Fire Protection, Services and Maintenance Management of Building
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Lecture – 41
Cost profile of maintenance

So, we have looked into how we actually find out the repair cycle for roof covering that is what you seen in the last class.

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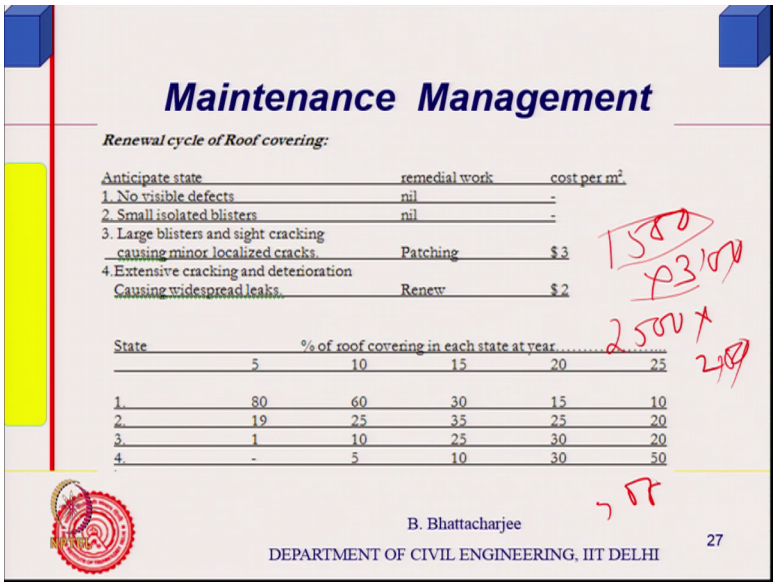

You seen in the last class; so, what we do is, we first define what you call you know anticipated state define them and remedial measures required. And cost then for every 5 yearly from past data, we try to find out how much percentage the area will be in a given state and from that to estimate the cost. And, when the cost of patch repair or repair is equal or more than the renewal cost, that is replace the whole thing all of them, then we do renewal. So, that is what we have seen in the next previous class right and then you have seen also related to painting.

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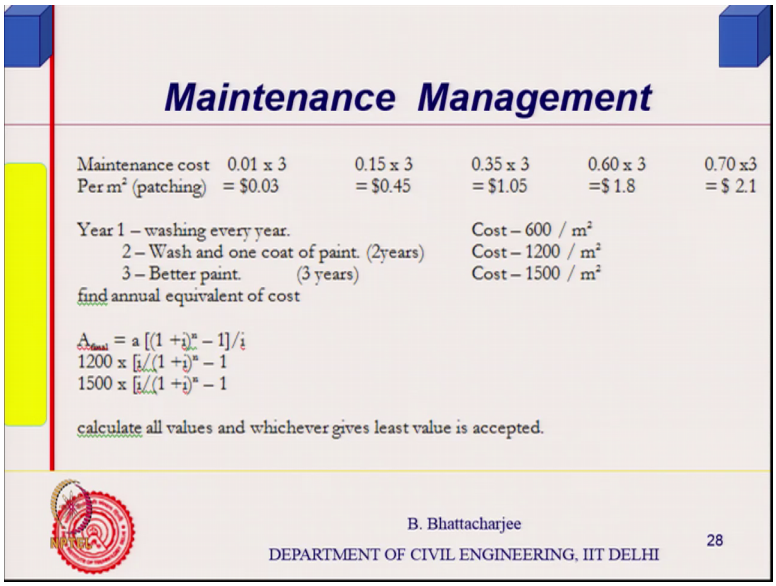

For example, also related to painting external painting or similar sort of thing what we said was that you can have options that washing every year, a second option could be you do wash one time one coat and then paint or maybe put a better paint every 3 years and the cost is known. When is the cost per unit area is known, you try to find out cost per year, but in all cases you can bring time value of money into consideration; that is interest rate and number of years involved. So, annual equivalent you can find out. I think that is all we have seen in the.

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I mean basically it is like this. If it is let us say the anticipated state is small isolated blisters for that we do patch repair. Now, even you see if a large area is there, as I said there are number of buildings one building may have a deterioration which is worse than small blisters may be large blisters, but then it is only one building area is still small. So, we do again locally repair.

So, this is the cost would be similar as the specified because, the cost different come difference comes because of the setup cost. If you have to setup for the whole area let us, you have 5 buildings or area is very large may be 50 into 50 square metres right. So, 2500-meter square of a multi storey top roof covering area.

Now, if the you know if it is extensive if you find that 50 percent of the area is in bad shape right and then 50 percent multiplied by 300 rupees or 3 times compared to if you do the whole 2500 you know like 1000 to 1250 multiplied by 3 or 60 percent 60 into 60s will be 60 percent would be actually say 60 percent of 2500 will be how much 1500, 1500 multiplied by let us say 300 or 3 units compared to 2500 into 2.

