Glass in Buildings: Design and Application
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Lecture - 06
Glass Design Tools for Safety, Sustainability and Aesthetics

Welcome all. So, today the session we will take you through how to design the glass for safety sustainability and aesthetics, and what are the tools that available or it can help you to design when you are using glass. But when whenever we use glass it has to satisfy all the 3 requirements, it has to start with safety at first, and then with sustainability, and then how it going to overall impact on the aesthetics.

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So, the basic requirement for the safety is actually a guideline which is given an national building code of India in the 2016 version. Means in fact, it is specifically requirement to glass, there are some demands been given there, under sustainability how to choose glass. So, then we need to understand what are the kinds of glass available, how do we manufacture that, what kind of glass that we need to select for India climate specific, and what kind of recommendations given in references from the codes the energy efficiency codes. And based on all we will be in the position to understand how to select glass for the building.

The third important parameter which will be driving the both above safety and

sustainability is aesthetics the aesthetical appeal. So, how the building has been imagined during the design phase was this how it going to come up with the product that has been selected which is satisfying your safety and your sustainability recommended. And what are the tools available; how can you make your simple decisions can be made simple using all these above tools.

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So, as the safety requirement to start with there is a very clear definition an NBC, what we are supposed to use it as a safety glass in your building. What it means is a glass which does not break under any likely forms due to human impact. Means even at a worst case if there is an human impact there are should not be any kind of human injury or I would call there cannot be any likelihood of cutting which has to which is has to be eliminated in your building design.

So, in the case, so there is an access to glass by then occupant or the end user. So, what kind of glass has to be used; in the sense what kind of process to glass? Here we mean process glass is what kind of value addition we do on the structural property of the glass. So, that is what been referred as safety glass. As per the definition of NBC 20 60 safety glass means the toughed safety glass and laminated safety glass.

So, when we want to design a building as per the safety requirement of the codal. So, there are two three things we have to follow: one - the location of the glass, two - the kind of process glass you have to use, three - the structural testing or the assessment that

has to be done to satisfy the codal requirements.

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So, second important parameter will be your sustainability.

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So, before getting into sustainability means how to select glass how to make a building energy efficient, how to select a right glass for the building, we need to have a small background on the history of the glass to understand it. When I say a history means what are the kinds of glass available how it has been originated from origin to what we have today so the basic is called the clear glass which is the float glass which is manufactured.

Then you can do the colours or tinted to the glasses. We can have green, blue, browns and grey, so that the 4 standard tinted glasses available in the market which again been manufactured as per the float glass technology.

So, once the float glass has been manufactured the basic float glass cannot give you any kind of performance impact, means it cannot have an impact on your life transmission or solar factor or your U-value of the glass, because the tints are given to give an aesthetical appearance not for the performance impact. So, when I have to achieve any specific performance say it can be a solar control or it can be a thermal insulation which is ideally calls the low e glasses, I need to have a coating technology which is the online coating technology or the offline coating technology.

Online coating technology as the name indicates the coating is done on the line which is the chemical vapour deposition process, whereas the offline which is the magnetron sputtering. So, the above coatings can be used to achieve whether it can be for the solar control or it can be low e. But the current technological growth has given a step forward where I can do both the solar control and thermal insulation in a single layer of coating.

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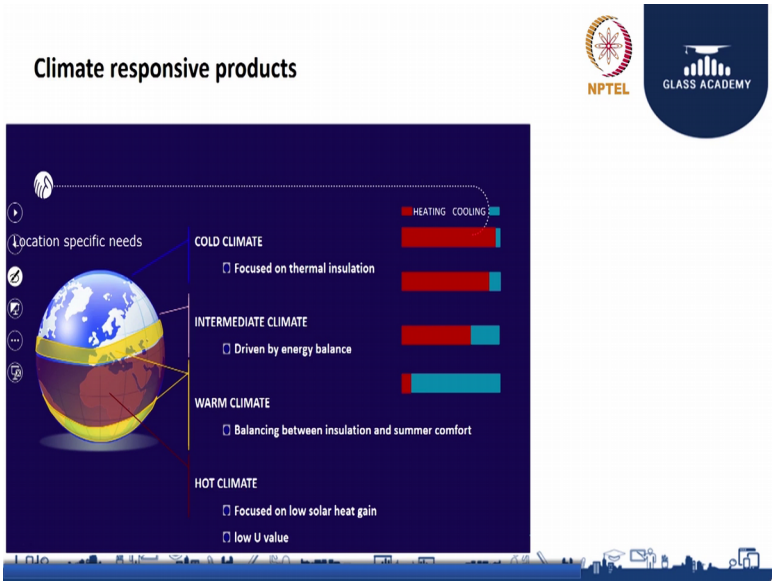

So, what kind of coating I should be using it in India? Because these coatings are again has to be selected based on the climate responsible? I mean ideally we have to take a decision based on the climate of the location say India or Asia specific or the global there are different climatic conditions been divided. It can be of a cold climate, it is there is an

intermediate, there is a warm climate and there is an hot climate whereas, based on the climate of the condition the kind of or the type of product used has to be different.

