Sustainable Architecture

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Lecture – 49
Introduction to Whole Building Simulation-I

Good morning, welcome back to this lecture series where we are discussing about Whole Building Simulations starting today. And we will be discussing different aspects of whole building simulation in subsequent lectures. And this series of lecture is part of this ongoing online course on Sustainable Architecture. So, far we have covered almost all the topics related to sustainable building, sustainable architecture. And here we are at the last series of lectures, which is dedicated to learning a tool for whole building simulation. Now, what is simulation?

So, what we are doing in building simulation is that, we are creating an identical building digitally. So, whatever design is being done for the buildings, the same design is being completed in computer using the material properties. So, when we are making it in AutoCAD if you are making 3D we are only looking at it visually, aesthetically from aesthetic point of view. However, when we are doing whole building simulation when we use this term, it implies that we are adding the material properties.

So, the thermal properties, thermo physical properties of the materials are also added here and then we go ahead and check. What is going to be the energy consumption of the building or what is going to be the level of comfort which will be achieved in the building? Now, why is whole building simulation required for sustainable buildings? So, beyond sustainable buildings here it is mainly require to prove the compliance for green building rating programs.

And here what we do is we compare the estimated performance of the proposed case of design with that of the base case. And through simulation, we have to prove that the design which we have done, which we have created which is the proposed case is better than the base case. And how do we prove that? So, while proving that we have two different cases; 1 is that of, conditioned buildings air conditioned buildings and to prove to compare between the proposed case and the base case, we compare by taking their energy use.

So, the energy use of proposed case has to be less than that of the base case and for non air conditioned buildings, which are naturally ventilated buildings, we will compare the number of comfort hours. So, in this case the proposed case should have a greater number of comfort hours where the comfort is met as compared to the base case.

This is how it can be proved. But, what actually is a simulated model of the building, whether it be proposed case or it be base case. So, we will look at the different components of whatever goes into the simulation of these buildings, but before that let us quickly see what all this comfort covered we have already discussed about it.

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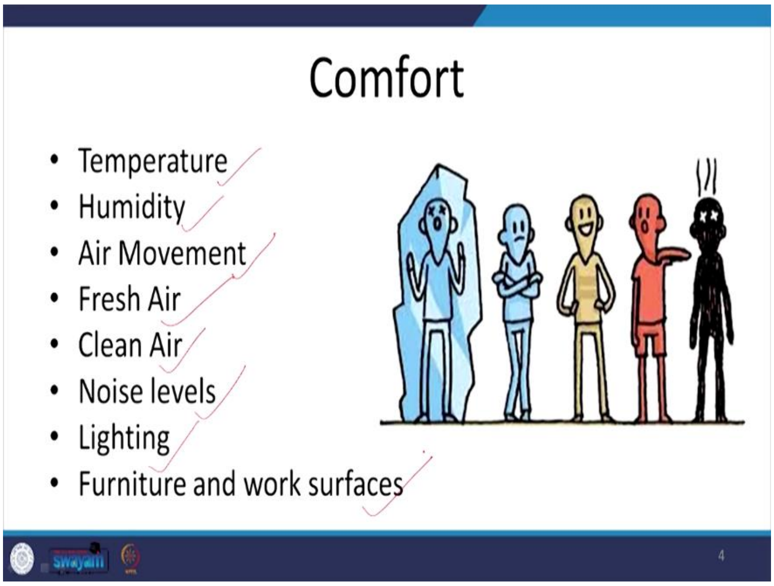

So, there are different components of comfort we take into account, temperature, humidity, air movement and radiation. In addition to that, we take the amount of fresh air, which is available and also the cleanliness of the air, how clean is the air.

So, polluted contaminated air, even though it is coming from outside fresh cannot be counted towards it not while we are talking about the green buildings, but otherwise we also take into account the noise levels the acoustic comfort, The lighting comfort, whether adequate amount of lighting is available. So, the desired lux levels, the illuminance levels whether they are met or not and then we also talk about the furniture and work surfaces.

So, what kind of layout? So, whether sufficient lighting, thermal comfort etcetera is available on the work surfaces or not? So, these are the criteria to decide whether a space is comfortable or not.