Now, this will be how much this should be this you know 200 or whatever it is you. So, you forget about this 200 terms is 5000 and this will be 4500. Now, you can see that they are nearly comparable. So, when the cost is let us say this goes to 1600 or something like that of 1700. Then, obviously, it is better to do the total area repair although in this one the cost you know; there will be some areas which is really in bad condition even in state 4. But then, if the area is only 10 percent is in state 4, I will still do patch repair as and when it comes.

So, the cost of patch repair or simple repair is essentially because for doing that 10 percent I have it is over 5 years of time. So, some time in 3rd year or 4th year I may have to do, but then they will come set it up and then do the repair and go away. But then after let us say 25th year, I decide whatever comes bad already, 70 percent is in bad shape which will require large scale repair I do the everything. So now, the 30 percent which is still good I do the repair. So, that everything is renewed now and I start a fresh that is idea, that is the idea.

So, that is why doing bulk repair is quite often advantages. So, that is what I think I was telling you in the last class you know I that is what I was telling you in the last class right. So, and then you can bring in time value of money wherever required. For example, as I said you can find out annual equivalent of money; that means, every year how much you should be spending. Suppose, in 2 things you have got different lives say one you know one alternatives have got a life of 7 years another has got life of 5 years.

While 5 years you spent less, but 7 years you spent slightly higher. Now, you want to find out compare all economic alternative which is better find out what is called annual equivalent of money. That means, if you have spent 7000 now equivalent to how much money every year for next 7 years. Another one if I spend some money now, how much is equivalent money every 1 year for next 5 years.

Now, all that assumptions I am making that after 7 years, again I will do the same thing after 5 years, I will do the alternative second again. So, this is the assumption I made and that is how we do engineering economics you have computation, I mean rather comparison that is what I was mentioning in the last class.

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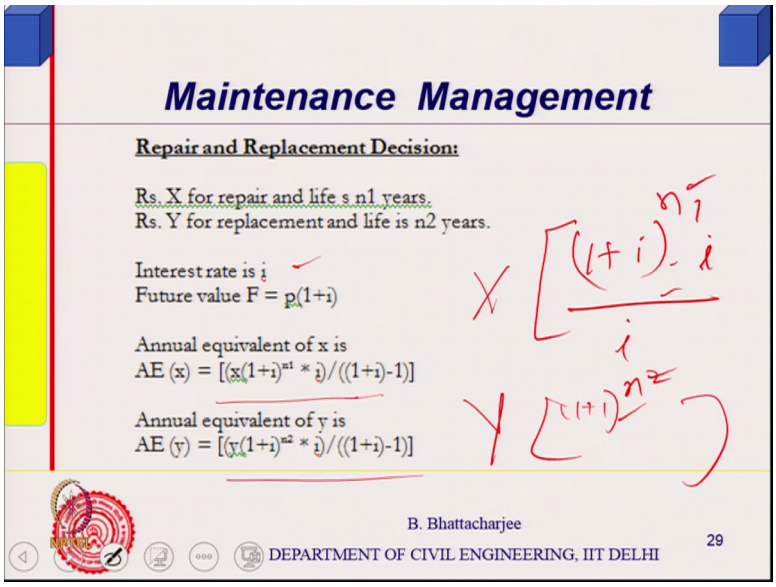

So, similar situation can arise in many cases. For example, X is the repair and life is n 1 years repair cost and Y's are replacement cost and life you know it is life is n 2 years. Then, interest rate is i. So, if I spend p now, after 1 year it will be p into you know 1 plus i and annual equivalent is given by this formula x into 1 plus i to the power n divided by you know 1 plus i to the power n 1 because n 1 here is the life into i divided by 1 plus i minus 1 or it is like this you know x into 1 plus i to the power n 1 years is a life right into i divided by simply i because you know. And if I want to find out it is I mean basically, if X is what I was spending now, because the Gibb series that I talked about.

So, Y similar one, similar one for Y you can find out and whichever gives you lower value this factor should be same. Only year number of year would change here it will become n 2 1 plus i to the power n 2 into not i. I mean into I think there is a mistake some are there minus I think we derived this in the last class. So, what was the annual equivalent formula we will have to use? I mean, you can again derive this. In fact, you can just do this.

