Solar Energy Technology
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Lecture - 39
Passive Architecture, Overhangs and wing Walls

Last time we considered some of the pastor devices, which are solar cookers, solar ponds, solar desalination or solar stills.

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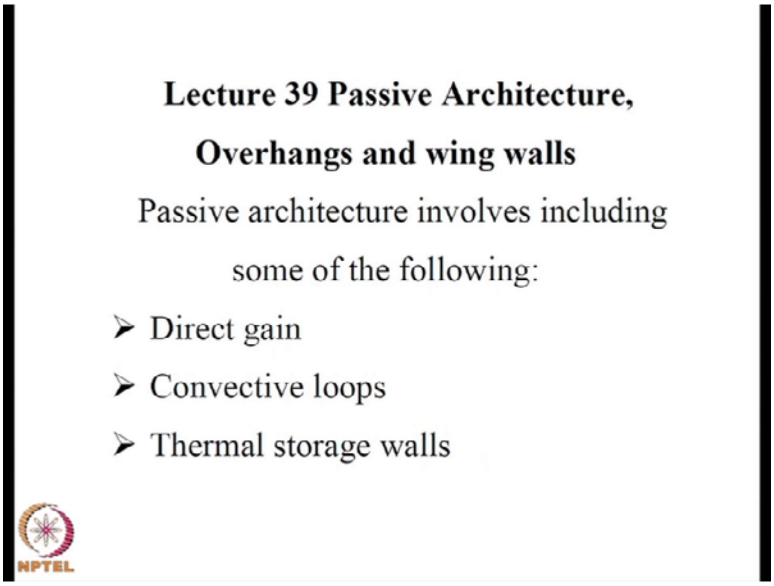

Now, as a (( )) of the building, many of the time the passive architecture is included either to heat the building or in cool climates or to provide little bit of cooling. So, that directly the sun will not enter into the building.

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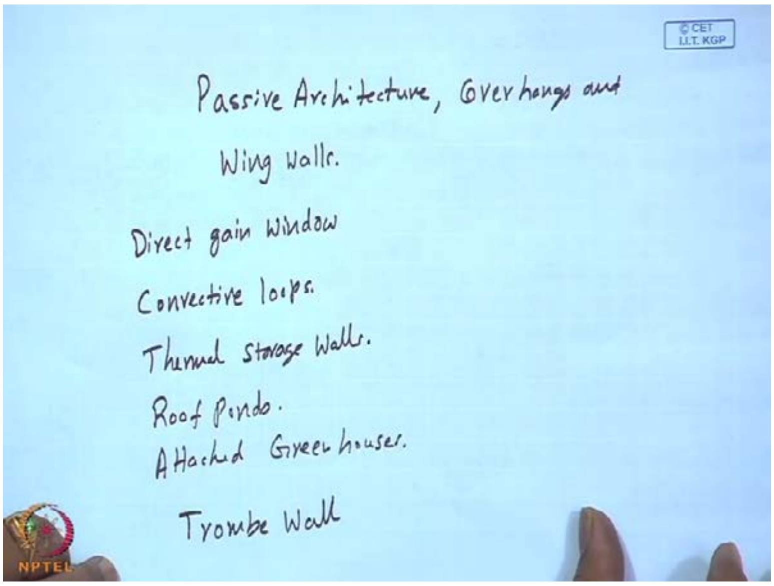

So, this we shall call it Passive Architecture, which will include Overhangs and Wing Walls, this all of us have seen it possibly we may not be knowing the name of it but then I shall tell you it is very simple. And there can be a direct gain window, it is just nothing but a window and if you close it, the solar radiation entering into the window will not escape after heating the body inside, because of the longer wavelength radiation.

And then you may or set up convective loops to keep the room or the enclosure warmer and thermal storage walls, which will accumulate the energy during the day time. And realize or emit or convict in the evening time, so that there is a comfort condition of higher temperature particularly useful in colder climates. And then you have got roof ponds, which will keep the room or the underneath floor much cooler, then you have got attached green houses.

In fact, many of them work on the principle of the green house, the solar radiation entering into the green house through the glasses will be reemitted at a longer wavelength consequently it will not escape. And the window glass has the property that it allows the solar radiation at a lower wavelength, but shall not allow the longer wavelength radiation to escape; hence the enclosure will be hotter or warmer. So, if you attached to a house, then in the evening time or the night time the heat emitted are realized by the green house from the green house will warm up the house. Then heat transfer controlled and heat storage these are general terminology, that are used instead.

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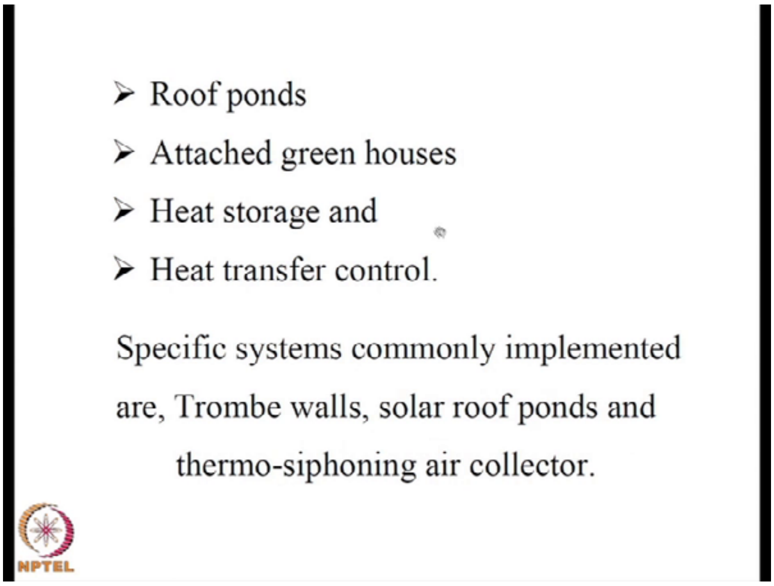

And very specific systems would be one of them is a Trombe wall and then solar roof ponds and thermo-siphoning air collector.

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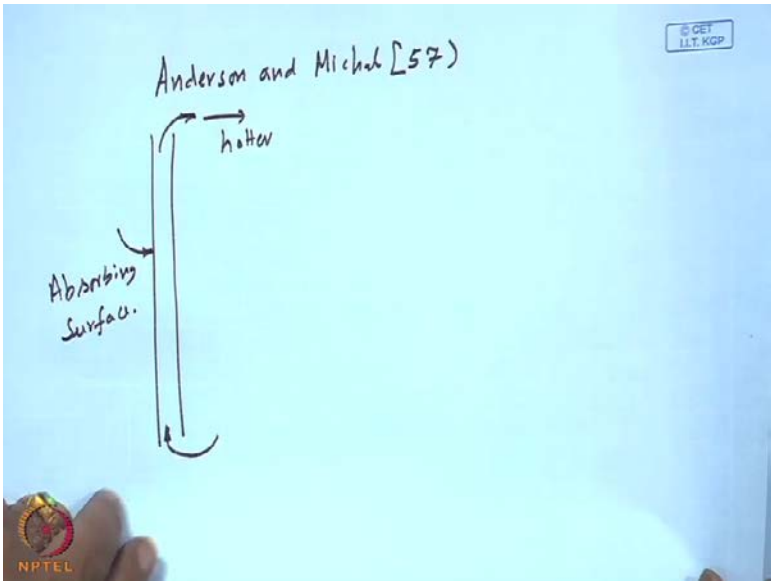

And you can see Anderson and Michal it is according to my number it is mentioned above the design of the common systems such as trombe wall. Trombe wall is nothing but a hollow wall with an hmm something like this, if this is the wall and a hollow space is there cold air gets warmed up and goes into the room and hotter this is a absorbing surface. So, basically it is a sort of hollow wall through, which air can be circulated, which will keep the room warmer.

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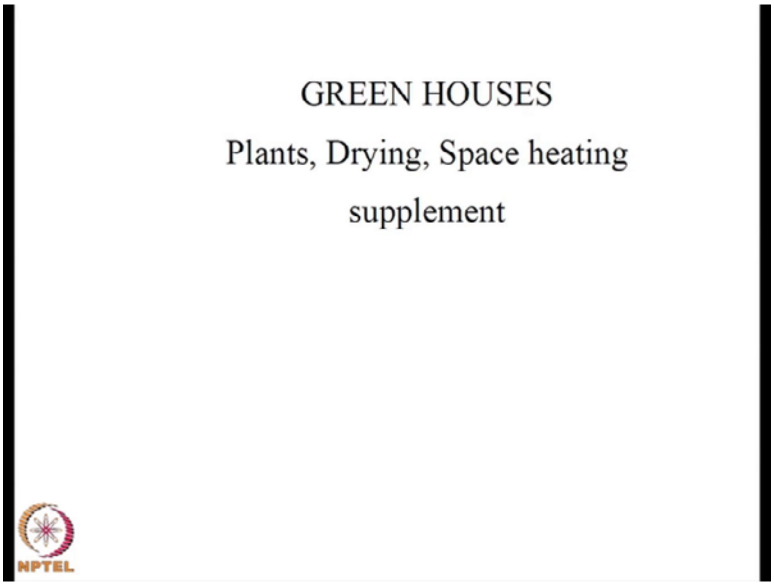