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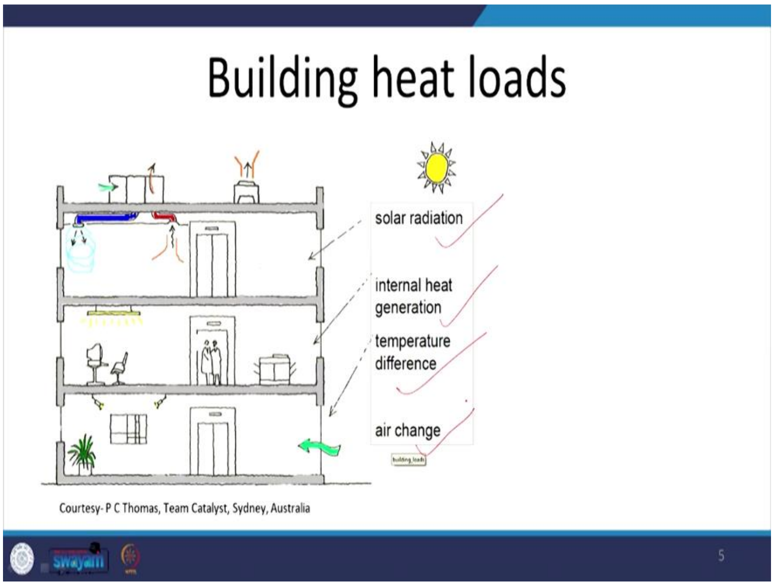

And when we are talking about energy and comparing proposed case or base case on energy, we take into account all these building heat loads. Now, these building heat loads are also contributing towards thermal comfort. So, we take into account the solar radiation. So, what is the amount of solar radiation, which is received by the building? We talk about the internal heat generation.

So, because of appliances and equipments and occupants how much of the internal heat is generated. We also talk about the temperature difference which is largely due to the climate of the place, the weather of the place. So, how much temperature differential is going to be there and how much heat ingress or the other direction of heat exchange will be there? We also talk about the air changes. So, minimum; number of air changes required are also already specified by the codes as we have already seen. So, due to this minimum number of air changes which are required, how much of the heat will be added to the building or how much of the heat will be lost from the building is what will contribute towards the building heat load.

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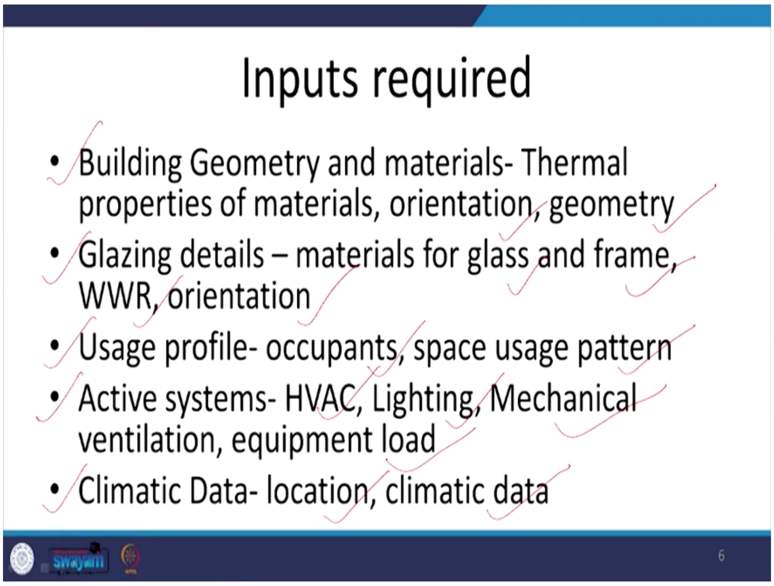

In addition to our understanding of comfort and the heat load or loss, we have to add a lot of inputs into the building simulation model that is when the model will be complete. So, I can very clearly categorize these inputs, which are required in five different groups and all these inputs are required before we decide to simulate the building. So, it is not that, while the design is not even fully done we have not thought about a lot of different inputs. We can go ahead and simulate and compare no, the design has to be completely thought of from all these point of view.

So, first of all it is building geometry and materials; here we are talking about the thermal properties of the materials, orientation of the building, the geometry so, largely the special design of the building. The next is glazing details, so we talk about the material for glass; we talk about the material for frame, the window wall ratio, the orientation of the building, orientation of the glazing fenestration.

