Glass in buildings: Design and Application
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Lecture – 73
Case Study: Envelope Design and its Impact

Greetings for the day and before we get into a today's topic which would be Case Studies on Building Envelope Design, I would like to just brief about what I do and what I have been doing in the space. So, I have been in this energy and the green space in building design for the last decade or so and we have worked on many projects across various types. So, a little bit about that we will see into what we will cover today.

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So, initially before we go directly into the case studies this would be the framework that we would be talking about in the next 1 hour. One would be the sustainability goals in building design. So, when we look at the larger the bird's eye view of the entire design process, we envelope is one part. But, how do we go about with the envelope is only when we decide on the goals of the design process itself, only then can we fine tune and come further down into the various components of the building of which the building envelope is one of it.

Then looking at the role of envelope in the climate responsive architecture. So, all of us today are talking about architecture that responds to our environment, responds to its

surroundings, to the climate and so on. So, what is the role of envelope in such a design process? Next would be your components of an efficient envelope.

So, this is coming down to exactly what we are going to be talking about and all the case studies we will cover one or all of these components that I am listing here. Again, this is not a comprehensive list; it is purely based on our experience over the last decades or so. So, one would be your building plan to enhance efficient envelope. So, why are we talking about a plan when we are looking at the skin of the building, all of us know when we say building envelope we looking at the skin of the building. So, why are we talking about planning?

So, it is just like what we eat or what we consume is reflected on our skin, similarly what you plan what you put inside the building in terms of function, shape or form or orientation would impact the envelope of the building and landscape. So, landscape is a less talked about subject as far as the building envelope is concerned. But, I will also bring out some points why landscape is effective and how it really helps especially in very a hot and humid conditions and window to wall ratio.

So, all of us know that the quantum of glass that is being used on the facade will play a critical role. And a choice of materials of course, how is the thermal property of each of these materials that you are going to be talking about in the skin of the building. It could be your roof, your wall, your glass, your roof skylight and so on. And last, but not the least your shading devices, how do they impact your building envelope. So, we will cover all of these through our case studies.

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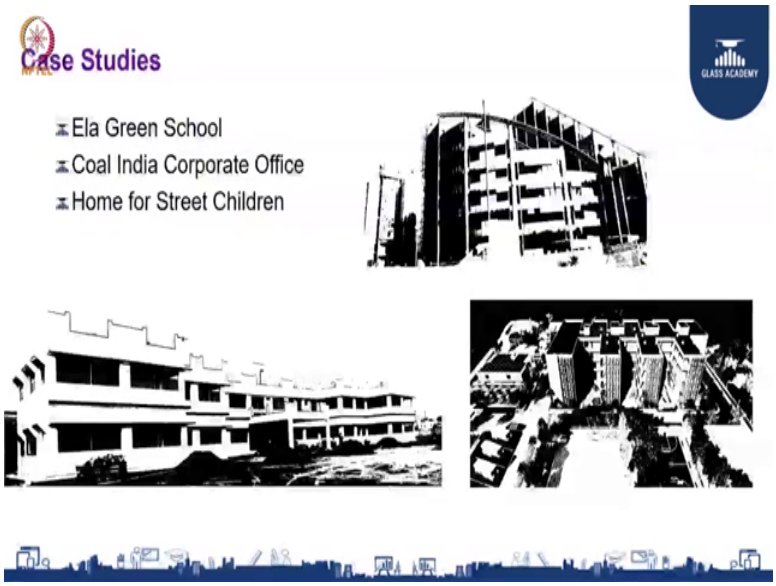

So, I picked 3 case studies and 3 across different categories. One as you see is a school building, an educational building. The other being an office corporate office building and the third category is slightly different which is basically I was looking at a residential, but a residential category which is pretty much for street children. So, it is called the home for street children, in it is in Hyderabad and why I picked these 3 categories apart from it being in different type of buildings.

Why is one the street children or the home for street children project is you know they wanted to go green, but they did not want to increase their budget. They want to get as per whatever they had originally initially estimated and planned, but never the less green and nevertheless the envelope also becomes a component of green and efficient design. The last case that is the Coal India corporate office building is a plush building. Coal India being a public sector undertaking has all the funds wanted a landmark building, had enough funds for the best possible features.