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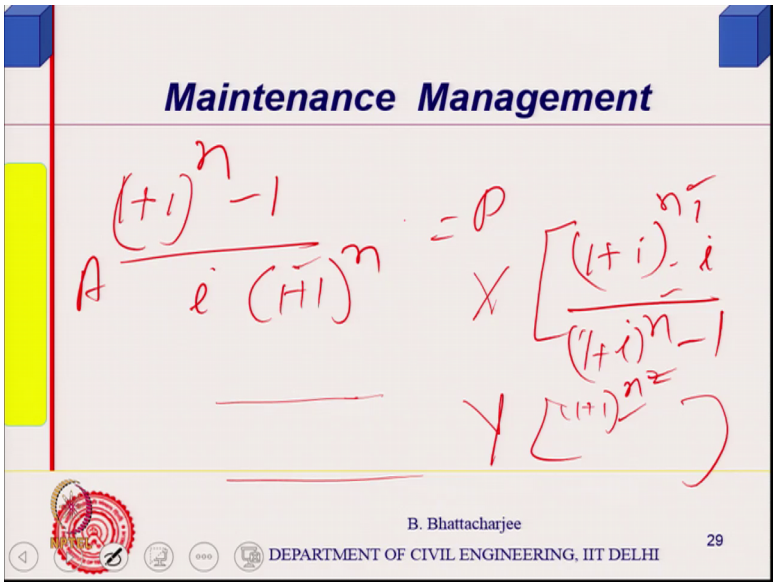

Because we said this is a Gibb series 1 plus i to the power n minus 1 divided by i right. So, that will be the future sum and if I divide by 1 plus i to the power n then I get the yeah. So, this should be 1 plus i to the power n minus 1 this is what it would be and 1 plus is a simply 1 plus i to yeah right that is right. So, anyway this formula is. So, if I have if I have a a every year if future sum present what value is present value is this much a multiplied by all these and if I know the P or X I am spending now, I am spending X now X now, then it would be equivalent every year yearly equivalent to 1 plus i to the power n multiplied by i divided by 1 plus i to the power n 1 minus 1.

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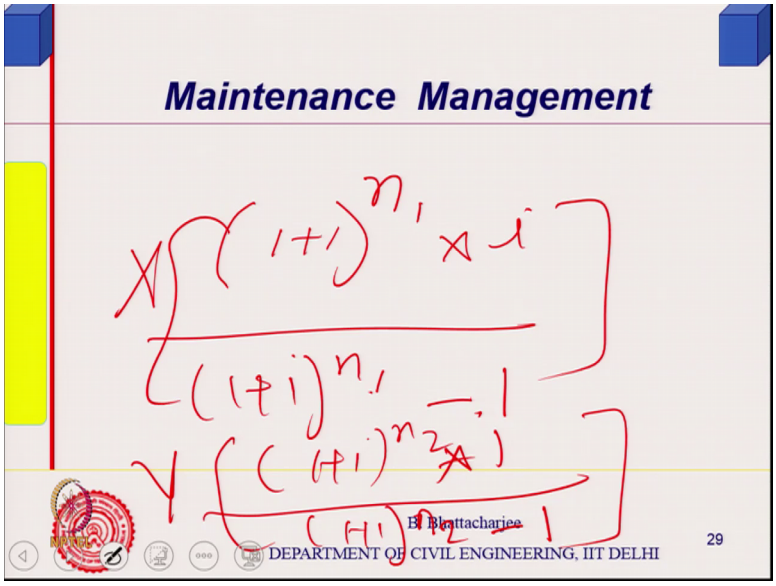

And for the second case, Y 1 plus i to the power I mean this term is in bracket 1 n 2 minus 1 into 1 divided into i divided by 1 plus i to the power n 2 minus 1. So, this is n 1 this gets replaced by whichever is lower you will take decision in favour of that. So, you can bring in time value of money now this can happen sometime. For example, when let us say, I have a now I am repairing one option is to keep the same system say roof covering system, you know same system right whatever was there and it will have given life which I know.

But, many modern materials might have come modern system might have come better waterproofing system might have come. So, if I put it now it might live for longer period of time, but the cost might be higher. So, I would like to compare. Which one is shall I do? Shall I keep the old one which will have let us say n 1 years of life or if I put a better one, which will have slightly higher life n 2 years of life? So, which one? So, I select. So, this kind of decision making can be done repair replacement decision. We can use these concepts this concept we can use annual equivalent of maintenance cost you can utilize right.

So, that is what it is right. So, time value of money can be utilised in this manner time value of money can be utilised in this manner right. As required in repair and replacement decisions repair and replacement decisions right repair and replacement decisions ok. So, that is it now ok. Now, having done that kind of thing, I am able to I should be able to find out.

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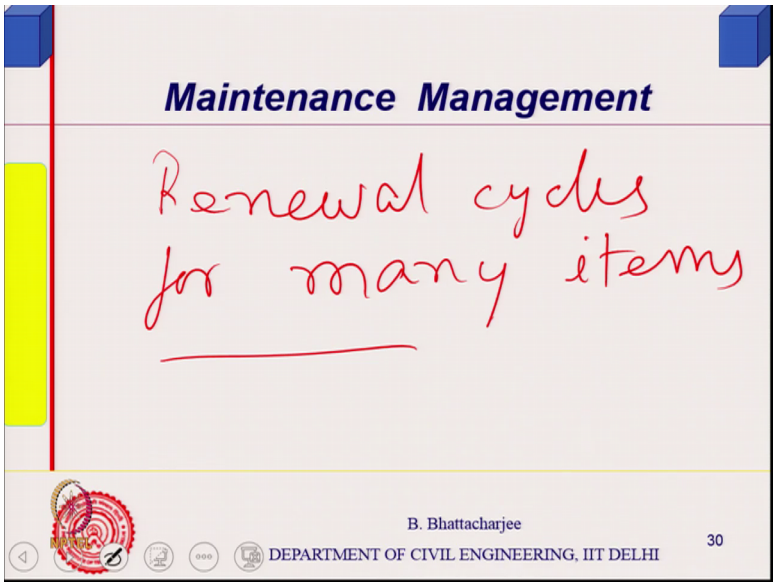

