Fire Protection, Services and Maintenance Management of Building

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Lecture - 01
Basic concepts of Fire Protection-I

So we start with Basic concepts of Fire Protection right and I just have some little bit of introduction about the fire, little bit of introduction then combustion process a little bit, then planning for fire protection and then will define what is called fire resistance.

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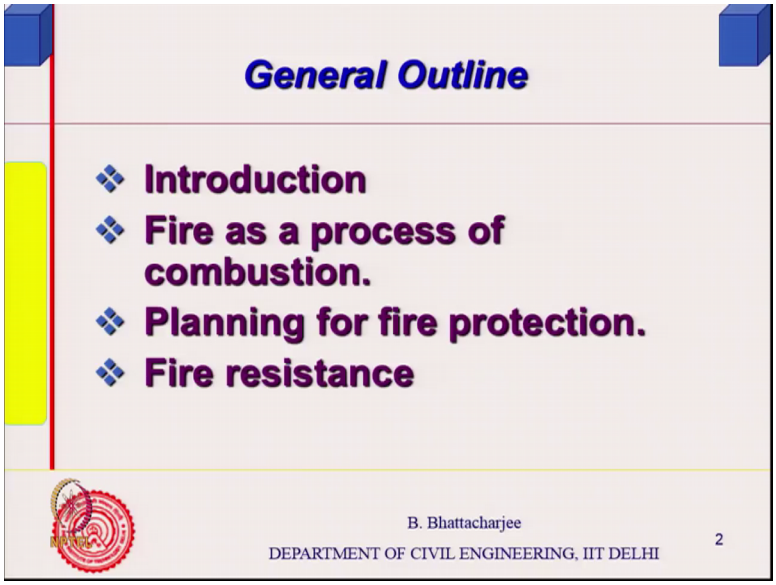

Because if you are designing a building, quite often you will come across you know what is the fire resistance of an element; so we will talk about that and then we will start with the effects of material.

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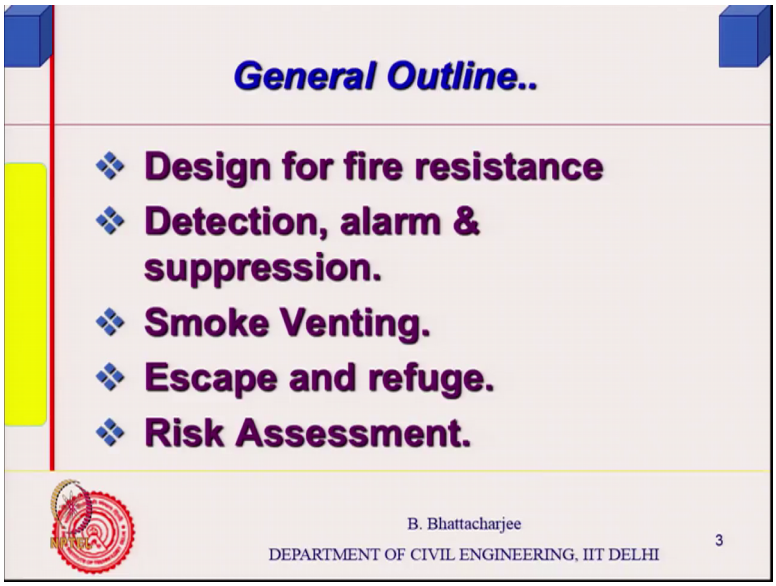

Now, if I look at design for fire resistance; the sequence goes on, then detection alarm system suppression, smoke venting, escape and refuge all this will be talking about some little bit of risk assessment.

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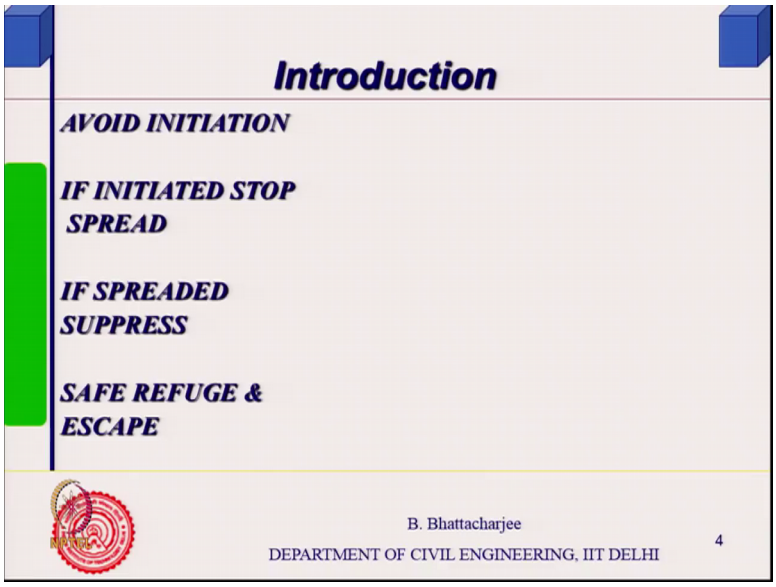