So, I will tell you why how the envelope was dealt with in that section. And, then the Ela Green School being our very own school, we have the luxury of all the expertise, the analysis, the tools at the least cost possible. So, I have picked across 3 case studies which come under 3 different categories, on how we can actually address the envelope irrespective of the fact that we have the sufficient budget or not.

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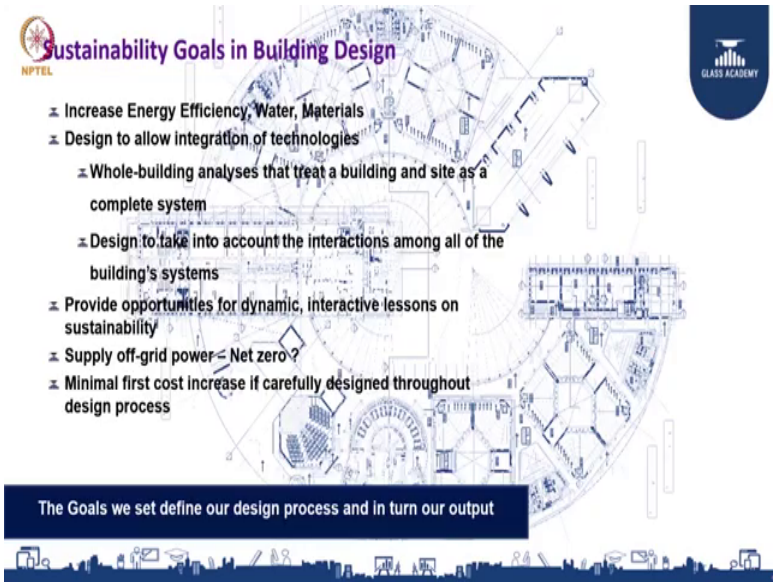

So, what we when I started this whole session I said goals in building design. So, how many of us actually set sustainability goals? We all have how a building should look or how should the shape of the building, the glass we have so, many other criteria. The kind of classrooms that we want or the kind of rooms that we want etcetera, but do we think of energy efficiency. Do we look at water efficiency being the primary criteria or do we look at usage of materials or do we look at a building that will allow for integration of technologies?

So, when I say integration of technologies what we do today it should be a flexible, it should be modular; can we do something which we even do not know exist today, but will that building be able to integrate that tomorrow. How is it flexible in design? So, in which case are we looking at a whole building analysis that treats a building and a site as a complete system. This is critical because, when you place a building on a site; if you look at it as just the particular site then we are really not doing justice to the entire design process.

So, for that we will have to see what is the site surroundings. How does it impact our site, how does it impact our building. And, also do we also look at the building and its various components of the building as the interactions between all of these components as one whole. So, one is the MEP, the mechanical person may be designing, the architect will be coming out with a beautiful design, the structural person will be coming out with

various design. So, how do we look at it as one whole and see the interactions between all of these components. What is the landscape consultant going to add value.

So, if we do not look at it together as one large picture as we call it as the integrated design approach today, we are probably not doing the best justice to that project. And, also are we going to look at providing opportunities for learning is this building going to be serving as a textbook for other people, is it an educational building or is it a building where it is going to have many visitors from different countries. So, do you want it to be physically or visually looking like something that people can learn from it immediately. And, are we looking at net zero, are we looking at energy as a critical focus. How much of if not net zero, if you do not have the budget for that what are we looking in terms of offsetting in terms of renewable energy.

And, critically what are we doing? Are we trying to not only just look at various elements in terms of enhancing the performance, but what would be the most critical component is how do we minimize our first cost. So, although we are looking at a payback etcetera, but how can we do that, can we do that at all? If you talking green does it necessarily have to mean that you are actually spending more; we will see as we move in through the case studies. So, what is critical here is the goals we set define our design process and in turn our output and output here being the complete building.

