Glass in Buildings: Design and Application
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Lecture - 82
Case Studies of Building Envelop Design for Sustainable Buildings

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The next case study I am going to discuss is also commercial building, but it is 24 7, 24 hours a day and 7 days a week used building. The building again is located in Delhi NCR where a total built up area of approximately 50,000 square meter. The building had deep plan offices so, the daylight was only limited to the perimeter of the building. Perimeter spacers are the spaces which are next to the building envelop or building facade the spaces, which are inside those or spaces which are too deep were not able to receive good daylight.

The building was ground plus 9 story having 2 basements and the client aspired to achieve platinum rating, platinum IGBC, green new building rating for this particular project.

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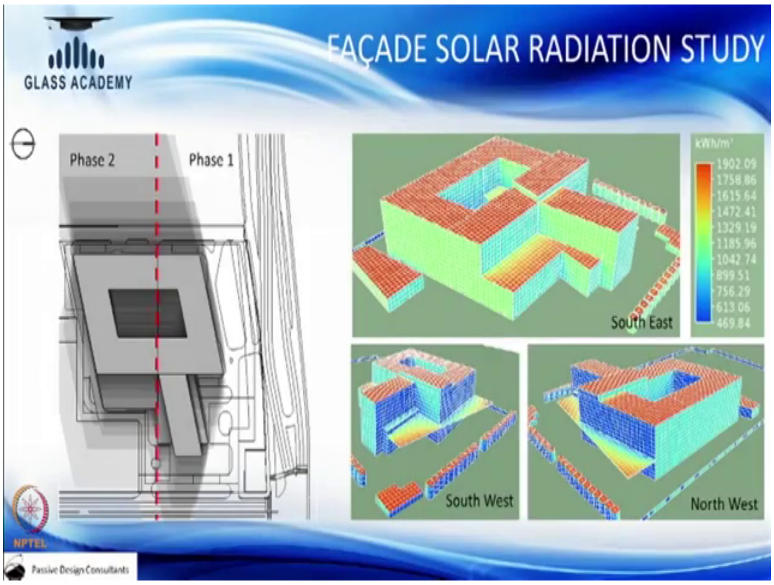

Again we started the project with a facade solar radiation study. On your left are showing you a building plan, how the building was planned to be in complete development. The project had 2 phases, phase 1 and phase 2. Front of the plot which was facing the main road was planned to be in phase 1.

However, the master planning studies were done for both phase 1 and phase 2. The project was observed that the front facade was actually the North facade and that is where through solar radiation we validated that we were getting the minimal amount of solar radiation falling onto that surface on to the north facade. While East, West and South were getting relatively much higher radiation as expected; loop was obviously, getting the maximum solar radiation which could be developed for optimising or harnessing solar energy through solar PV panels.

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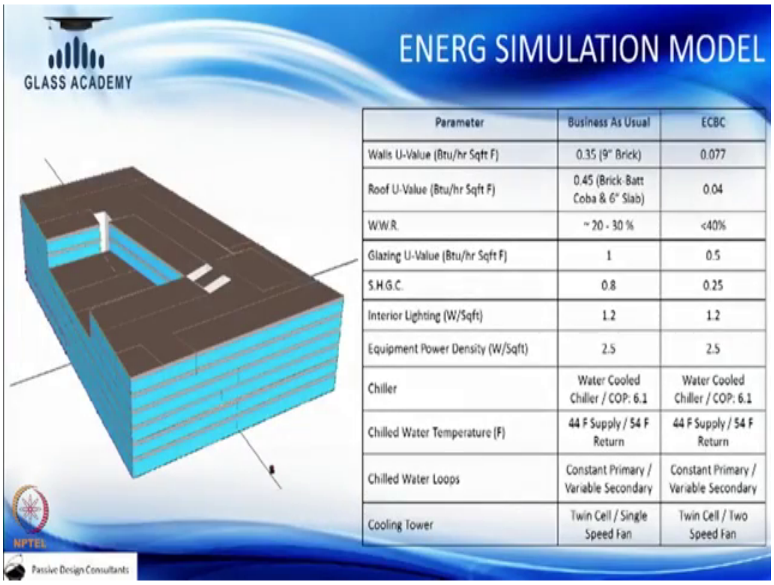

