Introduction to Accounting and Finance for Civil Engineers
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Module No. #04
Lecture No. #16
Replacement Analysis

Good morning, Namaskar, and Welcome to the course, once again. In the last lecture, we discussed about, the effect of depreciation and inflation, on our economic decision making. In this class, we are going to learn, one very important concept that of, Replacement Analysis.

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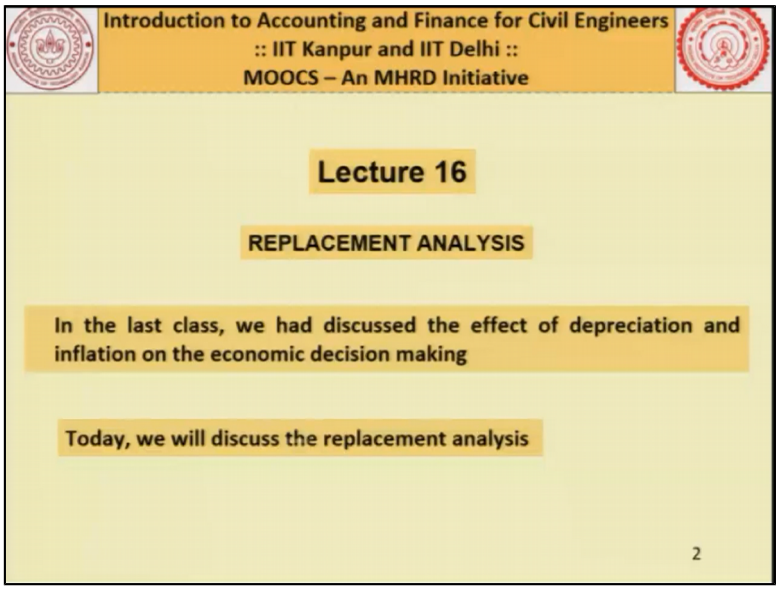

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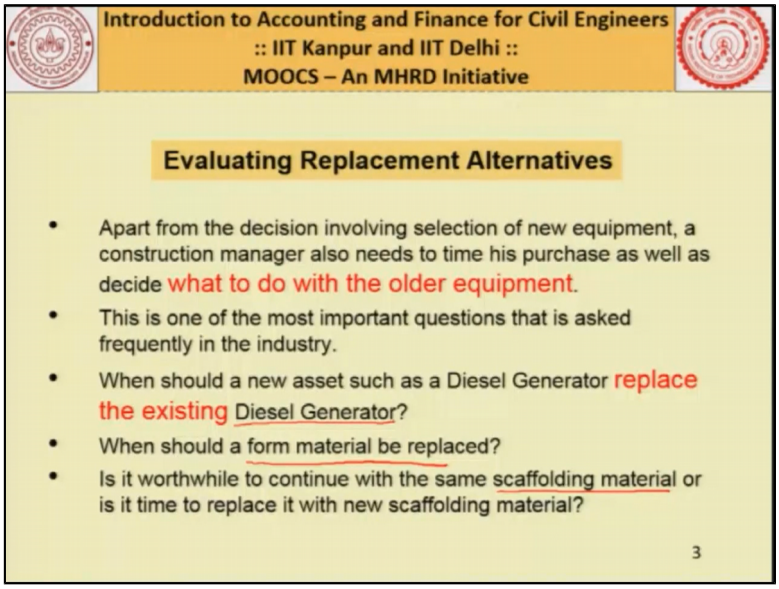

You come across many situations, in day-to-day life, in which, you have to decide, when is the right time, to replace an existing equipment. Sometimes, you also have to compare, the Defender equipment, with the Challenger equipment. When you say, Defender equipment, it is basically the equipment which, you are right now using it. It may be quite possible that, because of the changes in the technology, the current equipment, which you are using, may not be serving your purpose.

And, there is an equipment in the market, which has recently been launched, which can serve your purpose. So, you would like to compare, whether the current equipment, which you are using, is economical to you, or whether it is economical for you, to go for the new equipment. The new equipment, we are calling them as, Challenger. And, the existing equipment, we are calling them as, Defender. There are many definitions, which we have to learn in this lecture, so that, the analysis becomes quite simpler to you.

We would also like to see, what are the different situations in which, you would like to go for, replacement of an equipment. For example, you would like to see, is it the right time to replace, the existing diesel generator. You may be having, a diesel generator set right now, for so many years, you have been working with it. Is it serving your purpose? Does its operating and maintenance costs, exorbitantly high? Or, is it on a lower side, compared to the Challenger?

We would also like to know, whether the form work material, that you already possess, that needs replacement. The scaffolding material, that you have, it may be of steel, it may be of

aluminium, are they serving your purpose. Or, whether you would like to go for, the new scaffolding material.

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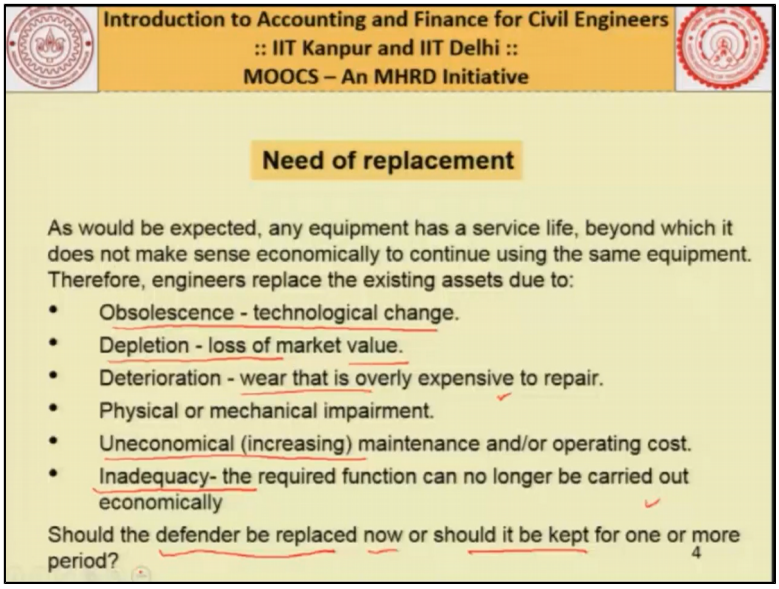

