Glass in buildings : Design and Application
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Lecture -74
Case Study: Envelop Design and Its Impact

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So, moving on to the Ela Green School, so these are some of the images that you see of the school. Owner of the Ela educational trust and we were the architects as well. So, the built up area is around 86000 square feet location is in Chennai.

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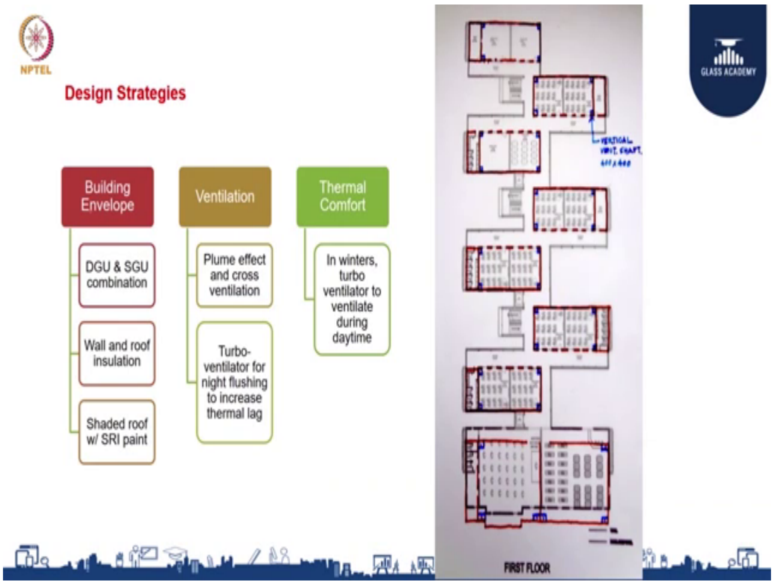

So, Chennai we all know is a very warm and humid climate. So, we followed so, we did a truly integrated design approach where all the team members; it could be the NEP consultants, the architect the electrical contractor, the HVAC contractor are. So, this was a precast building; so, we had the precast contractor. All of us had were on one platform, we sat and designed various parameters together at the same table to get the best possible output. So, this were our design strategies; if you look at the building envelope per say, we did not want to go completely with DGU.

So, the building itself is designed such that there are a lot of shading pockets that are created because of the form of the building. So, therefore, wherever there was direct impact and there was a harsh impact DGU was opted for and SGU wherever it, there was a shading component. And if you see, we have used both wall and roof insulation. This being a precast structure, it was easier for us to specify to the contractor that we wanted our walls insulated. Similarly the roof as well and roof also has not only the hollow core slab plus the insulation, but also reflective paint. So, what the reflective paint does is I do not know how many of you all have been to temples even Tirupathi temple; there they would have painted, there would be white paint near the black tar top road.

And why is that? Because you cannot walk on the black road because it is going to be extremely hot where is if you walk on the painted part of the road it you it is you can still walk. So, this is because this these are nothing, but high reflective paints which reflect the heat of the surface and keep the surface of the road cool. Similarly this is what we are trying to achieve on the roof as well.

And so, ventilation was another part of the envelope design which I will talk about it on because this we did not wanted to be a completely air conditioned building. Although it is air conditioned, we did not want to operate it as a completely air conditioned building throughout the year because some parts of the year are relatively cooler. And a primary goal again just as it would be with any envelope design is to make sure that the inside is the closest to comfort zone without any mechanical systems. So, that with that as the primary goal and the thermal comfort conditions, we back work on the envelope design. So, if you see this is one of the initial drawings of the project where we would have done sketches; if you see we marked, you can see some markings here. So, these are the initial concept design drawings of how we will try and bring in ventilation into the building.

