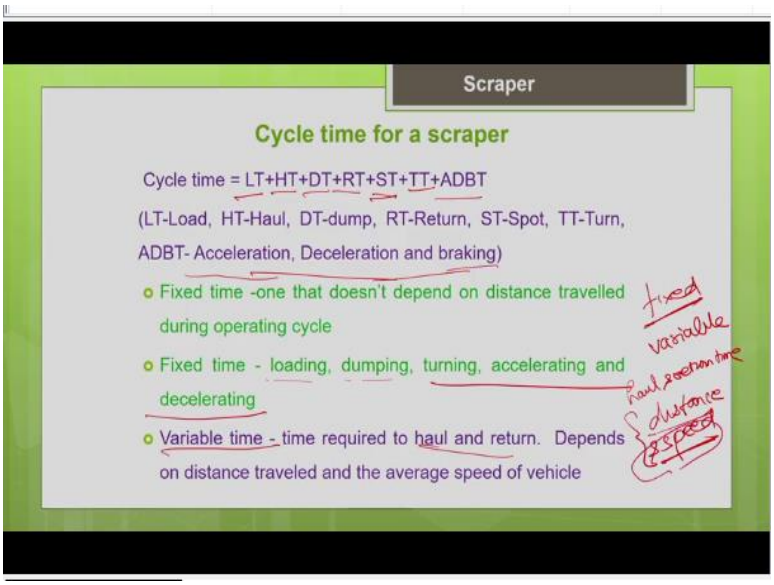


Cycle time = LT+HT+DT+RT+ST+TT+ADBT

(Where, LT-Load, HT-Haul, DT-dump, RT-Return, ST-Spot, TT-Turn, ADBT- Acceleration, Deceleration and braking)

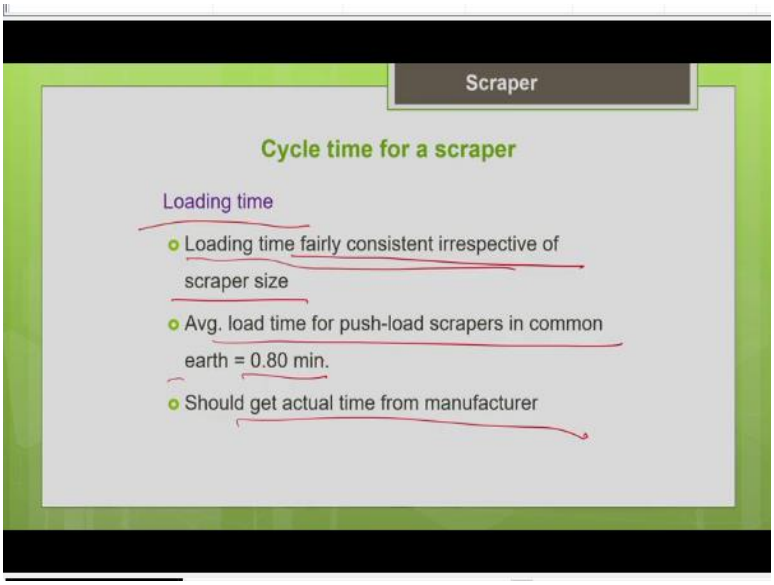
So, cycle time of a scraper, it is nothing but load time, hauling time, dumping time, return time spotting because most of the conventional scrapers a pusher loader scraper. So, it has to spot the pusher, that spotting time is also included then turning, then ADBT that means the time needed for increasing your speed or decreasing the speed, time needed for applying the brakes. So, all this manure comes under this ADBT acceleration deceleration and the braking.

So, basically you can split the cycle time into 2 parts. One is fixed time, other one is variable time. Fixed in the sense this part of the cycle time does not depend upon your travel distance. So, that is called as fixed time, say your loading, dumping, turning, your accelerating, decelerating. All these things comes under the fixed time. So, it is not dependent upon the distance travelled. The other one is a variable time, your haul and return is a variable time because it is significantly dependent on your travel distance.

So, your haul and return time depends upon your travel distance as well as the speed of your machine based upon that only you can decide your haul return time, obviously, you know that speed of the machine depends upon your project conditions. So, how is the underfoot condition

rolling resistance and grade resistance and your type of machine everything is going to affect the speed of machine. Now, let us see what is the loading time?