Parameter	Business As Usual	ECBC
Walls U-Value (Btu/hr Sqft F)	0.35 (9" Brick)	0.077
Roof U-Value (Btu/hr Sqft F)	0.45 (Brick-Batt Coba & 6" Slab)	0.04
W.W.R.	~20 - 30 %	<40%
Glazing U-Value (Btu/hr Sqft F)	1	0.5
S.H.G.C.	0.8	0.25
Interior Lighting (W/Sqft)	1.2	1.2
Equipment Power Density (W/Sqft)	2.5	2.5
Chiller	Water Cooled Chiller / COP: 6.1	Water Cooled Chiller / COP: 6.1
Chilled Water Temperature (F)	44 F Supply / 54 F Return	44 F Supply / 54 F Return
Chilled Water Loops	Constant Primary / Variable Secondary	Constant Primary / Variable Secondary
Cooling Tower	Twin Cell / Single Speed Fan	Twin Cell / Two Speed Fan

We develop the energy model for the project, you would see that the project was designed to be like a glass box which primarily had glass on all the 4 facades where having more than 80 to 90 percent window to wall ratio. These are the parameters which were considered if it is a conventional building what will happen what is generally used?

Shown here as building as usual with all the parameters for brick walls, roof having brick bat coba. Typically business as usual buildings have 20 to 30 percent window to wall ratios, but this building was having more than that, this was having almost 80 to 90 percent window wall ratio.

In comparison to that when we compare ECBC values U values for walls, roof are much more stringent as compared to business as usual. The window to wall ratio is also limited to 40 percent as given in ECBC 2017 as well. All the values, all other values were majorly much more stringent in ECBC. I would not be going through the lighting and the equipments and air conditioning part of it as we are not focusing on it, we are majorly focusing on the building envelop and the facade strategies.

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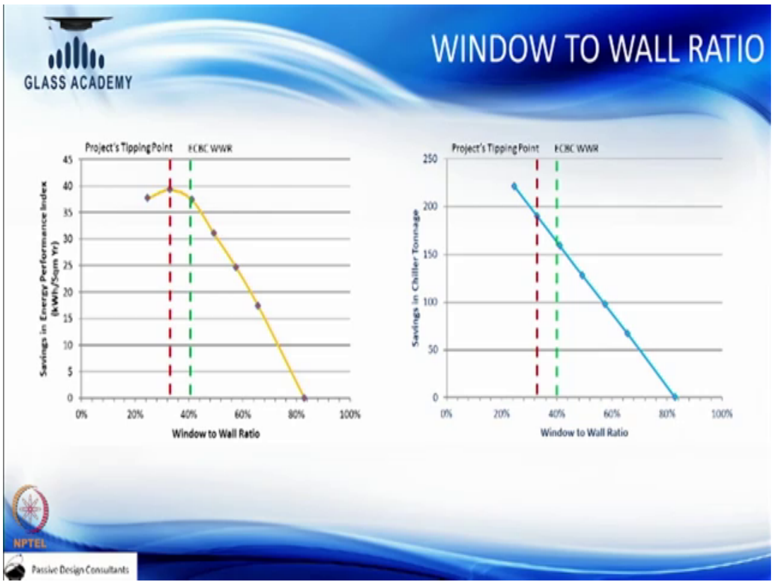

So, through building simulations for this particular case we relies and we showcase to the client how having such high window to wall ratio could really have a detrimental effect and poor performance of the building. We showed them how if we further reduce the window to wall ratio, the amount of glass on the facades, how further we can reduce not only in the energy performance index, the energy consumed per kilowatt hours per consumed per square meter per year. But, we also showed them how it would also reduce the overall chiller tonnage or the air conditioning load.

So, if our chiller tonnage or the air conditioning load is also significantly reduced that will also help us in reducing the capital cost of the building, not only the operational cost. So, the case study the simulations done showed that if the window to wall ratio was optimize somewhere around 35, 30 to 35 percent that would be the tipping point in the project where between 30 to 40 percent that is the most optimal solution for this particular project.

If the window to wall ratios are reduced below 30 percent, we the energy savings would start reducing. the reason for that is the daylight ingress and the building will start reducing significantly in the areas which could be potentially well daylight and that would lead to more use of internal artificial lighting.