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So, all of us do know that you know climate dictates a lot of our parameters of life. The way we dress, the way we cloth, our buildings, the way they are designed. So, you know in terms of food, in terms of festivals, in terms of colours so; obviously, architecture also becomes a very integral part of what the climate has influenced over many years. So, all of us do know that ancient architecture, our traditional forms of architecture were basically a dynamic synthesis of your environmental, your cultural and your social factors.

So, the critical component is we are not talking anything new and we talked about envelope design or when we are talking about green building focus etcetera. We are not talking anything new; we are only trying to see how do we actually bring in all these factors that once influenced our design process. Of course, today we face a lot of constraints in that process and how do we overcome that. So, if you see many features in architectural design per say are a functional response to our climatic conditions.

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So, I will just wanted to take one example, if you see the lattice screens and these are across the globe. So, you can see it in Jaipur, you can see it in Jeddah, you can see it in Cairo, you can see it in Tunisia. In all of these they had a specific purpose, they were derived because you know how do we cut out or intercept the direct solar radiation or the direct heat that is going to fall on the building and also to soften the uncomfortable glare. So, we do not want large openings where there is going to be a lot of glare. So, screens,

so basically instead of having what we have today screens inside our glass these were architectural features.

And, also it also served as an element to provide privacy. So, this becomes again a cultural, a social factor and the aesthetic value. So, in one in one country they use wooden lattice screens and the other it was stone. So, that depends from country to country, similarly those kind of concepts are being incorporated in today's modern architecture. So, it need not necessarily look like what it look, but it would have the same functional value. So, this is where we are trying to say let us try and bridge, what we trying to achieve through the green building design process, in terms of the principles of traditional architecture.

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So, this is one of so, just to take an example you know the Golconda fort; we were told that the thickness of the walls is something like 17 feet and in some places even 34 feet. So, this was primarily done for various reasons being a fort it probably was a safety security reason as well. But, also if you just step into the Golconda fort you will realize the temperature difference, you will feel much cooler inside. Of course, today we do not have that kind of luxury of space or we do not have that kind of budget and timeframes. In today's modern technology we are building 3 floors in 1 day in the more develop parts of the world.

So, how do we still achieve the same temperature differential in today's technology of let us say precast, let us say modular there are so many things that is available today. And how do we apply these climate responsive design measures in our today's buildings? So, when I say climate responsive measures what all do we come under. One is sun obviously, the sun path analysis. So, if you actually can see those images on the slides right now, that is one of the analysis that we have done, to just analyze the shading. At what time in the day, at what part of the year is the building going to be maximum shaded and how do we position it? How do we orient it according to the sun analysis and which will give us the optimal results.

So, just by placing your building right you would have done a whole load of good in terms of direct heat falling on the building and then in terms of wind. So, if it is a critically this would be an important component if it is a non air condition buildings. So, how do you utilize your wind direction? How do you position your openings? How do you channelize wind? Temperature so, what is the kind of temperature of that region and how do you how are we going to address it? Relative humidity becomes critical mostly in coastal areas, where you have your humidity levels are very high.

And, this is where most of your passive measures really do not work because your discomfort predominantly comes from humidity not so much the temperature. And, we are looking at microclimate. What is microclimate? It is nothing, but your site specific climatic conditions. So, you may be in Chennai, but you may be your site may be located near a forest or near a park space or your temperatures may be lower or they may be a water body. How do we actually study this that is specific site or that microclimate of that site to enhance your design process.

So, the first and foremost component of the building that needs to respond to the climate is your building envelope. So, when your when it is hot outside, the first thing that you find it uncomfortable your skin, your skin impact you are sweating, you are uncomfortable, it is burning. So, all of the impact of climatic conditions is first felt on the building envelope and that is why it becomes a very critical component for us to look into in our design process.