(Refer Slide Time: 25:48)

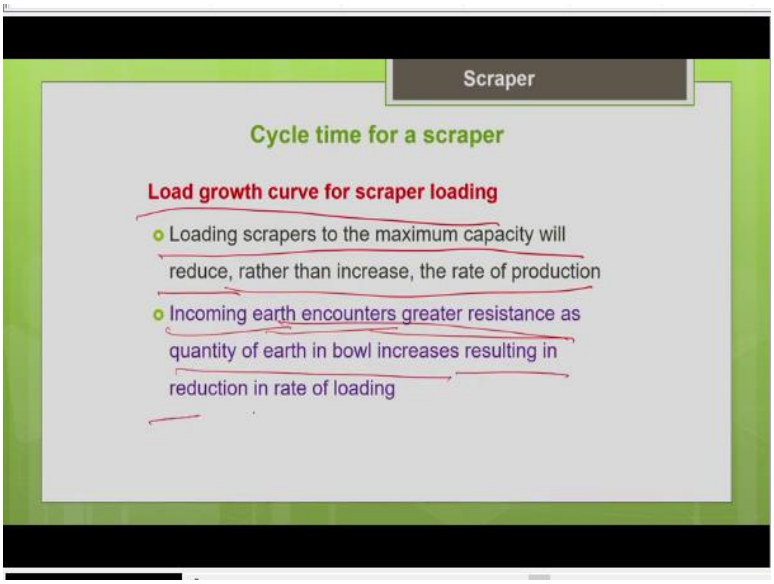


So, basically the loading time of the scraper is fairly consistent irrespective of the scraper size. So, that means whether it is going to be a smaller scraper or bigger scraper in both cases. So, commonly we can say that we are going to assist this scraper with the help of a pusher according to the size of the scraper the compatible size of the pusher you have to select and we are going to supplement the loading power.

So, that is why the loading time is going to be fairly consistent, irrespective of the scraper size whether it is a smaller one a bigger one since it is going to be assisted with the pusher the loading time would not change much. So, you can take the loading time actual time from the manufacturer for the particular scraper and the for the particular material. So, we can take it from the manufacturer.

The average load time for the pusher loaded scraper in common earth. Say for example this typical values given for common earth it is 0.8 minute. So, you can take these values from the equipment handbook hopefully from the equipment manufacturer.

(Refer Slide Time: 26:55)



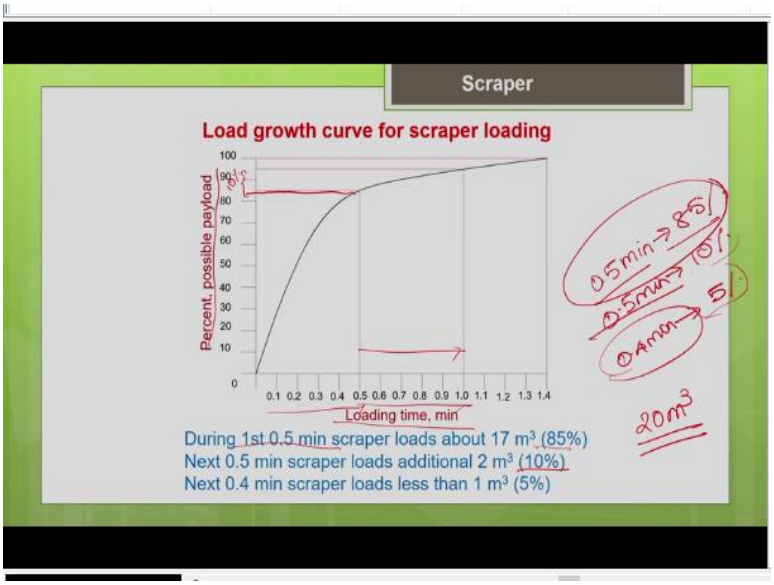
Another important concept which we need to know is about the load growth curve for scraper loading. So, we commonly believed that when we load this scraper when we fill the bowl of the scraper to the maximum capacity we are going to maximize a production. So, this is what is a common belief this is what is a common assumption, but that is not true. So, people have done the studies and they proved that when we tried to load the scraper to its fullest capacity.

