

**Glass in buildings: Design and Application**  
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**Lecture – 17**  
**Modeling the Building Envelope**

(Refer Slide Time: 00:21)



**CASE STUDY – BUILDING ENVELOPE**



So, we have kind of tried to introduce you to energy modeling, and how the various parameters used in energy modeling can actually help you to aid important decision making in your detailed design stage.

And now we look at actually a case study of an actual building which we had done, and where the client had asked us to actually create the simulation studies for energy simulation for a particular office building. They wanted to locate the building in three different climate zones and see how the performance of the building would be. They did not want to change the design. So, the design would be the same, but what would be the impact of locating the building in different locations. For example in India you have different climate zones.

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**PROJECT DESCRIPTION**

- A Commercial Office building is to be constructed in 3 different climate zones namely Hot Humid, Moderate and Hot Dry.

Building/Model Information	
Building Size	2B+G+ 12 Floors
Building Shape	Refer Model Images
Gross floor area	309142 sq.ft
Conditioned floor area	187822 sq.ft
Application	Typical Office Building
Schedules/Operating Hours	Typical Office Schedules as per ASHRAE
WWR-30%	
Window area [Approx]	31272 sq.ft



So, we are trying to will tell you how this building if you located in different locations the same design, how it is going to perform. So, that is something that you can look at and see where you want to locate the building right.

So, we chose three different climate zones, the hot humid moderate and hot dry hot humid is basically Chennai, which is a coastal area a moderate climate zone was for Bangalore and hot dry for Ahmadabad. So, these three locations were chosen and you were asked to do a study on how the building performance would change, because they had a very clear idea of not to change the design of the building. And yet see how the building is going to perform in these climate zones.

So, basically here we are talking about the various parameters of the building, the area of the conditioned area, the window wall ratio all those parameters are provided. So, 12 floor building.

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### Modeling Inputs

Exterior Wall Construction	a. 200 mm Solid block wall+12mm Plaster on both sides, U-factor=0.386 Btu/hr.ft <sup>2</sup> .°F b. 200 mm Aerocon wall+12mm Plaster on both sides, U-factor=0.124 Btu/hr.ft <sup>2</sup> .°F
Roof Construction	Insulation entirely above deck, R=15ci, U-factor=0.063 Btu/hr.ft <sup>2</sup> .°F Roof reflectivity=0.30
Floor/Slab Construction	Steel-Joist, U-factor=0.350 Btu/hr.ft <sup>2</sup> .°F
Window-Wall Ratio (Excluding Basement)	30%, 50% & 80%
Fenestration type	All Orientation
Fenestration U value	As per Glass selection
Fenestration SHGC	As per Glass selection
Shading Devices	None
Interior Lighting Power Density(W/ft <sup>2</sup> )	Office-1, Parking – 0.3
Day lighting controls	None
Other Lighting Control Credits	None
Exterior Lighting Power (kW)	11.99 KW
Receptacle Equipment Power Density & Elevator	Office – 1.6 W/ft <sup>2</sup> , Car parking – 0.1 W/ft <sup>2</sup> , Elevators – 72 KW



And here we are talking about the different modeling inputs that we would give to that building. So, what kind of envelope do you use, what is the what is the property of the roof the wall and so on and the glass the material.

So, here we are trying to look at, only those parameters which would influence the building envelope. So, as I said earlier the modeling has a lot of parameters you can play around with. So, here we are looking at only the passive design strategies, which you would want to adopt for this particular building in different climate zones. So, we would look at basically the window wall ratio the SHGC of the glass, and keeping all the other parameters constant. If I just keep changing the window world ratio, the glass property or the wall property, we will see how the building is going to perform in different these different climate zones and that will do a fairly good idea on what material you would want to choose in a particular climate zone on a particular facade for example.

So, all these studies will actually help you to arrive at the right kind of decisions comes to these are not a very practical case studies which is actually a real time case study. And these results actually were extremely useful for the customer to actually decide, what kind of material to use or which orientation you want to put the building in, what climate zone you want to put it in right. So, it actually justifies your decisions based on a lot of scientific studies right.