Now, if we look at fire strategy for any kind of nuisance any nuisance, you want to you know protect against any kind of nuisance, whether it is building or general environment or whatever it is; first thing is that stop at the source itself stop at the source itself, do not allow the source to grow; that means, avoid initiation of fire itself. So, avoid initiation.

Now, if you cannot you know accidentally initiation occurs even after taking precautions which can happen, then see that it does not spread it its intensity you know it does not spread over large space; its volume does not increase that is true for anything including even let us say we are talking of pollution today a lot just digressing a little bit from here.

So, if you want to reduced on the pollution level in the city, actually I should see what are the sources and cut down there itself. And you may be able to do it because there may be some constraints so, you may be able to do some, but you cannot completely stop it at the source, then see that how does it should not spread same thing goes for fire. We see that initiation should be stopped avoid as much as possible, and if it has initiated do not allow the spread to occur.

Then if spreaded accidentally because in case of fire it can happen that it has accidentally spreaded, then you should suppress it and then, in the meantime you must ensure that people there should go to a safe refuge escape out of the building except escape out of the. So, this is the kind of strategy followed in case of fire, and recently you have seen that there are several cases of death fire related death all over the world; the one in UK, recently one in New York 12 people died; you know 12 people died you can understand you can understand that in a country like India, this can you know we are not so, technologically well developed and neither we are so much our protection system is you know like the system is so much valuable; but even happening in developed world. So, anyway this is important; so that is why fire is.

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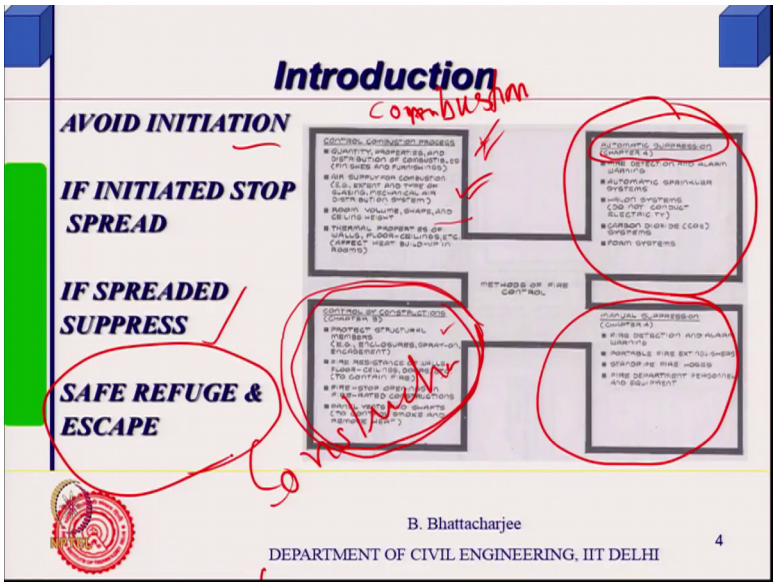

So, basically if you see this I have not very sure it is readable properly or not, but still what I will try to do is, I will write it on top of it. For example, this is control of combustion process you know control of combustion process; so that would avoid in this. So, therefore, this depends upon what will go into details, but just as an outline; quantity of the combustible material within the space right. Then air supply because as usual see just next slide, that three things are essentially required for fire; one is the fuel, other is air and it go to initiate. Therefore you need heat, after that it sustains on its own.

So, you have to sue this. So, air supply comes from ventilation into the building and combustible material present that provides the fuel and then, the its also depends upon the space, the volume of the room etcetera we shall see that. Then since the thesis to dissipate through the envelope or periphery of the room their properties are important particularly thermal properties are important. So, that is related to initiation. So, you controlled if you want to control them a little look into this, then also you can do control by construction that is what I am saying structural fire design, you know protect structural elements.

