Principles of Construction Management
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Lecture – 11
Economic Decision Making In Construction Projects

[FL] and welcome to this series of lectures on principles of construction management and today we will talk about Economic Decision Making in Construction Projects largely concentrating on time value of money. What we had done last time was to understand that in a construction project, the expenses as far as the contractors concerned are incurred throughout the project made been procurement of material, maybe it is in terms of hiring charges for equipment, maybe it is in terms of salaries of the people hired. The payment for those activities is received by the contractor at different points in time through running account bills.

This idea that expenses are being incurred over a period of time and there is revenue which is generated at different points in time. This requires us to understand what is called the Time value of money and that is what our focus in the discussion today will be.

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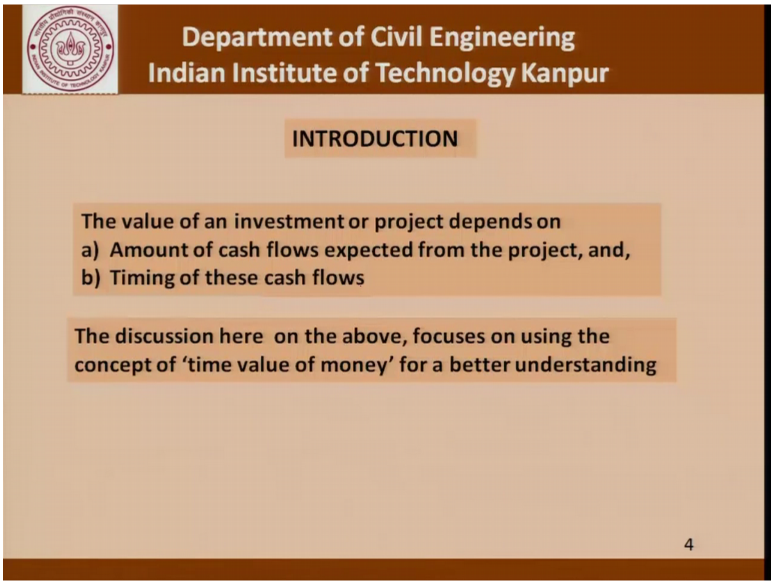

So, now to get started the value of an investment or project depends upon, the amount of cash flows expected from the project, and, timing of these cash flows. This is what we were trying to address when we said that for a given project the payment can be made all at once at the end of the project or installments as the project proceeds. What is the timing of these payments is what determines what is call the cash flow.

We must remember that cash flow from one party in the cash flow from the other party can be different. When I make a payment to someone it is an expense for me it goes out from my system, whereas it becomes a receipt for the other person who receives that payment, and now continuing the discussion here on the above focuses on using the concept of time value of money for a better understanding of decision making in construction projects.

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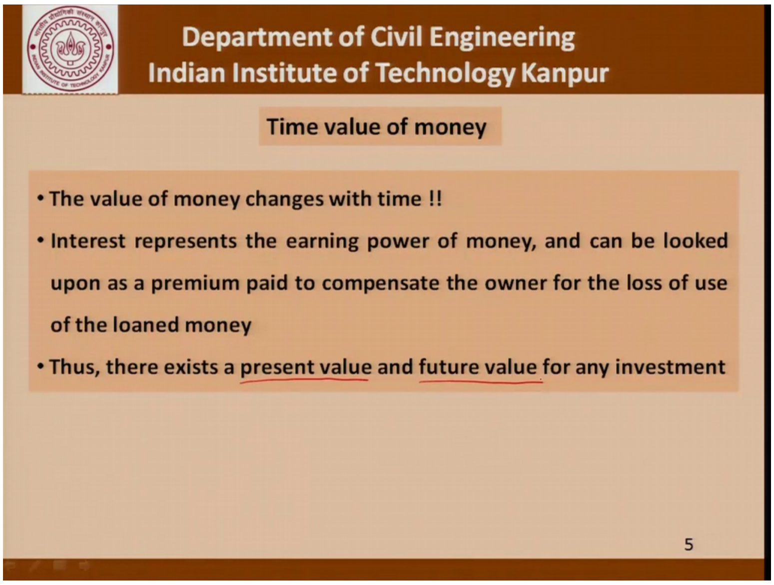

What is the time value of money, the value of money changes with time, what is a hundred rupees today may not be hundred rupees tomorrow, it would have gained some money, if there was an interest application. We are not in this discussion including the concept of inflation at all, where the values actually getting eroded on account of factors which are not governed by this concept of interests, we are largely concentrating on the concept of interest. What is the interest; interest basically represents the earning power of money and can be looked upon as a premium paid to compensate the owner for the loss of use of the loaned money.

When I keep hundred thousand rupees in the bank I get an interest of 3 percent, 4 percent whatever is the prevailing rate, because I forego the right to use that money at that point in time the bank; however, gives me 3 percent or 4 percent of an interest because with that money, it generates more money by giving out a loan to different investors. They are charged say 7 percent, 8 percent, 15 percent whatever it is by the bank. Therefore, they exists a present value and a future value for any investment. So, we can talk in terms of present value we can talk in terms of future value, in the discussion today we would largely concentrate on the concept from the point of view of present value.

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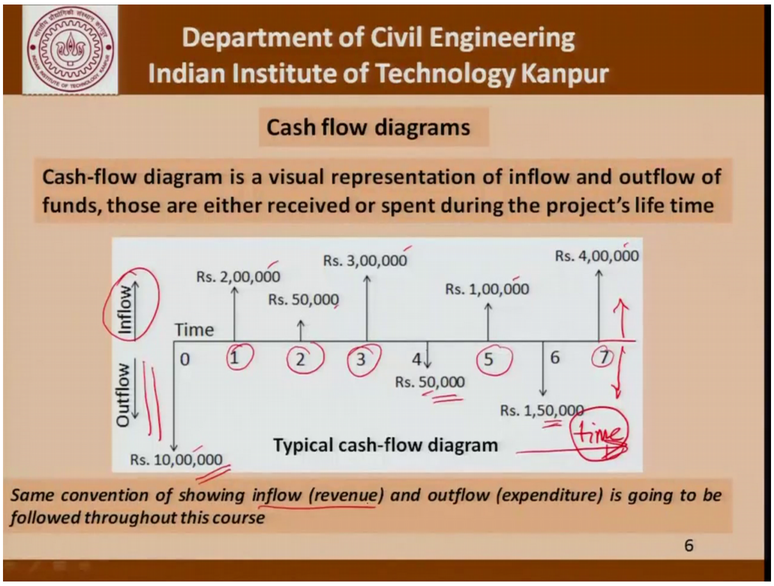

Let us look at Cash- flow diagrams which are basically a visual representation of inflow and outflow of funds, those that are either received or spent during the projects lifetime. What we are looking at let us say this is an example we plot on the x axis which is this line here time and plot the outflow of funds below this line here and the inflow of funds above this line. What it is showing is that there is an outflow of funds that occurs at 0.0 0. 4 and 0.6. Inflow of funds occurs at 0. 1 2 3 5 and 7 to be extent that the inflow is 2,50,000, 3,00,000, 1,00,000, and 4,00,000 and the outflow is 10,00,000, 50,000, and 1,50,000.

