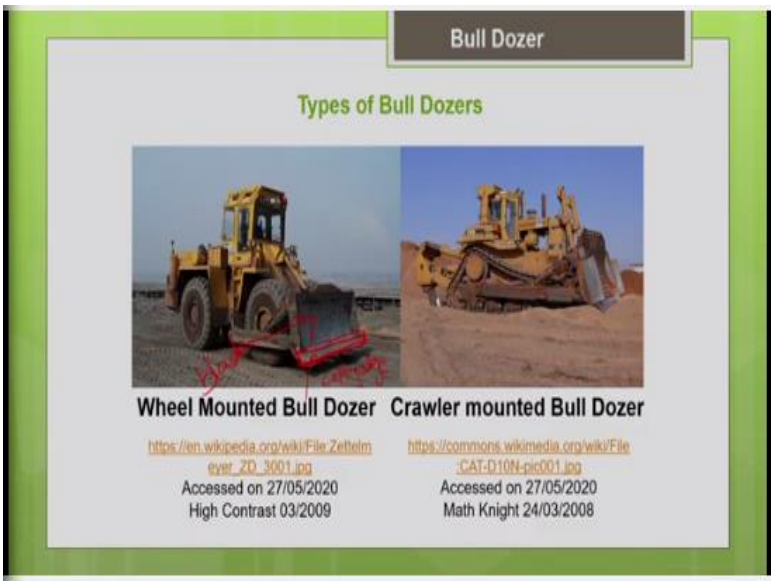

At the bottom of the blade, you can see a plate border. I mean this is the blade at the bottom what you have is the cutting edge; a steel plate is bolted to the bottom portion of the blade that is called as a cutting edge. So, generally this cutting edge gets worn out faster depending upon the usage, you may not replace the blade frequently, you need to replace only the cutting edge frequently.

So, this is easily bolted on to the bottom of the blade. So, we were discussing about the cutting ratio. So, cutting ratio is nothing but horsepower per meter of the cutting edge of the blade. So, that means, it depends upon the concentration of the power in the cutting edge, if the blades are smaller in dimension, then you can see the more horsepower concentration will be there in the smaller blade portion.

So, those blades will be very aggressive, so that can easily cut the earth and move the earth so that can easily cut the earth. So, cutting ratio measures the blades ability to penetrate the hard soil and obtain the load. If I say the blade has high cutting ratio, it means it can easily cut the soil and obtain the load. So, even it can handle a very hard soil conditions it can easily handle if it has high cutting ratio, so higher ratio indicates more aggressive blade.

Generally, blades which are smaller in dimension has high cutting ratio**.** Because obviously there will be more concentration of power in that the proportion of the blade, because the blade

dimension is smaller. So, those blades will be more aggressive and they will have high cutting ratio. So, the next is about the load ratio, load ratio indicates the pushing ability of the material.

So, it is nothing but the horsepower per loose meter cube of material retain in front of the blade. So, you have to clearly note here the volume of the material is indicated as loose meter cube, that means the material is in loosen state. After the material is cut, we are going to it is already in the loosened state we have excavated the material, we have cut the material, so the material is now loosen state and you are going to push the loosen material.

So, what is a pushing ability of the blade that is what is indicated by the load ratio, horsepower per loose meter cube of material retain in front of the blade is load ratio. So, it measures the blades ability to push the load once a blade is loaded. Say so, it is not referring to the blade capacity that is different. So, this refers to the pushing ability of the blade. So, generally the soil is highly dense, in that case the blade will find it difficult to push the soil.

If the soil has less density, it will be easy to push**.** So, it depends upon the type of material which we are going to push. So, generally higher load ratio means your dozer can push the load at a greater speed, it indicates the pushing ability of the material. That depends upon the type of the material which we are going to push and also depends upon the type of blade. So, as it is mentioned it is horsepower per loose meter cube of material if the blade is smaller in dimension. So, there will be more concentration of power per meter cube of material in the front of blade.

So, those blades can easily push the material. So, smaller blades will also have high load ratio. Say, it not only has high cutting ratio, it also has high load ratios, smaller the dimension more concentration of power will be there per loose meter cube of the material retain in front of the blade. So, those blades can easily push the soil to the other greater speed. So, this is how we assess the performance of the blade.

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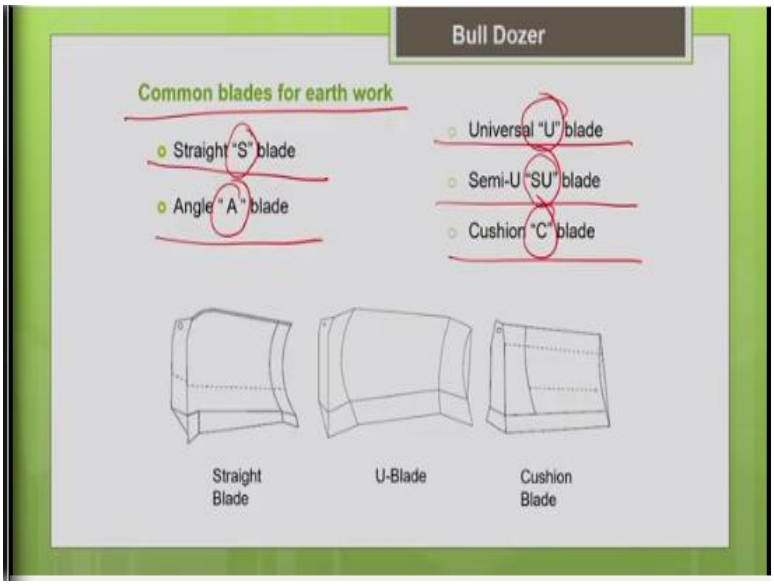

Now let us look into what are all the different types of the blade**.** These are the common blades which are used for the earthmoving operation, straight blade, angle blade, universal U blade, semi U blade and cushion blade. So, these are the standard notations used S refers to straight blade, A for angled blade, U for universal, SU for semi U and C for cushion blade. So, we are going to discuss all these blades one by one in the upcoming slides.