So, the production starts reducing beyond a particular time, why that is happening? Because you know that loading mechanism of the scraper hope you remember the scraper loading mechanism. So, the material you are lowering the bowl. So, the material is entering through the apron into the bowl. So, initially when the material enters into the bowl. So, initially when it enters it can easily enter into the bowl? So, say now, when the bowl is almost full say 85% volume of the bowl is filled with the material. Now, you can see that the loading rate will start reducing why?

Because the incoming earth encounters resistance from the material which is already lying inside the bowl. So, the material which is already lying inside the bowl will start offering resistance to the incoming materials, which is entering into the bowl, when the bowl is 80, 85% fill. So, because of that, you can see that the loading rate will start reducing. So, this they call this law of diminishing returns.

So, that is what is written in this slide. The loading scrapers to the maximum capacity will reduce rather than increase the rate of production. So, do not try to load the scraper to its maximum capacity. The incoming earth encounters greater resistance as the quantity of earth in the bowl increases resulting in a reduction in rate of loading. So, the material which is lying inside the bowl, so when the amount of material inside the bowl starts increasing, that will start offering resistance to the material which is trying to enter the bowl now. So, that is why the loading rate starts reducing. So, we can easily understand that concept by drawing this load growth curve.

(Refer Slide Time: 29:24)



See, you have the loading time in minutes in the x axis and you have the percentage possible payload in the y axis. So, possible payload in percentage means what is the maximum capacity of your bowl? So, how much you actually fill your bowl? So, that percentage will be plotted here. So, now you can say that during the first 0.5 minute say the scraper capacity is 20 m^3. The maximum capacity of the scraper which we have considered here is say 20 m^3.

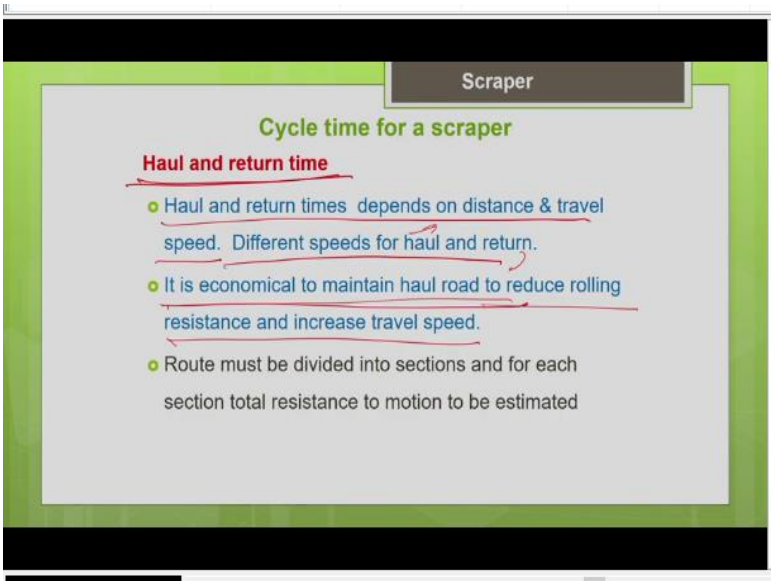
Now you are loading the material into the bowl for the first 0.5 minute, you can see for the first 0.5 minute. So, your payload percentage is how much you have filled 85%, in the first 0.5 minute I have filled 85% of the scraper bowl, but the next 0.5 minute say till 1 minute you can see how much you filled it only 10%. So, here I have filled only 10% for the next 0.5 minute. So, for the first 0.5 minute, I have filled 85%.

For the next 0.5 minute I have filled only 10% and the next 0.4 minute I am filling only 5%. So, by looking at this values, you can see that beyond 85% beyond 0.5 minute of loading, you can see that the rate of loading is reducing, the rate of loading starts reducing, that is why we have to draw this kind of load growth curves and you have to find the optimum loading time for the particular scraper for the particular material and we have to load the bowl only to that particular capacity.

So, we have to go by only optimum loading time that you can get it from the manufacturer, optimum loading time can be determined from the load growth curve and you can also get the value from the manufacturer. So, this curve clearly shows that only for the first 0.5 minute, you can see that the loading rate is good 85% you have filled, beyond that, your rate of loading has started reducing because the next 0.5 I have loaded only 10%.