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### Modeling Inputs – HVAC



Primary HVAC system type	System – R. VAV w/ PFP Boxes System Type – Variable air volume with reheat, Fan control – VAV, Cooling type – Chilled water, Heating type – Electric Resistance Fans in parallel VAV fan – powered boxes have been considered.
Fan Power	Fan Power (Calculations based on the Table G3.1.2.9 ASHRAE90.1 2004), Control – Variable Speed drive
Economizer Control	None
Energy Recovery	None
Demand Control Ventilation	None
Chiller parameters	2x110 TR Water Cooled screw Chiller with a full load efficiency of 0.6394 Kw/Ton at ARI conditions.
Chilled Water loop & pump parameters	Pumps are modeled such that the chilled water pump power work out to 22 w/gpm as per ASHRAE section G3.1.3.10 Medium efficient – VFD Drive
Boiler parameters	None
Hot water loop & pump parameters	None
Cooling tower parameters	Cooling Tower with Two Speed fan
Condenser water loop & pump parameters	Flow – 3.5gpm/ton The condenser pump power for the base case works out to 19 watts/gpm as per ASHRAE section G3.1.3.11, the condenser water loop has been set for a 10 Deg F approach to design wet bulb and 85 Deg F condenser inlet temperatures



And we keep all the other things constant right we are talking only about envelope design right. So, you keep the HVAC system the same, you keep the fan power the same, chiller parameters the same. So, you try to just play around with envelop and see how your performance is going to be right.

So, and of course, you can still model your systems based on the climate zone, you can still change the system slightly and then see the impact of envelop. So, here we basically kept the systems more or less the same since the temperature profiles were more or less the same, but except for the climate zone where you had more humidity in certain places and so on. So, only the envelop parameters were change changed and then we saw how the impact of that was when it came to energy performance.

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## Envelope Specs



GLASS SPECS				
Type	Brand	U Value (Btu/hr.sq.f.F)	SHG C	VLT
I	ET125 - ET 125, Clear cosmos/Evo [DGU]	0.352	0.23	23%
II	ST 136, Graphite/Cool-lite [SGU]	0.968	0.42	37%
III	5mm Planilux	1.02	0.86	90%

WALL SPECS		
Type	Brand	U Value (Btu/hr.sq.f.F)
I	200 mm Solid block wall+12mm Plaster on both sides	0.386
II	200 mm Aerocon wall+12mm Plaster on both sides	0.124

So, here you are looking at the different options that we had to evaluate right. So, you have the top table is talking about the glass specs you had different varieties of glass, which have different u values different SHGCs, we spoke about u while you we spoke about solar heat gain coefficient. The VLT is talking about Visual Light Transmittance is amount of visual light that that glass would allow inside, which means it has a direct impact on the amount of daylight that you will get inside the building right. So, as you can observe here as the SHGC gets reduced your VLT also goes down right. So, which means you are trying to balance the two, because the more the SHGC the more the heat that is going to come inside the building

So, you want to keep the heat content low at the same time you want more light right you want the best of the best of both, and that is a challenge for most glass manufacturers to make sure that you have a lower SHGC and a higher VLT. So, we want both the best of both. So now, that is not possible humanly right we cannot have both parameters favorably poised. So, we try to see how you can still reduce one and try to maintain the level of daylighting depending on the sun path and so on. So, you have a fairly good idea on combining the glass with the solar window and the solar path analysis and see where optimally you can put this glass, which facade you can put. So, that you get a fairly good idea on minimizing the SHGC at the same time you get more daylight right.

So, that is the philosophy and of course, you have wall also in your envelope, and what is the different types of wall that you can look at. You have a narrow cone block wall which has an over u value compared to a solid block wall, which has higher u value. So, you want to limit the u value because lower the u value the lower would be the heat ingress through conduction.

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### CLIMATE ZONE IMPACT




GLASS SPECS					WALL SPECS		
Type	Brand	U Value (Btu/hr sq ft F)	SHGC	VLT	Type	Brand	U Value (Btu/hr sq ft F)
I	ET125 - ET 125, Clear cosmos:Evo (IGU)	0.352	0.23	23%	I	200 mm Solid block wall+12mm Plaster on both sides	0.380
II	ST 136, Graphenecolite (SGU)	0.968	0.42	37%	II	200 mm Aconon wall+12mm Plaster on both sides	0.124
III	5mm Planitux	1.02	0.86	90%			

Climate Zone	Location	WWR	Wall Type	Glass Type	Total Energy Consumption (KWh/annum)	% reduction compared to Warm Humid
Warm Humid	Chennai	30%	I	I	4779027	N/A
Moderate	Bangalore	30%	I	I	3898923	18.42%
Hot-Dry	Ahmedabad	30%	I	I	4551566	4.76%
Warm Humid	Chennai	80%	I	I	6931009	N/A
Moderate	Bangalore	80%	I	I	4062406	17.62%
Hot-Dry	Ahmedabad	80%	I	I	4819542	2.26%