So, as a guideline the study showed that having window to wall ratios for this particular project between 30 to 40 percent would be more optimal. And that would also help a client to reduce their chiller size in this particular project by almost 175 tonnes.

Further, we showed how, what would be the impact of solar heat gain coefficient or the heat gain those windows in the project we started with having SHGC of 83 percent which is for a 6 mm clear single glazing.

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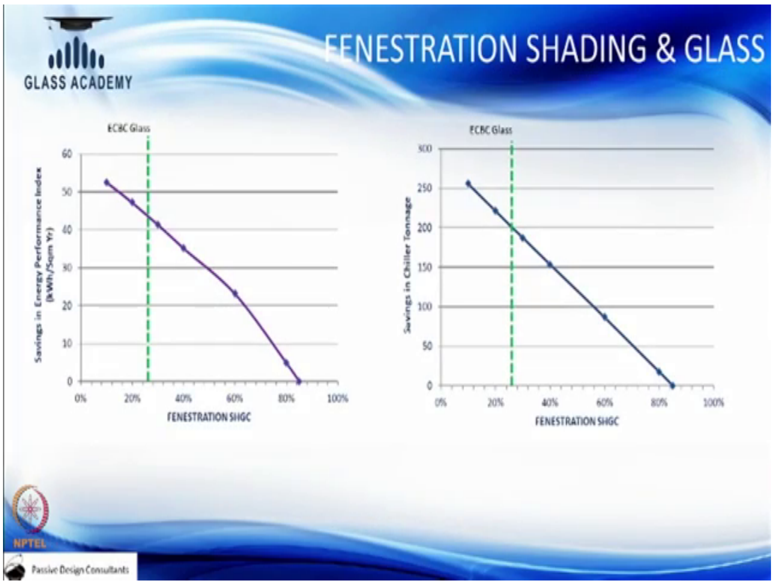

And checked different glass options available to us with reducing solar heat gain coefficient from single glass to double glass. We realise that the relationship between savings and energy consumption of the building and tonnage is quite linear with comparison with in correlation to solar heat gain coefficient. The more SHGC we reduce in the project lower would be the energy consumption and lower would be the heat gain.

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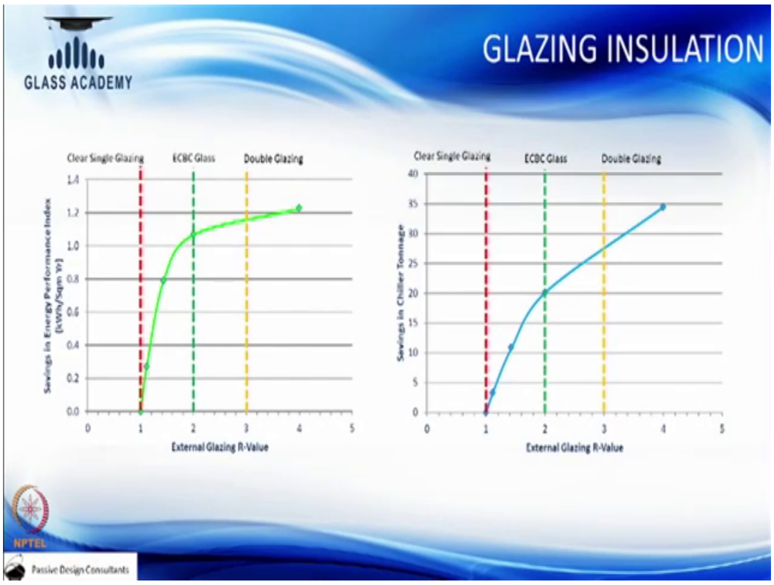

Further, we also checked what would be an impact of glazing installation on the energy performance of the building and the heat gains. It was observed in the project that the heat gains or the energy consumption because, of the U value would saturate almost after we achieve R value of 2 which was also and ECBD recommended glazing value glass U value. Beyond that if we keep on increasing the insulation the savings were not significant, either in terms of energy savings or chiller tonnage savings.

For the wall insulation for the facade insulation and wall insulation, we check where do we fall in comparison to ECBC recommended or prescriptive values. And 250 mm AC brick wall or may a single work which was proposed ultimately in the project. It was proposed primarily because through the simulations through this these glass that we are presenting here.