And the next 0.4 have loaded only 5%. So, that means that we should not try to load to its fullest capacity, we are actually wasting our time by trying to load it to the fullest capacity. So, find the optimal loading time by drawing the load growth curve.

(Refer Slide Time: 31:55)



So, the next important component of the cycle time of the scraper is your haul and return time, as I told you it is a variable time, it is going to depend upon your travel distance and the speed of your machine. So, that speed depends upon your project site condition underfoot conditions. So, haul and return time depends upon the distance and the travel speed. So, we can see that obviously,

different speeds are there for the haul journey the return journey onward journey and the return journey.

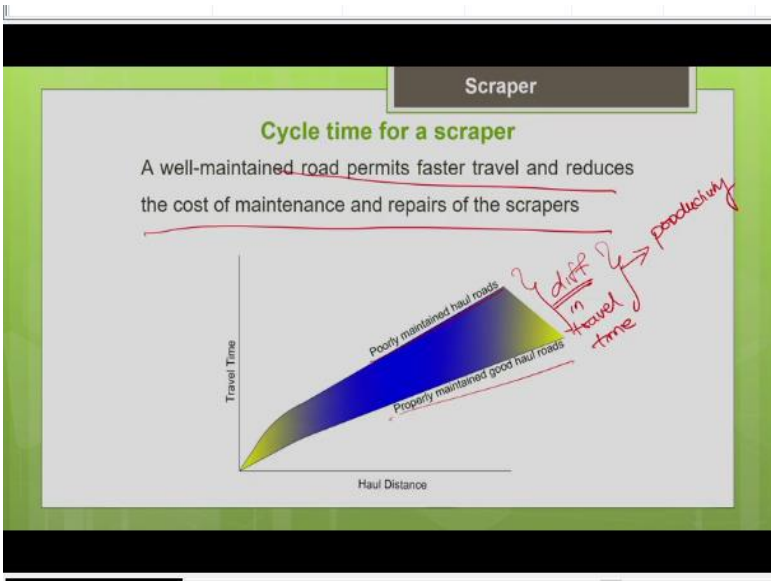
Because while hauling it is not loaded condition, in the return journey, it is unloaded condition, speed will be higher in the entirely unloaded condition. So, we should know that it is very important to note that we have to maintain the haul route; we have to spend some efforts in maintaining the haul route of the project site. Haul route you have to maintain it either with the help of a grader or a bulldozer, we have to maintain the haul route using water trucks, you have to sprinkle the water and maintain the moisture content in the haul route.

So, that you can avoid or control the dust to improve the visibility of the site, all these things need to be done carefully to maintain the haul route. So, whatever efforts you are putting to maintain your haul route, which will help in reducing the cycle time of your machine, it will help in reducing the haul and return time and that way it will improve the productivity of your machine.

So, it is economical to maintain the haul route. So, whatever efforts, whatever money you spend for maintaining your haul road, it is going to give you good return by saving your cycle time, by increasing your productivity and thereby reduce your unit production cost, it is economical to maintain the haul road to reduce the rolling resistance and increasing travel speed. Sometimes you can see in your project site, different sections of your haul route will have different types of the resistance.

So, the rolling resistance and the grade resistance will differ from section to section in a haul route. In that case, you have to determine the speed of the machine in every section independently. So, individually you have to break the haul route into different sections.

(Refer Slide Time: 34:26)