Now please remember that we will follow the same convention in terms of showing inflow which is revenue and outflow which is expenditure throughout this discussion today. Obviously, if this outflow is occurring here and this inflow is occurring here we really need to understand the concept of interest, and try to understand what is the present value of this 2,00,000 or this 3,00,000 or this 50,000 and so on. Similarly we must understand what is the present value for example, of this 50,000, 1, 50,000. On the other hand as I mentioned in a previous slide we can take all of these values here and try to find out what is their value at a future date and based on the present value or the future value we can determine whether this cash flow diagram or whether this investment which has this kind of an inflow and outflow is acceptable to us or not.

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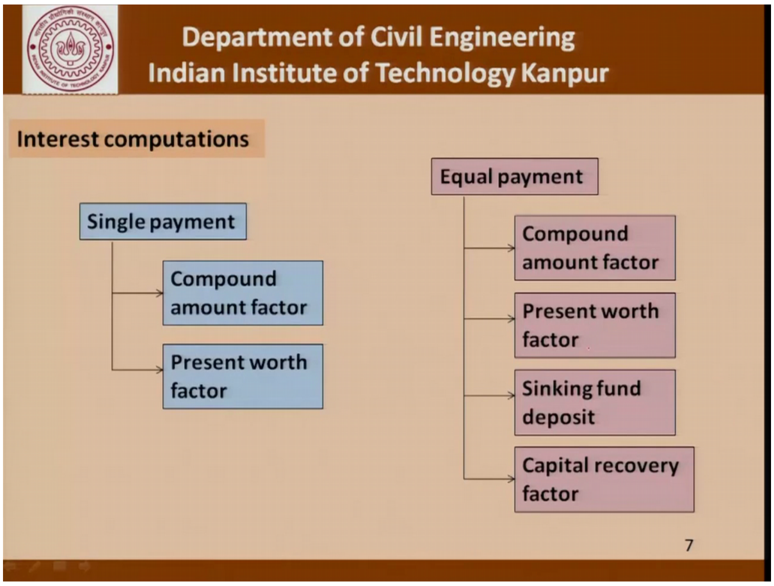

Let us move forward and try to understand how do we do interest computations. The basically 2 classifications that I have taken one is a single payment, where we talk in terms of a compound amount factor and a present worth factor and there is a system of equal payments, where we are talking about the compound amount factor, the present worth factor, the sinking fund deposit, the capital recovery factor and so, on.

These are very simple factors which can be determined from first principles, but instead of determining them from first principles all the time, there are tables which are readily made available to engineers who can immediately find a factor a number by which a certain income or an expenditure is multiplied to get the present worth and so on, and, so forth as we shall see in subsequent examples.

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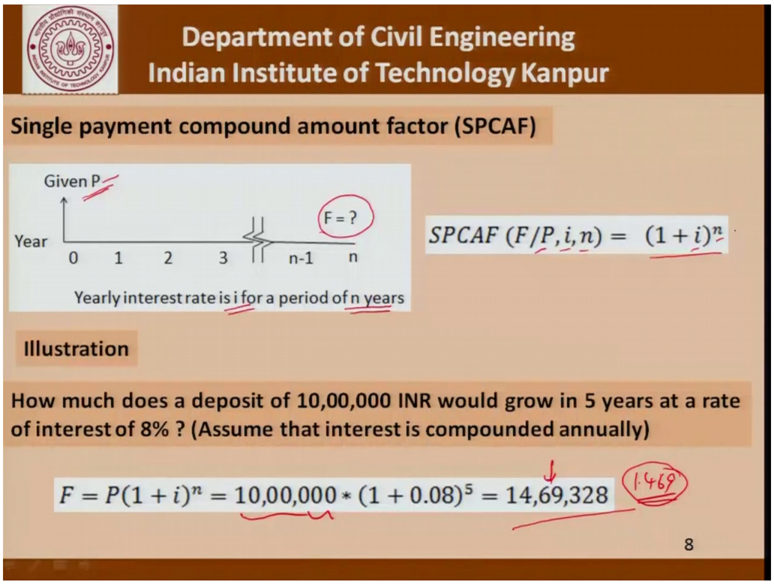

Coming to the single payment compound factor let us not bother, much about the nomenclature, but try to understand what is the physics and what is the principles involved. In this case here what we are saying is that given a principal P, a rate of interest i, for a period of n years, what is the final amount that is accruing. This is something which we know from our understanding of the whole concept of compound interest and we know that this is nothing but, 1 plus i, i to the power of n. In this course how we will read this particular situation is what is the F given P, i and n.

If we take our illustrative example how much does it deposit of 10,00,000 INR would grow into in 5 years at a rate of 8 percent compounded annually, if we use this formula we find the number to be 14,69,328. We now have a factor which could be 1.469 or something like that and this is what we multiplied by this amount here to get this value. So, what we have here is P is known to be 10, 00,000 the interest with the rate of interest is known to be 8 percent the n is 5 years and we find this growth in the investment made.

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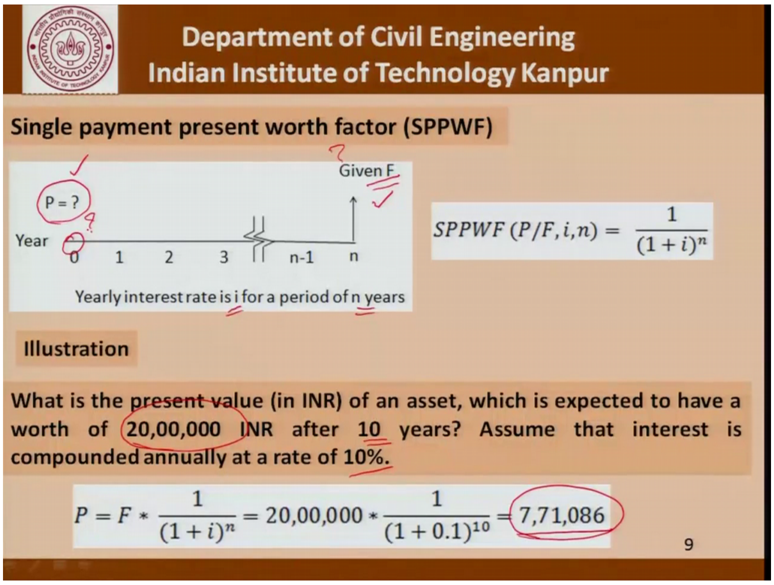

Similarly, a single payment present worth factor represents what is the P if we want an F for a given i and an n. So, like last time this single payment present worth factor is represented as one upon 1 plus I, to the power n which is just the reciprocal of the previous discussion and the illustrative example which I can give you is, what is the present value in INR of the Indian rupees of an asset, which is expected to have a worth of 20, 00,000 INR after 10 years assuming that the interest is compounded annually at the rate of 10 percent.

If we do that and use this given formula we find the number to be 7, 71,086, basically what we are saying is that, if we have this amount of money here. It will grow to an amount of money which is required at the end of a given period of time if we assume a certain rate of interest. In these 2 cases in one case we have this value known to us and we find this value whereas, in the present slide what we are showing is we are given this value and we are trying to find out how much we should have in hand today. So, that it grows to that required amount of money at a certain point in time later on.