For example if I take a cold climate or intermediate climate where the product selection has to be done based on the U-value of the glass or the thermal insulation property of the glass because the outside temperature might be lower than your inside temperature. In that case the challenge is to hold the amount of heat loss through my heaters which are placed inside the building. Whereas, when I come to the hot climate or the warm and humid climate where the conditions laid is different say like an example as a continent Asia. The outside temperature is always in majority locations higher than the inside side temperature, means there is a lot of possibility of the external heat can transfer into the inner portion of the building. So, how can I reduce that? Then you need a parameter called solar factor which is can be derived by the solar control glasses.

So, we have massively two different types of coatings one is called the solar control coating and another one is called the thermal insulation coatings. Solar control precisely been used to achieve a lower solar factor which is precisely can be a product for warm and hot climate. Whereas, a low e or a thermal insulation glasses where the intention is to reduce the overall thermal insulation value of the glass or the U-value of the glasses which is precisely can be useful intermediate or cold climate, where I have to retain the loss of heater efficiency.

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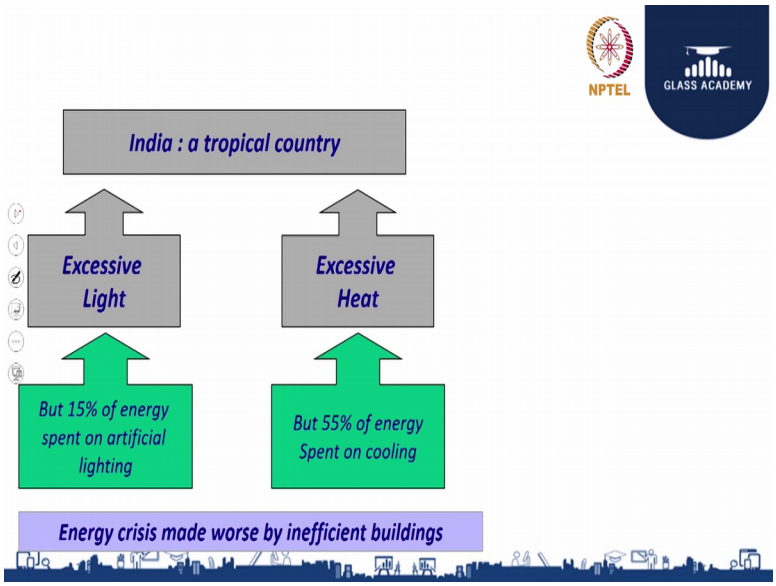

So, again as I said India we have two challenges and we need to have two important parameters which can be control by glass, one is the light, other one is the heat. If I divide the building energy consumption pattern about 30 to 40 percent of the energy is spent on cooling the building, about 20 to 25 percent is spend on lighting or the artificial lighting, used for the artificial lighting. Rest has been consumed by the due to the occupancy route or any other kind of electrical appliances. So, about 65 to 70 percent of the energy spent on every building is for the heat and light.

On the other side India as a country we have a abundant light or we can call it as an excessive light or we have excessive heat in the same format. So, what happens? I have a source which has which is able to give me more light, and more heat other side I am spending energy on light again on converting the hot or the hot air into a cold air which is ideally you are heating ventilation and air conditioning system does the job. So, what we can do? How this envelope material can play a vital role? Today the modern buildings majority of the building the envelope became or the glass became an envelope material which ranging from 10 percent even to 60 percent.

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So, based on based on the building under envelope requirement there are 3 important parameters that we have to select. One is the light transmission, another one is the direct heat transmission, another one is the indirect heat transmission.

