Construction Methods and Equipment Management
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Module No # 01
Lecture No # 04
Equipment Cost -Operating Cost

Hello everyone I welcome you all to this lecture 4 of this course construction methods and equipment management. So in this lecture we are going to estimate how to estimate the operating cost associated with the equipment.

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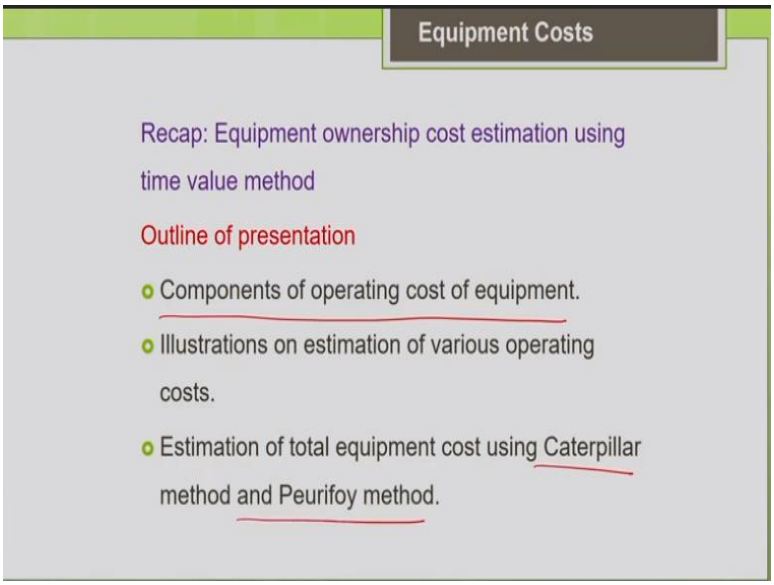

So let us have a recap what we learnt in the previous lecture so in the previous lecture we have seen how to estimate the ownership cost using the time value method. So this is the outline of amp today's presentation I will just introduce to you what are all the component of the operating cost of the equipment. So we will work some illustration on the estimation of the various components of the operating cost.

Then we will also discuss how to estimate the total equipment cost using 2 different methods one is Caterpillar method other one is the Peurifoy method which are the commonly adopted methods for equipment cost estimation.

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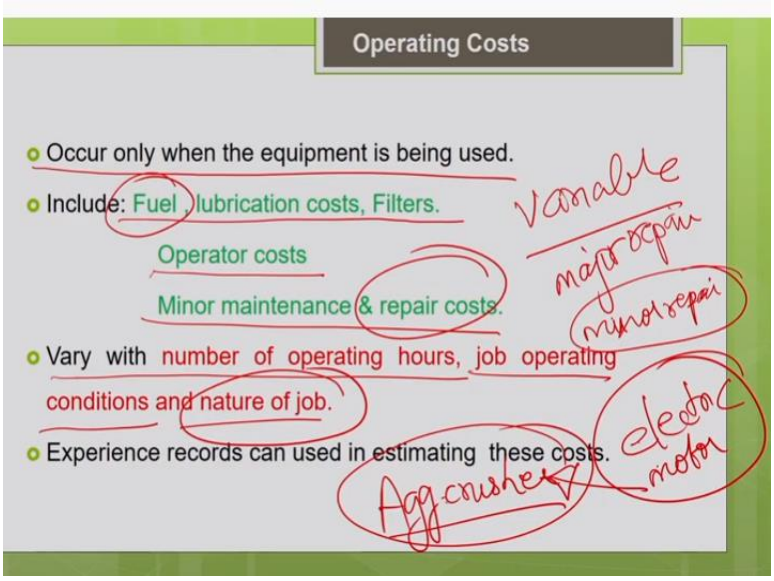


So what are these operating cost? So basically these operating cost occurs only when the equipment is used. So unlike ownership cost when we discuss about the ownership cost I told you that the ownership is incurred irrespective of whether the equipment is operated or not. Even if your equipment is ideal we are going to bare the ownership cost but in your in the case of operating cost the operating cost occurs only when the equipment is used.

This will be highly variable cost it depends upon the usage of the equipment but your ownership cost are generally relatively fixed annual cost every year. But this cost is highly variable it depends on the usage of a machine. First let us see what are all the components of the ownership cost? So basically you have this consumables, they come under the operating cost. Your fuel, lubrication oil, filter, grease and all the other small components which are getting consumed during the equipment operation all these are called as consumables.

So this forms the part of the operating cost then the wages what you pay for the operator that is part of the operating cost. Then your maintenance and repair cost so this maintenance and the repair cost can be either major or minor. Say major maintenance and repair cost means involves huge replacement of a particular part of the machine. It involves huge investment so those things the major repair will be usually consider are accounted under the ownership cost.

So only the minor repair cost is consider into the operating cost say for example you have an excavator. So you are going to change the complete boom of the excavator so that will be major

investment, so that will come under ownership cost. See we are going to just replace some small parts of the machine say you are going to change the wiring or you are going to change some small parts like headlight.

So in that case it will be the minor repair and it will be considered under the operating cost, so we will be discussing all these components in depth in the upcoming slides. So one thing what you need to know is your operating cost will vary with the usage of the machine, it vary with the number of operating hours of the machine. The more you use the machine the more will be the fuel consumption more will be the repair cost.

So the operating cost will also be more it depends upon the usage similarly it also depends upon the job operating condition. A same equipment if it is put under 2 different types of operating condition one is put in a very severe or tough operating condition one is put in a average operating condition. In that both the cases you can see a significance difference in the operating cost. Say for example an excavator so one is working in a Quarry.

So it is used to excavate the short rock pieces so the other excavator it is use in the common construction site where it is handling the ordinary earth. So when you compare the difference between these 2 excavators you can see the one which is working in Quarry is in a severe condition or tough operating condition. We can also call it as unfavorable working condition.

So in that condition the operating cost will be more, the fuel consumption will be more power consumption will be more. So it is repair cost wear and tear will be more so same machine when put into different operating conditions, you can see the difference in the operating cost. So we can give n number of examples in this perspective say for example a pile driving equipment.

We are going to discuss all these machines in detail in the upcoming lectures. the pile driving equipment I am using for 2 different sites in one particular site you have a cohesively clay. In another particular site I have the ordinary earth obviously the one which is working in the cohesive clay will incur more operating cost it is wear and tear will be more power consumption will be more fuel consumption will be more and the repair cost will be more.

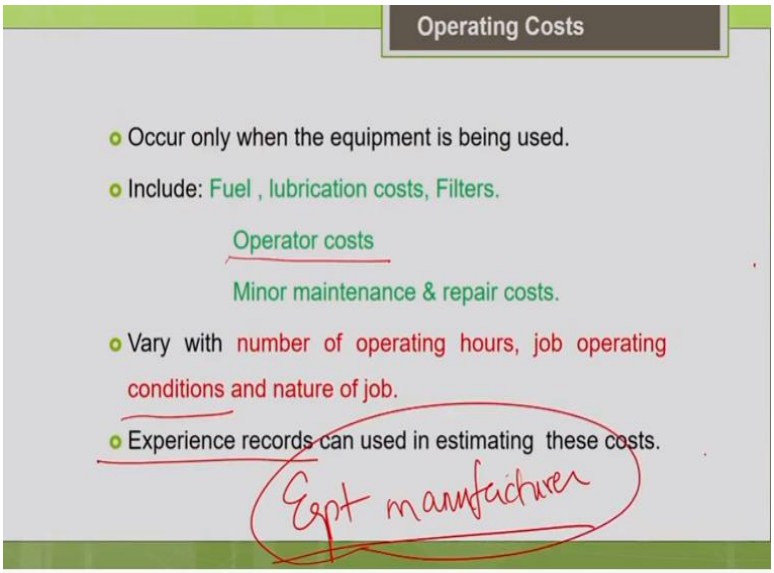
So like this we can give n number of examples so basically the operating cost depends upon the job also. It depends upon for what job we are using the job equipment's. Say for example this excavator the same example I am using it for excavating the earth I told you earlier also in the previous lecture that the excavator is commonly used for trenching and pipe laying, because same equipment can do the complete entire process.

So when we use the excavator for trenching when it is excavating it's power consumption will be more. Then later when I use it for only for pipe laying I will just change the attachment I change the rigging device and I handle the pipe with the help of the excavator that time you can see that the power consumption the fuel consumption will be less. So the operating cost will vary depending upon the nature of the job.

Similarly you can compare different examples say for example you can consider aggregate crusher. It is subjected to a very severe operating condition I can say it is subjected to more amount of wear and tear so it is nature of the job is very touch so the amount of operating cost invested in this machine will be more when compare to other sophisticated machine like a electric motor.

You compare aggregate crusher with electric motor, this is more sophisticated machine so the operating cost involve in this machine will be less. So it depends on the nature of the job so generally the equipment's which are more subjected to more mobility, they are more subjected to wear and tear they are operating cost is more. The equipment which are more stationary, which are subjected to less amount of mobility and which are not used continuously.

In those cases, you can say that the operating cost will be less so it is highly variable your operating cost is highly variable. Okay now so how to estimate these operating cost how to get information on all these operating cost that is very important. Because basically; you can get this information from the past experience records.



