Glass in buildings : Design and Application
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Lecture - 69
The Role of Windows in Building Design

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Let us look at some of the design considerations when we design a window. So, when we started this in 2003 and again I will come back to this, my experience is only from this company about 15 years. Windows I never thought was supposed to be designed. It is just simple 4 stiles used to be somehow join together, put a glass in and the window is done. My dear friend it is not that easy and it is not very difficult as well. So, there basically 3 parameters on which we need to look at when we design a windows, it is very simple to understand.

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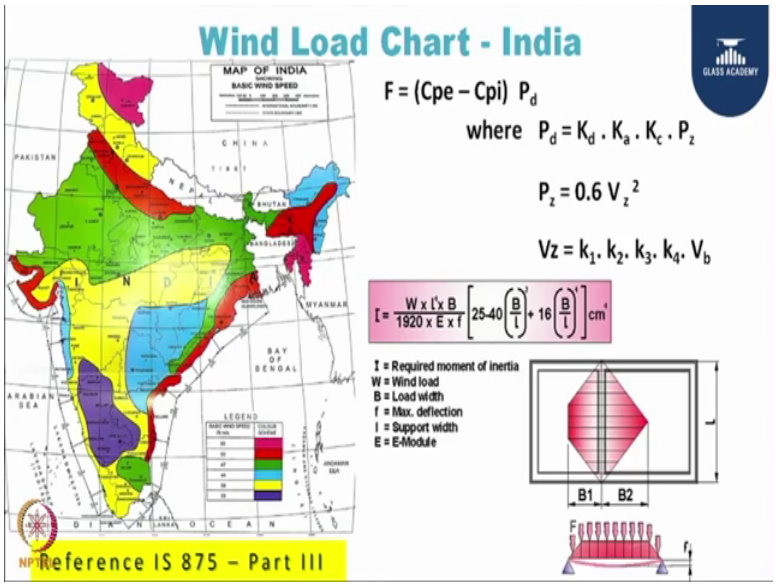

The first one is the wind load, I am sure most of you might be aware that all buildings which are constructed follow a norms which is IS 875 code or NBC 2016. So, you have those wind load charts already available. Since, the building perform to those wind load and window being part on the facade of a windows to need to perform on those. There has been a recent change in the 2015, where the wind loads have been revised and there has been a factor added into this call K a K b K c which is basically related to cyclone, area factors and so on so forth.

So, whatever you are seeing on this is screen is a very very simplistic form of IS 875, where you can actually work out what is wind load working in your city or in the building which might be multi storey. I am sure you need to also understand that the wind loads are defined for basic height of 10 meters and we call them as a basic wind speed. As we move up on the building from the 10 meters to 20 or 50 or 100, the wind speeds or the wind loads also change.

And, to calculate those wind loads you have to go through those standards and understand various factors like k 1 k 2 k 3 k 4 which needs to be factored in and you can actually get the wind loads. There is one more factor which we need to understand in the standard is Cpe and Cpi coefficient pressure coefficient internal and external, which is something you miss many a times. And, that is one missed to consider while designing

the wind load for a particular city. To give you a perspective how the wind load varies in a city, this is the next line.

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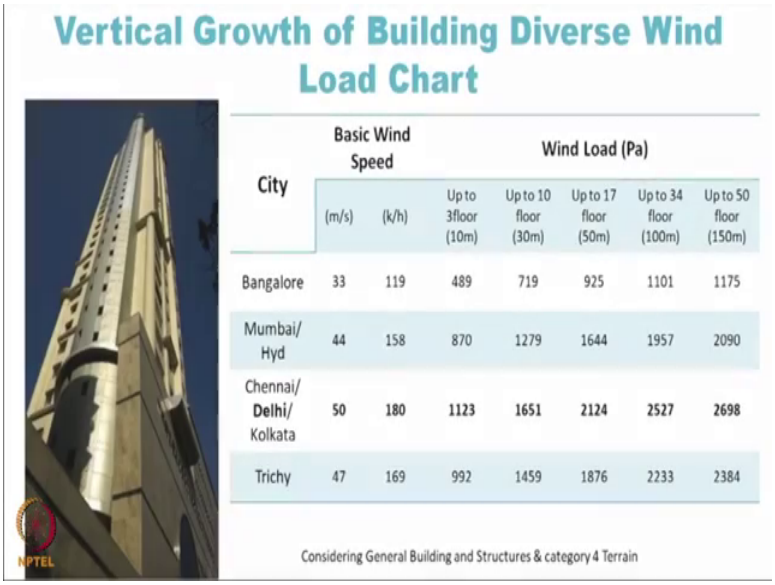

And, if you look at the basic wind speed which is the second column ranges from 33 to 50 meter per second. And, as you go up let us say if you look at the 3rd floor which is 10 meter or 10th floor which is 30 meter or 50th floor which is 150 meters. For a place like delhi, if you can see the wind load changes from 1100 Pascals to 2700 Pascals and that is what we need to understand. If we calculate the wind load rest of the things becomes very simple. We will see how to use this in our window designing or window calculation in the furthers slides. But, this is a first parameter which we need to understand that all windows which we design need to pass the wind load.