Now, we need to replace equipment, because of many reasons. As I told you, obsolescence is one of the major reasons, due to which, you would like to change your equipment. Then, there could be, possibility of the depletion, which is the loss of market value, for the equipment. And, for that reason, you would like to change the equipment. There might have been, excessive wear and tear, for your equipment. For that reason, you would like to replace your equipment.

The operation of your equipment, might have been, very uneconomical. And, that is the reason perhaps, you would like to go for replacement. Or sometimes, it may be because, your equipment is not serving your entire purpose. They are inadequate, for serving your purpose, and for that reason, you would like to go for the replacement. So, the question that we would like to answer here is, should the Defender be replaced now, or should it be kept for, one or more period. The period, could be year, or it could be month.

So, we would like to compare, the costs of the Defender, and the Challenger, and then we take appropriate decision. If we continue to work with the same old equipment, it means, we have already arrive at a decision that, continuing to work with the existing equipment, perhaps the best option available.

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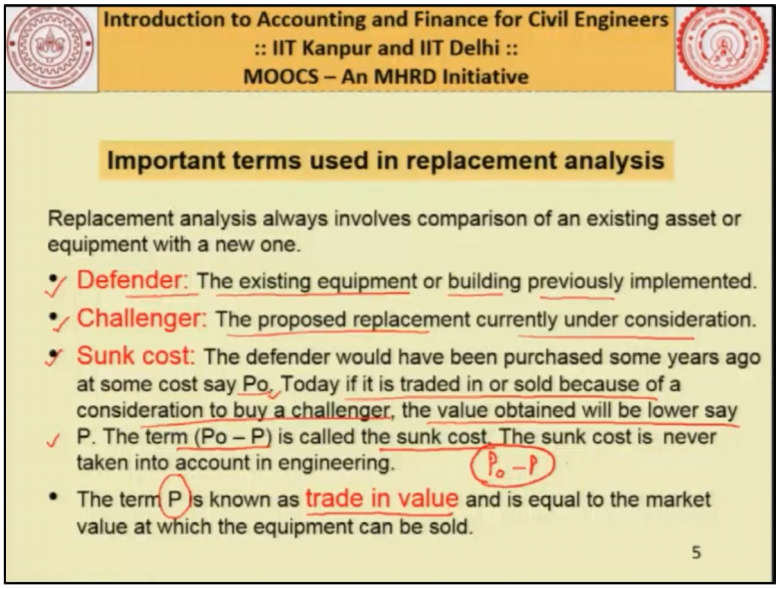

To start with, as I told you, we have to learn, few definitions. You already know, what is meant by Defender now. The exact definition is, the existing equipment or the building, which you have been previously using it, that is what, we are calling them as, Defender. Then, you have a Challenger. Challenger is the proposed replacement, currently under consideration. Then, there is a very important term called, Sunk cost.

Now, to understand the Sunk cost, you have to understand it like this. You might have purchased your equipment, sometime back, at certain cost. Let us say, that cost is P0. So, that means, the Defender was purchased, some years ago, at this cost, P0. Now, today, if it is traded-in or sold, because of a consideration to buy a Challenger, the value obtained will be lower. Say, this is P. The term P0 – P, we are calling them as, Sunk cost.

So, let us say, I purchase the equipment, 4 years back, at let us say, 100,000 Rupees. Now today, this particular equipment can be sold off at, let us say, 20,000 Rupees. So, the Sunk cost is, 100,000 - 20,000, which is 80,000. Now, in this particular analysis, between Defender and Challenger, sunk cost is never considered. So, whatever is the current value of that particular asset, that is what is of importance to us.

So, we also say that, the analysis has to be performed, from a third party angle. When you say third party, so let us say, I purchase this computer, 4 years back, or 5 years back. And now, I am selling it off for, let us say, 20,000. So, I lost this value, 100,000 - 20,000, 80,000. For a third party, it does not matter, at what price, I purchased it. He is more concerned, at the current market price, of this particular equipment.

So, all the time, when you compare between, Defender and a Challenger, you have to assume that, you are a third person. And accordingly, you have to take a decision. So, as far as the analysis is concerned, this P0 – P, which is Sunk cost, we never considered it, in our analysis. And, we are only concerned about the term P, which is known as the trade-in value. This is the value at which, this particular equipment can be sold off, right now.

