Sustainable Materials and Green Buildings

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Lecture 13

Alternative fuel for cement and embodied energy

We will continue form the where we stop. We said that we look in to that alternative fuel. The small calculation we did we will re-look into it. Last class when we finished we just doing that.

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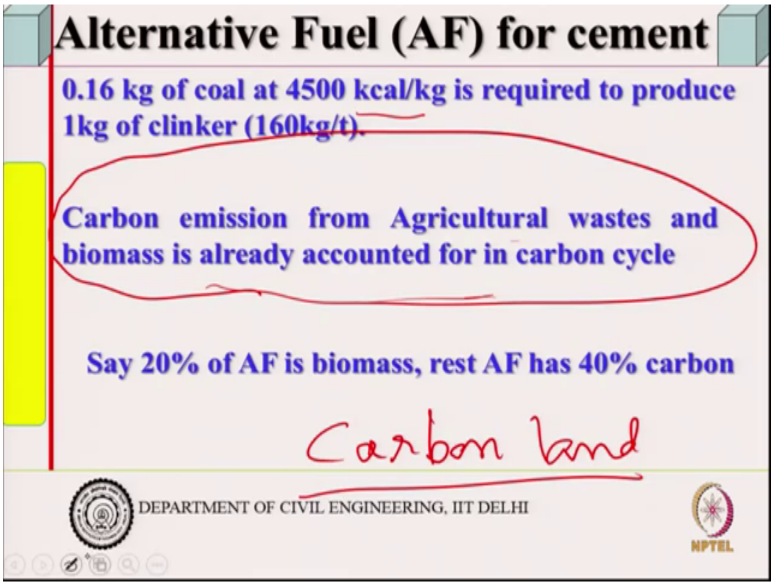

So, first thing is carbon emission from alternative fuel, if you are using agricultural wastes and, biomass. Than it is already been taking in to your account how? Because this agricultural waste would need or need additional land for carbon di oxide capture. Since, when we can calculate it carbon land if you remember. There is land require to absorb this carbon dioxide. So, you will have to have plantations. Which will absorb those carbon dioxide so, that is the carbon. So, the agricultural waste they would go into the ground mother earth and in future they would have got combated in carbon or, coal or, whatever it is in some form of fossil fuel.

So, therefore this is this is not accounted for in calculation of carbon emission calculation from fuel. While fossil fuel if you are taking extracting out there is a coal from the ground or, you are extracting say crude from underground. Then that will add additional to carbo dioxide to the atmosphere. While this one will go down and possibly they will go down in an accounting we just do not take them. So, they are the kind of future coal or future fossil fuel that you are using now. Because write of the strait forward of the time we are using so, additional is not required for that so, that is what it is. Now, supposing I have a, like 0.16 kg of coal at this is require to produce 1 kg of clinker. So, in that case 160 kg so, 0.16 kg is require to produce 1 kg of clinker.

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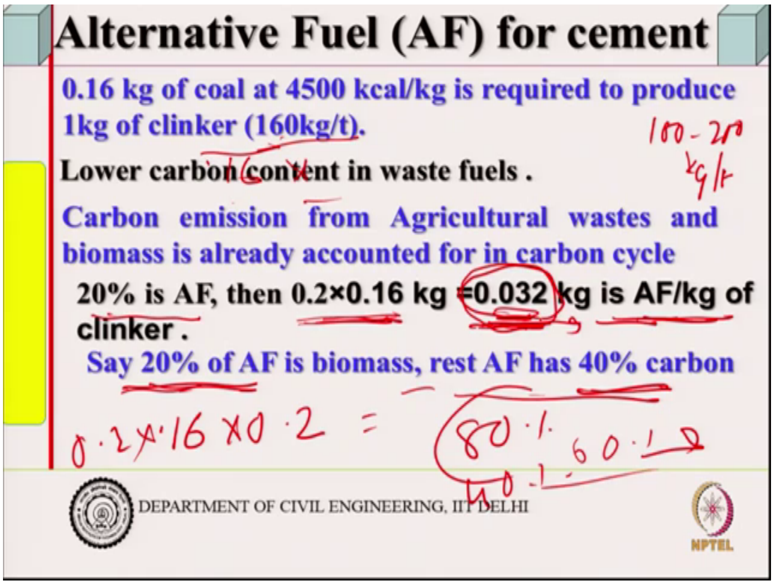