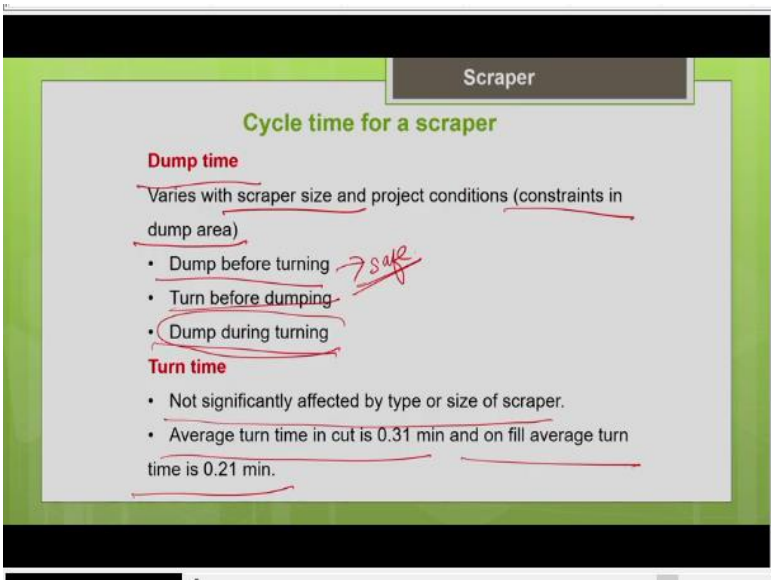


And for every individual section, you are supposed to determine the speed and the travel time. This picture clearly shows like what are the benefits we get by maintaining the haul route. This is just a schematic picture which shows how well maintained road permits faster travel and it reduces the cost of maintenance and the repair of the machine also. If you maintain your haul route, you can increase your life of a machine.

The cost of maintenance and repair that is your operating cost you can reduce and you can also extend your lifetime of your machine. So, there are so many benefits by maintaining the haul route. So, you can see the difference in the travel time between poorly maintained haul routes and properly maintained good haul roads, in properly maintained haul roads, you can see that the travel time is very much less.

So, this much difference or saving the travel time can have a significant effect on your productivity, you can have a significant effect in enhancement of your productivity and the reduction in cost associated.

(Refer Slide Time: 35:36)



So, the next important thing which we are going to see as a component of your cycle time is your dump time. So, your dump time of your scraper it depends upon your scraper size obviously, bigger the scraper your dumping time will be more. So, it depends upon the scraper size as well as it depends upon the material which it is handling, if it is a loose material. So, it will be very easy for the scraper to dump it loose flowing material.

So, if it is going to be very cohesive sticky material in that case dumping time will be more and also it depends upon the constraints in your dump area. Many times, you can see that the dumping site may be very narrow lot of congestion of other machines can be there the dumping site, in that case your machine has to wait for dumping. So, all these things depending upon the constraints of the dump area, it can affect your dumping time.

And another important thing which you also always need to remember is the scrapers are basically designed for to looser material. So, when you handle loose earth its productivity will be very high. So, that is very, very commonly you can see that if the terrain is going to be very hard terrain so very tough consolidative clay. So, in order to enhance the productivity of the scraper, what they do is initially they use a bulldozer with a ripper and rip the soil.

So, they loosen the earth the rip it, so that you can easily use a scraper for loading operation. So that way you can help the scraper to reduce the loading time. Now we are discussing about the

dumping time. So, you can see that there are different ways to dump in a project site. So, everything depends upon your project site constraints, you can see that sometimes your scraper will dump before turning.

So, it depends upon your project site. So, before turning itself it will dump and this is going to be very safe way because in a loaded condition if it is going to turn in that case it is not safe for the scraper. So, this is the best way dump before turning, in some cases depending upon your project site you can see that it will turn, before dumping. So, it will turn before dumping that means it is turning in the loaded condition.

This is relatively unsafe for the scraper, sometimes you can see that your scraper will do the turning and the dumping together. So, that will actually increase the dumping time. So, there are different ways to do which way you are going to dump it depends upon your actual project space constraint. Sometimes we have to even go for the third option dumping and turning together, it depends upon the space availability.

So, but the best thing the safe way is you dump the material and then make a turn that is really safe for the scraper then about the turn time of the scraper. So, you can see that the turn time is basically not affected by the type or the size of the scraper. So, hope you remember the picture which I have shown to show the production cycle of the scraper, you can see the scraper commonly you can see that 2 turnings are done by the scraper.

One is the turning in the fill area and other one is turning in the cut area. So, basically when the scraper makes a turn in the cut area the turn time is a little bit higher when compared to turning in the fill area. So, this is because you can see very commonly more congestion in the cut area, more equipment will be involved in the cut area because in the cut area you can see pushers also assisting the scrapers, so many machines have involved in the cut area.

