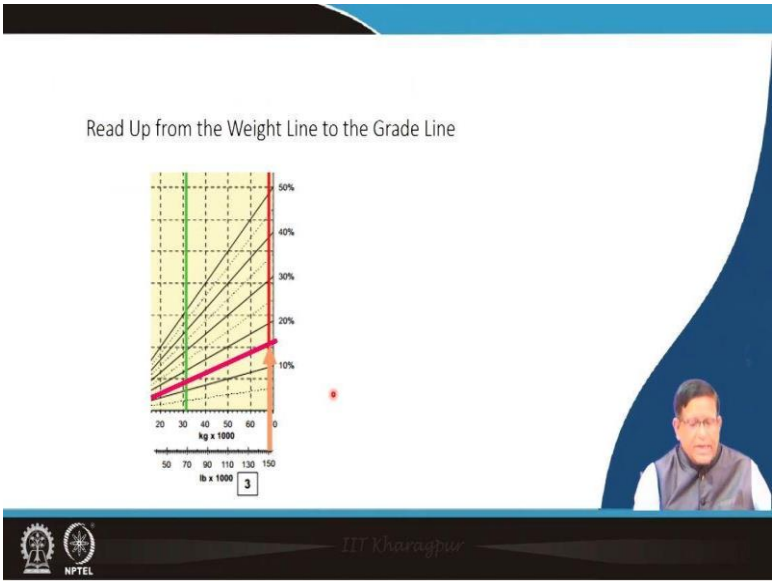

And once you take that then from here you will be going towards this to find out.

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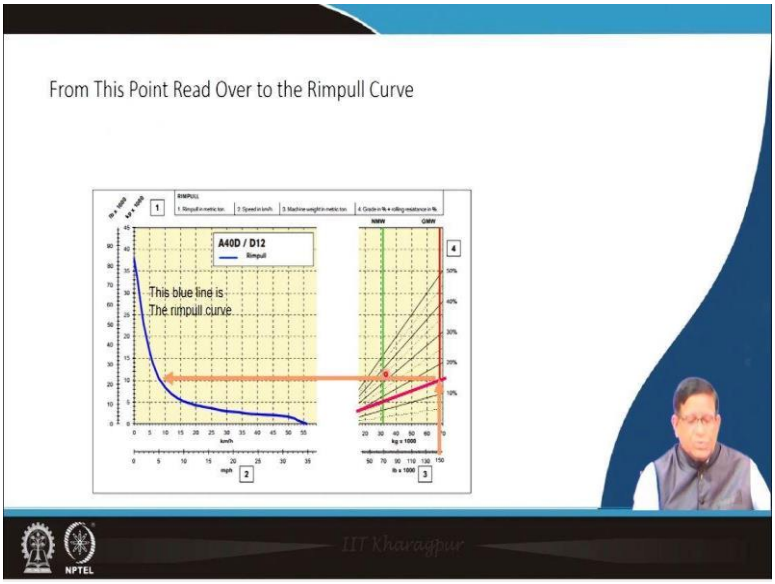

From here you will go and find here what is exactly your will be the speed.

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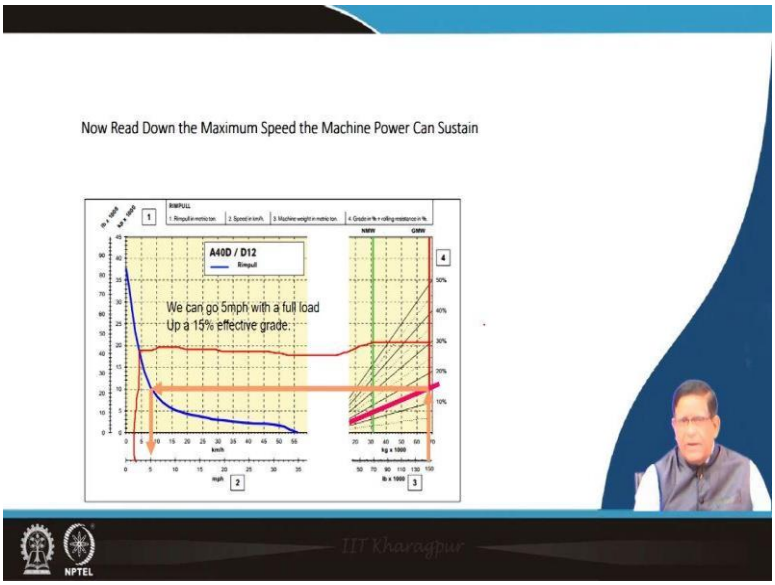

From here you can find out that the speed it is running at a say 7.5 kilometre per hour or that we can say this is giving a 5 mile per hour. So, that means if your this road is giving 15% resistance you are going over here. Now, same thing that is your you can find out that is a if your resistance is suppose you are having a very tough road going as a 30% resistance in that case this will be here you will find it will go like that.

