Glass in Buildings: Design and Application
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Lecture – 80
Building Envelope Design

Hello, my name is Sameer Divekar, I am director at DBHMS we are a green building and engineering design consulting firm.

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We have been working on various projects across India and have a good overall understanding about energy efficient buildings.

Topic I am going to talk to you today is about Building Envelope Designs. Overall in today's age we all hear things like energy efficient buildings, green building, sustainable buildings. So, there is a good amount of awareness which has come into the market. However, what I am going to talk to you today is about, how do we practically solve all these aspects what are the important aspects that we need to keep in mind before we arrive at different options or finalizing a solution for building envelopes.

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When we say building envelope, it comprises of the kind of walls that we select, kind of a roofs that we select, glass and kind of window systems that we have. All these formulate overall building envelop.

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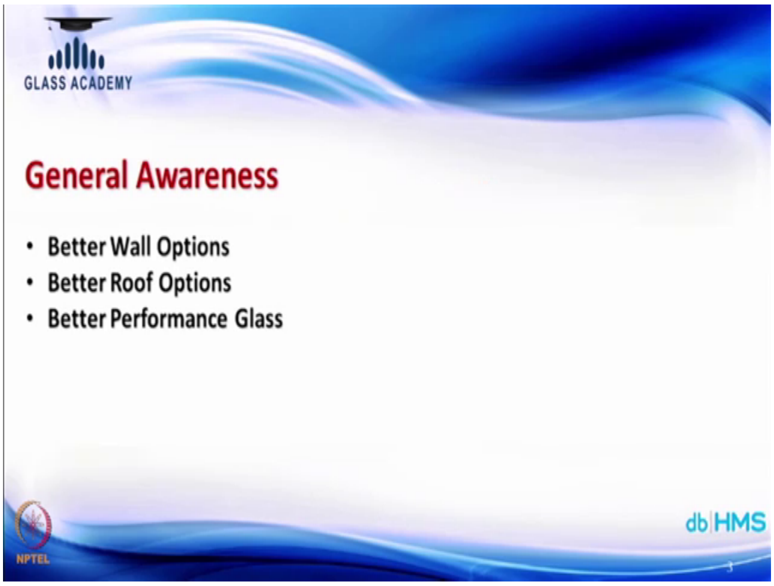

Regarding these various components there is a general awareness in design field as well as construction field about selecting good wall options or a good wall envelope, different roof options, better performing glass. So, people generally are aware that for a green building or for a energy efficient building, we have to look for good option of wall roof glass. There are various standards and guidance books who have given different values about it. So, they try to give for a particular climate, this is ideal value that you should select for each of these components.

However, there are various other aspects which needs to be looked at before we reach to a stage where we select a wall roof glass or a window and to get your focus more about these aspects first because unless we solve some initial aspect reaching and trying to arrive at a conclusion all these aspects will not add that much value to the project.

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So, the other important aspects which come before reaching to these values are overall impact of envelope on a particular project whether selecting a different wall is going to have a significant impact on a overall energy consumption of a building or not? Is glass being that much important factor or it is a very small contribution it has on a project? Are we also comparing the type of building scale of a building? Are we looking at overall orientation of a building? Whether we are looking at right window to all ratio? Are we looking at various shading strategies all these things need to be looked at?

So, I am going to show few case studies, where we look at all these aspects along with selecting a right U-value or r value of different components. So, these case studies are of a different scale. So, I will begin with a first study.

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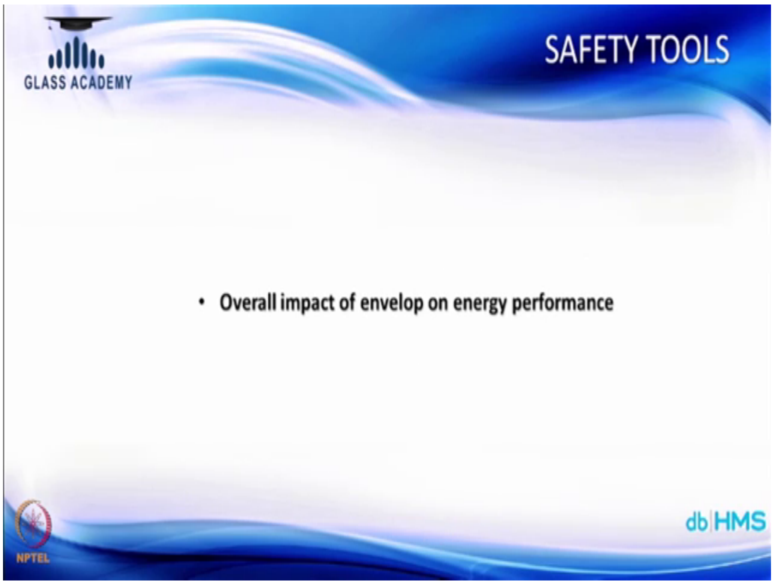

So, first aspect that we always look into is the kind of overall impact envelope is going to have on a energy performance.

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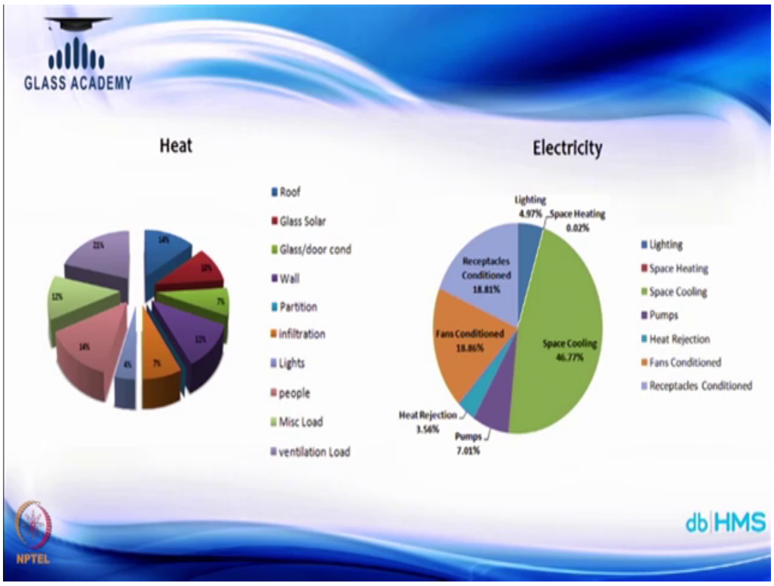

In today's age we have buildings of different scale there could be a project, which is of a small scale or there could be a large IT park.