If you have accounted, all the information consolidated and accounting the information properly from your past experience records you can get the information. If you have worked with the similar equipment's in similar site condition or operating condition so those fuel cost or the lubricating oil cost or the repair cost you can make use of for the equipment cost estimation. Otherwise we have to go for the manufacturer recommendation, so most of the equipment manufacturers, they supply equipment's hand book.

So in that particular handbook for every model they manufacture they give the information on the fuel cost estimation lubrication oil estimation for different operating conditions. Similarly what will be the repair cost what will be the tire life, so all these information I can get it from the manufacture guidelines also. So there are different hand books available, we can get this information from appropriate hand books.

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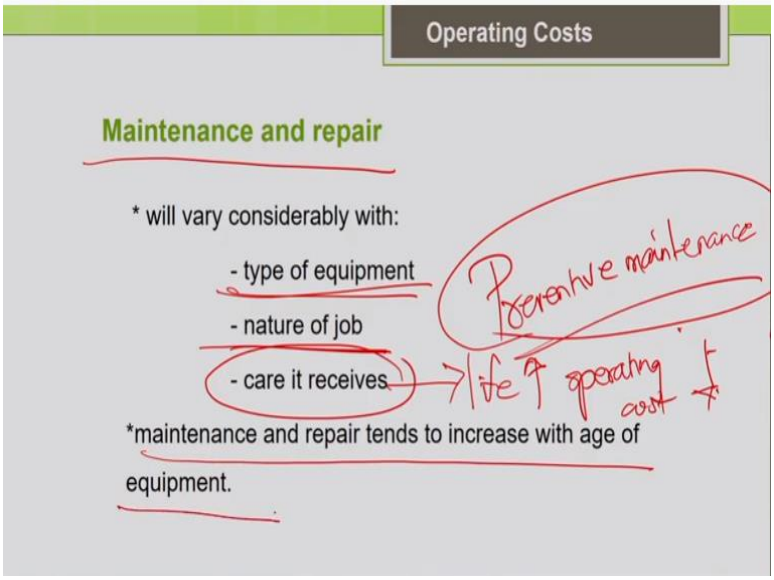

So now let us discuss about the operating cost one by one in detail the first one which we are going to discuss is about the maintenance and the repair cost. So this contributes to significant proportion of the operating cost of the machine. So basically as your machine age increases, as a machine ages obviously your repair cost will increased your repair and the maintenance cost is going to increase. Because the machine; has been subjected to more amount of wear and tear.

So it is almost worn out you have to replace some components, so cost of those replacement parts. So you have to replacement some components right the cost of the replacement parts. So for repair work you engage some labor, so the labor involve for the repair work so all these will come under the maintenance and repair cost. Generally, for a contractor who has a good equipment fleet so what he does is? He will have a maintenance facility in his site. He has a maintenance facility on his own.

In this maintenance facility he will periodically maintain his equipment's he will do periodical checkup of the machine, timely service, he will do cleaning of the machine. So he will engage some labor there to do the maintenance operation. So to set up this facility also some cost is involved so all these things makes up the maintenance and the repair cost. So as we discussed just now we can see that the maintenance and the repair, considerably vary with the type of the equipment and the nature of the job.

The one which is subjected to severe working condition or tough working condition or unfavorable working condition so that will be incurring more amount of repair cost, it will be more worn out than this sophisticated machines which are subjected average working conditions. So it will depend upon the type of equipment and the nature of the job. And your maintenance and repair cost will depend upon the care it receives, so the preventive maintenance it is very important for any job.

So basically if; you have your own maintenance facility and if you periodically maintain your equipment periodically do the checkup and do the timely service for the machines do daily cleaning of the machines. If you do take of the machine very well in this way you can extend the life of the machine, your machine life will get extended and your operating cost will get reduced how the operating cost gets reduced?

Because you can reduce the major breakdown of the machine so the major repair will get reduced that will significantly save your total cost. So that is why it is always preferable to go for the preventive maintenance we have to take care of the machines properly. So this we have discussed just now maintenance and repair tends to increase with age of the equipment we know the reason already.

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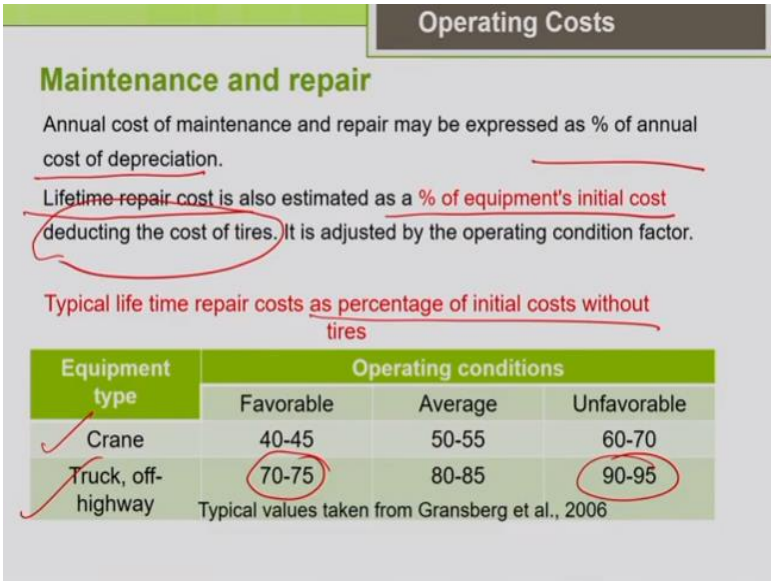

So generally this is the maintenance and the repair cost if you look into literature there are different ways by which it is estimated. In some literature they express it as a percentage of the annual cost of the depreciation of the machine. So percentage of the annual cost of the depreciation of the

machine in some cases you can see that the life time repair cost is estimated as a percentage of equipment initial cost.

So there are different ways by which you can estimate it but when you estimate it as a percentage of equipment initial cost you are supposed to deduct the tires cost that is very important. Because the; life of the tire is different from the life of the remaining part of the equipment. So it is depreciating rate is also very much different when compared to the remaining part of the machine.

So the repair cost of the tires will be considered separately so we will not consider it along with the remaining part of the equipment. So that is why you take the life time repair cost of the machine excluding the tire it is estimated as a percentage of the equipment's initial cost minus the tire cost. So you can see the values are available related to the life time repair cost. You can get the life time repair factor as a percentage of the initial cost of the machine without tires for different types of equipment's for different operating conditions like favorable, average, unfavorable.

So for different operating conditions and for different equipment type you can get these values from literature. So these values are taken from Gransberg you can find this similar kinds of information from different literature also. So you can make use of this information to estimate a repair cost. So one thing I wanted to tell you here is your lifetime repair factor that is repair factor depends upon the type of the equipment.

There are different types of equipment just to show some sample values I have just represented only crane and the truck it is called as off-highway the truck. These trucks are not permitted on the public highway that is why it is called as off-highway truck it is used in the site construction project site or quarries wherever. So this you can see based upon your operating condition as soon as based upon the equipment type your repair factor is varying a lot. So basically when it compares crane and the truck you can see the repair factor is more for the truck when compared to crane.

Obviously you know the reason because it is a highly mobile machine we use it continuously and it is mobility is also very high it is subjected to high mobility. So that is why which repair cost will be more when compared to crane which is not highly mobile. So we do not use its mobility to greater extent and also the crane use would not be continuously like truck, it will be used in intermittent way.

The crane is used intermittently when compared to truck that is why you can see the repair factor is less, but in the truck the repair factor is high. Similarly, when you compare the unfavorable condition with favorable condition you can see that in unfavorable condition the repair amount is very high. Say a truck is operated in a rocky terrain so on a steep terrain poorly maintain haul roads in that case obviously that is unfavorable condition.

So you can see that obviously your repair factor will be more, same truck when it is operated on a properly maintained haul road on a gradient which is not very steep. In that case that is favorable condition you can see that the repair factor is less, 70 to 75%. So you can see in the literature even the definition of the operating conditions will be given for different types of equipment. You can find that information in the equipment handbooks.

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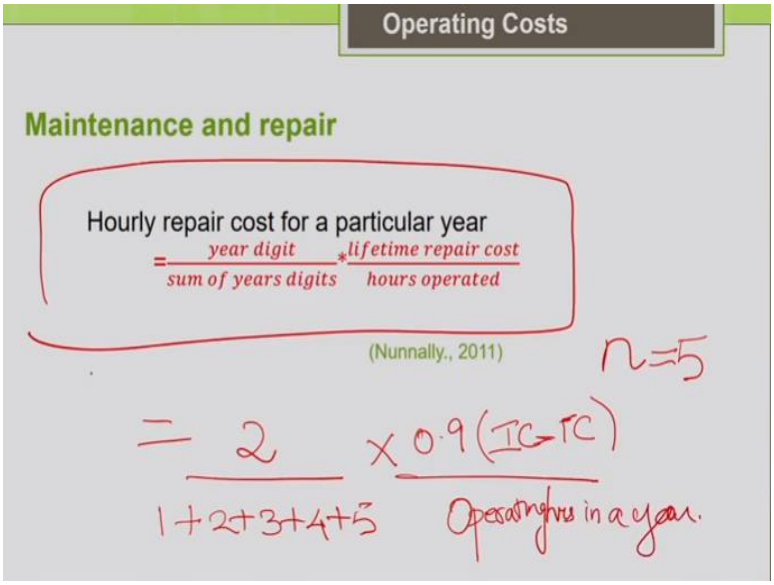

Now let us see how to estimate the hourly repair cost for a particular year say this formula if you remember this is somewhat similar to what we used for estimation of depreciation using Sum of the year's digit methods something similar to that. The formula is as follows: -

$$Hourly\ repair\ cost\ for\ a\ particular\ year = \frac{year\ digit}{sum\ of\ years\ digits} \times \frac{lifetime\ repair\ cost}{hours\ operated}$$

So the hourly repair cost for a particular year how to calculate so say for example you are going to estimate it for the second year of the equipment operation.