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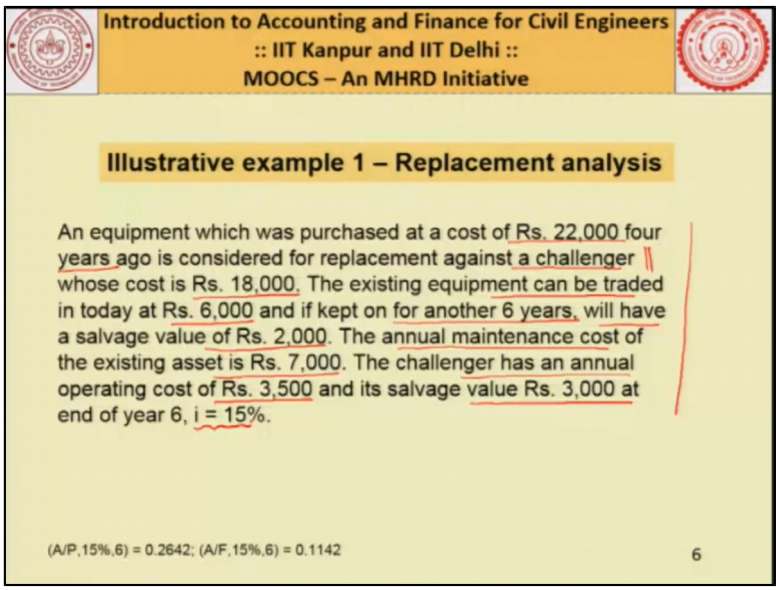

Now, this will be more clear, if we take one small example. Now, if you look at this particular example, it says that, an equipment, which was purchased at a cost of Rupees 22,000, 4 years ago, is considered for replacement against a Challenger, whose cost is Rupees 18,000. So, you had purchased an equipment, for Rupees 22,000, 4 years back. And now, you want to see whether, it is the right time to replace it, with a new set of equipment.

That new set of equipment, which we are calling it as Challenger, is available for Rupees 18,000. The existing equipment, which we are using right now, it can be traded-in for Rupees 6,000. That means, if you sell it off, right now, you will realise, 6,000 Rupees. And, if kept on for another 6 years, will have a salvage value of Rupees 2,000. The annual maintenance cost of the existing asset is, Rupees 7,000.

The Challenger has an annual operating cost of Rupees 3,500, and its salvage value Rupees 3,000, at end of year 6. Now, the minimum attractive rate of return given is, I is equal to 15%. Now, as usual, we can apply, either the Present Worth Method of Comparison, or Future Worth Method of Comparison, or Annual Cost Method of Comparison, to decide between the

two.

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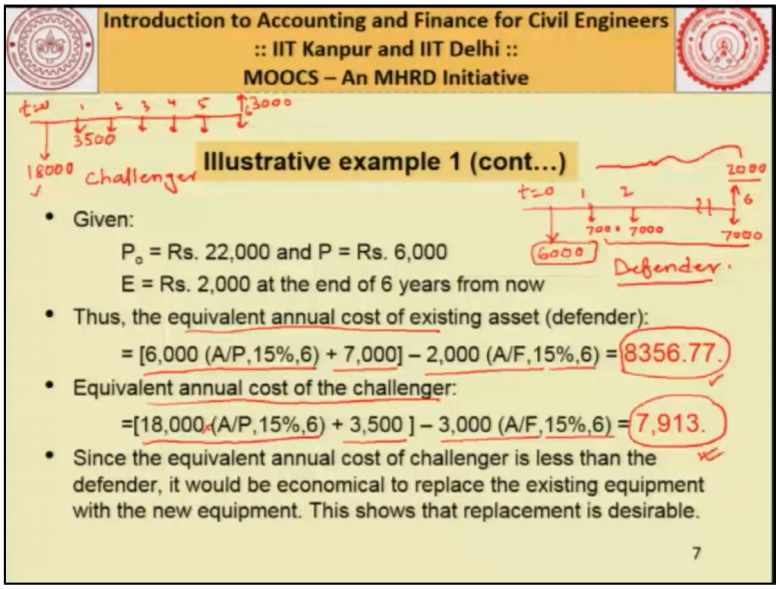

So, if you want to calculate, the equivalent annual cost, let us try to work it out using, Annual Cost Method. So, I can draw the cash flow diagram, for the Defender. So, Defender, at time T is equal to 0, is available for 6,000 Rupees, to a third party. So, although you might have purchased it for 22,000, 4 years back, but right now, if you want to sell it off, it can be sold only at 6,000. So, that is what is of importance, to a third party.

Now, every year, the cost is given to be, how much? You can read it, from here. The annual maintenance cost of the existing asset is, Rupees 7,000. So, 7,000 every year, is the maintenance cost, for this equipment. And, this is therefore, 6 years. Because, life is 6 now. And, its salvage value is, 2,000. If you see, the salvage value given was, 2,000. So, this is, as far as, the cash flow diagram, for Defender is concerned.

Defenders, cash flow diagram. So, at time T is equal to 0, 6,000 at year 1, 2, 3 and 4, 5 and 6, We have to spend 7,000, as annual operating cost. And, if you are disposing it off, at the end of 6 years, you can realise, 2,000 Rupees. This the cash flow diagram, for Defender. Now, in the same manner, I can draw the cash flow diagram, for Challenger also. So, Challenger is available for, what price? You can see, it was given to be, how much? 18,000.

So, the Challenger is available for, 18,000. So, I write 18,000 here, at time T is equal to 0. And, every year, the maintenance cost is also given. So, this, I will write it here. Year 1, 2, 3, 4, 5 and 6. And then, you have salvage value. Salvage value is 3,000. And, operating cost is

3,500. So, this is 3,500. And, this is 3,000, that you realise, at the end of year 6. So, this is the cash flow diagram, for your Challenger.

So, I have drawn, the two cash flow diagram, as usual. Whether you do it for, acquisition of an asset, or whether you do for, carrying out the Replacement Analysis, the first step remains same. That is, you have to draw the cash flow diagram. Now, I can apply, either the Present Worth Method, or Future Worth, or Annual Cost Method. In this particular problem, let us try to solve it using, Equivalent Annual Cost Method. So, for the Defender, it is going to be, if you consider, cost also as positive.