The role that envelop plays on energy consumption for that scale of a building very significantly, for example, if it is a small building there is a possibility that envelope heat gain or overall energy consumption because of envelope is quite high while on the other side if it is a large IT park building, where it is a large deep loads, load space there are many a times the overall envelope contribution could be a smaller component of it. For example, the pie diagram you see on the left side of a screen is telling us different components which contribute heat in the space; for example, heat comes from roof, it comes from glass, it comes from wall, partitions, infiltration, lighting, occupants other loads, ventilation loads. So, all those elements contribute heat inside the building.

So, whenever we start looking at a building we create this pie diagram for that particular location for that particular exactly that building how much is contribution by each of these components? For example, for this particular case what we see on screen is overall roof contribution is around 16 percent, overall glass contribution is in the range of 12 percent, 7 percent.

So, as we see on the screen the overall envelop contribution is not that significant while as if we study any other building there is a possibility where almost 70 percent of load is contributed by envelop. So, broadly we can divide buildings into two parts; buildings which are internal load dominant buildings and then there are some buildings which are external load dominant buildings. Buildings which are external load dominant buildings have more heat impact because of building envelop and the buildings which are more internal load dominant buildings, they have more heat contribution because of occupancy load, lighting load other miscellaneous load or overall ventilation load.

So, first before we decide on how much energy and how much depth we need to go into building envelope understanding we need to decide whether the building is internal load dominant or it is a external load dominant building. So, the pie diagram on the left side is giving us indication about heat contribution the diagram, which is on the right hand side is giving us overall impact on electricity consumption.

So, many times depending on a building is an air conditioned building or it is a naturally ventilated building we need to look at both these sides of diagrams. So, that the overall understand how much is the envelope contribution on overall heat as well as overall energy consumption. So, this becomes the first point that we need to study.

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Then we come to selecting various wall roof and glass combinations.

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Today we have various of these options which are available and most of the times this is determined by U-value k value or regarding glass it is about U-value SHGC value and VLT number. So, what we generally do on a actual practical projects is we create a kind of a comparative graph. So, what you see on a screen is, there are various there are four options for wall assembly. So, there is a regular brick wall, there is a aerated concrete block, flash block or a brick with added insulation.

So, after putting in various r and U-values on envelope we can create a diagram like how much is the impact of heat on this building because of these different wall options also there is a various options about roof a regular RCC roof or RCC with a cavity or with a 25 mm insulation or with the 50 mm insulation, how much is the differential heat contribution on a project. If we do not apply it on a particular project, and if we purely go by comparing between two options; for example, aerated concrete block is; obviously, more better insulating material than a regular brick wall.

If we take an example that AAC block has a three time better value than a regular brick wall we can assume. If it is a one third of a poor performance of a brick wall we cannot assume that the energy consumption is going to be one third. What we need to really do is apply it on a project in the last slide we create a diagram where we try to predict that the overall contribution by wall to a project was let us say 15 percent and one third improvement on 15 percent will have a smaller contribution and it would not be one third on energy consumption. So, it is very important that we take it back and apply it on a particular project. This will change depending on scale location of a project as well.

So, in this slide we try to compare different options and heat contribution on a project and not purely based on a difference of U-value. So, that is a very important step that we need to really understand on and with this then we can create different options like which is the worst of best option into this and which is the worst option into this. For example, in a first case brick wall comes out to be the worst option, because it is contributing the more the most amount of heat compared to all different wall options and the other ac block is coming out to be a winner in this option. But, if we also try to put cost for each of these together it might give a different story whether the difference is sufficient to justify the additional cost that we going to incur on a project.

So, point to note in this is we should look at overall contribution on a project and not conclude based on only comparative technical or a U-value differential.

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So, we looked at a slide, where we are trying to compare wall roof and glass separately.

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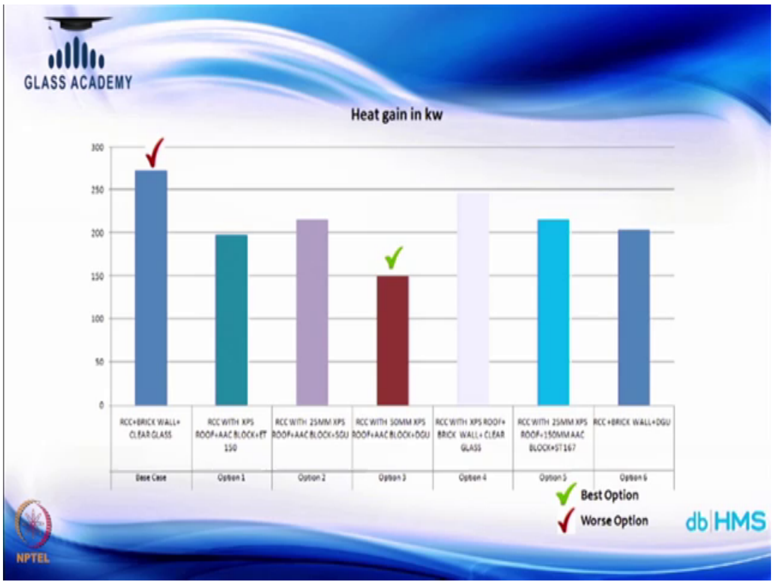

Now, once we have selected best and worst cases out of it, we can also combine all these things together and can compare overall impact on a project with different combination of wall roof and glass. For example, on one case we realize that a particular glass is better for a project, but cost wise it was quite expensive. So, we might choose that we may not go with the best choice of glass. However, we can go with a best choice of wall and roof and together as a combined option that might be more attractive in nature which is be a good addition on a project.