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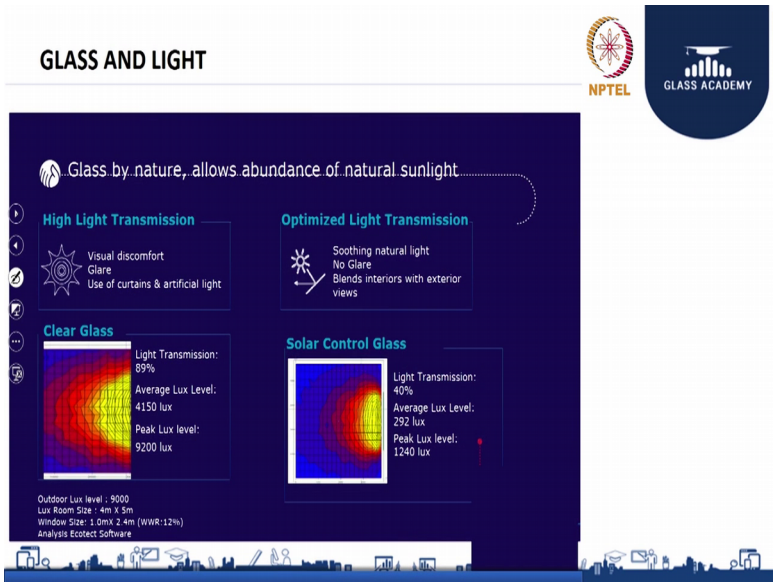

To get more detail into the light transmission how it going to impact the overall selection of the material or the comfort of the building. I have two cases in front of you one is a one is a plant which has very high light transmission, you can see the average next level is about 4150, where I use a light transmission is around 40 percent and you can see an average lux level will comes to 292.

So, what we trying to understand in this image is there are tools available. So, based on the window wall ratio I can try to understand; what is the amount of lux level on the flow rate. So, for the same building when I have an average lux level is which is around 4000, so I would call this areas as a glare area and you can see the more yellow is mean there is a more glare area.

So, it is very easy with the today technology where I can understand the impact of light transmission of the glass based on the window wall ratio. So, it is a very important criteria whenever we select a glass the light transmission has to be the first criteria to be identified, because this going to drive the entire comfort of the user. The more light you are going to end up in a glare and which you have to then solve the problem by using a blends. Again these blends are going to diffuse the purpose of missing the glass. The usage of glass in a building is for two purpose one is to see through from inside to outside, second is natural light coming in. So, moment I have anything to block intermediate we going to disturb the entire design intent of using glass.

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So, another classic example is traditionally you will believe when I need to increase the window area in a building with a with the current modern design where we have even every homes as a French window means ideally a bigger windows. And we believe that it will increase the energy consumption of the building because traditionally the clear glass which is used when you increase the area of clear glass usage your through it will increase the energy consumption of the building, because you are allowing more heat into the building through glass. But currently there are high performance glass available, whether it can be a online coated glass or it can be a offline coated glass.

For an example in this case you have opening index ideally I can say it has window wall ratio; however, 16.4 percent as window wall ratio where the electricity consumption is 4 point kilowatt hour per meter square per year. When I increase a window wall ratio even to 25 percent the electricity consumption has came down. This is because for the case one I have used the clear glass which has higher heat ratios mean amount of heat that transfers from outside world to the inside the building will be higher. When I increase the window wall ratio instead of using a clear glass I have used an high performance glass which has an ability to cut both the light to an extent with that we need plus the heat ratios. So, this will give a very comfort environment for the inside.

The left side pictures clearly show you the impact of very high light transmission. When we use any building when you when you say any building with a blends it mean ideally

the glass selection is made not done properly or the glass has higher light transmission which is giving discomfort to the end user.

So, next step towards the product selection is your direct heat and your indirect heat. What is direct heat?

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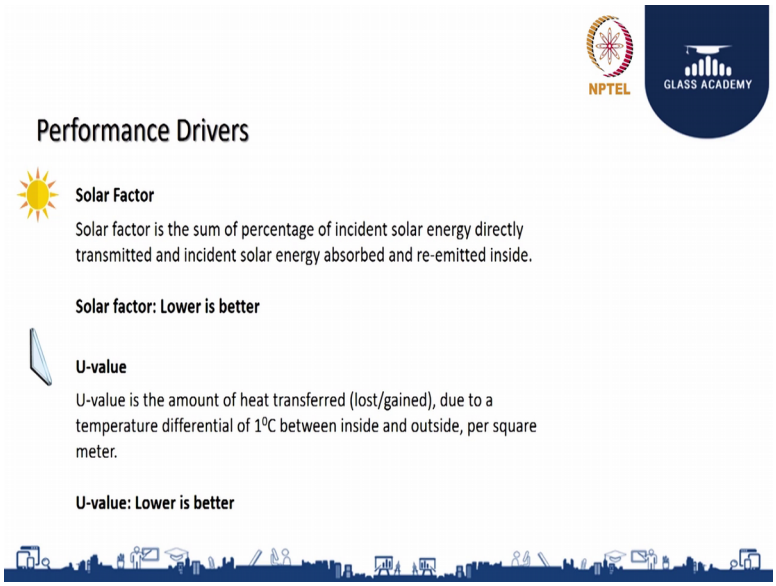