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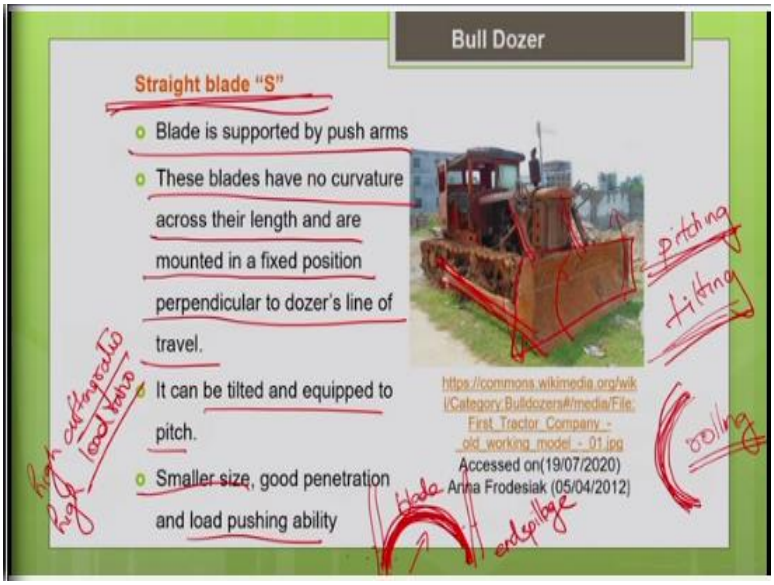

So, first we are going to discuss about this straight blade. Straight blade it is denoted as S, S blade. As the name indicates straight that means your blade is fixed straight perpendicular to the direction of the travel. So, this blade I cannot either angle it to left or right angle it to right, angling is not

possible with this blade. It is fixed perpendicular to the direction of the travel**,** so that we have to note it.

So, you can see the type of connection, these blades are commonly connected to the tractor by this kind of tilt cylinder and pusher arm arrangement. So, with this we can have the possible blade movements. So, what are all the possible blade movements with this kind of arrangement one is pitching, other one is tilting. So, only these are the 2 movements possible for this blade. As I mentioned earlier, angling is not possible with the straight blade.

So, it is fixed perpendicular to the direction of the travel, hope you remember what is pitching, pitching means you can pitch the top end of the blade forward or backward. So, tilting means I can raise one end of the blade upward and the other end of the blade I can lower it downward. So, it is a movement in the vertical plane, tilting is the movement in the vertical plane.

So, only these are the 2 movements possible with this straight blade. And another important thing to be noted is generally all the bulldozer blades most of a bulldozer blades have the curvature in the vertical plane. So, the blades will have the curvature in the vertical plane like this. So, what is the main purpose of the curvature? You can see in this picture also a curvature in the vertical plane.

So, what is the main purpose of the curvature? See you want to push the material, so the material should roll in front of the blade to facilitate a rolling effect we have this curvature. So, that the material can easily roll, for the rolling purpose to make the material easily roll in front of the blade, I have the curvature in the vertical plane. All the blades will have the curvature in the vertical plane, but there are some blades which also has a curvature in the horizontal plane.

So, some blades you can see it will have a curvature in the horizontal plane also the blade is curved like this. So, the main reason why the blade is curved like this is, so that the material will be contained inside and you can reduce the spillage of material at the ends. At the end always when the dozer, blade is pushing there will be some spillage of materials at both ends of the blade.

Say this is the blade at both the ends of the blade, there will be some end spillage. To reduce the end spillage some blades have the curvature in the horizontal plane also, that is along it is length. So, in the length also you have a curvature, so those blades are called as U blades, that we are going to discuss later. But what I am trying to say here is in the straight blade, you do not have the curvature in the horizontal plane.

So, this blade is straight, that means it has a curvature only in the vertical plane, it does not have a curvature in the horizontal plane. And this blade is fixed perpendicular to the direction of travel you cannot angle it to the left or right, this is what is to be noted. So, the blade is supported by pusher arms and tilt cylinders, the blades have no curvature across the length, and they are mounted in a fixed position perpendicular to the dozer line of, so it is fixed, you cannot angle it.

So, what are the possible moments with this blade, it can be tilted and it can be pitched. So, these plates are generally smaller in dimension straight blades are smaller in dimension. So, what are the benefits of having smaller blades? You can have high cutting ratio and high load ratio. That means these blades will have high cutting ability or penetration ability and it will also have high load pushing the ability.

So, generally when you are going to encounter hard terrain, it is preferable to go for this kind of smaller straight blades. So, it can easily handle the harder terrain.