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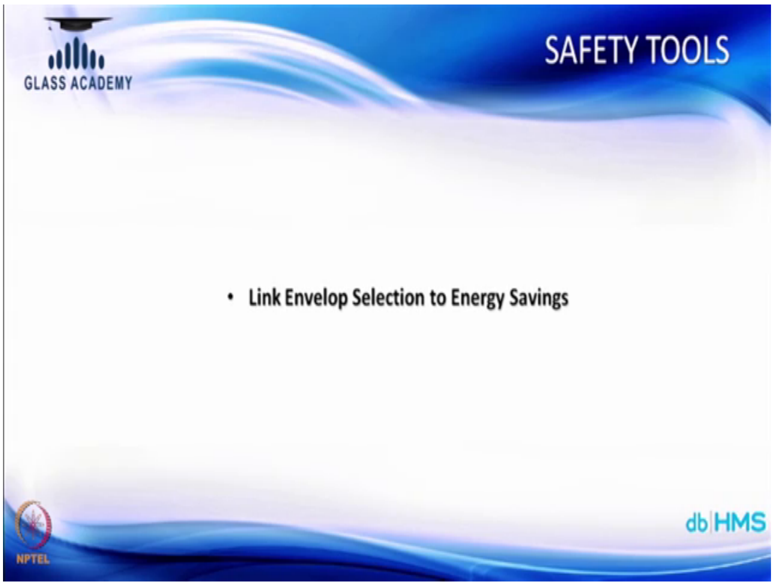

Then, we also need to link all these overall contribution on a energy consumption level as well.

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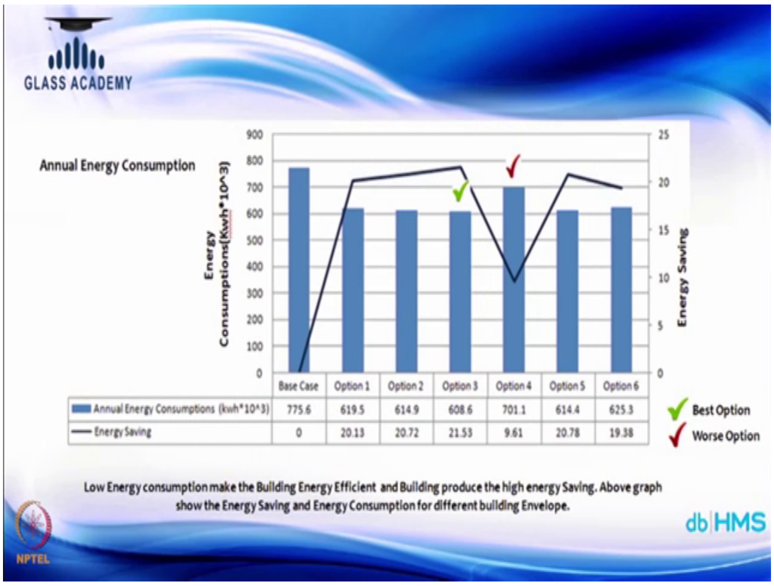

So, in a same study we can overall also impact how much is the kilowatt hours of saving that, we can get on a project. So, linking cost U-values and kilowatt hours becomes a quite good parameters to select on a building.

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Another aspect which is very important when we talk about building envelope is the overall area of envelop that we have.

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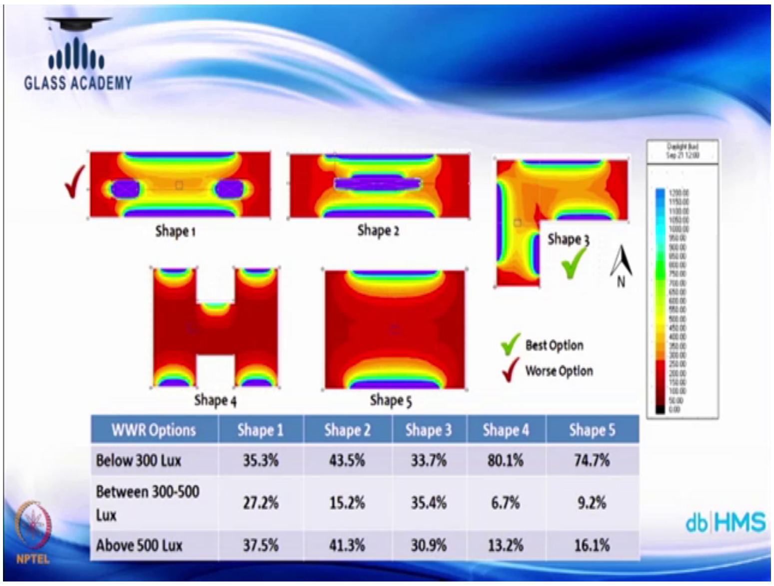

So, whether we have a compact building or we have more spread building that also has a impact on energy which is going to come through envelope. For example, what you see on screen is different shapes of a buildings all of them they have same square feet area, but their shapes are different.

Now, how do we select which is the better shape for a building. Generally, in India we always think courtyard buildings are ideally suited for Indian climate, but we also need to understand is courtyard buildings also have larger surface area. So, we cannot blindly decide that courtyard is the best suited option, we need to wet between the daylight impact, ventilation impact and a heat contribution. So, in many cases courtyard might come out as a better option, but not necessary in each and every project it will come out as a best option.