So, 6,000, A given P, 15%, for 6 years. So, this I convert it into, Equivalent Annual Cost. 7,000, is already in terms of annual cost. And, 2,000, this also, I want to convert it into annual cost. So, - 2,000, A given F, 15%, for 6 years. If you take the appropriate factor values, you will find that, you are getting a value of, 8,356. It only means that, if you continue to use your existing equipment, your cost liability is 8,356.77, every year, for next 6 years. Now, let us try to work out the cost liability, as far as, Challenger is concerned.

So, Challenger is available for 18,000, at time T is equal to 0. I convert it, in its Equivalent Annual Cost, for 6 years. So, this will be done, by multiplying 18,000 with, A given P, 15%, 6 years. + 3,500, is the operating cost, which is same every year, for the next 6 years. And then, salvage value also needs to be converted, into equivalent annual cost. And, if you work out this, you will find, you are getting a value of, 7,913. That means, if you buy the Challenger, your cost implication, for the next 6 years is going to be, 7,913.

So obviously. The choice is simpler now, you will go for the Challenger. This is because, the cost implication for the Challenger is, lesser than, the cost implication for the existing asset, that is the Defender. So, this is one type of problem, in which, you compare, the costs of keeping the Defender with you, or going in with Challenger. Now, there could be another type of problem in Replacement Analysis, which is basically to find out, the accurate or the optimum time of replacement.

Let us say, you purchase the car. Initially, you will find that, your operation and maintenance costs are very low. But, as and when, the car starts growing older, you will find, the operation and maintenance cost becomes higher. So, you will find, that the total cost of keeping that

particular car, in the beginning years, would be low. But, as and when, the age grows up, you will find that, the cost of keeping that particular car with you, is going to be higher. So, we are interested in finding, what is the right time of replacement, of that particular asset.

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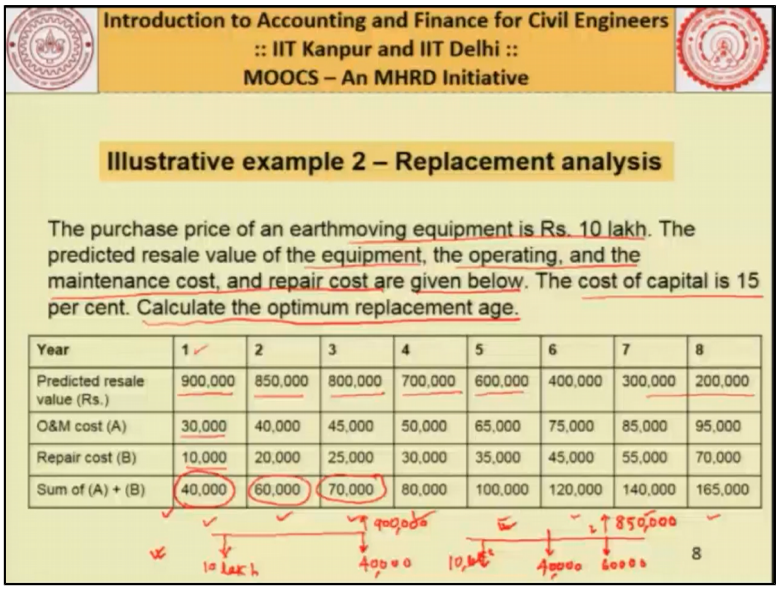

So, for that, we take one again small example, in which, we are given that, the purchase price of an earthmoving equipment is, Rupees 10 Lakh. So, in 10 Lakh, I purchased this earthmoving equipment. The resale value of the equipment, again, these are predicted value. The operating and the maintenance cost, and the repair costs, are also given below, in this table. The cost of capital, that is the interest rate is 15%, I have to find out the optimum replacement age.

So, this is the second type of problem, that we come across in, Replacement Analysis. I have taken, very few variables. For example, I have taken only the initial cost. I have taken the resale value. I have taken the operating and maintenance cost, and the repair costs. In addition, there are many other variables, which will see, little later. So, I will tell you, the various steps, which we have to perform, in order to find out the, accurate replacement age, for any given asset.

So, you can see, if you are planning to sell off this particular equipment, at the end of year 1, your resale value is likely to be, 900,000. Second year end, 850,000. Third year end, 800,000. Fourth year end, 700,000. Likewise, for up to 8 years, we are given the predicted resale value. That means, if I sell that particular asset, or the earthmoving equipment, at that point of time, I am likely to get, this much money. The O&M cost for the first year is, 30,000. Repair cost

is, 10,000.

So, total it is, 40,000. For the second year, 40 + 20, it is 60,000. Third year, it is 70,000. You can see, this O&M cost is gradually increasing. In the beginning, it was very low. Then, it started increasing. Towards the end, you will find, it increases at a very high rate. So, we have to find out, what is the right time, to replace this particular asset. Now, I can do this, with the help of small cash flow diagrams also, every year. Or, I can do this, in a very systematic manner, using a table.

I will tell you first, how I could have done it, using a cash flow diagram. So, let us say, at time T is equal to 0, you purchase this equipment, for 10 Lakhs Rupees. Now, at the end of year 1, you would have spent 40,000 as, O&M cost and repair cost. And, if we would have sold this equipment, at the end of year 1, you would have realised, 900,000. So, I can find out, what would have been my annual cost liability, if I would have sold this equipment, at the end of year 1.