So then you have to put the year digit as 2 and the sum of the years we have to take what is the total n say the useful life of the machine is say 5. Then the sum of the years digit in the 1 + 2 + 3 + 4 + 5 so multiplied by the lifetime repair cost. So lifetime repair cost you know it depending upon the type of the equipment depending upon the operating condition it is expressed as the percentage.

Say for example if it is 90% of initial cost minus tire cost. So divided by the total operating hours of the machine in a year so operating hours of the machine in a year so this will give you may hourly repair cost for a particular year.

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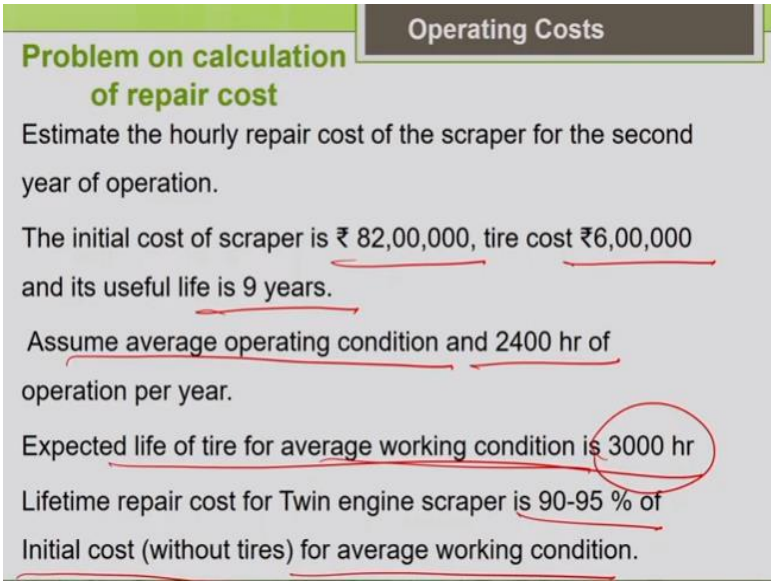

Now let us work out an example on how to estimate the repair cost, estimate the hourly repair cost of a scraper for the second year of the operation. So the initial cost of the scraper is 82 lakhs I have to retain the same input data from the beginning, you can see the tire cost is 6 lakhs and the useful life of the machine is 9 years. And the assumed average operating condition so operating condition is given to you and the scraper is working in a average operating condition and the annual usage of the machine in hours is operating hours of the machine in a year is 2400.

Expected life of the tire for average working condition is 3000 hours so this information also you can also get it from the hand book. The manufacturer can provide the data so what will be the expected tire with for this working condition you can get it from the manufacturer guideline or you

can go with the your past experience data. So in this problem it is given to you directly then the life time repair cost for this scraper machine is 90 to 95% of the initial cost of the machine without a tires for average working condition.

So the factor is also given to be directly in this problem so we do not search for this factor in any equipment handbook. So the values are directly given in this problem if it is not given you have to look into the handbooks equipment handbooks or the manufacture guidelines.

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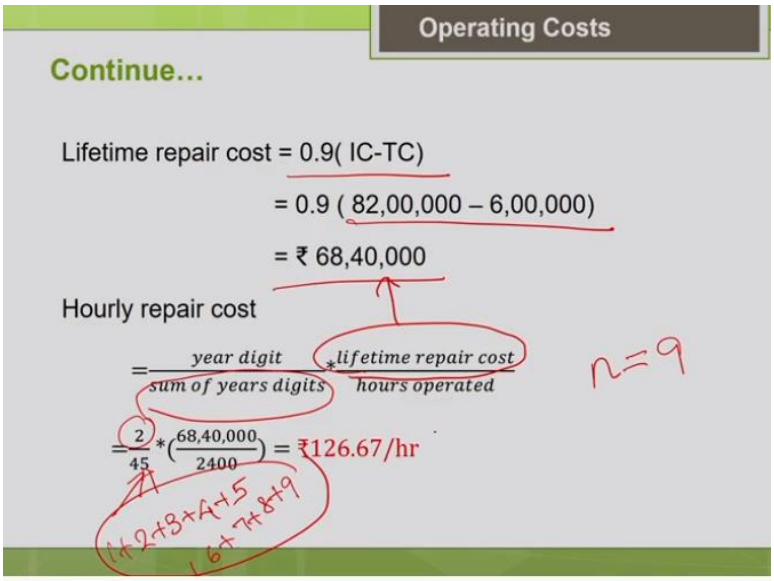

Now let us estimate the life time repair cost, it is nothing but it is given as 90 to 95% of the initial cost. So this value I am just checking it as the 90%, 0.9 into initial cost minus tire cost 0.9 into 82 lakhs – 6 Lakhs it is comes around 68,40,00 that is a life time repair cost. Now I can calculate the hourly repair cost for the they have asked you to find it for the second year of the equipment operation.

So the year digit the numerator we have to put as 2 then in the denominator sum of the years digits. So what is the total life of the machine n = 9 so how did you get this 45, 1 + 2 + 3 + 4 + 5 + 6 + 7 + 8 + 9. So sum of the digits in the life of the machine that will give you 45 now what is a life time repair cost? So you have estimated it already, you can put the lifetime repair cost as 68,40,000 divided it by the hours operated in a year it is nothing but 2400.

$$Hourly\ repair\ cost\ for\ a\ particular\ year = \frac{year\ digit}{sum\ of\ years\ digits} \times \frac{lifetime\ repair\ cost}{hours\ operated}$$

$$= \frac{2}{45} * (\frac{68,40,000}{2400}) = ₹126.67/hr$$

If you multiply you can get the value as 126.67 per hour, this is your hourly repair cost for the second year of operation of this machine. So this is how we estimate.

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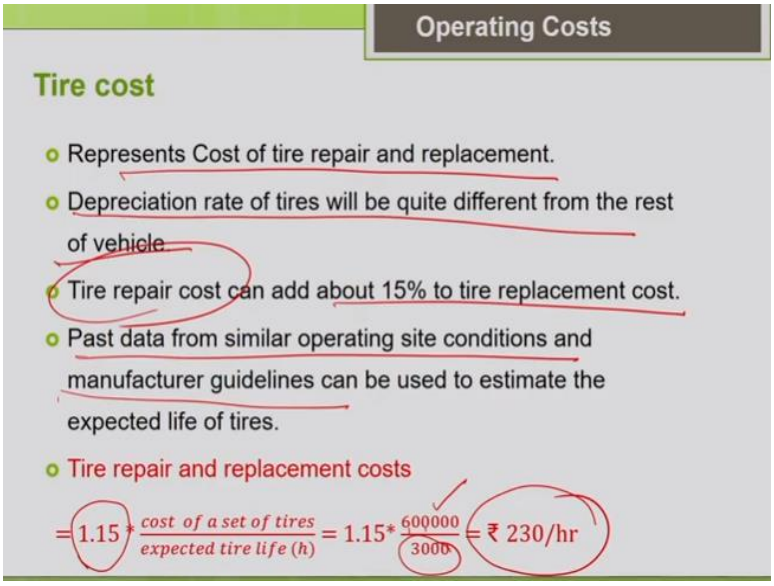

So now let us see how to estimate the tire cost so this tire cost is really a little bit uncertain and more difficult to estimate. Because there are so many factors affecting the tire cost in the tire repair. So it depends upon the life of a tire is highly variable it depends upon your project condition it is highly variable. It also depends upon operator skill, so with a very good operator the tire will last for a longer time, with a very poor operator the tire life may be lesser.

So it is really little bit difficult to estimate but anyway you can get this data from the past experience record which is similar equipment and similar operating condition or you can go for the information in the equipment handbook as given by the manufacturer. Basically tire cost represent a cost of the tire repair and the tire replacement. The life of the tire is very much different and it is lesser compare to the life of the remaining part of the machine.

And the depreciation rate of a tire will be quite different from the rest of the vehicle obviously your tire will depreciate at the faster rate when compare to the other part of the vehicle that is why we are calculating the tire cost separately. If you do not have much information on the tire repair cost you can just add 15% to the tire replacement cost to determine the tire repair cost.