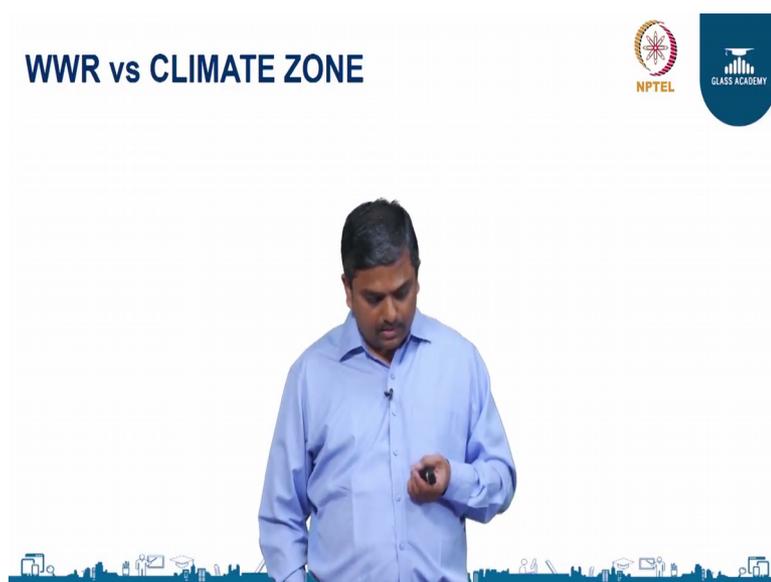
So, if you look at this slide the next slide from about the climate zone impact. So, what if I keep all the glass and the wall the same and just alter the climate zone. So, here you can see if I keep every parameter the same and simply change only the climate zone, everything else about the building is the same. So, then what is the performance, how do you see the energy performance. So, you can see the warm humid zone which is Chennai has got the highest energy consumption right with these types of glass. So, if you have a wall type 1; type 1 is talking about glass SpecC of ET 125 with a U value of 0.352 SHGC of 0.23 and the VLT of 23 percent that is glass type 1.

Wall type 1 is 200 millimeter solid block. So, you can see from this table that the climate zone naturally has an impact on the energy performance. So, warm humid climate zone has today has higher energy performance for the same spec of wall and glass compared to humid or moderate right. Similarly you have. So, we are keeping everything else the same right of course, you need to optimize the others also, but just to get an idea of how the energy performance varies just by altering the envelope right.

So, similarly you can change the wall and then see how the energy performances. So, if you look at the top value and the bottom table, you can see that in the warm humid zone itself your energy performance is going up when you are shifting to a higher WWR, which means you are having a higher wind overall ratio in a particular facade from 30 to 80 you have made and you are seeing that energy performance actually is kind of going up right.

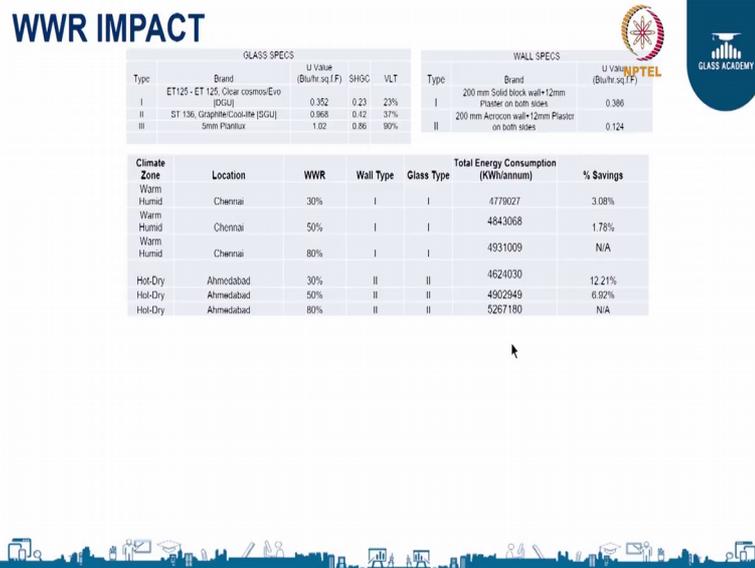
So, there are various studies you can do with just modifying the envelope elements and see how your building performances. So, you can actually arrive at an optimal window wall ratio for that particular climate zone given your design, and then see how you can optimize the amount of glass in different facades, based on the solar path and actually optimize your building design.