We realise that after beyond 10 R value the savings were not as much significant as much they were before. And even reaching to a point where the insulation is matched to ECBC prescriptive value it will not lead to significant energy savings; however, capital cost games would be significant capital increase in the project cost would be significant. So, recommended to the client to stay with 250 mm AC blocks which would give us R 10 value in the project.

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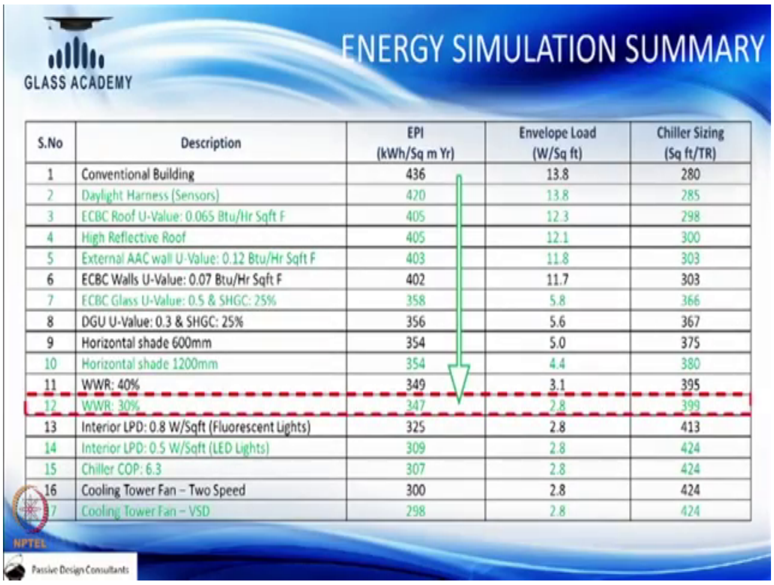

S.No	Description	EPI (kWh/Sq m Yr)	Envelope Load (W/Sq ft)	Chiller Sizing (Sq ft/TR)
1	Conventional Building	436	13.8	280
2	Daylight Harness (Sensors)	420	13.8	285
3	ECBC Roof U-Value: 0.065 Btu/Hr Sqft F	405	12.3	298
4	High Reflective Roof	405	12.1	300
5	External AAC wall U-Value: 0.12 Btu/Hr Sqft F	403	11.8	303
6	ECBC Walls U-Value: 0.07 Btu/Hr Sqft F	402	11.7	303
7	ECBC Glass U-Value: 0.5 & SHGC: 25%	358	5.8	366
8	DGU U-Value: 0.3 & SHGC: 25%	356	5.6	367
9	Horizontal shade 600mm	354	5.0	375
10	Horizontal shade 1200mm	354	4.4	380
11	WWR: 40%	349	3.1	395
12	WWR: 30%	347	2.8	399
13	Interior LPD: 0.8 W/Sqft (Fluorescent Lights)	325	2.8	413
14	Interior LPD: 0.5 W/Sqft (LED Lights)	309	2.8	424
15	Chiller COP: 6.3	307	2.8	424
16	Cooling Tower Fan – Two Speed	300	2.8	424
17	Cooling Tower Fan – VSD	298	2.8	424

As a summary of the studies conducted for this particular project we realised that if the project had the project being a conventional building having all the conventional building parameters like 9 inch brick wall, non insulated roof with just brick bat coba, on top single clear glazing and on. The project could achieve an EPI value, energy performance index kilowatt hour per square meter annually. The consumption would be 436 kilowatt hour per square meter.

However, through different facade optimisation strategies like good daylight hardness by probably integrating the daylight sensors and the perimeter spaces, by insulating roof, by having high reflective finish on the roof, by using AC wall on the AC block work for the exterior walls having high performance DGU for the windows. And for the glazing having SHGC solar heat gain coefficient value of 25 percent and further improving the solar heat gain coefficient by having horizontal shades on South, East and West facade of 1200 mm deep.

And reducing our window to wall ratio to 30 percent. With all those strategies we could reduce our energy performance index or building energy consumption from 436 kilowatt hour per square meter to 347 kilowatt hour per square meter. This also reduced our building envelope load from 13.8 watt per square feet to 2.8 per square feet.