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Just add 15% to the tire replacement cost to find the tire repair cost, as I told you get there is information about the tire life, tire cost and the tire repair all these information you can get it from your own past data or from the manufacture guidelines. Now let us see how to estimate the tire repair and replacement cost for the previous problem. So I am just assuming that repair cost will add to 15% to the tire replacement cost. So I multiply 1.15 with the tire cost so the cost of set of tires is known to you it is 6 lakhs divided by the life of the tire 3000 hours.

$$Tire\ repair\ and\ replacement\ cost = 1.15 * \frac{cost\ of\ a\ set\ of\ tires}{expected\ tire\ life\ (h)}$$

$$= 1.15 * \frac{600000}{3000} = ₹\,230/hr$$

So it will depend upon the operating condition, so it depends upon the so many factors as I told you even it depends upon the operator so you can get the information from the equipment handbook or from a past experience. So for this problem the 3000 hours is directly given in the problem so we can estimate it we can find the value as rupees 230 per hour it is your tire repair and replacement cost.

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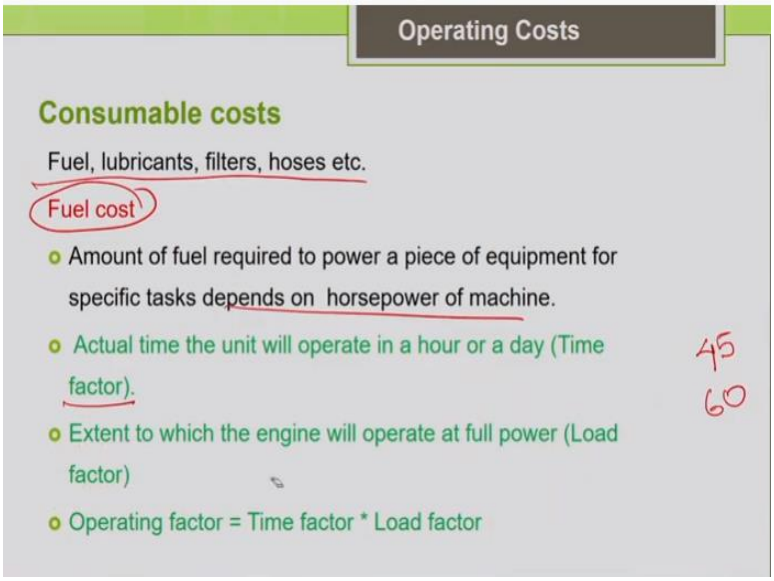

So now let us see how to estimate the consumable cost so consumables also form a part of the operating cost as we know your fuel, the lubricating oil, grease, filter all the other small parts whatever small components what we used which are consumed during the operation of the machine they are called as consumables. So until the first we are going to discuss about the fuel

cost. So the amount of the fuel consumption it depends upon the engine type so all the construction equipment's are basically IC engines, internal combustion based engines which may be either diesel operator or gasoline operator.

So the fuel consumption it is going to depend upon the horse power of the machine it is very important it depends upon the type of an engine and the horse power of a machine. So the amount of fuel required to power a piece of the equipment for a specific task depends upon the horse power of the machine. So greater the horsepower of the machine a fuel consumption will be more so this is one important thing we have to note it. So depending upon the horse power of the particular engine or the particular machine your fuel consumption will be varying.

And another important thing is your time factor or a working efficiency that is also going to effect a fuel consumption. So basically you know that in 1 hour so the entire 60 minutes the machine is not going to work on an average maybe the machine will be working from either for 45 minutes or 30 minutes. So depending upon the job productivity needed at your project site so your machine work for the entire 1 hour so that is what is called as the working efficiency.

So how do you find the working efficiency say for example if a machine is working for 45 minutes in an hour your working efficiency is 45 by 60 so that gives you a time factor. The actual time the unit will operate in a hour or a day that is called as a time factor. The next important factors which are going to consider is a load factor. So one thing we have to know that your machine may not be working at full power always.

So whenever it is working in a very tough condition or whenever it is doing at a tough nature of job that time only the power consumption will be maximum. So remaining part of the production cycle you can see that the power consumption may be average or it may be more than the average but it may not be the maximum so that thing we have to notice. Say for example. a scraper is a earth moving machine.

So we will be discussing the scraper as the upcoming lectures so this scraper is used for the earth moving operation. So basically it can cut the earth, excavate the earth and then load it into the bowl. During the cutting operation the power consumption will be maximum, it will be working

at full power. But when the bowl is full when it is just carrying the bowl or hauling the material it will be working at an average power only.

So for how much part of the production cycle or how much time so it is operating at full power and how much time it is operating at average power that we need to know because accordingly your fuel consumption will vary. Similarly, for different types of machine we can consider that is the importance of load factor because that is going to influence your fuel consumption. So based upon this time factor and load factor you can calculate your operating factor. So your operating factor is nothing but your time factor multiplied by a load factor.

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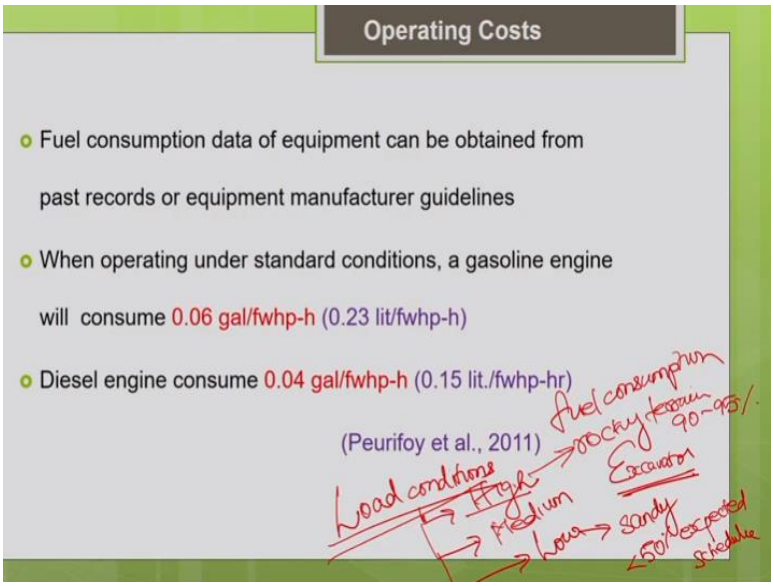

Now regarding the fuel consumption, as I told you can get the information about the fuel consumption for a particular machine particular type of the equipment and there are, particular operating condition. So you can classify the operating condition accordingly so in different literature you can see different types of classification. So just now we saw the textbook by the Gransberg et. al. it was classified as unfavorable operating condition, average operating condition and favorable operating condition.

So you can classify this way so another different equipment handbook if you go through the definition of the operating conditions terminology may be different. Say for example if you refer the Caterpillar handbook which is published by the Caterpillar equipment manufacturing company, it is a very popular company, so they have published a Caterpillar handbook. So the link of the

handbook is given in the references you can download the handbook and you can go through what are all the different factors and how they estimate the cost?

Okay it will be very useful to you so basically you can see that the Caterpillar handbook they are classified different load conditions. So load conditions they have classified into high load conditions, medium load conditions and low load conditions you can see that. Say for example take an example of excavator in the Caterpillar handbook you can see that for every model they have manufacture.

For an every model of machine they have manufactured for that particular model you can see the fuel consumption estimation for different load conditions. If you look into the excavator a particular model number, you can see for high load conditions what is the fuel consumption you can get the value directly there are tables. And for medium load condition what is fuel consumption value you can get it directly similarly for the low load condition.

And the definition of the load conditions also given accordingly say high load conditions means your excavator working in the rocky terrain so it is a tough condition. Also the expected job productivity is 90 to 95% schedule. So they are going as per the expected the productivity schedule of 90 to 95% so that means the usage machine is for a more amount of time. Similarly low condition means your excavator working in a sandy terrain so which is not very touch for the excavator.

And similarly the productivity you can see it is less than 50% of the expected, that means a machine is not working for a longer duration. So this is called low condition so the definition of the conditions also define and for different operating conditions for a different model what is the fuel consumption value directly you can take it from the tables.

So let this different equipment manufacturers have published own hand books and in that handbooks you can directly get the fuel consumption value for that particular equipment model. So then when, operating under standard conditions.

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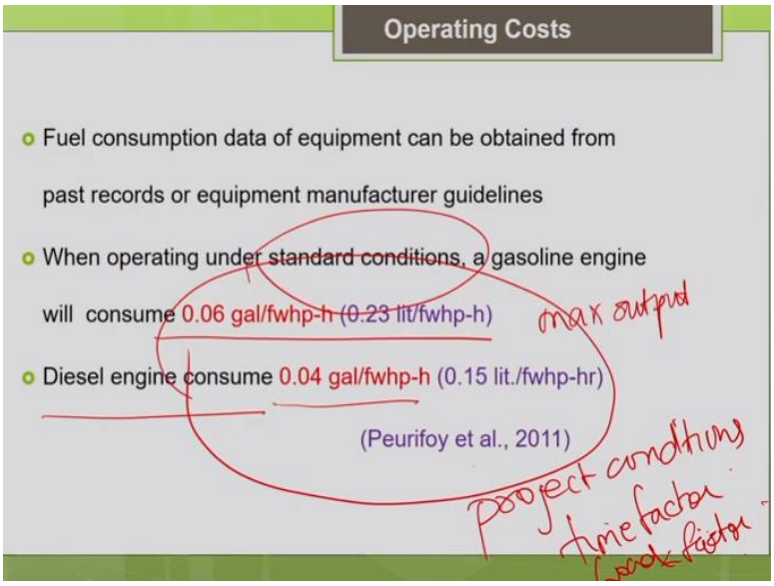

So these are the theoretical values which we have determine from the literature. So the literature also gives you some standard values so when a machine is operating under the standard conditions a gasoline based engine will consume 0.06 gallons so if gasoline per flywheel horsepower hour. In SI units if you see 0.23 liters per flywheel horsepower hour so if the machine is going to be diesel based engine it will consume 0.04 gallons per flywheel horsepower hour or in SI units it is 0.15 liters per flywheel horsepower hour.