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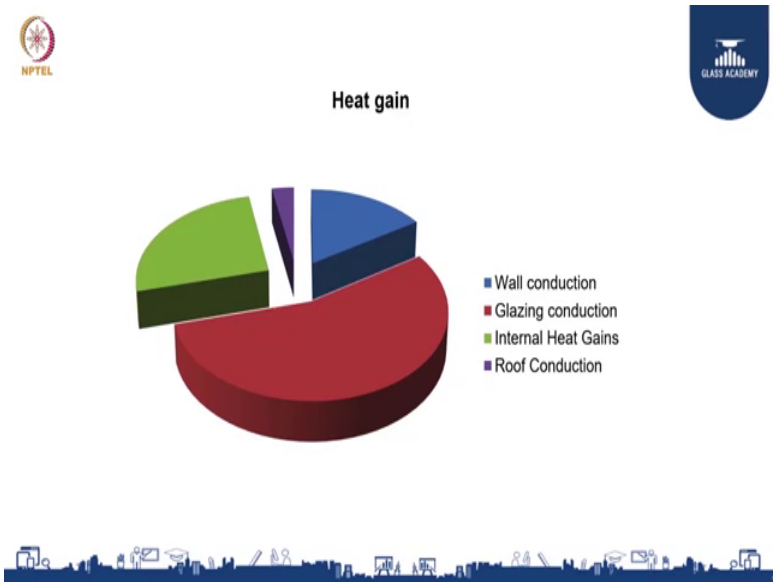

So, this is just a chart to show how critical is the building envelope to us. So, when we look at the heat gain into a building, I am sure all of us know that the most important maximum amount of heat comes into a building through glass. So, this is just a high rise building that we have taken out of various case studies that we have done. It is not a hard and fast rule, but we all know that more than 50 percent heat gain comes in from glass.

And next would be your wall. So, wall is again, it depends if it is a high rise building it is wall, if it is a flat structure it could be roof. So, wall versus roof would be your second important. When you see the green component which says internal heat gains it is nothing, but your lighting, your equipment, your computers etcetera and that is something that we do not have much scope to play around with. So, where we can actually make a difference is in terms of your glass, in terms of your wall and roof or if you have a roof skylight.

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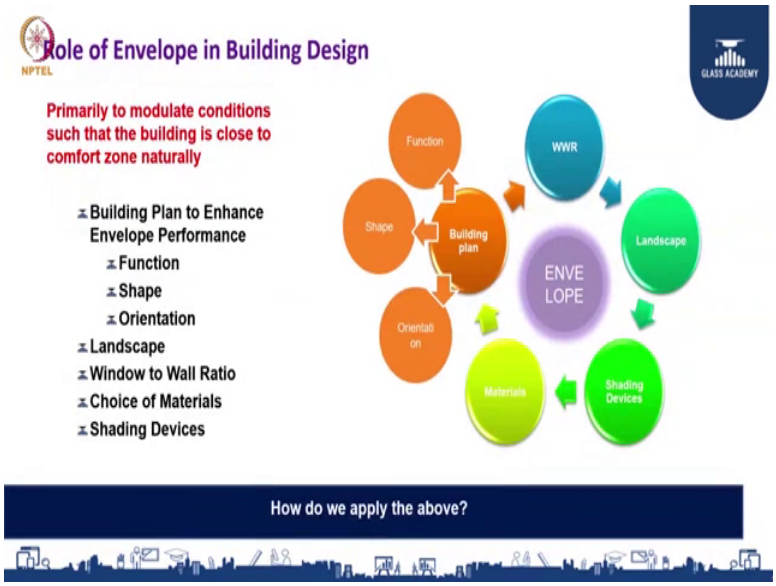

So, now that I spoke about you know how the envelope is critical, let us just kind of a break it down into various components that impact the design of the envelope. So, one I said is the building plan. So, until you plan your building which could be a function, your form or shape and your orientation, all of this will have a direct impact on your building envelope. The second most critical thing is your window to wall ratio. How much of glass do we actually think this building requires? So, if you are saying my building needs to look like a building from the west, it has to look beautiful, it has to have glass. Then how do we design it? How do we make sure that we still have glass, but at the same time we try and you know minimize the direct heat gain.

