Energy Efficiency, Acoustics & Daylighting in building
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Lecture – 02
Introduction & Environmental Factors (contd.)

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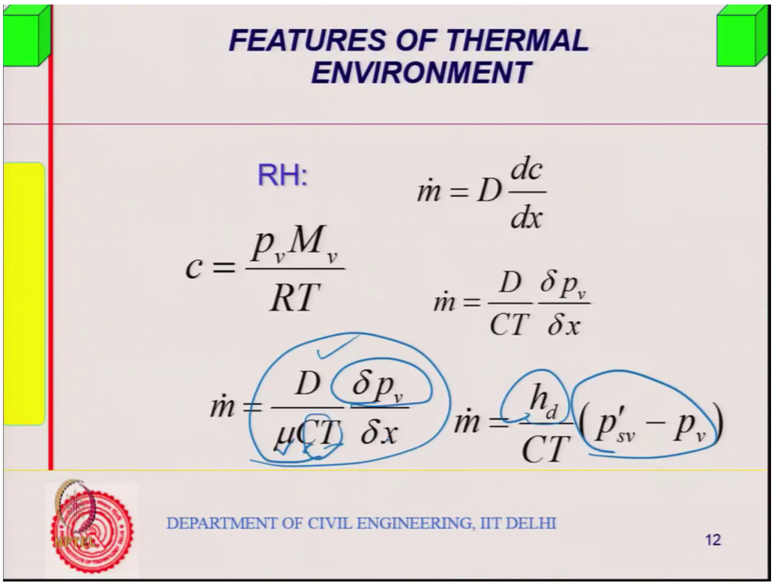

So, continuing from what we have done, what you have seen is you know rate of flow you can be written in this manner what this is a resistance term R divided by M v C, T temperature as their deficient coefficient. Now, this I can write supposing you know this part vapour pressure difference delta p v del p v and h d corresponds to all other terms right other than this. So, D mu and the distance across which it is. So, this is something similar to a kind of a convective term. So, this is a convective. Now what is convective term perhaps it is looking at slightly you know this is for the new for you.

If you were if you remember in case of cooling Newton's law of cooling, the rate of cooling is proportional to temperature difference. Something analogical to this here, we will discuss that convection later on something analogic to here the late rate of vapour transfer or mass transfer is proportional to the.

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Vapour pressure difference. So, this is what it is, this is what it is. So, we are trying to get an expression to show that T minus dry bulb temperature minus wet bulb temperature that is the wet bulb depression is a function of relative humidity, that is all we are trying to do.

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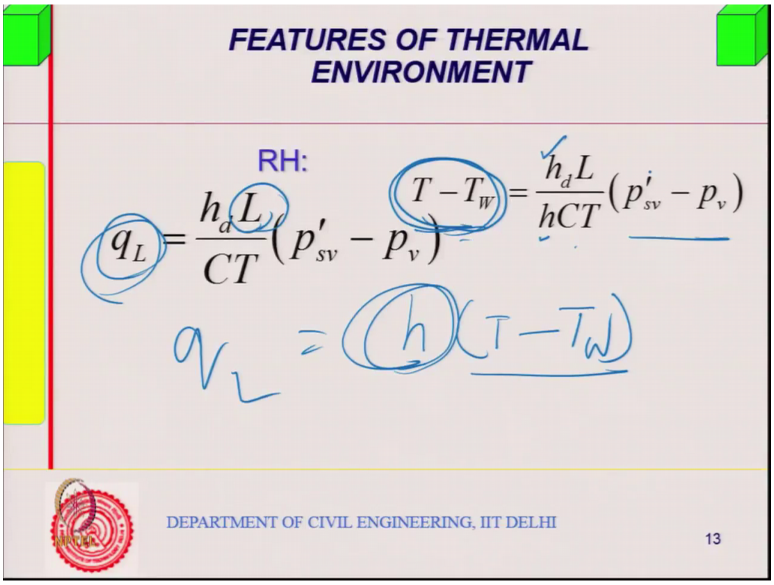

So, you see the amount of heat that will be transferred, this is the mass transfer multiplied by.