So this is the fuel consumption rate given for 2 different types of engines one is gasoline engine other one is diesel engine. So this has been worked out for standard condition you can get it from the literature. So standard conditions mean your machine is working at maximum output so this value whatever if you are going to use this fuel consumption value for your project condition we have to adjust this value according to your project condition.

You have to adjust this value according to your project condition say for example based upon your time factor how much time your machine is going to work? Based upon a load factor for how much part of the cycle it is working at full power so based upon that you have to adjust these factors according to your project conditions that is what you are going to see. So you can make use of this fuel consumptions factors from the literature but you have to see a project conditions and accordingly adjust and use it.

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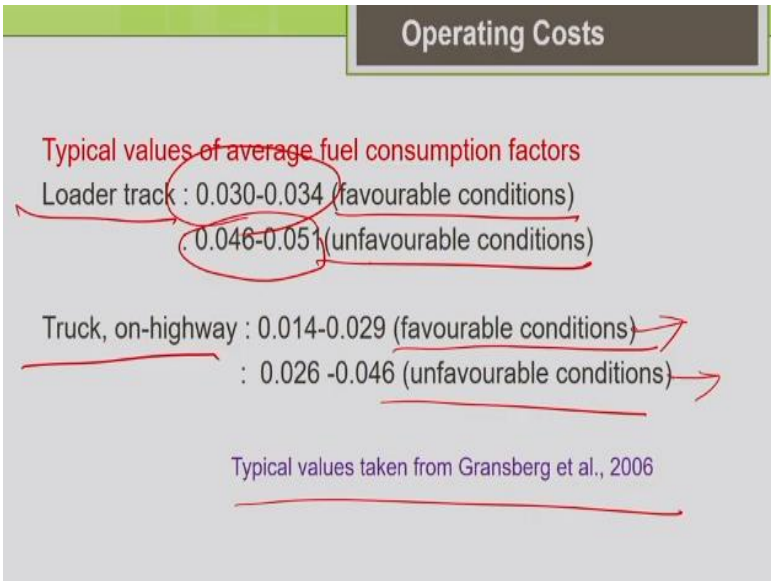

So these are typical values of average fuel consumption factors which are taken from the textbook by Gransberg et. al., it is given in the reference. So he has given this fuel consumption factors for different types of equipment's for different working condition favorable, average, unfavorable condition I am just showing only some sample values. So one thing you can see that the fuel consumption varies depending upon the type of equipment for a truck and loader if you compare the fuel consumption are relatively more for the loader.

You can say that track mounted loader consumes more amount of fuel when compared to the highway trucks. So it depends upon the nature of job it is doing, so it is doing little bit tougher job so it is fuel consumption will be more. Similarly, unfavorable condition you can say that fuel consumption is very high when compared to the favorable condition. so depending upon the fuel consumption is going to vary. As I told you already truck you can say that if you work it out on a very poorly maintained haul roads the fuel consumption is going to be high. Similarly, if you work on a properly maintained haul road it is fuel consumption is going to be less. So the definition of the project conditions also given in the literature accordingly.

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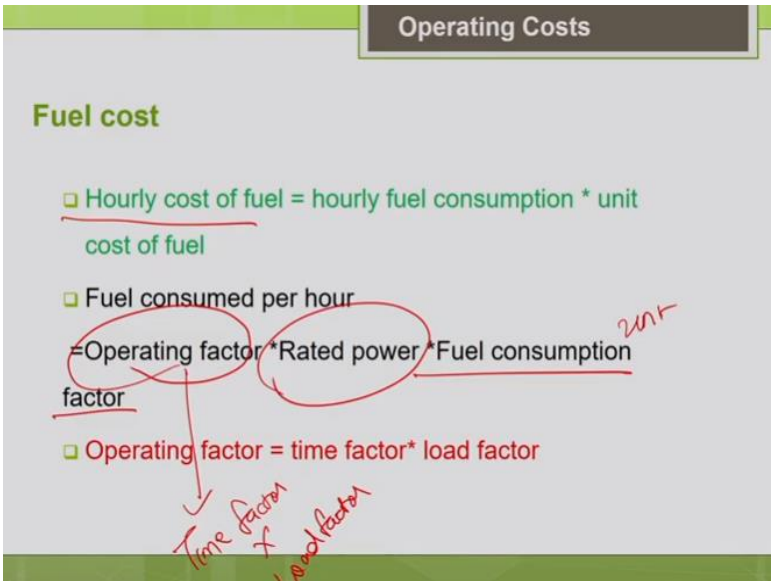

Next let us discuss about the how to estimate the hourly cost of fuel. Obviously estimating hourly cost of fuel we need to know what is it fuel consumption what is the hourly fuel consumption we need to know what is the hourly consumption multiplied by the unit cost of fuel. If you know these 2 things you can estimate obviously the hourly fuel consumption going to depend upon the type of the equipment and it depends upon the project operating conditions.

And the cost of the fuel will vary from face to face it depends upon the cost of the fuel in that local place. So this is going to influence your fuel cost estimation so how to find fuel consume per hour you can get the fuel consumption factor from any literature. From the equipment handbook of a many other source of reliable literature you can take the fuel consumption factor corresponding to the particular type of the equipment and project working conditions.

Then you have to adjust the fuel consumption factor according to your operating factor. So operating factor is nothing but your time factor multiplied by load factor, so according to your project condition you adjust And according to the horse power of a machine greater a horsepower obviously a fuel consumption will be more. So this is how we have to adjust the available fuel consumption factors which are available theoretically or from the handbooks according to your actual project conditions.

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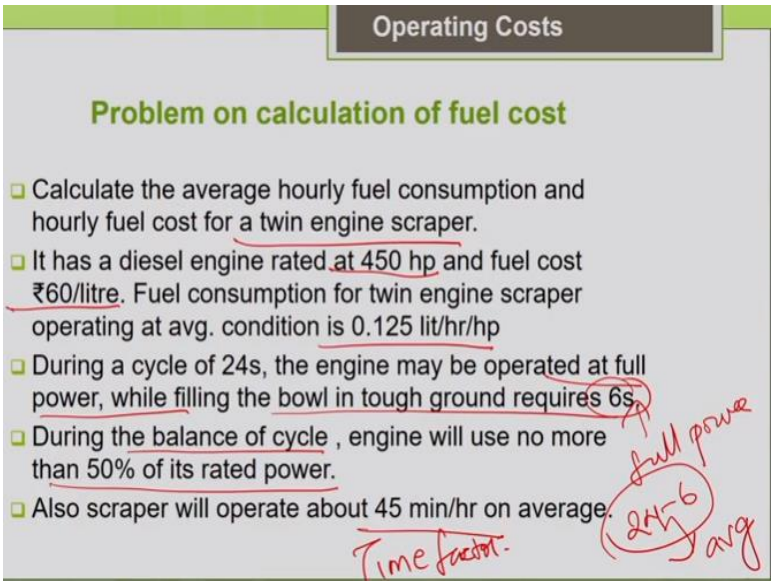

Now let us workout an example on how to estimate the fuel cost of the machine. So calculate the average hourly fuel consumption and the hourly fuel cost for a twin engines scraper machine. It has a diesel engine rated at 450 horse power and the fuel cost price is given as rupees 60 per liter. And the fuel consumption for twin engine scraper operating at average condition is a 0.125 liters per horse power per hour, the fuel consumption factor is given for this particular machine for the average working condition.

So you can directly visit because it is given in the question otherwise you have to look for the equipment handbook. Then during the cycle of 24 second of its production cycle you can see that engine may be operated in full power while filling the bowl in the tough ground. So it is filling the bowl the scraper is filling the bowl cutting the earth and filling the bowl for that it means 6 seconds.

So only during the 6 seconds time it is working at full power so the reaming 24 – 6 seconds during the balance of the cycle the engine will use no more than 50% of the rated power. So it is working at average power in the remaining part of the production cycle and it is working efficiency is 45 minutes per hour. So your time factor is also given here so with this input data now we are going to see how to estimate the fuel cost of the machine.