The renewal cycles for renewal cycles for renewal cycles for many items or systems you can say. And we have seen that we can actually many all the items in the building I can classify them into several classes some of them will slowly deteriorate, some of them will deteriorate and then I am I will replace them or repair them. Some will suddenly fail; we have classified them.

So now I can take all the building all the items in the building and classify them. For example, I said that normally frames structural system foundations etcetera should not be requiring any repair. So, if I identify them if I am able to identify them, in that case I repair, I can find out, I can do a planning right. In the beginning of my you know right at the time of construction, that what would be my projected maintenance cost from time to time for a given building or a set of building which are constructed at a given time or set of similar buildings, let us see how we do it.

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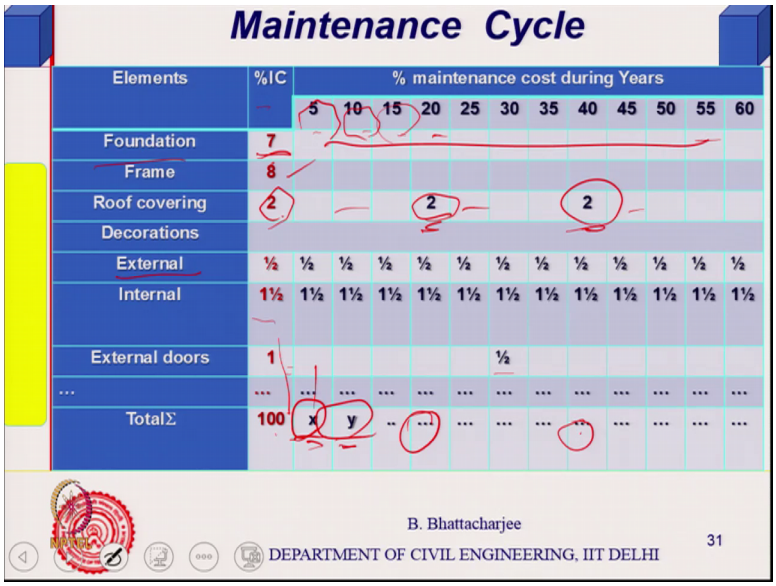

So, one way is to do is to let us say let us say this I will come back first I will have this slides then I will go. So, for example, foundation if you look at foundation, it initial cost is 7 percent let us say 7 percent of the total cost of the building right and it does not require any maintenance these columns are percentage of initial cost these column 5 years 10 years maintenance cost during life 5 10 15.

So, 0 to 5 years all the cost here 5 to 10 years, 10 to 15 years and up to intended design life of 60 years we are considering frame, say let us say some percentage I have put in 8 percent and it does not require anything. That is what I am saying roof covering 2 percent is the cost and I have found out the renewal period is 20 years. So, my maintenance cost major maintenance cost will come 20 years later when I will replace all of them. So, after that again 40 years, I will do repeat it.

So, I will incur 2 percent cost here and 2 percent cost after 40 years right and these I know right in the beginning. Similarly, if you look at it external decorations half percent of the building and every 5 years, I have to do that half percent I will incur. So, I can put it half internal one and half percent 1 and half percent etcetera etcetera and external doors 1 percent then half percent I know 50 percent. I will required to replace in 25 years or 30 years of time and so on.

So, total I will have 100 percent cost involved because initial cost 7 percent 8 percent 2 percent etcetera etcetera. All will add up to 100 percent some will not require repair at all

some will repair periodically you know repair or renewal cost and this I can actually find out. Then, I can sum them up after every 5 years. So, after 5 years let us say, X after 10 years let us say Y and so on so forth.

Therefore, right in the beginning, I can actually find out what would be the maintenance cost of the percentage of the initial cost because, why it is preferable to take it as percentage? After all, there will be inflation is 10 stern cost index might change, but initial cost I know and how much will be escalated cost over 5 years you know, I can estimate all when I am doing budgeting right in the beginning, I express everything in terms of percentage cost.