Likewise, I will draw the cash flow diagram, for second year. So, first year again, I bought this equipment for 10 Lakhs. Year 1, I spent 40,000. Year 2, I spent 60,000. And, if I would have sold this equipment, at this point of time, I would have realised, 8,50,000. So, this is year 1, this is year 2. Now, for each one of these cash flow diagram, I can calculate the Equivalent Annual Cost.

So, it means, what could have been my Equivalent Annual Cost, if I would have replaced this equipment, at the end of year 2, or at the end of year 3. This is what, I could have done it, by drawing individual cash flow diagram. But, I can do this, in a slightly different manner, in a more systematic manner, in the form of a table.

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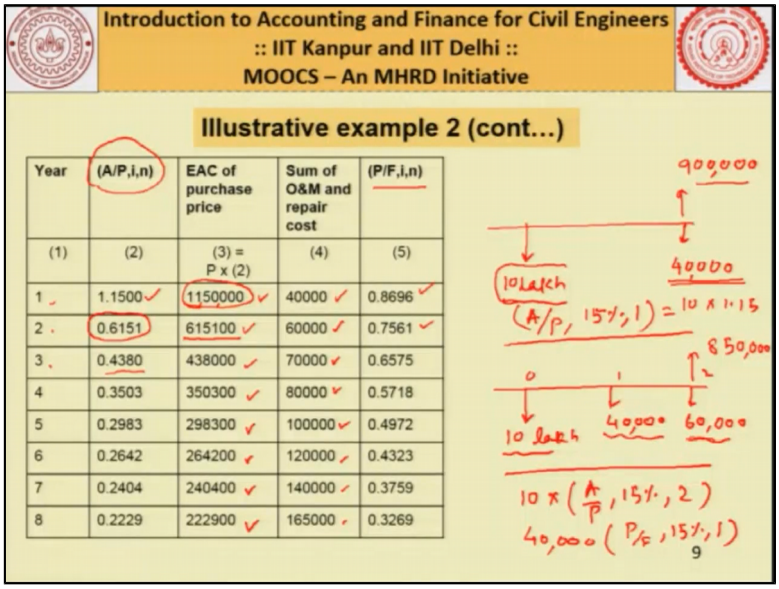

So, what I do? I draw a table like this, in which first, I write the year. Year 1, 2, 3, 4, 5, 6, 7 and 8. Then, I write this factor, A given P, for an interest rate of I, for time period N. So, it is like this. I have to redraw that, cash flow diagram. So, this is 10 Lakhs here. And, if I am disposing it off, at the end of year 1, I am realising 900,000. And, my annual cost would have been, 40,000. So, this is the cash flow diagram.

So, what I am doing? I am writing, all the factors here, A given P. Likewise, if we would have disposed it off, at the end of year 2, it would have been like this. 10 Lakh, here. For the first year, 40,000. For the second year, 60,000. And, the disposal costs could have been, 850,000. So, this year 1, 2, and 0. So, if I would have replaced this, at the end of year 1, the Equivalent Annual Cost of purchase price could have been, 11,50,000.

How I am getting this? This is my present worth. Now, I want to find its equivalent A. So, I will write, A given P, for 15%, for 1 year. So, this would be, 10 Lakh, multiplied by 1.15. So, its Equivalent Annual Cost would have been, 11,50,000. This is what, it means. 40,000, is already in terms of annual cost. And, this also, in terms of annual cost. So, if we would have kept this equipment for 1 year, what would have been your equivalent annual cost, that we will find it out.

Likewise, here also, if this particular equipment is likely to be sold off, at the end of year 2, for this, the Equivalent Annual Cost would be 10 Lakhs, multiplied by A given P, for 15%, for 2 years. The factor here is, 0.6151. So, if you multiply this with 10 Lakhs, it is 615,100. So likewise, I can calculate the Equivalent Annual Cost, depending on, whether I am likely to

sell it off, in year 2, year 3, year 4, year 5, year 6, 7 and 8.

So, this column is generated, like this. Now, sum of O&M and repair cost, you can easily find it out, from the previous table. I am just simply adding, this 30,000 + this 10,000, 40,000 for first year, 40 + 20, 60,000 for the second year. So, this column is representing this, 40, 60, 70, 80, 100,000, 120,000, 140,000 and 165,000. Now, I am also writing the factor, P given F, for an interest rate I, for a time period N. That is, just to convert these values, at time T is equal to 0.

Suppose, I bring this 40,000 here, and 60,000 also here, so how do I convert. This 40,000 will be treated as F, and I want to find its equivalent P. So, I will multiply this 40,000, multiplied by P given F, for 15%, for 1 year. So, I multiply it with, 0.8696. Likewise, 60,000, I multiply this with, 0.7561. So, this is how, you generate this table. Some more columns of this table, is shown in the next slide.

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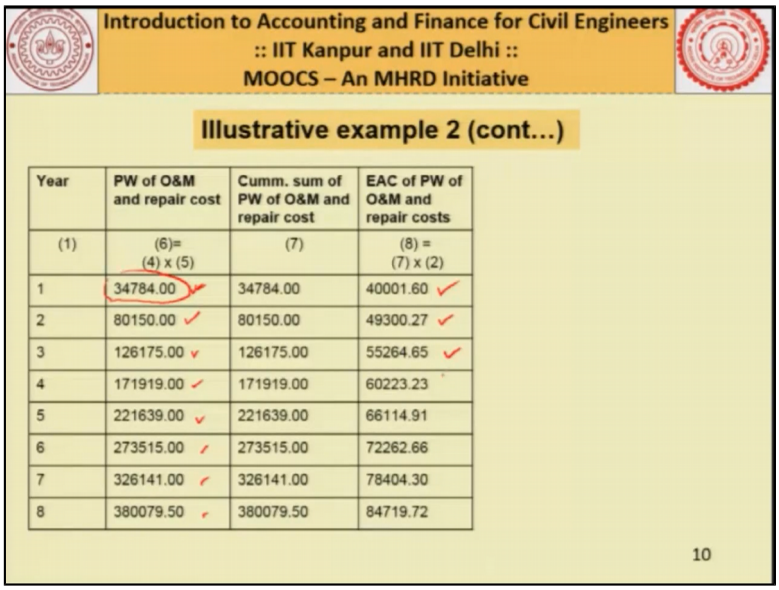

