Sustainable Materials and Green Buildings

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Lecture 26 - Carbon Balance, Comparison of various types of Brick Kilns and Sealants, Paints, Adhesives

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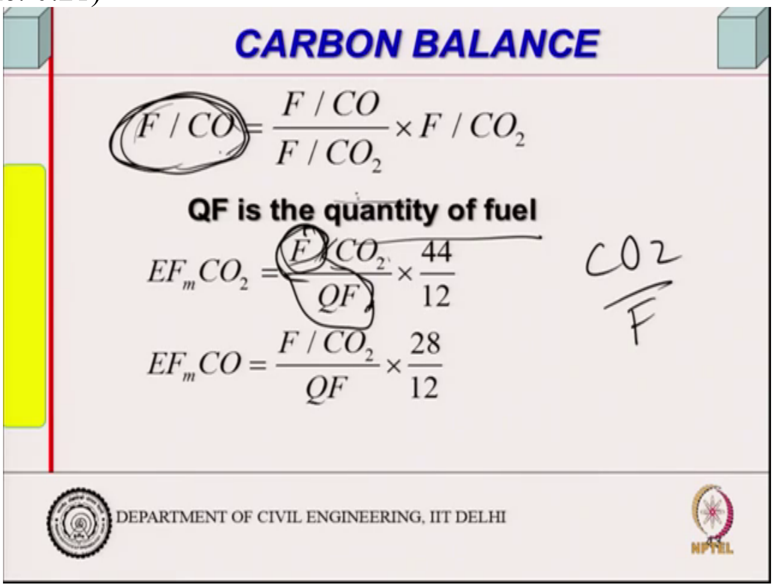

So we can continue with carbon balance. So that is what we are seeing now. So you know what was F? F is flue gas cubic meter, you know in terms of cubic meter per hour. So rate and so you know the ratio of the, I mean basically how much carbon monoxide, if I want to find out this, you know this can be written in this manner: Rate of flue gas and carbon dioxide present there. And QF is the quantity of fuel. Then F divided by carbon dioxide because we know from the carbon dioxide in fuel, so if the QF is the quantity of fuel, this fraction is this is in cubic meter, this is the quantity of fuel and this is the cubic meter of the flue gases.

So for per unit fuel how much is the flue gas you are producing, and divided that by carbon dioxide. You know divided that by carbon dioxide.

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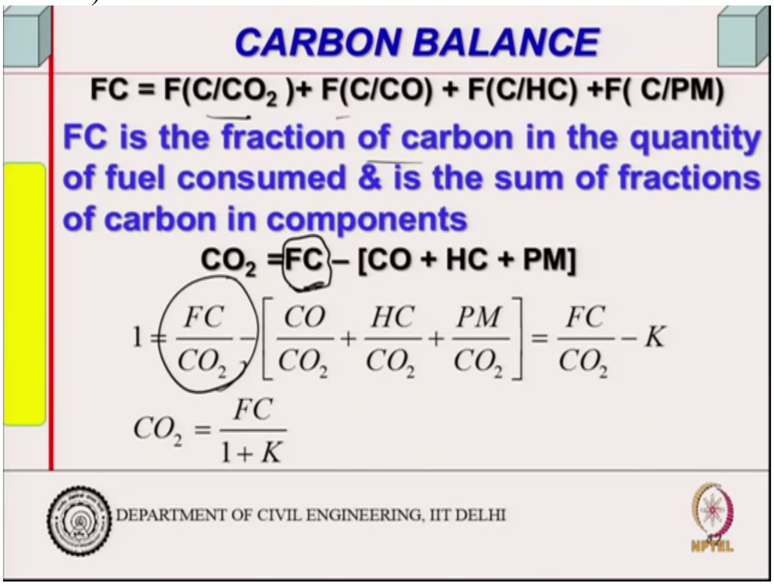

There is amount of, because F what we have defined earlier was, we called something like FC by CO2, you know that is carbon issue. But we were saying we have defined something like FC is the fuel, fraction of carbon in the quantity of fuel. And this is the ratio of carbon dioxide in the quantity of fuel. So FC by CO2 we defined earlier. Because this was the fraction of carbon in the total fuel divided by carbon dioxide, divided out of which the carbon dioxide that is produced.

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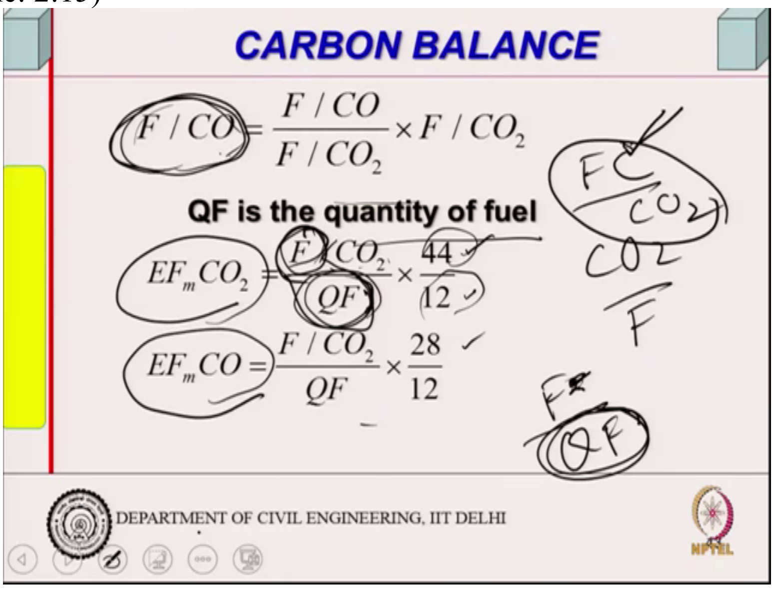

So this quantity if the quantity of fuel is this, if the quantity of fuel is this, quantity of fuel is this, the ratio FC divided by CO2 was the amount of, this is the fraction of carbon in the fuel divided by amount of carbon dioxide it produces. So this performance factor is defined. Because if I, how much quantity of fuel I am using, it is related to the quantity of fuel.

So if this is the typical fuel if I am using same one, let us say coal, now in coal how much is the total carbon and how much is the carbon dioxide that I know. So ratio of the total fraction of total carbon I produced per unit carbon dioxide, that is what is given by this. And this is the quantity of fuel. So this is 44 is the carbon dioxide, 12 is carbon. So this is you know this is the carbon dioxide, basically this will give me F. If F is my fuel rate, fuel production rate. quantity of fuel I am using is this per unit, this was per unit kg. So this is for unit kg. I mean I am producing for total fuel is this much. Sorry, this is the quantity of fuel I am using, and F divided by QF gives you for per unit fuel how much I am doing. And this gives me in terms of how much carbon in carbon dioxide.

That is 44 by, this is you know and then multiplied by 44 by 12 will give me E F m for carbon dioxide. Similar for E F m for performance efficiency factor for carbon monoxide because carbon monoxide is 28, carbon monoxide is 28. And same thing for other particulate matter et cetera, et cetera. So one can actually obtain this you know this performance factor one can actually obtain. Performance factor for carbon dioxide one can obtain. Performance factor for carbon monoxide one can obtain using this kind of relationship.