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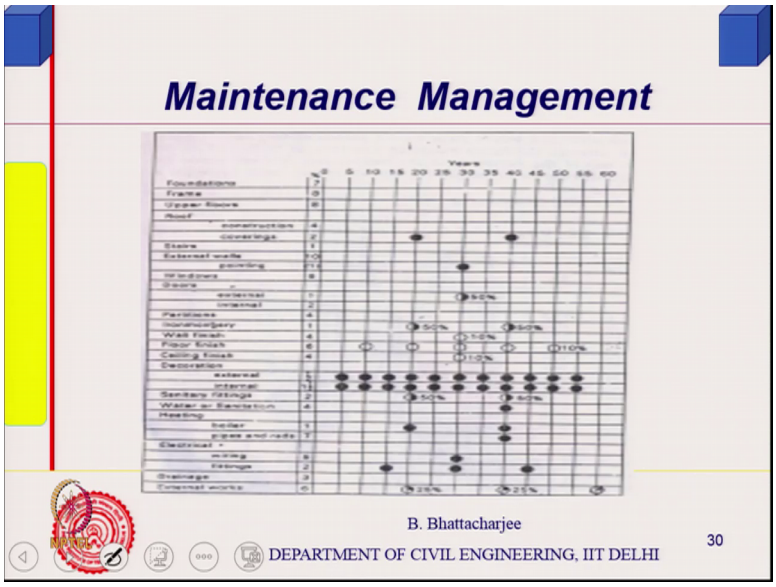

So, if I do this for the whole building, I can do this for the whole building and I will get you know I can put it dot dot lines or whatever it is for all items all items for a given building of or you know each for each building itself and once I have done that, once I have done that then I will get this sort of thing this I can plot or I can use it in budgeting.

So, what I know is that 0 to 5 years I have need this much of money for maintenance 5 to 10 years. I need this much of money for maintenance and for whole 60 years and you will find that at this point of time possibly there will be lot more at this point time, there will be lot more because there is a cycle around 20 years and it will tend to increase at that point of time you know. So, that is how it is.

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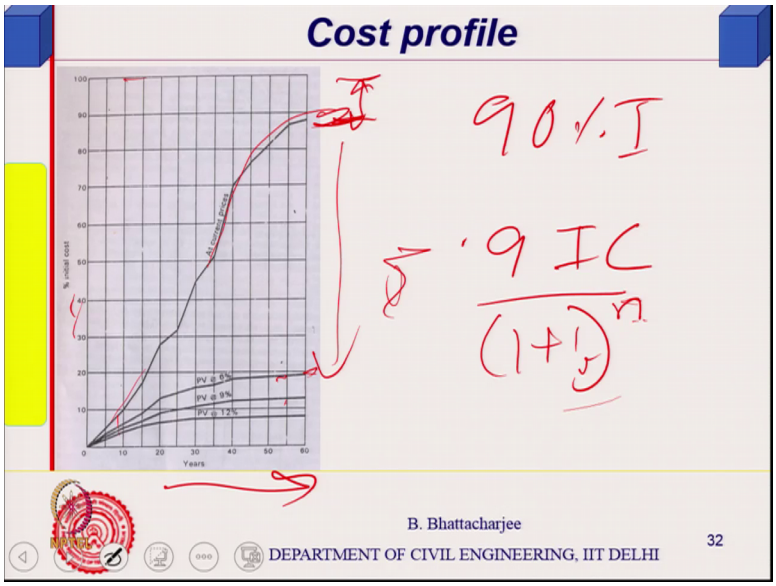

So, one can plot this cost profile this is called maintenance cost profile as a function of time. So, this is time this is the initial percentage of initial cost 100 percent is here and this is the maintenance cost. So, you can find that by 60 years of it is life nearly 90 percent of the things I would have replaced at least once or maybe more sometime twice thrice. So, I spent almost same cost or nearly same cost during the life period of the building for maintenance itself, but then it is distributed over 60 years of life.

If you take time value of money into account; that means, put interest rate then this value comes down because present worth of this value will come down whatever you are spent here let us say this is a something like 90 percent of the initial cost. So, 0.9 IC divided by 1 plus i to the power n will come 1 plus i to the power. So, since this interest rate if you take this value will come down you know because, this is will be sum total of I mean, whatever it is because there will be some n value would of course, vary because it will be over many periods of time right, first 5 years.

So, if you take time value of money into account it tends to show you that possibly you know, it would always tend to cause ask you to delete the maintenance because current value will be relatively less. So, if you take interest rate this is what it would be, but you can find out you can compare different buildings different building system. So, this is called maintenance cost profile and you can generate it right, in the beginning itself

during the construction phase itself that how much percentage of the initial cost you will be spending every 5 yearly for maintenance purpose.