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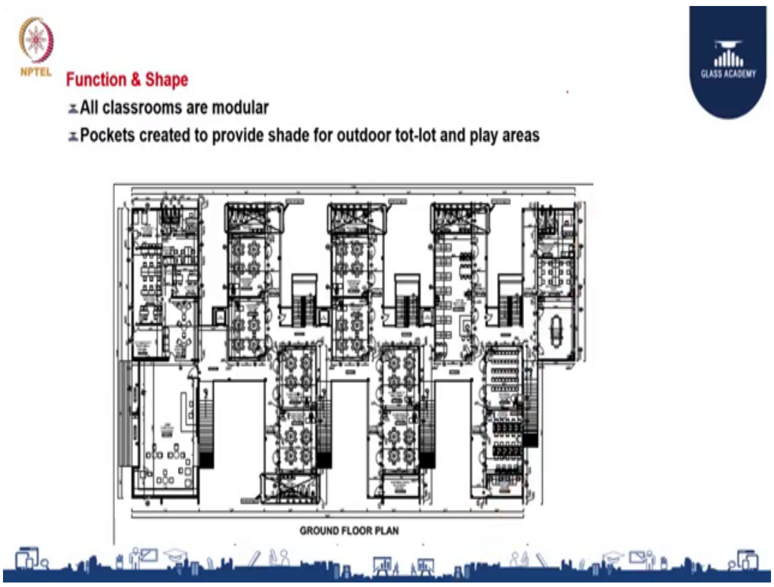

So, this is later on this is the final version of the drawing after various iterations etcetera, if you see all the classrooms are modular. So, I can either convert this space into one whole library or I can have. So, everything its modular, so you just starts it is repetitive in nature. So, that way we can you know kind of keep it flexible for future expansion, growth, incorporation of technologies any of those kind of parameters. And if you see we also created spaces here this pockets the purpose of these pockets were so, the school building is basically a pre kg to a grade 12 building and grade 12 or the higher grades sixth, seventh, eighth and so on are ok. They can play outside and the harsh sun and they will they still fine, but what about small children and we know we have more summer than rainy season in our climatic condition.

So, what we do is we wanted the tot lot areas to be shaded. So, all the tot lot areas and the play areas for children to interact had to be shaded. So, the building, the entire planning was done such that we have these pockets of spaces which would be shaded.

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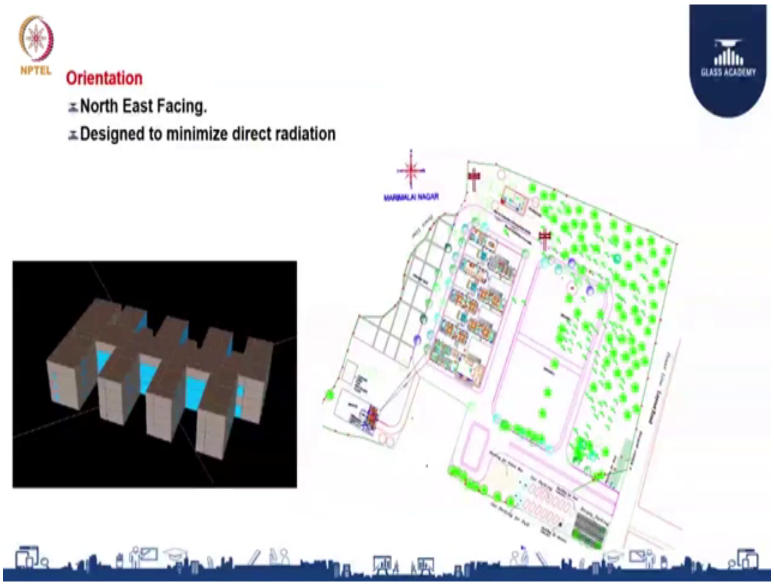

So, the building is again North East facing based on our simulation analysis and was also designed to. So, if you see this is our north, this is our north and we also planned our glazing elements to be minimal, in fact. So, I did speak about landscape in the fascade or in the envelope design which actually has an impact. We also know that studies by the Lawrence Berkeley laboratory indicates that temperature under trees can be 14 degrees Celsius cooler than temperatures over tar top roads. So, actually the original design has a lot of roads around the building this is required for the fire movement, fire engine.