And then your speed will be much less here over there. So, like this in this way you use your Rimpull diagram of the vehicle to find out in a particular route condition. So, these three factors are very important that your what is your total grade resistance and the total load which is coming and then what speed you will be moving.

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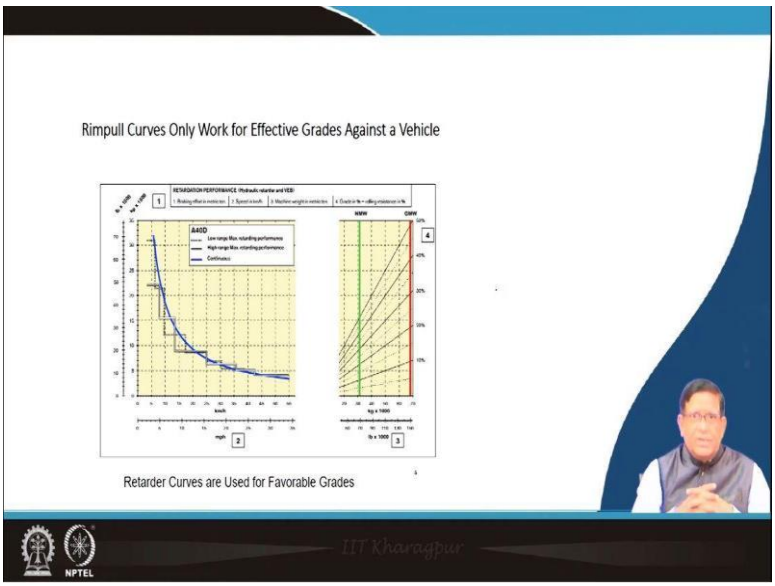

Once this is done the other thing is the retarder graph. So, here in a that exactly the retarder crops it is for a your favourable grade when you are working that is exactly your the vehicle is having different gears. So, under different gear they have got different speed. So, if your at the time of returning when you are going in a favourable gate in a downgrade at that time you will have to apply this resistances.

And under that condition at what speed you will be moving that is also determined from these curves.

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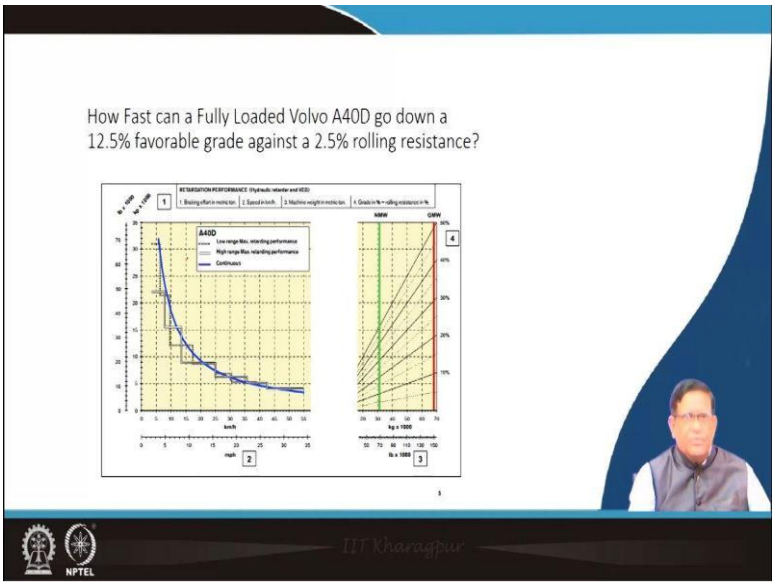

So, to do that you exactly you need to know that if you are going down the grade.

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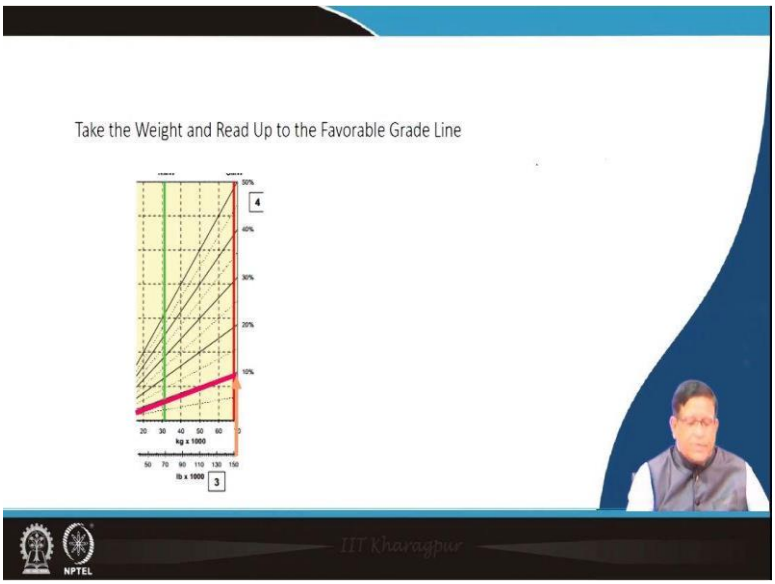

In such type of things you will be finding out and from here.