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Latent heat of evaporation. Mass transferred was this much, mass transferred was this much, I have replaced all things by a constant h d C T remaining here. So, D mu and D mu per unit length that I have done transferred into h d equivalent as if it is per unit length. So, this is you know this vapour pressure difference is this. Now, if I want to find out the amount of heat that will be transferred because of the vapour transfer has occurred, vapour or moisture transfer is occur know it will be related to mass because m dot is the rate of mass transfer, mass of moisture vapour that transfers. So, the latent heat associated with this. So, if I multiply this by l, I get the rate of heat transfer associated with this.

So, I simply multiply this by q L is a heat flux per unit area. So, everything has been per unit area. So, latent heat transfer I have just multiplied by latent heat. And this is you know this latent heat transfer I have just multiplied by this. So, amount of heat transfer is this and this will be also equals to from convective law of convection. If the temperature difference between the dry bulb temperature the wet bulb temperature, temperature difference is this much. Then the amount of heat that will be transferred is given by convective heat transfer coefficient multiplied by T T W.

So, therefore, T minus T W is h d divided by h etcetera, etcetera. So, wet bulb depression is a function of the it is related to saturation vapour pressure minus the vapour pressure you know saturation rule. Supposing I have moisture on my skin, then this is in a saturated state of affair T W I can assume, surrounding is there is some dry bulb temperature existing. And this difference is related to the vapour pressure difference saturated vapour pressure minus vapour pressure difference, so that is how we are trying to show that T minus T W is a function of you know this wet bulb depression as we call it we can estimate this also from vapour pressure. And that is the empirical relationships are possible and you know I can find out.

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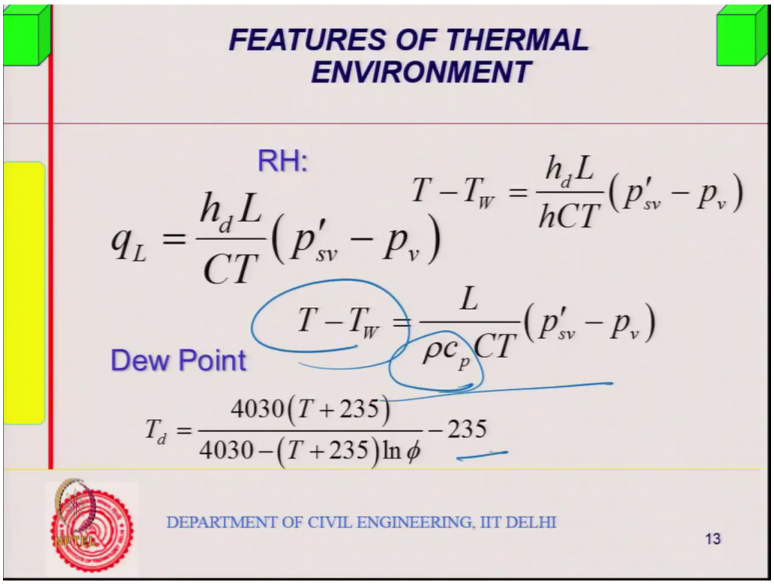

So, T by it can be written as h d by L also related to the specificity and density of the this can be related to specificity and density of the C p stands for specificity of the air under constant pressure. I think we will be further clear when you discuss them somewhat later on. So, all that I was trying to point out here is wet bulb depression is related to the relative humidity..

What is dew point? Dew point is that temperature at which moisture will become you know supposing I reduce down go on reducing the temperature of the air, now a point will come when it will become saturated, so that is the dew point. If you try to cool it further actually condensation will occur, so that is dew point. So, dew point there is an empirical formula like this. I think I will not discuss this much, this is an empirical formula available for dew point. So, this is absolute you know this is absolute 4030 etcetera, etcetera this is relative humidity minus (Refer Time: 05:31). So, this the dew point is I do not think I will be interested further on this at the moment.