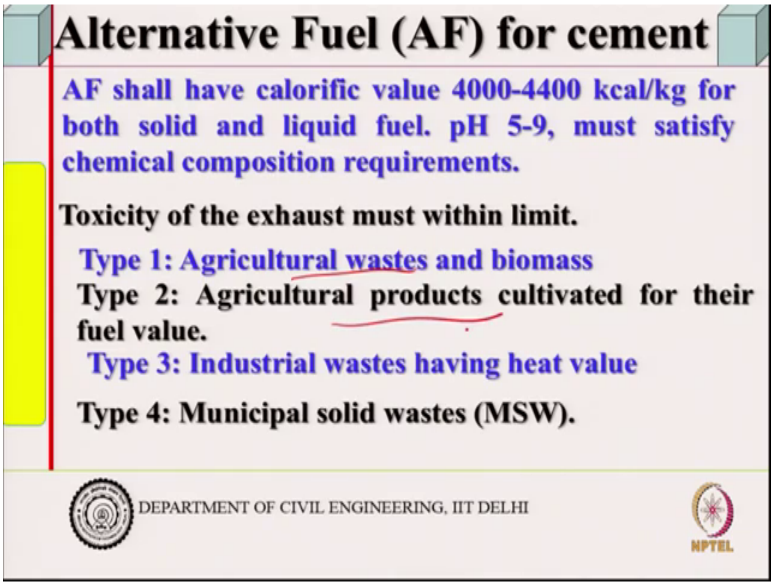

Now, there is 160 kg per ton. Because you said 100 to 200 you remember that we need kg per ton we need for production of clinker. This needed we have taken 160 kg now, for 1 kg therefore 0.16 kg will be require 160 divided by thousand. So, this is we want to find out basically how much is a saving in the carbon dioxide carbon from the fossil fuel part.

So, this one just out of this let us say 0.16 kg is what I need for 1 kg of cement, 20 percent i am using is alternative fuel. Than this is your biomass plastic waste everything put together, biomass, plastic waste or, paints waste. And i just said mentioned a couple of class earlier that, this are the kind of agricultural waste, agricultural product industrial all this municipal solid waste all that. So, industrial product and all that and out of this 20 percent i am using this alternating fuel. So, 0.16 into 0.2. So, this how much it is this is what i will be using this much amount i will be using alternating fuel 20 percent i am saying is biomass.

Sorry i am using yes say out of this just now supposing I am using 20 percent so this kg of alternative fuel per kg of clinker. Now out of this 032, let us say 20 percent is alternate fuel from biomass and rest has 40 percent carbon. Only agricultural waste and biomass you are not accounting. But, if you are using plastics or something of that can that, will go into accounting. Because, this will not get converted into anything else coal in future or something of that kind.

So, this will go in accounting so, let us say out of this 20 percent is an alternating fuel and, rest 80 percent has got 40 percent carbon. 60 percent is something else 60 percent is something else which might oxides etc etc nitrogen or whatever it is some might give energy and totally it is giving 160. So, 80 out of this 80 percent 60 percent do not give carbon 40 percent is carbon, 40 percent is carbon. So, 20 percent of 032 let us calculate now you can calculate out so another point 0.2. That i need not account for because, i said if it is biomass. So, total fuel require is 160 kg per ton for 1 kg I need 0.16.

And out this 20 percent is alternating fuel alternate fuel. So, alternative fuel basically. So, this is 20 into this much kg of alternating fuel per kg of clinker. Alternating fuel per kg of clinker. Now, out of this again 80 percent is not biomass or agricultural waste 20 percent is biomass. So this 20 percent will not go in by carbonic accounting. So, this is the alternative fuel 80 percent of this has got 40 percent carbon.

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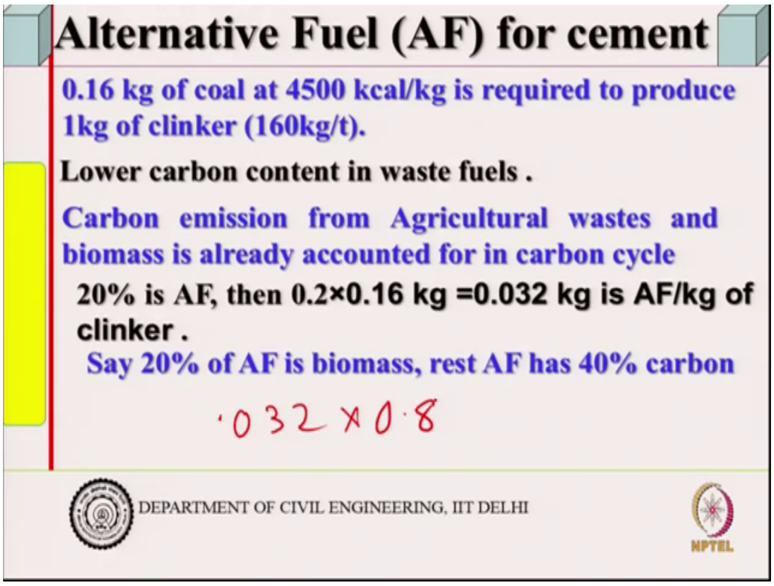