For example, you could not stop I mean it has initiated on its o you know accidentally, it should not be spreaded to the next room. Therefore wall etcetera should be designed in such a manner that fire does not go to the next space. Also one of the major important thing would be the structural system should not collapse. So, that structural control you

know control by construction. So, this is construction part of it construction control by construction and then so, when it comes to suppression automatic suppression. So, you can see certain automatic suppression here. So, you can have sprinkler system, alarm system etcetera, etcetera which will discuss and then manual suppression also could be there. You will see that manual firefighting systems are there will talk about them.

So, that is basically the kind of strategy generally we adopt, see that initiation do not occur; if its occurs, then it should not get spreaded and if its spreaded, then it should be suppressed. And in the meantime of course, you should take out the people; people should go to save escape in it was that the basic principle alright.

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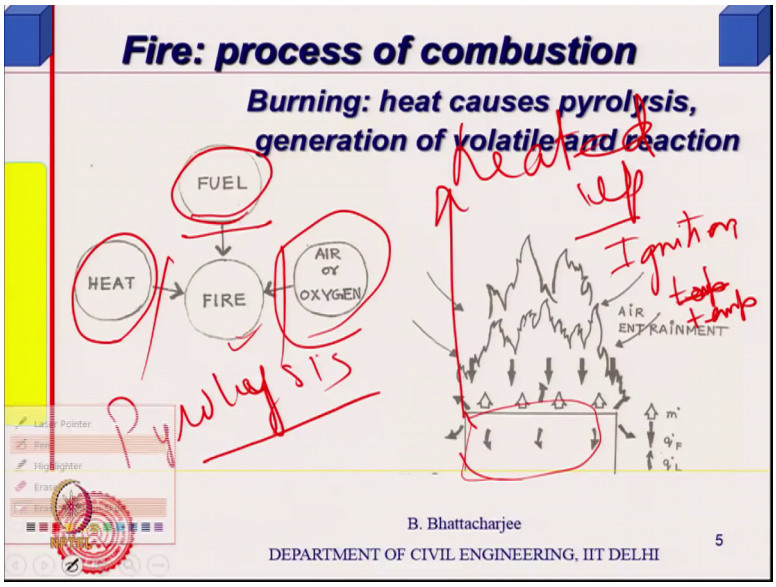

So, these are the three things required for fire, the fuel most important heat and air or oxygen I mean air has got oxygen 21 percent or so. Therefore, you know that is three things are essential.

Now, will also talk about it later on sometime when you talk in suppression I cut any one of them then fire will stop or I talk cut any one of them, fire will stop. And this will only when reach is finished then again firewood stop. So, even fire suppression system or otherwise I the strategy comes from this. So, basic understanding is I need three things for continuation of the fire. So, how does it occur? Something like this.

Let us say this is my fuel you know now fuel is what? Furniture's, wooden furnitures, combustible material; many of them are combustible papers, many of them are combustible materials. So, these are the so, this is why it is it shown like this; this is these are the ones.

Now, supposing for some reason or another, this gets heated up heated up; what will happen? Some of these molecules you know these combustible materials. Basically what happens is the molecules get broken down into finer molecules. The process is called Pyrolysis. Basically say wood or something when you heat it up or you know they are basically or polymers, they are large molecular weight material when you heat them up, they become smaller molecular weight and might go as volatile.

So, from volatiles and that for that it means energy. So, when you have supplied sufficient energy a time would come, then this will all get you know broken down into smaller molecules and came volatile mix with the air, in the gaseous form, and combustion process reaction with the oxygen will start this combustion process. So, you need heated up to what is called ignition temperature; heated up to pyrolysis will occur heated up to ignition temperature.

So, the ignition temperature generally would range from around 400 degree centigrade etcetera etcetera; maybe some of them even you know much less, but if you have inflammable fluid liquid, they instantaneously catch fire. So, that is basically the process of quick in the understanding of process of conversion. Now once you know once it has start as volatile started reacting, this is self generates heat once the volatile starts reacting with the oxygen; this process is exothermic you know only then only the fire would I mean fire would occur; fire is their gaseous in the flame is a gas phase phenomena.

Because when the combustion occurs, the reaction with the oxygen occurs; there is a combustion reaction, it would generate lot of energy, dissipates lot of energy. There is a exothermic reaction. Some of the energy is in form of light. Therefore, you see the flame right otherwise it generates lot of heat.