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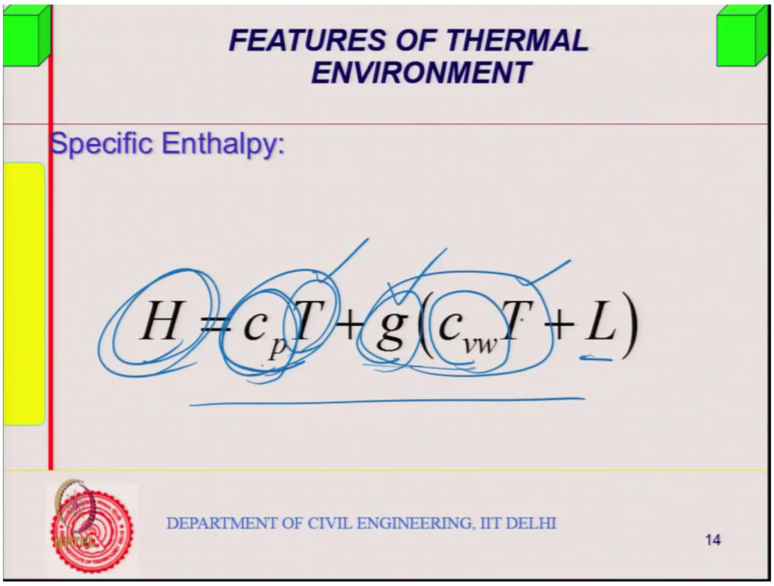

Now, we define something called specific enthalpy. What is specific enthalpy? Enthalpy is the heat content of the air actually, we are talking of air here. And we measure we can only measure the change in enthalpy you cannot measure the enthalpy as such. So, we measure the enthalpy change from a relative temperature; in our case it is 0 degree centigrade. So, if the specific heat of air is C p, temperature absolute temperature is T then this will be the specific component because of the dry air its temperature being higher, mass into specific heat into temperature difference. So, it is for per unit mass. So, this is the amount of heat content of the air per unit mass unit kg at a temperature T. And this is the moisture content, this is the specific heat of moisture vapour and this is latent heat.

So, we assume also that all vapourization takes place at 0 degree centigrade. So, if it has got some moisture content, that moisture will come from it would have evaporated let say as an assumption at 0 degree centigrade itself and it has got some heat content that is what we are going to look into right. So, this is specific enthalpy. And all these are they are in the psychrometric chart. So, if you see in the psychrometric chart, you know dry bulb temperature, there will be a line for specific enthalpy also related to dry bulb temperature and moisture content.

So, specific enthalpy is a function of dry bulb temperature and moisture content right. So, it is actually you know it is like this is the product of course, g into t, but; however, we have lines. So, in psychrometric chart therefore, lines are there for specific enthalpy, the lines are the curves are therefore, relative humidity you know saturation line and so on which I showed you earlier. Let me see if I have yeah we have I will go back again to that diagram.

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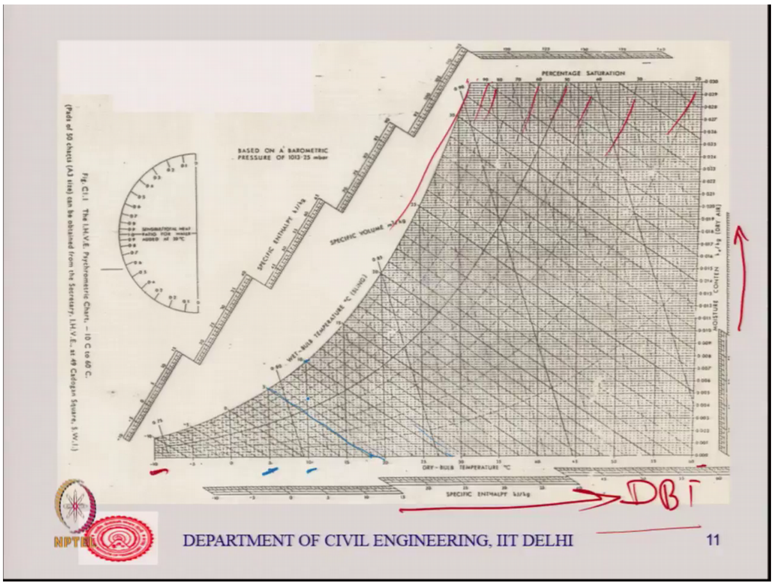