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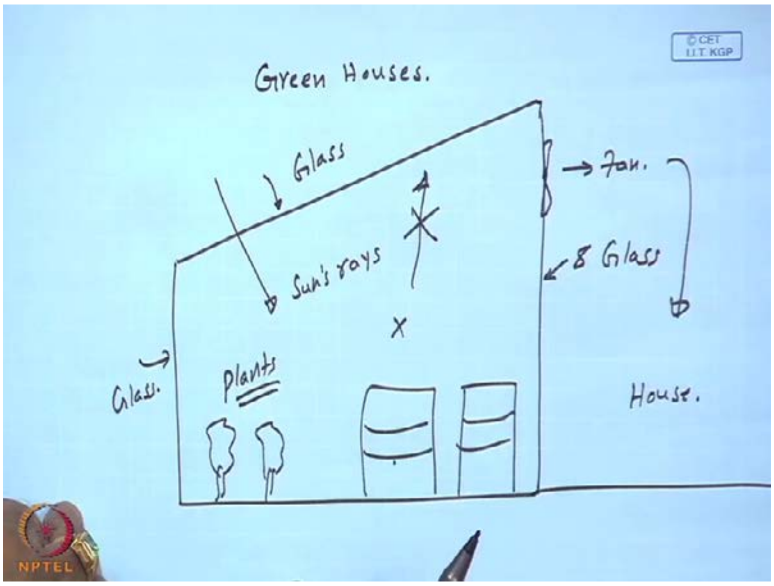

Then you have what is very popularly called Green Houses. A typical arrangement could be something like this with certain slanted roof. And you may have an exhaust fan over here and depending upon the purpose you need you may have plants and then may be storage trumps of water like this. And the whole thing may be attached to a house that is what we had earlier in mind or this is glass this is glass is debatable and depends upon the direction still you do not lose anything by having a glass on all sides including this particular side.

Now, if you have a situation like this the solar radiation entering sun's rays cannot go back, because of this will be emitted at a longer wavelength compared to the radiation at which it is entering 0 to 4 microns typically the solar radiation right. So, this gets warmed up and this drum of water gets warmed up and in the night it realizes heat. And you may divert this fan into the house, which will give the house warmer in addition, in winter the plants they can survive with a temperature of a 20 C or 30 C right; instead of sub 0 temperatures.

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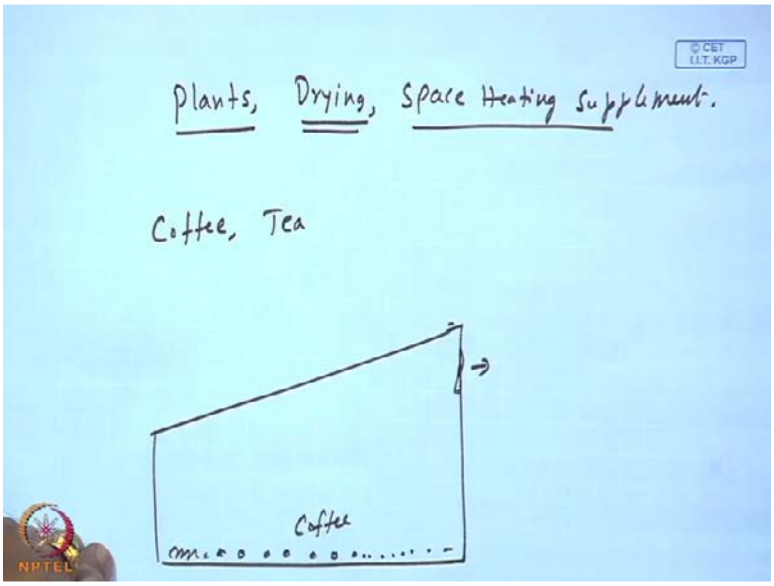

And in general these green houses you can use it to protect the plants or survive or may be even for drying and space heating supplement. So, plants we covered space heating supplement also we have mentioned, what about this drying. In case you have a like coffee for example, or even tea if you have a green house and of course, we shall use the fan to remove the hotter humid air. And there will be a layer of Arabica Robusta coffee, one can think of a number of other arrangements, if you or tea leaves.

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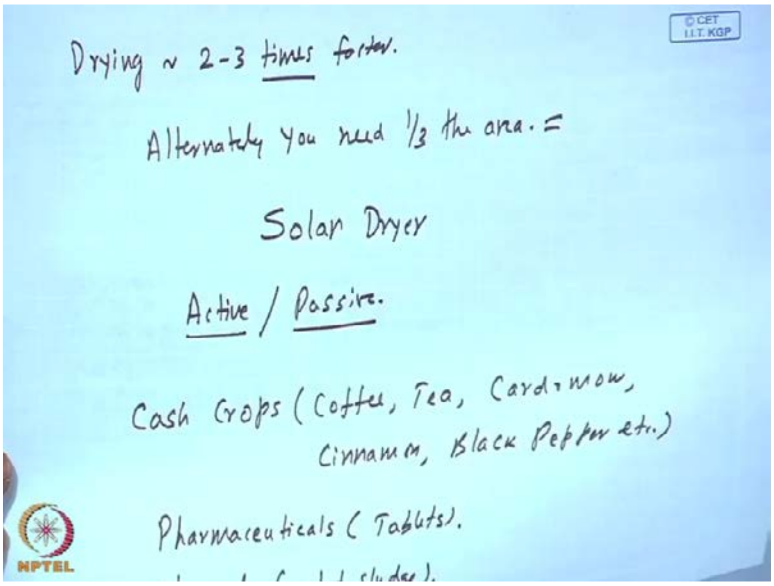

The advantage is if a typically the drying is 2 to 3 times faster that is compared to open sun drying if you do it in the green house it will be 3 times faster or 2 times faster. And if that is, so alternately you need 1 3rd the area, so a coffee plantation if you are using a 20 acres of coffee for the land you may require let us say 2 acres for drying. And then I need only 2 by 3 or less than 1 acre for drying, if I use it in the form of a green house. Consequently the remaining 2 acres can be realized for cultivation of the coffee, which will in general will be much more pairing, than whatever you spent on the green house for the drying purpose. So, this is one particular area where you have got a very attractive solar application.

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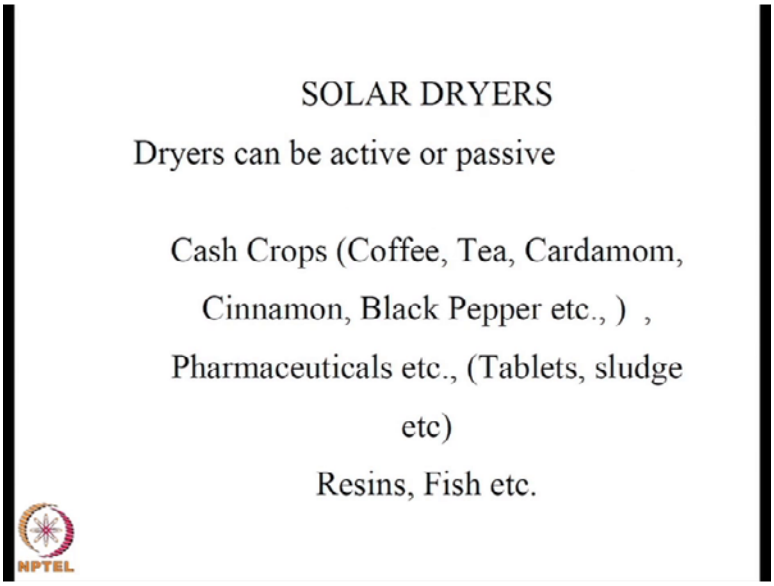

We thought much investment, then you can have a conventional solar drier, which may be active or passive. This is particularly important because the investments particularly in the case of passive systems or lower compared to active systems. And you have got a number of cash crops, which may be coffee, tea, cardamom, cinnamon, black pepper, etcetera. And if you have got pharmaceuticals tablets and a chemical lot of sludge, after the process you may have a colloidal semi solid, semi liquid type of waste material that is being discharged from many chemical industries and pharmaceutical industries.

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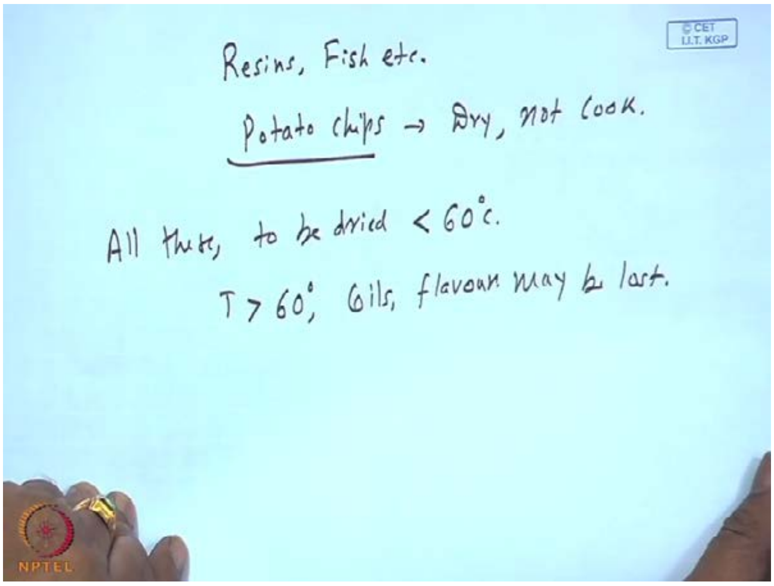

Then in addition you may have resins and fish etcetera and including even may be even potato chips one should be careful that you should dry and not cook, this can happen if the moisture is a little higher and the temperature is a little higher. Now, these are a particularly mentioned all these to be dried, say less than 60 degrees c, the reason being if the temperature is more than 60 degrees or oils and flavor contained in these things may be lost.