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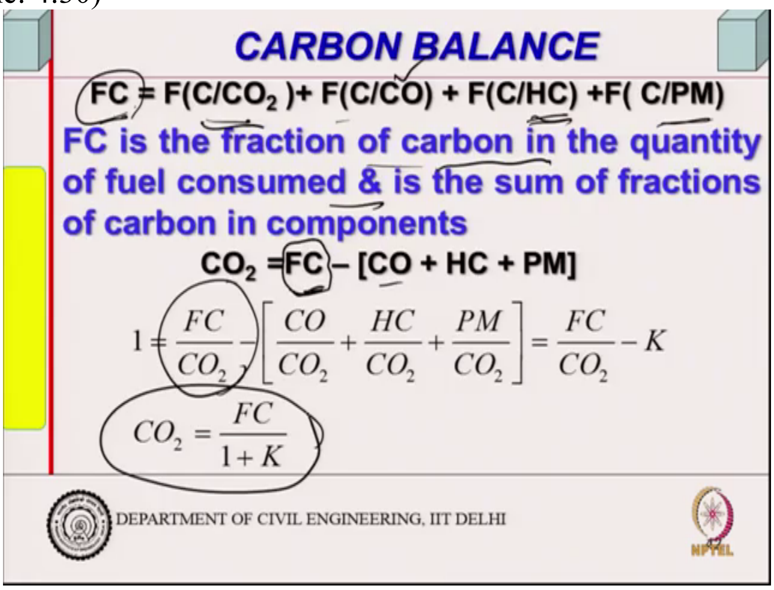

Once you know this (propo) this proportion, that is you know how much carbon dioxide, how much carbon dioxide is there in the system, how much carbon monoxide is there in the system, how much particulate you know hydrocarbons are there and how much particulate matter is there, so FC is the fraction of carbon in the quantity of fuel. This is the fraction of carbon in quantity of fuel. So you got to know in the fuel how much carbon dioxide contribution will be there, how much carbon dioxide it will produce or carbon monoxide, how much hydrocarbon and how much particulate matter carbon you know particulate matter that contains carbon it will produce. So then FC defines this. So then this ratio gives you for unit production of carbon dioxide how much is the fraction you know, fraction of this FC which is a fraction of carbon in the total quantity. So this is what is used. So carbon dioxide content is found out in this manner.

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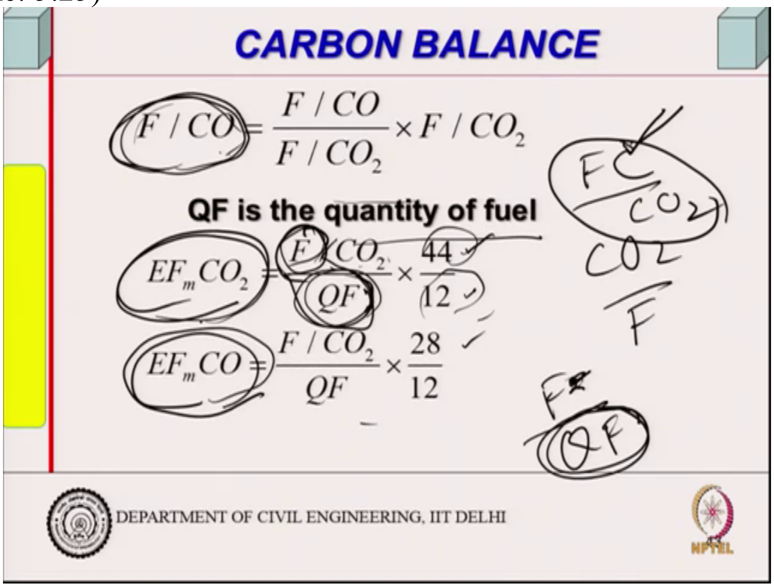

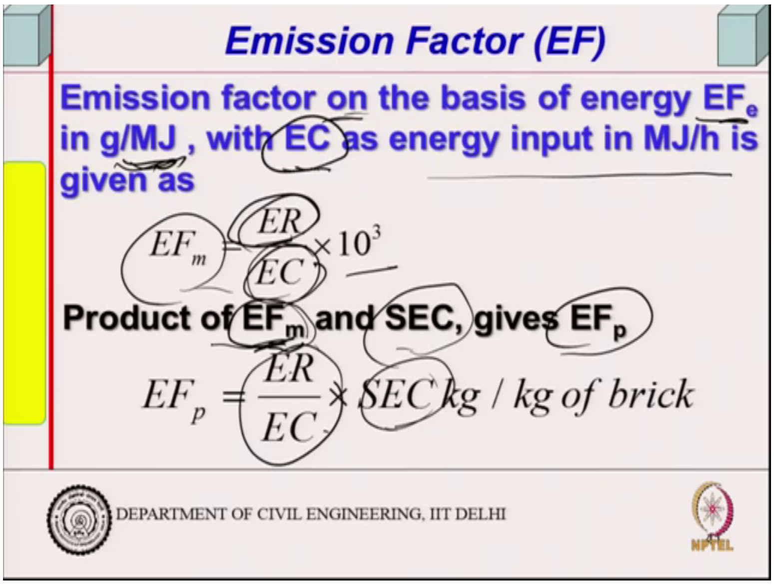

And using this formula, you can find out this E F m which we have defined earlier. We have E F m which have defined earlier. E F m is the emission factor. You know emission factor I mean not, no, it is a product, this is the emission factor, in a way emission factor performance actually. Emission E F m gives you the product of per unit energy. This is emission factor in terms of per unit per megajoules of the energy that is used. This is in terms of, this is in terms of grams per megajoules emission factor. That is what you know one can use.

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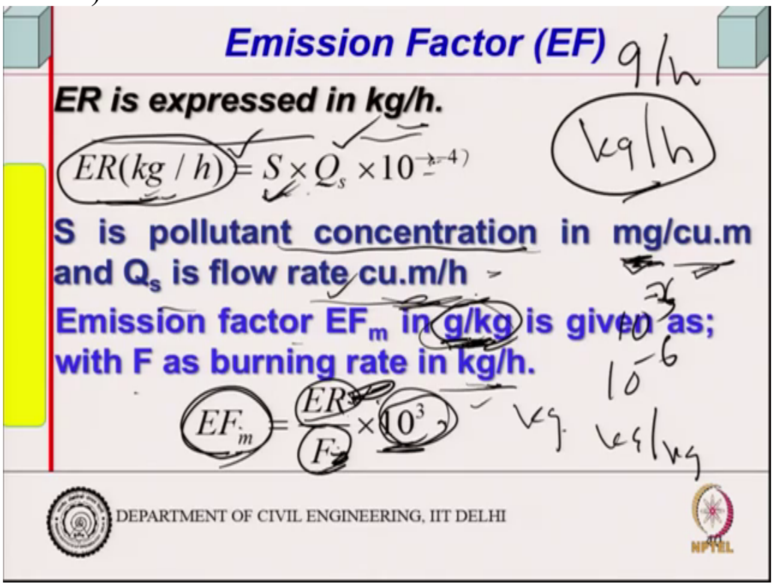

Another is basically energy one, this energy input we have used, you have used, if you look at it ER is the emission factor in terms of grams per kg of the fuel.

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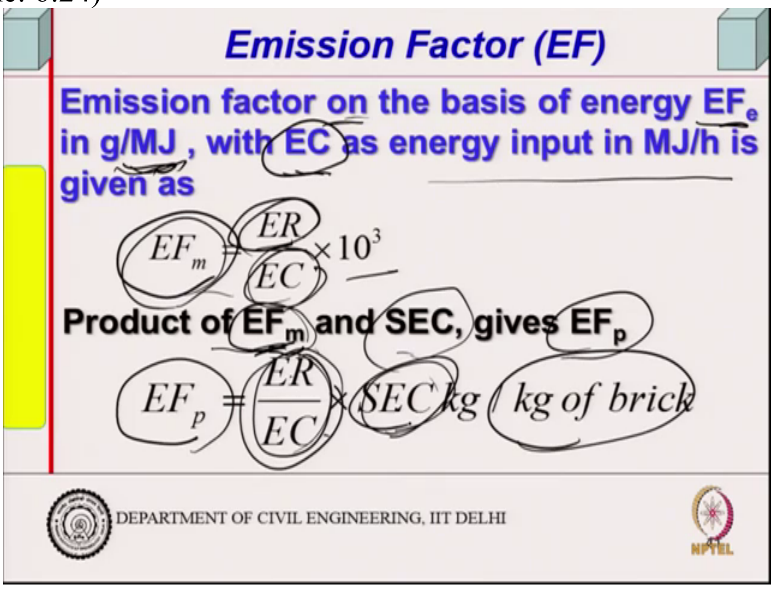

Then this was in terms of mass per unit megajoules of the fuel. And you know so emission performance factor in terms of per kg of the brick would be given. Because you can multiply it by the SEC is the specific energy. That is energy you require for unit 1 kg of brick. So this is with respect to per megajoule. This is in terms of megajoules per kg. So per kg of brick you can find out in this manner.