So, what you see on a screen is a study of daylight. So, different shapes and we have divided the overall day lighting distribution. So, let us say it is office building and the requirement of daylight is between 300 to 500 Lux. So, we have distributed how much percentage is below the requirement daylight levels, how much is above the requirement level and how much is as per the required daylight levels. So, this study very clearly says that shape number 3 has maximum amount of area, which is under required daylight levels. So, that might be a better option to go. So, how much is the surface area we have has a direct relationship with how much is the heat which is going to come inside we go from envelop.

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Another very important aspect is window to wall ratio.

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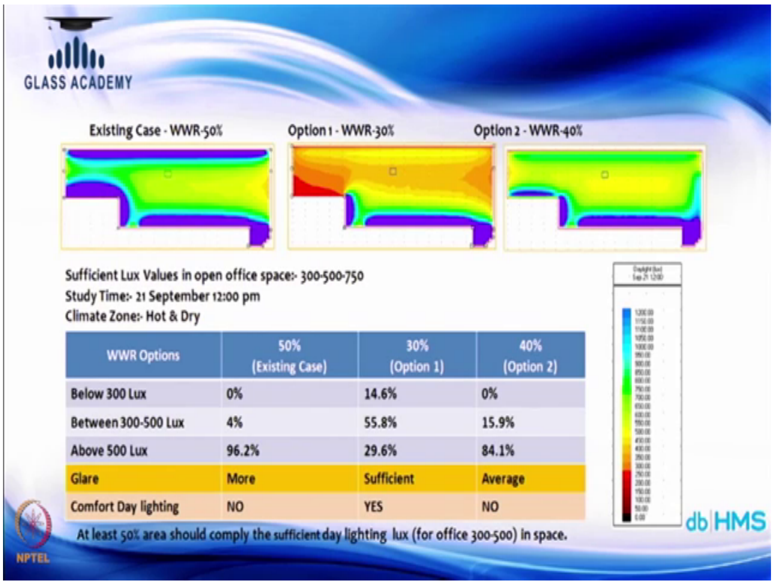

So, in this slide what we see in the most topmost options is all of them they have same shape, same orientation, but they have different window to wall ratio. So, again the kind of a window to wall ratio that we select has a impact on envelop heat contribution

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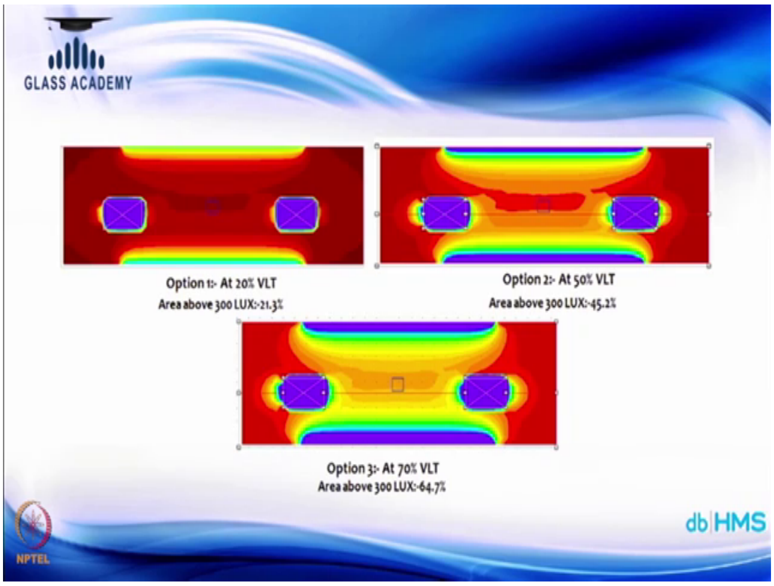

Then if we cannot change orientation or if we cannot change the building shape if we cannot change the window to wall ratio, then we come to a last resort where we have only one alternative to change the performance which is kind of a glass. So, today we have various glasses which have different U-values, different SHGCs, with different VLT values. So, we have wide spectrum of glass properties which are available to select from.

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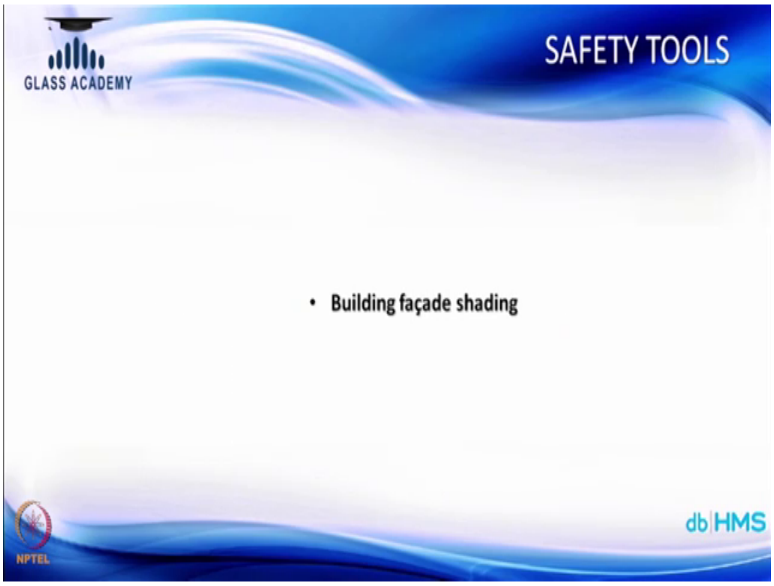

Another very important aspect for building energy contribution is shading.