So, you do not want to do it to fast by using a higher temperature, but you would like to do it faster than what you can achieve under natural conditions in open sun drying. And open sun drying has the other advantage disadvantage rather or there may be contamination coming from various sources. And if there is a sudden shower or you the product almost dry, may get wet will get wet and may lead to degradation the quality if not completely spoilt.

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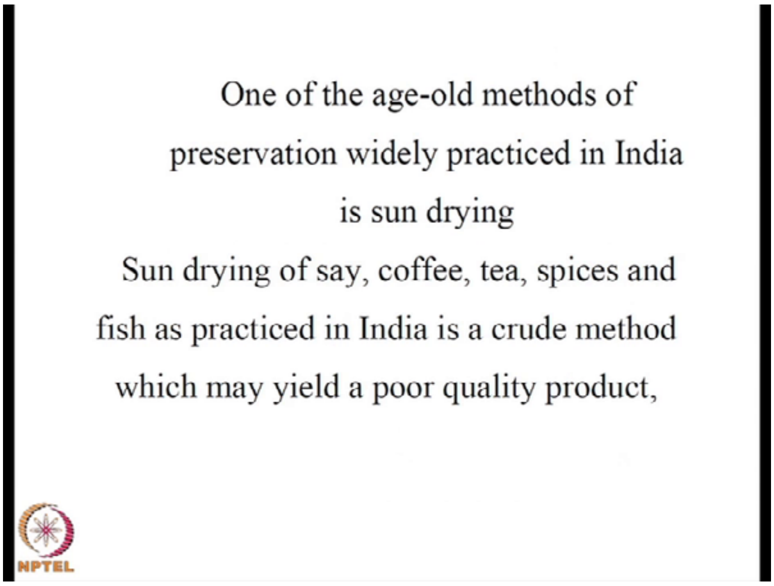

So, this is of course, an age-old method it is sun drying and particularly is a crude method which may yield a poor quality product.

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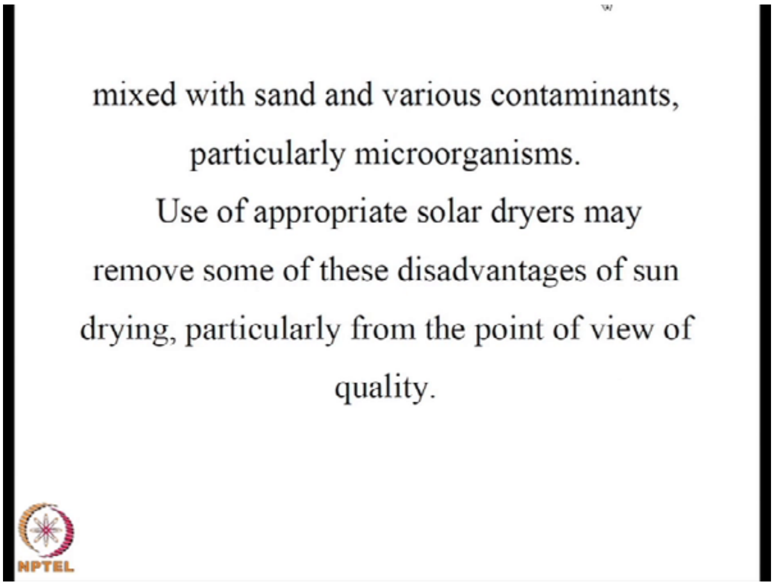

And microorganisms can be growing and use of appropriate solar dryers may remove some of these disadvantages of sun drying, particularly from the point of view of quality. So, even if you spent a little higher amount the quality will be better and also faster, consequently if your prime agricultural land, which is devoted for drying even if half of it is released the pay back will be quite attractive.

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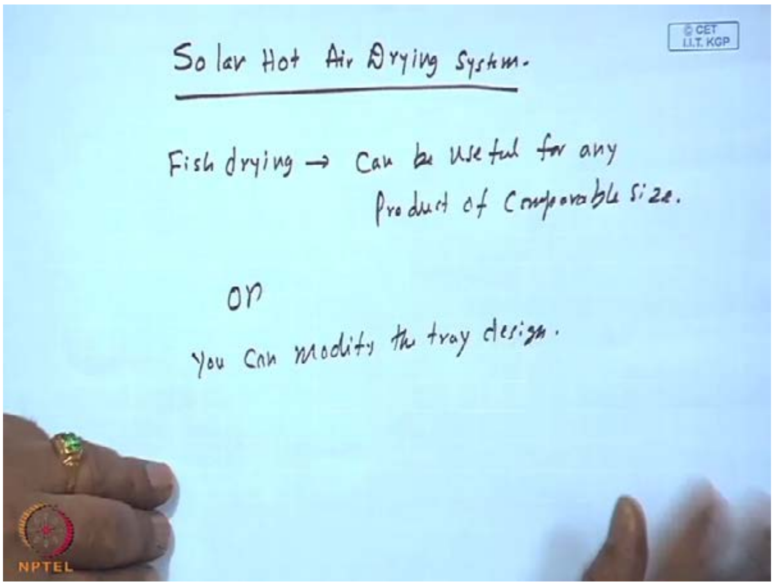

So, we were talking about a solar hot air drying system, in variably they use whether be it a direct gain window or be it a trombe wall or a green house essentially it is a air based system. And in fact, typically it is called for fish drying in the particularly eastern part of India and can be useful for any product of comparable size or you can modify the tray design.

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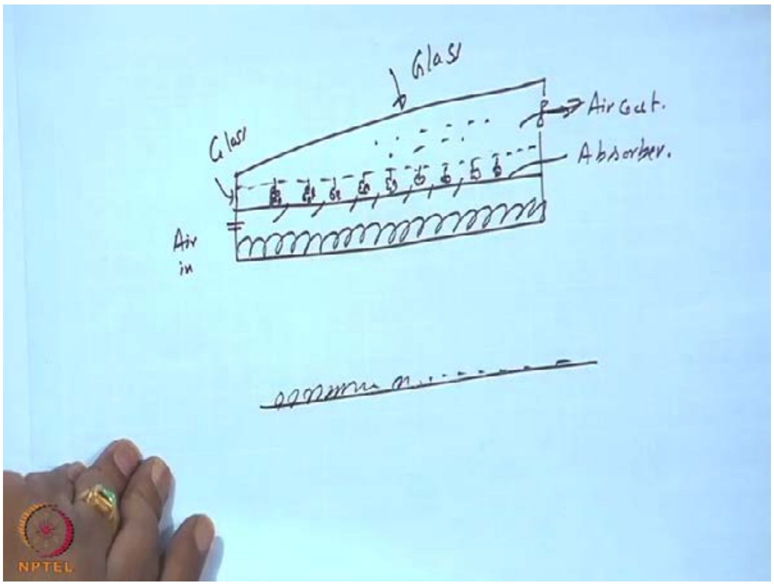

For example, if you take a simple cabinet type of dryer, which I may show like this bottom is insulated, there is a plate I will let in air in there may be a fan air out and this is sort of an absorber just like solar still except there is no water. And the entire thing there may be a grill or a what you call mesh and I may hang resins or grapes which are to be dried. And one can suitably choose the height of the this mesh above the absorber depending upon the length of the bunch of the grapes or you can alternately put on this either coffee seeds or cinnamon or any of these products and appropriately may or may not have necessarily the grill. So, you can easily modify if it this is essentially this is glass again of course, you can have glass this is to let the cold air in passes through the spaces carries the moisture and gets out through the air duct. And in addition to direct heating or direct drying from the top surface. So, if you close it completely there will be an accumulation of moisture it may start working like a solar still rather than a solar drier.

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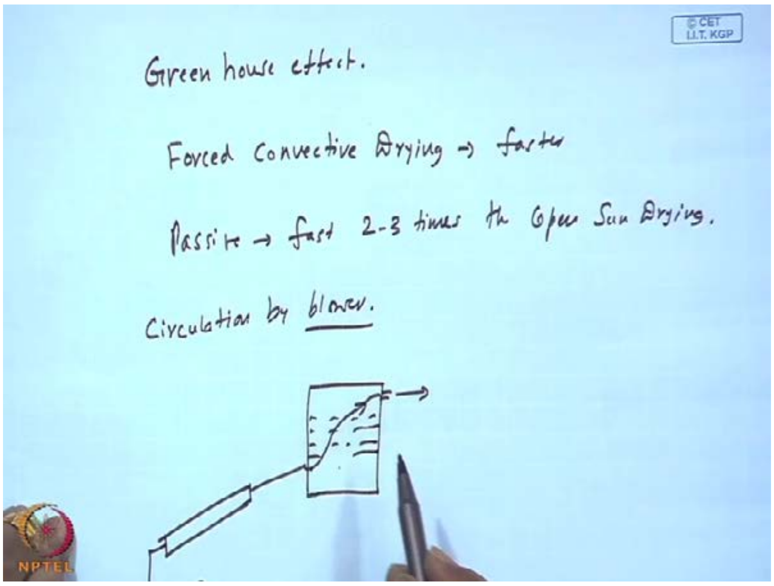

So, this is a cabinet type basically they are all green house effect. So, if you have a forced convection will be faster obviously, but this passive is faster 2 to 3 times, the open sun drying the fringe benefits are contamination free.