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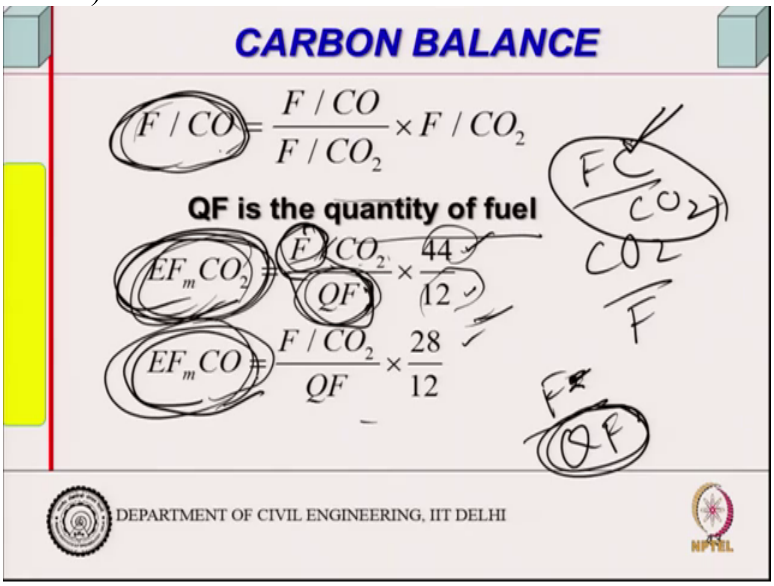

So this is how actually obtained, one can obtain the amount of carbon dioxide potential or efficiency which is efficient, I mean what you call emission factor with respect to per carbon dioxide, emission factor with respect to carbon monoxide.

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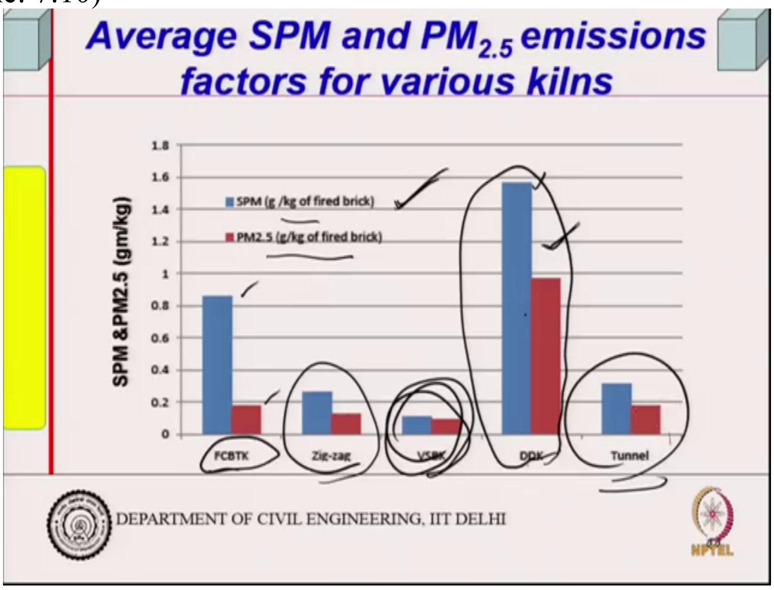

Okay, average particulate matter for different types of kilns are available here. You know SPM and SPM 2.5, so this is SPM per kg of total SPM, suspended particulate matter. Kg per kg of fired bricks, suspended particulate matter. And this is the particulate matter below 2.5 micron which are more dangerous from health point of view. So if you see, this is a fixed chimney bull's trench kiln. This is here and this is here. And Zigzag is obviously will be somewhat less because it uses less fuel. And vertical shaft brick kiln, that will be the least because that uses minimum fuel. And downward you know this kiln and tunnel kiln downward this was downward. DOK kiln actually DOK kiln. This is uses maximum, so that is the least efficient because this requires maximum fuel, so it generates maximum so you know particulate matter both point in terms of 2.5.

Therefore, if one has to use possibly one has to use more of this rather than using this which are more this is inefficient and meant usually meant for small kind of production in batches holding onto the kiln for 7 days. Because there is a cycle, there is a cycle. And tunnel kiln of course is somewhat better.

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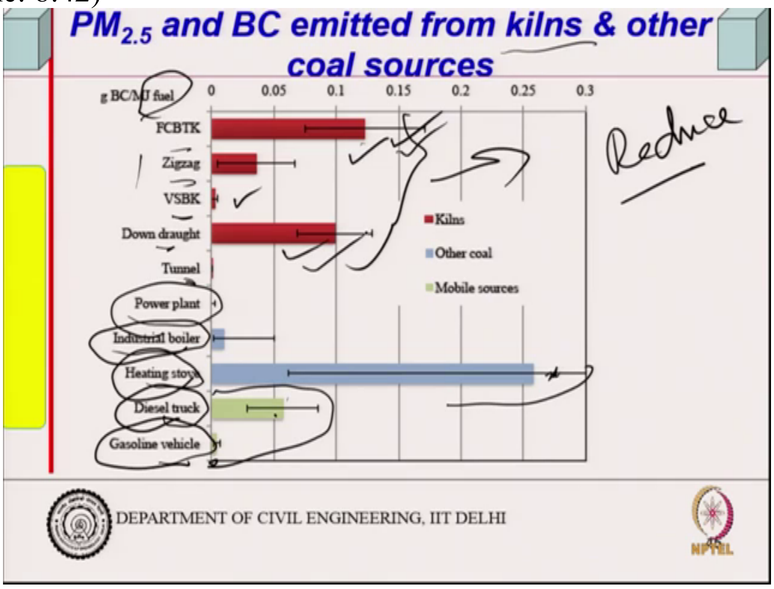

So from you know emitted from various kilns for types of basically various kilns and if you compare with other kind of industry, for example gasoline vehicle, diesel truck, heating stove, industrial boiler power plant you know and this is the tunnel, down draught, vertical shaft brick kiln, zigzag and French fixed chimney bull's trench kiln. So you will see that heating stove of course produces maximum. These are of course mobile sources, these two are mobile sources like diesel truck or gasoline vehicle. But this is comparable, so is this comparable. This is quite high compared to this from the, this is per megajoules of fuel we are doing. So they are all kind of normalized. So per megajoules of coal fired sources, this is of course moving vehicle not coal. But diesel or you know like gas, petrol or whatever it is.

So you find that there particulate matter emission for big kilns are very very high, relatively very high, except the heating stove, heating stove which uses again coal fired heating stove.

And power plant of course is much less that way, so these are big sources of actually particulate matter as well as carbon dioxide. So one can reduce now their use as much as possible. And if you are using, might use efficient kiln, rather than using something of this kind or even this kind which seems to be very popular.