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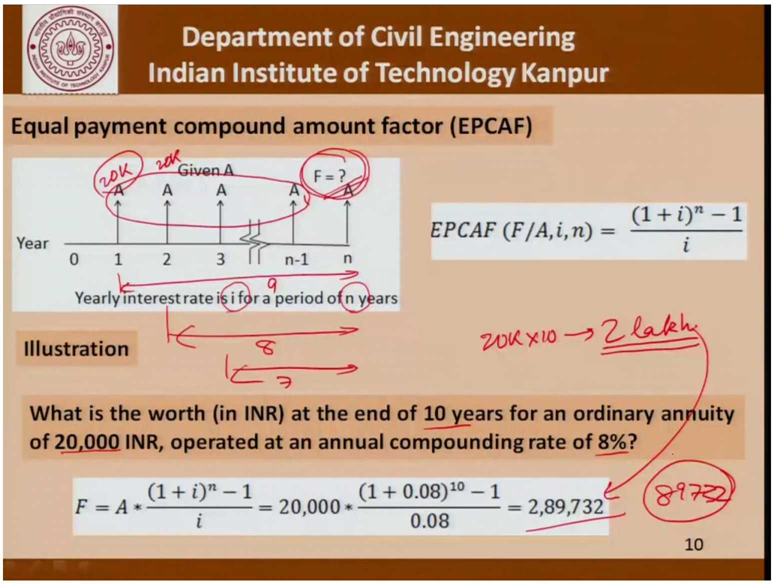

Now coming to those more distributed investments let us talk about the equal payment compound amount factor, which basically says that if we keep depositing or setting aside an amount A for a period of n years, at the rate of interest i, what would be the final F. This is what is the equation which turns out to be, we are not deriving these equations you can derive those equations from first principles I am leaving that out as an illustrative example let us talk in terms of what is the worth in rupees at the end of 10 years for an ordinary annuity of 20,000 INR operated at an annual compounding rate of 8 percent.

What we are saying is that really set aside 20,000 every year for a period of 10 years and if the rate of interest is 8 percent what would this final amount be. If we operate this equation we find that the amount is 2.89,000. If we look at our investment directly what we are doing is we are investing 20,000 for 10 years which is basically we are investing 2, 00,000. Now this 2,00,000 is going to 2.89 because this 20,000 is earning an interest for 9 years, the next 20,000 is earning an interest for 8 years this one is for 7 years and so, on and this total interest is 89,732.

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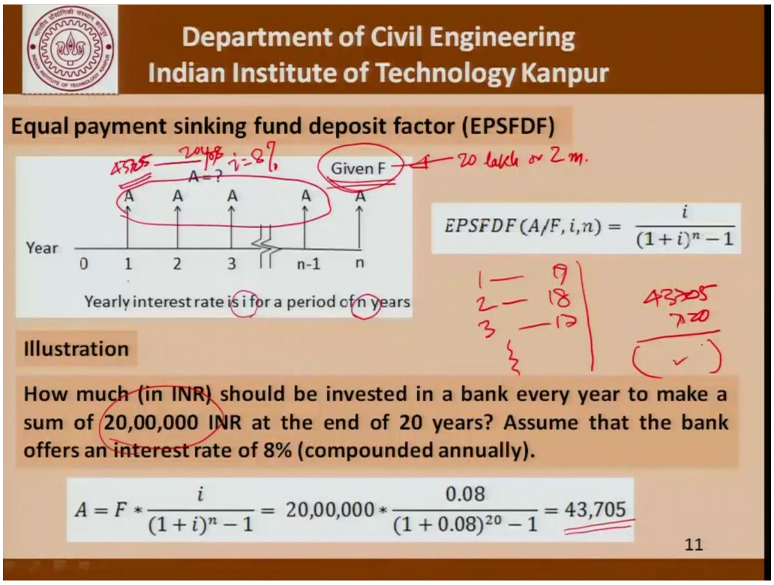

This is the way to look at an equal payment compound amount factor, continuing with our discussion there is an equal payment sinking fund deposit factor and like I said it is not bother about the nomenclature what we should understand is the principle involved. How is the cash flow being modeled and how to calculate the present value or the future value of that particular investment? So, coming to this factor here what it says is that, if we want a certain amount at the end then what should we being setting aside every year for n years at rate of interest of i.

That is what the question is that how much should be invested in a bank every year to make a sum of 20, 00,000 at the end of 20 years assuming that the bank offers an interest of 8 percent compounded annually. If we do this the answer is 43,705, if we keep setting aside 43,705 for 20 years and the rate of interest applicable is 8 percent compounded annually the amount payable to us at the end will be 20,00,000 or 2 million. This again is the same idea where this first investment earns an interest for 19 years, the second investment earns for 18 years, third investment earns for 17 years and so on, and the total interest that we get is actually the difference of 43,705 multiplied by 20 with respect to the 20 00,000 that we are getting.

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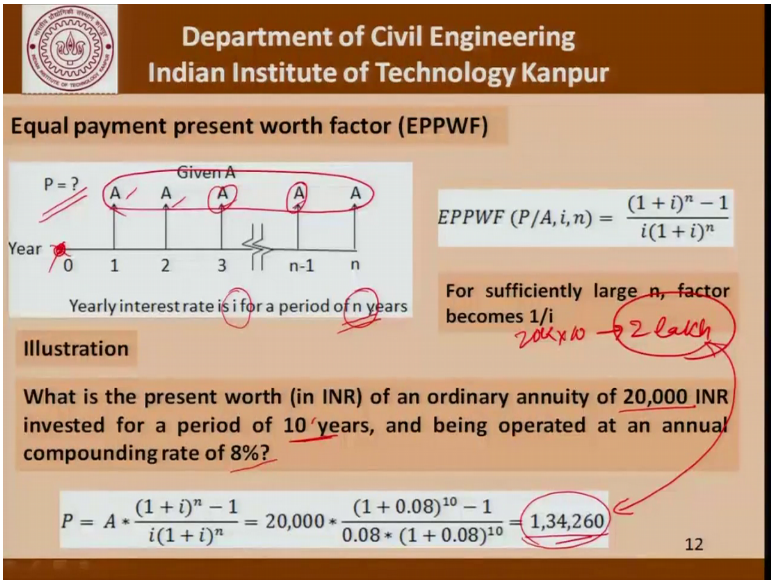

We are investing surely a lesser amount of money here and leaving it to you compute that and the final amount that we get. There is another very interesting and a very important factor, call the equal payment present worth factor, which basically something like this, that if we make this investment for n years every year at a rate of interest what is the present worth of that entire investment.

We would be investing an amount A over a long period of time and the present worth of all these as would be different because they would have different periods of time where the lock in is occurring and that can be determined using this formula and as an illustrative example let us say that what is the present worth of an ordinary annuity of 20,000 invested for a period of 10 years, being operated at an annual compounding rate of 8 percent.

If these were the conditions being applied the present worth of this investment is 1,34,260, now please see the difference we are talking of the present worth being 1,34,260 for a total amount which is 20,000 and 10 years which would make it let us say 2,00,000. The difference between 2, 00,000 and 1.34 lakhs is arising because that 1. 3 4 is the present worth of this entire investment, which is being distributed over a period of 10 years. I would also like to mention that for sufficiently large n the factor becomes 1 upon i, that is if the investment continues for a long period of time then the factor can be taken to be 1 upon i as a thumb rule.