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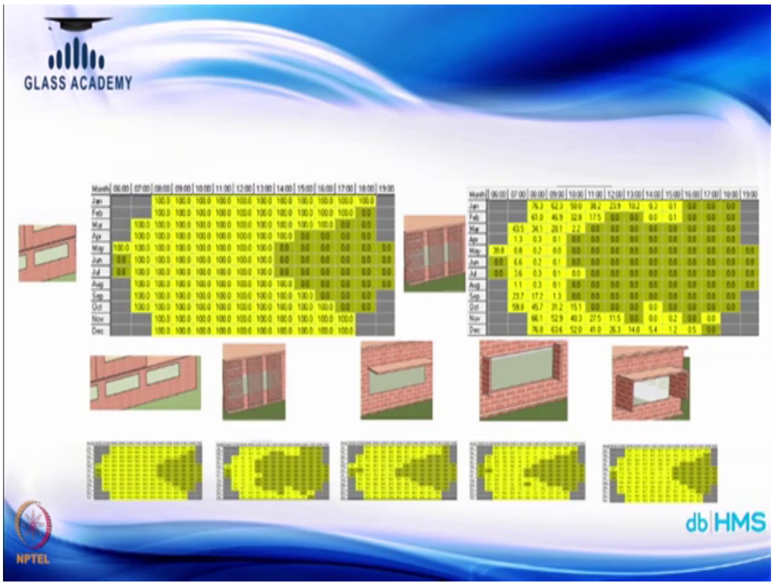

This is a software output for one of the project that we are working on. So, one on a left hand side if you see there is a window which is not having any kind of a shading device and a graph is telling us on a one axis we have January to December all months in a year and on the other axis we have all hours in a day. So, wherever you see 100 in a yellow colour that is telling us that particular glass is 100 percent exposed to solar radiation. So, all the radiation falling on that particular glass is contributing heat inside the space. On the right hand side what we have done is, we have added some louvers in front of window and now you can see the overall contribution.

So, compared to left hand side which is mostly 100 percent exposure on a right hand side you see a significant reduction in the exposed area; that means, the heat which is going to come inside from that particular shading selection is going to be quite smaller compared to that on a left hand side. So, this is just one of the option, but as you see below there can be various other options that we have different shading devices which we can play with. So, this is dependent on direction of a window as well. So, this is this study is for a particular direction.

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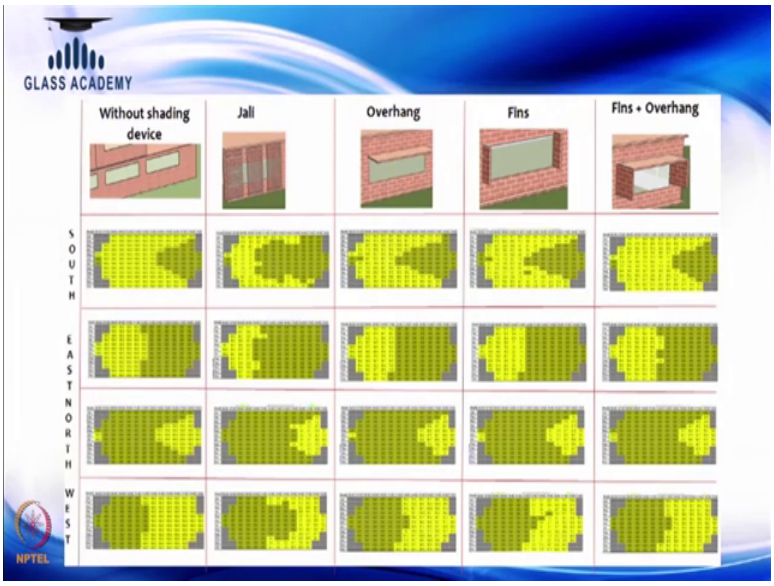

But, we can carry out similar kind of a study for all direction north, south, east, west or if a building is also exposed to another 45 degrees angles we can also do this kind of a study for all kind of angles as well.

So, this is telling us how much is the overall solar radiation falling on a particular window.

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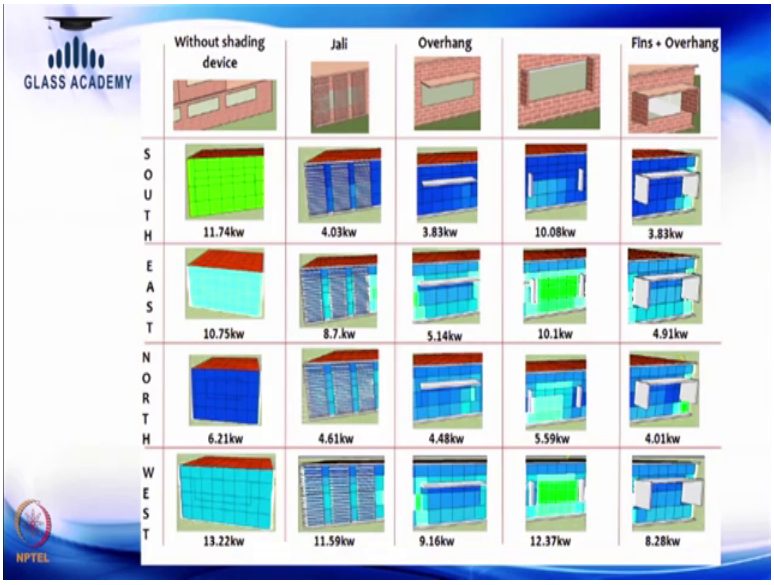

A same study can also be taken ahead and we can also check how much is the kilowatt heat contribution, because of change in a shading device that we have. So, what you see on a screen is how much is the overall kilowatt heat contribution happening because of different options.

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So, if we do such kind of studies there various kind of a shading devices which can become a solution. For example, what you see on screen is one is a modern solution to it one is a old way of solving the same problem. But, important aspect is if we solve if we have a well shaded windows that we need to factor in when we select a kind of a glass or a kind of a envelope.