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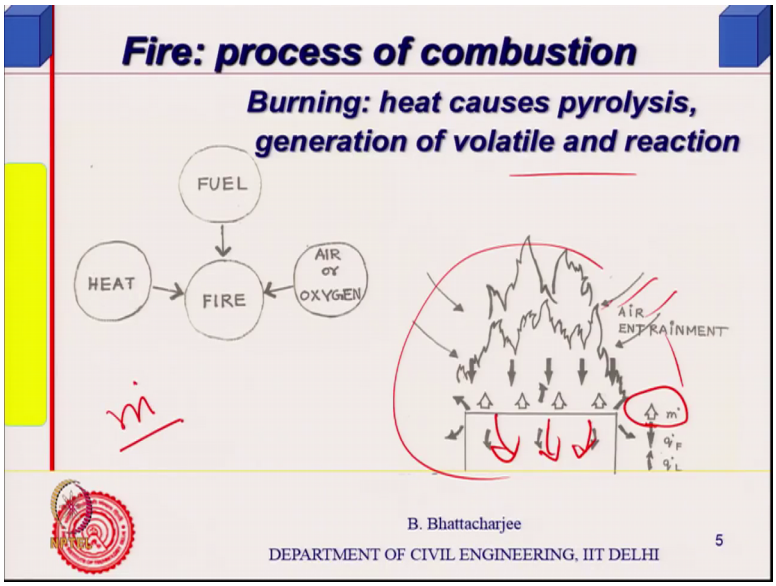

So, this heat energy again what it does? It supplies heat back to the fuel itself; supplies say heat generated will supply some heat back to the fuel itself and then, more combustible material will get pyrolyzed and if sufficient oxygen is available here is available, the combustion process will sustain itself till all the fuel is.

Student: (Refer Time: 11:14)

Consumed all the fuel is consumed right. So, this is what it is. So, essentially you know these are this is the process of combustion; this what occurs and then we do a little bit of quantification also. We can talk in terms of burning rate m dot. I will define this a little bit later m dot; dot is usually there is a nomenclature used in many books. So, dot is for rate, m is the mass. So, rate of volatile generation is what is defined as a burning rate. Rate of volatile generation mass of volatile per unit area mass of volatile, I will have a formal expression I think somewhere later, mass of volatile generated per unit area of the fuel right per unit time that is what is we call as burning rate burning rate right. And q F is the amount of rate of heat generated right. Part of this heat will go, part of it will you know it will heat up this and then further heat will be generated and so on so forth.

So, some heat would be required to evaporate them. So, one can actually get an expression, some will be dissipated outside; some it will be dissipated outside will look into that little bit later on right.

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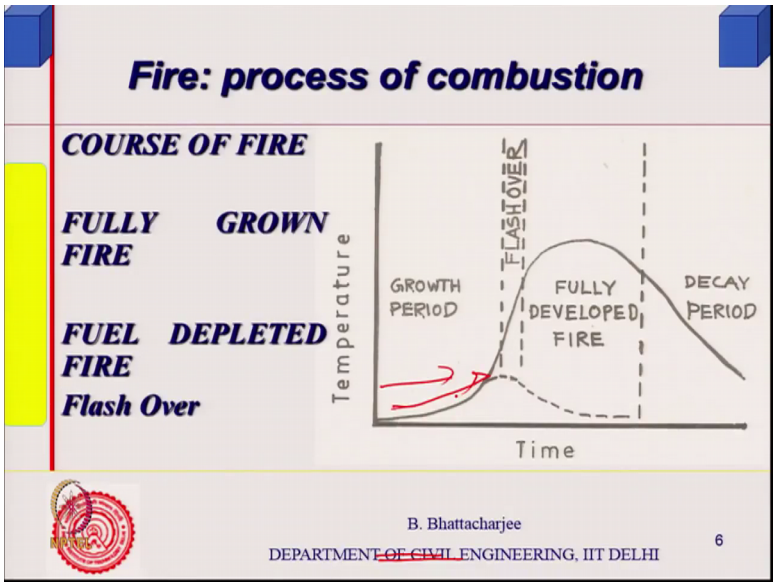

Now, within a building what happens within an enclosure? You see as the as the fuel goes on burning or combustible material like furnitures paper etcetera goes on burning, since it is a closed space, heat will not dissipate out completely. So, it what happens it with time, you find there is some amount of increase in the temperature.

But fire starts at some corner of the space, the room volume somewhere in the corner it starts and once it starts then temperature average temperature of the room starts increasing slowly. So, initially slow increase would be seen average temperature of the room. Localized in corner where the fire is actually occurred, it would go is the temperature will go high, but if you look at the whole room it has not captured whole the room. But subsequently what will happen is, normally I suppose I have another diagram will see that this is what happens is if I have a if I have a ceiling at the top, the fire causes hot gases to generate fire causes you know this is the flame let us say flame.

