So, once the loading of scraper 1 is completed, the pusher will back-track return back and spot the next a scraper, scraper 2 and start pushing it in the same direction. So, that is what is a back-track loading. So, first it is pushing the scraper 1, as a scraper 1 is completely loaded it will start moving on its own. Once the scraper 1 is loaded, your pusher will get detached and return that is backtracking, backtrack and it has to travel some distance and spot the next scraper 2.

And then start pushing again in the same direction, it starts moving again in the same direction. So, that is what is your back-track loading method. So, one limitation of this back-track loading method is it needs additional time for returning back backtracking. So, that is why we call this as a slowest method. So, this is the slowest of all the methods which we are going to discuss now. So, here you can see that the return time is more, return time is more because of the backtracking.

So, everything the actual value will depend upon your project site. So, we cannot tell the exact value but basically your back-track method takes longer time because the pusher has to return back, it has to back-track and spot the next scraper and then start pushing it again in the same direction. But this is more commonly adopted by everyone because the people prefer the cutting in the same direction.

So, that is why they prefer the back-track loading method. And the next method which we are going to discuss is your chain loading method. So, this we commonly follow for long cuts, long narrow cuts like your roads, we can follow the chain loading method, say here your pusher is pushing the scraper 1, once a scraper 1 is completely loaded the scraper 1 is now in fully loaded condition. Now your pusher will get detached from the scraper 1 and the pusher start pushing the next scraper.

But here is what happens the scraper 2 will come and wait near the pusher. Your pusher may not backtrack again; it may not return back again and spot the next scraper. So, the scraper 2 will come and wait near the pusher. So, this is commonly adopted in long roads I mean long narrow cut like roads. So, here also since the returning time is reduced. So, you can say that the chain loading cycle time will be less.

The next one is shuttle loading, this is not commonly followed, but you can follow it when you have 2 fill areas. That means you have a fill area in this direction as well as you have fill area in this direction. If you have fill areas in both the direction, then you can follow the shuttle loading. So, what happens here is the pusher is pushing the scraper 1. The scraper 1 is now completely fully loaded, it is fully loaded.

After that your pusher is getting detached from the scraper 1 and it starts pushing another scraper in the opposite direction. Your pusher is pushing another scraper in the opposite direction that means you have a scraper moving in both directions in this particular site because we have fill areas in both directions. So, in that case it can go for shuttle loading, here also return time is reduced.

So, the cycle time is reduced. So, when you compare all these 3 methods, you can see that your back-track is the slowest method, the cycle time is relatively higher because it has to back-track or return to support the next scraper but your chain and shuttle loading though they are not commonly followed so, but they are having the lesser cycle time and we know the reasons already.

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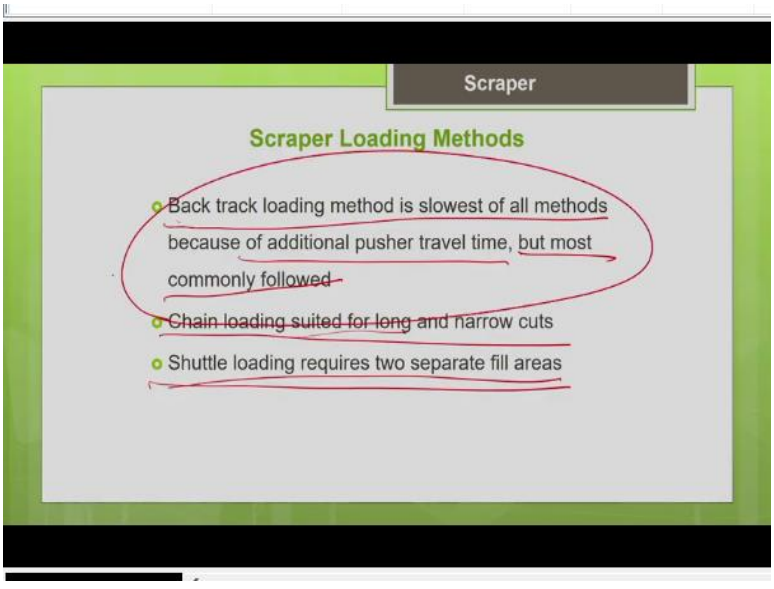

So, to summarize back-track loading method is the slowest of all the methods because of the additional pusher travel time for backtracking on returning. But most commonly followed because people prefer cutting in same direction. Chain loading, it is suited for long and a narrow cut, here

the return time is reduced. Shuttle loading requests 2 separate fill areas in both direction. So, you can see scrapers moving in both directions, this is also having shorter cycle, but this is the one which is commonly followed.