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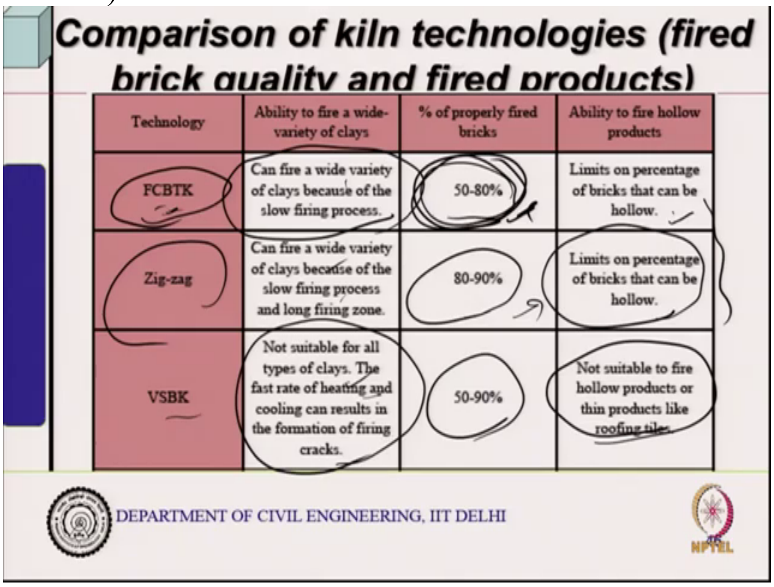

So if you compare the technologies of the firebrick themselves and quality of the brick you get, friends you know fixed chimney bull's trench kiln, it can fire wide variety of clays because of the slow firing process. Because it can fire kaolinite clay or other kind of clay. All kind of clay it can fire. And percentage of porosity of the, can be very very high, 50 to 80 percent even. Limits on percentage of bricks that can be hollow. So you cannot produce much hollow bricks because the process. Hollow bricks would be heating from all directions.

Zigzag you know, sorry percentage of properly fired bricks is around 80 percent. So 20 percent will definitely go to waste. This improves 10 percent will go to waste. And vertical shaft brick kiln not suitable for all types of clay. This can fire wide varieties, because this is a similar and limits the percentage of hollow bricks that can be used. So same, this is almost similar not suitable for hollow bricks. So this is bad even from the production point of view. Wastage is of course relatively less compared to this. And cooling results in formation of you know because slow process, this is fast heating and cooling can result in formation of firing, formation of firing even crack, crack formation can occur. So products, some of the products can be bad as well.

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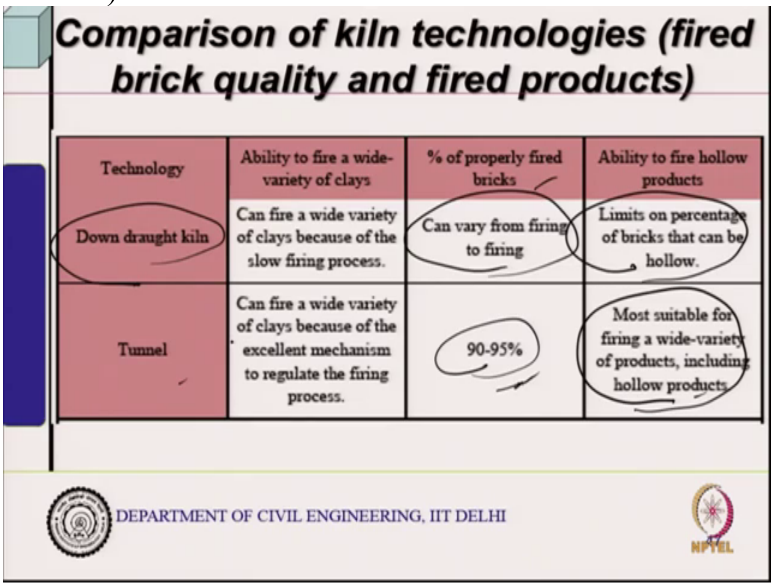

Then if you look, compare to down draught kiln can fire again wide variety. It can vary from firing to firing and limits percentage. Tunnel can fire wide variety of clay because of excellent mechanism. So loss is it can be you know the waste bricks, wastage of properly burned bricks are more. And most suitable for wide variety of products including hollow products. So tunnel is there and the vertical shaft (brick) brick kiln, I mean we did not have the data. But that would be definitely far better.

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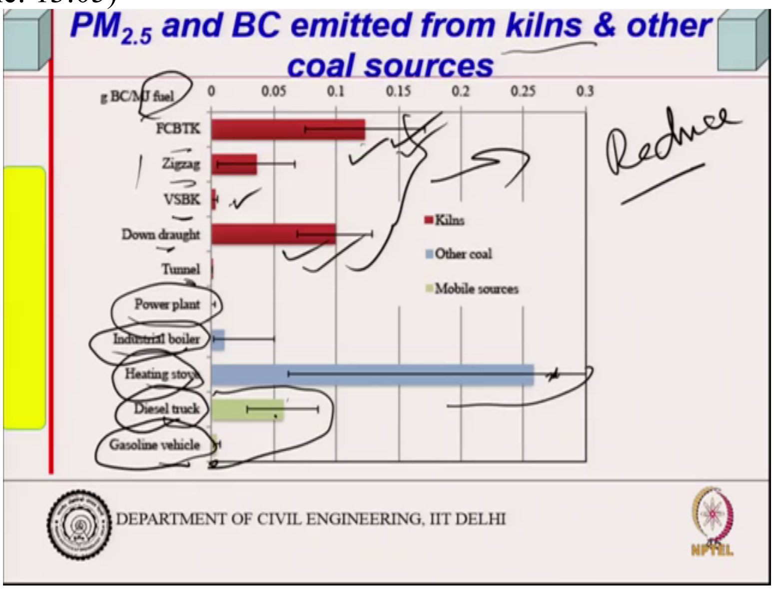

You know the vertical, because we have seen in almost all performances, we get vertical shaft kiln gives you a better one. And this can be you know this is also not very fast process. So you can use, the data is not available by the moment.

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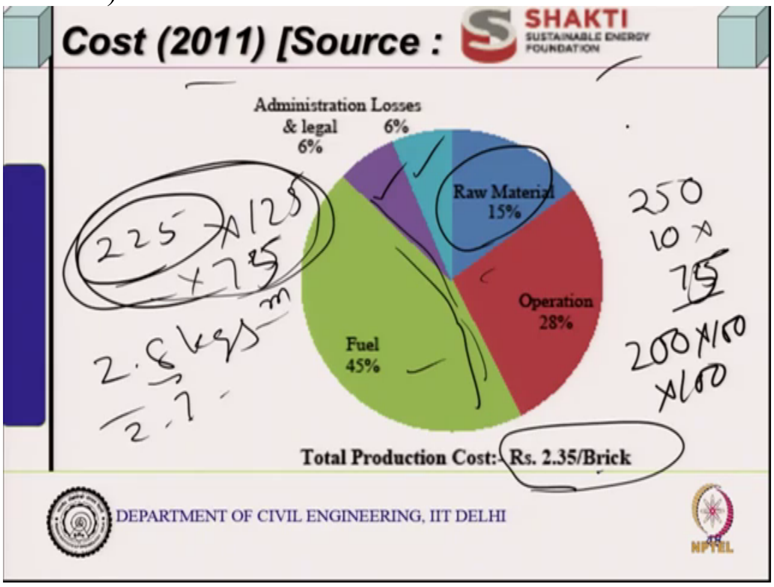

This people did something, you know Sustainable Energy Foundation and then look at the cost also. So if you look at the cost, the proportion of the cost, raw material constitute around 15 percent. Well when they did it, it was production cost with 2.35 rupees, I am not sure this might have, there might be inflation might have occurred. This was in 2011 and some there is losses would be 6 percent, administration and legal cost. Fuel cost is the major cost. Then is the operation cost. So cost point of view we said that we should look into 3 issues, one is their energy and emission of the carbon dioxide and particulate matter. And third issue look in the economic side of it. And this is the economic side of it actually.