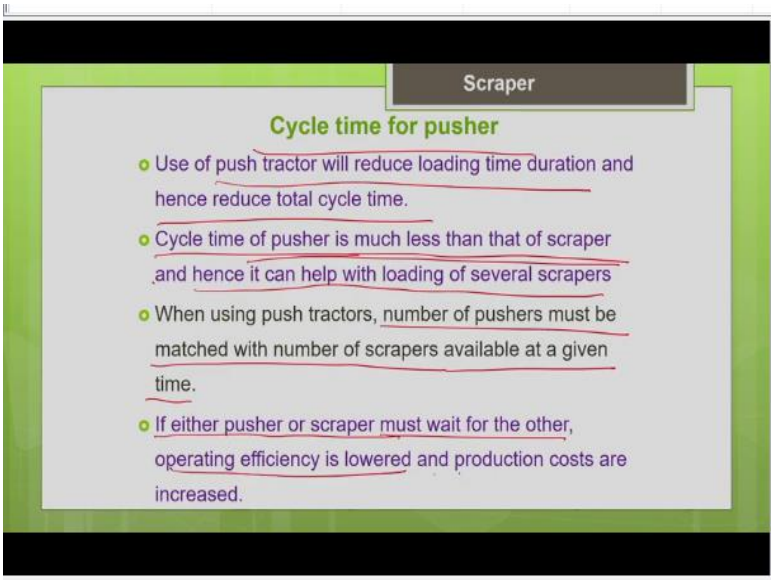
And another thing is your machine has to turn and then spot another pusher to begin the next cycle. So, it has to spot the pusher also. So, all these things will increase the turning time in the cut area when compared to the fill area. So, you can see that average turn time in the cut is 0.31 minute,

but on the fill the average turn time is 0.21 minute. So, slightly the turn time in the cut is greater. So, based on studies people have determined the researchers have determined these values, we can make use of these values for our estimation of the cycle time and the productivity of the scraper.

So, far we have discussed about the cycle time of the scraper. So, we have the 2 different parts of the cycle time, one is fixed and the other one is it variable. So, under fixed we saw the components like you have the loading time, dumping time, turning time, say turning at the fill area, turning at the cut area and you also have the time needed for acceleration, deceleration, braking, all these things makes up the fixed time**.**

The other part is the variable time and the variable time you have your haul onward journey time as well as the return time, that is your return journey. So, all these makes up the cycle time of the scraper. Now let us see how to estimate the cycle time and what all the components of the cycle time of the pusher?

(Refer Slide Time: 41:02)



So, as we discussed earlier when you use a pusher for assisting your scraper, you can reduce the loading time of the scraper, it will help you to increase the productivity of the scraper and reducing unit production cost of the scraper. So, use a push tractor will reduce the loading time duration and hence reducing total cycle time and another important thing to be noted is the cycle time of the pusher is much less than that of the scraper.

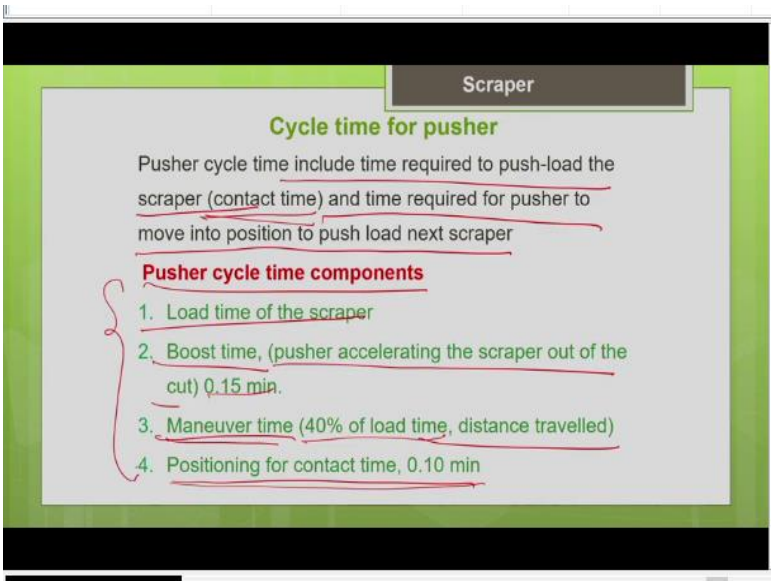
Because you know that the pusher is helping the scraper only during the loading phase. Once a bowl of the scraper is completely filled then the scraper will get detached from the pusher and the scraper can do the hauling operation on its own after that it will become independent. So, you need the help of the pusher only during the loading phase of the scraper. So, that is why the cycle time of the pusher is much less than that of the scraper and one pusher can serve even up to 4 to 5 scrapers.