So, that is why you can find out a from here you can find out, so the specific enthalpy line say here. Wet bulb temperature and dry bulb temperature is same at 100 percent. So, if you see this is this is let us say 4 degree or this 10 degree and this is the wet bulb temperature is also 10 degree. So, wet bulb temperature lines are inclined like this wet bulb temperature lines are inclined. So, this is 10 degree wet bulb temperature, 10 degree driver. So, this is the temperature line. So, wet bulb temperature lines are inclined, they are same at 100 percent vertical lines are dry bulb temperature.

So, wherever you know when it meets that 100 percent saturation line that will corresponds to 100 percent 10 degree same amount or 10 or you know whatever temperature is same wet bulb temperature. And otherwise, it is inclined because for lower humidity difference between wet bulb temperature and dry bulb temperature is high. So, if you look at this line, let us say which is a 10 degree here at 20 degree, the wet bulb temperature is 10, dry bulb temperature is something like 18 or something like that you know for zero relative humidity.

So, they are inclined in this manner then there are specific enthalpy line as I said specific enthalpy lines there you know. So, the other lines are also their wet bulb temperature specific enthalpy lines this. So, in psychrometric chart, you might have a look at that in s p 40 on I think I have given you reference and you get that it you get that in our you get in website straight away. Most of the institution I mean IIT, Delhi is definitely a member of Indian Standard Institution. So, in our library website, you will get sp 41 and you get this one straight away. So, you can you can click and get it there is no problem, but if you look at the code anyway it will you will get it. So, if you look at the code anyway you will get it.

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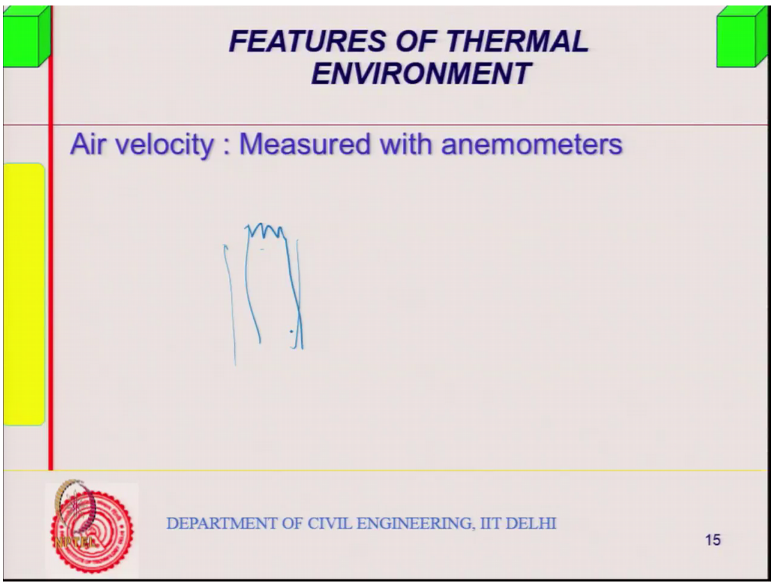

So, coming back to this. So, then let us look at relative humidity of looked into let us look into air velocity. We have talked of also specific enthalpy because it is a part of the psychrometric chart. Let us look at the air velocity next temperature we have looked into it quickly I have told you how we can do the measurement. And then relative humidity I talked off. And I said that if you know wet bulb temperature you can find it out from psychrometric chart or some empirical equations are there which I just showed you, but I think I solve a problem sometimes so that it becomes clear better.

Next parameter is air velocity. Now, it is measured with anemometers, anemometers right. There are of course, very common is what is called hot air hot wire anemometer hot wire anemometer. So, basically nothing but a small you know this is a base, and you will have a small resistance. Now, this will be connected in you know you got to measure the resistance as you know you know resistance will change its resistance change with temperature. So, what is done is this is exposed, there are one can use two principles and it is a part of an arm of Wheatstone bridge or whatever bridge it is measuring resistance measuring system.