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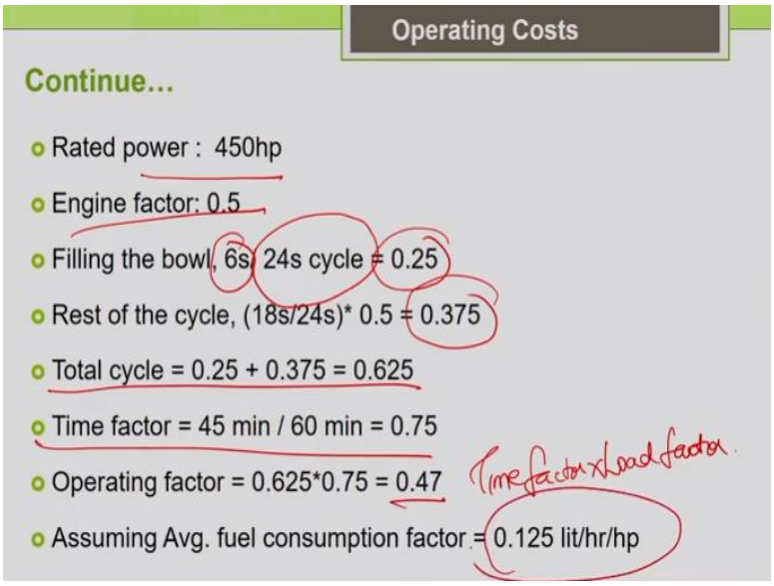

So the horse power of the machine is given the rated power 450 engine factor is given. So as I told you while filling the bowl it is consuming full power so it is taking 6 seconds out of the total production cycle time of 24 seconds to fill the bowl. During this cycle it is using full power, 0.25 into 1, so during the rest of the cycle that is 18 by 24 seconds it is using average power that is into 0.5.

So that will give you 0.375 now you find the total cycle, so while filling the bowl it is 0.25 during rest of the cycle just for hauling the material it is using 0.375. So the total cycle amounts to 0.625 now the time factor it is working for 45 minutes in 1 hour. So it is working efficiency is 0.75 now the operating factor is nothing but your time factor multiplied by load factor. So this is your load factor 0.625, this is your time factor 0.75 if you multiply you will get the operating factor as 0.47.

Assume average fuel consumption factor so it is given in the question the fuel consumption factor for this particular type of question for average working condition it is given as 0.25 liters per horsepower per hour.

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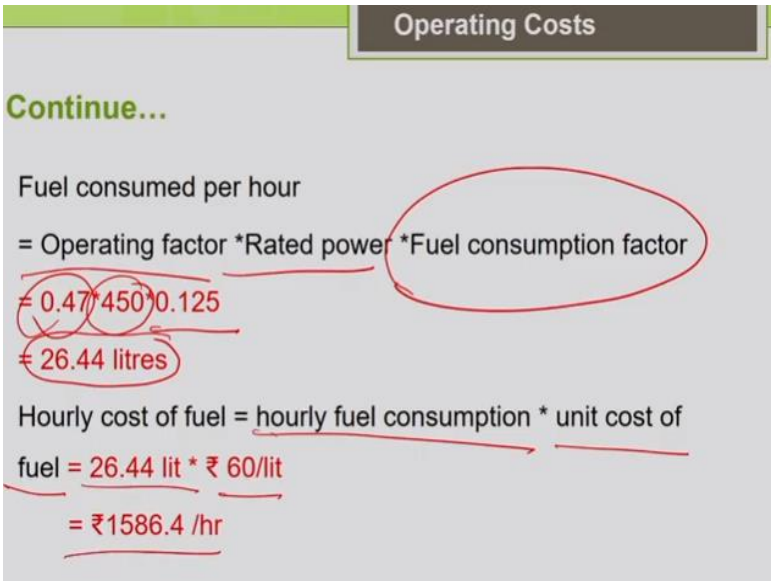

Now let us find what is the fuel consume per hour? So the operating factor multiplied by rated power into fuel consumption factor. So this fuel consumption factor which is determined for the standard conditions may be we are going to adjust it according to your project operating factor and the rated power of the machine. So the fuel consumption factor is nothing but 0.25, it is per horsepower per hour your horse power of the machine is 450 and the operating factor is 0.47.

So your fuel consumption per hour is 26.44 liters now what is the hourly cost of the fuel? Okay you know the hourly fuel consumption multiplied by the unit cost of the fuel. So it is nothing but 26.44 liters multiplied by rupees 60 per liter. It gives you rupees 1586.4 per hour so this is your hourly cost of fuel estimated for this particular machine. So let us continue our discussion that the estimation of the lubricating oil cost.

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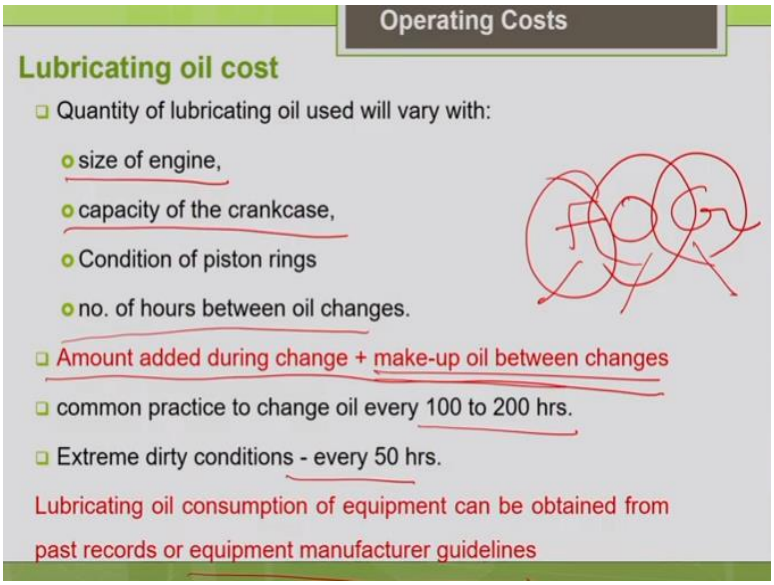

As we know that how much quantity of lubricating oil is needed it will vary it depending upon the size of the engine, the capacity of the crank case obviously. And condition of the piston rings and also depends upon the project conditions here. So if the project working condition that are extremely dirty. In that particular case we have to change the lubricating oil very often. So everything depends upon the project working condition and depends upon the company policy like the interval between the oil changes number of hours between the oil changes.

It depends upon the company policy normally you can say that it is common practice to change oil every 100 to 200 hours. But if the conditions are very extremely dirty in that case even for every 50 hours we have supposed to change the lubricating oil. Everything depends upon the project working condition and also depends upon the company policy also. Then the total lubricating oil the amount of lubricating oil is equal to the amount added during the change plus the makeup oil between the changes.

That means the amount of oil needed for a complete change of the lubricating oil and in between we just fill the small gap in between that is called as make-up oil between the changes. Just to fill the small gap left so every time we do not completely change it so we just fill the gap in between at the particular frequency only we do the complete change of the lubricating oil. So the total amount of lubricating oil needed will be the total amount needed for the complete change plus the make-up oil between the changes.

So this information also we can get it from the past experience records, for the similar type of the engine or similar type of the machine we might have past records about the machine amount of the lubricating oil consumption or you can go by the equipment manufacturer guidelines. So let us say for example if you go through the Caterpillar performance handbook, so for every model of a machine manufactured by them, for different operating conditions.

So they have given you what is the amount of the lubricating oil consumption per hour so not only lubricating oil we call it as FOG. So filter, lubricating oil and grease so the hourly consumption of filters for every model of machine and hourly consumption of the lubricating oil for every model of the machine and hourly consumption of grease for every model of machine manufactured for the different project conditions or operating working condition.

You can get the information from the Caterpillar performance handbook then we can just multiply by the unit cost of the lubricating oil or the filter or the grease to get the corresponding the hourly cost of the consumables. So the manufacture guidelines can provide you the sufficient information to get this data.

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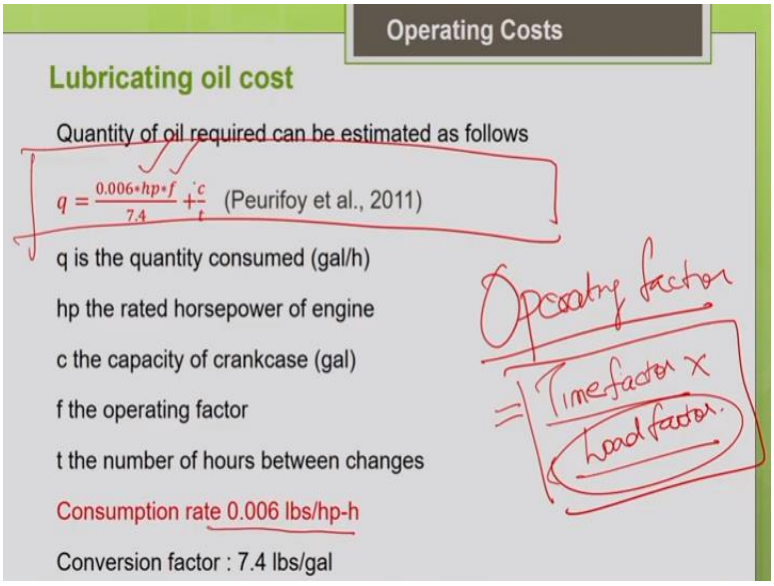

So another the thing is we also have this theoretical formula available in various literature how to estimate the lubricating oil.

$$q = \frac{0.006 \times hp \times f}{7.4} + \frac{c}{t}$$

So this is one such formula you can see q is the quantity of the lubricating oil consumed so in gallons per hour. So this 0.006 is the consumption rate of lubricating oil is 0.006 pounds per horsepower per hour. So it depends upon the horsepower of the engine.