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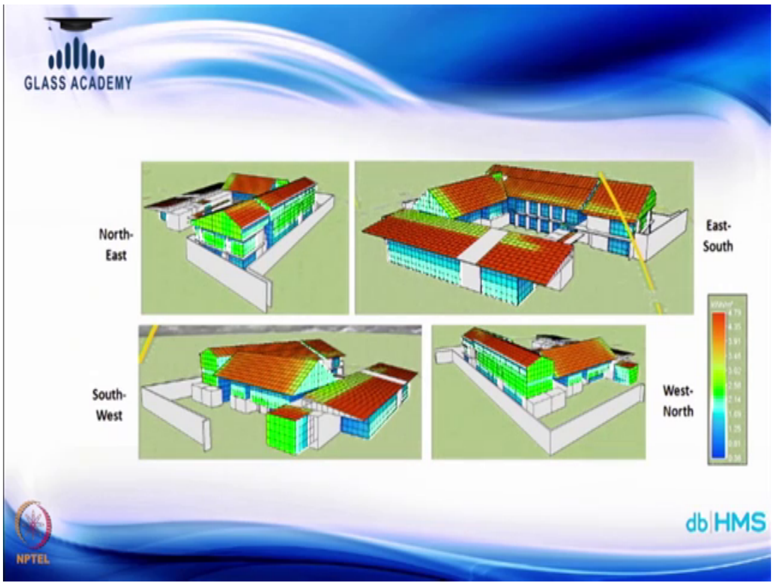

Lastly, overall we can predict, so, what you see on a screen is a solar radiation falling on a building. So, red color is a maximum intensity and blue colour is a least intensity. So, what you very clearly see on screen is most of the roof areas have maximum intensity. But, most of the facades which are wall and glass if you see have a blue shade; that means, whatever studies are done and when finally, a solution is arrived at we have facades which are naturally well shaded.

So, when we reach up to this point we are very sure that we have a well designed building and only after this point we can start looking at technical aspects of wall roof and glass. So, only after solving all these things is a right point, where we start looking at what are the U-values, what are the resistance values, what are the VLT values for a glass, roof, as well as walls.

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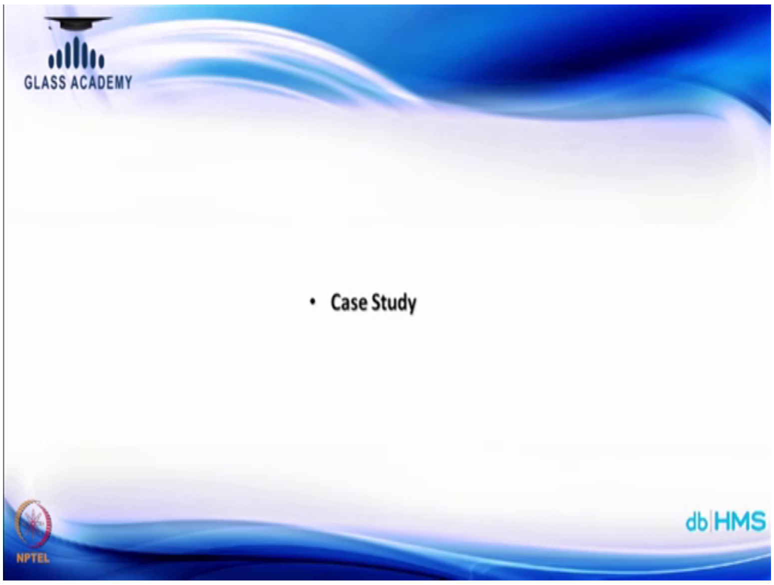

Another case study.

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So, the earlier case study that we talked about is when we start at a early on a project and we have flexibility to select orientations window to all ratios shadings as well as different qualities of wall and glass. Many times we can also be on a project, which is quite advanced and we have a limited area to improvise on. So, there we might be looking at more about selecting a right U-values and more technical aspects of it.

So, this is a case study it is a kind of a corporate office project is in Delhi and this is the overall view that we have. So, that different floor plans that we have.

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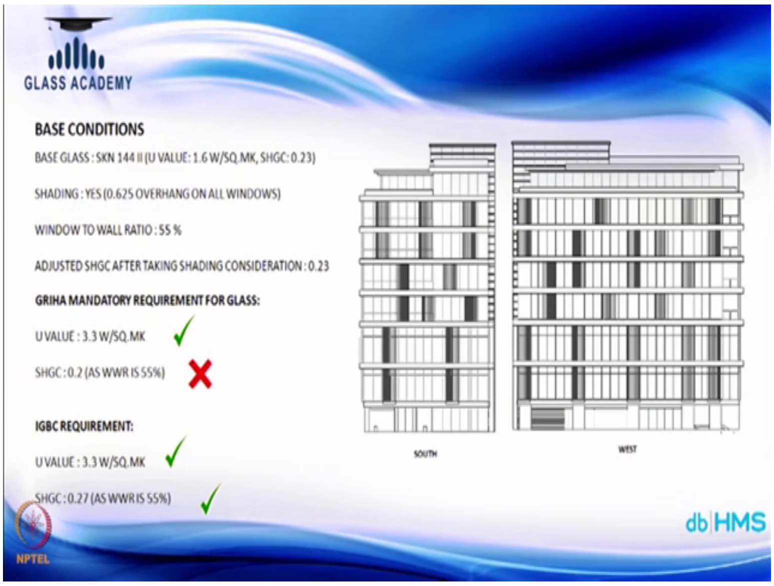

So, earlier when we started looking at this particular building there was a facade that we had in front. This building was also going with IGBC as well as GRIHA rating. So, IGBC as well as GRIHA both of them they give a prescribed value U-value for wall and roof and SHGC U-value and VIT ratios for a glass that we select.

So, when we started looking at it where we where is a project was trying to go ahead with a particular glass which was qualifying under one rating, but it was not qualifying under a different rating the window to wall ratio was qualifying overall and SHGC was slightly a challenging scenario.