So, hence it can help with loading of several scrapers. So, when using push tractors, number of pushers must be matched with the number of scrapers available at a given time. That is very important. So, how many number of scrapers you have and how many number of pushers you have at the project site and we should properly optimize a balanced otherwise what will happen either the scraper has to wait for the pusher or the pusher has to wait for the scraper.

If this happens, it will increase the waiting time and that will increase the cycle time and that will decrease your productivity and increase your production cost. So, that is why we need to balance the number of scrapers and number of pushers, balancing interdependent machines is very important to optimize the production and reduce the cost. So, we are going to discuss that in detail later.

And we will even work out some problems on how to balance the number of scrapers and the pushers? So, this is what is explained here, if either the pusher or the scraper must wait for the other operating efficiencies lowered and the production cost increased. So, that is why we need to balance the number of scrapers and the pushers. Now let us see what makes up the cycle time what all is the components of the cycle time of the pusher? So, as I mentioned earlier the pusher is assisting the scraper during the loading phase.

(Refer Slide Time: 43:30)

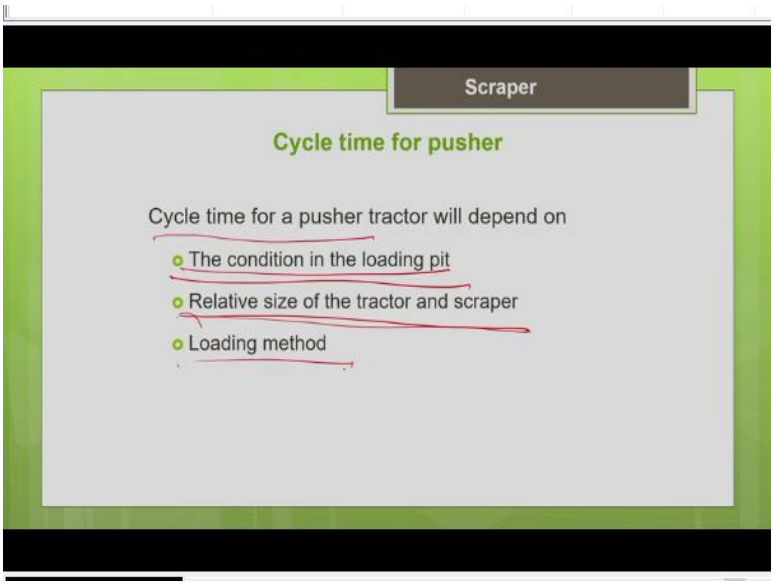


So, that is its contact time with the scraper contact time of the scraper with the pusher. So, after that what happens your pusher will get detached from the scraper and it has to travel and spot another scraper and get ready for pushing the next scraper. So, all these things makes up the cycle time of the pusher. Pusher cycle time includes time required to push load the scraper, that is its contact time with the scraper during its loading phase and apart from that the time required for a pusher to move into position to push load next scraper.

So, depending upon your site, it has to travel and spot the another scraper and get ready to push it. This makes up the pusher cycle time. Let us see in detail what are all the components? One is the loading time of the scraper and the other one is a boost time. The pusher will accelerate the scraper out of the cut. So that is called as a boost time. Pusher accelerating the scraper out of the cut say approximately 0.15 minute can be taken as a boost time, apart from that you have the maneuver time as I told you the pusher has to travel after pushing the first scraper it has to travel and spot the another scraper and get ready for pushing it.

That is a maneuver time. It can be taken as a 40% of load time. That is a distance traveled. There are other things positioning for the contact time. So, contact time with the pusher has to position. So, that it establishes its contact with you the scraper that positioning time is 0.1 minute. All these things makes up the cycle time of the pusher.