Direct heat is nothing, but the amount of heat transfer that are going to happen from the source directly into your space or the frequency bandwidth between 780 to 2500 which comes from your source called sun which is trying to enter into your building, as such that is called direct heat transmission, which I ideally call it a solar factor in glass. So, to define you the solar factor is sum of the percentage of incident solar energy directly transmitted and incident solar energy absorbed and reemitted from outside to inside; so, just to understand as soon as solar factor is good to go.

The second parameter which is U-value which is again this happens because of the temperature difference between outside the environment to inside the environment. So, the glass does not understand which is outside and which is inside only thing it understand is as physics I have to observe from the higher temperature side and I have to transfer it to the lower temperature time. So, glass U-value is 5.7 watts per square metre degree Kelvin for every one degree temperature difference.

So, far a up for a condition see outside is at 40 to 45 degree an inside my set temperature

will be around 25 to 26 degrees. So, there is a possibility to have a difference delta t difference of about 15 to 20 degree. So, the outside temperature is been absorbed by the glass transmitted into it and into 20 because every one degree there is a transfer of 5.7 watts. So, into 20 will be the amount of heat that transferred to indirect.

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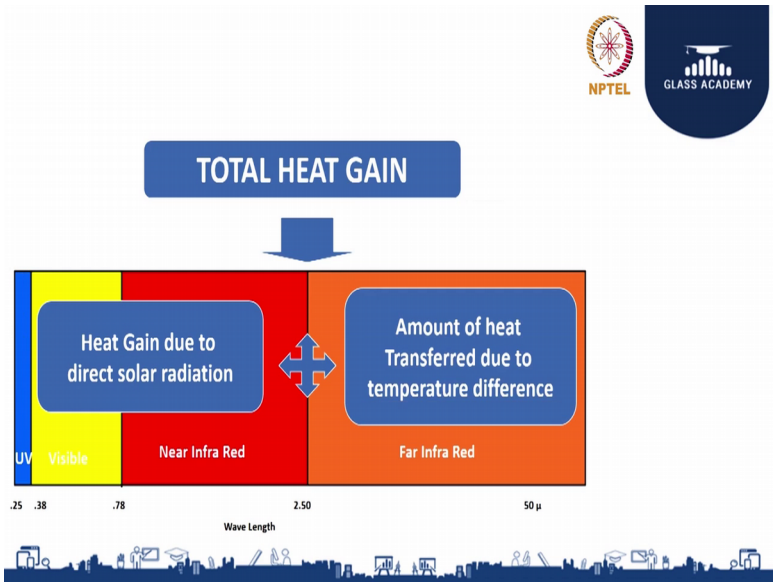

So, what will be the total heat that going to come into my building? There is a portion of direct heat and there is a portion of indirect heat that is how we call it as total heat gain or relative heat gain. When you take the entire spectrum what about the spectrum after 780 to 250 nanometer and the heat that pass through which is called the direct heat transfer and then from near 2500 to 20000 which we call it as far infrared radiations which is also called indirect heat ratios which transfer into a building. So, when I have to calculate the overall cooling capacity of a building I need to calculate the two important parameters, one is called that heat comes through the envelope, another one is called the occupancy heat load.

So, the moment I go to the heat coming through envelope that envelope carries two parameters; one is a direct heat portion and the indirect hat portion. It is very important in case of a glass selection.

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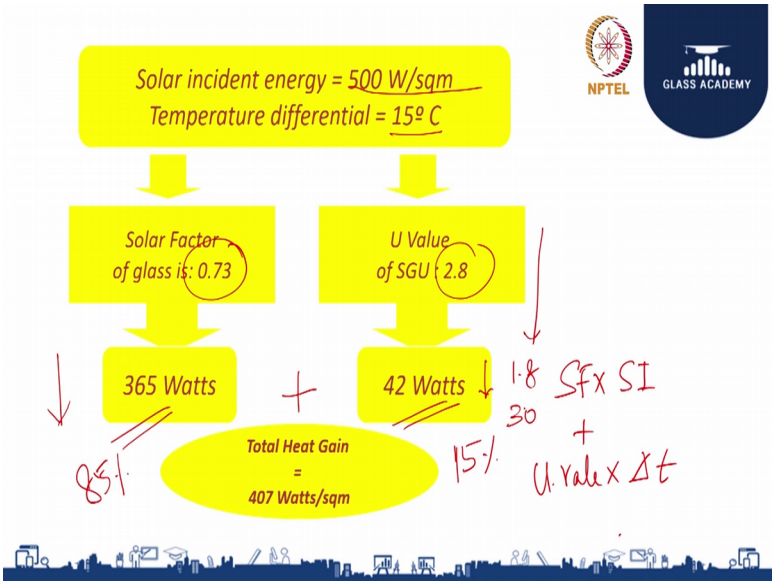