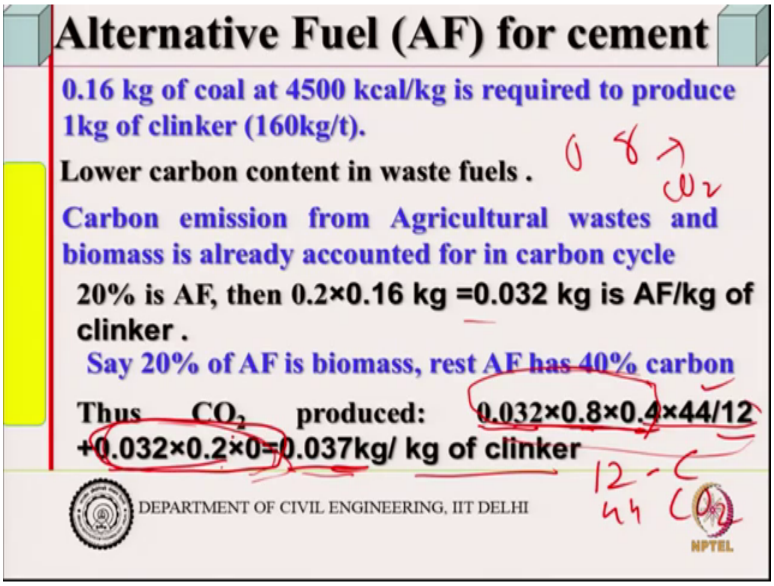

So, 80.8 this is multiply by 0.8 this multiplied by 0.8, 0.032 multiplied by 0.8 is an alternative fuel which i must consider for carbon. But is has got 40 percent carbon so, again multiply it by this and that will go in accounting. So, you can see how much is saving. So, see that is what I am saying. So, 0.032 into 0.8 into 0.4 this is the carbon it will produce carbon contents c contents straight. Now, you need c produces 44 I mean 12C produces 44 carbon dioxide. So, 12C produces 44 carbon dioxide. Therefore this divide this by 12 multiply it by 44 that will be the carbon di oxide production because rest all is zero.

The other 20 percent i don not account for them. So, we will have 0.037 kg per kg of clinker from this alternative fuel. And which is must less because this will have no much less because rest 80 percent my regular fuel. And, from there I can calculate out. Depending upon their fuel efficiency and, all that i can calculate out how much is the carbon di oxide that they produce. So, in 1 ton of cement actually otherwise you this much would have been this much quantity additional carbon dioxide you would have produce. If you are not using biomass. So, that is the advantage using this biomass and agricultural waste and all that.

And this has got some other kind of advantage. Because you do not know you would have to dump them somewhere many of them are not biodegradable. They have to go incinerator or something. So, supposing you have put it incinerator they would have generated that much amount of carbon dioxide anyway. And for cement production you have to use foundation or something else. So, this has got indirect benefit where this where our calculation were directly you are getting some benefit out of this. So, this the small calculation i want today do this last class. I am just repeating i think it very simple there is complicate in it. Now, let us look into concrete.

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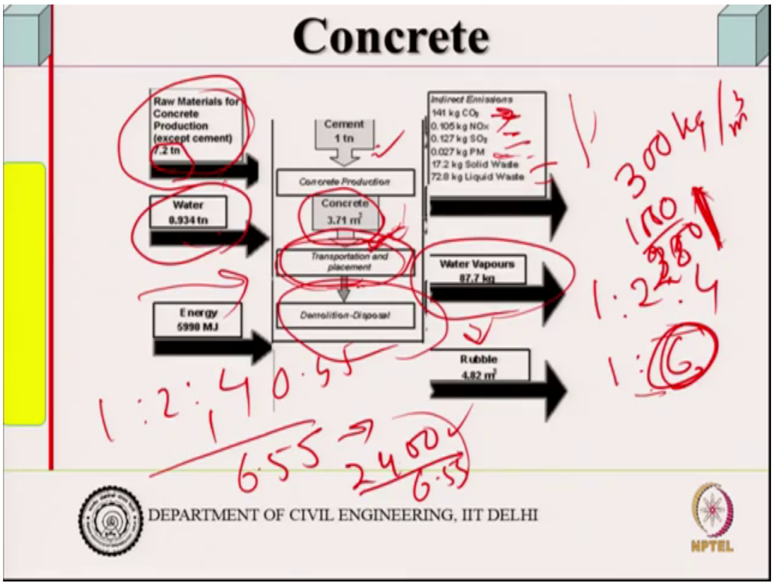

So, that is what i am saying during concrete production during concrete production. Suppose you are using 1 ton 1 is to some ratio there is some waste. So, let us say i mean just a crude kind of a concrete of good old days. So, 1 is to 2 is to 4. Which would mean 1 is to 6 is your rest of the material. Except water so, water is separate let us say now this would have some wastage also. There you have to add some percentage of wastage. So, if you put all that together will get 7.2 ton roughly you just one calculation solve as by somebody.