So, we can easily find out, the present worth of, O&M and repair cost. How? You can see, this is 334,784, how it has been generated? It has been generated like this. 40,000, you multiply it with, P given F, 15%, 1, which is 0.8696, so, if you multiply this, you will find, you are getting a value of, 34,784.

Likewise, for the second year, we can generate a value like this, third year, fourth year, fifth year, sixth year, seventh and eighth year. Now, we are adding it. So, we are saying, cumulative sum of, present worth of O&M and repair cost. Why? Because, if you see, for this

40,000, you have brought it here. And, that was coming to be about, 34,000. This 60,000 also needs to be, brought here.

So, you know, we can calculate this, by multiplying 60,000, with P given F, 15%, 2. So, if you add both, and add it in 10 Lakhs, so that will become, the total present worth. And, that I can convert it into, Equivalent Annual Cost. So, this way, if you go on doing it, you can calculate the Equivalent Annual Cost here, like this.

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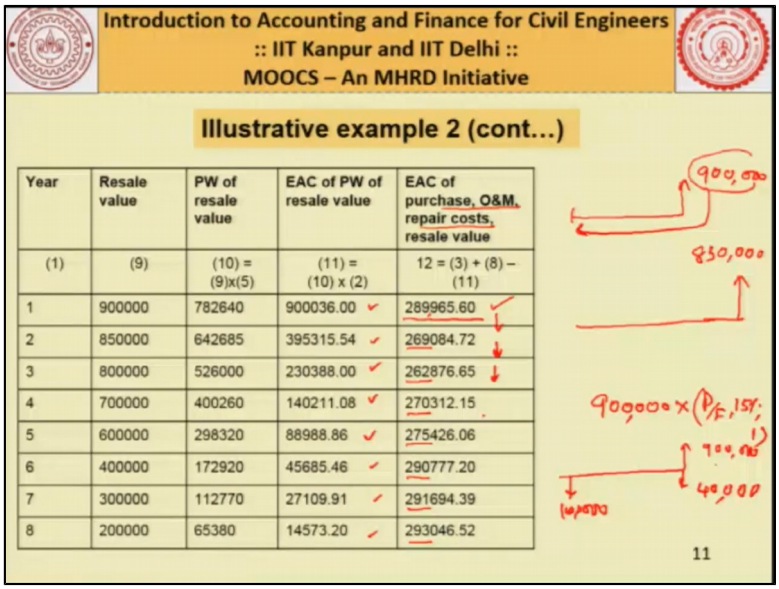

Year	Resale value	PW of resale value	EAC of PW of resale value	EAC of purchase, O&M, repair costs, resale value
(1)	(9)	(10) = (9)x(5)	(11) = (10) x (2)	12 = (3) + (8) – (11)
1	900000	782640	900036.00	289965.60
2	850000	642685	395315.54	269084.72
3	800000	526000	230388.00	262876.65
4	700000	400260	140211.08	270312.15
5	600000	298320	88988.86	275426.06
6	400000	172920	45685.46	290777.20
7	300000	112770	27109.91	291694.39
8	200000	65380	14573.20	293046.52

And then, we come to the resale value. Resale value also needs to be converted, into its Equivalent Annual Cost. For example, in the first year, the resale value was 900,000. This also needs to be converted, into Equivalent Annual Cost. In the second year, it was 850,000, that also needs to be converted into, its Equivalent Annual Cost. So, what we are doing is, we are bringing this, at time T is equal to 0, by multiplying 900,000, multiplied by P given F, 15%, 1. So, this way, this value is coming at, time T is equal to zero.

And, that is getting converted to, Equivalent Annual Cost, by multiplying that, with the factor. And, that way, if you continue doing this, you will get these values. These are the Equivalent Annual Cost of, present worth of resale value. Now finally, what I am doing? I am adding up, all together. And, you find, if you do it yourself, you will get, for the first year, if you are disposing it off, your Equivalent Annual Cost of, all these things put together, purchase, O&M cost, repair cost, resale value, if it is all put together, you are getting a value of, 289,965.

So, I will give you this, using the cash flow diagram also, this is 900,000, this is 40,000, this was 10 Lakhs. So, what I am doing is, I am converting everything, at time T is equal to 0. And then, I am multiplying it with, the Equivalent Annual Cost factor, to generate the annual cost. Likewise, I will do it for, this one also, for year 2 also.

Everything is being brought at, time T is equal to 0. And then, I multiply it with the factor, Equivalent Annual Cost factor, to generate the Equivalent Annual Cost. So, this way, if you want, you can perform the calculations. So, you can see, this last column, very clearly, first year, if you want to dispose it off, your total cost liability is, 289,000 + second year, it is 269,000.

Third year, if you are disposing, 262,000. Fourth year, it has increased. Fifth year, it is 275. Sixth year, 290, 291, 293. So, you find that, initially, the costs are coming down. Up to third year end, the cost has come down. This is the least cost, at the end of year 3. Then, it has started increasing. This has been captured, in the form of a pictorial representation.