The third is usage profile. So, we talk about the occupants, what is the occupant density what is the space usage pattern, what is the occupancy schedule? So, we talk about all of the usage profile here. The next is active systems where we talk about the different components of HVAC their efficiencies, their performances, we talk about the lighting systems, where we talk about how much wattage do the lighting systems consume, what type of fixtures are these, what is the illuminance level for each of these fixtures. We also talk about the mechanical ventilation; we talk about the equipment load which is going to contribute towards the internal heat gain.

And in addition to all these we also talk about the sensors and controls as part of the active systems. And last, but probably the first thing to be procured as input data, is the climatic data. So, we have already seen what all are the components of climatic data. So, including the temperature, rainfall, humidity, solar radiation, wind speeds, the directions so all of that ground temperature, surface temperatures, all of that would be part of climatic data, which is usually dependent upon location. So, we will have location as well as climatic data when we talk about the climatic data.

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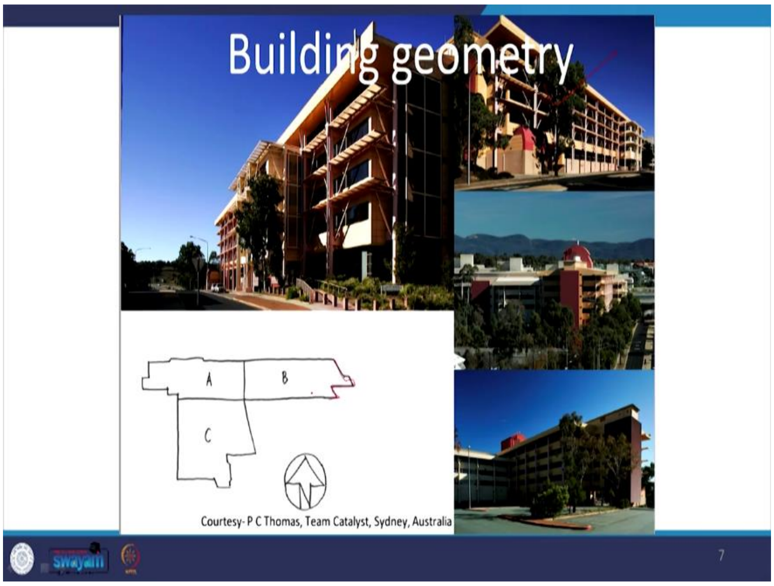

Let us quickly go over each one of these and understand what is required. So, first of all most important is this building geometry. So, what we have to have is, how the building design is going to come up. This includes the outer shape of the building, it includes the fenestration patterns, it includes the shading devices, it includes the roof profile, it includes the earthberms, if at all they are there so all that is part of the building will be considered as building geometry.

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So, for the same building which we have just seen, if we convert it into a simulation model and this particular image is generated using a whole building simulation software called design builder, which is what we are going to learn in couple of next lectures.

So, this kind of an image now design builder is not the only software there are many other software's which are equally capable of carrying out the simulations this is just one which we are taking here due to shortage of time. However, all of you can go ahead and learn any software and use any software which has similar capabilities. So, when we are simulating the building which we have just seen in the previous slide this is the kind of profile which we will get. So, this is about building geometry along with the orientations. So, we would know, what is the orientation of the building? So, that is about building geometry.

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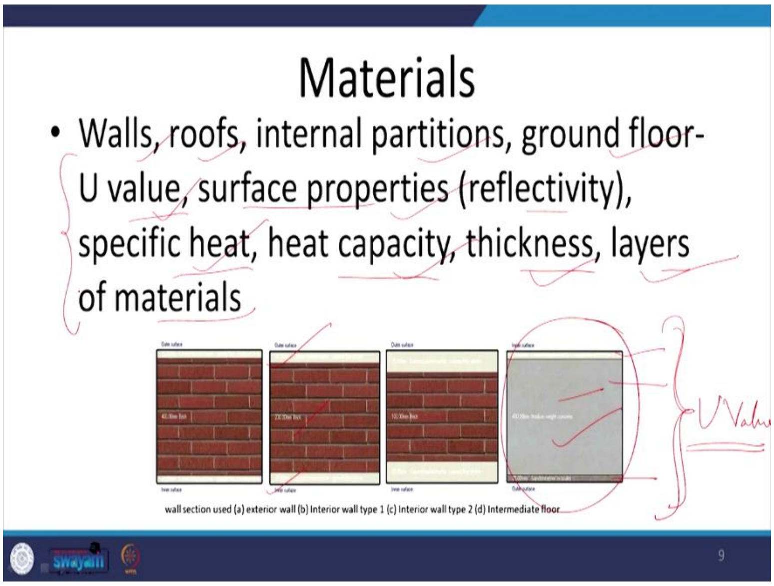