Landscape, how does landscape actually help in the facade of the building or the building envelope, shading devices, your choice of materials. So, this is what based on our experience we just kind of broken it down and put into various parameters and we will talked about it. So, every building not necessarily will have all of these components, but as I show you in the further slides how some of these components have come to play an important role. So, the first project would be our orphanage or the home for street children.

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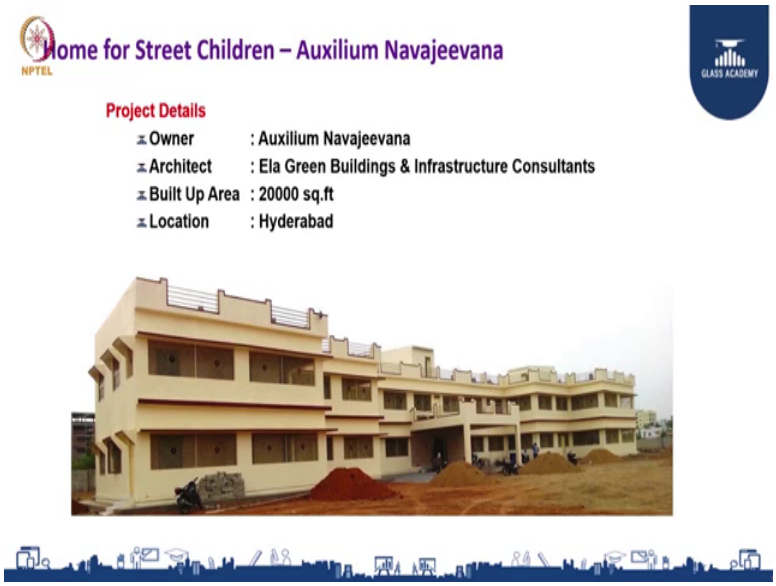

And, the owner being Auxilium Navajeevana, it is a Salesian Sisters Group and we have been the architects Ela Green Building and Infrastructure Consultants. It is not a very large building about 20,000 square feet ground plus 1 structure and location is Hyderabad. So, all of us do know Hyderabad is relatively pleasant throughout the year, maximum summer your temperatures can go even up to 47-48 degrees. So but, summer lasts critically for a period of 2 to 3 months.

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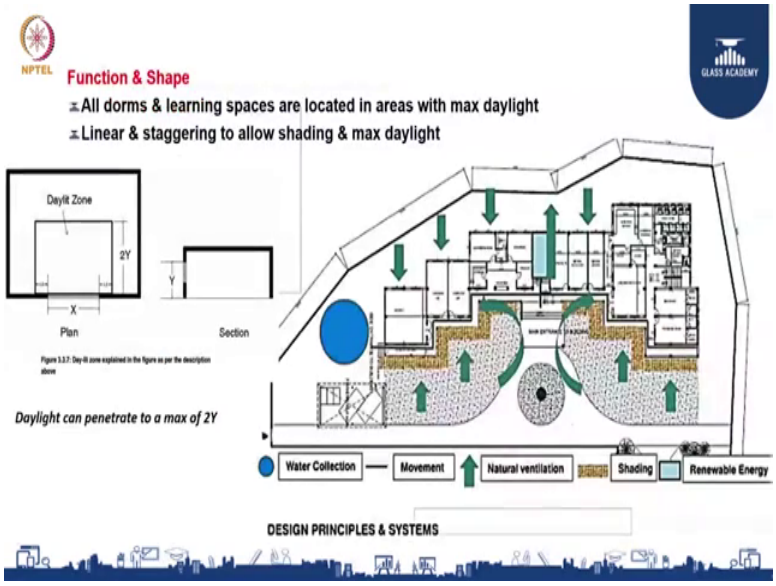

So, again as I told you this is an orphanage building and we had absolutely no budget to play along. So, what we have to do is make sure that our plan and form and shape can actually this requires no additional cost. So, we made sure that the building faces the north; the majority facade of the building faces the north because, from the north you have maximum daylight and at the same time minimum direct heat gain. And why is that? It is just common sense sun rises in the east sets in the west. So, direct harsh rays are more likely to fall on the east.