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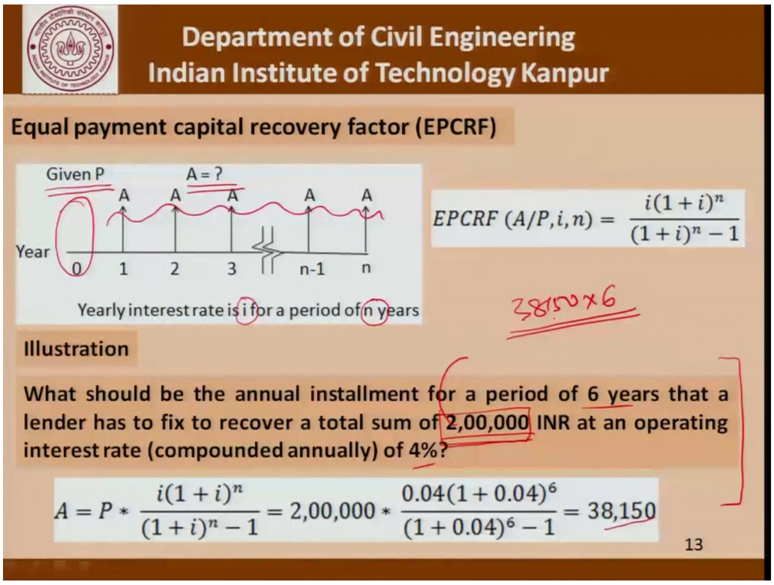

Now equal payment capital recovery factor which is EPCRF again not bothering about the nomenclature what we are talking about is given a P, what should be the A for n years, at a rate of interest of i and this is the formula which comes out of this and illustrative example would be what should be the annual installment for a period of 6 years that the lender has to fix to recover a total amount of 200,000, at an operating interest compounded annually for 4 percent. If there is a 2, 00,000 which is occurring here what should be the annual installment, which is to be taken in this case it turns out to be 38,150.

What does being said is that 2,00,000, if it has to be recovered in a manner that the rate of interest is 4 percent and the period of recovery is 6 years, then the installment should be 38,150. So, effectively what is been paid is 38,150 multiplied by 6 and what was lent was 2, 00,000. The difference between these 2 is effectively the interest component, what I would like to leave you as a thought would be they try to do it on a spreadsheet and try to find out that if there was a loan which was taken and an interest at any rate accrues in the first year, or the second year and so on and so, forth. Then if a certain amount of money is returned to the lender, whether that money should be going towards servicing the interest or it should service the capital or it should be both.

Depending on this exercise there would be some very interesting results that you would see and in fact, that is the kind of thought process which we have when we talk in terms of soft loans banks try to induce people to take loans by playing with this distribution of the servicing. What we are doing here is what I am leaving to you to find out as far as how this particular 38,150, whether it is going towards the payment of the interests or whether it is going towards the payment of the capital those are things which I am leaving out from the discussion at present because of the simple reason that this is not a course an economics. We are trying to just show you different parts of a construction management course where we are trying to explain to you or get you interested in what it entails to be a construction manager.

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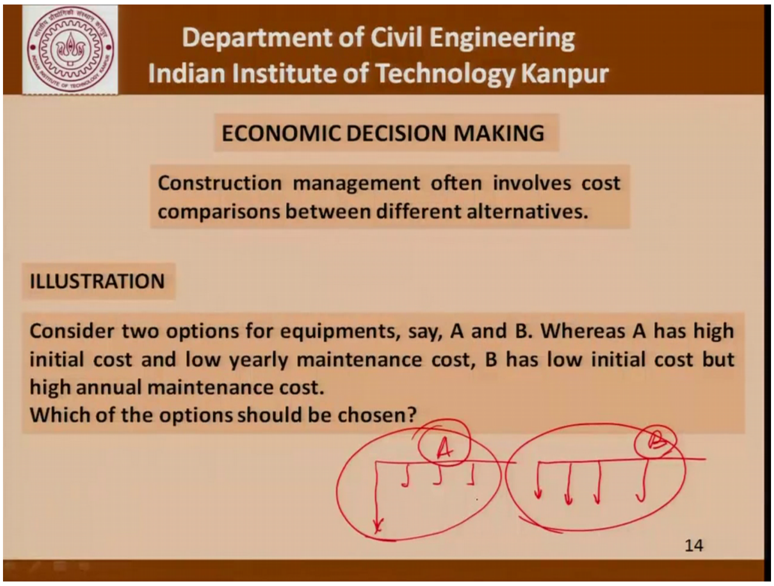

So, going forward let us talk of Economic Decision Making now, construction management involves cost comparisons between different alternatives and this very commonly happens, when we are trying to buy an equipment which has different capital cost and they may have different maintenance costs as an illustrative example consider 2 options of equipment let us say A and B, were A has a high initial cost and low yearly maintenance, but B has a low initial cost what high and we will maintenance.

What we are looking at as far as option A is concerned this outflow is very high, but subsequently this is lower whereas, in case of B if this was AB this is lower, but these are it is a higher. So, how do we compare this option with this option this can easily be done if we follow some of the principles that we have discussed so, far.

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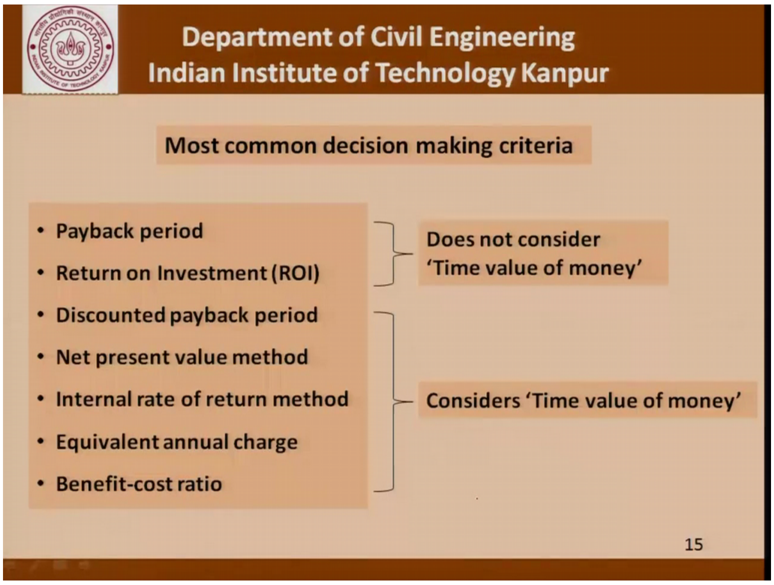

This slide list some of the common decision making criteria, the Playback period, the Return on Investment, Discounted payback, Net present value, Internal rate of return, Equivalent annual charge, in the cost benefit ratio. These 2 do not consider the Time value of money, but these 4 consider the Time value of money. In our discussion today we would not touch upon the Return on Investment and the Equivalent annual charge and cost benefit ratio, but we will talk about other things.