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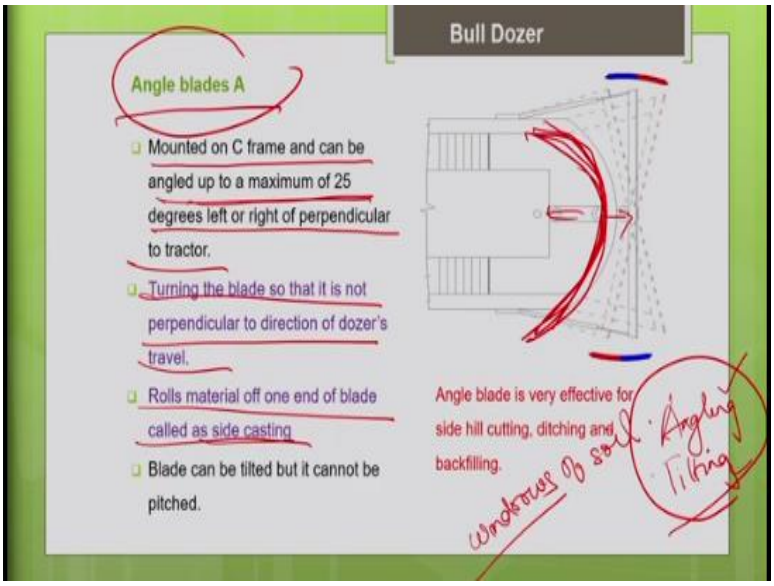

Now let us move on to the next type of blade that is the angle blade. So, these angle blades as I discussed earlier they are connected by C frame. The C frame is connecting the tractor and the blade. So, because of this C frame, it facilitates the angling moment. So, you can see the angle can be turned left or turn right to maximum of say 25 degrees. So, it is mounted on a C frame and can be angled up to a maximum of 25 degree left or right of the perpendicular of the tractor.

So, we have already discussed the main applications. So, when you are working on one side of the road or side hill cutting or if you wanted to backfill the trench, all these operations can be easily done by this angle blade. So, you can turn the blade to left or right, so that it is not just perpendicular to the direction of the dozer travel. So, this rolling the material to one end of the blade is called a side casting.

So, with this help of this blade, I can just roll the material to one end of the blade and that is called a side casting. So, this blade can easily do the stripping work and deposit the material in windrows, they call windrows of soil. So, what are the possible movements with this blade? One obviously I can do angling, I can angle it to the left or right maximum of 25 degree and I can also tilt it, tilting is also possible but pitching is not possible.

So, because of the C frame connection, I will not be able to pitch my blade. So, I cannot pitch the top end of the blade forward or backward, that is not possible with the angle blade, only possible

movements are angling and tilting. These blades are not considered as highly productive blades for earthmoving operation when compared to straight blades. So, the productivity will be only 60% of the straight blade ok. But this is for a special application as I told you.

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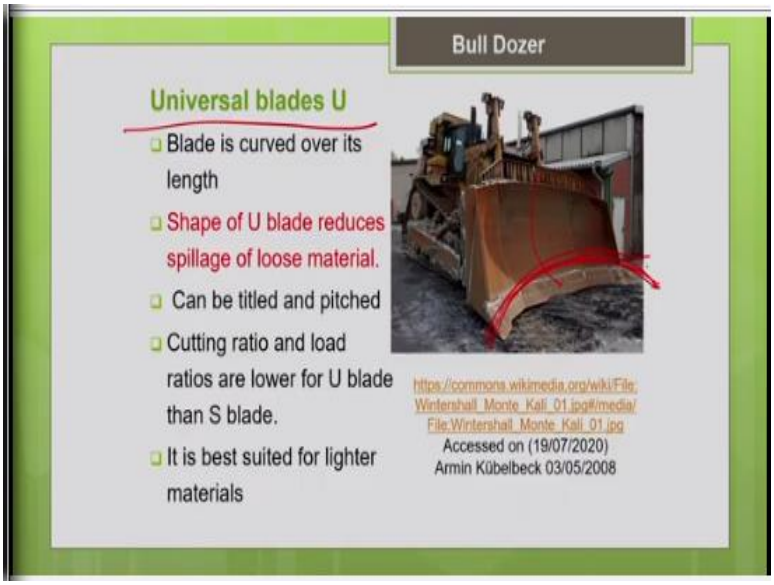

Universal blade, U blade, this is what I mentioned little bit earlier, like this blade has a curvature in the horizontal plane also. All the blades have the curvature in the vertical plane; in addition, these blades also have the curvature of the horizontal plane.

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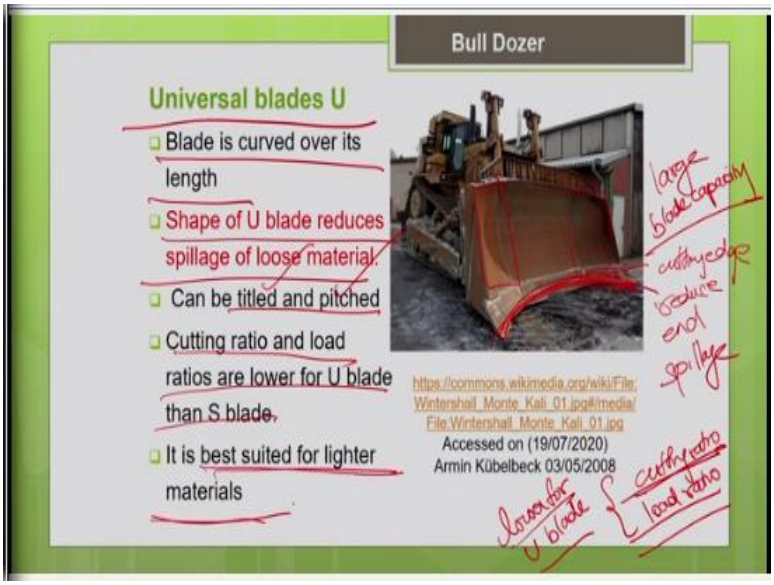