Of course, we do have a lot of analysis tools that are available to us to do the study; I will talk about them as well as we talk in our case study. And, if you see also the dormitory spaces so, that is the space where most of the children are going to be spending most of their evening hours. But, morning hours there are a lot of learning spaces that are also there, there are language spaces, there are the homework rooms etcetera. So, all of them is what would be critical because, that would be during the day and that is when your direct heat is going to be hitting on the building.

So, how do we place those spaces in such a fashion that it is one of the most comfortable locations of a building. So, when I say functionally placing certain spaces; let me just take an example of let us say academic building. We have an auditorium, we have classroom spaces for example, an auditorium ideally does not require windows. Because, you will have to; you know you will have to make sure that the audience focus on the stage, you will have its own set of lightings and etcetera. So, you really do not need to place an auditorium at the periphery of the building, whereas if you are looking at classrooms you need to make sure that students or children have access to views, have access to daylight.

So, how do you position this inside your building such that there is a maximum, there is an benefit because, of functional spaces that you have allocated in your building. So, similarly in this orphanage we make sure that the evening time spaces are ok, it is fine we can locate them where you do not need maximum daylight. And so, most of the evening time spaces would be in the central part and of course, east and west were masked by toilets and your core areas, your service areas. And, if you see also the depth of the flow plate we did not increase the depth of the flow plate too much especially for the critical spaces. So, that there is enough daylight and to why there is a science behind this; daylight does not penetrate beyond a certain depth. And we calculated all of that just

to make you understand. If you see the width of the window as X and the height of the window from the ground level as Y, your depth of penetration of daylight is maximum 2 Y, giving a distance of 1 feet on either side of the window.

So, when you see this is all that your daylight can penetrate. So, during the daytime we do not want children using artificial lighting; one to minimize energy and also there would be no need to do so. So, if you see the depth of the flow plate has been designed accordingly. The corridor spaces if you actually see, this area all the corridor spaces were comfortably designed. So, there is enough shading for these classrooms and dormitory spaces before the direct heat hits the building so and even on this facade we had a lot of shading elements that I will show you in the photographs. And, all this was also taken into account after studying the wind direction as well.

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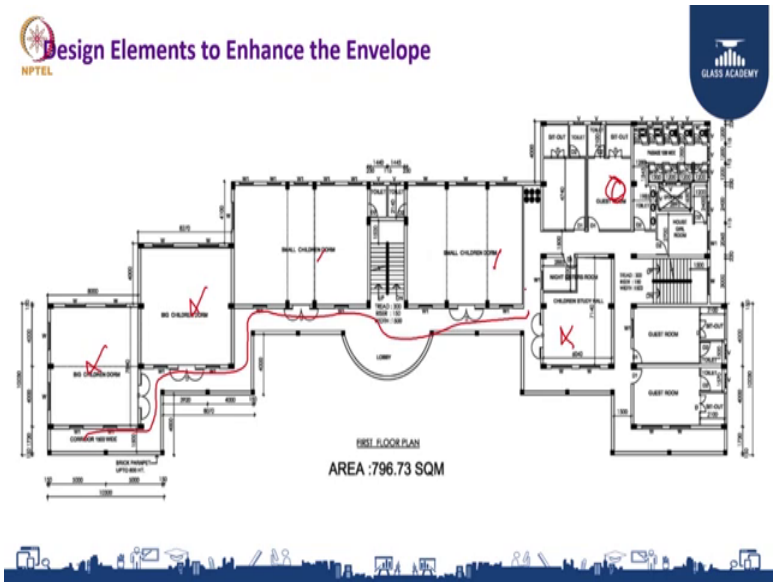

So, this is a typical flow plan, if you see the 1st floor we have the small children dorm which is here and here, then we have the guest room. So, the guest room if you see does not have access to maximum daylight or its why because, it is not going to be occupied mostly during the day. And, you have children study hall here, the big children dorm big children dorm over here. So, most of these spaces are a well spaced out with access to. So, there is only one point where they can enter the building, also keeping in account your safety and security as well.