Because when you take for an example when I take my solar incidence which is my source value which is at 500 watts per square metre Similarly, I just for an argument for pan India average I have taken a temperature difference of 15 degrees. So, when I have a clear glass which has a solar factor of 0.73 in a double glazing which is which is this and I have an U-value which is 2.8 for a double glazing format. So, the relative heat form how to calculate relative heat gain is solar factor into solar incidence plus U-value into delta t.

So, in this case if I take solar factor which is 0.73 into the solar incidence which is 500 which gives you 365 watts, similarly solar incidence U-value which is 2.8 into delta t which is 15 which gives you 42. So, sum of this becomes 407.

So, what it mean you can understand the impact that going to happen for your building through the direct heat and indirect heat. Here the direct heat ratio is about 85 percent and indirect heat is about 15 percent. So, this is very important to understand. What will happen if I have a glass which has a coating to reduce the solar factor? So, automatically I can reduce this to a certain extent.

Similarly, if I have a coating which is called a low e coating which have a tendency to reduce the U-value further from U point 2.8 to 1.8 the still the 42 watts can come down to less than 30 watts. It mean there can be a drop of 10 percent in 42 watts which is possible 10 to 20 percent, similar 10 to 20 percent of if I can do it by a solar control glass

there is a huge reduction on the overall percentage of heat that comes in.

Just to make you an understanding I have take an similar cases or several options.

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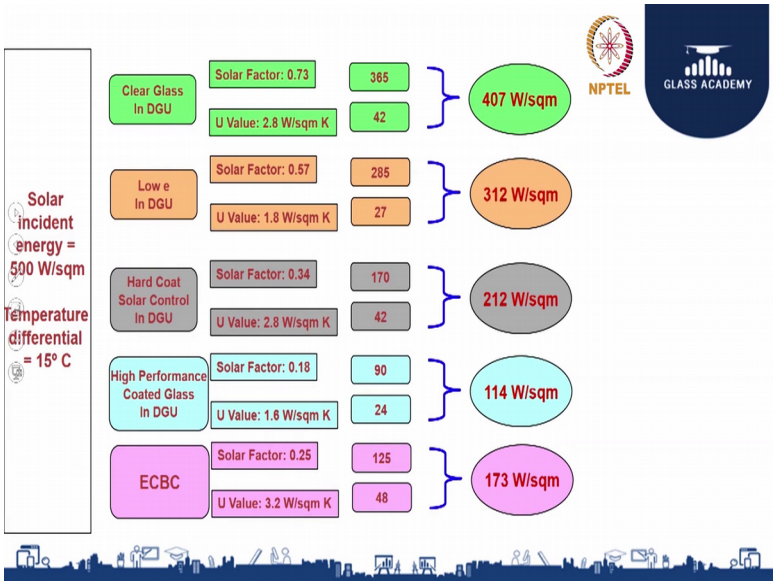

I have taken the same solar incidence value and the delta t temperature difference in a clear glass where the same value of 0.73 into 0.8; you know its 407 watts. I have a low e glass or a thermal insulation glass means ideally I have done a coating on a clear or tinted base to reduce the overall U-value you can see the U-value reduced from 2.8to 1.8.

The coating has an impact on the solar factor to a certain extent, it can reduce into 10 to 15 percent because of the low e coating also. So, when I do the same solar incidence into solar factor and delta t into U-value the overall heat comes in come to 312 watts. As an option two I have taken on hard coat or online solar control glasses which is a first generation glass where the coating has been done to reduce the solar factor portion. Since it is solar control coating the U-value can notice it will be same like your clear glass 2.8 , but still you see the 365 has came down to 170. So, that is an impact that solar control glass can be given.

So, you can see the difference from 407 watts to 212 watts which is ideally dropping 50 percent of your heat coming in. What is going to impact because of this? The cooling capacity of a building is calculated based on as I said on the envelope heat load and internal occupancy load. The internal occupancy load going to remain constant based on

any kind of glass selection you going to make. So, I have a portion which is the envelope heat load which is ideally going to be the 60 to 70 percent of the heat load.