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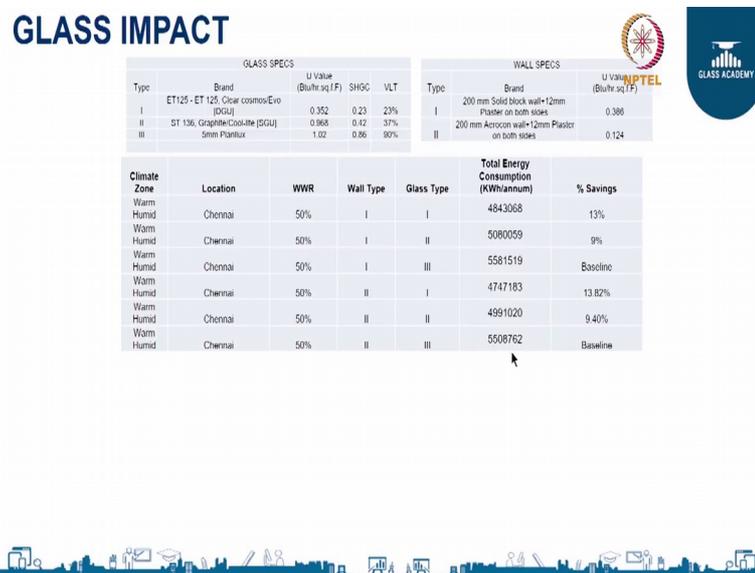
So, you can see that the next slide is talking about the window wall ratio and the climate zone impact. So, as we increase the window wall ratio in different climate zones, you have different kinds of energy performance values. So, as you increase the WWR and the same climate zone your energy performance is going up or the energy consumption is going up.

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So, that is what is actually illustrated in the slide that follows. So, we have just tabulated the values of the various glass types and the wall types, and how the performance of buildings actually changes when we alter these parameters.

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Similarly, you can do the same study for different types of glass. So, if you look at the next slide we are talking about just varying the glass type, it keeping the wall the same and the WWR the same what if I change the glass. So, if I change say to a lower it SHGC glass, you can see that there is a substantial improvement in your energy right. So, at the

same time you are also not impacting the daylight. So, you can actually do you can combine these simulations, which are energy simulations with the daylight simulation and see you can match the two and see how you can actually improve your daylight at the same time use a lower SHGC. So, that involves a lot of studies on sun path and trying to align your building to the right kind of orientations. So, that you get the optimal light inside the building right.

So, all these studies can actually give you a fair a bit of insight in on what to use, when what type of material to choose from when you do your energy studies. A fairly powerful and with the amount of extent of weather data that is available today, we have actually a fairly accurate prediction of the energy performance that we can look at.

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## WALL PERFORMANCE

GLASS SPECS				
Type	Brand	U Value (Btu/hr.sq.ft.F)	SHGC	VLT
I	ET125-ET125, Clear cosmos/Evo (IGU)	0.352	0.23	23%
II	ST 136, Cospire/Cosulite (IGU)	0.368	0.42	37%
III	5mm Planitex	1.02	0.86	90%

WALL SPECS		
Type	Brand	U Value (Btu/hr.sq.ft.F)
I	200 mm Solid block wall+12mm Plaster on both sides	0.386
II	200 mm AAC block wall+12mm Plaster on both sides	0.124

Climate Zone	Location	WWR	Wall U Value	Glass Type	Total Energy Consumption (KWh/annum)	% Savings
Moderate	Bangalore	50%	0.386	I	3975943	Baseline
Moderate	Bangalore	50%	0.124	I	3927674	1.21%
Warm Humid	Chennai	50%	0.386	II	5080059	Baseline
Warm Humid	Chennai	50%	0.124	II	4991020	1.75%
Hot Dry	Ahmedabad	50%	0.386	II	4981069	Baseline
Hot Dry	Ahmedabad	50%	0.124	II	4902949	1.57%
Moderate	Bangalore	80%	0.386	I	4062406	Baseline
Moderate	Bangalore	80%	0.124	I	4048875	0.33%
Warm Humid	Chennai	80%	0.386	II	5291549	Baseline
Warm Humid	Chennai	80%	0.124	II	5257282	0.65%

So, the next slide is talking about the wall performance. So, what if I keep the glass the same and start changing the wall u values. So, that gives you some fairly good idea of the incremental benefit that you we get by changing the wall alone keep in my class the same right and the WWR the same. So, all these studies can actually give you a fairly bit accurate prediction of the incremental benefit that you will get. For example, you can see that is a 1.75 percent improvement in savings if I use a glass type 2 versus a glass type 1 or a different WWR. So, these studies will actually help you to arrive at prudent decision making during your design process.