So fuel constitutes the major one. And therefore, you know basically that is the wherever whichever is fuel efficient, that will be the better form of brick. One can compare these bricks with let us say, this is per brick one takes and usually they would be talking in terms of per bricks would mean around 2.8 kg or so. 2.67 kg too because it is around you know 225, because this is not, this is it will vary from zone to zone in the country. Some places you find 10 inch brick you know 250 mm by 10 mm, by possibly 7.5 mm brick. And in Northern India you find 225 by something like 125 by 7.5 you know 75 mm. These are all in mm. This is 75 mm. So these are in mm but the modular bricks, machine cut bricks, wire cut bricks actually there will be they can be you know like you can actually use 200 by 100 by 100.

So while molding they are wire cut, the molds it is not put it in the mold but in a larger one you mold it and then wire cut to sizes what you need. Even fire brick sizes are of this you get. So if you have this kind of sizes, generally you will get around 2.7, 2.8 kgs per brick. Now if you look at this, the mass is also relatively high compared to let us say aerated concrete complete block or you know fly ash bricks.

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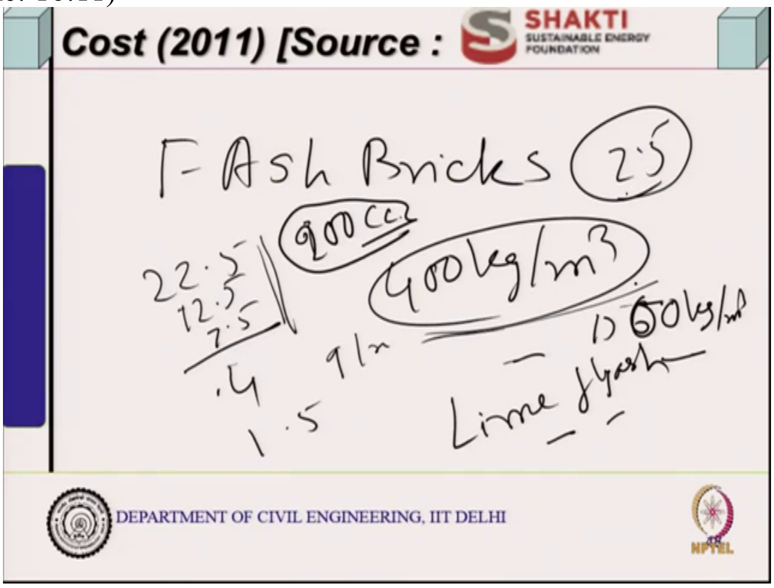

So if I look it fly ash bricks something like you know fly ash bricks which I was talking about, fly ash blocks or bricks, the density of this one I can vary. I can vary in the sense that if I am using of course aerated I mean autoclaving, then obviously it can go even 400 kg per meter cube to 1500-1600, 1500 kg per meter cube. So density can vary in that manner. Or in other words could be 4 you know, so 0.4 to 1.5 grams per Cc.

So if you are using 22.5 and similar sized bricks let us say 22.5 by 12.5 by 7.5 all in centimeter, so this volume of this will come out to be something like, you know something like 200 Cc approximately somewhere around about let me take it. And if I have something like, so it might its weight can be very low. They can float on depending upon but if you are not aerating them also, fly ash bricks normally will weight some of, weight will be somewhat less. But more importantly you are not using any fuel for burning. So simply you know you can have lime fly ash bricks together with some sort of sand. So they would be definitely more efficient because you are not using any fuel anywhere. And if you make it lightweight, then obviously you are you have, this is you are producing with the expense of energy.

Aerated aeration you know I mean what you call autoclaving if it at higher temperature, you would use some amount of energy. So if it is autoclaved aerated bricks then you will spend some energy. But if it is you are using kind of a foaming agent and making blocks, that would be, that can how much lower density. And your energy required will be much much less. So therefore this clay bricks are not really, not the best thing to use. And if, if at all it is to be used then type of kiln that should be chosen should be of that kind which is relatively more efficient in terms of more efficient in terms of you know fuel use because fuel is the one which contributes to everything, the cost.

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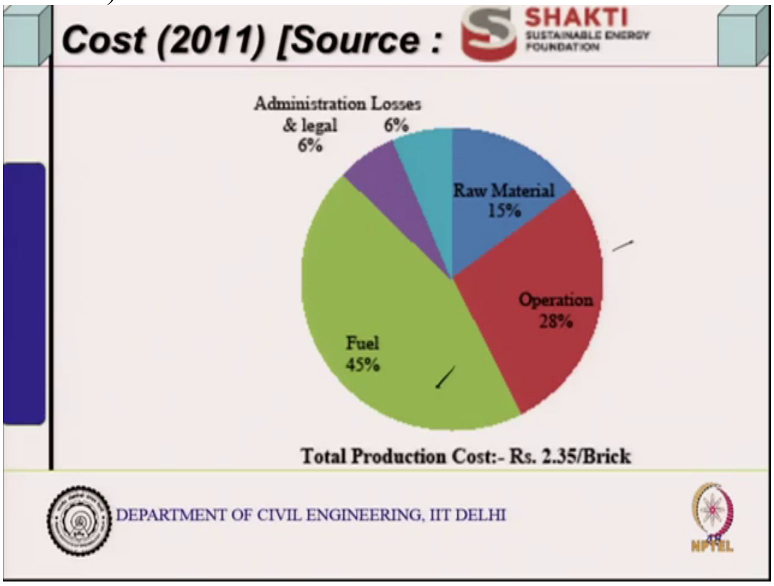

Fuel use means you know it contributes to the cost. It contributes to the cost as well as to particulate matter, carbon dioxide. So all three issues, energy consumption also increases with fuel. So it has to be efficient with respect to fuel. So I think that is the issue related to bricks.

We have already discussed about fly ash and similar scenarios earlier. You know related scenarios earlier. We will see, when we look later on, already the properties thermal properties and similar things we have discussed. So if you know later on we can look into the same thing again if required in terms of properties of some of the fly ash bricks and things like that. But I think we have already discussed the density and ranges. Those, we might have discussed when we are talking about cement and concrete.

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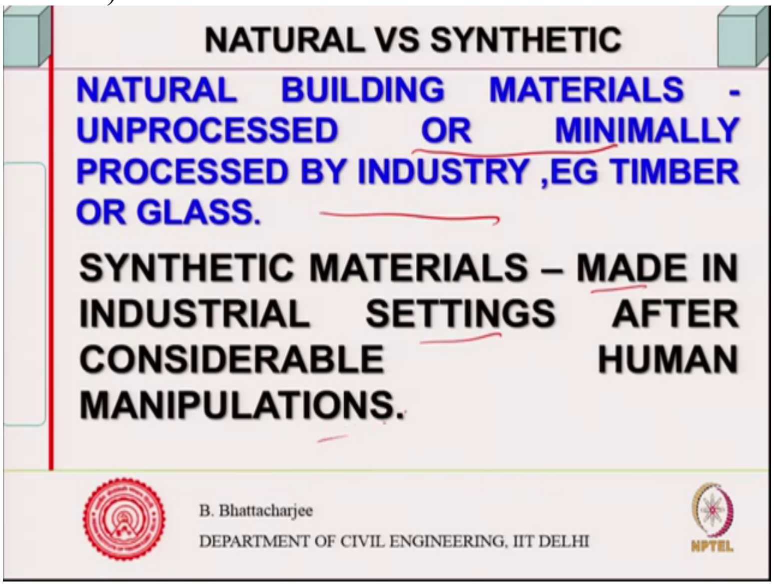

We can look into sealants and paints because they contribute to indoor air pollution, mainly it is related to that. So generally natural building materials are unprocessed, natural building materials are unprocessed or minimally processed by industry, for example glass or timber. Synthetic materials made in industrial setting after considerable human manipulation that is what we have seen in the beginning.