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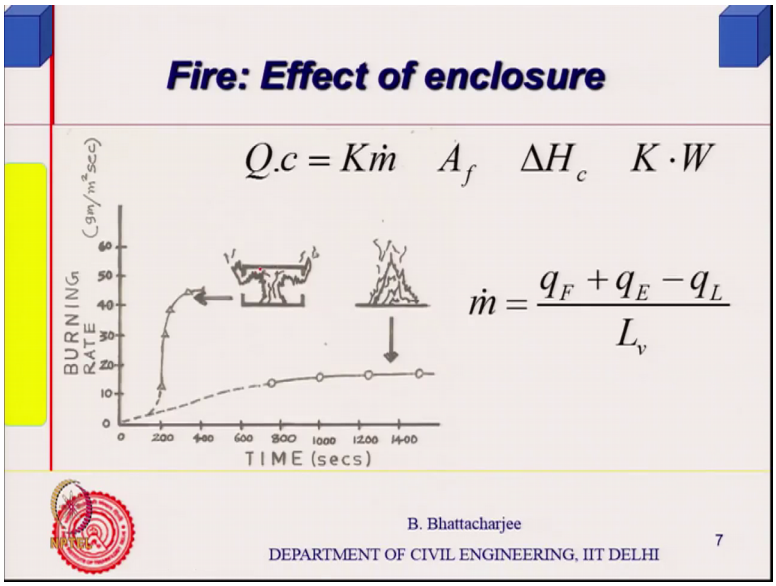

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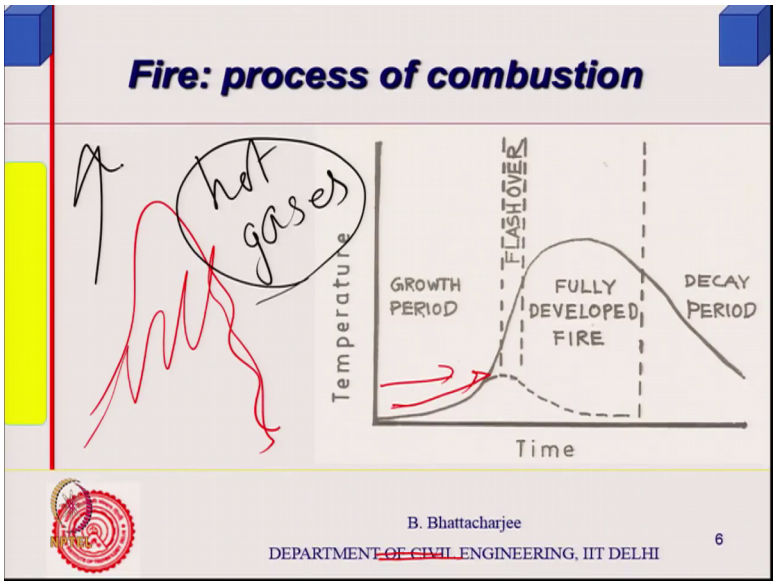

Now hot gases will come out of it hot gases right there air around at the product of combustion carbon dioxide, you know even my various gases could be there which you will see again; there are some of them are related to human health condition and all that. So, hot gases would be generated and this hot gases will have a tendency to go up; hot gases will have a tendency to go up and they tend to accumulate in the over the ceiling. Hot gases will tend to go up and they tend to accumulate over the ceiling, and this when ceiling is all heated up, let us say the space in the space you know this is the fire and the space around is space around is something like this, this is the space.

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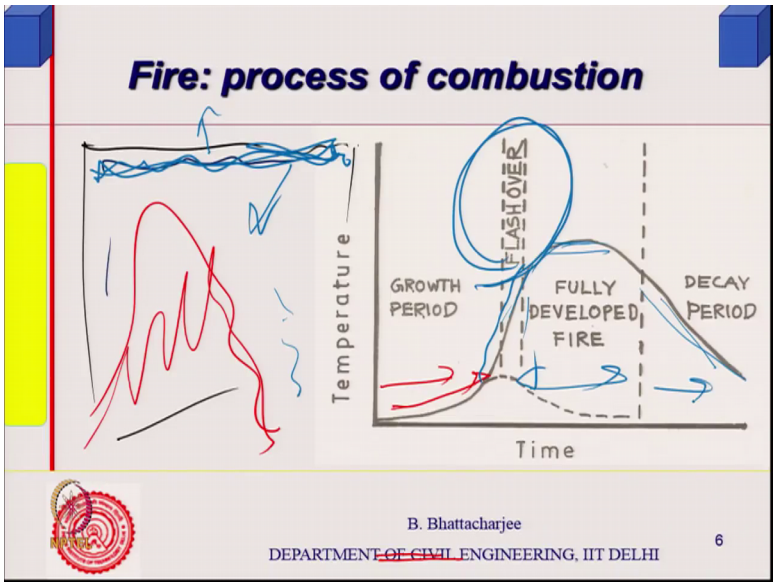