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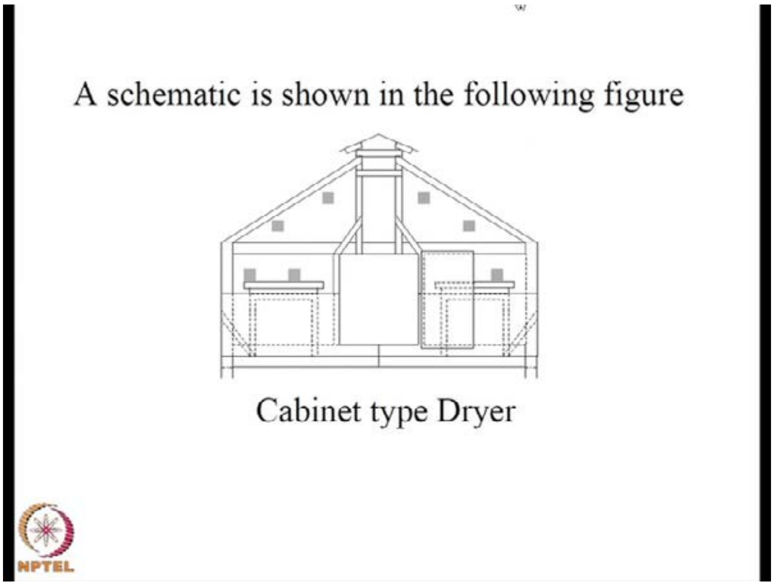

So, I have whatever you I have described it could be a cabinet type of dryer with if I can see you can see on this or these may be glass roofs, this glass and various arrangements can be thought of for putting the product. So, this is a essentially a cabinet type of dryer, which I have shown one side of it.

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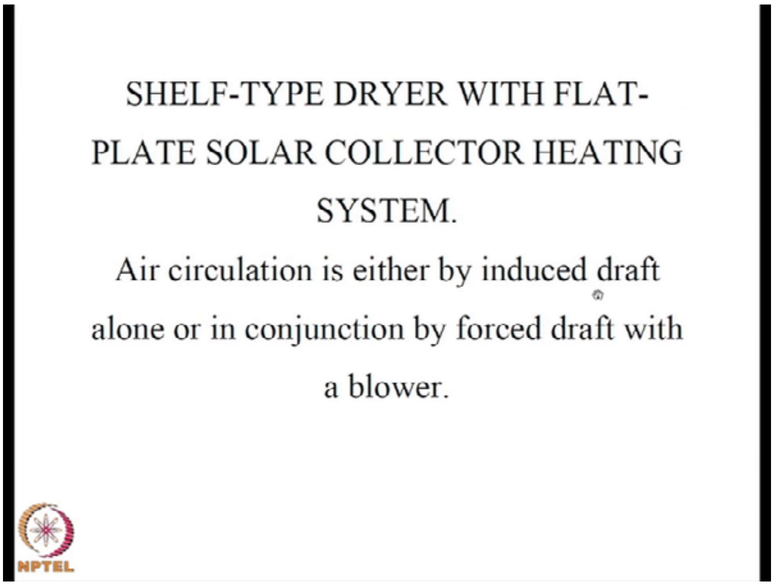

And shelf type dryer with flat plate solar collector heating system, now you may have a circulation by a blower strictly these are not pos, this is not a passive device, but I have included in this, because of as an application of drying. So, you have a solar collector and you may have here a conventional dryer, if you like I would like to this is your solar collector through which air is being circulated this goes to a cabinet dryer; and I may have n number of trays and the air goes up goes out. So, in that process of course, you can shuffle these trays from bottom to top and top to bottom, so that there is a uniform drying at the end of a certain period.

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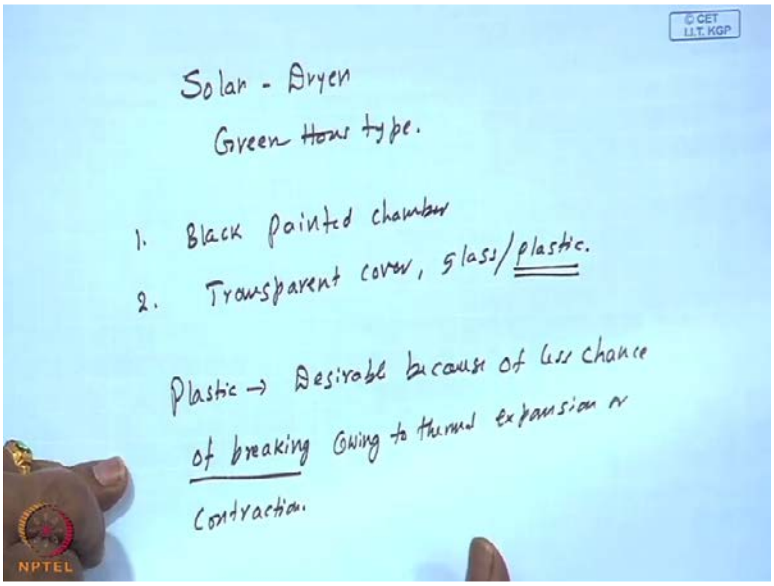

So, basically this green house type of solar dryer, if we have understood the idea behind it solar dryer green house type, basically passive it is a contains a black painted chamber. And your transparent cover it may be glass or plastic this about plastic materials in general is desirable, because of less chance of breaking; owning to thermal expansion or contraction during day and the night.

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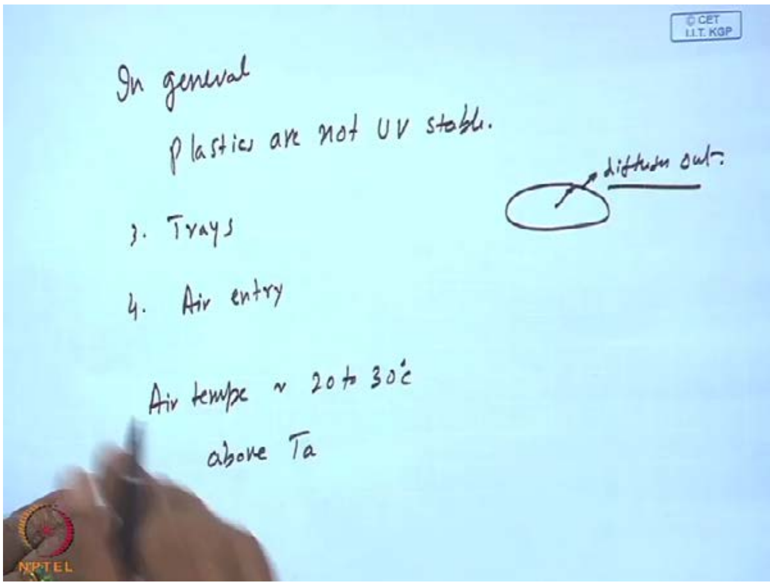

But, the disadvantage is, in general plastics are not U V stable, the ultra violet radiation 2 percent or 4 percent that will make the plastics unstable and after while they lose their color, they lose their rigidity they simply break up. In fact, our common experience shows one fine morning when you are picking up a bucket full of water that bucket breaks down after 5 years or 4 years of service. And you cannot the reason why it happens, but that is basically the U V instability.

And particularly those things that are used outside exposed to the sun are more liable for this sort of a damage rather than the completely used inside the house and transparent cover which can be glass or plastic. And then three of course, the trays precise and stacking depending upon the size of the product to be dried that is what I have already. And air entry ports 4 air entry this is not, so much to heat the air and use the hot air to dry, but this is essentially to carry away the moisture when once drying has started place.

So, for example if you take a food product, so the moisture in that will come to the fore front or the skin then diffuses out, so this needs to be carried out. Now, the drying time in addition to the total moisture will be depended upon what type of a skin the particular vegetable or the fruit has. For example, if you take coconut you cannot dry the coconut, so easily right and if you take onion it is relatively more easy and if you peal of the outer layer it will be even more easy.

Because, the outer most layer will have less porosity and it will not allow the moisture to defuse out, that is these are the tricks as a matter of fact for you. For example, you take potato if you peal it and cut it will be more easier to dry, if you do not peel it then that skin will be a quite resistant wall for moisture diffusion; possibly it will cook inside rather than drying. So, the dryer is aligned east, west length wise and about 5 meters above the ground. So, the air temperature is about 20 to 30 degree centigrade above the ambient, if there are no rains and at least 11 to 3 P M.