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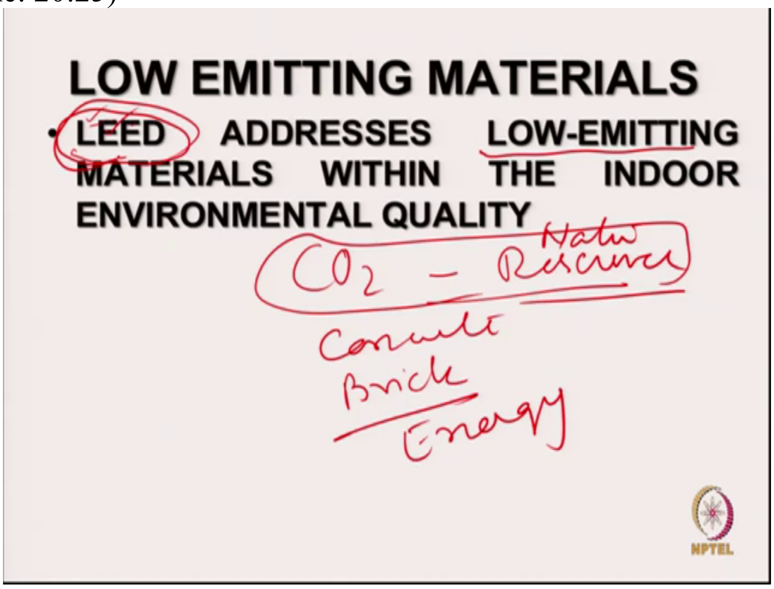

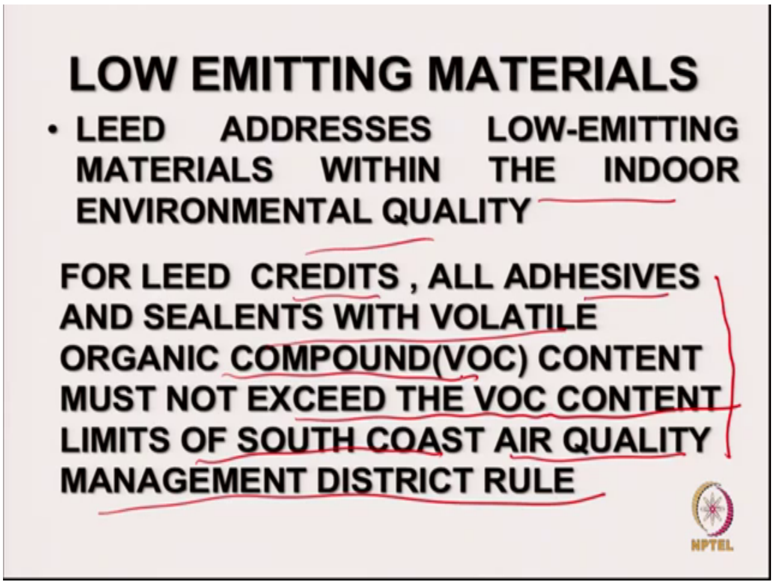

And emission is important here. You know if you look at green buildings, any kind of criteria, for example leadership in energy and environment, leadership so this is leadership in energy and environment design which is which we look into at the end or something similar in Indian scenario is called griha, then this issue is very much there. So what we have so far we have been trying to look into? One the major issue is the carbon dioxide emission and resource consumption from resource utilization. You know natural resource utilization from materials like concrete. And then we try to look into brick, clay brick and similar sort of thing. Then these are the major issues, then other issue is the overall energy consumption.

So we will see that when you look into this or any other such performance criteria, it list down energy as a component, it lists down emission as an, indoor emission as also a component. So you know so if you have low emitting material, you are expected to get some amount of advantage in terms of environmental performance and green performance. So that is what we are trying to look at into.

So for now we will look into this. So, low emitting materials within indoor environmental quality, so this addresses this. Or for any other for any other similar credits, because there are several of them which I will just mention, there are several of them because not every country uses Leed, Europe they use something different, Australia they use something different, so we just look at all of them sometime. But all of them will address this relative weightage given to each might different. For example, some of these might use more weightage for energy, less weightage for water or something like that, relative proportion might vary.

So for Leed credits, all adhesives and sealants with volatile organic compounds content must not exceed the VOC content limits or south coast air quality management district rule. So this is that rule actually. All the time I am trying to point out is that it is important to look into the volatile organic compound emission from the materials that are used within the building space, so within the you know habitable spaces that you are using.

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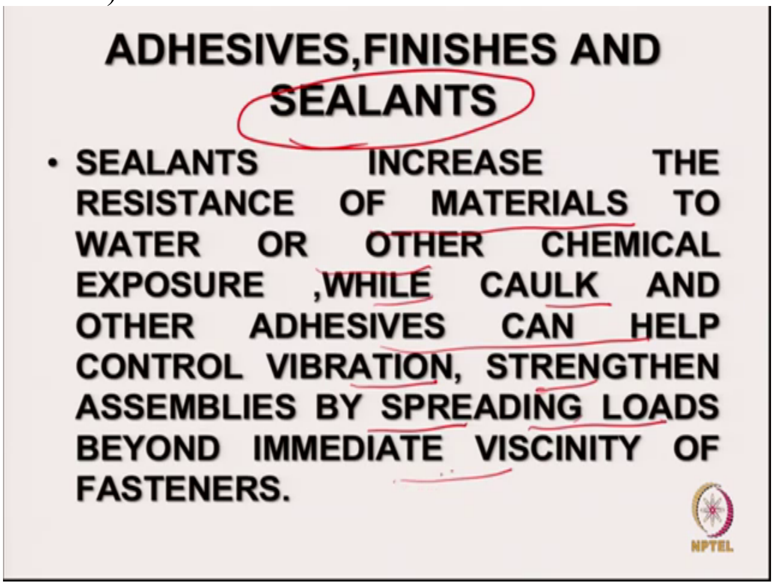

So therefore that is why we are looking at adhesive finishes and sealants which are used in buildings. Now sealants are essentially, sealants are what are sealants. They seal the gap, they seal the gap. So increase the resistance of materials to water or other chemical exposure. So do not allow anything to come in while caulk and other adhesives can help control vibration, strengthen assemblies, so some of those adhesives are they are bond. And the some other things might spread the load in the immediate vicinity of fasteners and things like that.

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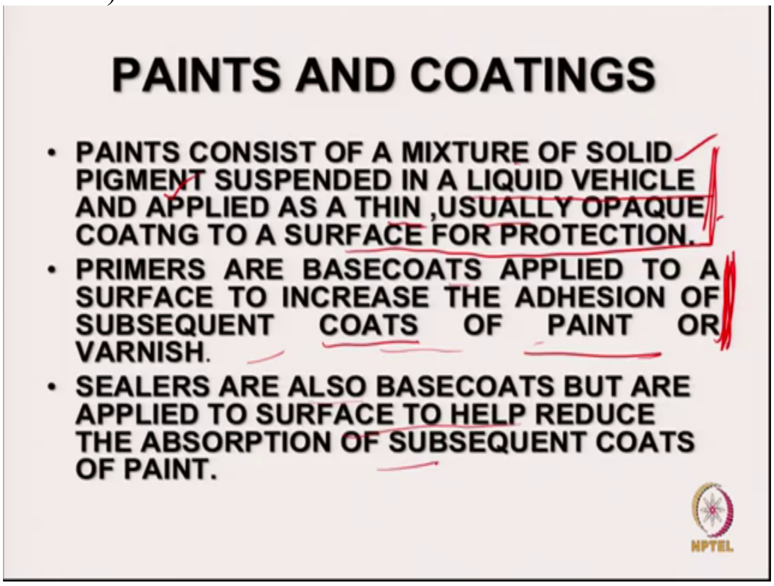