Then we have to add materials here now, this building which we have created and we were seeing the walls and roofs and everything here. Each of these components will be specified with specific material. So, we have to specify the materials for walls, roofs, internal partitions, ground floors, intermediate floors. So, all the opaque materials are described here for their U values for their surface properties, specific heat, heat capacity, thickness, layers of materials. So, here this is an example, where different layers of materials are taken.

So, this is the regular brick wall which is 230 mm thick brick wall with 25 mm of internal power plaster and 25 mm of external plaster, which is added to it; a software like design builder and almost all others. They already have the thermal properties of these individual materials in built into the software here it is for concrete.

So, the moment we select these different layers automatically the software allows to calculate the U value for this combination of the material, this composite including all the layers. So, if the material is available suppose, we want to add concrete which is already there in the material library; however, if we want to use a certain material for example, CSEB the Compressed Stabilized Earth Blocks. May be that the material specifications of properties thermo physical properties for CSEB is not available as part of the available library in the software.

In that case, all these properties for CSEB will have to be tested. And those values will have to be put in and a new material will have to be created which will then help us calculate the U value of the composite, the combination of these materials.

So, these properties are essential because the moment we talk about energy simulation whole building performance simulation. We are talking about the exchange of heat through this material. And therefore, without these properties we cannot work. So, the moment we decide that as an alternate of material I want to use a dope, I want to use brickbat coba or I want to use some other material, which is not conventional material.

We will have to have the properties of these materials and only then can we go ahead and prove that this material, this new material that we are using is a better material or will provide more insulation or will be better for energy efficiency of the building overall. So, that was about materials.

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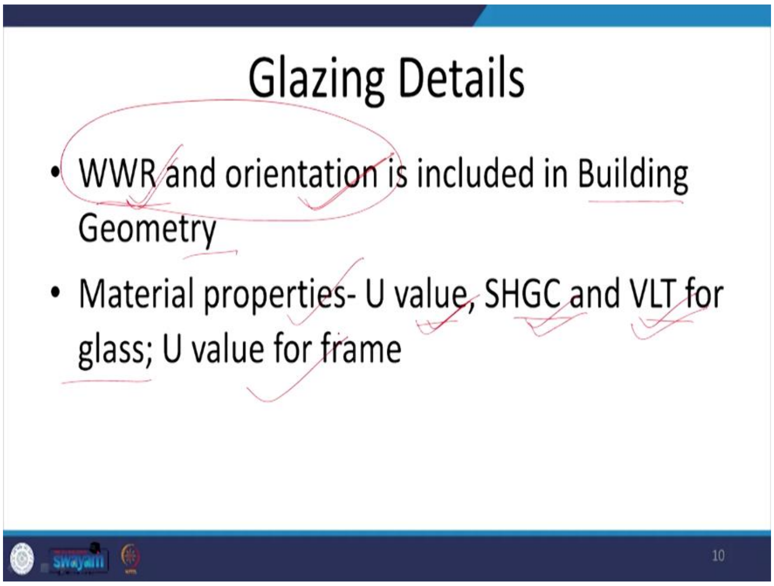

The next we have is glazing details. So, the moment we talk about glazing details, we are talking about 3 things here, first of all window wall ratio, second is orientation. Now, both of these are included while we are creating the building geometry. So, when we are making the building geometry in the software, we will be adding windows as part of the building geometry. So, automatically the window wall ratio and orientation is taken care of it is already included in the building geometry. In case, we are going ahead for base case which we will gradually come to the WWR may also be specified in the specifications while we are creating these glazing’s. So, as to equally uniformly distributed on all the sides.

The next within glazing details is material properties. So, while we are talking about material properties; here we will be talking about U value, SHGC and VLT for the glass. We all already know about these properties. So these properties for the glass if it is being used will be selected. Now, often most of these whole building simulation software they come with a huge glazing database which is taken from the international glazing, glazing database it is called IGDB.