So, you can see the curvature in the horizontal plane in the form of U. So, what is the purpose of this U? So, that I can contain the material within the blade, so these are generally larger blades,

the dimension is very much bigger when compared to straight blade. You can see the kind of wings are attached on both the ends. So, they call these as wings the left wing and right wing, so it increases the dimension of the blade.

These are bigger blades you can see at the bottom cutting edge, this is the cutting edge and you can see the U curvature. So, because of this U curvature I can contain the material within the blade, I can reduce the end spillage that is a main advantage of this blade. End spillage can be reduced on both the ends. So, these plates have large blade capacity, blade capacity is high because they are bigger blades, the dimension is bigger, so that is why the blade capacity is bigger.

But one thing to be noted, the cutting ratio and load ratio these are lower for U blade when compared to straight blade. So, the cutting ratio and the load ratio are lesser for these new blades when compared to this straight blade because they are bigger in dimension. Only smaller blades can have high cutting ratio and the load ratio because of the greater concentration of the horsepower per unit meter of the cutting edge.

But here since the blade dimension is bigger, these are laser cutting ratio and load ratio. So, then why do we use this blade? See if you are going to handle some average terrain, average terrain means soil conditions are not that dense, soil conditions are not that hard to handle. So, for lighter materials, it is the right choice it can easily push the lighter material which are the less dense and you can use it for a relatively longer distance less end spillage. Because of the U curvature the end spillage is less.

For those applications you have to choose this new blade. So, you can see the blade is curved over it is length, the shape of U blade reduces the spillage of the loose material. So, the possible movements of tilting and pitching, for this blade only tilting and pitching possible, only for the angle blade you can do angling. For all the other blades you can see that most of the other blades you can see the common movements possible are only tilting and pitching. Cutting ratio and load ratio are lower for U blade than the S blade. It is it is best suited for the lighter materials.

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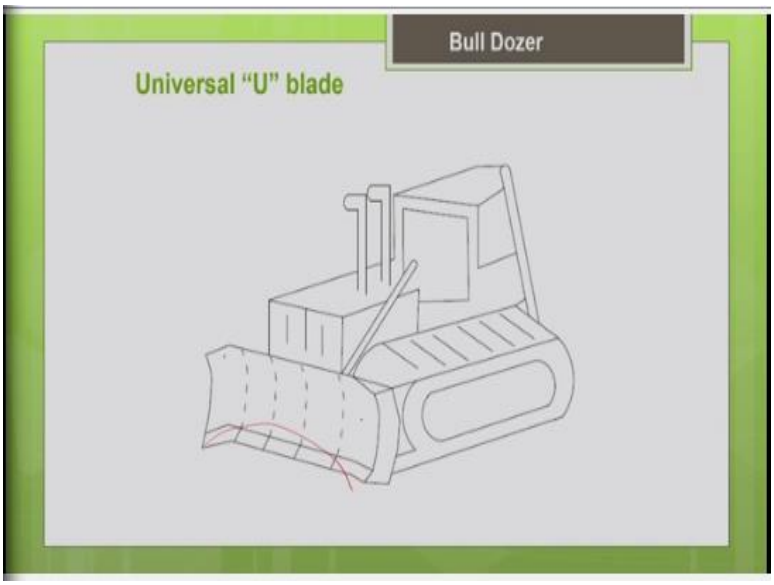

So, this is again a schematic sketch showing the U blade connected to the bulldozer, you can see they are larger in dimension and they have a U curvature. And you can see the wings attached on both the ends.

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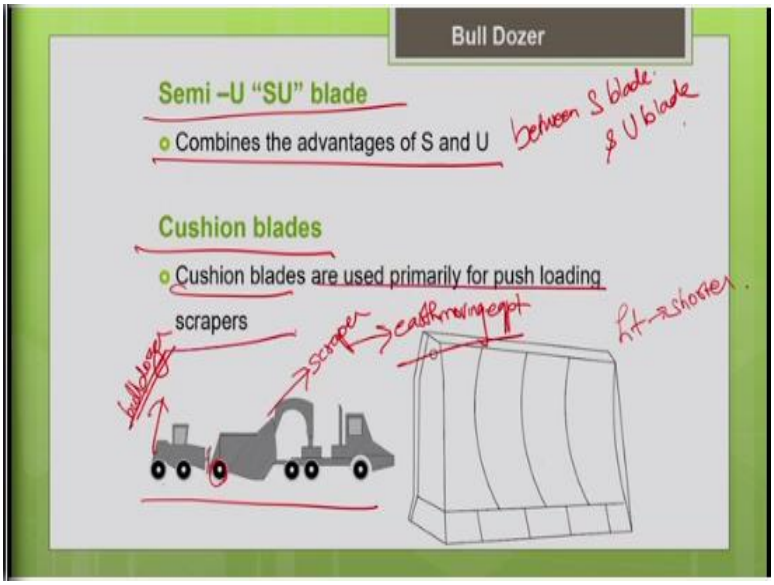

Now let us see what is this SU, semi U blade. It is something between straight blade and U blade, it is between S blade and U blade. That means it is dimensions bigger than the S blade but smaller than the U blade. Similarly cutting ratio is the lesser than the S blade but better than the U blade. So, it is something between the S and U blade. So, accordingly you have to make the choice according to your requirement.