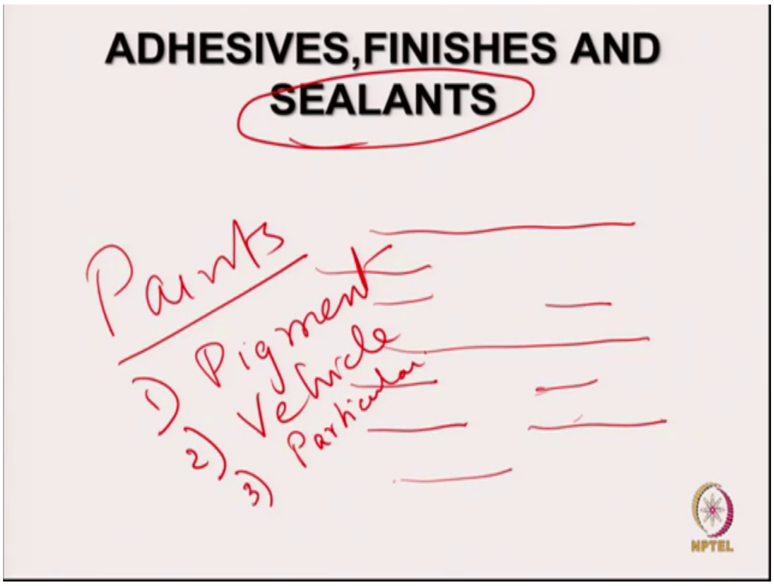

Paints, paints essentially consist of mixture and paints you know internally we use paints, sealants, all of them we use. And paints essentially you will have, paints essentially will have one pigment component as pigment because it has to give us a color. But you got to apply it, so some sort of solvent or vehicle because you have to apply it through brush, spray whatever means is possible. And then there are some sort of other additives might be there. And might have some particulate system which might you know in terms of (pig) pigment because they will remain, what remains is the solid. The liquid or the solvent which is there, that actually evaporates out leaving the colored particulate matter onto the surface.

So paints are these ones. Paints consist of a mixture of solid pigment suspended in a liquid vehicle as it is called it is a solvent, and applied as a thin usually opaque coating to a surface for protection and of course aesthetic purpose also. Sometimes we use what we call a primer. Now this can have emissions also, this can have also emissions. The primers are base coats applied over the substrate that is your brick or plaster or concrete or whatever it is to increase the adhesion of the paint with the substrate, the plaster. So paint or varnish does not have particulate material. Varnish does not have particulate material. You know varnish is one which will not have particulate material. No solid. You want to reduce, also this is you know the particulate matters are added as fillers sometimes which will reduce the consumption of the vehicle. So this is what paints are.

So some other sealers or sealants could be also base coats. And they are applied to surface to help reduce the absorption and subsequent paint. So sometimes you might put something which will get absorbed in the substrate which is porous. So you will reduce down the use of the paint. Otherwise paints will be….

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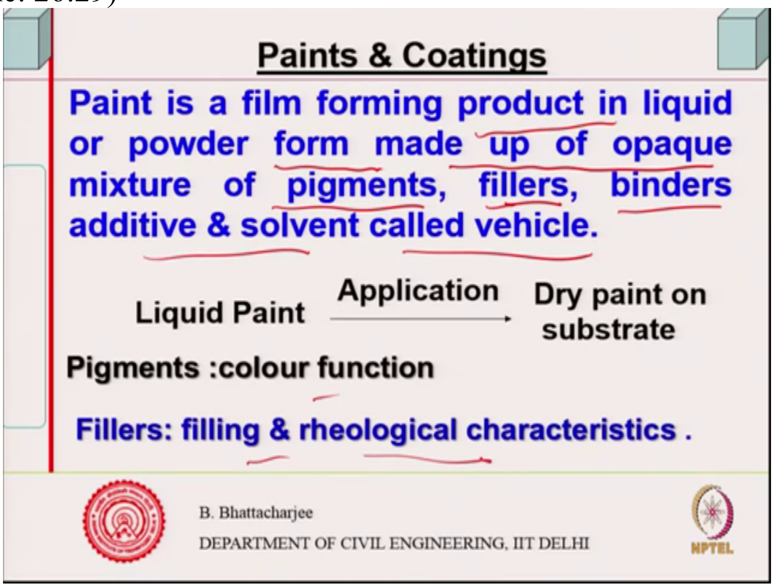

So paints is a film forming product in a liquid or powder form made up of opaque mixture of (pigment) pigments, fillers and binders, additive and solvent called vehicle. This solvent actually evaporates out. So you apply a liquid form paints, application dry paints on substrate. And pigments function is a color function. Fillers for application characteristics, rheological properties and filling.

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So with powder material the composition is, with no powder material it is called varnish. With no powder material it is called varnish. So binder essentially it has to bind to the substance. So this ensures coating of the powdery material. And most important these are materials are vinyls, epoxies and silicones. These are the binders which will bind it to the substrate. Wetting agents, sometimes we use fungicides, we might had. And solvent is a vehicle makes application possible, may evaporate or aids reaction. Some cases they might react to solidify. So they are usually oils or acrylic resins, chlorinated rubber, epoxies, polyurethanes etc. They are usually the solvents.

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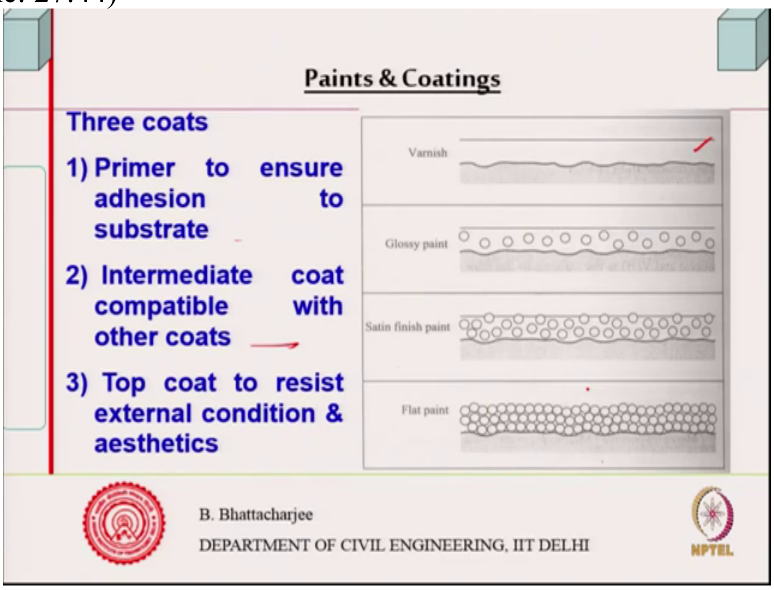

Primer as I said is ensure adhesion to the substrate. Intermediate coat, it might be between the primer and the final coat and top coat is resist external condition and aesthetics. So that is what it looks like. So varnish will have no solids. Glossy paint will have less solids so that it is glossy finish. A Satin finish will have some and the flat paint will have lots of rough finishes at the top. So this is what paints are.