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These are sum of the examples which I would like to show you like for example, we had Hud Hud cyclone and we had Vardha cyclone.

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You could have seen some of these viral videos where the facades where dismantle with the high wind speeds and they were all flowing in the air. However, if a window or a facade is well designed, considering those wind loads we have been talking about I do not see a chance of this happening. And, why I say this is because some of our windows

were in this region where we have seen this type of tornadoes coming in or the cyclones coming in. And, we did not have absolutely any problem on those windows.

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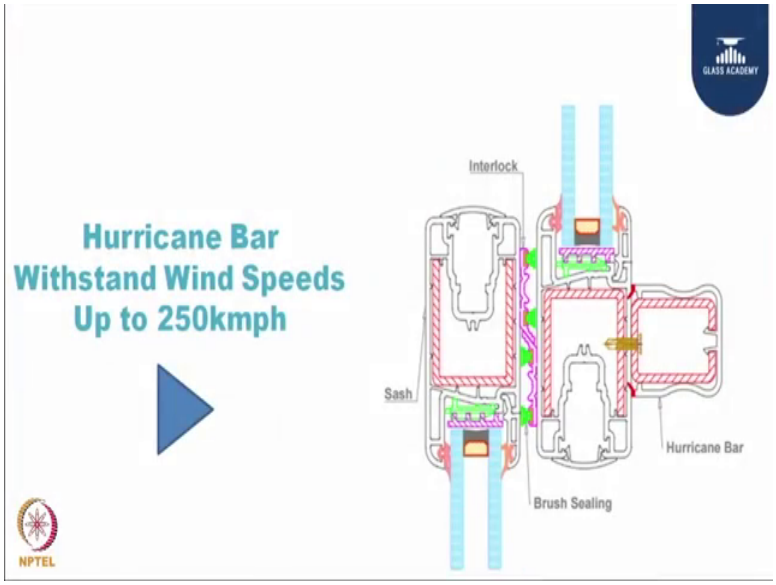

Just to demonstrate you how we achieve this strengths, this is a typical cross section of a sliding system. And, if you can see here that the red has section is the steel member which is supported with the hurricane bar. And, I will play this video just to demonstrate you how this some of these are really working in the industry so far.

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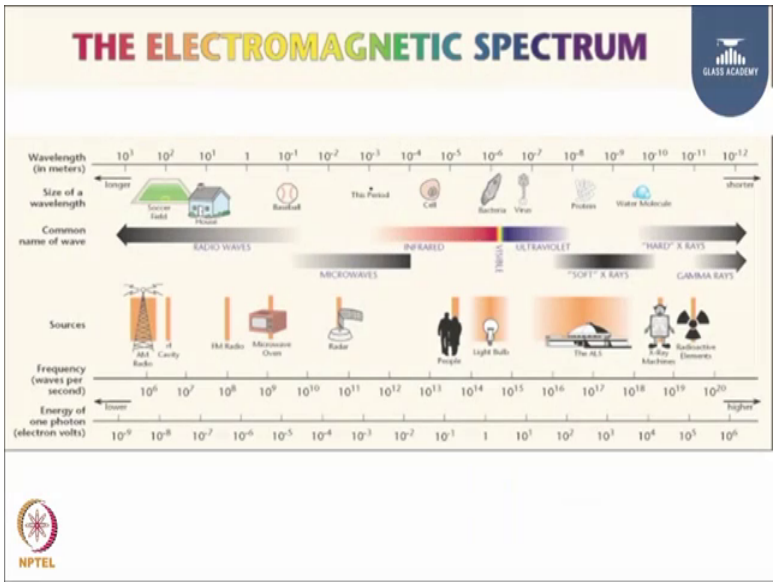

The second important design parameter I like to speak about is the UV and before we talk about UV, I am sure you are aware about the electromagnetic spectrum. And, in the electromagnetic spectrum, the one which is most important for us to discuss here today is between the ultraviolet and the infrared.