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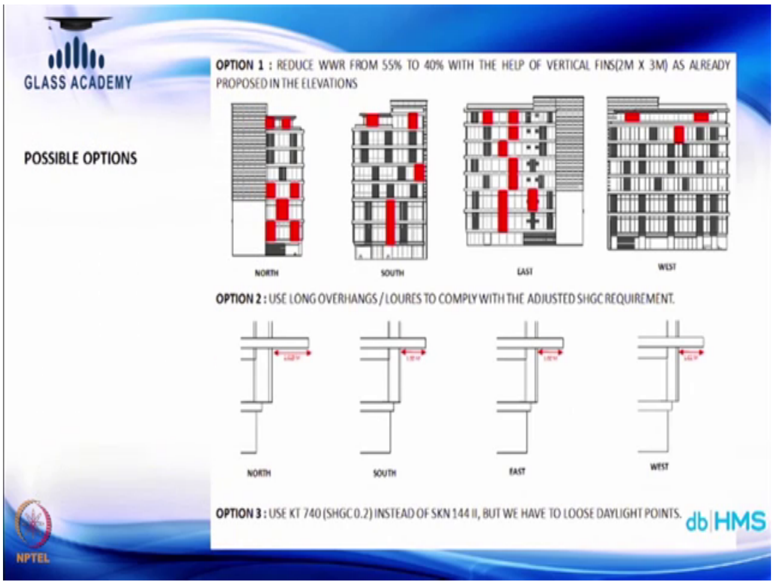

So, after going through various studies what we realize is there are three ways to tackle this scenario. So, option one was we reduce the overall window to wall ratio because less is a glass less is going to be the contribution. So, if we have less glass then we can have slightly more clear glass or we have more leeway on SHGC value that we can select on. So, where one of the option was to add some more shading devices on a facade and this is also specific to direction of ah the glazing as well. So, we suggested various difference percentage of shading devices spread across various facades that was one option which was possible.

Another option which was possible is to change the overhang length. So, we tried out various depths of overhangs. And, the third option which was possible was clearly changing the kind of a glass, but if we do not do option one or two, then the option that we were left with is having a particular glass which was quite darker in nature. So, it was not giving a kind of a look to the building, as well as from inside it was not giving nice views outside.

So, on this particular project we went ahead with first option and then improvising different kind of glass properties on different levels of a building as well.

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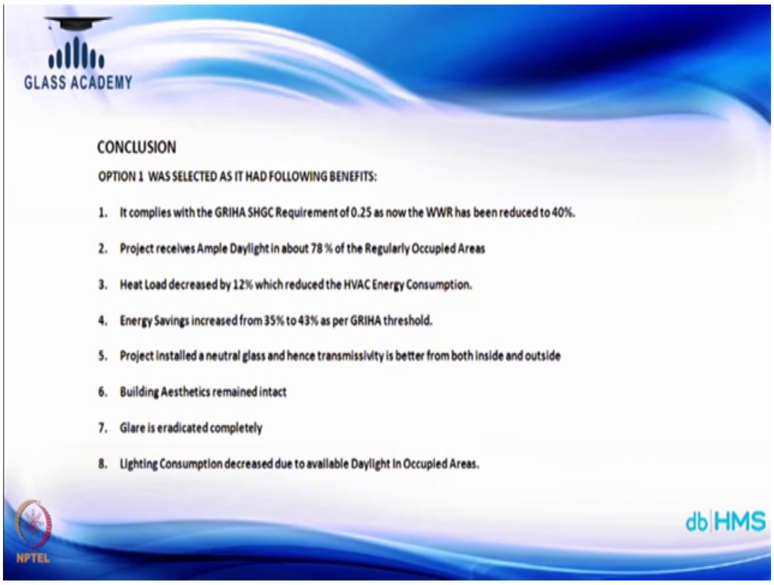

So, overall reduce the overall window to wall ratio we changed the overall VLT values to achieve maximum daylight. We achieved the overall heat reduction of almost 12 percent. The overall energy impact of that was almost around 35 to 43 percent aesthetically we managed to keep it a good looking building as well and not make it too dark.

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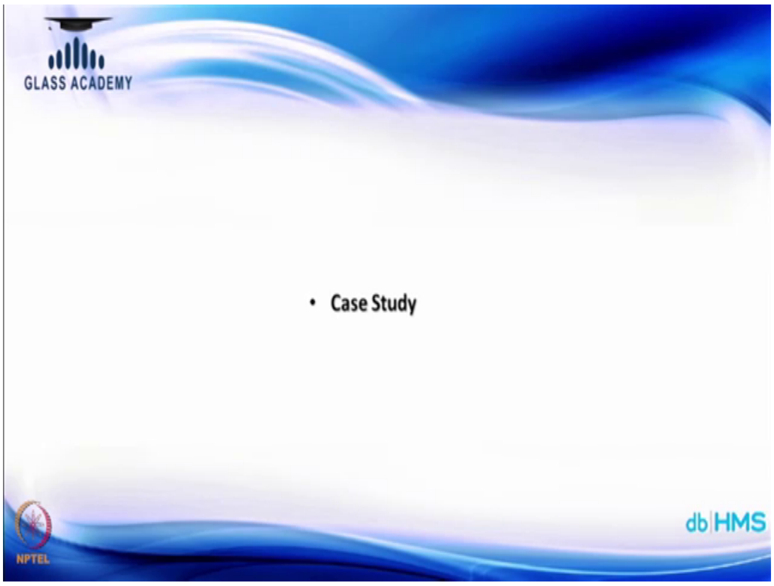

So, the various good aspects which really came out of this study the next study I am going to talk about is another project.

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This is in Gurgaon. So, it is a large again corporate office building the overall architects vision was it should look more lighter in nature. So, the first kind of a instant was to go with all glass kind of a building, but that was not a good choice as we all know that it really has a direct impact on air conditioning load as well as energy consumption.