So this 0.006, so we are going to adjust this value according to our project conditions say for example depending upon your horsepower of the engine you have to multiply it on 0.006 by horsepower of the engine accordingly. Similarly depending; upon the project condition say for example depending upon your operating factor. So I have discussed about this operating factor already operating factor is nothing but your time factor multiplied by load factor.

So how long your machine is going to operate in 1 hour, what is the working efficiency that is your time factor. And load factor is nothing but your production cycle for how much duration the machine is going to work at full power. And for how much duration is working at average power or the lesser than the full power. So if you know that we can calculate the full power so the product of these 2 will give you the operating factor.

So according to your operating factor you have to adjust this theoretical value 0.006 so then another thing is a crankcase capacity that will depend vary from machine to machine. So according to crankcase and between the number of hours in the changes that depends upon your project working condition. Whether it is too extremely dirty condition then we have to change it frequently and also depends upon the company policy as I told you earlier.

So the number of hours between the changes and this 7.4 is a conversion factor so this q is nothing but the quantity of oil consume in gallons per hour. But the consumption rate is a pounds per horse per hour so the conversion factor is 7.4 pound per gallon. So this formula you can estimate a lubricating oil for a project condition. So whenever you take some theoretical value you have to adjust it accord to your project conditions based upon the horse power of an engine.

Based upon; an operating factor, based upon the crank case capacity, based upon your company policy of number of hours of the changes of lubricating oil. So this is how we do so similarly this formula where we are estimating the quantity in gallons per hour. So I have just converted same formula in SI units so that we can estimate the quantity in liters per hour.

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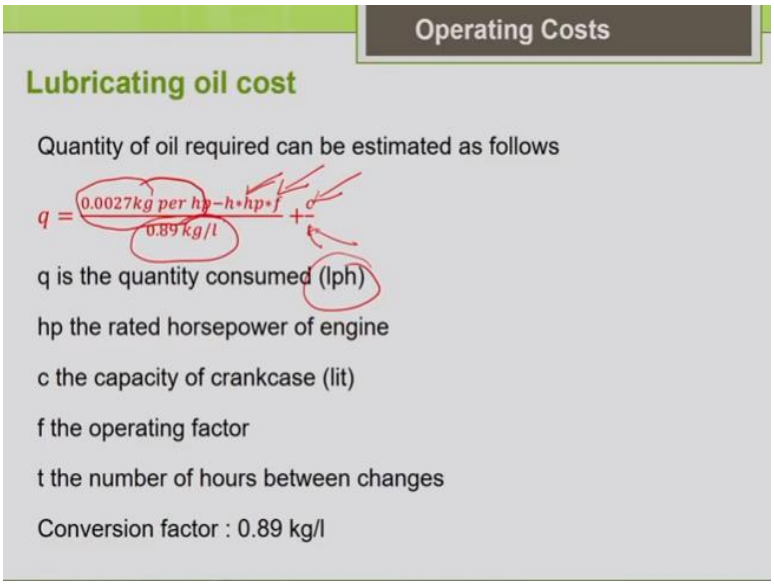

That is the only difference so here you can see the consumption rate is 0.0027 kg per horse power. Accordingly, you have to adjust according to your conditions into horse power into the operating factor into the plus crankcase capacity divided by the number of hours between the changes. And the conversion factor here is 0.89 kg per liter so the final quantity you will get it in liters per hour using this formula.

$$q = \frac{0.0027kg\ per\ hp - h \times hp \times f}{0.89\ kg/l} + \frac{c}{t}$$

So this is the theoretical formula available in the literature so that you can estimate your lubricating oil per hour.

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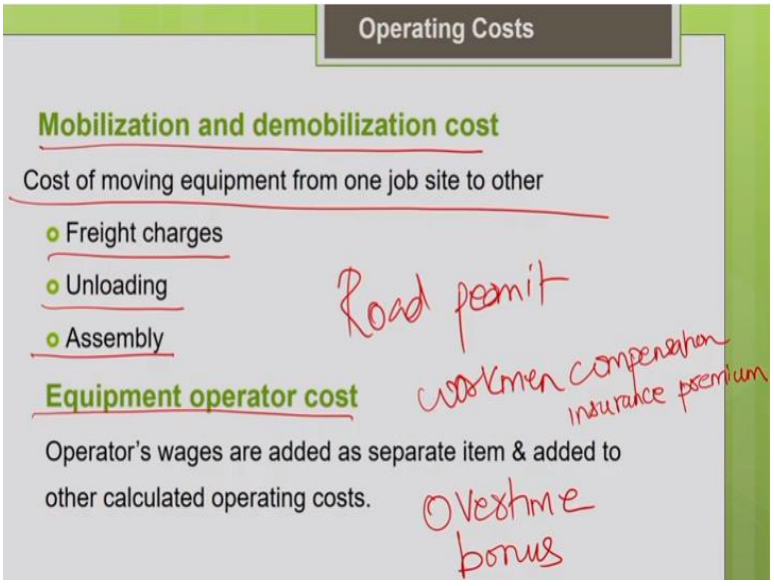

So the other important component of the operating cost is the mobilization and the demobilization cost. So already we discussed about the mobilization say when we purchase a machine, so the initial cost is inclusive of all the freight charges to procure the or mobilize the equipment to your project site. So apart from that you may have to shift the machine from one project site to other project site.

So in that site you have to calculate the mobilization cost separately and it will be included in the operating cost. So the cost of moving the equipment from one job site to other so this includes your freight charges your transportation charges and as well as your other loading charges and the unloading charges of the machine. So loading unloading charges and, the road permit so even the road permit charges for mobilizing the equipment to the particular project site.

And getting the equipment ready or installation assembly charges everything comes under this mobilization and the demobilization cost everything should be accounted. Accordingly, you can estimate the hourly cost. Now next is an equipment operator cost this includes your normal operator hourly wages. So normal hourly wages of the operator and also you have to include all the other benefits let us say for example is over time charges benefits other bonus what he gets.

Everything should be included under the equipment operator cost even the workmen compensation insurance premium which the employer pays on the behalf of the employee or the worker. So that premium is also included in this workmen compensation insurance premium so everything is included in this operator cost and you have to calculate the correspondent hourly operator cost. So operator wages are added as separate item and added to the other calculative operative cost.

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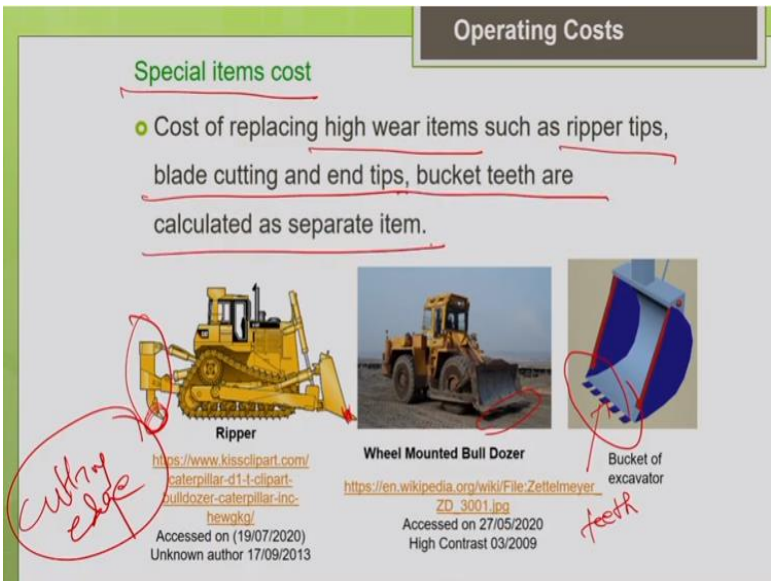

So the component in the operating cost is a special items cost means they are called as high wear items. That means they deteriorate they are subjected to wear and tear at the very faster right. They deteriorate at the faster rate their life is very shorter say for example the Bull Dozer blade. At the bottom of the blade you can see the cutting edge so the cutting edge it is just bolted at the bottom of the Bull Dozer blade so this cutting edge gets worn out fast depending upon the project working condition.

It is a very rough or severe working condition wear and tear will be very faster so the cutting edge gets worn out faster. We have to replace the cutting edge at a very shorter time interval, so generally we do not replace the blade very frequently we just replace the cutting edge frequently. So these are called as the high wear item similarly your ripper which we use it for loosening the earth at the booth of the repair you can see the tip.

This tip also gets worn out fast we have to replace the tip in a shorter interval this picture clearly shows the cutting edge at the bottom. So another thing is your, this is the excavator bucket so you can see the edge of the bucket you can see the teeth of the bucket teeth. This also gets worn out faster we can they are just bolted down to the bucket so you can just replace it very faster as its gets worn out.

So basically these are high wear items which gets worn out faster so special item means cost of replacing the high wear items which is the ripper tips, blade cutting and end tips your bucket teeth all these are calculated as the separate item or the special items.