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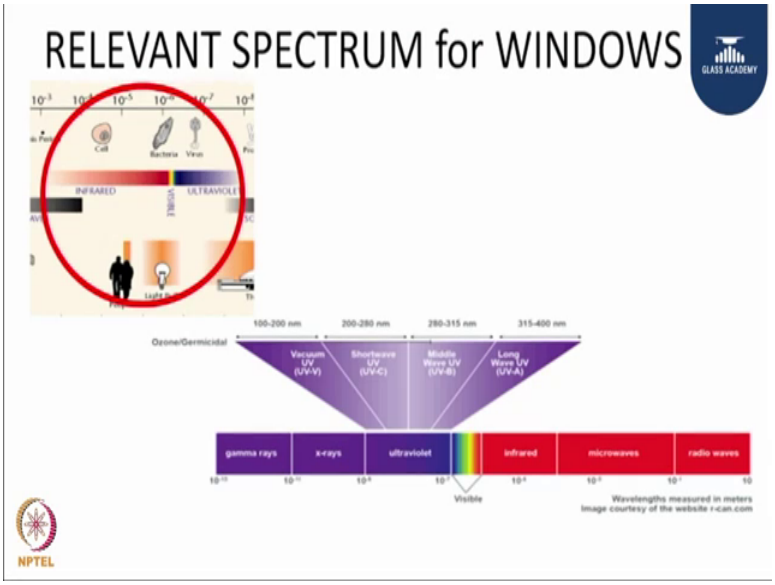

Some of them are detrimental for the surface of it, infrared gives the heat and the glass visibility comes from the lights. So, the one which is close to this 3 segment is what is important for us. As we discuss about this ultraviolet, let me also give you certain examples how it works for us.

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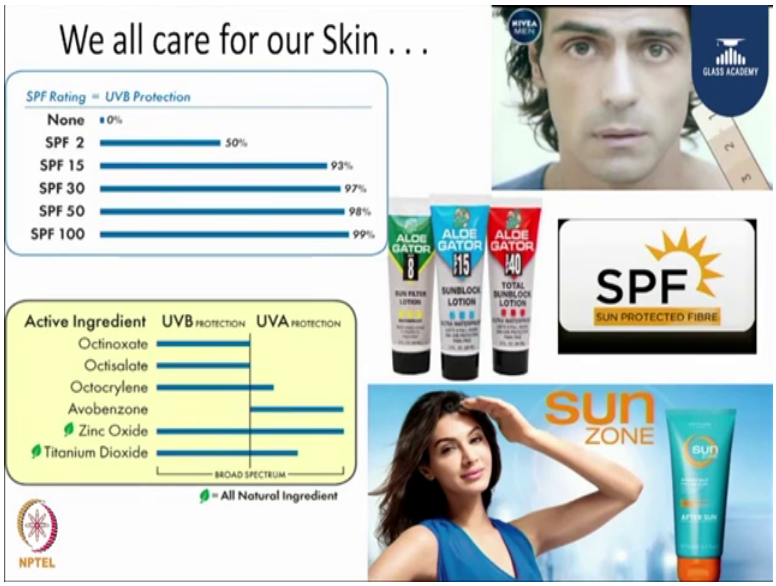

Ultraviolet light is not only detrimental for PVC, but it is for any plastics and this is because the wavelength is such that actually interferes with the polymer chain and eventually disintegrates or degrades the plastic. However, the slide which is on the screen it is more relevant to give you a correlation with they creams we use in India or tropical climate or anywhere for sun protection. If you look in this slide there are 2 types of UV, UVA and UVB which are the concern areas for all of us.

And, to prevent those there are 2 materials which are used like zinc oxide and titanium dioxide; in helping us reduce the UV impact. And this is done by something called SPF. So, I am sure if you are using UV cream you will be able to understand SPF of 50 or SPF of 30 has a better protection then SPF of 2 or 15. Similarly in plastics also, it is a titanium dioxide which is used to prevent it from the UV degradation, it is the same composition.