So, even if you looking at reflective paved roadways also there is going to be a large impact of heat, heat gain into the building as a result of road area. So, this is why we had planned a lot of green walls in the facade. So, the front facade to make it look better has the green walls in this fashion; the rear facade also has green walls, but creepers will be used. So, we spoke of glass. So, when we said glass, glass varies from the cost of glass you have glass varying from 75 rupees of square feet to say 275 rupees square feet.

So, which means you it can you know triple the cost of your usage your glass component if you are looking at the best performing glass. So, how do we make sure that you know we can keep the cost of glass minimal, at same time have the same impact of you know using a high performance glass. So, this is where we tried and studied where all should we use the double glazed units because there are there is a lot of shading elements that you see that, shading because of the building design. And if you notice this building does not have any external shading devices.

So, there are components of the building which has direct glass and all of those components will use double glaze unit, but all those which face corridors etcetera will have single gaze single glass. And also the window to wall ratio; so, if you see the original design which is this image, you have three windows on one facade and you have one window where as you can see the dark pockets in the entire classroom. So, we do want such dark pockets at the same time we do not want extreme glare coming in as well.

So, this light green yellow portion shows uncomfortable light whereas, the dark blue portions indicate adequate diffused light. So, what we did? We converted the doors also. So, there are doors on either side which were initially constructed to be opaque medium have been converted to glass. So, that way we actually achieve adequate diffused light and our window to wall ratio is designed at 31 percent which was ideal for us to bring in you know adequate daylight as well into the classrooms.

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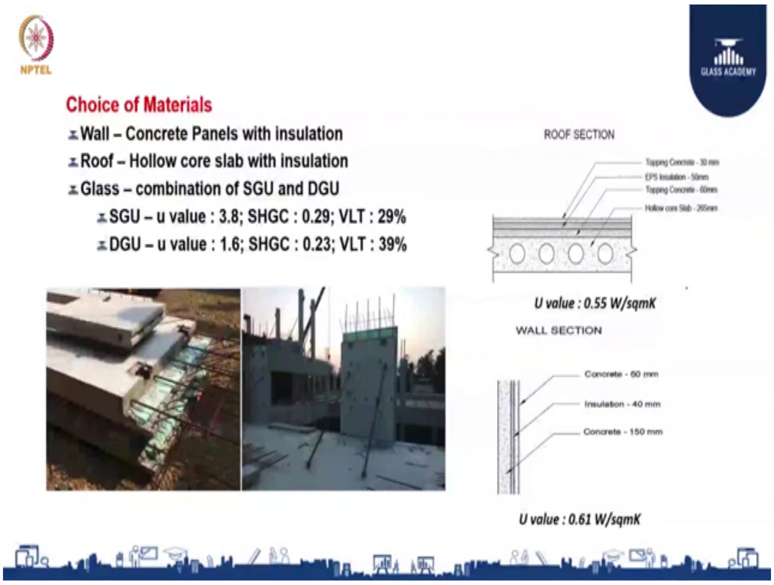

So, I also spoke of choice of materials. So, this being a precast construction, these are some of the photographs that were taken during construction. If you can see you can you see this green portion here that is our insulation. So, we have used about 40 mm of extruded polystyrene insulation between sandwiched between 2 concrete panels. Again the insulated panels were not used everywhere there is a combination of panels that were insulated and a combination of plain concrete panels depending on the direct heat gain analysis again.

So, only those areas which had to face the direct heat or the direct sun rays had insulated panels. And if you see the roof this is our section of the wall 60 mm concrete, 40 mm insulation and 150 mm concrete. Similarly if you look at the roof so, the precast system comes with a system of hollow core roof slab and, then again all though topping concrete your waterproofing etcetera. Your insulation was 50 mm. So, this gives us a desired u value or thermal property of 0.55 watts per square meter Kelvin and for again wall we are looking at 0.61.