Then let us see what is this cushion blade, I have shown this picture earlier. So, when we discussed about the application of bulldozers, I told you that the bulldozers are also used for supporting the other machines, so it helps in assisting the other machines in it is job. Say this is the schematic sketch showing a scraper. So, this is the bulldozer, so your bulldozer is helping to push the scraper.

So, this scraper is also when earthmoving equipment, we are going to discuss about this equipment in detail in the next lecture. This scraper has a bowl and a cutting edge. So, the scraper will cut the earth and fill the bowl that is called as a loading operation. So, during the loading operation, I have to supplement the power of the scraper with the help of a pusher, this pusher is nothing but your bulldozer.

So, this bulldozer will supplement the loading power of the scraper thereby you can enhance the productivity of your scraper. So, only during the loading operation I need the help of the bulldozer. So, for those bulldozers, so I am not going to use the blade for earthmoving operation. So, I need a blade for just pushing the machines that blade is called as cushion blade, C blade.

These blades are generally the height will be shorter. So, that the height of the blade, the blade will not disturb the rear wheel of the machine which it is pushing. So, the blade height is shorter and this blade no movement is possible, I cannot tilt or pitch or angle nothing is possible with this cushion blade it is just fixed. So, these cushion blades it is productivities also less**.**

With respect to earthmoving operation it is not commonly used for earthmoving operation, it is used primarily only for pushing the other machines. So, we have discussed about different types of blades so far. So, straight blade, U blade, angle blade and cushion blade and SU blade. Straight blade as I told you for harder terrain, you have to go for straight blade, because their cutting ratio and load ratio is high.

But the problem with a straight blade is you will have end spillage, when you push the earth, there will be spillage of material at both ends of the blade that will reduce the productivity of the bulldozer. So, in that case I have to go for the U blade, if you wanted to reduce the end spillage, you are going to push the material for a longer distance and if the material is easier to handle it is

preferable to go for U blade. Because U blade has a greater blade capacity also, bigger in dimension. So, similarly the cushion blade it is used only for pushing the other machines, when the bulldozer is used for assisting the other machines then it you can go for the cushion blade.

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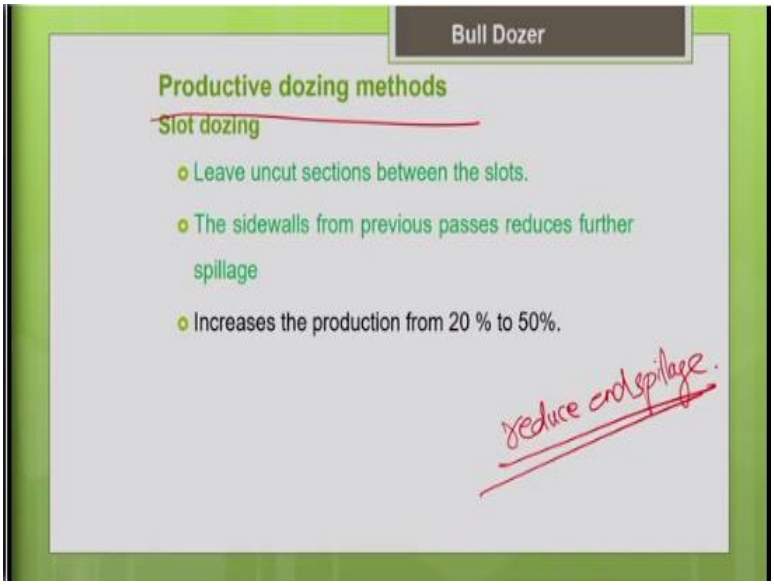

Now let us see what are all the different the dozing methods which are commonly adapted to enhance the productivity of the bulldozer. To enhance the productivity of the bulldozer, I need to reduce the end spillage of the material which is happening at both ends of the blades. How to reducing the end spillage? What are all the dozing methods which can help me to reduce the end spillage?

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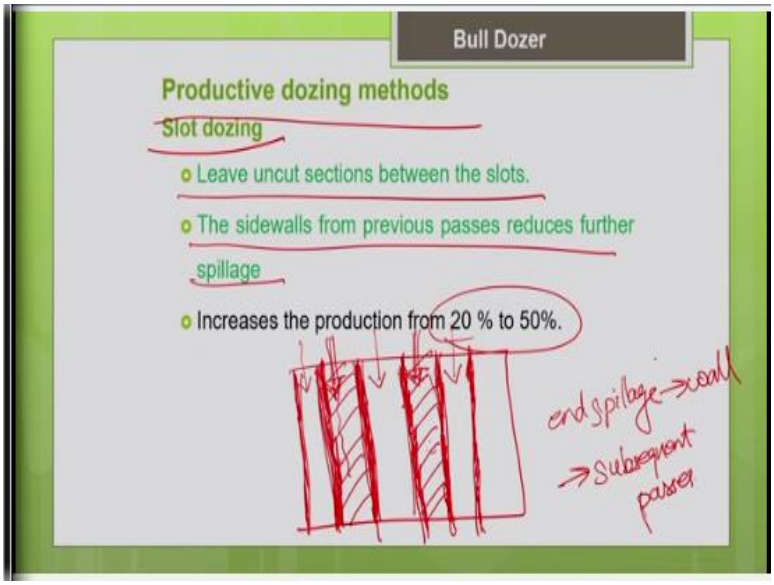