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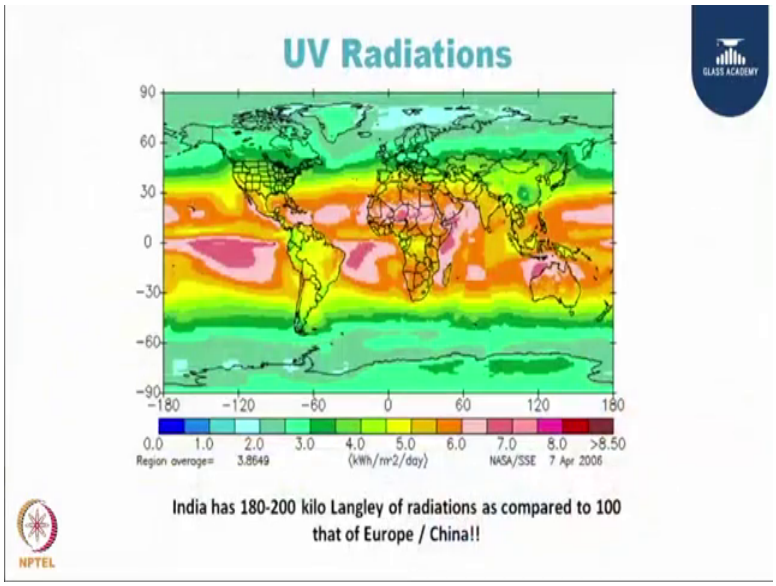

And, by doing so you are able to prevent the high UV radiations which you can see in this global map. If you look at the UV radiation in India versus Europe or China the green area, India would be double that of Europe or China. Therefore, the formulation has to be one which can sustain those type of UV radiations. Now, how do you do that is by using the titanium dioxide as we discussed in the formulation part of it. And, if it is not done the initial way to figure out is the yellowness of the window of course, there are many other reasons. But, mostly the UV impacts the first stage of the degradation is by the yellow in the windows and eventually it may disintegrate, it may breakaway as well.

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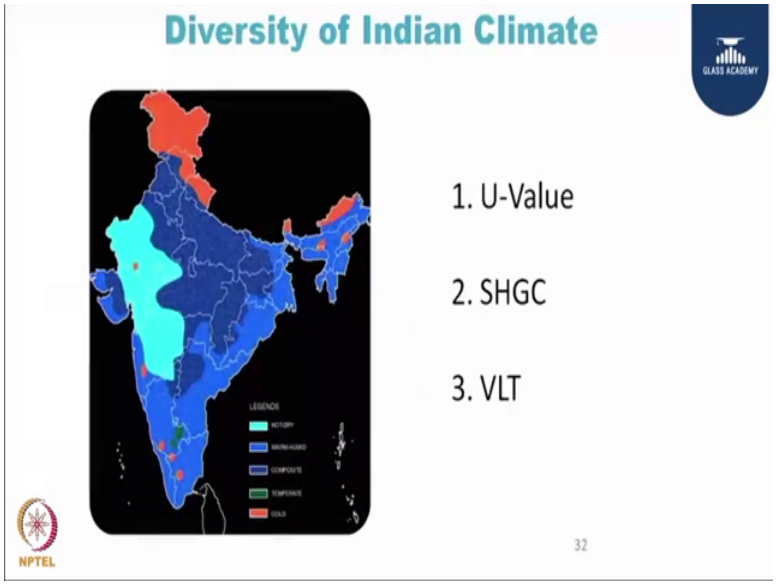

The third criteria we are going to discuss about the climatic conditions. So, India is basically divided into 5 climatic zones and based on this climatic zones one needs to have a certain parameter, which needs to be meet like U-Value, SHGC, VLT. These 3 parameters needs to be basically looked from the perspective of these 5 zones and it is specified in the green building documents from either IGBC or GRIHA.

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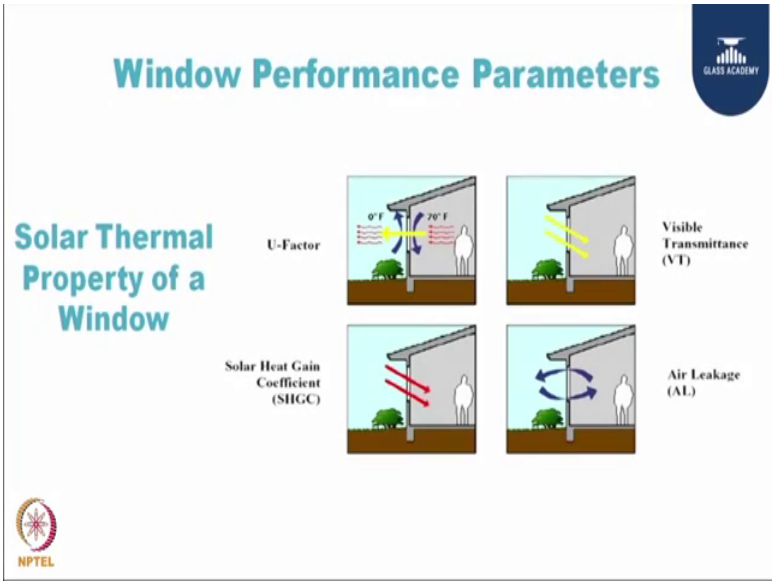

So, once we have done this designing of windows with 3 parameters, how do you know that your windows have performed to the levels or how do you measure the performance of these windows. So, internationally there are 4 parameters which are used for measuring window performance. We talk as U-value, SHGC, VLT and Air Leakage, using this 4 parameters you can define what is the performance of windows. But, nowadays there are couple of more parameters being discussed not as of formally made, but they are been discussed to add like for example, we talked about sound insulation or dust insulation.