So, hot gases hot gases let us say hot gases starts accumulating here, hot gases starts hot gases will start accumulating here. Now this gas they would you know they would some of the heat will get transferred outside by conduction process through the roof ceiling, but it will also radiate back some heat to the furnitures and combustible material inside and they will all get heated up. So, initially started in one corner, but gradually it would try to heat up most of the combustible material in the room. And when almost all the materials combustible materials in the room attain nearly ignition temperature which can occur because now, the heat is retained and heat is be you know it is ready start heating the space total space.

More or less you will have some kind of an uniform temperature in the whole room and a time will come when whole room will attend or the ignition temperature of the combustibles which are average one an average would be similar line. Suddenly you find there is an increase in the temperature; suddenly you will find there is an increase in temperature the point where this occurs we call it flashover. We call it flash over. So, there is a flashover in these terminologies in some other places also fire related you know wherever. So, there is a flashover point; flashover means everything now has caught fire this is you might have experienced.

If you have if you have burned some you know what you call this there is the rumble, what is that agricultural waste what do they call it these days you see news.

Student: (Refer Time: 17:16)

Ah

Student: (Refer Time: 17:17)

Not husk not the husk.

Student: (Refer Time: 17:18)

No no no no no no no the tag thatch is prepared from what? See this the now they are like supposing you are burning. Supposing let us say forget about this, supposing you are burning something like straw in a heap and you have started the fire in one corner, you will find that initially spreads a little bit suddenly a large area gets you know captured by the fire itself. So, that is basically kind of flashover is occurring.

So, once flashover occurs once flashover occurs, the temperature rises rapidly and then, it continues there continues there as long as fuel is available combustible material is available and then there is a decay periods. As the combustible material depletes the combustible material because they already burnt out then there is you know decrease.

So, this is called fully developed fire, this flashover then there is a decay period. But anyway if I am suppressing it, then it might come somewhere there you know if I am suppressing it if I am able to suppress it might even follow this. So, if I can suppress it is fine. So, this is called this is you know growth of fire in an enclosure in a room right. So, fully grown fire and fuel depleted this is flashover we have already defined fuel depleted fire here, fully grown fire somewhere there.

So, actually it builds up suddenly everything catches fire, then there is a steady period maybe how the small it may be and then there is a decay, because fuel will now consume you know it will get consumed and reduced in that is all the fire occurs. So, that is the process of fire in a building space in a building space this is the kind of fire.

Now therefore, one thing what is an indicator? Supposing I want to consider the you know quantify the fire; quantify the fire very dangerous fire or not so, dangerous fire or let me put it in appropriate words, very severe fire and not. So, severe fire it would depend upon what?

Student: Temperature.

Temperature and also the time; supposing I have a lot of fuel then the steady period would be longer. I mean say I am talking of fuel density, room volume remaining same let us say you have a higher fuel density then it would require longer time to burn out right it will take longer time to burn out. So, temperature and time this is the two issue. So, fires are defined by time temperature curve, fires are defined by time temperature curve right fires are defined by time temperatures come we will come back to this again we will come back to this again. So, fire you know you define fire by time temperature curve will come back to this.

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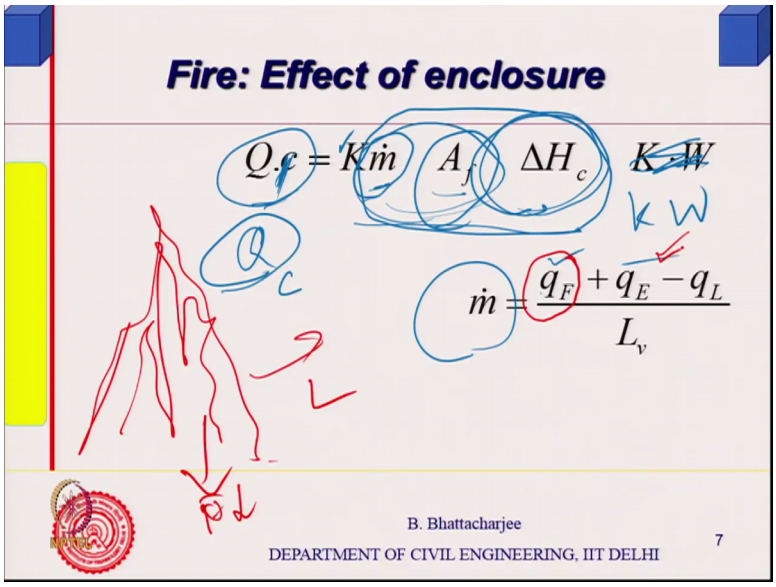

Now, we see this small equation not very complex I said m dot.