So, out of the 70 percent I can drop 50 percent, means the overall cooling capacity requirement which is called which is defined in the terms of tonnage of cooling system can be dropped to a percentage of 30 to 40 percent which is huge, because you have two kinds of impact because of that. One is because of your capacity reduction you has a huge savings on your capex investment that you are going to do plus the maintenance for an argument you going to have a modal building which has 100 tons of air conditioning versus on similar building which is used a high performance glass which is going to have 70 tons of air conditioning. Means, I am going to pay the maintenance cost for 17 tons versus my comparative building or the base case building which is at 100 tons of air conditioning.

So, I have two kinds of coating as I said one is thermal insulation another one is solar control, but the today's modern technology which is ideally the offline or magnetron sputtering coating technology, I can reduce both the solar factor and the U-value by the single set of coatings by having multiple layers of coatings which can bring the even the overall heat coming in to one-third or one-fourth even there are the possibility to play between one-third to one-fourth.

So, in this example itself you can see from the current base case of 4 hundred watts of heat coming in we can reduce the heat coming into 100 watts which is ideally one-fourth. Means you count the 70 percent of the heat load which is driven by envelop can be reduced. So, ideally the capacity can be reduced by 50 percent.

What the energy conservation building coat says? Based on the based on the kind of building your solar factor has to be at 0.25 and v value has to be 3.2 to 3 between the types of building whether it is ECBC to super ECBC to ECBC plus buildings.

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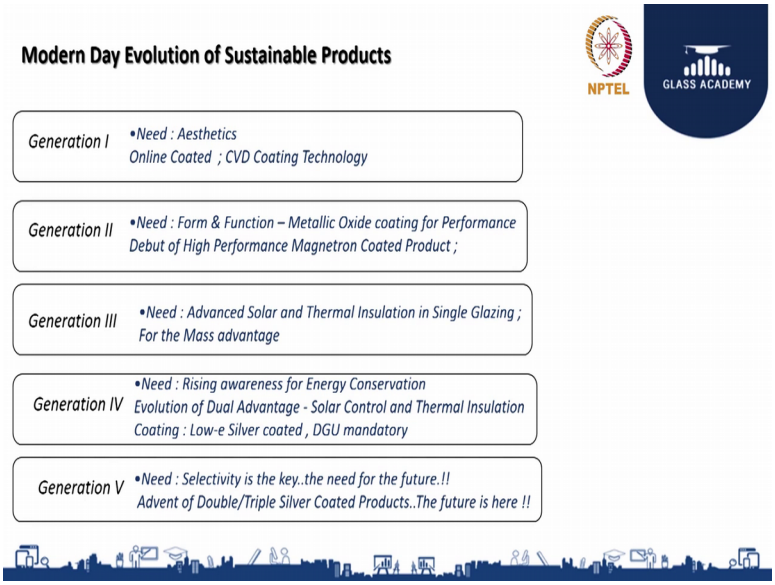

So, how this is all possible? How can I reduce the solar factor? How can I reduce the U-value? So, there is a generations of products been developed based on the market demand, climate demand or the design demand. So, when we when the initial generation of products are started the initial requirement is more on aesthetics, the designer wanted to have the building more visible, more shiny I would say. So, the focus is plus basic energy requirement compared to the clear glass. So, because the clear glass light transmission heat transmission extremely high, so the market is looking for both the aesthetics and the marginal performance whatever it is possible. So, the industry having its technology called online which is called chemical vapour deposition.

So, this technology as a technology has its own restriction to have more layers of coating or to add more kind of, more types of products or more shades of product. So, the market or the entire industry glass manufacturing or the offline coating industry mood from one generation 1 to the generation 1, where the market started requesting for lower refraction products. And which they wanted to look very soothe lighter then which is in that case I need to have more number of layers of coating which is I have a challenge in my old online coating. So, we move to now offline coating technology where I can stack layers of coating onto the surface of the glass which can help you to achieve what the market demands.

Then market wanted to have both the solar control and thermal insulation in a single

layer of coating. Traditionally whenever I used to achieve thermal insulation property I use materials like silver coat which is called the single silver or the double silver or the triple silver layers of coatings.

Moment I use silver we know what going to happen when silver is going to get exposed to the environment it will get oxidized. So, these set of products are supposed to be used only in the double glazing format which is the generation 4 and generation 5, but the performance that this product going to bring in will be extremely high. Means if I take the performance recommend achievement to the generation 1, generation 2 versus the fourth and fifth what we currently using the market the energy of the heat ratios can be reduced to an extent of 50 to 70 percent in the new generation products.