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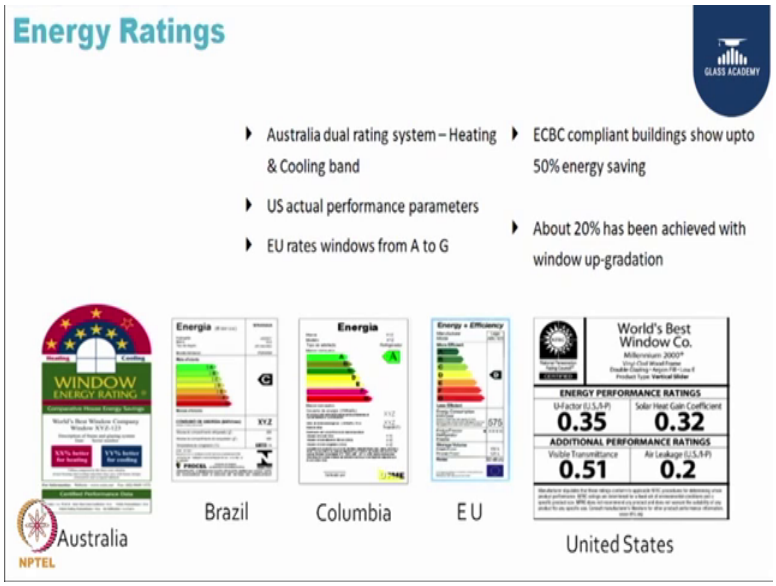

These parameters which we are talking about some of the countries have already started, already are using rather for window rating. For example, in Australia they have heat and cool star rating, U.S has a star rating on this 4 parameters, U.K. has a star rating with nomenclature of A B C D E F G H. So, this is something which is going to come in India may not be in the next 1 or 2 years, but definitely in the coming few years.

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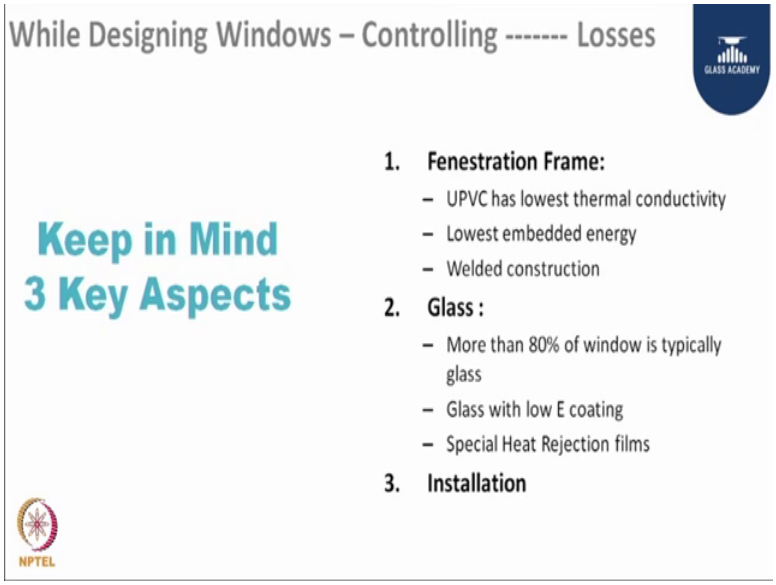

When you design windows there are 3 things we need to keep in our mind, specially when you talking about energy performance. The first is about the frame, what frame do

you use? Whether it is rod, whether it is steel, aluminium, UPVC. And, while selecting it I think you need to look at the lowest embedded energy in any of the frame material and which has the highest insulation. The second most important part in a window is the glass, as more than 80 percent of the window is glass; choosing the right glass at the right glass configuration is most important thing in controlling the energy losses.

And, the third thing we call it as insulation though most of the places we do not talk about insulation, because you might have a very good window designed, good material selected for frame and glass it is manufacture in world class factories. But, if you do not install it correctly, do not seal it between the (Refer Time: 10:43) and the window, ultimately whatever you wanted to save leaks through those gaps. So, installation place a very very vital role in designing a window and for controlling any type of losses or enhancing the insulation characteristics.