So, that corresponds to typically 40 to 65 degrees in tropical climates which is rather ideal for drying of resins, coffee, tea, black pepper, etcetera. The higher temperature is not desired, because it will take away the oil in that or make them sort of soft by semi cooking rather than only drying. So, green house and trombe wall, which are shown here which we have already covered or discussed about yes.

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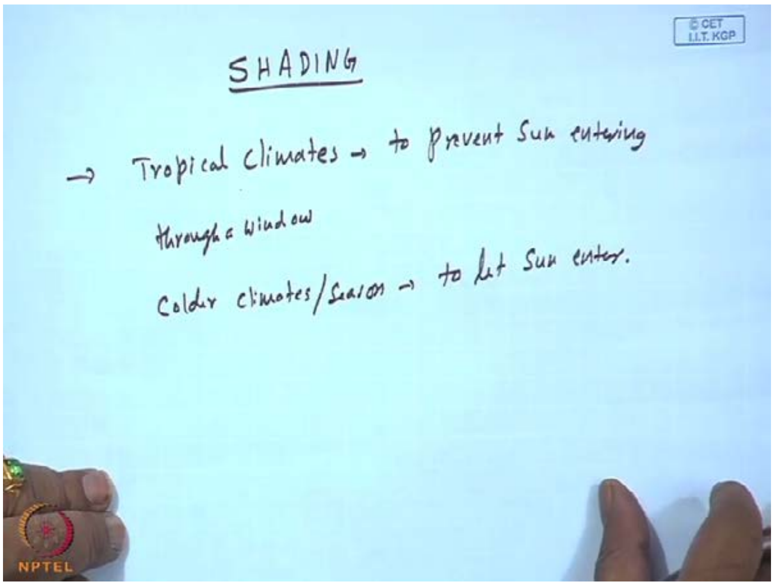

The shading is an important aspect, particularly in tropical climates to prevent sun entering through a window. And in the colder climates or season to let sun enter fortunately the suns position favors this.

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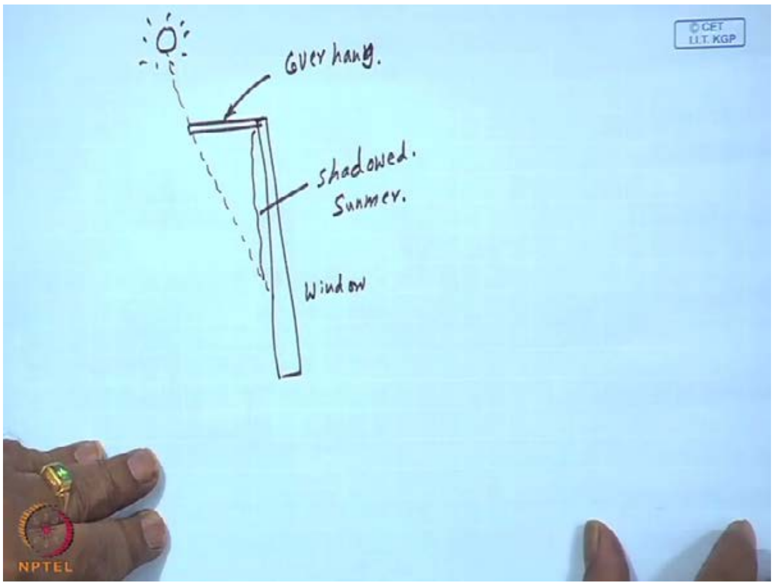

If I consider a window let us say this is a window in the side view and this is the sort of a you will see often, what you call a overhang. So, if the sun is somewhere here right above, this will be shaded or shadowed if you like it, this may be summer because sun is right up it will cast a longer shadow on the window.

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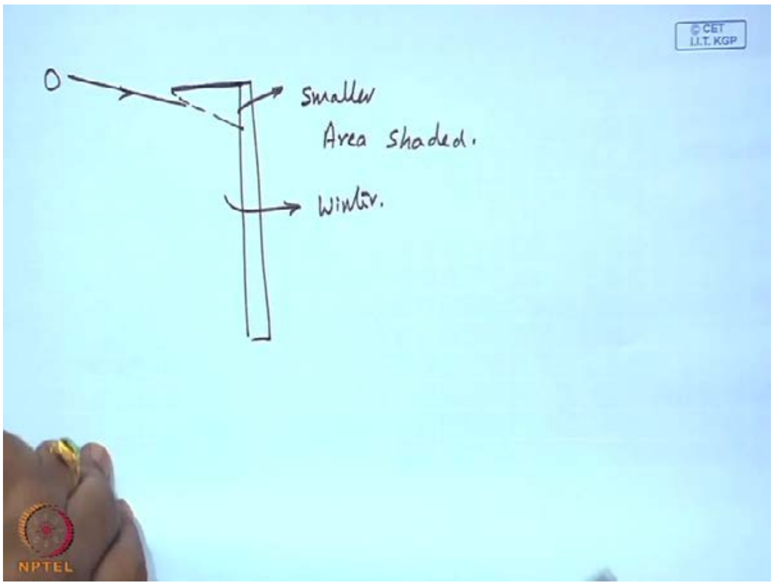

And if you see the same thing in winter sun may be somewhere over here and it will cast a small shaded or shadowed. So, it will let in the sun in winter, whereas it prevented, so much of sun to enter during summer, the positions of the sun at least in the northern hemisphere as shown here it is pretty low in winter months or declination negative in general. And in summer months it will be high up almost at the right at any time right above your head, so consequently cast a longer shadow shading the window. So, this is not just for protection against the rain and you have a overhang to provide additional heating in the cold climate or not allow the sun if not directly cool, it indirectly let it be cooler by not allowing the sun to enter the room.

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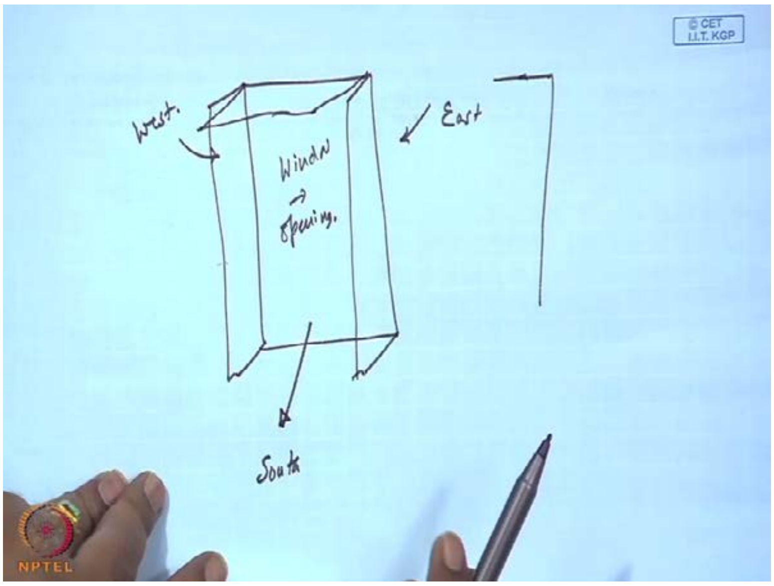

And you can have if you see some of the buildings which you may think that it is sort of an architectural beauty, but really they are functional you have a wing wall; this may be a window or opening just like the over hang projection for the window these are on the sides. So, that if this is south and if this is east and this is west these wing walls will prevent sun's rays entering the window or the opening in the morning time from this wing wall and in the afternoon by this wing wall. So, consequently they will project some kind of a box type of structure, which will not allow the sun to enter and if you combine it with a overhang also and it can be completely shaded as your desire, if that is the...

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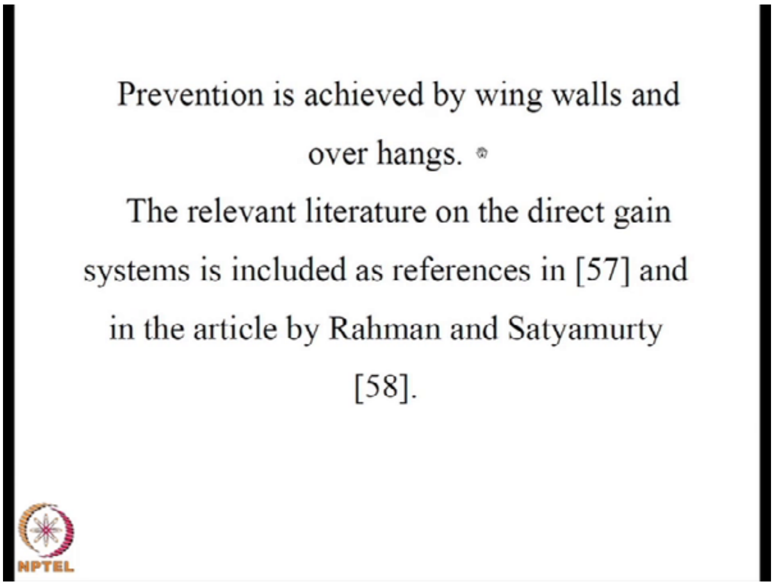

So, there are quite a few relevant literature is in 57 and 58 on the over hangs and the wing walls, but the basic things I shall cover over here.