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So, as I said to give you some insight about how this been manufactured the online or the offline; online as I said it is a old or the first coating technology I would say which has a very limited challenges means it has a limited performance or it can have an very limited aesthetics options. Means I can have every one base I can have one product or the performance can be of limited say I can achieve a range of 50 to 60 percent light transmission with again 50 to 60 percent of hat ratios. But due to the development of green building movement in India where we wanted to still reduce the amount of heat coming in, but not the amount of light coming in that case there is a huge challenge.

So, then how to introduce more layers of coating? Online coating technology does not

allow me to coat more than 2 to 3 layers of coating. So, in offline where I can add n number of layers has given a provision to improve the efficiency of the product or I would say superior energy performance is possible in this technology.

Since I have a different provision to add n number of layers of coating with an single base I can develop multiple shades of glass say from clear I can go to clear towards grey, clear towards blue, from clear towards green or clear towards browns or gold. So, any colours is in today's technology it is possible with one clear base which can open up the entire scope for developing projects with more aesthetical appeal and all these products are temper able. Means whatever I produce can go for any kind of value addition, it can go for a tempering or toughening process, it can go for heat strengthening process, it can go for a lamination it can go for a bending, it can even go for a ceramic printing or end with a double glazing format.

So, any of this value addition it is possible in your offline coated products, because currently the durability requirement for whether it is online or offline are very strict and stringent as per the norms. So, it has to pass through a multiple durability process like your erection brush test or your faber test to understand the complete durability process.

So, here I will show you a small video how the coatings are been manufactured because even when I take you to a factory this is all done in a closed environment which is not easy for us to visualise it. So, to for a easy to understand I have done a small I will take you through a small coating video which has a voice over on its own to brief how the coating is done, and what kind of coating is done possible in online, and what kind of coating is done in offline and take you through what is the environmental conditions that how to take through my glass if I have to do the online and I have to offline.

So, welcome back. So, after the coating you might have been a have a clear understanding on how the coating is happening now as a video says your online coating is happens when the glass is getting manufactured whereas, the offline coating is happening after the float glass. So, the basic glass is being manufactured I have to take it to a separate line for a coater. As you been visualising through the video based we have to create such kind of an environmental condition. So, that the target material gets sputter on to the surface of the glass and I can do n number of layers ideally we can do about 18 to 24 layers of coating possibilities in India to achieve a very high performance

requirement of the from the market.

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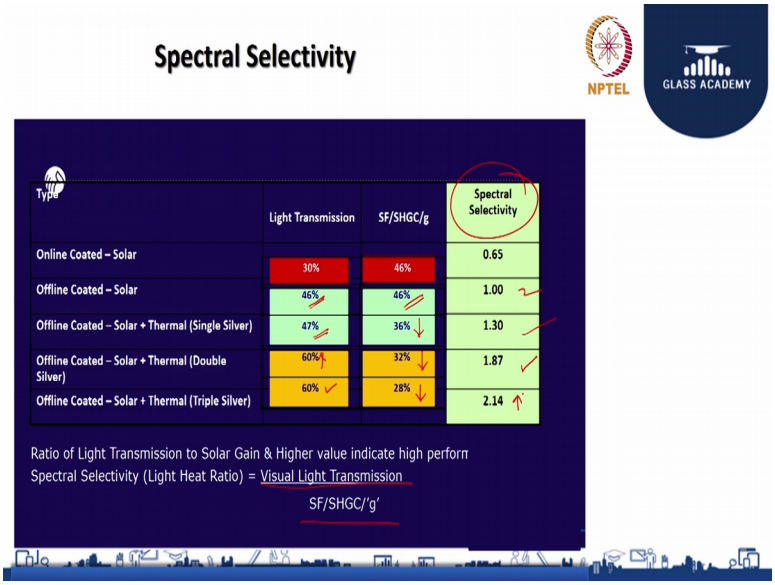

So, what we mean high performance? How can common designer can understand what is been high performance? It is very simple to understand if you can see through this there is a an online coated glass whose light transmission ranges from 30 to 46 percent. There is an very important parameter which you should be able to understand which is called the spectral selectivity, it is nothing but visual light transmission by solar factor visual light transmission by solar factor.