And the chiller size would be reduced from 280 square feet per tonne which is generally there for a conventional building to almost 400 square feet per ton. So, with this strategies with only strategies involving facade we could reduce the chiller tonnage to 400 square feet per tonne which is in my opinion quite well performing.

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Moving on to what case study 3, this is also a commercial core and shell building located in Delhi NCR. This had a total built up area of approximately 1000 square meter where building height ground plus 8 and having 2 basements. This particular project is aiming 5 star GRIHA rating under version 3.

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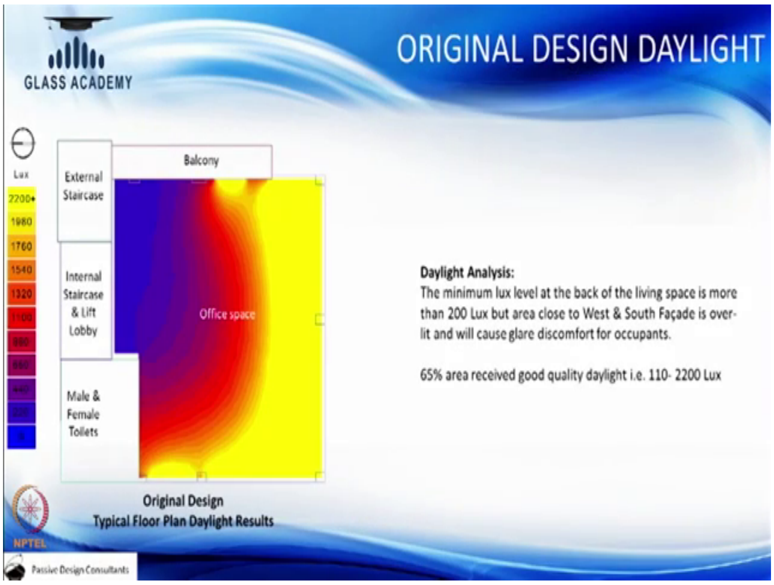

We started through so, I will just quickly take you through the third case study just showing you what we had initially. So, when the architect give us the project the project was receiving only 65 percent area which was achieving well daylight. This was the area which was receiving good daylight between 100 and 10 LUX to 2200 LUX.

However, the project also had significant glare problem from the South and Western facades which must be optimised in order to really harness good daylight in the building and to improve the energy efficiency of the project.

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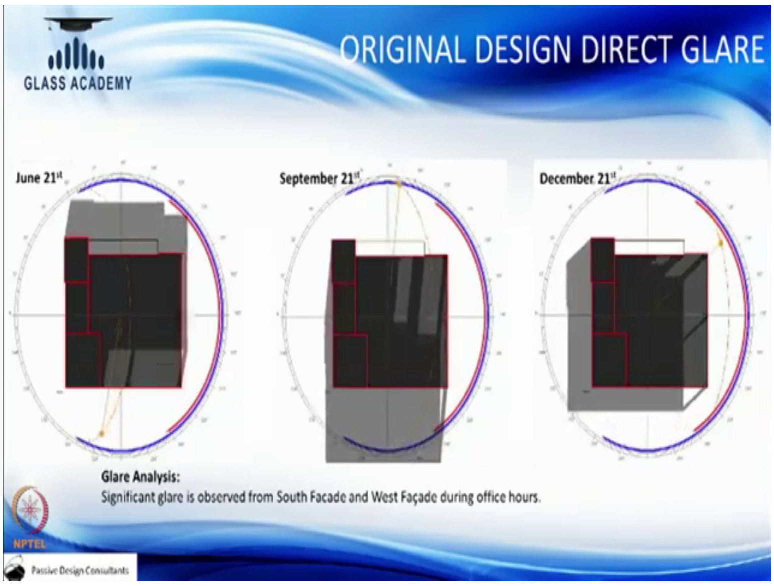

We realised that we showed through to the client through the glare analysis that we can see that on wind summer solicitous there was significant glare coming in from the South and the West facade. The East facade also had little glare, but that glare was not really a problem for this project. Since, this project was an office building and the glare was only there till 9 or 10 am and typically office building start working after 10. So, we were not really so much concerned about glare from East.