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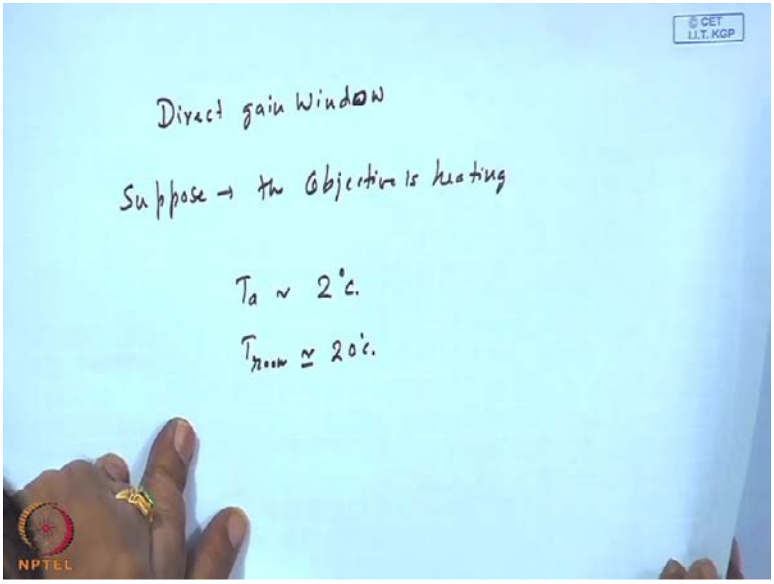

So, as we said that now the direct gain window, so whether there is over hang or not there will be certain amount of solar radiation entering. Suppose the objective is heating your T a may be 2 degree c and you; obviously, want T room to be approximately let us say 20 degree c right. So, you have at let the sun enter to heat the room up to 20 degree c through a direct gain window.

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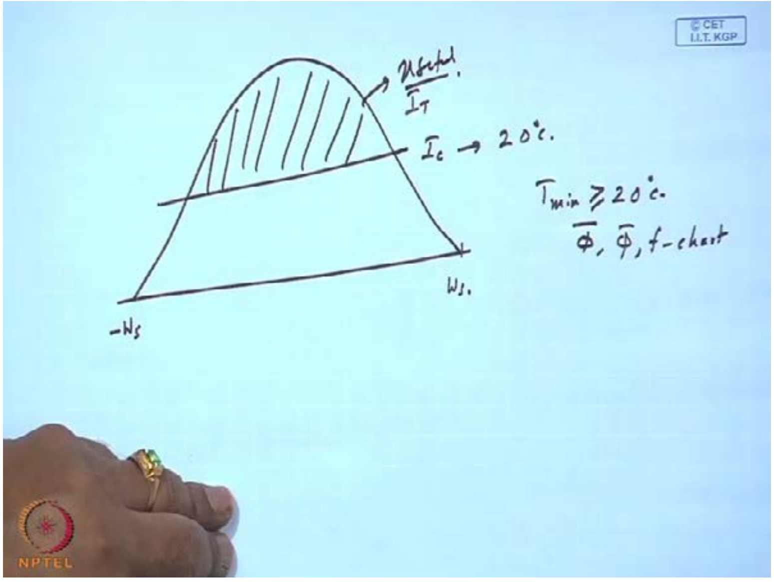

If you look at your solar radiation distribution something like this I T this is minus omega s this is plus omega s, this I c just like in the utilizability will correspond to 20 degree c. So, I will calculate my non dimensional or dimensional critical radiation level corresponding to a temperature of 20 degree c. Now, when we want the energy delivered to be t minimum greater than or equal to 20 degree c in your phi bar or. So, called phi bar f chart method, then the radiation above the critical level is useful in the case of a direct gain window.

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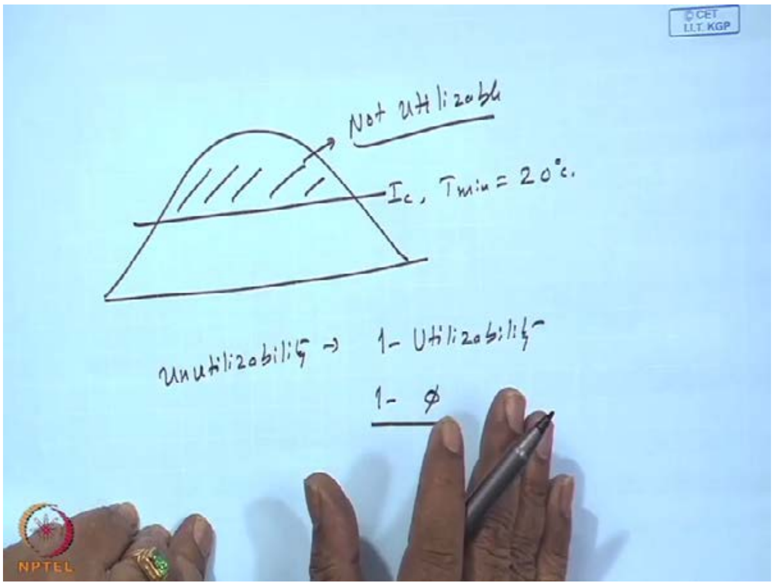

This is I C corresponding to t minimum, let us say 20 c this not utilizable; in other words when the radiation is above this critical level or it heats the room beyond 20 degree c which we do not want. So, my un utilizability is one minus utilizability on any time scale if phi is a hourly utilizability for a day or a for a monthly average day then one minus phi will be the un utilizability. In the word in other words the solar radiation above a certain level is not useful in heating by a room. So, whatever we try to do as far as a useful energy gain is concerned with this direct gain windows you calculate utilizability as if it is a collector. So, applying A T minimum of 20 degree c and that utilizability 1 minus of that is the one actually that is utilizable and the above 1 is unutilizable you do not want to heat it up beyond the requirement.

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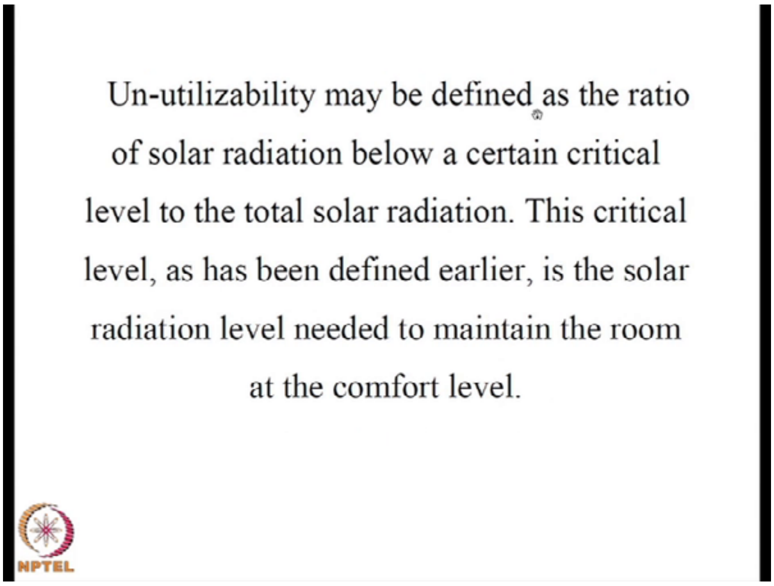

So, I have given the definition here un utilizability may be defined as the ratio of solar radiation below a certain critical level to the so total solar radiation. This critical level as has been defined earlier is the solar radiation level needed to maintain the room at the comfort level.

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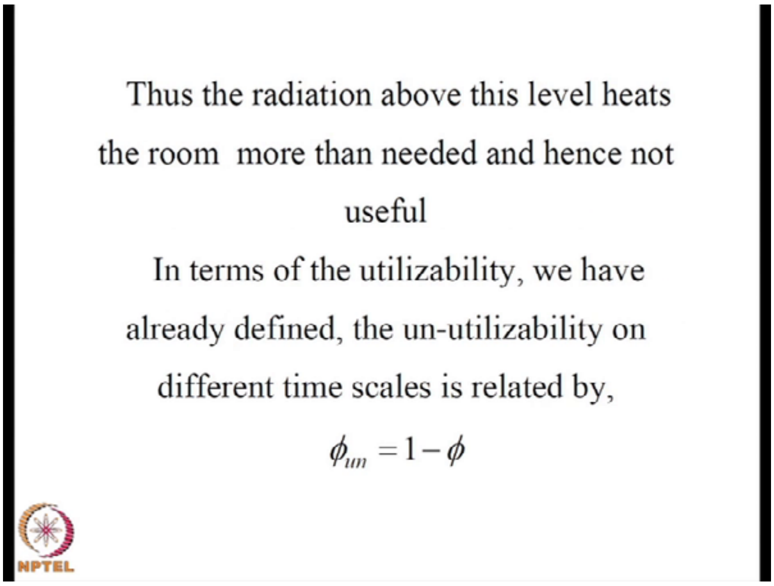

So, the radiation above that level is not utilize useful, so I may call it phi unutilizilable equal to one minus phi utilizable.