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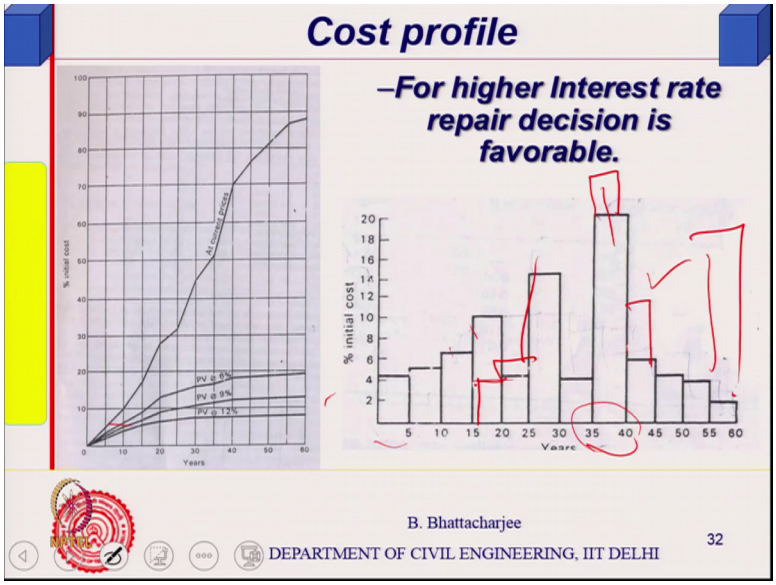

So, that is what it is maintenance cost profile. Now, for higher interest rate of yearly repair decision is favourable late repair and replacement decision is favourable. So, when you will do that and you plot a histogram form something like this percentage of initial cost 0 to 5 years you will find that the cost is less this is cumulative and this is histogram plot. So, you will find the peak come somewhere around 30 to 40 years because many things will require replacement at that point of time know. So, as time goes and then once you have replaced them again the maintenance cost will come down. So, there is a peak.

Now, if it is a single say for 50 meter by 50-meter square building then this would be the profile. But, if you have large number of such buildings, then what will happen? Then, basically all the buildings should not be constructed at the same time; like if you see this campus, as I said you know 1960s it is started and you will find that 60s, there are the main buildings came academic buildings and some quarters staff quarters came. Then, the blocks are added time to time block you know 3 4 5 etcetera. They were added time to time right. So, they were added time to time, but they are similar kind of buildings again.

If you see quarters they are also started time to time. Actually, they have been added similar kind of buildings, hostels. They have been added time to time. So, when you superimpose such maintenance profile you might find that actually they tend to even out sort of for many buildings constructed at different times, the peak should actually you know just let me go to the previous diagram.

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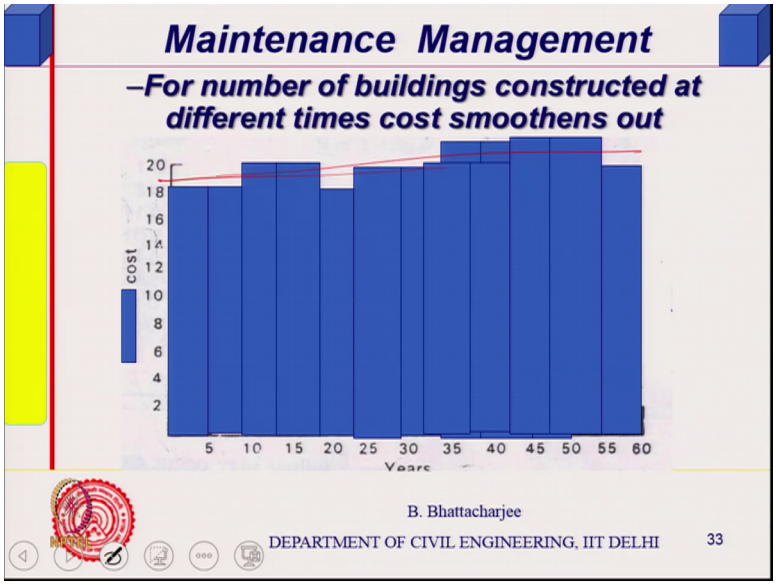

So, another set of building might have started somewhere here right started somewhere here and this peak would be somewhere there another set of building might have started somewhere there and the you know. So, if you have several such set of buildings started at different times in an estate, you will find that they tend to even out somewhere because the peaks will be occurring at different times. And if you sum them up superimpose one over another, you find that there is a tendency to actually kind of neutralize and balance.

So, your total maintenance cost of the estate you can estimate from this right, estimate from this and update it. Also, because you will add new buildings it will get updated, but then percentage cost you can find out if scientifically you can find out percentage cost you can find out right, there is another aspect of course, the other aspect that is there are another aspect is also there.

So, this is one aspect. When you have large number of buildings of the similar kind or not even of the similar kind, there is a tendency in an area estate area or let us say you

know some kind of a housing society where of course, buildings more or less starts together. But, there are 1 or 2 more than one housing society nearby by the same organisation you find that the overall maintenance cost tend to you know sort of uniform becomes a uniform over period of time. So, this is one reason why it becomes.