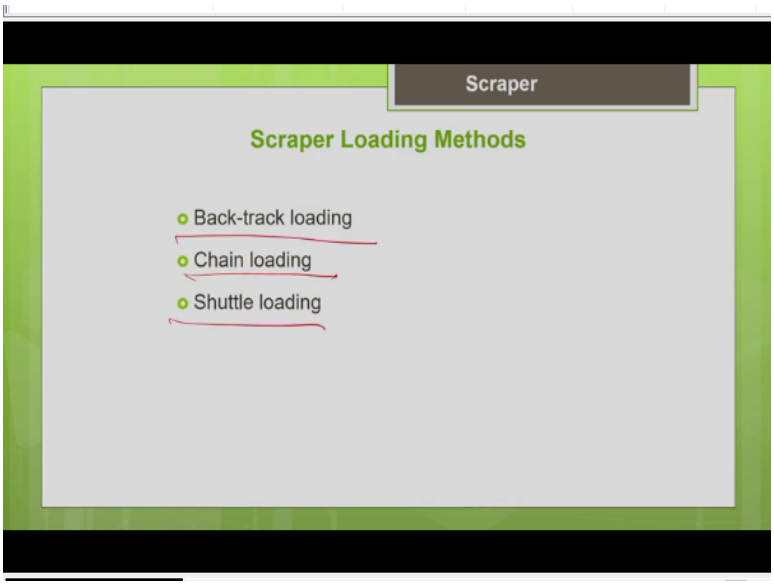
(Refer Slide Time: 45:14)



So, this cycle time of the pusher is variable it depends upon various factors, say it depends upon the condition in the loading pit, say if the loading terrain is very hard, consolidated clay. So, in that case, more time is needed for the pusher to assist the scraper. And also it depends upon the congestion at your site. If the site is very congested, it will be difficult for the pusher to spot the scraper. So, it depends upon the condition in the loading pit. And the relative size of the tractor and the scraper is very important.

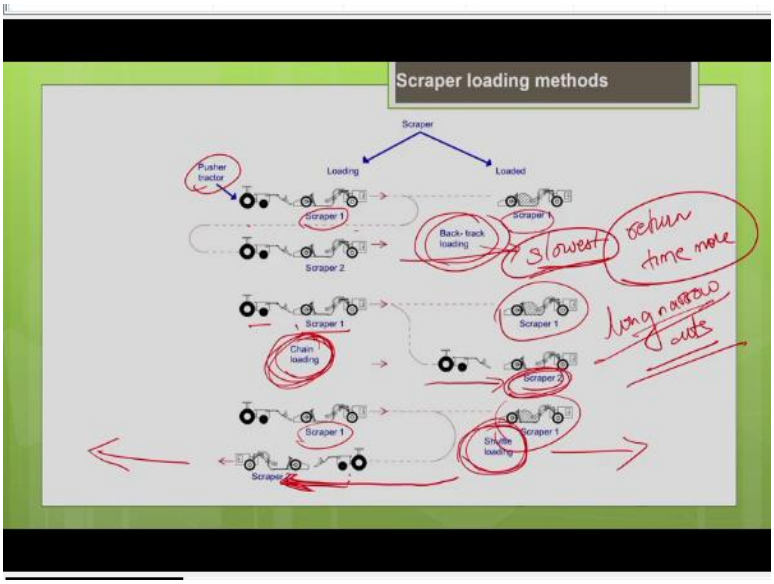
So, we have to select the pusher size compatible with the size of the scraper. For a bigger scraper, you need to choose a appropriate bigger pusher. So, that you can reduce the cycle time. So, the relative size of the tractor and the scraper also affects the cycle time of the pusher. And another important thing is the loading method. There are different loading methods. We are going to discuss the loading method also one by one.

(Refer Slide Time: 46:15)



So, let us see what are all the loading methods? Scraper loading methods, back-track loading, chain loading, shuttle loading. So, what are these loading methods we are going to discuss now?

(Refer Slide Time: 46:24)



The first is the back-track loading method. So, this pictorial representation will clearly explain the different types of loading methods. So, the first one is a back-track loading, the second one is a chain loading and the third one is shuttle loading. So, what is this backtrack loading? So, the first is the pusher helping the scraper 1, the pusher tractor it is helping the scraper 1 for loading phase for loading. So, once the scraper 1 is completely loaded, your pusher will get detached from the scraper and it will back-track.