And this in the process we will produce some amount of indirect carbon dioxide. Because you will be operating some machines batching plant. Now, if they are diesel operated they will produce carbon dioxide. If it is in and of course in a permanent batching plant you might be using a electricity. But then if you it is an electricity you will taking from the greed than proportion of the fossil fuel used in the greed from that you can actually calculate out. We will sometime see that later on again.

So, some amount of carbon dioxide, some amount of NOx, some amount of SO2 etc etc. Particulate matter this must kg some solid waste and some liquid waste. Because washing mixture machine washing and all that there are liquid waste generated. Which are treated and handle in different in given way. But first to start with it we will generate all this. And then you produce a supposing like if the volume of concrete it say, something whereas say 300 kg of cement per meter cube of concrete roughly or 300 or something.

So if take 1 ton of cement, I will have how much meter cube? 1000 divided by 300. I have 1 ton of cement 300 kg per meter cube of concrete. That is the typical kind of mix for low grade concrete not a very high strength concrete. The concrete you are familiar with the, those who have done concrete technology you would know that it is of that order. So, even if out you calculate this out very simple. Because, I said 1 is to 2 is to 4 so is to let us say water cement ratio around 0.55 or something that amount of water.

So, total material is 6.55 out of that 1 is cement mass wise mass basis. And, if take density as 2400 of the concrete 2400 kg per meter cube in 2400 kg you will have 6.55 divide this by 6.55 than you will get the amount of cement. So, this will come around 250 - 260 or may be less than 300 or somewhere around 300, something of that order. So, this is the, volume of concrete that you will produce. Because 300 kg roughly, I am just saying you can do exact calculation for actual concrete.

So, 300 kg goes in produces 1 meter cube of concrete, 1000 kg will produce some 3 point something. So, this is not 300 it is possibly taking 280 or something. 280 kg produces 1 meter cube of concrete you can calculate this also. So, roughly this of this order will be similar but, it will vary from concrete to concrete. So, it will produce something of this order of the volume of concrete. Then transportation and placement is there what are you will need is some amount both for mixing water washing etc etc.

There additional water is required. So, this is not the exactly the water cement ratio, it is more than water require to do much higher than water cement ratio. Because than you will do wastage than cleaning rest of them are other water is required the process. So, put together let us say this typical values. Than it will also generate water vapors 87.7 kg some rough idea. And then transportation and placement and then later on demolition and disposal out which you will get some amount of rubble.

That means you can crush them make them demolition waste as aggregate out of them. And obviously in the process you will need the energy to produce this. So, you can see that cement that we had need energy well to produce concrete we also need energy. And that is all and then transportation and placement there will be some additional energy. Because the truck which must be using energy for transportation. So, total energy therefore would be this overall constitute that embodied energy and this is the emissions that will come from the concrete that is the thing. So, therefore if i am looking at concrete i must look at it life cycle energy implications life.

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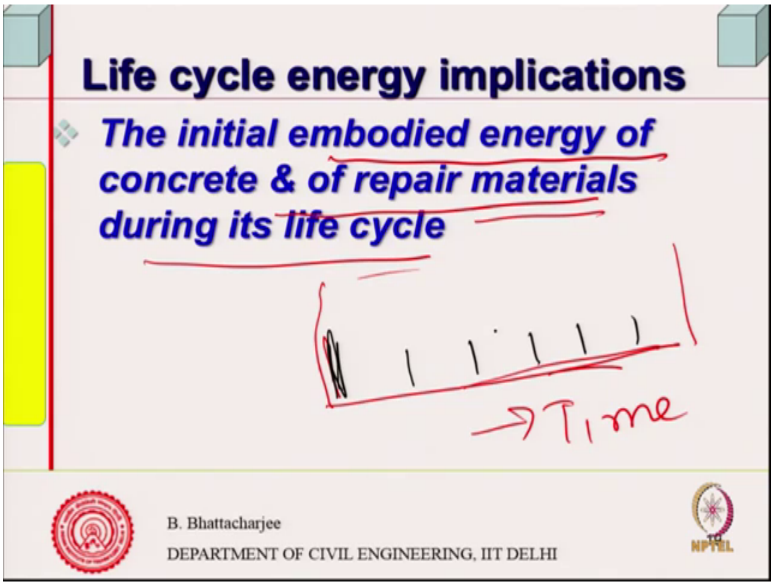

So, initial embodied energy of concrete and of course if the life cycle if am looking at than during the life i might some do repair. Which means that some concrete has deteriorated. I additional concrete than I have put in some form of or other in same concrete or may be a better concrete there are some defect. So, there are some repair reoccurred during it life so, this would be cycling. In the sense that there if i take time and look at the life of structure intended design life or planning organism. Whatever it may call economics you call it planning organism when you are looking at the economics analysis.