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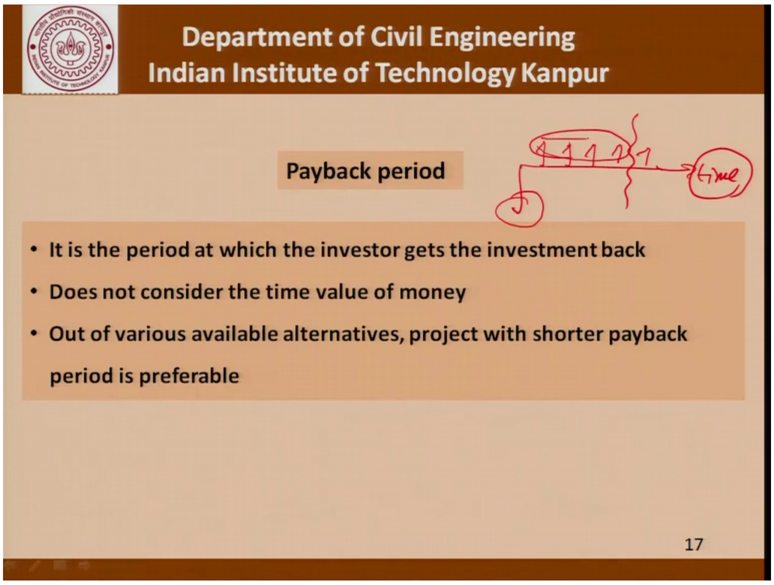

The first thing that we need to talk about is the Payback period, now it is the period at which the investor gets the investment back and as we mentioned in the previous slide this does not consider the time value of money and therefore, out of the various alternatives a project or an investment with shorter payback period is preferable. What we are saying is that if we make an investment today and we keep getting something out of this at what point in time this is our time axis. At what point in time this amount here becomes equal to the sum of these amounts here. So, that is my Payback period and since we are not talking of the time value of money we can simply algebraically sum these revenues.

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As an example let us consider 2 alternatives A and B, the initial investments for both projects are estimated to be 50,000. Option A is estimated to give 10,000 in the first year, 20,000 in the second year and 15,000 in the next 4 years, whereas, Option B gives you 10,000 for all the 6 years which is a better alternative.

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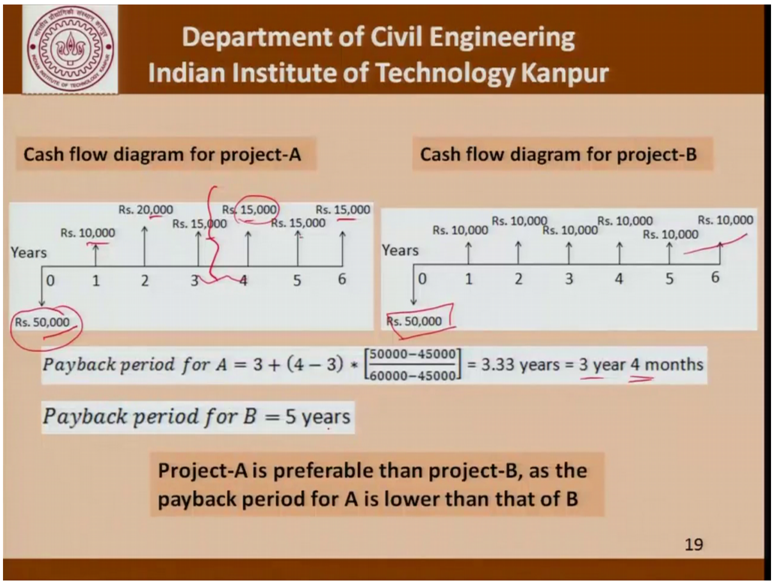

So, for that we simply draw the Cash flow diagram for A which is 50,000 of an investment 10,000, 20,000, 15,000, 15,000, 15,000 and 15,000, whereas, for option B it is 10,000 for all the 6 years. What is the period, in which this 50000 is being recovered in the 2 cases, the payback period for A is 3 years and 4 months because 3 years gives you a recovery of 10 and 15, 25 and 20 is 45 and all that you need to recover is 5,000 out of this 15,000 assuming that it is happening linearly it is one - third of that year which is 4 months. In the case of B the situation is simple it is 10,000 for every year and therefore, the payback period is 5 years. Which of them is better project A is preferable than B as the payback period for A is lower than that of B.

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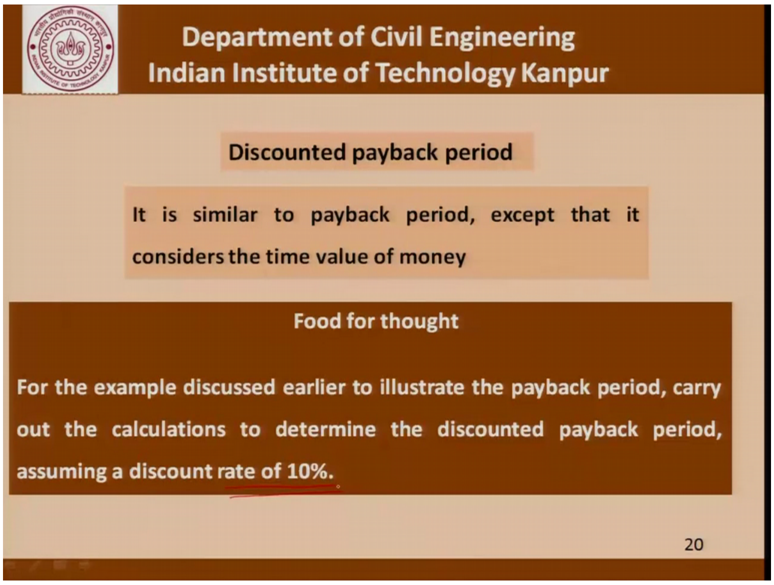

Let us talk in terms of a Discounted payback period it is similar to the Payback period except that it considers the time value of money and that is something which I am leaving out of the discussion today, I am not taking it up for solution I will leave it to you to find out the payback periods assuming that the discount rate is 10 percent.

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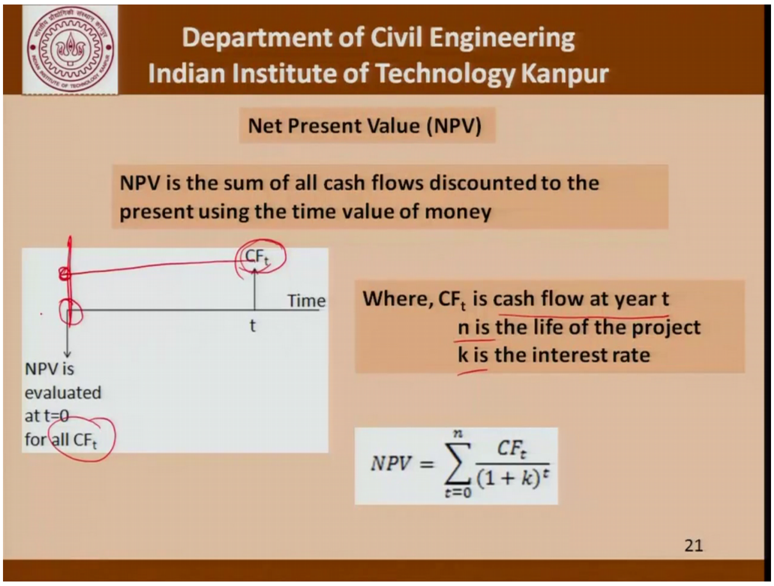

Let us talk about the Net Present Value the NPV, now this is the sum of all cash flows discounted to the present, using the concept of time value of money. Let us try to see what happens, what we are doing is for all the CFt, the CFt is the cash flow at year t, n is the life of the project; k is the interest rate for all the CFt that occurs. We bring all of this down to a value at present that is what I said that in this discussion today we would concentrate on the present value. We can do the same exercise for the future value as well, but once we understand how to would present value we can easily do it for the future value as well.