So, one such method is your slot dozing method, slot dozing. So, basically how to carry out this slot dozing? You have to divide your land, your area where you are going to do the dozing operation into many parallel cuts divided into parallel cuts. So, if you have a larger area, it is easy to implement this method. Divide your area into parallel cuts and allow the bulldozer to move through alternative cuts first, let it move through alternative cuts first.

So, when the bulldozer is moving through these cuts obviously at the both the ends you can see the end spillage will be there. As the bulldozer is pushing the earth there will be end spillage of material at both ends of the path, so here also the end spillage is there. So, now this end spillage will act like a wall, for the subsequent passes.

So, now after this, now you allow the bulldozer to go through the gap between the 2 cuts. So, now we are going to allow the bulldozer to go through the gap between the 2 cuts. So, when this is now going to this gap already the end spillage which is formed back by through the earlier passes, this is acting like a wall. Since this act like a wall the spillage, further spillage is reduced when the bulldozer is passing through this path.

Similarly, when it is passing through this path already you have end spillage formed here, that will act like a wall. So, this wall will prevent the further spillage during this pass. By this method, I can reduce the spillage and I can increase the productivity from 20% to 50%. So, basically you are going to leave some uncut section between the slots. So, these are the uncut sections, so you have left the gap between the slots.

So, first you finish these slots, then come back to this uncut section, when you do this section, the earlier passes spillage will act like a wall for this the passage, so this will further prevent the spillage. So, the sidewalls from the previous passes reduces the further spillage. So, this will increase the production as I told you from 20 to 50%. This is one method which is commonly followed to reduce the end spillage and to increase the productivity of the bulldozer.

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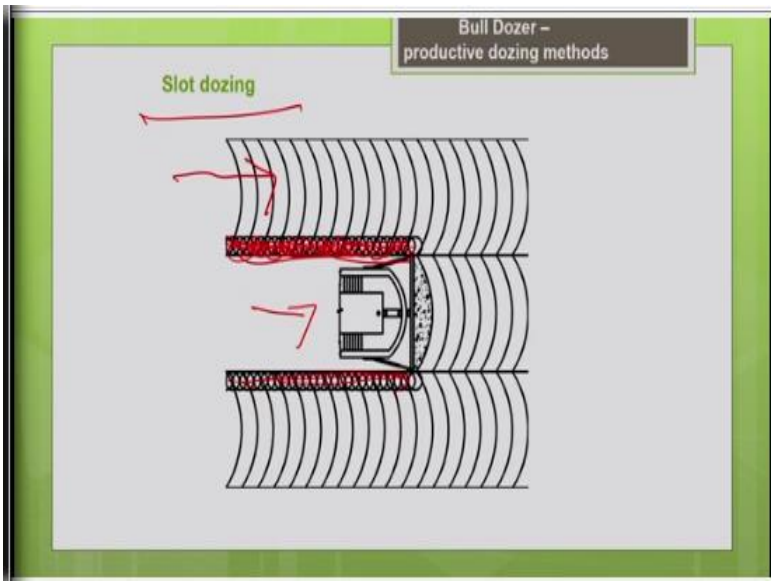

So, this picture also indicates the slot dozing. So, you can see when the bulldozer is moving through this particular cut, you can see the end spillage being formed at both the ends of the blade, this is the end spillage. So, after this, so when you go through the other paths. So, this end spillage will act like a wall for the subsequent passes, the end spillage formed during this particular pass will act like a side wall for the subsequent passes when the bulldozer is passing through this path, this will act like a wall and prevent the further spillage.

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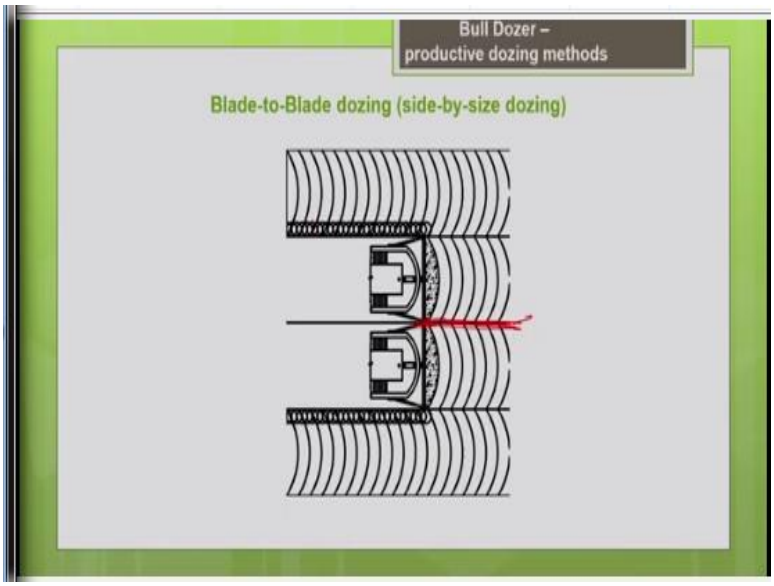

Now let us see another method of productive dozing method to reduce the in spillage. So, here what we are doing is we have to employ 2 bulldozers together and maneuver it in such a way that the blades are coming closer to each other almost touching the blades are brought closer to each

other. So, when the blades are closer to each other, obviously you can reduce the end spillage between these blades.