Generally you call it intended design life there is intention that building or structure would last for last for that many years; that I think I mention some time. That bridges might not surely taken on 100 years or 400 hundred years of dams. Thousand years for possibly for atomic reactor you building and things like that. So, during that the period of time obviously you will have initial there is some initial energy requirement we here, energy initial requirement will be here. But then you will have repair energy from time to time.

Because, repair material go in there embodied energy must take into account. More number of repairs obviously the more energy goes into it. I mean more carbon dioxide everything more. It would need more resources and so on. So that is too also been seen.

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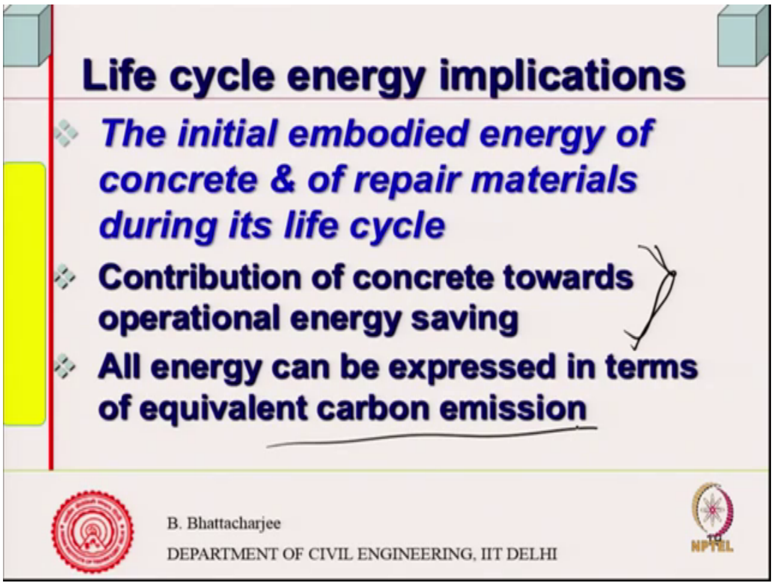

So, during the life cycle n this can be an only with respect to building. If there is operation energy for example you have use an RCC slab in the roof. Now, this will we have shown in implication in cooling lode. Supposing instead of RCC of a given kind i use another insulating type of RCC. May be it will have light weight aggregate concrete or something of that kind, there is implication will be different. So, this is contribution towards operational energy saving if there is any, so will be taken. And all can be expressed in terms of equivalent carbon. We shall see that how we will see that. All this everything can be expressed in terms of equivalent carbon simple equation and that is.

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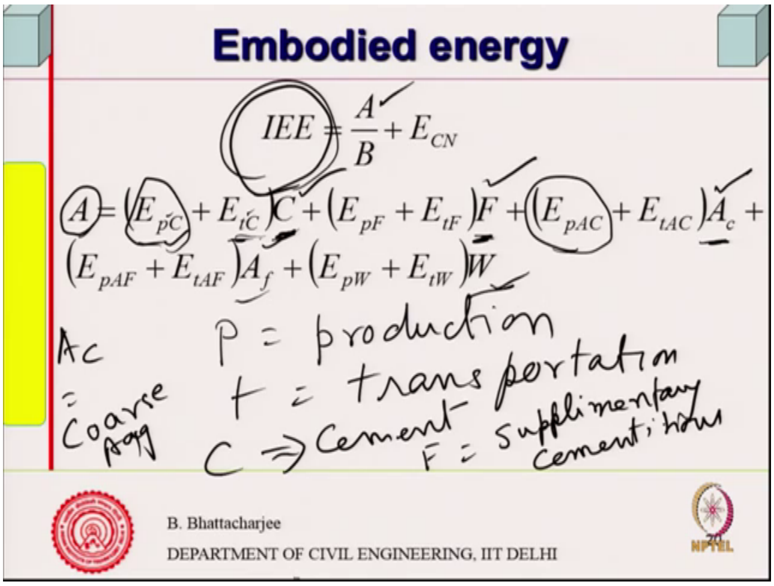

So, let us say embodied energy initial embodied energy is something like this last class. Sometime we have mention that embodied energy of concrete is how much giga joules per ton. i had a diagram and i said that is ok. That is that is not very large really that is usually small but, worldwide used we used too much of concrete. Compare to any other material therefore or even in a given building concrete contributes maximum to embodied energy. Because, quantity is used is very large so that is the thing.

So, any way initial embodied energy I can expressed it in this manner. First A is this term by B because, i will calculate per unit mass or per unit volume. . Therefore let us see, so A is this that E stands for embodied energy, subscripts p is stand for production, and c stands for, I mean sorry t stands for transportation. Now concrete has got cement let us say if am using some sort of fly ash or something some supplemented cementitious material. Course are aggregate fine aggregate and this is water.