Now, if I pass a constant current through it, and air velocity changes then this temperature of this one will come down because it will get cooled by air stream. Now, temperature will come down, same current I am trying to pass or I can maintain the same temperature by changing the current means resistance keep the resistance constant change the current, so that current is a function of the air velocity itself. Or if I am measuring the resistance change because of a constant current, the change in resistance is a function of the can be correlated to the air velocity though that is you know in a cross manner that is the kind of principle hot wire anemometers uses. And they can be used versatile 0 to 13 meter per second. So, we can use them inside the room and even outside for wind velocity measurements.

But has to be study, but then he would have seen cup anemometer, vane anemometer, you might have seen on building top cup anemometers you know. So, they will have three cups right and they will rotate. So, as the wind velocity causes them to return or windmills. So, these are this is the one, so largely one can measure with anemometers there is something called a kata thermometer. A kata thermometer also measures air velocity, because if the air flows the there could be a depression in the.

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Apparent depression in the you know there can be apparent depression.

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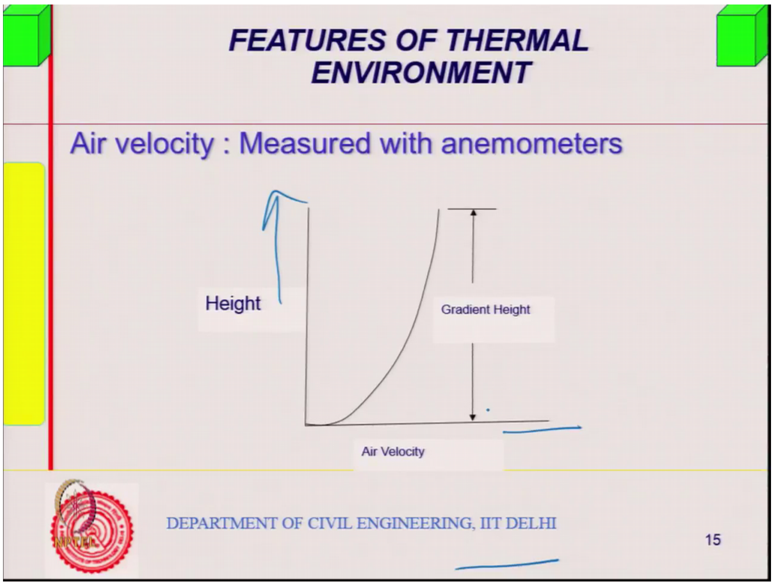

Now, velocity varies from ground level to the height, because you have done course on loads wind load. I am sure many of you would have done a course on wind load. And if you have done that you would have remembered that we measure the wind velocity at 10 meter height. And you have you know k 1, k 2, k 3 factors multiplying for the load now one of them is related to topography. So, as the topography changes this height will change. The velocity near the boundary ground boundary is 0, it increases and a height beyond which it does not increase further we call it gradient height. So, wind velocity varies with height.

So, we measure at 10 meter. So, 10 meter is you know where your meteorological department will measure airports stations and all those you know air bases or airports they measure because the needed aviation people. So, 10 meter is height where it is measured, but there is something called gradient height. So, as you go up, it is it increases and becomes constant at a given point which you call this gradient height.

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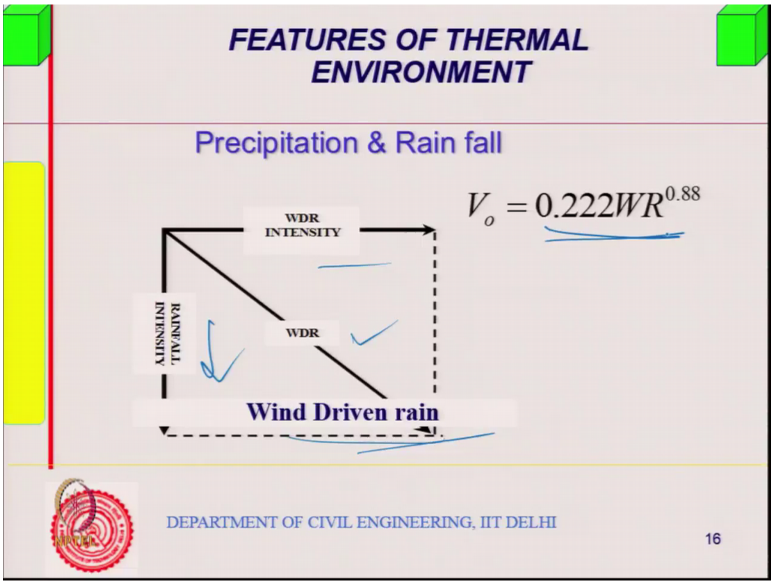