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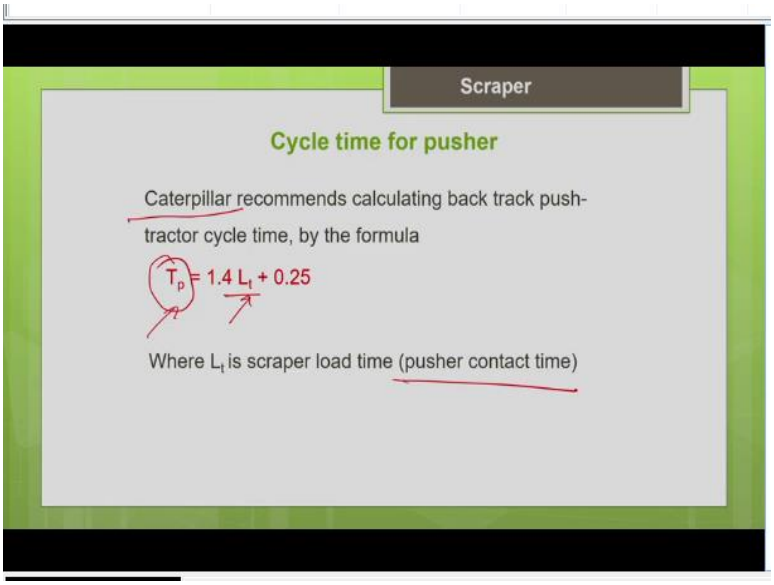

So, there is a thumb rule formula given by the caterpillar to determine the cycle time of the pusher, if you know the loading time of the scraper you can determine the cycle time of the pusher. Tp is the pusher cycle time and Lt is the scraper load time, the contact time of the pusher with your scraper during the loading phase of the scraper. So, if you know the loading time you can calculate the pusher time using this formula.

$$T_p = 1.4L_t + 0.25$$

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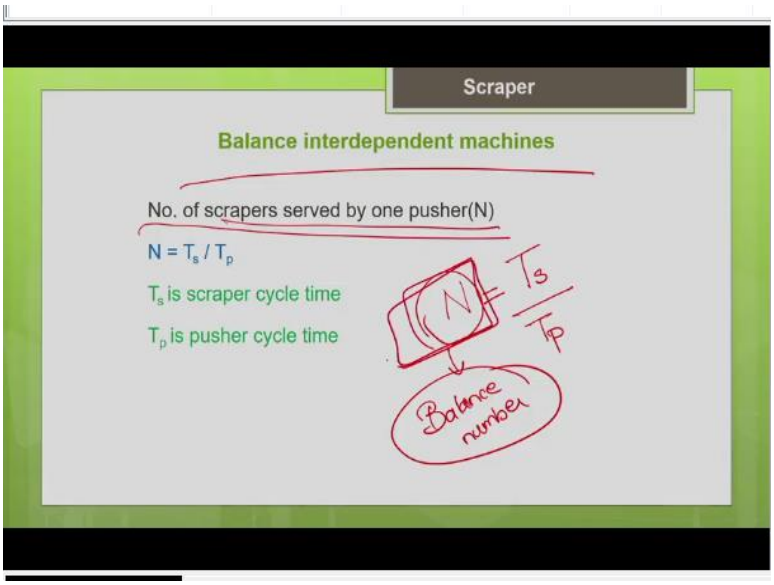

Another important thing as I mentioned earlier, we need to balance the interdependent machines, your scraper and pusher are interdependent machines, they work together. So, we have to balance them, we have to choose the correct number of scrapers and pushers, so that one need not wait for the other. So, we have to reduce the waiting time of the machines, so that we can reduce the cycle time, increase the productivity and reduce the production cost.

So, how to find the number of scrapers which can be served by one pusher? As I told you pusher cycle time is less it is assisting the scraper only during the loading phase of the scraper. So, one pusher can serve even 4 to 5 scrapers. So, now how to determine the number of scrapers served by 1 pusher? So, N is the number of scrapers served by one pusher, it is equal to cycle time of the scraper divided by a cycle time to pusher. This gives you the balanced number. So, this is your number.

$$N = \frac{T_s}{T_p}$$

So, when you choose the balance number of scrapers and pusher you can see that there will be minimum waiting time of scraper and pusher and you can see that when you adopt the balance number the production level of both the machines are same, the production level will be same and the scrapers and the pushers will be working at the maximum production capacity, when you have the balance number of scrapers and the pushers because they are waiting time is less. So, that is why it is always preferable to go for the balance number of the scrapers.