So, there are two components in embodied energy one is the production another is transportation. Now production can still be estimated relatively better but, you can estimate. You say it is a laborious job so, we have to take data from several sites and then, average it out for a given region given place etc. Similarly transportation energy it will depend upon mode of transportation. Now generally when we talk of cement, cement will be transported from the factory either in bagged or, in bulkers.

Which are pneumatically put in to vehicle closed vehicles and can be pneumatically pumped out. what you call bulk transport of cement. Cement is also transported by ship if, there is possibility. So, same thing pneumatically just pump the cement, pneumatically pumped into the ship tank and this will carry it is done it is a western coast. Ambuja cement so Gujarat Ambuja their factories on the ambuja nagar which, is on the sea shore.

So, the cement produce is straight away, put in to the ship pumped into the ship pneumatically and transported Surat, Mumbai or, wherever or in even to the eastern coast of some places. Because, it is the cheaper mode of transport possibly uses less energy too. So, that is what it is So, this is a cement so if I have C amount of cement per meter cube of concrete. I am trying to find out per ton. F is the amount of flyers or something of the other kind. And we are not taking it to account of small quantity of mixtures.

Which you used which you would be may be point very small percentage not more than 2 percent in any case of the cement. And this is a course aggregate it will have some production energy so P stands for production t subscript is for transport, C stands for cement, F any supplementary cementitious material you are using Pozzolana on a cementitious. Then Ac stands for Ac is a course aggregate and this stands for fine aggregate and this is water. So Af is fine aggregate. So I think I can erase some of them out.

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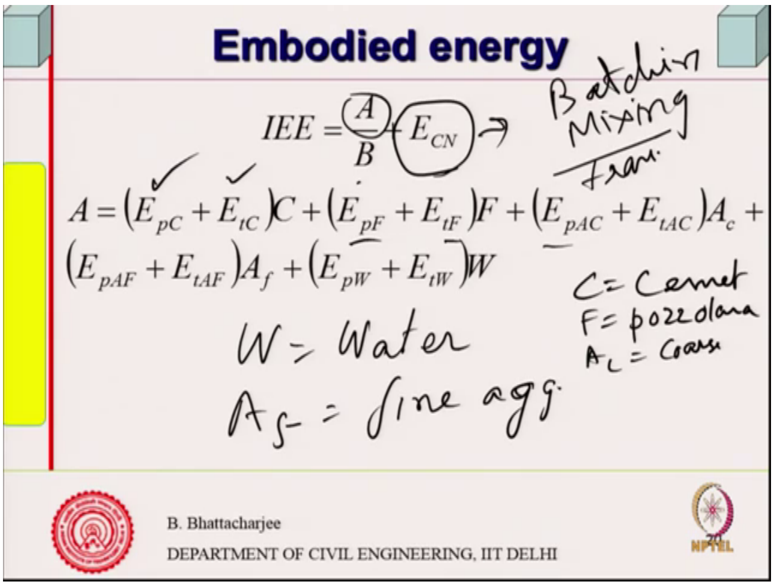

So, W stands for water, Af stands for fine aggregate, C cement as I said earlier and F pozzolana or something of that kind and Ac course aggregate. And two components of the embodied energy transportation and production and transportation for each one of them. So, that is A the total. I will come to b Ecn is the energy during construction this is the material embodied energy. And just now we have seen that when you make concrete you give something like this.

This one we just saw 5 9. This particular case they are saying 6 and 5 9 0 mega joules. Because you have to do mixing energy Ecn involve then this will be batching to start with batching during construction. Yes batching mixing and transporting the concrete as a mass from the batching plant to the mole. And also if it is overall concrete element we are looking at the mole preparation everything all those energy will construction energy will covered in mole preparation the reinforcement laying.

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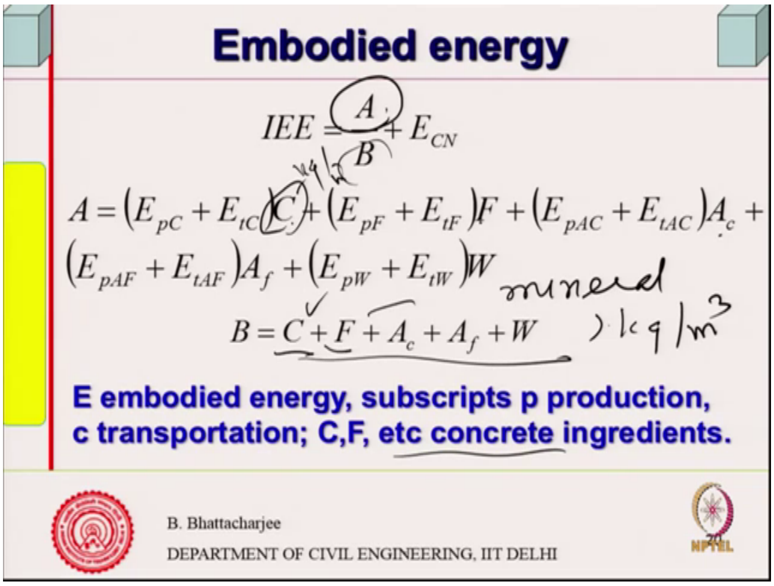