Precipitation and rain fall is the other feature. Precipitation is what it is both snow, rain everything put together we call it precipitation. And driving rain index is very important in certain type of climate. Rainfall intensity you know we would like to protect the building from rain as well. So, in certain for example, if you come from Kerala our northeast in India you have a lot of rain fall. And therefore, and you know wind driven rain as we call it, it would like to push it inside into the room or space that you know.

So, wind driven rain is important not only that when it impinges on your wall the moisture can penetrate through the wall. So, design against such kind of moisture movement is wind driven rain is a factor. Although we will not discuss this in our class wetting and drying condensation or moisture movement in building materials or walls or building envelop will not talk about that in this class, but this is a parameter important parameter.

Now what is w d r w d r is actually is the intensity of rain fall multiplied by rain fall intensity multiplied by the wind velocity. Some factor multiplied by wind velocity. So, WDR is wind driven rain. So, this is important, but precipitation itself is important to classify the location or you know its which zone of climatic class it belongs to.

Without going to the climatic classification right now, which I will come to you a little bit later on. As you can understand those who have come you know say like Delhi, Delhi has got a climate which in the month of May and June if you are here it would be very,

very dry and very hot about 40 to 43 degree centigrade sometime. And if you compare that with let us say Mumbai where there is a lot of rain fall, the temperature do not go that high, but the humidity is very high.

So, you see when you are designing your building for functional purposes thermal comfort, you take got to take these aspects into account you go to take these aspects into account. So, therefore, we can classify these places according to their climatic situations I will come to climate later on and that are why those parameters of the you know which through which you classify the climates or parameters or factors of environment that is what we are discussing one by one. First, we discuss temperature, then relative humidity air velocity and now just now I mentioned about precipitation and rainfall.

So, this is called wind driven rain the formula for wind driven rain V 0 – 0.22 this given by one lacy Mr. lacy from IHV guide Institution of Heating and Ventilation Engineers England. He published this you know this equation there; its guideline it was available now they call it Chartered Institution Building Services Engineer. So, whatever it is V 0 is 0.222 W, where this is the wind velocity R is the rain fall intensity to there is an empirical equation, so that gives you the flux or rain flux. Again I said I will not discuss wetting and drying that says that can be you know 42 hours lectures is not sufficient , but I wanted to introduce these parameters to you when we are looking at the subject.

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So, desirable air and radiant temperature, relative humidity, air flow, air velocity, control through proper choice of proper orientation, envelope fenestration design. So, all these aspects you know at temperature or temperature coming from those hot surfaces of the building, relative humidity etcetera, etcetera, I can actually control somewhat through proper design of the you know envelope.

Now, what is building envelope, it is basically there is a formal definition I may give you in the next class if possible; formal definition is defined in some quotes actually. So, it is the basically all everything that is in contact with your surrounding environment you know just immediate interaction of the surrounding environment who is the building envelope. So, which will include in fact the sunshades; and things like that the walls and the roof and so on. So, I can design that also design the fenestration.

Now, what is fenestration? It is the openings, which are left by choice by design for day lighting and ventilation purpose natural ventilation purpose. As opposed to infiltration which is not by choice by default. For example, leakages through you know gap in the window, window does not close, does not seal, there will be some gap, so air can enter through that is infiltration. So, infiltration is not by design is by default poor construction you know etcetera, etcetera, while this is by design fenestration is by design. So, proper orientation etcetera, etcetera and we look into in this course we look into all these issues.