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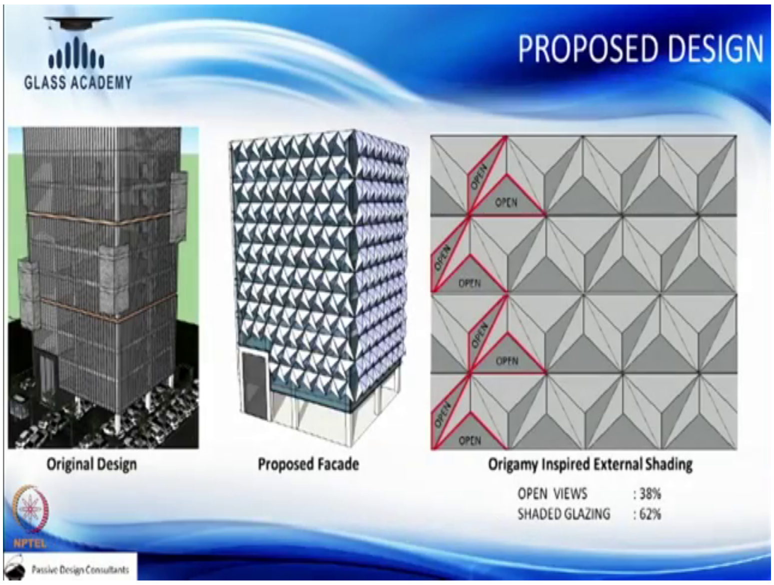

So, as a replication after many iterations and many design solutions we reach to a level where we propose to the client and origamy inspired external shading device. The shading devices would be static these are not dynamically operated shading devices. The shading devices were designed to have at least around 40 percent open views. So, that the views are not 100 percent block for the people who were sitting inside. While the shaded area would be more than 62 percent.

And on the slide we show you how the original design load and with the proposed facade it would actually have a better aesthetical statement and this facade would also work well.

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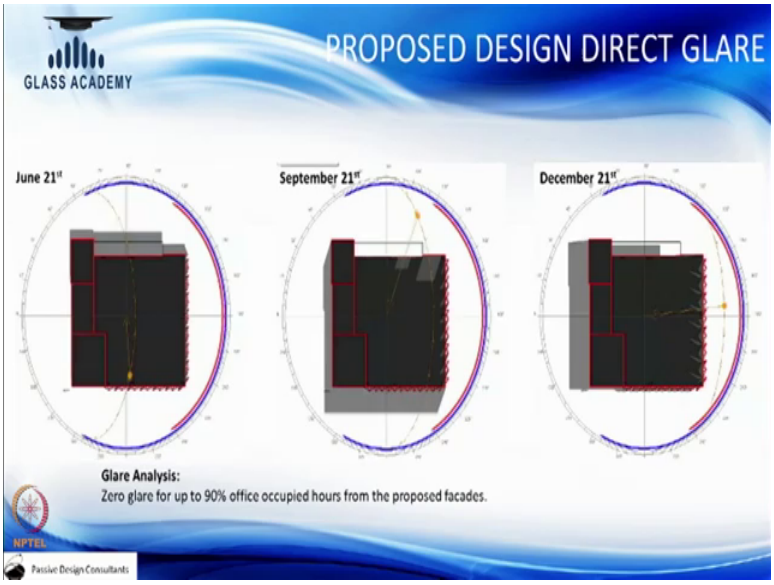

The studies here would show you how we were receiving almost minimally glare or negligible glare during office period from South and the West façade in both June and a September. While in December there were a little glare, but again as we realise that in the month of December or during winter the outside conditions are primarily foggy and they would not be much direct sun available. So, this is not really a problem.

So, for with that this design the glare was prevented and 0 glare was observed for more than 90 percent period in the project with the proposed facade.