Let we are not looking at steel contribution. If you look at steel contribution you can calculate out that way. So, this is the total embodied energy that will come very simple accounting only. And what is B? B is the quantity of cement per meter cube quantity of supplementary or mineral and mixtures this could be mineral and mixtures. I have given you three names for these they give me pozzolana, supplementary cementitious material or, mineral and mixtures they have used.

I mean anyone other than cement that you have using with those people used ground granulated blast furnace Slag. Might use simply limestone powder some percentage and that, kind of material. Silica Fume so on those talked about. So, E is embodied so this is what is said so this is what is so sorry this is etc is the concrete ingredients. So, therefore per unit this is C per meter cube so this is b actually all in kg per meter cube. And these was all in kg per meter cube.

So, therefore the total mass in 1 meter cube you are actually dividing by that means you are converting into mass. This was the mass this is cemetery mass per head meter cube this is the mass per meter cube everything is in per meter cube and this total is also mass per meter cube. So, you are actually getting per unit mass. And per unit mass what is the amount of energy is consumed it is what the initial embodied energy. If you look at life cycle embodied energy

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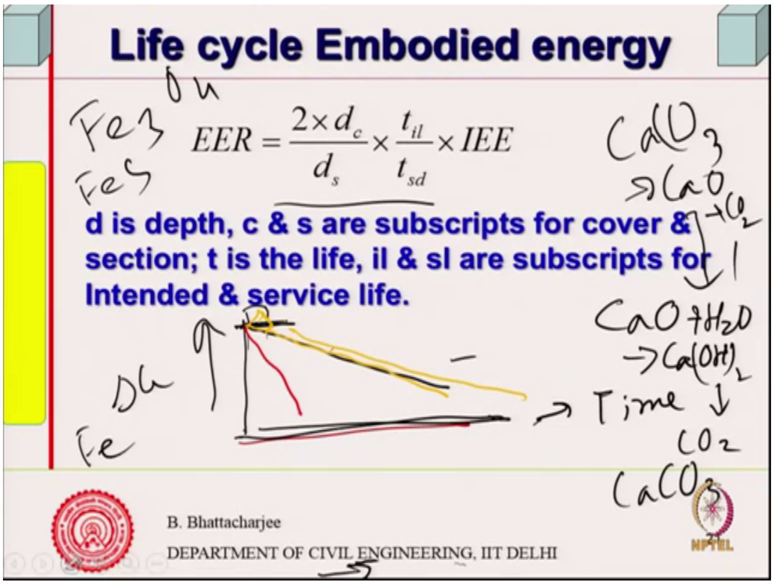

Then, i got to explain you little bit more although i have got put an extra slide there because, this if those you have done concrete structure durability than it will be clear. Normally, I have not added here this that slide here you might done the course concrete technology than you have to have if you recollect. If you recollect something like this we said that concrete is not maintenance free no either steel. You cannot expect them to remain stable because thermodynamically we, have produce them with the expense of energy.

So, if I look at if the analogy given is if i because, have i produce them with the expense of the energy. So, analogy is given something like this is let us say this time this is with time. This excess is time and this is what you can put it in terms of Gibbs free energy delta G or, some energy let us say not left not used the thermodynamic terms to scare you of. But, some energy you have given to produce so you produce something at the expense of energy. Means you give delta G lifted up in terms of chemical potential.

Let us see for example calcium carbonate we said that is a stable material you heat it up to get calcium oxide. So it have more energy per mole because, you heat it up and carbon dioxide of course is produce. So this is a mole energy per mole. Now this energy if will like to dissipate. So, the moment you put together to calcium oxide with water the material that is available in abandoned term to the earth surface. Because that is what everywhere so, it will form calcium hydroxide. Readily, with heat of evolution a little bit of there will be also second line.

And this is also not stable it, will take back some carbon dioxide from atmosphere to the came down calcium carbonate. So, this is the energy that you have given so you have actually by giving calcium carbonate of cementing by making you are doing the same thing cement. Steel, is available in this form hematite, magnetite FeS is not available in Fe it is never available in nature. Only noble metals are available in nature for example, gold Au or platinum Pt there are available in nature.

So also they do not react because there are various ways of looking at their potential electro chemical potential tendency to loose electron etc. All this are there. So, therefore this is what you have done so they will have tendency to react. Although you can do is you can i can put I have lifted it up and put it over a platform. So if I put it over a platform now, it will not come down but it will have a tendency to come down. I mean somebody pushes it little bit it might come down.