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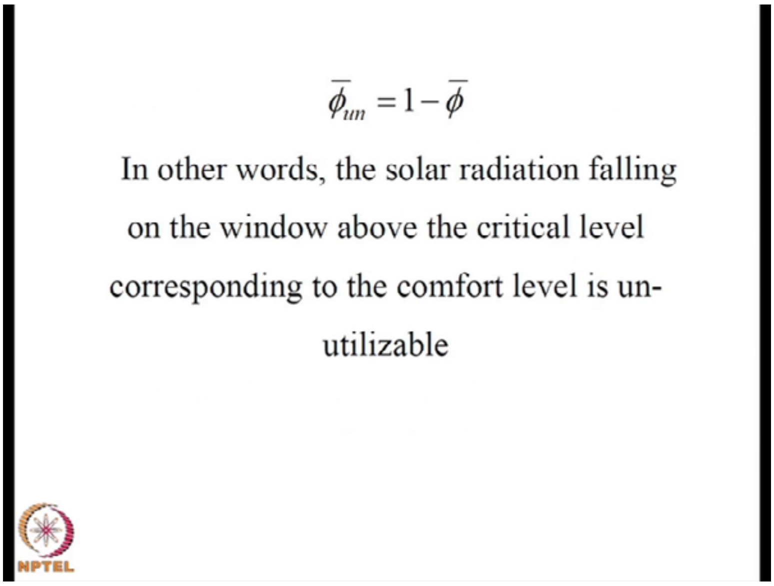

Similarly, I can extend to different time scales, so phi bar unutilizable it will be 1 minus phi bar.

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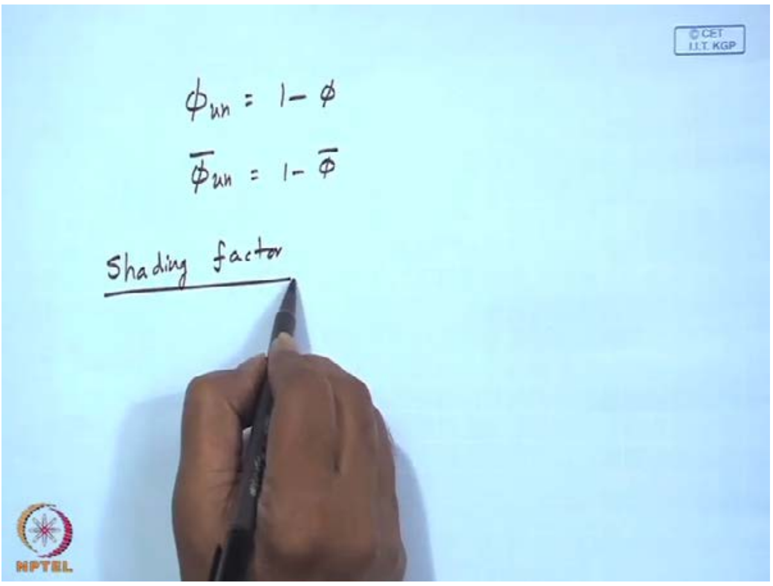

So, from overhangs and shading and direct gain, so we come to this unutilizability . So, you calculate as usual your utilizability and 1 minus phi bar will be utilizable multiplied by your H T will be the energy that will be going into heating the room to the desired level of let us say 20 c.

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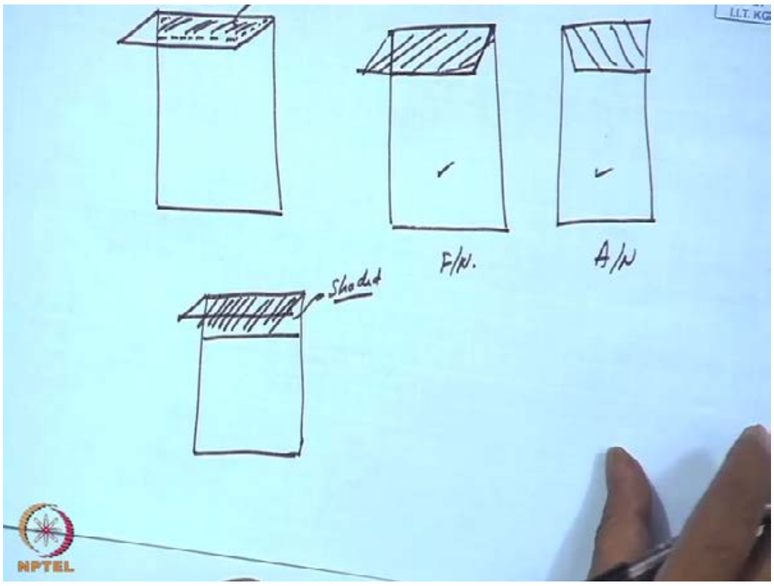

Now, the shading factor, so we have seen if you have got a window let us for the simplicity assume that it is facing south. And we have got overhang of certain thing right first with the top of the window and that will cost a shadow like this right. So, if I do if I want to make it clear to you I will not show the overhang, but I will show the different types of shadows that it can make. So, you may have a shadow something like this out of which this is the area of the window that is shaded right or I may have for example, a perfect rectangle.

For example, if it is solar noon time facing south or the corresponding gamma in the corresponding time, you will have a simple rectangle if the overhang is equal to the width of the window I will just have a rectangular thing. But this could be the morning and I may have forenoon rather not morning this may be afternoon and this may be forenoon, so if this is east this is west. Now, the whole idea is to calculate what is the solar radiation entering through the window with the shadow shaded by the wing wall.

And if it is equal to the width of the way window then I can have a situation like this where a sort of trapezium is shaded and a complete rectangle could be shaded. If it is exactly in the facing the south or facing the sun or it could be a degenerate case of like the ones I have shown here or here, depending upon whether it is forenoon or the afternoon or the afternoon.

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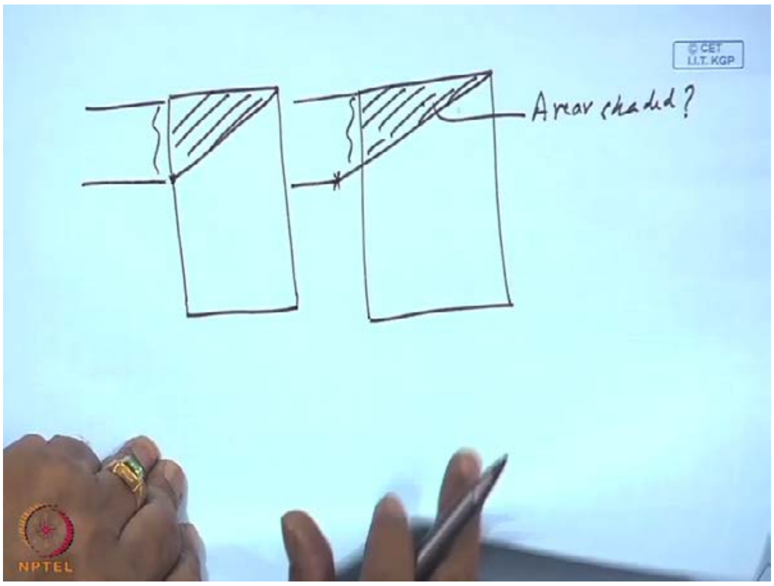

And you can have still further degenerate cases I am showing only the shadow and this can come right up to here and go, so this may be the shaded area right. And still it may do little more than this it will not end here, but it may be like this what we are trying to say is this edge may on the edge of the window or may be below beyond the window.

So, now, the problem is what is the area shaded, so that depends upon this or this and in the case of a complete rectangle no problem width multiplied by the thickness. But we need to know whether this shadow belongs to a triangle category just ending at the edge of the window or beyond the window or a rectangle or some sort of a trapezium like the ones we have shown earlier.

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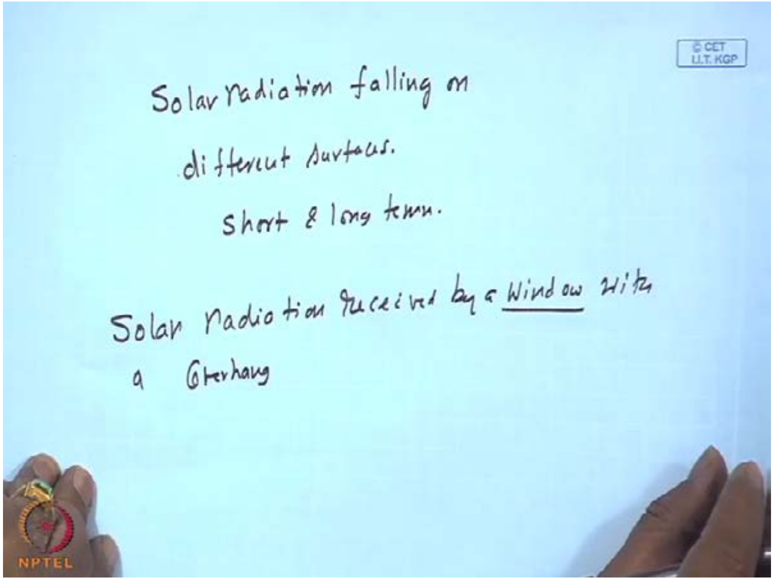

So, now the issue lies that we have calculated a solar radiation falling on different surfaces both shorter and long term. Now, the question is what is the solar radiation received by say window with a overhang, it does not have to be a window it can be any surface which is shaded by sort of a overhang. So, one can we do have results for this accurate description of the shadow, in then Rahman or in available 58 reference, which I shall give at the end of this lecture series.