NPV mathematically is represented like this.

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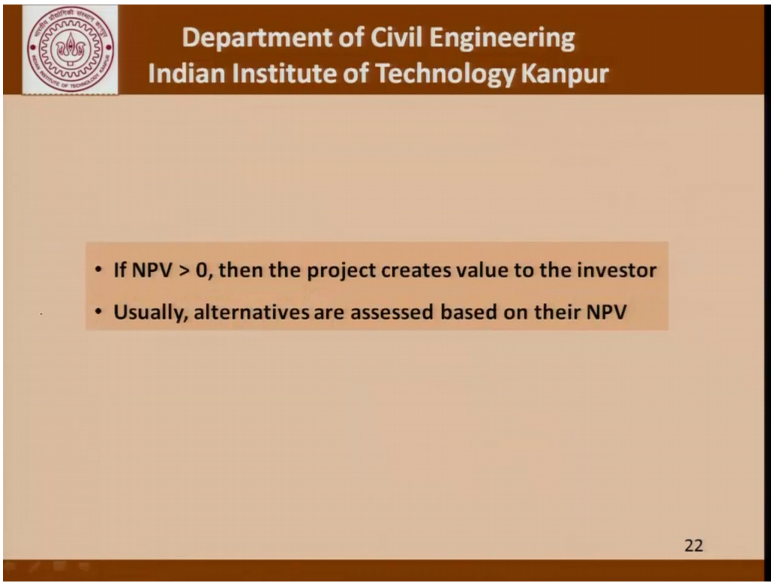

And if the NPV is greater than 0, then the project creates a value to the investor and usually alternatives can be assessed based on their NPV and that is try to understand the importance of time value of money in cash flows.

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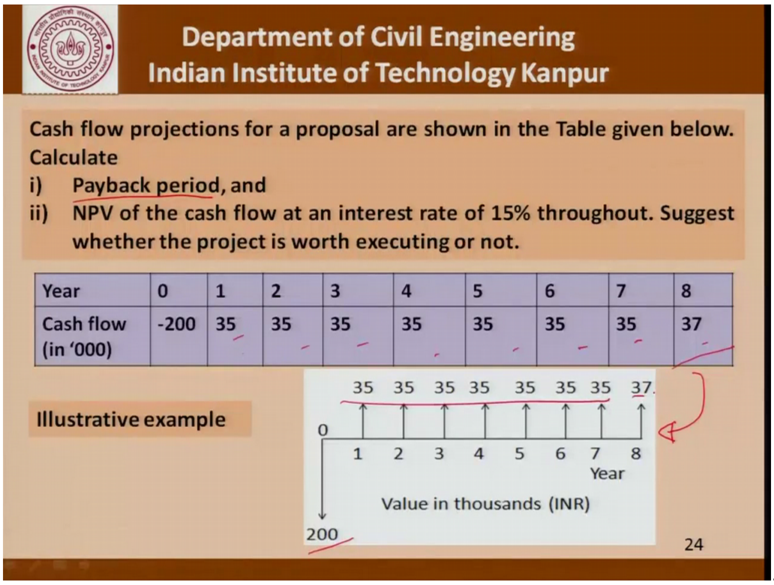

Let us take an illustrative example where there is a table which shows you the different cash flow parameters, it gives you a cash flow of minus 200 initially and then a positive cash flow for 7 years and for the eighth year the cash flow is a positive 37 and what we are ask to do is to calculate the payback period and the NPV of cash flow at an interest of 15 percent throughout. We have to find out whether the project is worth executing or not we have to basically find out what is the NPV, whether it is greater than 0 less than 0 by how much and so on and so, forth.

If we translate this information given in the table to a cash flow diagram this is what we are looking at, we are look at 200,000 going out and 35 coming in for 7 years and 37 coming in the 8 year.

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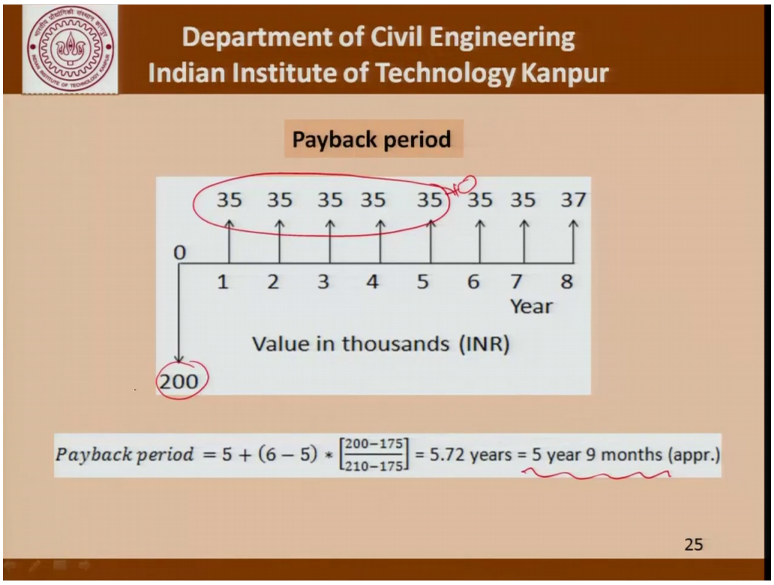

With this if you simply calculate the payback value, without considering the time value of money and that is what is the definition of the payback period we find that the period is 5 years and 9 months. So, in 5 years and 9 months this plus something would total to 200.

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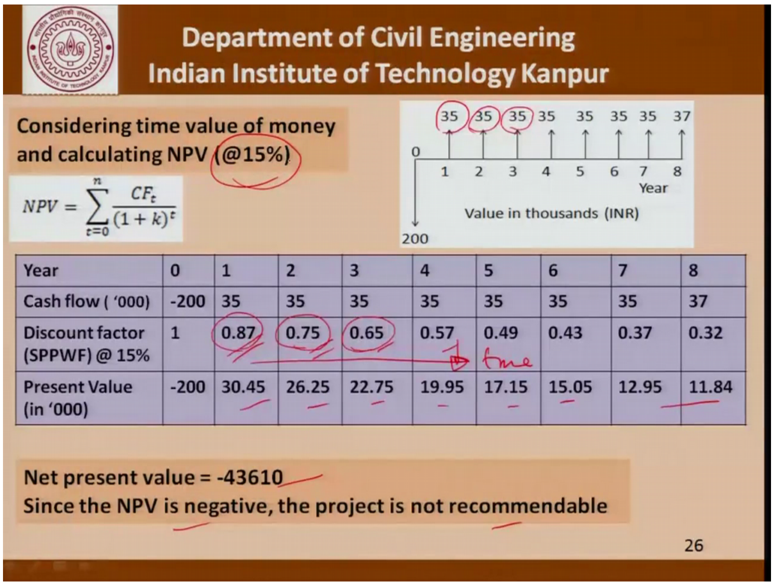

Now, moving to the next part of the problem which is to calculate the NPV using the time value of money at the rate of 15 percent for this diagram we have these discounted factors for each year.

Each of these numbers here gets multiplied by these factors that these factors are reducing as time goes on, because these amounts of money are available to us for longer periods of time. If we sum up all these numbers here we get the net NPV which turns out to be minus 43,610 and since it is negative the project is not recommended; now this is not recommended at the rate of 15 percent. If this rate of interest was to change how was the situation change and that is something we can always do a simple exercise, haven done this exercise at 15 percent.