The spillage of material between the blades can be reduced. So, but the thing is there will be some additional time taken for maneuvering. The driver or the operator should be skilled enough to maneuver both bulldozers in such a way that the blades are closer. So, by this I can reduce the end spillage at the end of the blade. Obviously, the spillage is here but the spillage can be reduced here.

So, but this cannot be adopted for a very short distance for a very, very shorter haul distances because you need some sufficient time for maneuvering. So, there should be some sufficient distance, so that you can maneuver.

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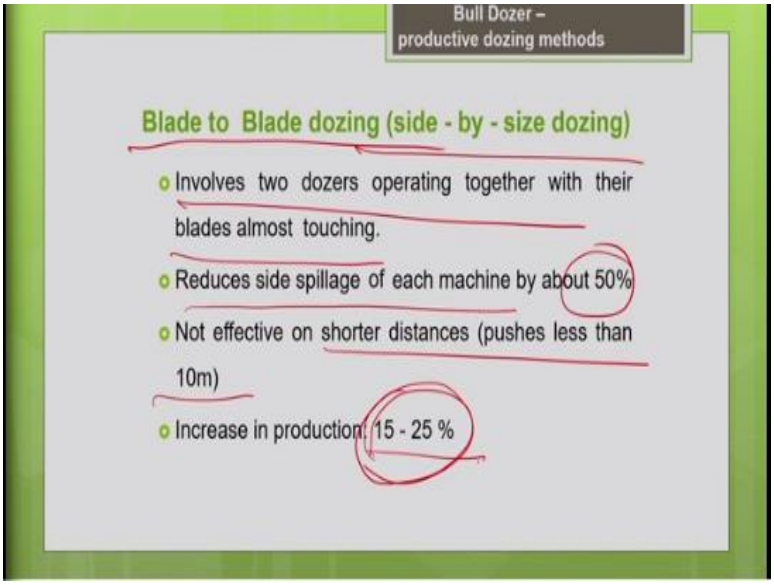

So, this blade to blade dozing it is also called as side by side dozing. Involves 2 dozers operating together with their blades almost touching, it reduces the side spillage between each machine by about 50%. But as I told you like some amount of time is needed for maneuvering, that is why I cannot use it for a very short distance say less than 10 meters, I cannot adopt this method.

So, because of the increase in the maneuvering time the effective increase in production you can see it will be about 15 to 25%. So, though it reduces the end spillage to certain extent, but it increases the maneuvering time, so the effective increase in production will be from 15 to 25%.

So, we have discussed about different types of blade movements and we discussed about the types of blades, how to assess the performance of the blade**.**

And also, we discussed what are the productive dozing methods to reduce the end spillage and to increase the productivity of the bulldozer. Now let us see what are all the factors which affect the productivity of the bulldozer?

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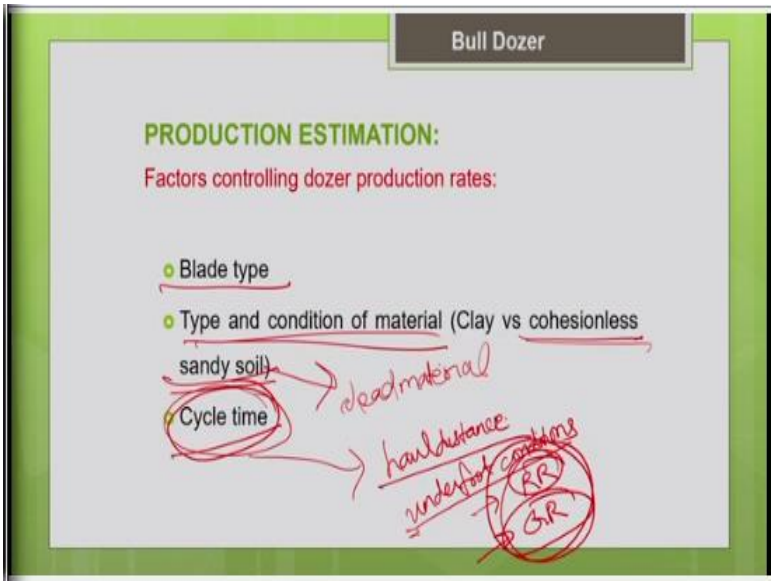

So, obviously your blade type will affect the productivity and the material with the blade is going to push the type of the material, the density of the material all these things will affect the productivity of the bulldozer. How the blade type will affect, we know it already, we have different types of blades straight blade, U blade, angle blade. So, as I told you for hard terrain straight blade will give you high productivity.

So, if it is just an average terrain, loose soil I can use U blade, there U blade will be it will be more productive. So, then angle blade, it is for a special application, angle blade is not that highly productive in earthmoving operations when compared to straight and U blade. So, depending upon the blade type, your productivity will vary. And as I mentioned earlier the material type, if the material is going to be cohesive, it is easy for the material to roll in front of the blade.