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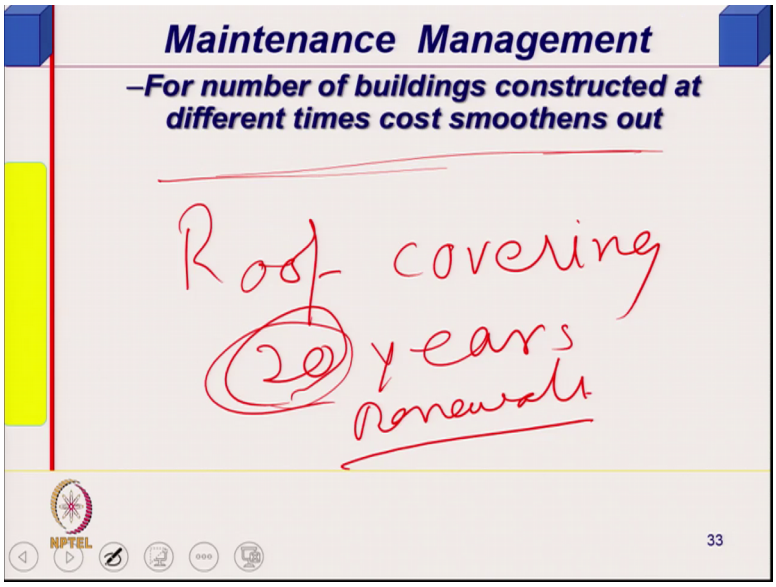

A second reason, why it becomes is second reason why it becomes is you see although we have said, let us say roof covering we said the renewal period is 20 years right. So, all the buildings suppose think as giving example of 7 hostels of the similar kind constructed almost similar time. Now, each one might even area of let us say something like 100-meter square of the rooftop right. So, if 700 meter square or something of that kind or you know something of that order let us say now it may. So, happen that renewal cycles I have estimated on the basis of my past experience.

Now, there is certain amount of uncertainty in this probabilistic because the you know it is depends upon the environment the rainfall and things like that actual variation in the materials of construction and the system. So, there is a kind of uncertainty involved that is it is probabilistic. So, on an average possibly 20 years of time most of the building should require renewal, but out of 700 meter square maybe one building requires you know out of 7 buildings or 8 buildings maybe one building by inspection you have seen that it requires complete renewal after 15 years.

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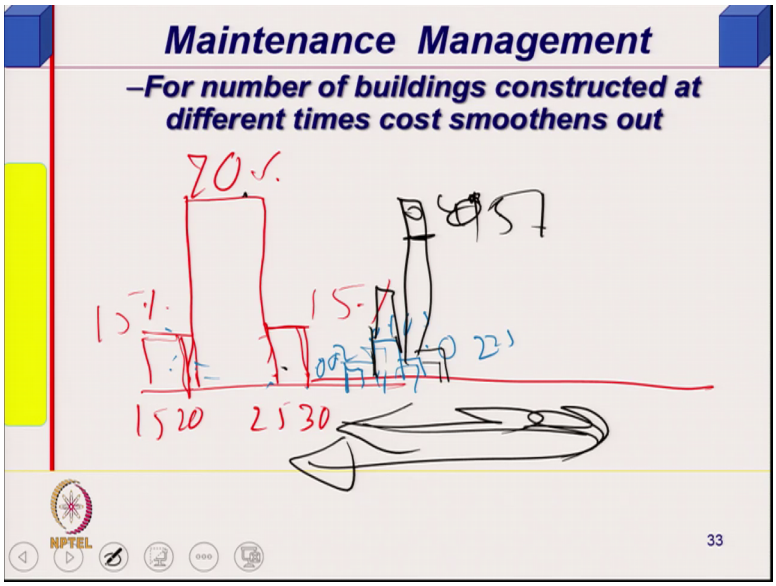

So, actually it would be distributed in this manner possibly you know something like. So, let us say one out of 7 is how much one 14 percent or 15 percent 15 percent and 70 percent possibly would need (Refer Time: 22:24). So, this is 15 to 20 years this is 25 years and 25 to 30 years. So, what if I find? When it is large number of building not 7 buildings are too small, when I have large number of buildings or it is a large organisation dealing with large number of buildings, there might be possibility there might be a probability that some 15 percent would require repair. Earlier, some 70 percent would possibly require as I estimated and another 15 percent will require later.

Now, what will be it is implication in the second cycle the one which are repaired here now right this would one which have repaired here now this should actually now 5 years 10 years 15 years 20 years. So, you know here it will get distributed here in this manner 70 percent of 15 percent. So, these after you know after 20 years most of it again would require repair, but it may. So, happen that 50 15 percent of it requires repair earlier a 15 percent repair earlier. So, this will be actually 0.15 percent of 15 percent.