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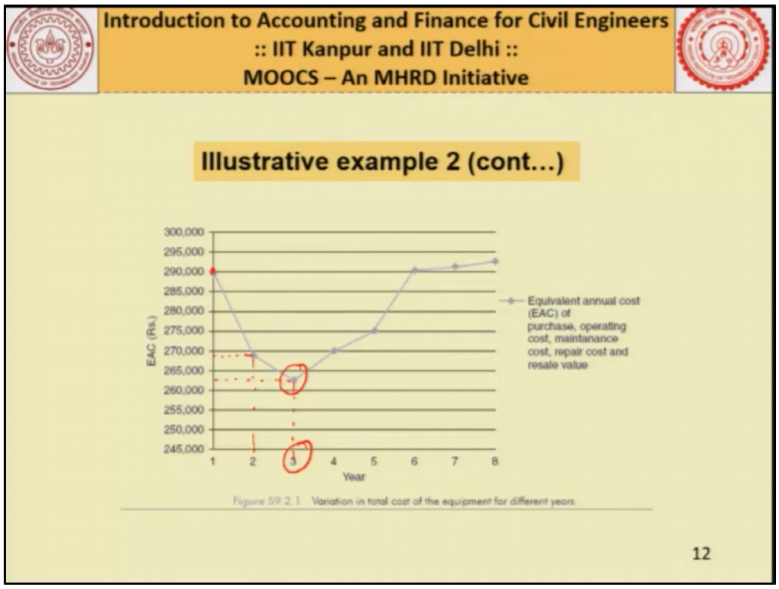

So, you can see, in year 1, if you are disposing it off, this cost implication is, this much somewhere. Second year, it is somewhere here. Third year, you can find, the cost is the least. So, this is the right time, to replace your equipment. Because, beyond this, if you want to keep the equipment with you, its cost is going to be increasing. So, this is the right time, to replace your equipment. So, we have seen, two examples.

And, now you understand, how to carry out the Replacement Analysis, for both the situations.

Now, in real life situation, you come across, many other variables. If you remember, in the previous example, we undertook only two three variables, one was the investment cost, the resale value, the operation cost, and the repair cost. However, in real life situation, you will find that, in addition to this, you have many other variables, to take care.

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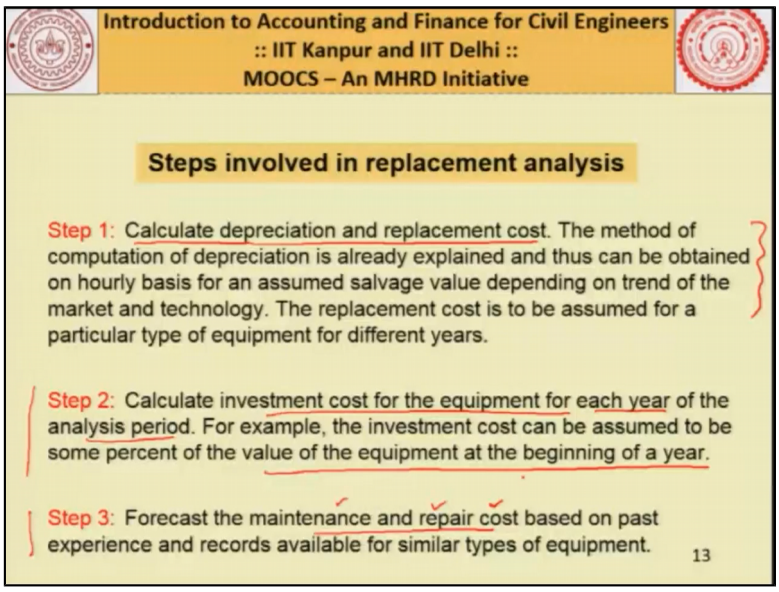

For example, you also have to calculate, the depreciation and replacement cost. So, step one, you calculate the depreciation and replacement cost. You already have been exposed to, finding depreciation, using different methods. Now, sometimes, it is better to convert that depreciation cost, into an hourly depreciation cost. And, you can also convert replacement cost, in the form of hourly replacement cost. So, step one, when you have to do the detailed analysis, you will calculate the hourly depreciation and replacement costs, every year.

Step two would be, to calculate the investment cost, for the equipment, for each year of the analysis period. For example, if the investment cost is assumed to be, some percent of the value of the equipment, at the beginning of a year, you can easily take this into consideration. And, in the third step, we forecast, the maintenance and repair costs. In the last example, these values were given to us. So, you understood, how do we take this, into consideration.

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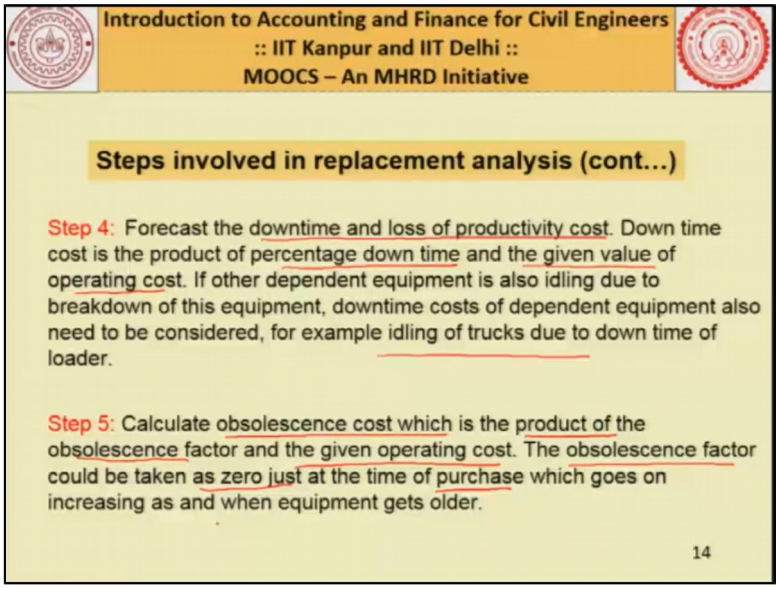