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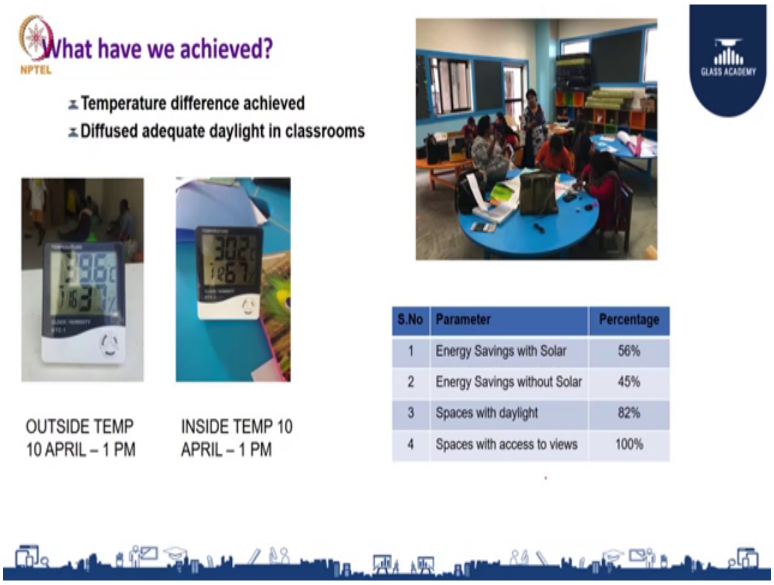

So, what did we achieve? We done this whole exercise and you know double glaze was a single glass daylight analysis or energy simulation analysis. If you can actually see the classroom, we change this to glass doors. So, if you actually see this adequate diffuse light in the classroom. Look at the temperature difference. This was recorded on tenth April at 1 pm which is one of which is pretty much your peak summer time, your outside temperature is 39.6 degrees, your inside temperatures 30.2. So, what is a differential that we are looking at, we have achieved a good differential of 9 degrees or so, 9.4 degrees or so.

So, even in summer you walk into that classroom at 39 degrees outside temperature, you immediately going to find it more comfortable. And please note this is just by the use of the envelope, this is just by appropriate insulation, landscape on walls and you know glass, high performance glass all of that we achieved this. Now in addition so, when we took these temperature readings, we also did analysis on how do we increase ventilation. So this, the ventilation mechanism was not in place, this is just an average building with your walls, roof and your glass taken into account.

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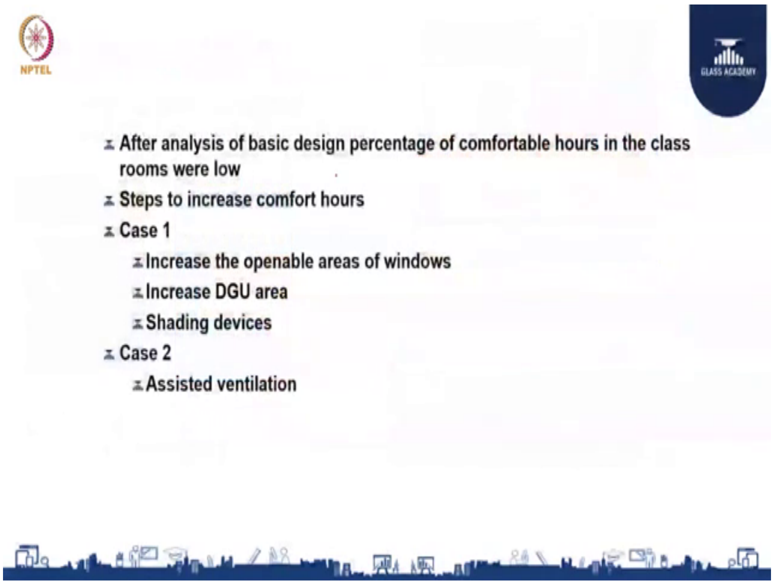

So, remember when we did our initial integrated design approach with all our consultants contractors in place. We actually wanted to enhance the indoor air temperatures or enhance the performance of the building in terms of thermal comfort inside the classrooms without air conditioning systems. So, case one we said you know how do we do, it we increase the openable window area, we increase DGU area, we add shading devices to our building. Second we said let us try in something called the assisted ventilation. How did we achieve that?