So, that is the 0.025 225 0.02, 0.02 percent will be here 0.02 percent will be here and point one you know 105 percent will be 225. So, if you sum them up this will get distributed in this manner while this 70 percent will get distributed 70 percent will get distributed in some manner like this. You know, it is 15 percent of the 70 percent will

come here and 70 percent of the 70 percent will come here and there will be another small amount here and third one also.

So, you will find that in the next cycle it gets spreaded over a longer period of time with the peak going to 49, maybe 49 plus 0.002 and you know 51 percent or something like that instead of 71. So, it gets spreaded over a period of time. So, there is a uncertainty the probability is involved and that again tends to even out in case a large estate, but then this all presupposes that you will have a nearly inspection 5 yearly plan and yearly inspection.

In that case, you can find out that the cost of maintenance by enlarge would even out in a large estate over a period of time. It will even out or you know they will tend to remain similar, same does not have too much of fluctuation with certain percentage variation. You can do it what all why I am telling you, telling about all this because this allows us to do a planning of those maintenance works. Otherwise, it is very difficult and economize on the whole thing make it more efficient you can do planning.

While if you do ad hoc basis, just a complaint comes and you know you observe some problem or some complaint comes and then act on to it in that case it would be extremely costly because doing it time to time on an emergency basis is always costlier than doing it in bulk even though some case some things are really remain good. So, this is what is we call you know advantages of the maintenance profile and it can even out and you can plan right in the construction phase make a maintenance manual when one should do what and that kind of thing.

Now, another example; so, example of this repair cost being cheaper, then you know replacement cost being cheaper than repair cost I have given you roof covering there may be similar many other situation, but few one I will like to few one I would like to bring into your you know attention one of them is a lamp replacement.

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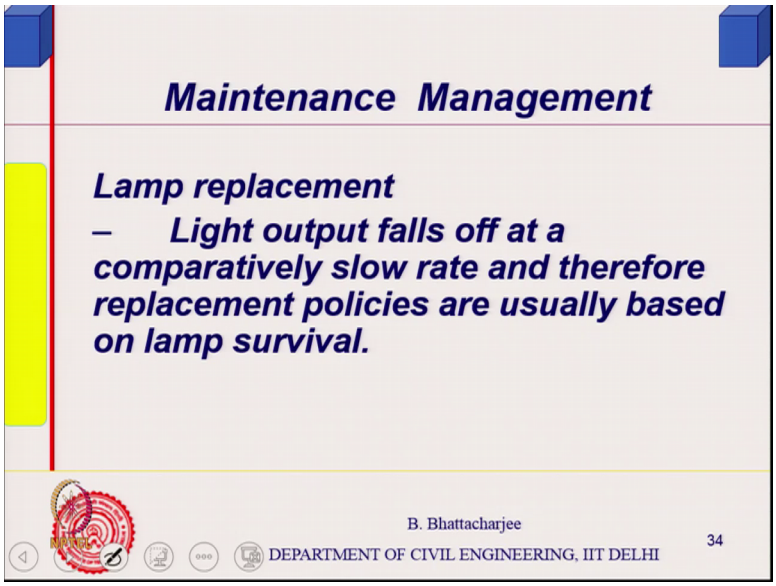

Now, this is done quite often in industrial buildings or it can be done even in it for example, it or similar hospital or similar sort of thing. Now, one thing 2 issues are there even modern lamps modern lamps CFL and LEDs they too will have similar kind of thing only thing their life is longer their life is longer the 2 things are important one is the output from the lamp output from the lamp. That means, the lumen output you know the light is measured in lumen light output is measured in lumen that is basically lumen is something synonyms to what actually, but much smaller value. So, lumen output means actual light energy output one is electrical consumption other is a lumen output.

So, for one-watt lumen output would be you know how much for example, earlier 40 watt should have something like 2250 lumen or something like that current ones might have for 15 watt it might be given or maybe 8 watt or you know something might be giving similar kind of lumen output. Now, this lumen output tends to falls reduce down with time, but at a small rate. So, that is not an issue at all that you know still lumen output will still be sufficient.

So, you to do not replace lamp on the basis of their lumen output, but what happens is if you look at a incandescent lamp they will start failing fusing out simply they will actually they will give up you know the wire the filament will break or something of that kind. Now, life of you know this lives are actually tested this lives generally tested. They do actually kind of an accelerated testing; that means, subject them to similar kind of

failure in higher voltage because after heat will come. So, one can do testing and find out the life.

So, what they do is they find out what is called mortality curve the mortality curve is with time how much percentage is failing. So, time versus percentage survival that is what is plotted that is called a mortality curve. So, based on that mortality curve one thing you will find that initially it does not fail much, but suddenly the rate of failure is very high.

So, in that case you do not do patch repair I mean one lamp has got bad change it no you might even find it economical to change 3 all the lamps, but now this time would be much higher because, it is now you know the life of CFL or LED lights are longer, you know lamps are longer. Earlier, much shorter period you do you have to do replacement maybe you will have to do it more.