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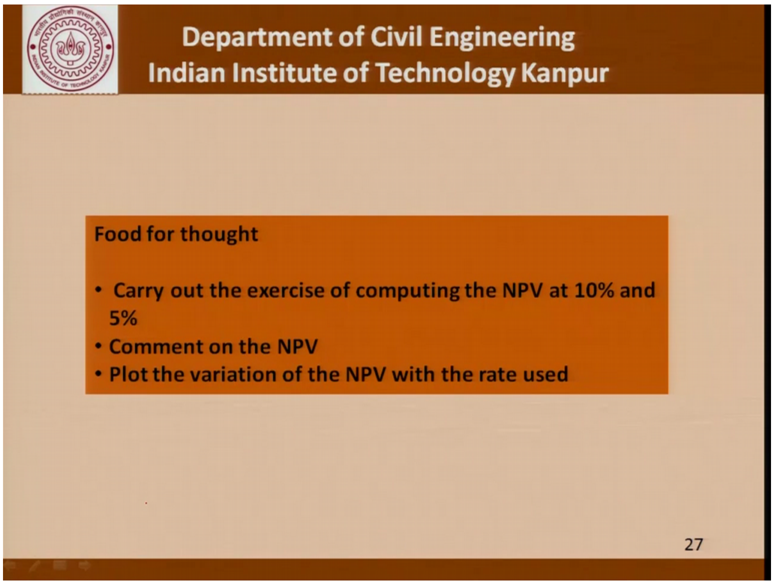

What I am asking you to do is to carry out the exercise of computing a NPV at 10 percent and 5 percent, you will find that the NPV; obviously, changes try to see how it changes and then plot the variation of the net present worth the NPV with the rate of interest that you have used and what you will find is you will be able to determine what is called the Internal Rate of Return which is IRR.

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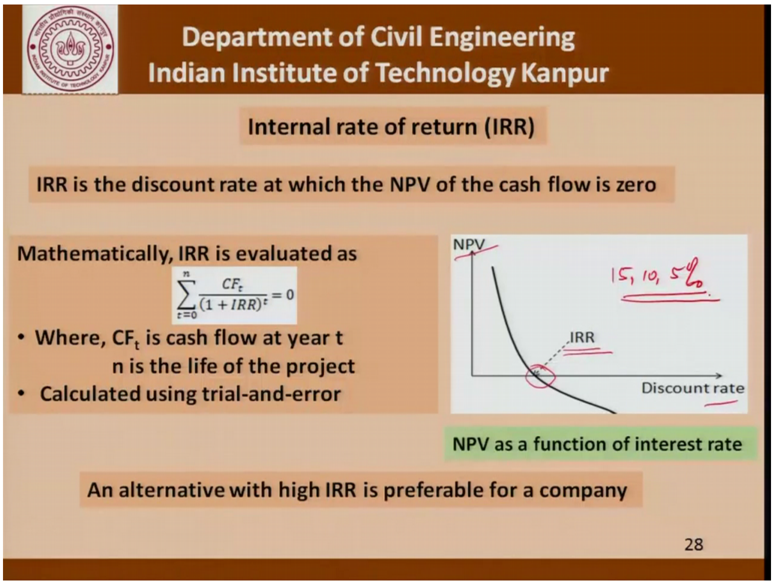

Now let us see what IRR is, it is the discount rate at which the NPV of the cash flow is 0 effectively what it means is we are looking at a situation it, if NPV is plotted against the discount rate there will be a point of intersection like this and that is what will be the IRR or the internal rate of return and that is what I am asking you to plot once you plot the example for 15 percent 10 percent and 5 percent I think you should be able to find out the internal rate of returns for the example that we are working on and an alternative with a higher IRR is preferred for an investment.

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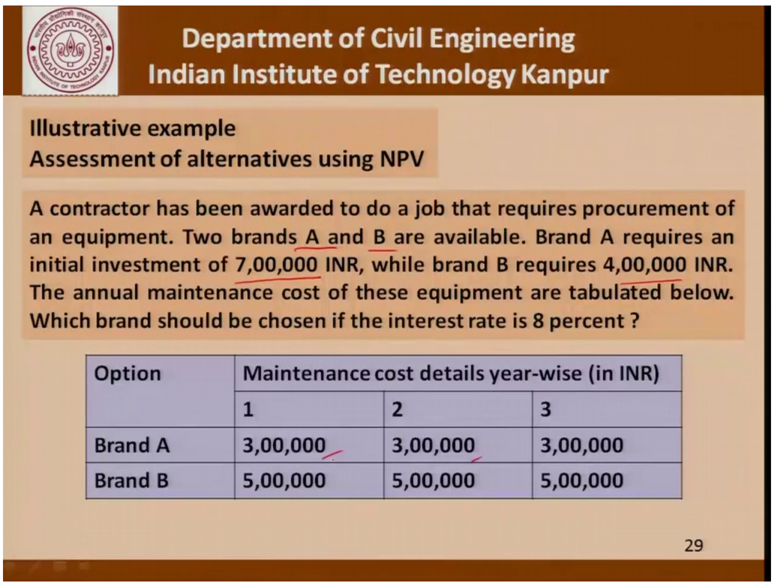

If we talk in terms of how to make a choice between alternatives using NPV let us try to look at an example where there are 2 brands of equipment A and B, which cost differently there is an initial investment of 7, 00,000 in one case and 4, 00,000 in another and the annual maintenance cost of these 2 equipment are given here for A and B. A has a maintenance cost of 3, 00,000 every year whereas, B has the maintenance cost of 5, 00,000 which of these equipments should be chosen.

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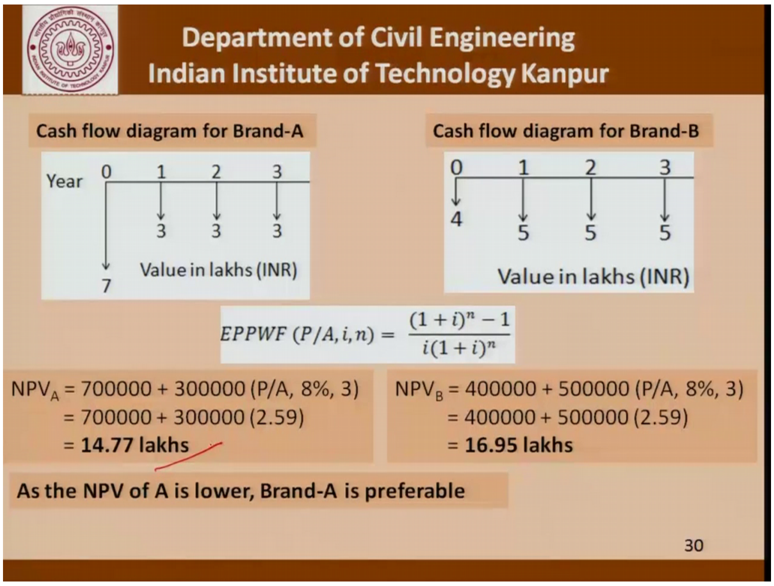

If we look at the cash flow diagram for A this is the representation similarly for B the representation is given like this and using this equation that we already talked about the Net Present Value for A is 14.77 lakhs whereas, for B it is 16.95 lakhs. So, given these 2 NPV s the NPV of A is lower and therefore, is preferred. This is how we have used the time value of money and the Net Present Value kind of concepts to find out which of the alternatives makes more sense.