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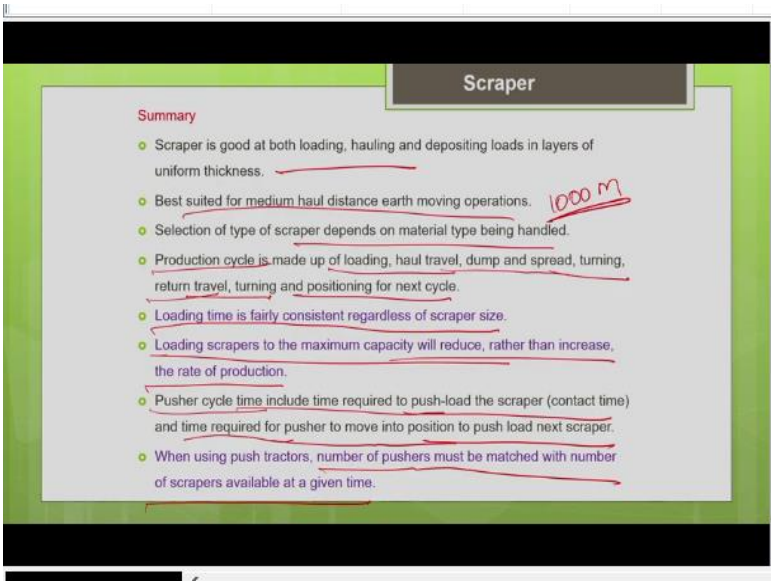

So, now let me summarize whatever we have discussed in this lecture 11. So, we know that the scraper is good at both loading, hauling and it can dump and spread the material in layers of uniform thickness. So, that is advantage that makes it more versatile, it is both good in loading and hauling and it can be used for depositing the material your dumping and spreading can be done in one continuous operation.

So, best suited for distances up to 1000 meter the scraper economical haul distance is up to 1000 meter, so more preferable for the projects like roads and dams. And there are different types of scraper; the selection depends upon the type of material. So, we have even discussed the chart which shows the zone of classification of the type of scraper with respect to the material type. And we know what all the components of the production cycle, it is made up of loading, haul travel, dumping, spreading, turning, return travel, again turning.

So, you have turning in the fill area as well in the cut area and then maneuver positioning for the next cycle. All these things makes up the production cycle of the scraper and we also discuss that loading time is fairly consistent regardless of the scraper size. So, whatever may be the size of the scraper are compatible with that you have to choose the size of the pusher. So, since we choose compatible sizes, the loading time is going to be fairly consistent.

The loading scrapers to maximum capacity will reduce rather than increase rate of production. So, we should not try to load the scraper to the fullest capacity because we saw that as a scraper bowl is almost full, you can see that the incoming material will encounter the resistance from the material which is already lying inside the bowl. So, you can see that unnecessary it will result in increase in your loading time.

So, do not try to load scraper bowl to its fullest capacity, find the optimal loading time from the load growth curve which you can get it from the equipment manufacturer and you have to follow the that particular optimal loading time. Then the pusher cycle time includes the time needed for push loading the scraper so you are going to push load the scraper as well as the time needed for moving the pusher into position to push load the next scraper, all these things makes up the cycle time of the pusher.

And when you are using the push tractors, we have to balance the number of scrapers and the pusher, number of pushers must be matched with the number of scrapers. So, that we can minimize the waiting time of the scraper and the pusher.

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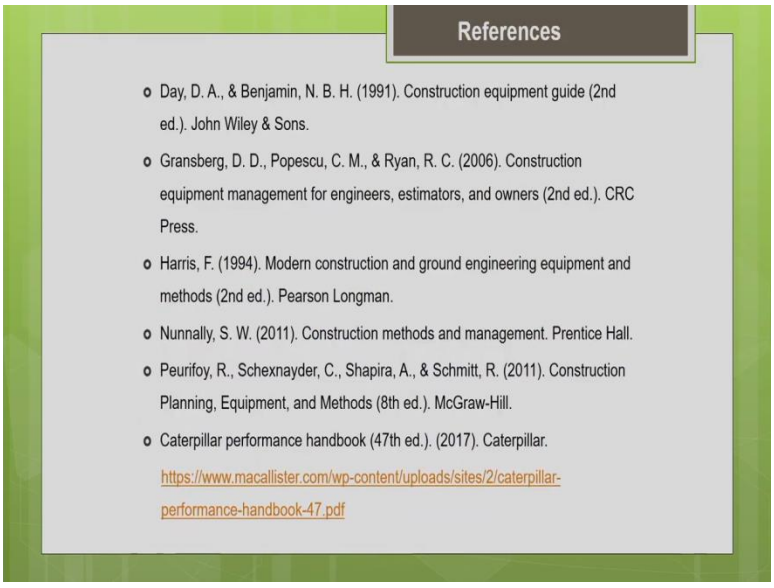

So, these are the textbooks which I have referred for this part of the lecture. So, in the next lecture, we will be working on some illustrations on how to estimate the productivity of the scraper and also we will work out some problems and how to balance the interdependent machines like scraper

and the pusher, how to decide number of scrapers and the number of pushes for a particular project, so that we can reduce the waiting time of the machines. Thank you.