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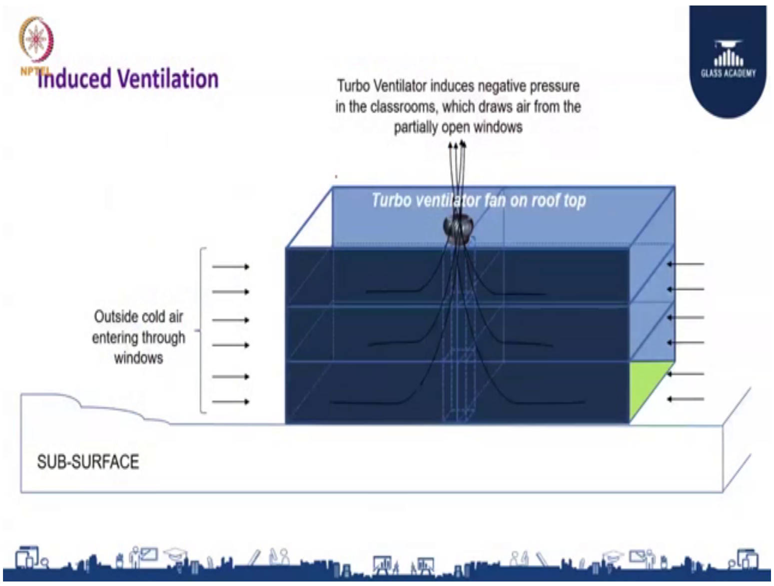

So, every classroom has two shafts. Again all of this was done with a scientific analysis to support all our calculations. So, once we come up with a design and a theory or to prove that we have we are doing the right thing, we can always back it with various analysis. We have today a lot of tools that help us in terms of day lighting, in terms of energy, in terms of air flow. So, we did a CFD analysis as well. So, this has a turbofan on the roof which connects all basically a hollow shaft that connects across the classrooms vertically and you have turbo fans at the rooftop which create a negative pressure.

So, you are basically trying to increase your wind velocity. So, this is what I said it would be a typical floor here classroom. So, initially we had said we will have shafts in 2 directions, but later on after the analysis we realized not. So, much as per the analysis, but in terms of our precast systems, they said it was wiser to have diagonals shafts. So, today we have actually every classroom has two diagonals shafts, this is not there.

And so, this is why we need also every team member to be a part. So, let us say I have you know, we decided to put in a shaft, without the approval or the knowledge of the precast contractor; we cannot take some decision like this. So, it was always good to have everybody on the same platform and this is what was a system design. So, this was a CFD analysis to determine the size of the shaft. The size of the opening in each classroom; so, if you see this is our CFD analysis. So, when the air leaving the exhaust is at 29 degrees right. So, we are showing a 2 degree differential with the usage of shafts which will still so, if I can my 9 degree differential when I operate the shaft can make it 11 degree differential; I do not need to use AC; 39 degrees outside and if I am able to achieve a 28 degrees inside my room, I do not need an AC.

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Monthly Comfortable hours

Months	No. of operating hours	Max. adaptive comfort temperature	Base Case		Case 1_Increase in operable window area+Shading+DGU clear glass		Case 2_Case 1+Assisted ventilation	
			No. of comfortable hrs	% comfortable	No. of comfortable hrs	% comfortable	No. of comfortable hrs	% comfortable
Jan	176	28.30	104	59%	152	86%	176	100%
Feb	160	29.12	89	56%	106	66%	128	80%
Mar	184	30.44	46	25%	60	33%	99	54%
Apr	160	31.45	12	8%	34	21%	65	41%
May	184	32.23	14	8%	21	11%	39	21%
Jun	176	31.98	12	7%	26	15%	44	25%
Jul	168	31.55	25	15%	51	30%	74	44%
Aug	184	31.11	31	17%	57	31%	76	41%
Sep	168	30.98	30	18%	54	32%	71	42%
Oct	176	30.18	38	22%	63	36%	113	64%
Nov	176	29.09	89	51%	125	71%	162	92%
Dec	168	28.68	124	74%	154	92%	168	100%
TOTAL	**2080**		**614**	**30%**	**903**	**43%**	**1215**	**58%**

So, this is just to show you, this is the chart basically our analysis chart. So, if you see this is a school building right. So, we take the operating hours from 8 AM to 3 PM and from Jan to December, if you see the number of operating hours is 176, 160, 184 depending on number of working days Saturdays Sundays etcetera. Now what is maximum adaptive temperature? So, in Chennai somebody if I am sitting in Chennai, I am very comfortable at 30 degrees.