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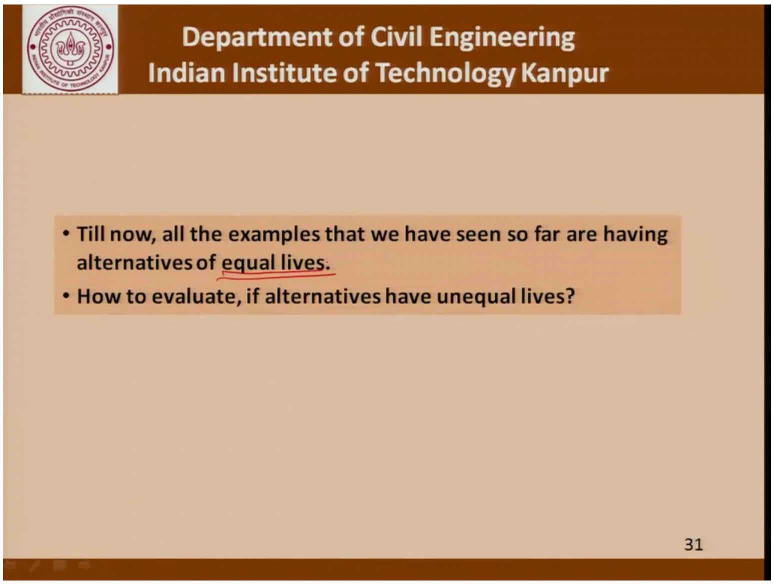

However till now, we have taken examples in a manner that they had equal lives. So, for example, what we are talking about just now was in both cases we are talking of 3 years was the service life of the equipment, but of course, there is always the possibility that the alternatives may not have equal lives, they may not have equal maintenance cost at different points in time, but those are things which we can incorporate in a thought process fairly easily and evaluating alternatives with unequal lives in most situations the alternatives do not have equal lives and to be fair with the ranking process of alternatives the life should be modified.

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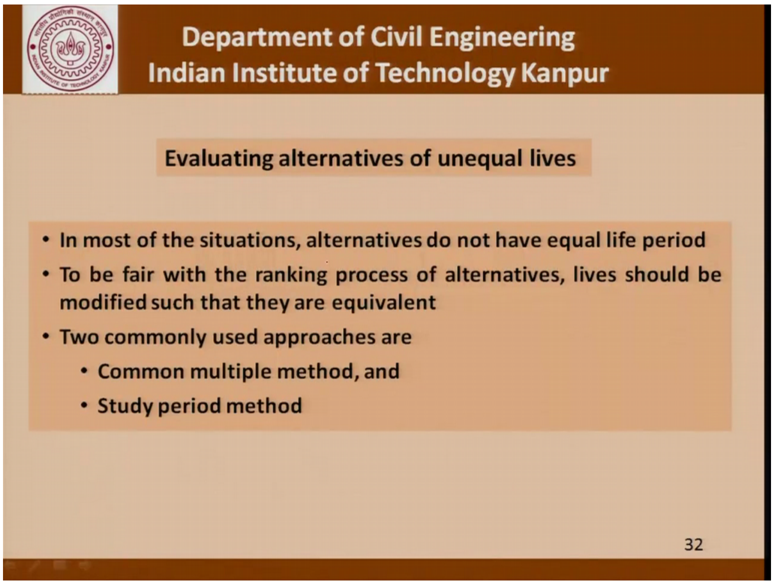

Such that they become equivalent the that is the only way to be able to make a fair comparison. The 2 commonly used approaches are Common multiple method and a Study period method.

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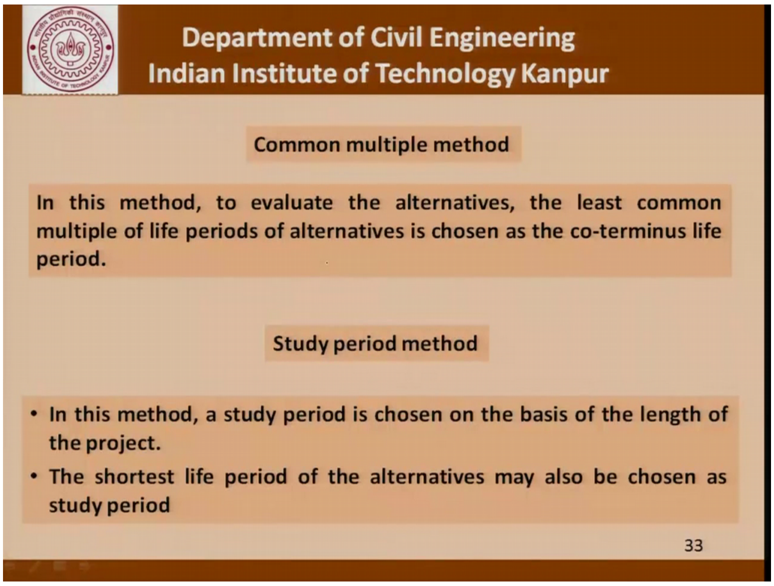

What these approaches really mean is that in the Common multiple method we evaluate the alternatives the least common multiple of life periods of alternatives is chosen as the co terminus life period. So, what we are saying for example, if there is an equipment which has a service life of 3 years and another one which has a service life of 4 years. We can say that over a period of 12 years we will need 4 replacements for this and 3 placements for this and then try to do the exercise that we have carried out just now and we will have an answer to our question as to whether equipment A or B should be preferred. So, what happens in the study period method is given here and with this we come to an end of our discussion.

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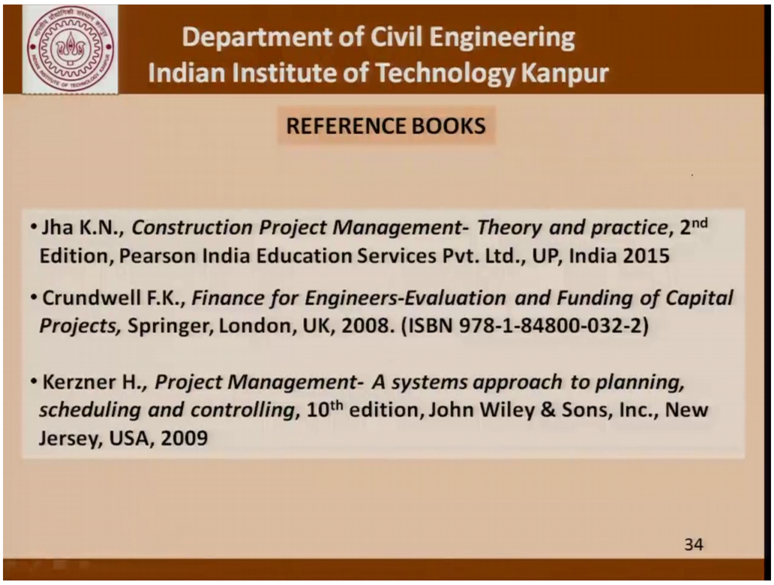

Today the references like one by K N Jha, F K Crundwell and H Kerzner would probably help you understand the concepts that we have gone over and with this we come to an end of the discussion.

Thank you.