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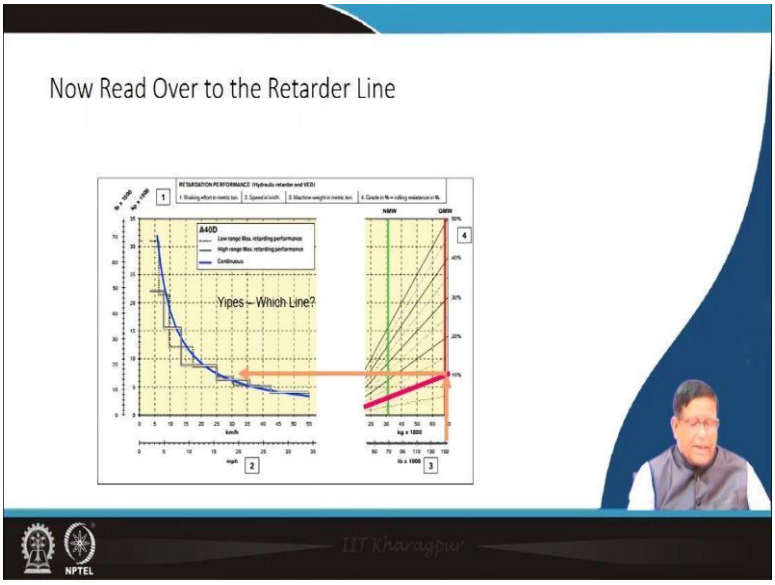

Again, you just remove it with that your 10% gradient now your rolling resistance will be in a favourable. So, from the 15% you have come down over here and you can see in this case your speed gets down over here. So, this is the way how you determine that when you are retarding at that time the speed is increased but you will have to apply the brakes. So, that you do not over run.

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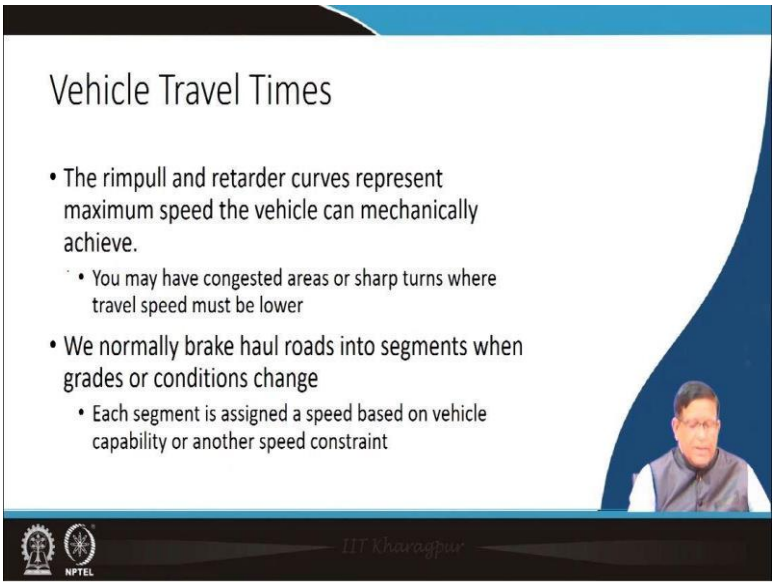

So, then once you know these things that from the speed you can find out what will be the travel time. The Rimpull and retarder curves they will represent the maximum speed the vehicle mechanically can achieve. So, you may the that have the congested areas or sharp turns where the travel speed must be lower or under that conditions if some when in a mines you will be going from one directions.

If another ramp is coming up over there at that time you will have to control the speech those other operational point will have to be taken. So, that we normally break the haul roads into segments. So, what is done in a mine that is your mine haul road will be showing sometimes that is exactly how the haul roads in a mines are designed. So, they will be having some horizontal parts there may be some ramp.

There may be some horizontal curve there may be some over vertical curve. So, under different conditions that will have to have the segment in each segment what should be the speed. And that what gearbox what gear you will be running that is given as a training your subordinates or your operator will have to be given training on that so that you should not exit.