Almost all the glasses which are manufactured by different glass manufacturers are included in that database. And the moment you select one type of glass, it will automatically come with its U value, SHGC and VLT which is required for whole building performance simulation. The next thing that we were also require along with this is U value for the frame. So, this is also largely available. So, different types of materials which are commonly use for frames for example, wood, iron steel, aluminum, UPVC all others are already included. So, the thermal properties the U value for the frame is also included in the software library, the material library.

So, this is what we will require when we are going ahead and simulating the fenestration. The next what we require is, occupancy schedule. So, for a building which is going to be constructed, a newly constructed building which is proposed. Here we may have to assume the occupancy schedule based upon the brief from the client. So, when you are say suppose we are designing an office building and it is an open plan office. So, in that case, the brief would already be available from the client, that this open plan office is meant, for 100 employees plus ah, 5 more employees in senior category. Who will be having their individual cabin and then there will be around 10 administrative staff, the ministerial staff. So, overall occupancy will be given.

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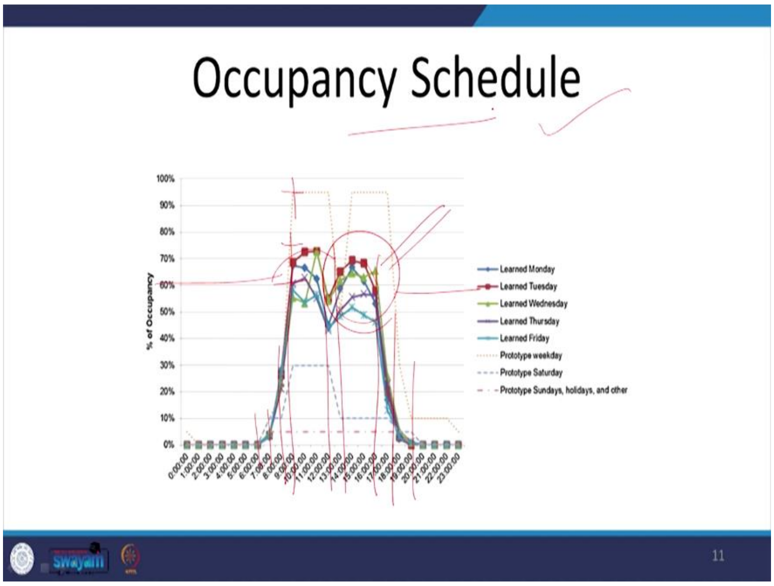

When we are simulating a building the occupancy schedule will have to be created as to when do people come in. So, suppose it is a daytime use building. So, we see that from 6:00 AM to 7:00 AM the occupancy is just 5 percent of the total occupancy, and from 8:00 AM it starts to increase and by 9:00 AM it has become around 70 percent. Now this is the actual, when we are proposing, when we are calculating, the performance of the building estimating it. We will assume the occupancy to be higher and it will be taken somewhere close to 90 percent.

Sometimes for example, in buildings, like hospitals the occupancy may be taken as much lower it will be taken at 75 percent; when we are talking about say hotels the occupancy may be taken even lesser it may be taken at 60 percent. So, depending upon the use of the building, the type of the building, the occupancy schedule will vary. So, it dips back around lunch, when people would be going out for lunch and for other times it will be almost close to the peak and then again towards the end of the day it sharply goes down.

Suppose it is a 24 hour building, then we have to also look at the other shift and we will have the occupancy schedule, now how does occupancy schedule help in estimating the energy performance of the building? So, one the occupancy is a big contributor to the internal heat gain, internal heat load so that is what it adds to the second in case we are using sensors we can also optimize the use of sensors to optimize the lighting loads and, the ventilation loads, HVAC loads. So, these sensors because occupants are not there, we have to just assume, based on this occupancy schedule we can also schedule how the HVAC mechanical ventilation and lighting would be functioning and thereby achieving energy savings through the active systems.

So, occupancy schedule is very very important and on the basis of occupancy schedule many other schedule are also decided.