But if it is going to be cohesion less sand, the sand will act like a dead material**,** it will not roll in front of the blade. For this sandy soil, it is very difficult for the blade to push the soil, so the productivity gets affected. So, the type, the density of the soil, everything affects. If it is going to be denser material, it is difficult for the blades to push, if it is going to be less dense, it is easier for the blade to push, so accordingly the productivity will vary.

Then the cycle time, the cycle time it depends upon how much distance you are going to travel, say the haul distance, your path, so the which route you are adopting. So, what is the condition of that haul route? The project conditions, the underfoot conditions, the underfoot conditions are going to affect your cycle time. Say what is the rolling resistance, what is the grade resistance which are prevailing there**.**

Whether you are going to move up the slope or down the slope, all these things will affect the cycle time. So, your haul distance and the project underfoot conditions, the site underfoot conditions, the resistance is which the vehicle is going to encounter, all these things will affect the speed of the machine. And that is going to affect your cycle time.

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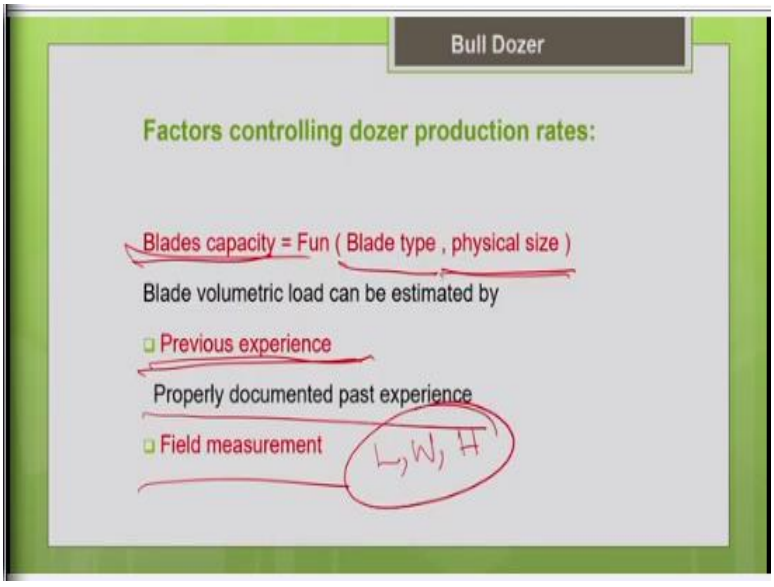

Now let us see how to estimate the blade capacity. The blade, so it is not like a bucket or bowl. So, how much material lies in front of a blade that defines the capacity of the blade. It depends upon your blade type and the dimension of the blade. Obviously as I told you straight blade are smaller

in dimension when compared to U blade. So, the greater the dimension, bigger the blade, your blade capacity will be more.

So, how to get the information on the blade capacity? I can get it from the manufacturer**.** So, the manufacturer will provide you the specifications like what is the capacity of the blade; I can get it from the manufacturer or from your own previous experience. So, for a similar type of blade and for a similar type of a dozer and for the similar type of terrain the material, soil. So, from your properly documented past experience, you can get the blade capacity, that is also possible.

Or you, yourself can do the field measurement at your project site. So, do the dozing operation, obtain a heap of earth in front of the blade. So, now you find what is the length of the pile along the length of the blade? Then perpendicular to the blade, what is the width? And what is the height of the pile? So, based upon the dimensions of the pile of material you can find the blade capacity.

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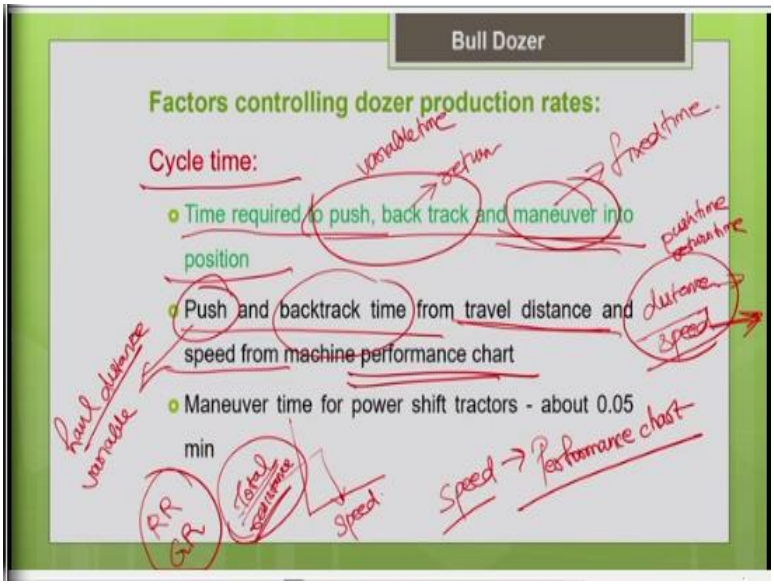

So, now let us see how to define the cycle and estimate the cycle time of the bulldozer. Say the bulldozer is used for earthmoving operation, how to define one production cycle of bulldozer? So, basically the bulldozer will cut the earth, once the blade is full, completely loaded, it will just push the earth till the dumping place, then it will return back to it is original position where you wanted to do the dozing operation again.