You put me in Berlin winter I will freeze, I will freeze at 20 degrees also because I am used to this. So, people in Chennai are used to a certain adaptive comfort temperature which is what we will take into account when we are doing our comfort analysis. So, we can always say the comfortable temperature is 24 plus or minus 2. So, 22 to 26 not necessarily may be comfortable for most of us who sit here.

So, if you see the adaptive temperature is around 28, 29, 31sometimes in June, so, this is again standard analysis. So, the initial design that we did, we were able to achieve the number of comfortable hours. If you see this column this column what we were able to achieve is 194 which means only 59 percent of the time in January, we were able to achieve comfort conditions during operating hours. Similarly if you take in June only 7 percent of the time, we were able to achieve comfort hours. Now, I will add my case number 1 I add DGU, I add some shading elements, I do all of those analysis and I have achieved; if I do all of that. My analysis says instead of 59 percent, I increased it to 86 percent.

So; obviously, compared to the first you know 104 hours I increased it to 86 percent from 59 percent which is still good. Now what do I do? If I add my assisted ventilation shafts, then I increased my number of comfortable hours to 100 percent. So, from my original design of 59 percent, I have moved to 100 percent in January. So, I do not need AC in January; similarly in February I have increased it to 80 percent, I do not need AC again, March it slowly becoming 54, 41, 21 percent my worst case scenario, but if you actually see I have increase it from 8 percent to 21 percent.

So, I can use AC, but I will be using it for 80 percent of the time. Approximately I mean not necessarily I could probably use it throughout the day, but this is what I am trying to achieve by saying bring the building closest to thermal comfort conditions that you can. So, without the AC I most of the time; so, 1, 2, 3, 4, 5, 6 months in a year I do not have to use AC at all maybe the other 6 months I can make it. So, this is how at an average from 30 percent, I have increased my design, my performance of my design to make sure that 60 percent of the time its comfortable which is twice as much.

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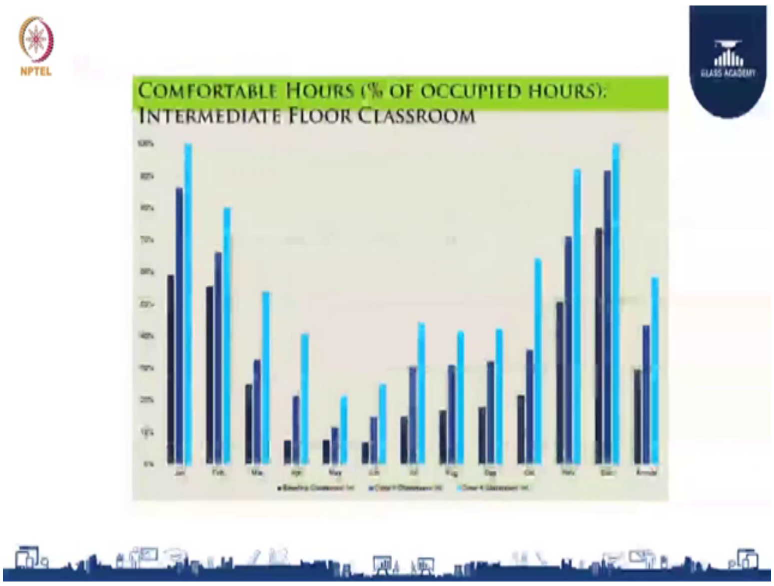

This is just a bar graph to show initial design second and ultimately with your use of assisted ventilation shafts. So, moving on to the next case where this is the Coal India Corporate Office Building, the owner being Coal India the architect was famous architect from Delhi, Raj Rewal associates; built up areas to 2,50,000 square feet. So, we were basically the green consultants in this project and this was one of our first few projects I think we started working on this in 2010 or so, and location is Kolkata, again a very hot and humid climatic condition.