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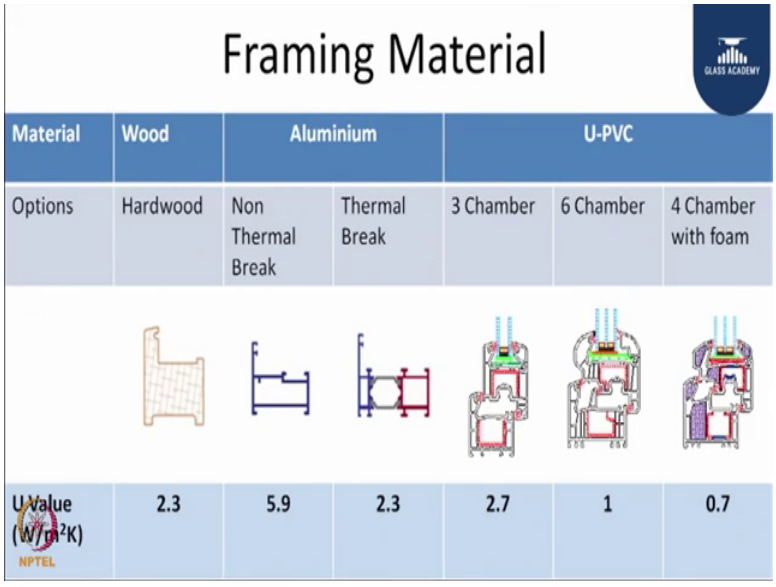

So, to give you an example about framing material for example, if you take a note you have a U-value of 2.3. You take an aluminium system and will have around 6 or non thermal break or if it is a thermal break it may have almost same like the hardwood which is 2.3. A 3 chamber PVC might be around 2.7. However, if you go for 4 5 6 4 chamber with foam you can go below 1 as well. So, a very very low U-value can be achieved in PVC system with the various configuration of multi chamber and foam

insulation. And, this is a trend which has been look more in Europe rather than India, but just to give a perspective of different types of framing used in the industry.

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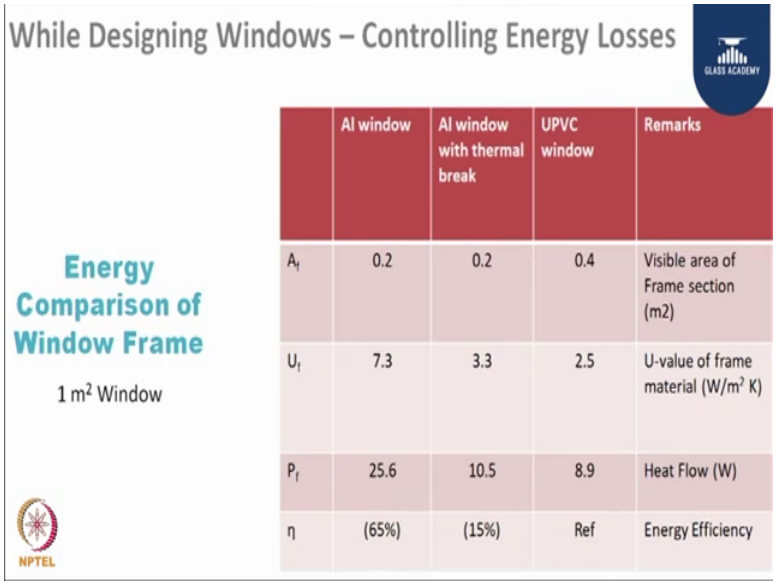

	Al window	Al window with thermal break	UPVC window	Remarks
A_f	0.2	0.2	0.4	Visible area of Frame section (m2)
U_f	7.3	3.3	2.5	U-value of frame material (W/m^2 K)
P_f	25.6	10.5	8.9	Heat Flow (W)
η	(65%)	(15%)	Ref	Energy Efficiency

This slides talks about if you want to compare the energy in performance of a frame material which is for a, in this case we considered UPVC window frame as a reference 3 chamber system was an aluminium window with a thermal break and aluminium window; you will find that thermal brake system may be almost at par with UPVC. However, the normal aluminium which is without thermal break is 65 percent less efficient.