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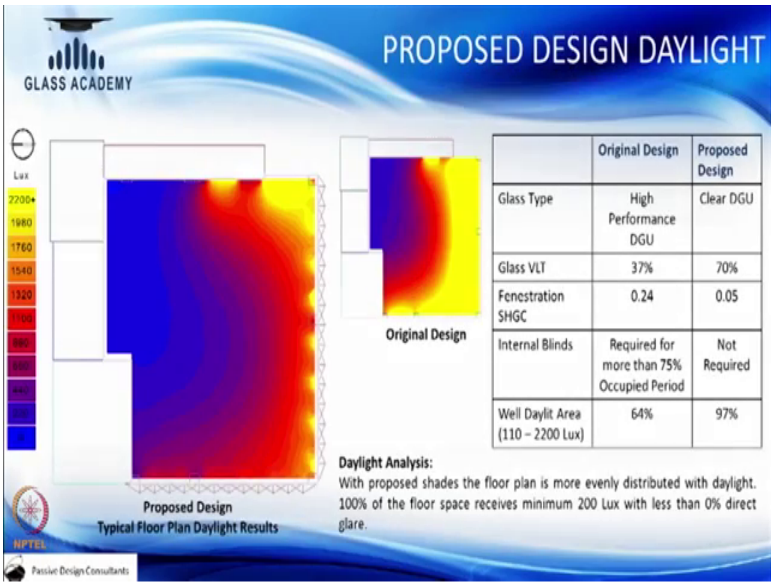

The project was achieving 97 percent well daylight areas, areas receiving more than a daylight between 100 and 10 LUX to 22,000 LUX. In the proposed design we were not required to go with a high performance DGU. A clear double glass was proposed as the external direct solar heat gain was primarily prevented or the external heat gain was primarily prevented through external shading devices.

So, tinted glass or high performance double glass was not really required. This kind of clear glass would have a VLT of 70 percent. Fenestration, the overall effective fenestration SHGC was calculated to be only 5 percent, which is much below even the ECBC recommended 25 percent.

The internal blinds were at not at all required in this particular building design as the external shading devices were quite effective and like I said receiving more than 97 percent area getting 110 to 2200 LUX. Only 3 percent areas were getting more than 2200 LUX which was next to the southern eastern facade because of the clear DGU glazing.

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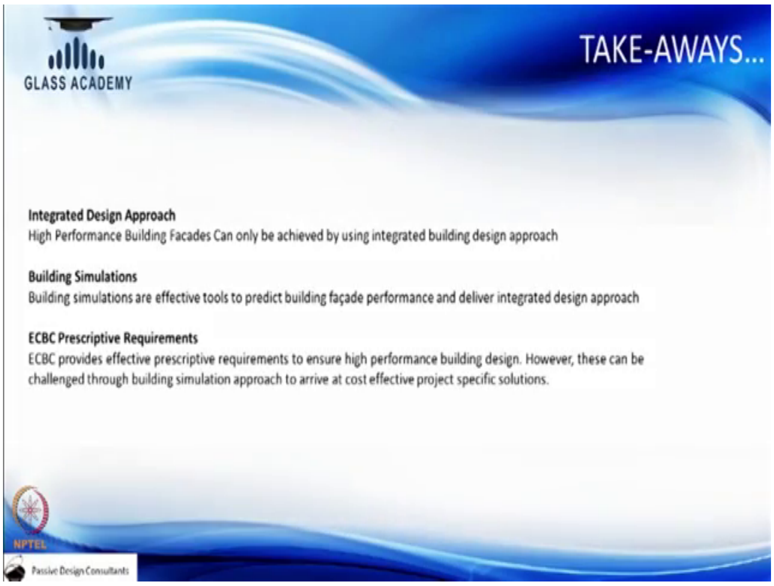

With this I will be concluding the session, I believe the take away from these case studies are that one we need to go for integrated design approach. An integrated design approach not only looks at the energy performance of the building, but also looks at a good well daylight interior spacer with good quality daylight, not just high amount of daylight which where glare is a problem.

So, well daylight spaces with 0 glare and with good energy performance would lead to a good performance facade which can only be achieved through integrated design approach.

For an integrated design approach we definitely need building simulation tools. These tools help us predict the performance of the facade and the building in advance and not leave us to a the end product later where the building is built and then we realise that the facade is not performing. So, we can actually prevent such cases through building simulations, they are a really good tools that we have available in the market.

And thirdly, ECBC prescriptive requirements which are given to us as a guideline, they are quite effective and actually achieving a high performance building facade; however, by using building simulations we can negotiate with those values. Still have high performance values while minimising the overall project cost.

Thank you.

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