So, when I divide this light transmission 30 by 46 which comes to 0.65 means this glass has spectral selectivity which is 0.65 means the light transmission of the glass is lower than the percentage of heat that is going to transfer into it. So, the challenge in front of the glass manufacturing is how can I improve the selectivity of the product without increasing the heat transmission. So, if you see the next generation of the products where I am able to achieve 46 percent light transmission with 46 percent heat transmission which has brought the selectivity to 1.1, 1 to 1.1, there are the basic generation of the product. Mean what are the light transmission say I can have a product which is at 67 percent light is 67 percent heat, 50 percent light with 50 percent heat, 35 percent light with 35 percent heat or even 20 percent light with 20 percent heat that is called the first generation products.

Then there is a improvement in the product where market was moving towards a silver

base glasses which is ideally a single silver or the double silver products where I still can increase light transmission of the glasses, but not the hear. For example, in this I have retain my light transmission as same, but whereas, I am able to reduce the heat transmission to an extent where it improves the selectivity ratio to 1.3 from 1.

Second, when this it is first single silver; so, the market mood further improvement in the selectivity. So, we introduce a double silver coated glass mean ideally I have two layers of silver as a part of the number of layers of coating where you can see I can increase alight transmission, but still I am reducing the solar factor. So, the selectivity ratio comes to 1.82.

Further the next generation glasses which we started producing in India where still you can retain the same light transmission and further reduce a U-value solar factor. So, the selectivity has gone to is one of the highest in the world which is about to 2.1. So, this kind of products are called high performance glazing where I do not allow more heat coming in, but still I can allow more light coming in. Again the percentage of light requirement has to be designed based on your building requirement.

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So, third important parameter after safety, sustainability which is the aesthetics. So, what I can do for aesthetics? As an dreamer, as an architect, as a designer you will have a particular colour during the design phase of your building. But when we have a safety and performance, which can be visualised, which can be tested, which can be understood

in various formats are do are we making a wise decision in selecting glass.

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When it comes to aesthetics it becomes a challenge. What traditionally we will do? We will go for a mock-up as you see here you can have a different mock-ups stand. But what is the challenge in the mock-up? The mock up is not actually making you to visualise the real condition the building going to come in reality because when you do mock-up the entire environment the other environment of your building is kept opened and you will be having a mock-up at a certain height say second and third floor. So, the way you see the glass, the way you see through the glass you sometimes the lower higher light transmission glasses you will be seeing through the environment of the building through the glass and that gives a improper notation on the light in the colour of the glass. And the mock-up size are quite small. You can do a mock-up of say around 6 feet to 4 feet or 1800 to 1200 sizes.

When compared to the size of the building the mock-up sizes are small, and the product looks very lighter because environments are open. And its very costly process because you may not be able to select with 1 or 2, you might have to try with at least 4 to 5 options then you have to try with a different manufacturer sheets. So, it will increase the overall cost of your building by doing a mock-up, ok. Even by doing all this spending money even though it is an costly offer is it going to answer your question do my design aesthetics is matching with my with the building when it is going to get completed. No,

we will say no, because as I said the environment conditions are different when the building is completely glazed towards end.

So, how can we do it? Traditionally you might be doing a rendering, but the challenge in rendering is when you do a rendering you may render the product or you may render the building with the colour that you like it. But when it comes to the glass because of the transparency property or because of the reflection property the way the same colour looks is it will be a different.

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So, as a, so what is the wave forward option? There are no physico realistic rendering solutions available with the manufacturers where you can see the picture in the left hand side, where ideally you can try a building with the product that you wanted to see against what this same kind of a building in artistic to view you might be in rendering.

But in reality you cannot get the picture what you seeing right because the colours used in the rendering or comparatively not realistic. Whereas, in the left hand side when I do a physico realistic I am trying to imitate as real as the environmental conditions the lighting conditions or the source condition recall and the glass properties from the glass ideally the measurements been done for the product and the same measurement been integrated into the software where the software renders it the actual product and then it gives you what is going to be the colour. This can be developed with multiple conditions, like whether you wanted to see the building in a cloudy day, sunny day, longer view; I

mean long shot view or the very closer view of the building.

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So, this has a tool there is a tool called glass pro which is available where you can do the same process in a very simple steps. To just to make a first impact on the colour you can goes to the kubus where you can try with the different colours or the tinted options available with the different high performance products and you can select 3 or 4 options from that. To further to make you more clarity the selected option can be put into an urban scene where it is called a template building I would say where you can put the selected products and you can see how this building or how the products going to look in a massive scale manner.

But still if you are not able to understand what will this products will happen along with my other building materials or how my design going to match with the colour of the glass I have selected there is an option 3 available where you can do it on your real building. So, we will take the basic drawings, modelled drawings where the products are been product values have been integrated and then the rendering is being done and the final output can be presented to you.

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