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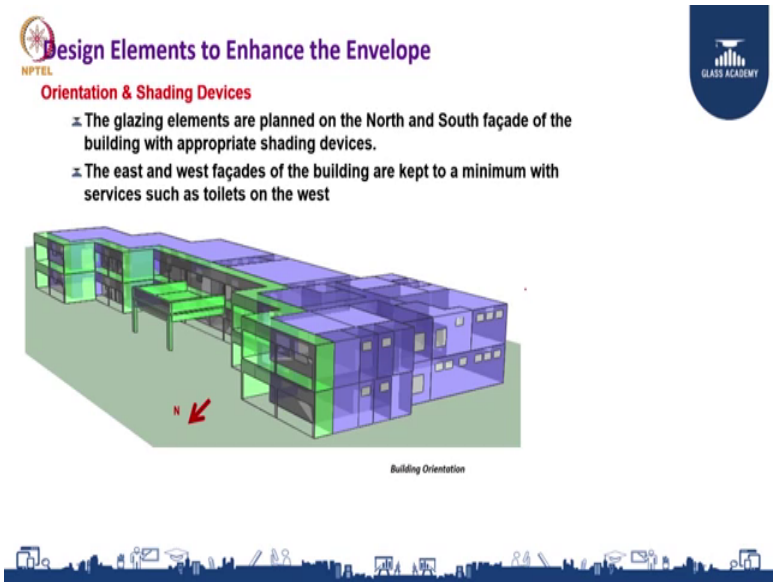

So, this is what when I said we do our energy analysis and fix the best possible orientation. So, we use the IES software, there are various softwares available today which can help you, assist you to take the best possible decisions at the least cost possible. So, when I say how this can happen is when you creating a simulated model, you are creating a base case which is basically based on international or Indian standards.

So, if your building has to perform efficiently as per a standard design you have before the building that you will get designed you will get a certain energy consumption; let us say x kilowatt hours. You run it through an energy simulation exercise for the parameters that you want to do, let us say you do not want to spend so much on glass. Let us say you want to use roof insulation or you do not want to use. So, then you will actually add these parameters unto your design model. And, see if I do use a roof insulation let us say which is costing me 5 lakhs my energy savings is 1 percent.

But, let us say I do shading devices which is costing me say 7-8 lakhs, but my energy savings is to the tune of 16 percent then you would rather spend that money on you know using shading devices rather than roof insulation. So, these are certain things that we can play around at the design stage to achieve the best optimal solution. So, here again the glazing elements, the entire large components of glass that we have planned comes in the north and the south. So, the north having a lot of shading elements and the east and west facades are kept to a minimum and as well you kind of block it with toilets.

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So, this is some of the construction. So, in terms of usage of materials we did not want to use regular brick because, we had opted for Flyash bricks because, the thermal properties of these bricks are much better than regular bricks. So, regular brick could be anything around 1 watts per square meter Kelvin whereas, the u value of Flyash bricks is about 0.72 watts per square meter Kelvin. Now, when I say the u value, what does it mean? It just means it is a measure of heat gain through conduction.

So, when I say a 1 or my u value is 1 2 or 3, the higher the basically it the u value, the higher the u value the more heat gain happens into the building, the lower the you value the lesser the heat gain. So, heat conduction is nothing, but heat travelling from a warmer space into a cooler space. So, the lower the u value lesser is the heat transfer. Similarly, if you see if you look at this portion we had we already have corridors.

The corridor spaces have grills plus an additional shading device also was provided, that is because if you see these windows are the south facade windows which bring in most of the daylight. These windows that are on the north facade also bring in daylight, but only to a certain extent because, you are trying to bring in a lot of shading as well. So, what did we achieve at the end of the day? So, this being an orphanage they did have some sponsorship for solar energy.

So, the savings that the solar energy brought in was 25.5 percent and the energy savings without solar was 19.7 percent. And, spaces that were daylight was 76 percent and spaces

with access to views were 100 percent. So, this is what we had achieved by the envelope design, only by basic planning orientation form and usage of Flyash bricks. So, we could achieve a temperature differential of 3 to 4 degrees between the outside and the inside. And, this is a lead silver certified building.