Student: (Refer Time: 20:22)

What is m dot it is burning rate.

Student: (Refer Time: 20:27)

Burning rate of burning that is rate of volatile generated per unit time per unit area multiplied by the fuel area, multiplied by the fuel area. So, that is that this one will give me mass of volatile generated from the total fuel area in the room, multiplied by heat of combustion this should be kilowatt this kilowatt right. Delta H c heat of combustion.

What is heat of combustion? It is the heat generated by burning unit mass of the material, completely burning unit mass of the material or in mass means what mass I am talking of? I am talking of the volatile when oxygen supply is abundant you know there is no problem with the oxygen supply.

So, delta H c is heat of combustion, which actually is you know amount of heat that will be generated by the volatile which is generated. So, this is the amount of heat that will be generated in the exothermic reaction multiplied by a factor k which is accounting for un you know incomplete burning and things like that some factor. So, quantity of heat that would be generated would be given by Q actually it should be in Q c Q c it should be written like this Q c, heat generated in combustion should be you know should be it can be given by like this can be given like this right.

Now, I was just telling you about effect of. So, it is actually K m dot f delta H c kilowatt Q c quantity of heat rate of heat generation anyway we are talking about, because its mass generated per unit area per unit time and multiplied by the area. So, the area part is gone. So, this is the quantity that would come out in per unit time and each unit mass generate this kind of heat. So, total heat generated per unit time is this that is why it in kilo kilowatt or watts or whatever it is and this is k is for incomplete burning.

So, m dot is given by q F that is the amount of heat generated per unit area. Because you know when you talk of we denote capital Q is a total quantity right for area is not involved and this is small q you normally use for per unit area heat flux, it is the heat flux per unit area. So, q F is a heat generated or heat generated by the fuel per unit area right which would come from here if I divide by A f. q L is a heat loss to the surrounding. Because when we talked about earlier this diagram if you remember I talked about something like this, you know when we talked of fire you know fire we said that some heat goes away lost, some heat goes to the fuel, some heat goes to the fuel again and you know some heat is lost and q F is the amount of heat generated by the fuel, if there is a radiation back if it is coming from the surrounding right.

For example I said if there is a wall or ceiling, it will get heated up gases they will heat up and they will supply the heat. So, if the heat you know it gets some more heat from there that also should be added minus whatever is a heat loss from the fuel divided by latent heat of you know pyrolysis, latent heat for volatile generation. Because we want to

generate the unit mass of the volatile, how much heat do I need to generate unit mass of the volatile how much heat I need that much heat is L v. So, its latent heat required to generate unit mass of the volatile. So, this is the total heat available divided by the heat required to generate unit mass. So, if I divide by this I get the mass flow rate mass flow rate so, that is what it is right.

So, I think this must have been also there in the previous diagram you see, q F q L is the lost; q F is coming to the fuel and q E is coming from the environment actually surrounding environment you know surrounding environment. So, that is how I will be I will I will I define the mass flow rate.

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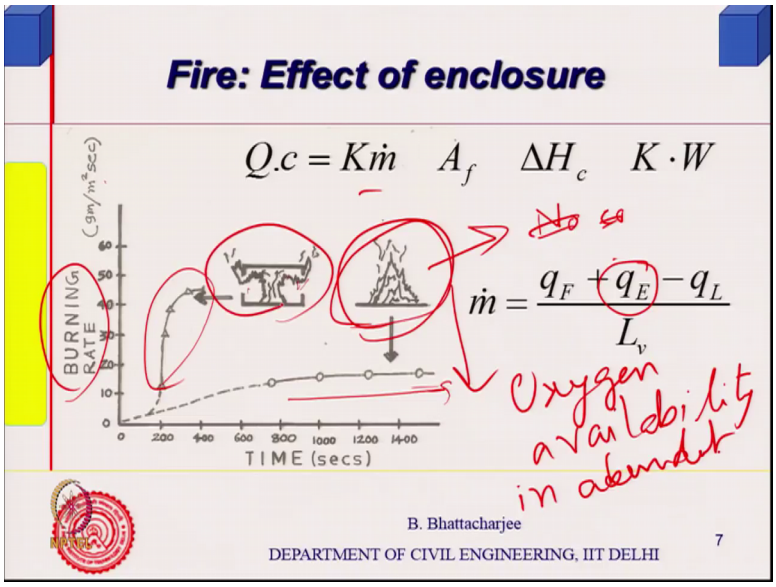

And if I have a ceiling, you can see this component will be higher if I have ceiling if I have a ceiling rather than in open field rather than in open field right like you know fourteenth January you have Lohri.