Proper glare free lighting through day lighting that is what is another aspects we should look into glare free lighting now glare I will define again later on, but quickly glare occurs when you are looking to the car headlight. Do not see anything it is called disability glare you do not say anything, but the glare can be a kind of discomfort glare also which can happen in a classroom sometime we will discuss that sometime later.

We design the illumination task illumination for writing for example, if the light is not sufficient you would not be able to write. Contrast between say this is blue in color, this is black in color and background is white. So, there is a contrast. Now, when I am making the slides if I make it yellow you would not be able to read it right the contrast has to be there or if the background was by and large blue and I have written black maybe you would not see it so well. So, the contrast is important. Brightness contrast illumination design takes care of all those. And noise control privacy through various kind of zoning, planning, barrier design, insulation and acoustic design I will talk about this. So, this is what we will cover in this particular course in general; and just now I talked of environmental features measurable features through which I define the environment.

So, I think after that we can look into thermal issues. And in that context I must look into earth energy balance. A part of this is available in a book written by Suzhou Lake Kenneth Berger and all those in a right there given in the reference say cheap book available you can look into it. So, also I have a written lecture notes on the subject typed out given two previous years batch you can look into that and it is available written material is available maybe I will upload it sometime. So, in order to look at a thermal issue, I should look into earth energy balance, and you must be hearing about global warming quite a bit of it now.

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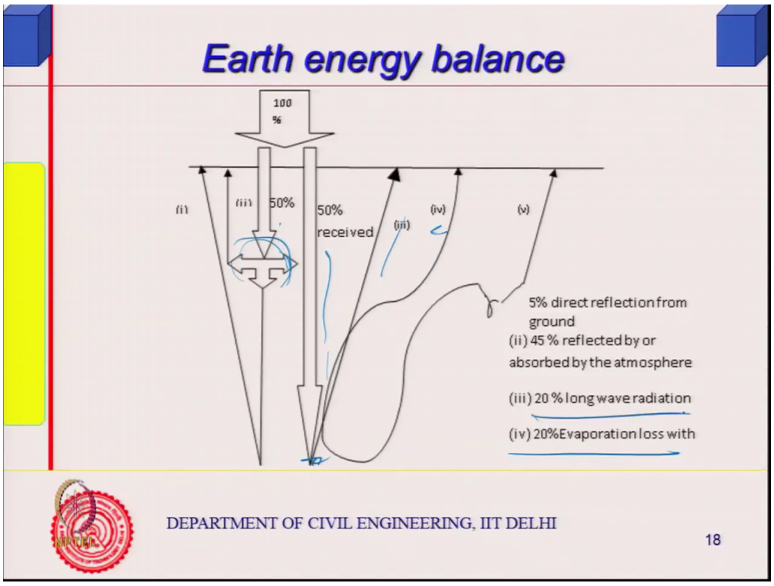

So, this might be relevant to that. You see at the top of the atmosphere, we get 100 percents you know supposing I get 100 percent solar radiation. Now, what happens is if you look at it some of it directly 50 percent is received to the ground some of it will go away reflected away straightaway at the top of the atmosphere. Now, this is 4, and number 4 is 20 percent by evaporation loss moisture is there, if the ground level sea is there so evaporation loss. And this is you know this is 50 percent comes is absorbed each one of them will look into 50 percent is absorbed in the atmosphere itself, 50 percent is received. Out of this 50 percent some goes out reflected directly and some of it will be absorbed in the atmosphere.