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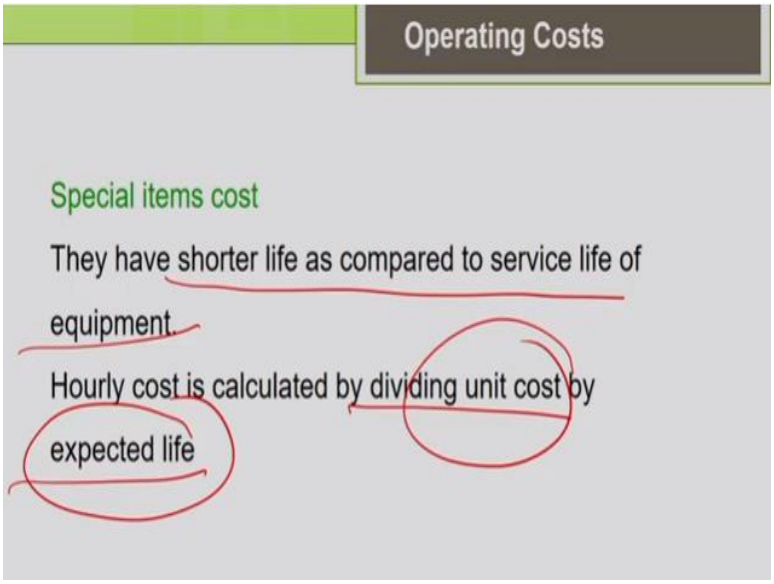

Because they have shorter life when, compared to the service life of the remaining part of the equipment. So for this also you have to calculate the hourly cost to know the hourly cost you should know the unit cost of the item and you should divide very expected life of these items. So this information you can get it from your past records or from the manufacturer. So manufacturer handbook will provide you the information on the expected life of this particular unit for different operating conditions.

So based upon that you can get the information and also the unit cost you can get from the manufacture so based on that you can get the hourly cost of this special items.

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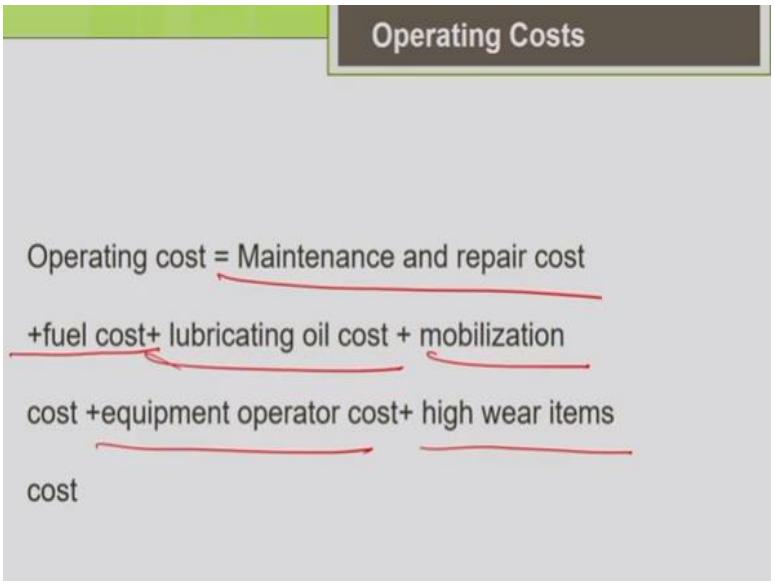

So what are all the components so far we have discussed under the operating cost let us summarize. So maintenance and repair cost your fuel cost, lubricating oil cost all these are consumables, the mobilization cost, equipment operator cost and cost of special items of high wear items. So all these things we have operating cost of the machine.

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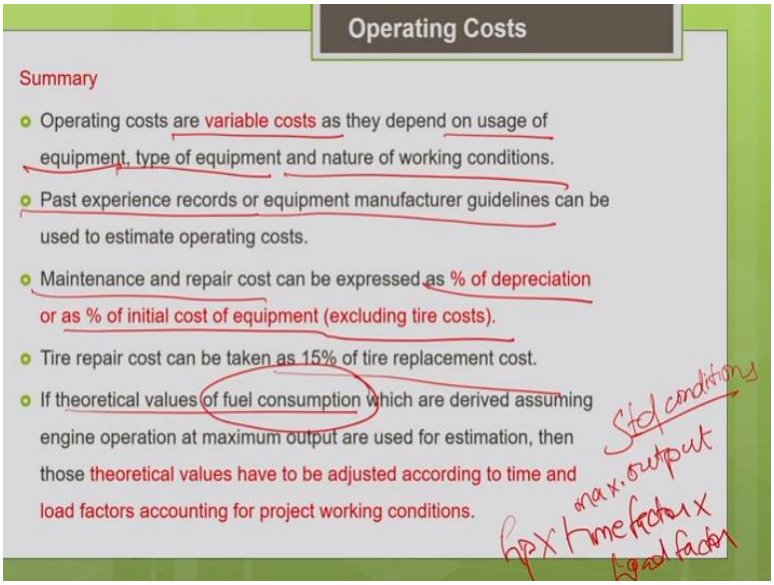

So let us just summarize with this we are coming towards the end of the lecture 4. So basically as I told you in the beginning the operating cost is highly variable cost unlike ownership cost which are relatively fixed. Operating cost are highly variable because they depend upon the usage of the equipment more you use the equipment more the number of operating hours the fuel consumption is more the repair and maintenance will be more.

So everything depends upon the usage depends upon the type of equipment if it is going to be the highly mobile equipment it is operating cost will be more. So depending upon the nature of the job nature of the working condition and the same machine will put into severe working condition and put into normal working condition you can see there will be huge difference in the operating cost.

We discussed all those things with various illustrations so this information of the operating cost you can get it from the past experience records. If you have accounted or if you are maintaining records properly from your own past records you can get the information on similar equipment or you can go with the guidelines given by the equipment manufacturer in the equipment handbooks.

Another important thing to be noted is your maintenance and repair cost of the equipment, it can be expressed either as a percentage of the depreciation. Or it can be expressed as a percentage of the initial cost of the machine excluding the tire cost. Because tire repair will be considered separately because, the life of the tire the deterioration rate of the tire, everything is going to be different from the remaining part of the equipment.

So when you calculate the maintenance and repair cost of the equipment they exclude the tire cost from that. So if you do not have much information the tire repair cost you can take it as you can just add 15% to the tire replacement cost to get the tire repair charges. And another important thing to be kept in mind if you; are going to use the theoretical values of fuel consumption from some literature.

So for the particular type of machine we have chosen the fuel consumption factor from a literature where it is derived based on standard conditions or maximum output rate. So when the fuel consumption factors which are given in the literature are given based on standard conditions where the machine is working at the maximum output rate. Then you are supposed to adjust those fuel consumption factors according to your project condition.

So how to adjust it according to the horsepower of the machine, you have to multiply the fuel consumption factor and another important thing is according to the time factor and load factor. So which is nothing but the operating factor so according to your operating factor so you have to adjust those theoretical values and so that it can reflect your project conditions accordingly.

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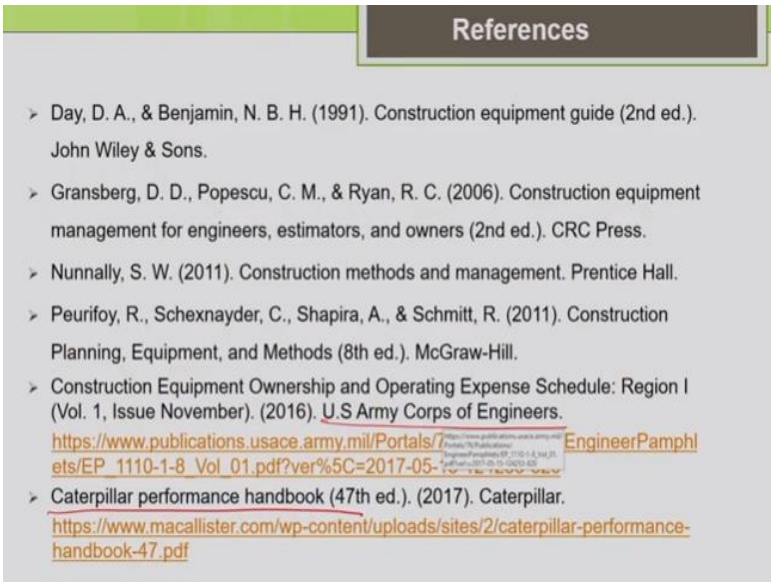

So with this we have come to the end of the lecture 4 so these are the reference which I have to use for this lecture 4. So basically I would like you to download this Caterpillar performance handbook even the link is given. So as I mentioned earlier lot of information on the fuel consumption your filter, oil, grease consumption for different models of machine and the repair factors, the tire life.

So all this values you can get the much clear information by going to this handbook and also there are lot of illustrations worked out which will give you more information to learn this the subject. So there are also other handbooks not only caterpillar performance handbook there are other handbooks supplied by different manufacturers. So you are free to download it and go through that and this is another handbook which is published by U.S army Corps of Engineers. This also provides a lot of information on how to estimate the equipment cost, thank you.