Student: (Refer Time: 25:24)

And you have Bhogali Bihu in Assam right. So, they also barn a heap of straw and the house made their small you know. So, early in the morning because a harvesting festival all over the country you find that I think Pongal is also similar time. So, it is basically the crop that comes out celebrate that all over the all over this subcontinent anyway. So, some somewhere you call it Sankranthi, somewhere you will call it Lohri, in western part

of country they call it Sankranthi Makar sankranti they celebrate Gujarat Maharashtra in the east they call it Bihu and in fact, south the other name; so, whatever it is.

Now, you burned something of this kind there, this burning is open burning. So, when you have open burning it finishes of much faster and since this component is not there the temperature rise is also lower. It burnt might complete fuel burning might take a little bit longer time, but the temperature rise here would be higher because it is all enclosed the gases occupy here and they tend to. So, dissipation of the heat is less here. So, temperature you know. So, burning rate is higher in case of burning rate is also seem to be higher gram per meter square per second is higher when I have when I have an enclosure, when I have enclosure also temperature goes high in such situation right.

So, because heat generated would be higher and it is retained anyway.

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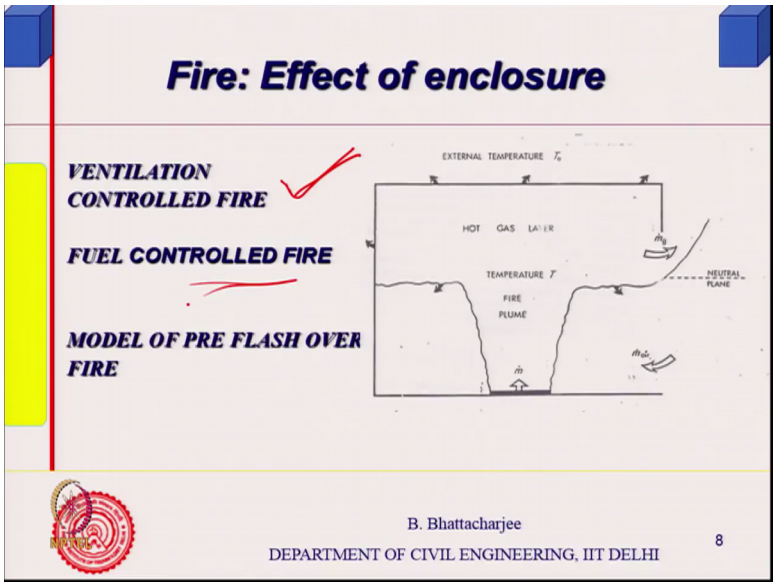

So, effect of enclosure is like this, now other issue is the ventilation, because oxygen is the other thing. So, if you will see this here I had all oxygen was available all the time, no depletion you know no constraint oxygen is no constraint or no you know oxygen availability is oxygen availability in abundant where this here you may not have sufficient depending upon the ventilation condition. So, if oxygen is not available again, you know it will slow down because burning rate will be now governed by the rate of oxygen available volatile is available alright.

But the volatile cannot react because the amount of oxygen required to react with the volatile generated that will not be there. So, volatile will remain as it is it will not react therefore, burning rate is controlled by the oxygen supply, where there is a constrained in oxygen supply. So, these are called ventilation control fire typical building is ventilation control fire, because it is not open thus some windows some doors I mean some of them may be open or may be closed, but some of them would be open and if nothing is even open you will have infiltration. What is infiltration? Leakages some oxygen will be there, but no oxygen.

Now, suppose supposing it is not there at all, then fire will simply extinguish itself on its own it will consume all the oxygen present within the room and beyond that it cannot really sustain itself. So, we call that as ventilation controlled fire, where ventilation is in short supply, oxygen is short supply and when I have got fuel less lot of oxygen that we call as fuel controlled. Because you know less fuel we call it fuel controlled less oxygen we call it ventilation controlled right. So, will see that quickly will look into this. So, there as somehow how do we model this will look into it. So, maybe this is how the behave fire behaves. So, will break here if you have any questions I will I will take it and then proceed forward right.