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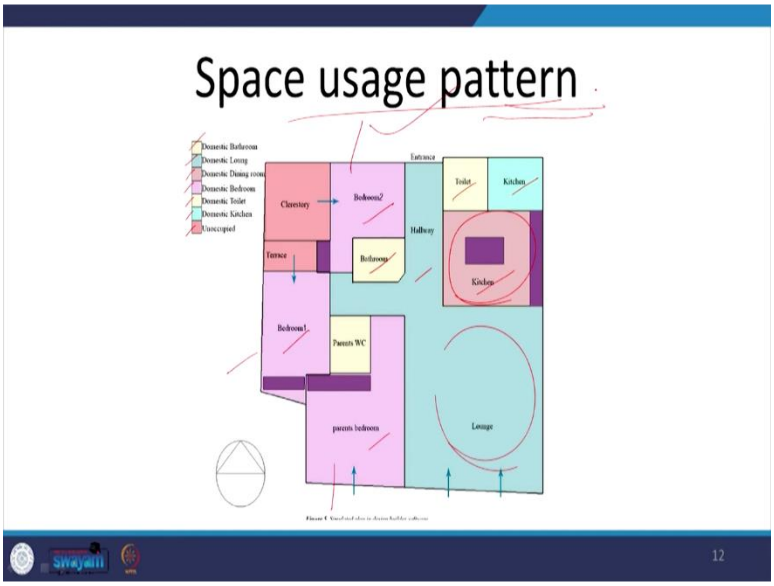

The next which is also very important and it is often incorporated as part of the building geometry is the space usage pattern. So, suppose this is a residence a plan of a residence, where different types of spaces are given different types of space usage.

Now depending upon the usage which is assigned to a space the energy consumption would vary. The density of people would vary, the space usage pattern the occupancy pattern through the day would vary and each of this would be then accounted for or it will be contributing towards the energy consumption pattern.

We can also decide in this whether this is going to be an air conditioned space for each space then we can have a different air conditioning schedule which can be there. So, when we are talking about bedrooms say. So, we may have air conditioning only from say evening 7 till morning 7, while in the lounge it may be on and off, in kitchen we may not have an air conditioning at all.

So, depending upon the space, we will have the occupancy pattern, occupancy schedule, the lighting schedule the HVAC schedule and all of those. So, space usage pattern were also be have to be identified right in the beginning. Suppose in an office building where the space usage is not varying much. So, it is an open plan and a huge open plan is going to be there, there the space usage pattern will not have a bigger role to play in that case thermal zones will have to be created. So, we will come to thermal zones when we are discussing in detail about, how the base case is to be created, but right now we are only discussing about the input patterns. So, space usage will also be required.

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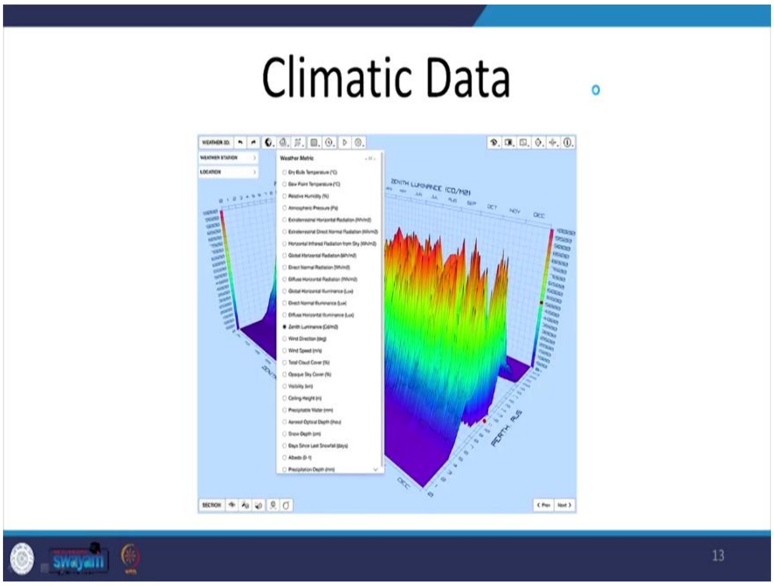

And the last one is the climatic data we have already seen what a weather data file looks like what all different data it includes. So, it includes temperature humidity, the radiation air speeds, the direction of the wind the ground temperature the surface temperature. So, all of that is included as part of the climatic data. So, all this is required before we decide to proceed ahead with whole building simulation.

So, I will conclude my first lecture here. And in the next lecture, we will be discussing about the requirements of base case and propose case with respect to this input data.

Thank you very much for being with us. See you again in the next lecture bye bye.