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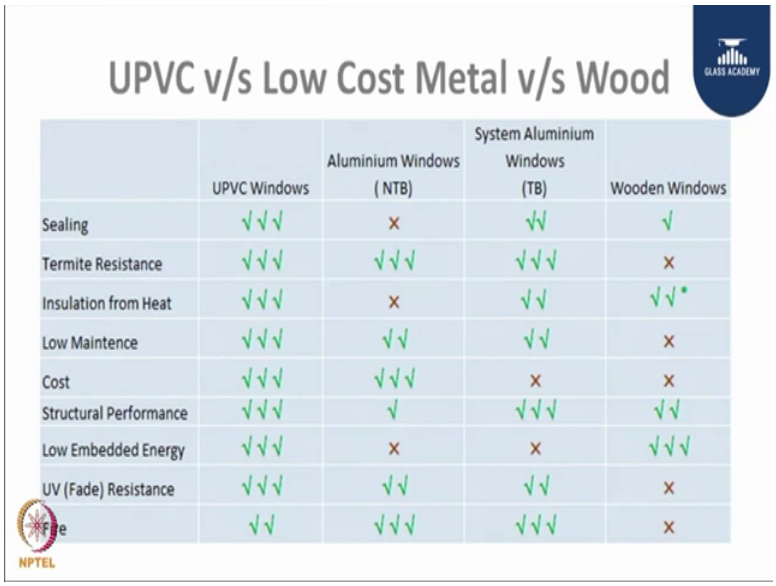

	UPVC Windows	Aluminium Windows (NTB)	System Aluminium Windows (TB)	Wooden Windows
Sealing	√√√	×	√√	√
Termite Resistance	√√√	√√√	√√√	×
Insulation from Heat	√√√	×	√√	√√*
Low Maintence	√√√	√√	√√	×
Cost	√√√	√√√	×	×
Structural Performance	√√√	√	√√√	√√
Low Embedded Energy	√√√	×	×	√√√
UV (Fade) Resistance	√√√	√√	√√	×
Fire	√√	√√√	√√√	×

Comparing different types of framing material in UPVC you have a double sealing system between the frame and the sas, sas on the glass. In aluminium windows you have a design gasket group, but tactically there is no gasket in the installation and therefore, you do not have any installation. System aluminium windows do have a design as well as a there are some quality controls, we have a much better insulation. However, UPVC windows itself has a insulating characteristics which gives you betters mechanism then rest of the other 3.

In this slide there are various positives and various negatives for different systems. One needs to choose carefully the framing material which one is going to use. Of course, wood is something which is not a predomly available in the market and it is of course, the natural resources people like to prevent from being consumed. And therefore, the alternative with low embedded energy if you talk about is one of the biggest alternative is UPVC window so far.

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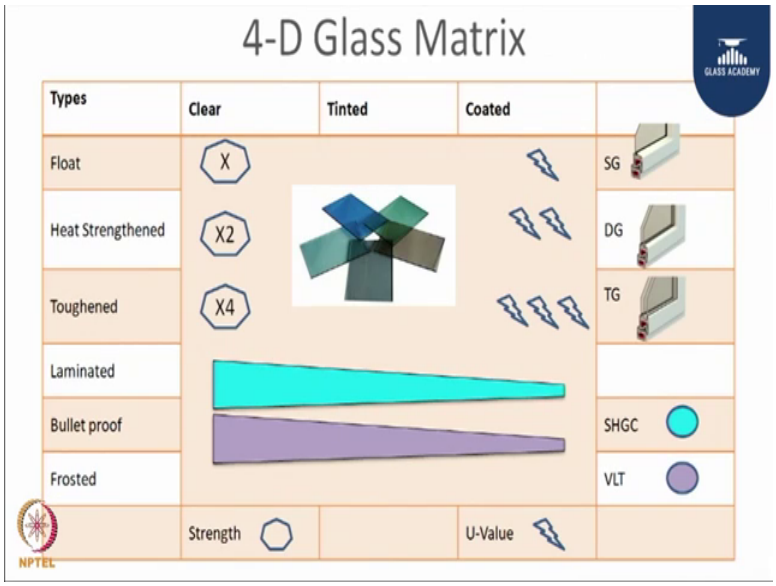

On the glass site of course, there would be lot of information on the glass, but I have tried to put this 4-D glass matrix just to give you a snapshot about how to choose a different types of glass along with the framing material. So, on the left hand side you have float glass, it can be heat strengthened or toughened. So, your strength becomes double or 4 times. You can have then a laminated glass or a bulletproof glass or you can have a process of frosting. If you look at the on the right hand side which talks about single, double and triple glazing.