So, that is why when you are managing the operational site for a haul travel you will have to take care of that.

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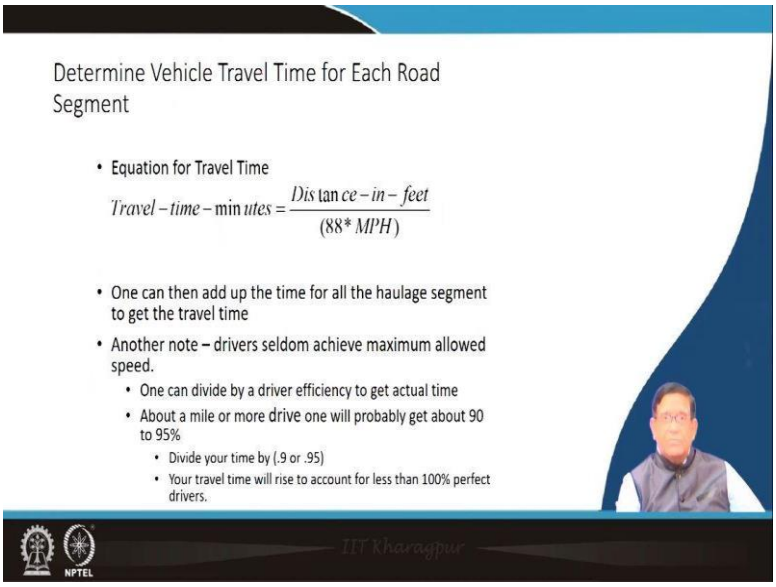

Now, this travel time you can easily find out it is just from the your distance and the speed you are and then once you get your that is your how effectively you are using your shift period that will be depending that is how many trips you can make over here. Because if your travel time if it increases that means you are telling the dumper cycle time will be increased. That haul mining because the dumper as you have shown earlier with that video.

It is coming to the shovel and from there it is going taking the material dump and come back that is what is the total cycle time. So, once will be going for the calculating the productivity of a dumper and the shovel applications over there we need to take this timing considerations over here.

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So, exactly what we have given you a brief idea about the procedure for calculation the drawbar pull of a truck under given conditions.

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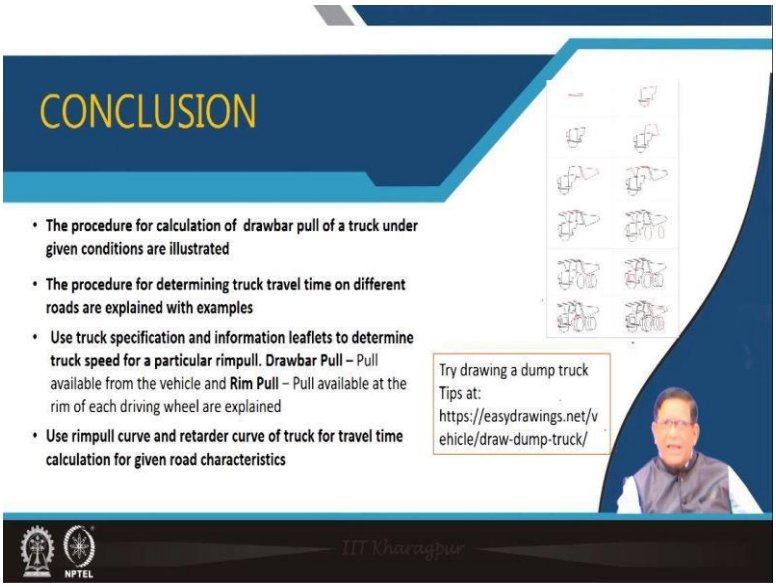

And then the procedure for determining the truck travel time on different roads it is just mentioned over here and the truck specifications and information leaflets you will have to use that thing for determining the drawbar pull. And that the drawbar pull which is the pull

available for the vehicle. And the Rimpull is the pull available at the rim of each of the driving wheel that is we have just explained briefly.

And then you need you can now use the Rimpull curve and retarder curve for truck for travel time calculations or for a given road characteristics that is briefly introduced over here. So, you can start doing some activity about how exactly the dump trucks are used but for fun as a learning fund you can start drawing the dump truck and for that some tips you can get this easydrawing.net.

This easydrawing.net is a good for undergraduate students to learn how to do simple sketches like your you can have some sketch drawing could be possible. So, you can go through this and then you can see that how where you should start drawing. If you want to draw a trump truck like this it, is they can do these small things some of the steps they give. This particular site you can see there that and you can make a fun.

And you can do and then you can improve it over there. And that is what a learning activity you can take with the dump trucks, thank you.