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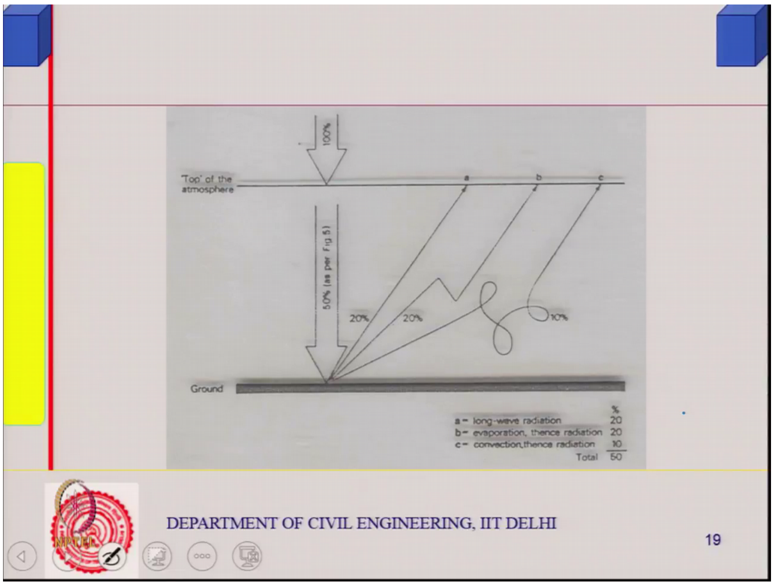

Now, there is a terminology 20 percent long wave radiation you see what is long wave radiation that is what it is. So, if I 50 percent is received, 50 percent is absorbed in the atmosphere part of it will go back straightaway and part of it will come to the ground and get reflected. Finally, of course, you can understand there is a periodicity in the whole thing, annual periodicity. Every year we receive energy from the sun, whatever you receive today 365 days later, you are likely to receive similar kind of thing not exactly same, but it is likely similar almost similar. So, there is a annual periodicity.

Now this whatever energy the earth is receiving over that cycle it must be dissipating out the same. Otherwise, temperature of the earth would have increased over this years, and you know and by the natural process and the temperature would have increased, but this is not happening. Well, what is being said now is this because you have got a layer which allows what are called greenhouse gases which allow suns radiation to come in, but does not allow radiation from the earth to go out therefore, there may be some kind of a global warming scenario. So that is where the long wave stamp terminology becomes important.

Maybe just I will take talk about that in more details later on, but maybe just quickly introduce is the sun's radiation belongs to wide range of wavelengths starting from ultraviolet, visible range, then infrared radiation red, you know red infrared radiation. So, if you look at all of that which we will look at it at which we look at some time look at some time, if you look at all of them a part of it is only visible light. A good lot of it is infrared region just actually heat radiations they are you know heat radiation and longer wavelengths is more.

Now, the characteristics of the radiation that comes from a body depends upon the temperature at which it is radiating. So, sun radiates at very high temperature million degree centigrade etcetera, etcetera fusion process and so on therefore, sun's radiation is of that variety. They are shortwave to long-wave radiation visible radiation everything. While if you look at earth, you know the cosmos is cool. So, radiation heat tests exchange always takes place between hot and the cool bodies. Earth itself is warm compared to the outside outer cosmos. So, it will also radiate the heat. Now, this quality of this radiation depends upon the temperature of the earth terrestrial radiations. So, these are all long wave radiation. You do not see that radiation, but they are heat radiation.

For example, you have a hot plate here, which is not glowing, but it is just hot. You can still feel the heat, you do not see the radiation you know if you are you are close to some hot plate which is not really red hot now no color changes occurring still you can feel the heat, because the infrared radiation that is occurring. So, bodies at lower temperature radiate long wave radiation and that is what we are talking about.

So, terrestrial radiations are all long wave radiation. For example, radiation heat exchange between you know the roof ceiling of this room, if it is at different temperature then my skin temperature that would be actually all long wave radiation heat transfer. So, it is all long wave radiation heat transfer. And some gases like carbon dioxide methane etcetera at the top of the atmosphere, if they are there moisture vapour they do not allow long wave radiation to go, but they do allow shortwave radiation to pass them like glass does. So, we will discuss about that later on. And when such thing is occurring the sun's radiation can come in, but the earth radiation cannot go back and that is why this you know this concerned about that global warming.

Anyway, but for our purpose we look into this because this has something to do with our temperature outside climatic zone and things like that all right. So, I think we will stop here for the day and start from earth energy balance in the next class.

Thank you very much.