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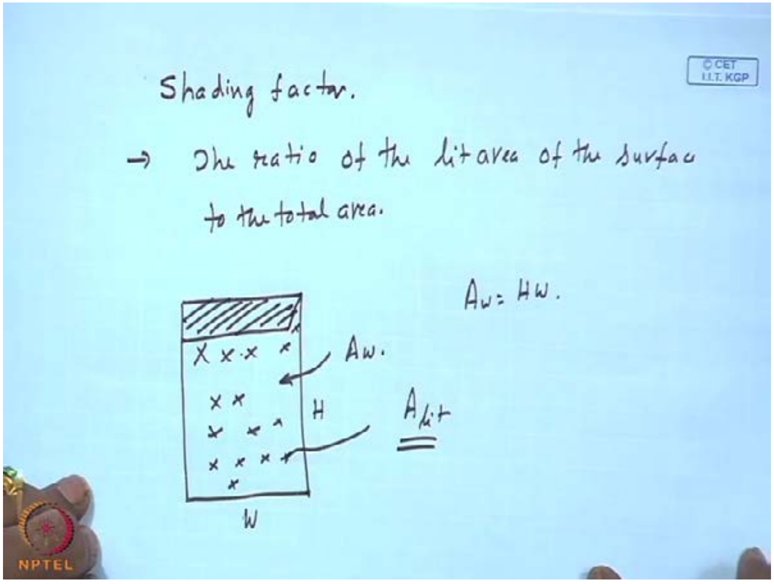

So, we define what is called a shading factor, this is the ratio of the lit area of the surface to the total area. So, with reference to the window if I am looking directly at the window standing in front of it let us say this is my shadow. So, the whole thing is A w window area and this is let me see, if you have at this to be I do not know what notation I used. A w will be H into w and this crosses area is the a lit; that means, it is lighted to some extent and this part is shadowed.

So, that is what the shading factor concept and I think the one without the lines is the overhang, and this one is the shadow. So, this at any instant the shading factor is A lit by A W. So, if there is no shading a lit is 0 consequently a lit is equal to A w, sorry.

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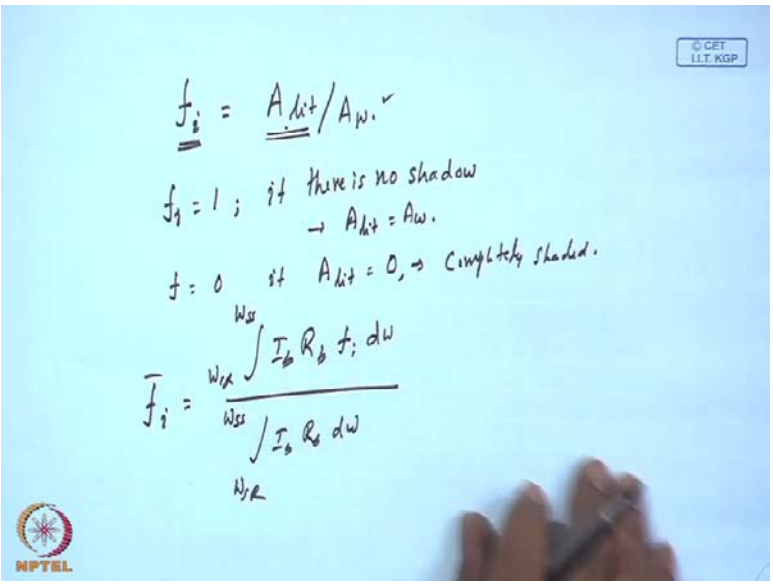

So, f i will be equal to 1, and f i will be equal to 0 if a lit equal to 0, which means a completely shaded. So, initially it was confusing even to me the shading factor is defined not in terms of the shaded area, but in terms of the area that is lit still. So, A lit by A w is the shading factor and if a lit is equal to A w there is no shade; that means, it will be equal to one when there is no shading at all. And it will be equal to 0 when a lit is 0 and a lit will be 0 means that the window is completely shadowed.

So, if you have got this f i on instantaneous basis A lit keeps on changing just like the solar radiation and also because of the position of the sun. So, if I want a longer term f i bar I should use this (( )) from the calculation of R b bar this in general will be omega S R to omega S S omega s r to omega S S. So, the denominate numerator represents the solar radiation falling on the collector sorry window surface and a part being shadowed and this is the radiation that the window would have received if there is no shading at all.

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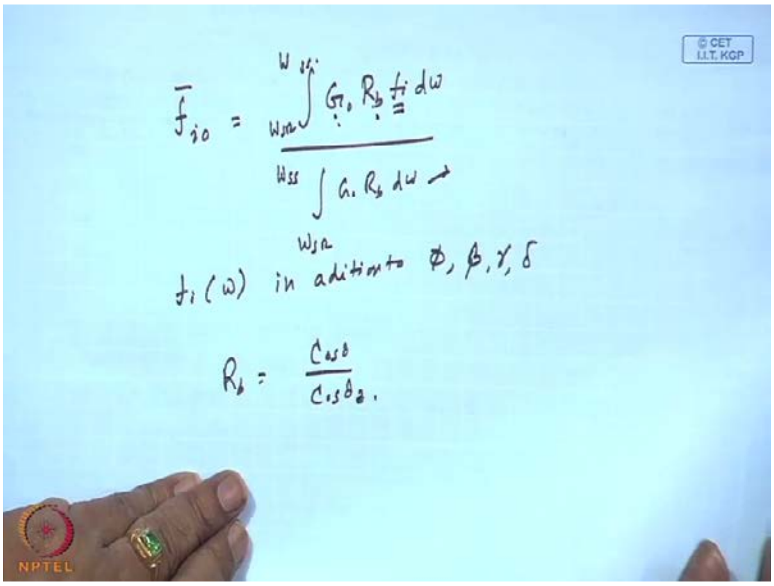

So, just like you can compromise under extra terrestrial conditions will be integral, of course I will use the intensity G 0 R B f i d omega upon G 0 R B d omega again omega S R to omega S S. So, the total radiation that will be falling on collector surface if there is no shade compared to that if there is a shade with a shading factor of f i and this f i is a function of omega in addition to of course phi beta, gamma, delta.

So, it is a function of time and if I can have an algorithm for f i g 0 is analytical cos R b is your original cos theta by cos theta z we may or may not be able to this can be integrated. This we know it and we may or we not be able to or do an analytical integration for every case, but nevertheless it is average value over a time period a day or the monthly average day or between t 1 and t 2 during a day will be g 0. And the instantaneous R B multiplied by the instantaneous f i if I have a analytical expression for this upon the radiation falling had the solar window, window had not been shaded.

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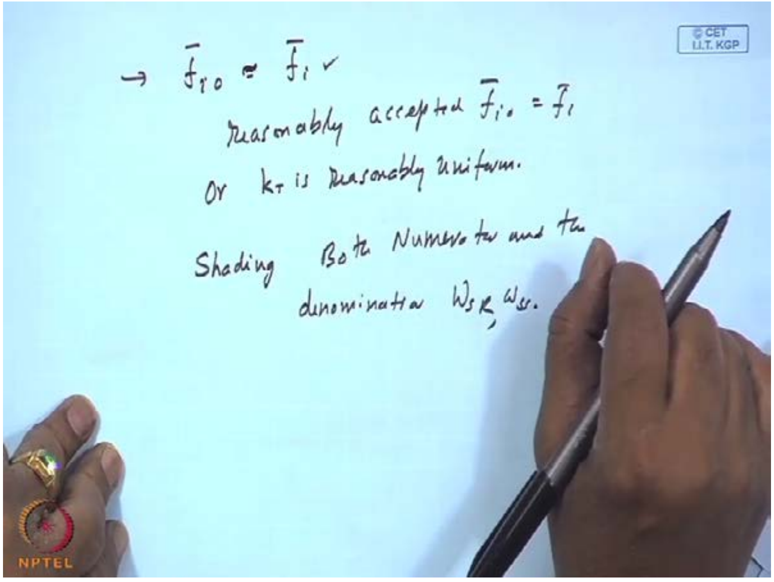

Now, you can go through the same logic f i bar 0 approximately equal to f i I mean there is a reasonably accepted, because of I mean error being committed both in numerator and the denominator. Or and your K T is reasonably uniform if it is equal to 1, this relation is exact, but what we also proved earlier was that well this relation is not too bad even though it is evaluated under the extra terrestrial conditions. Because you are committing a mistake both in the numerator and the denominator and on top of it for the as far as shading is concerned both numerator and the denominator are integrated from omega S R to omega S S.

Unlike in the case of or flat plate collector solar radiation received the integration is between omega S R to omega S S in the tilted radiation; whereas, and twice of 0 to omega S in the denominator. And that could make a difference in the time element of the numerator and the denominator, but as far as the shading factor is concerned both of them or during the time period that they receive the radiation. If the radiation is not received by the solar collector; obviously, there is no point in calculating the shading factor. We shall continue it tomorrow, because a lot of approximations have to be made. However, a large number of tables or graphical results are available, but here I am essentially trying to tell the concept that this is one order of magnitude little more complicated than R b bar.

Thank you.