Then, in step four, we forecast the downtime, and loss of productivity cost. Now, downtime cost, is the product of percentage downtime, and the given value of operating cost. In some cases, it may so happen that, if one equipment is idling, it is affecting other equipment also. So, if your mixer machine fails, it will impact the working of your transit mixer also. Because, as long as, this mixer machine is under breakdown, you cannot utilise your transit mixers.

Or, for that matter, pumps. So, all of them are idling. And, so accordingly, you have to take care of those, idling cost also. Again, all these are considered, in terms of hour. Now, in real life situation, we also consider the obsolescence cost. Now, this is nothing but, the product of the obsolescence factor, and the given operating cost. For many equipment, researchers have found, the obsolescence factor. And, there are tables available, through which, you can find out the obsolescence factor.

And, when you multiply it, in the given operating cost, you will get the obsolescence cost. This is again calculated, in terms of hour, hourly basis. Now, the obsolescence factor, as you could expect, it will be taken as 0, just at the time of purchase. Because, that is the new equipment, and that is not obsolete at all. So, you can take this as 0. Now, this factor goes on increasing, as and when, equipment gets older.

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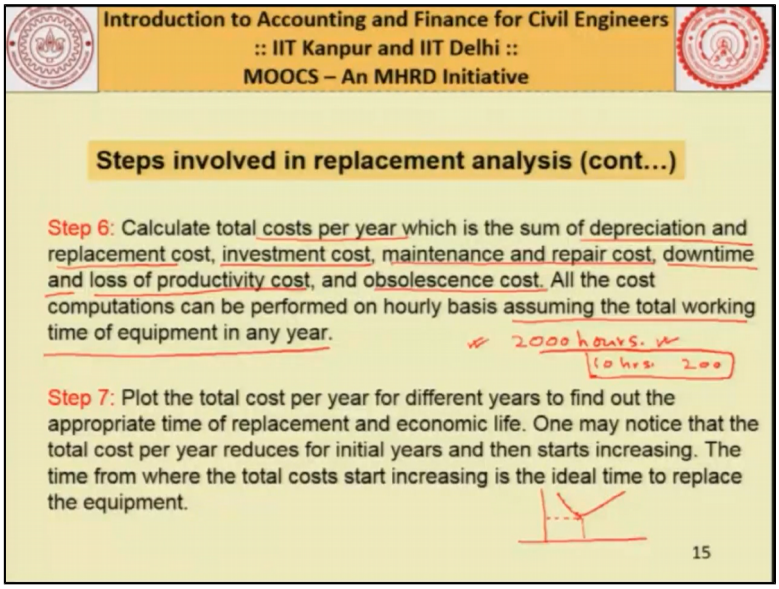

Now, having calculated, all these individual hourly cost, you can calculate the total cost per year. Now, you can remember, this is the sum of the depreciation cost, the replacement cost, the investment cost, the maintenance and repair cost, the downtime cost, and the loss of productivity cost, and obsolescence cost. So, all these, you have already calculated, in hourly basis. You add it up.

And, this, we are assuming, the total working time of equipment, in any year. Normally, we consider 2,000 hours, which is a very typical value, for any equipment, in a whole year. So, we assume that, equipment is working for 10 hours a day, and 200 working days. So, that gives me a figure of, 2,000. So, roughly we take that, any equipment is working for about 2,000 hours.

So, whatever cost, you are calculating, you can divide it by 2,000 hours, to get the hourly cost. Now, this total cost on hourly basis, is plotted. One such plot, I had already shown you, for of course, small variables. So, this is how, you plot this. And, you can calculate, the right time at which, the equipment should be replaced. So, you will find, something like this, you will get. Initially, you will find, the sum of all these cost, will go on decreasing.

There would be a point at which, this will be the least. So, that is the time at which, ideally you should replace your equipment. So, in this class, we have essentially understood, the process of replacement, which is very important decision, faced by any engineer, during his career. Replacement could be, with the set of Challenger, or replacement could be, on the basis of total least cost, that is being observed, at a particular point of time.

We discussed, two problems. In one problem, we compared, the Challenger with the Defender. Now here, in this analysis, we never considered, the Sunk cost. Sunk cost is the difference of the cost between, the purchase price of the equipment, and the sales value of that particular equipment, at that point of time. So, essentially, we are carrying out the analysis, from a third party angle. So, any emotional value, that we attach to with our equipment, should not be there, in the analysis.

And, that is why, I am telling you that, we take it like a third party. So, for a third party, it does not matter, at what price, he or she purchased that particular equipment. What matters is, what is the price at which, this equipment is being sold, at this point of time. Now, using the concepts of, either the Present Worth, Future Worth, or Annual Cost Method, you can calculate these values, and take appropriate decisions.

In the second problem, we considered few variables, the predicted resale value, the operating and maintenance costs, repair cost. And, based on these few variables, we try to find out, the optimum time of replacement. We also considered other variables, which are considered in real life analysis. And, how to calculate the total cost, summing up all those variable costs. And then, how to take decisions. So, at this point of time, we would like to stop, and see you some other time, in the next class. Thank you, very much.