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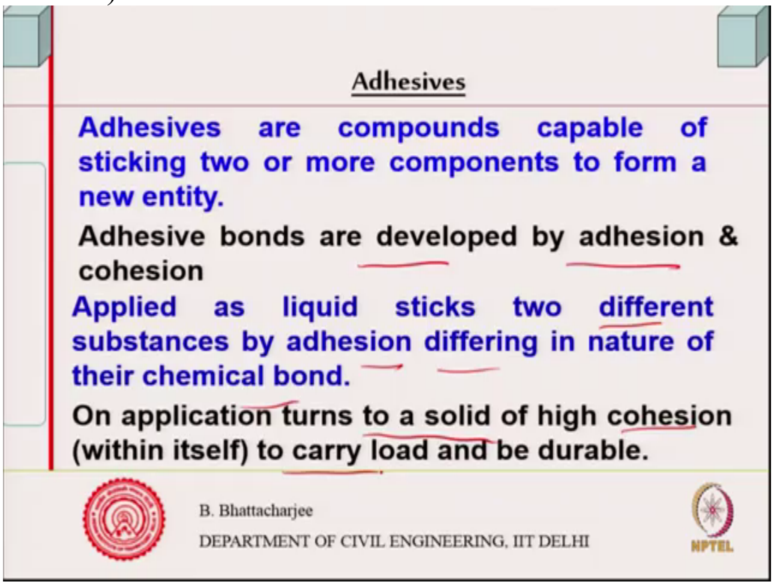

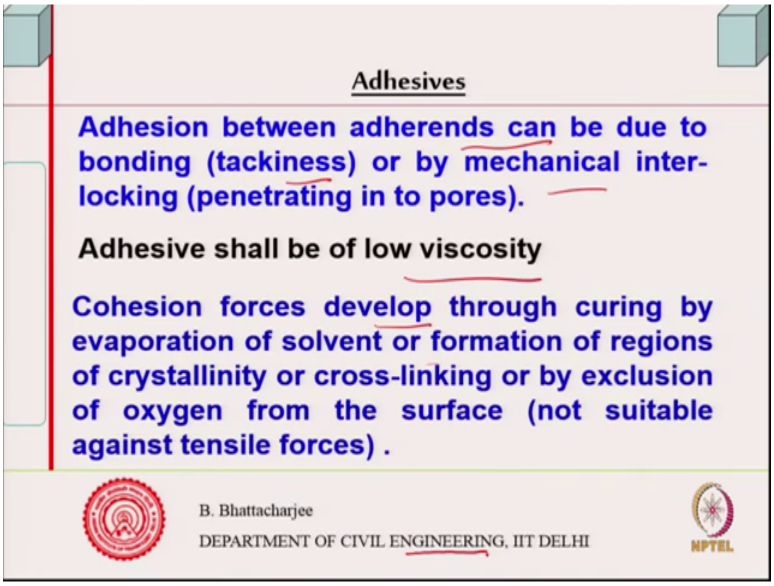

Adhesives are compounds capable of sticking two or more components to form a new entity. And adhesive bonds are developed by adhesion and cohesion process, applied as liquid stick to two different substances by adhesion differing in nature and they are chemical bond. So ask you can see all these are organic chemicals and they can give you volatile organic compound.

So on application turns to solid, this one, these adhesives. For example, you have something like M-seal, is actually epoxy. So it solidifies, two components it will solidify, can act as a bonding agent as well as sealant. You know perfect sealant but permanent sealant. Similarly you have other similar one like various kind of other formulations which will do the you know adhesive. So these are adhesion between adherent, it can be due to bonding usually by mechanical interlocking. Sometimes you have bonding but usually interlocking. They should have low viscosity. And cohesion forces develop through curing by evaporation of solvent as I said. Some cases solvent evaporate. Or, by reaction where oxygen is excluded from the surface. So brittleness should not come, it should not break easily.

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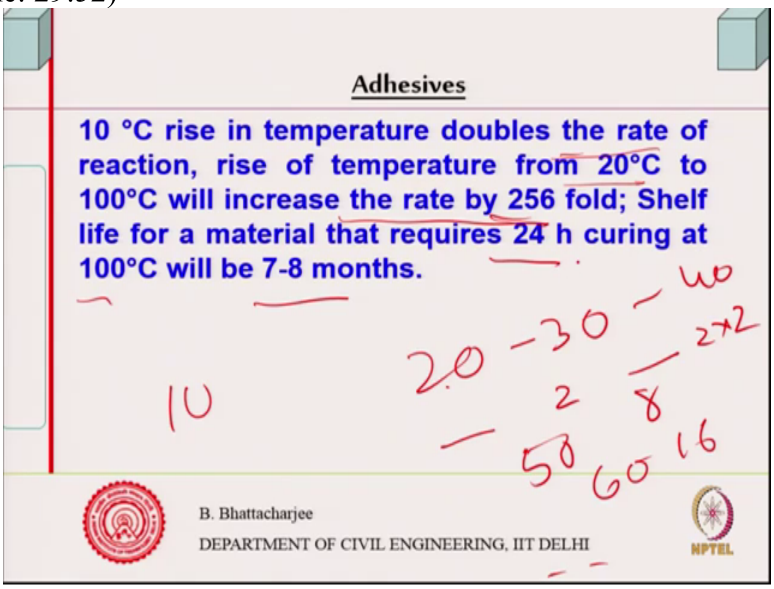

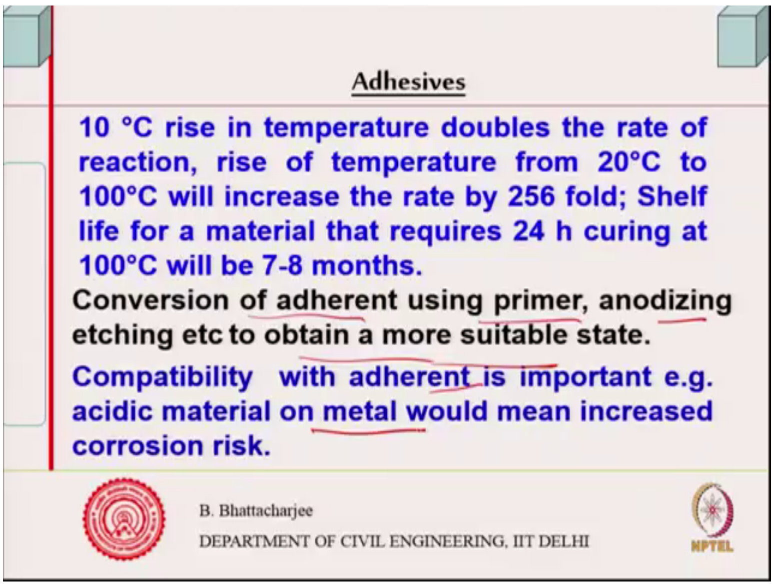

Now rate of reaction depends upon temperature. So 10 degree temperature, rise in temperature doubles the rate of reaction. So therefore if I have 20 degree to 30 degree, reaction will be twice. 30 to 40, reaction will be 2 into 2, 4 times. And so on, so if I go from 20 to 100 degree, it will increase by 256 fold. You know 20 to 30 degree reaction will suppose initial was 20, reaction rate will be doubled. 40, 4 times; 50, 8 times; 60, 16 times and so on. And 256 times, then we go to 100 degree. So therefore there is something called shelf life. So shelf life for a material requires 24 hour curing at 100 degrees will be 7 to 8 months. If you know the amount of the reaction rate for 100 degree would be 256 times compared to 20 degrees. So if it takes about 24 hours, 1 day it will take to 256 days at 20 degrees.

So therefore you know 100 degrees one is tested in the laboratory. So there is a shelf life and beyond that shelf life it will not, they will not perform as they are supposed to perform, because it would have got oxidized or some reaction with just oxygen you know surrounding environment. So Sometimes this is what is done. Anyway, so conversion of adherent using primer, anodizing, sometimes etching to obtain most suitable substrate. It is important to see that it is compatible with the adherent. If it is a metal, acidic material will increase the risk.

So I think that is what adhesives are sealant. But what is our interest, we look into sealants also. What is of our interest is to look into their volatile organic component emission you know. Now this can come also from things like many of the polymeric or plastic materials that you use in buildings, for example a carpet. You know from various kinds of finishes that used in building. So one has to test this actually for the VOC. Sealants, adhesives and paints they are used extensively, particularly paints. So they are paints and besides that like furnitures, many of them have got today polymeric materials. Even paint should be there in those ones also.

So we go, we try to find out how you measure or how you find out volatile and what are the possible limits because this use of low volatile VOC contain volatile organic compound content material. They would give you advantages in terms of greenness and similar sort of things. So we look into the sealants and rest of the things next.