So, the tendency is always there or i can put it over a slope instead, of doing this I have decided to put it over a slope. So, I have put it over a slope now and now it will come down very very slowly relatively faster. This will take infinite time this will take some time and, there can be third situation where i putted in this slope then, it will come faster this are related to kinetics. This is related to kinetics, rate at which will come out al in any case they will detoriate. Structural elements because, they are known mostly made of manmade materials they will tend to detoriate. So, therefore you need to have repairs or occasional repair.

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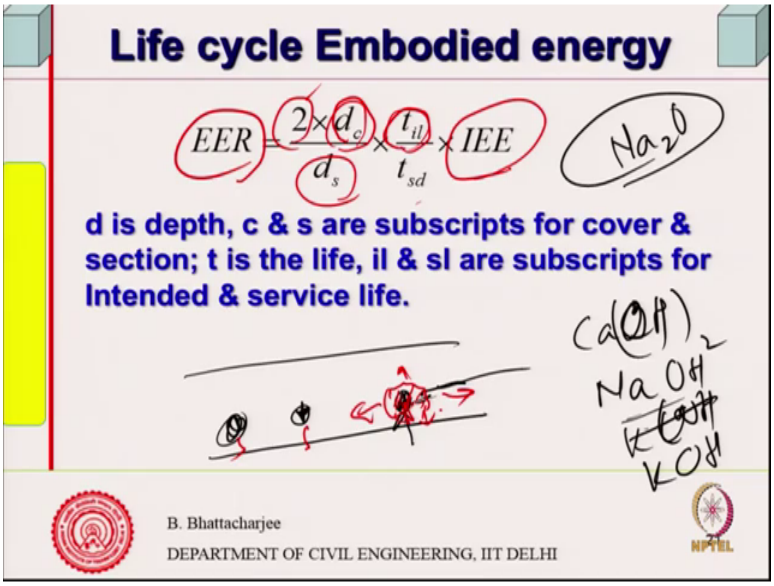

So, you generally what you see you have a concrete element whereas say if say you have a concrete element. Let us say slap or some reinforcement concrete element. Generally reinforcement concrete simple case and I am taking this as steel bar. Reinforcement concrete element now there many detoriation process they will give you many detoriation process.

But, generally if the detoriation exposes let us say detoriation process I am not going to discuss here. But i will just mention a couple of them for a very common one is the reinforcement corrosion. Now that occurs because, water would have gone into the concrete. Also here some aggressive agent like chloride might have come in or the PH might have changed on the concrete. Normally, concrete is of cement hydration produces calcium hydroxide.

And there is obviously in cement this materials are always there sodium and potassium that there. And you have to you cement this comes either they are as impurities as flux of them with them they are everywhere. Sodium potassium you will find alkali anything, you have to extract out you find sodium potassium some amount would be there. So, they would be there in cement some amount either coming from raw material or some time added if required to add to flux.

But, depending upon the situation i mean not talking sodium alone i am talking of about many oxides. Many things you might add a little bit to control the clinkerisation of process and many thing might come as impurities. But, whatever it is in cement hydrate you will find calcium hydro oxide, sodium hydro oxide, potassium hydro oxide etc. So, this maintain alkalinity of concrete and this alkaline concrete protects the re- work because, it does not allow active corrosion or detonations of concrete worker.

I am not going to the further mechanism of this but, my point here is if corrosion occurs what happens is? Corrosion product will come surrounding, and corrosion product will be formed. This relative sound stems and this extracts pressure outward this, extract pressure and this side material been less the cracks will come here. So, cover concrete is a concrete which will get damaged, if you have alkali aggregate reactionless so another reaction nothing to steel. Then also the moment the reaction in which is an expansive kind of a reaction which causes a cranking of concrete.

The moment cracks exposes the river i must repair it. Otherwise reinforcement corrosion will go in a first faster way and concrete cut take tension. So, even structural particular location if conducive condition not repaired long time it might even show some sort of collapse collapse of elements somethings like that. So, the cover concrete is most vital. In repair what we do you replace the cover concrete. So if i have to estimate the embodied energy of repair.

I have to address the cover concrete and in the extreme case there are two sides covers are there. At least in a section you any section if there could be more but at least two types two sides covers should be there is in a slap. So, it will be actually two or four depending upon the situation in an extreme case. Let us say i am repairing or repressing all the covers concrete so this that cover depth replays the covers know and this depth of the section.

Multiply it by time of intended design life and, this is time one is the repair time and another is just i will come that back we will have a break. And i will address some of the occasion and i will back to this. And multiply it by so i assuming the energy that has gone in it will repeated number of times but only for the cover concrete so we will have small break take some of your questions and then come back again.