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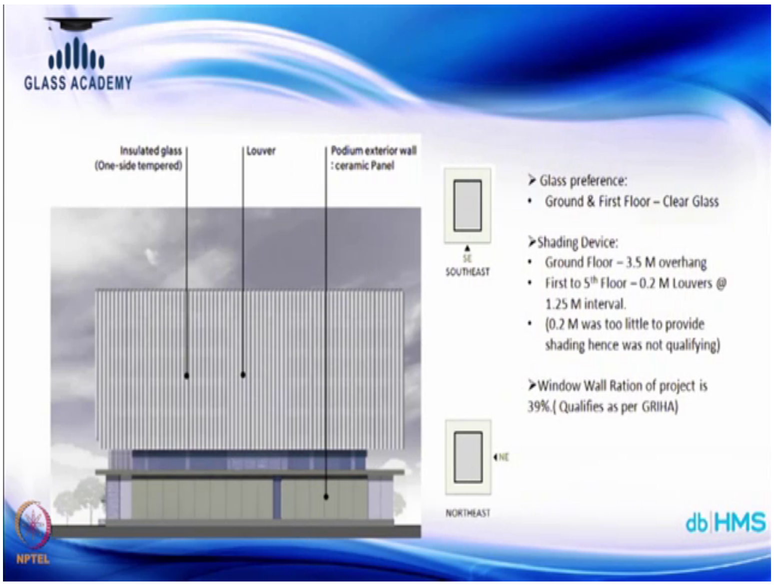

So, what was really done is the overall facade do it looks more of a glass is divided in two different types of glasses on one some part where it is directly between sill and a lintel level we have clear glass, but on a sill level and on a lintel level, which on a lintel level above generally we have false sealing. So, all area in front of that was made do it look kind of a glass from outside it is opaque from inside same is true at a sill level as well. So, using that, we were all reduce the overall window to wall ratio on a project.

Another aspect that we introduced is louvers. So, there are louvers all around on all directions. The depth of louvers varies based on which direction we are in to. So, we also worked out various options of how much will the overall depth of each and every louver.

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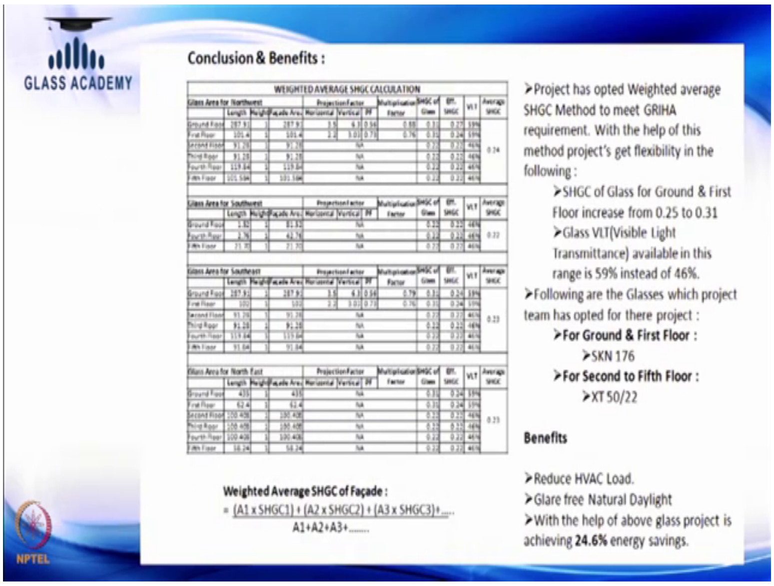

Another aspect that we also looked at into having different kind of a glass based on what kind of a function is there on each floor. For example, the lower most floor was more kind of a showroom kind of a activity. So, they wanted more clear glass so that people from outside can very easily see inside. So, on a lower most floor we have gone with a more clear glass. While as on a floor above where above where we do not need that much of a clarity there we have gone with efficient a SHGC value. So, we have more kind of a reflective glass.

So, on a weighted average methodology we can also change kind of a glass on different sides to really achieve the overall saving. So, though the overall building still looks more like a glass the overall window to wall ratio shading kind of high performance glass all has been overall taken care of. So, in this particular project we are achieving almost 24 percent of energy savings compared to the baseline given in IGBC as well as GRIHA.

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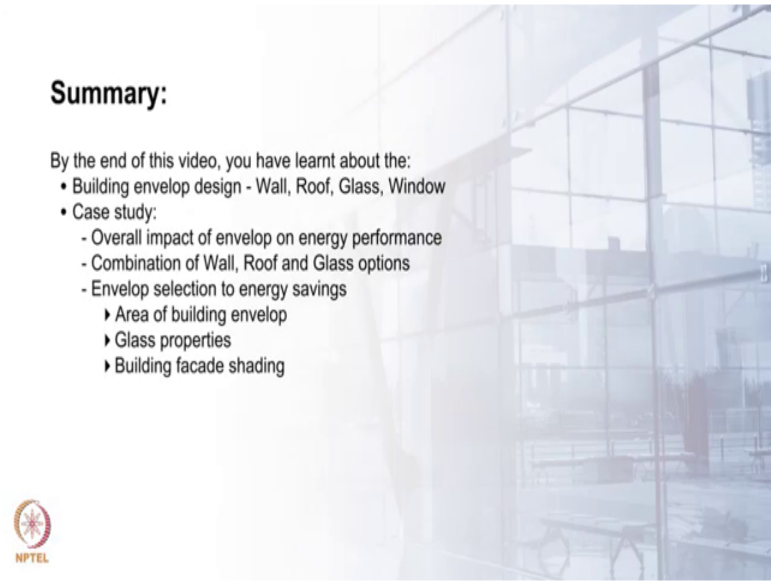

Thank you.