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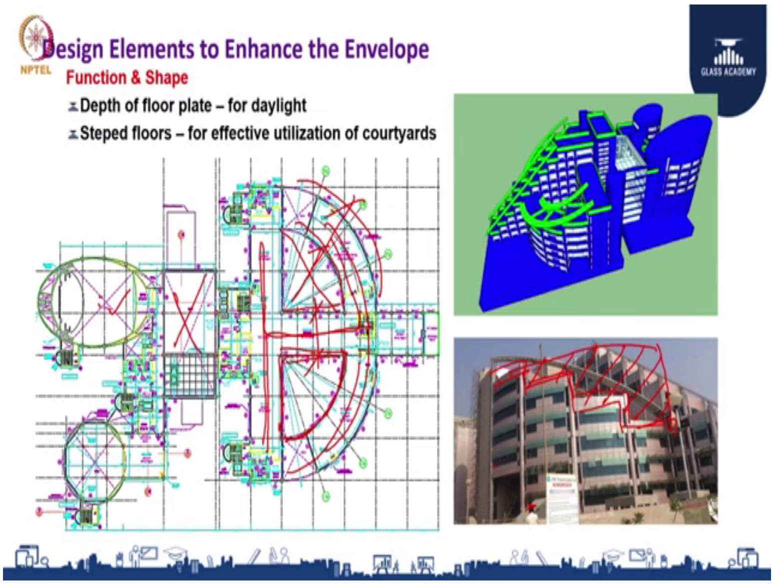

So, here we really do not have the flexibility to play around with design because again the architect has done his own set of analysis. So, if you see the function and shape is that a pointer here ok, if you see the function and shape here; there is the floor plate that is designed like this. So, why is a flow plate the depth of the flow plate this is the open office area again all of this is the open all of this is the open office area, the depth of the flow plate. In all these areas is kept to such a to width so, that there is adequate daylight penetration from both sides and that is why is given us the central courtyards in the center right and this is the central atrium this is the MDs and the chairmen block; this side that you see here.

So, the most critical component where a lot of people would be working and would be sitting around would be this stretch. Now these two why if you can actually see the building is in a stepped fashion. Any reason why stepped fashion? We have a central courtyard here, now if the central courtyard has to be effective we need to make sure there is enough daylight penetrating even to the ground floors. So, what happens is a cylindrical form if let us assume there was no step and this is how the building was, then you are creating a cylinder over there and this entire portion is going to be blocking your daylight inside as well. So, the lower flows will not achieve the adequate daylight. So, there is a reason why he has done this. So, this is our energy analysis. Now initially all of this was glass. There was a lot of glass that was being used in the initial design.

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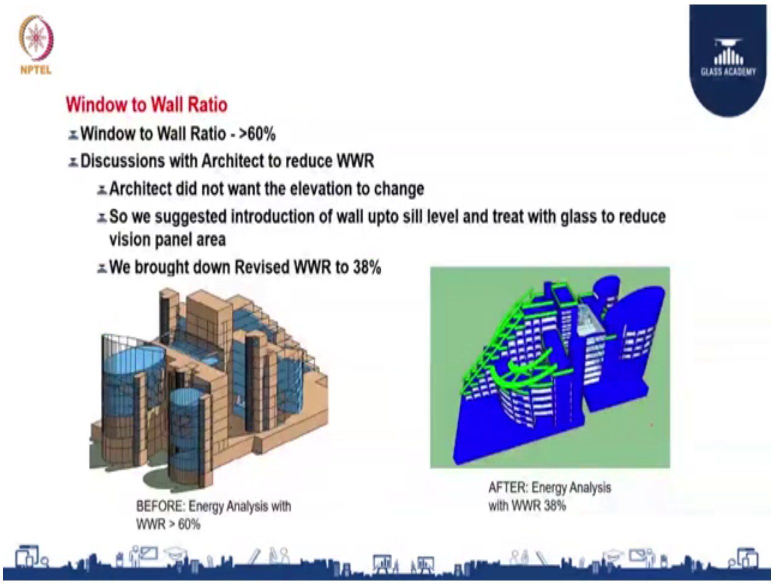