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Analysis - Summary



Warm Humid Climate zones show higher energy consumption compared to Hot Dry and Moderate Zones for similar buildings

Within the same Climate Zone, Energy savings of 3 – 12% is achieved with lower WWR of 30% compared to a WWR of 80%

Energy Savings of 13-15% can be achieved with a high Performance Glass (SHGC of .23) compared to a glass with SHGC of .42 and a WWR of 50%

Walls with low U values show greater savings at WWR of approximately 30%.

WWR of 28% -30% is optimal for energy performance.



So, just try to summarize the value.

But what is presented here is a fairly toned down version of actually what was (Refer Time: 10:50) presented to the client. We are just trying to give you some basic idea on how you can tweak these parameters to give you some to help you to aid decision making. So, that is the idea of this exercise. So, it its actually family a bit more involved it has a lot of parameters to work with, just try to cut down some of it. And try to just give you some basic idea on what you can do with these tools and make your design decisions more effective, and how you can combine these tools with. And manage your various stakeholders in the building lifecycle to make sure that they are all in line with what you are expecting as an owner or a building important stakeholder in the building design.

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### In Summary

Energy modeling in design is not ADDITIVE to regular building design and should not be conceived as a separate feature with an add-on cost

Integrated design approach amongst project team members is required to build green with little or no added cost

Energy modeling, though still evolving, opens several doors to applying building science to architecture and engineering

Caution - Quality of model is as good as the quality of inputs<sup>†</sup>



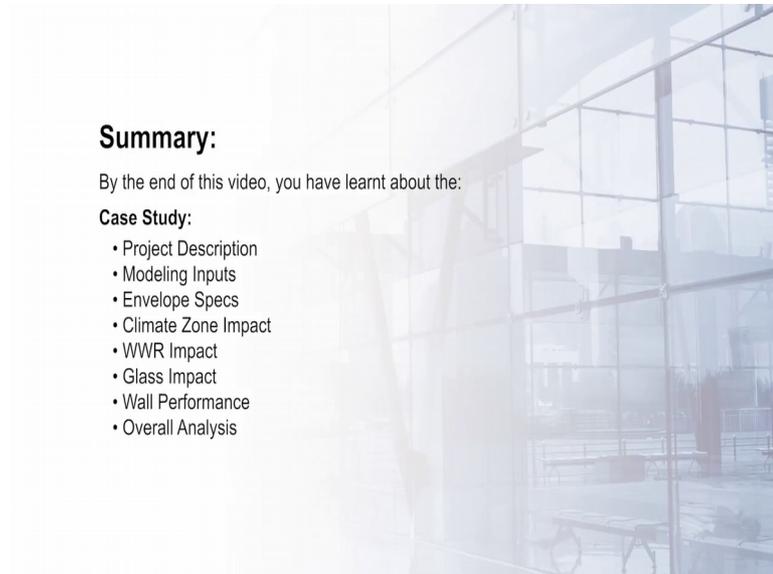
So, to summarize we are trying to see how energy modeling should not be treated as an additive to design, it should actually be part of integrated design and it should go along with all the phases of the building lifecycle, starting from pre design, to schematic design, to detailed design all through construction and see how your building performance changes as you elaborate the design.

So, it is extremely important and on top of that you continue to use this model during the operations as well and try to retrofit your model or calibrate your model continuously to the actual energy performance based on utility bills that you get during your operations. So, what happens is throughout the lifecycle of your building, this model is evolving and it is always calibrated to the actual performance. So, two more when you do an energy audit and you are finding certain energy conservation measures, you can actually put these energy conservation measures into the model to see actually how much benefit do you get. And you can start looking at cost benefit analysis and what is the percentage savings you will get. All those things can be done for every retrofit that you intend to do during the operations of the building that makes it even more effective.

So, I hope we have tried to give you a fairly good understanding of the basics of energy modeling, it is a fairly involved subject, it is got a lot of branches and various areas where you can focus on, depending on her area of interest and I hope you had a good

fairly bit good understanding of this process and the various parameters involved in energy modeling.

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**Summary:**

By the end of this video, you have learnt about the:

**Case Study:**

- Project Description
- Modeling Inputs
- Envelope Specs
- Climate Zone Impact
- WWR Impact
- Glass Impact
- Wall Performance
- Overall Analysis

Thank you all the best.