So, much so moving to window to wall ratio our window to wall ratio and the initial design if you see this is our initial model was greater than 60 percent. So, we had discussions with the architect and we come back and say you know this is what our analysis indicates, we need to do something of course we do not want to compromise on the elevation as well because the architect has put in a certain effort into the design process. So, what we did is we actually brought in an introduction of wall up to the sill level. So, wherever when I am saying wall up to sill level, so, this is your slab then this is again the other flow slab right. So, here this whole thing becomes your vision panel. So, your glass is completely there, but let us say we introduce a wall up to sill level.

So, now, only this portion is your vision panel although you have glass here, this will be glass from the outside view, but will not be vision panel. So, for us in terms of energy analysis, we will only take into account this portion as your window to wall ratio. So, after our energy analysis we did read it after the sill level came up, our window to wall ratio was brought down to 38 percent.

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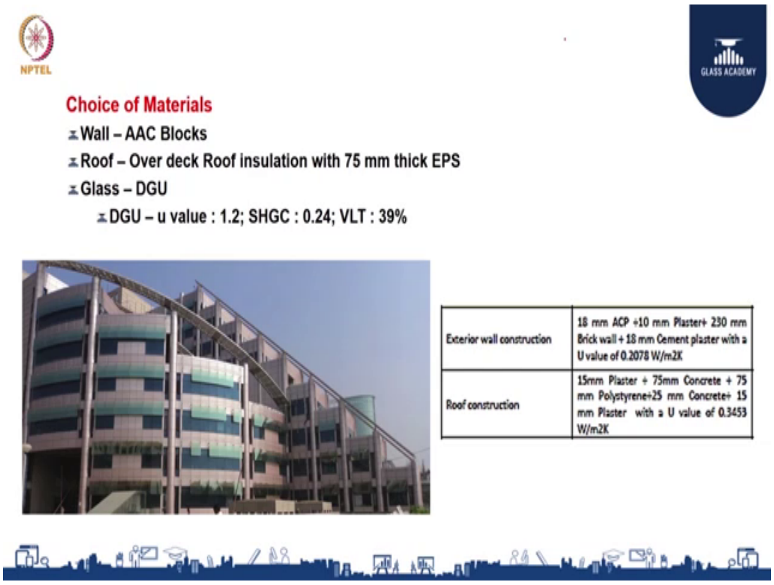

And as I told you we had all the luxury, so, we used DGU use I think they belong to the (Refer Time: 23:00) series from Saint Gobain which had 0.24 SHGC and a visual light transmittance of 39 percent and roof over deck insulation was used. So, they used 75 mm thick extruded polystyrene and for wall there was a lot of wall area.

So, to bring in an insulation would not have been the right thing. So, what they did instead is going for 200 mm thick aerated Aerocon blocks. I think they were able to achieve a fairly good u value of 0.2 or so which is quite an effective value to achieved. And also if you see, there is an additional layer of glass. So, the architect if you see here has used an additional layer of glass again this is to avoid the harsh glare. So, that they do not have to actually use your blinds or screens inside the building so and at the same time use usage of glass rings and some kind of daylight as well. So, I was told that they actually do not use blinds in the building.

So, what did we achieve? We achieved energy savings with solar close to 60 percent and they this project used if you actually see the solar I will try show you that. If you see this 140 kilowatts of solar was integrated into the building envelope design because we did not have enough roof area all of this is solar that has been planned on the building. So, 140 kilo watt of solar was also planned. So, the envelope as such was effectively designed to include all of these parameters glass your wall, your solar as well. So, we achieved without solar 42 percent, additional solar was 58 percent and spaces with daylight was again 78 percent and spaces with access to views were completely 100 percent because most of your regularly occupied areas was under the open office area.