So, as you move from single to triple glazing you are able to enhance reduce the U-value. So, your U-value actually goes down as you move from SG to TG. And, the bottom right corner if you look at the SHGC and VLT as you move from clear tinted and coated glass, your SHGC drops in and at the same time your VLT also drops in. So, somewhere between the strength U-value and the VLT you need to choose different types of glass, based on the need of the application.

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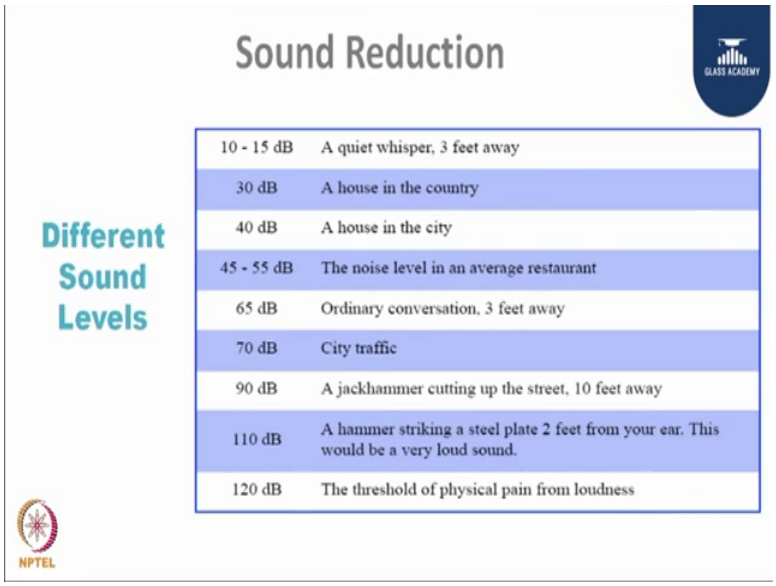

We talk about sound as one of the key perspective about window and we have been looking at this is one of the key drivers in the window industry. When we talk about sound we all must be aware that anything above 80 decibel, if it is on a continuous exposure it impacts your hearing process. And therefore, the designers are looking at ways and means of designing window which can actually cut down the sound as much as possible.

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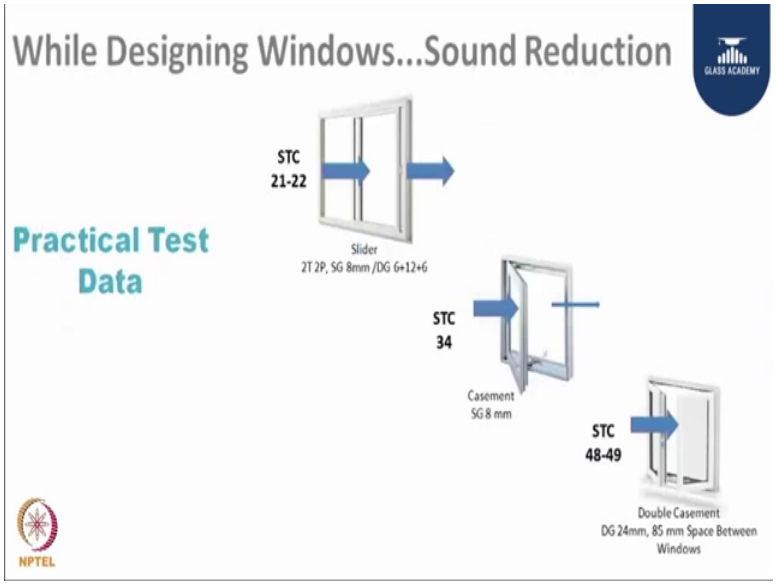

Now, when we talk about sound as insulation parameter for the sound or the noise, the easiest way to compare between different material is the sound transmission glass. So, whatever building material is being used in the construction they are all classified as a sound transmission glass. And, in window when we talk about various types of configuration of window whether it is sliding, casement or double window; the STC can be evaluated. So, as a composite product when you have the windows which is installed in an aperture and with different types of glass the slider has lowest STC which is around 21 to 22.

To give you an analogy a brick wall typically will have a STC of 50 which means, the slider windows are almost half that of a wall; that means, it is a weak point from where the sound can come into your house. But, the moment you move into a casement window which is open able with the multipoint locking and double sealing, the STC goes up to 34. And therefore, it is at least I would say one-third poor than the wall, but at least it is much better than the slider.

However, nowadays double window system is something which has cashed up specially on highways, busy highways where lot of trucks or you have a aeroplane noise; double windows are installed which can go as high as 48 to 49 STC which is very very close to the wall performance. So, while designing windows this is the 4 parameter which one needs to look at for reduction of sound.

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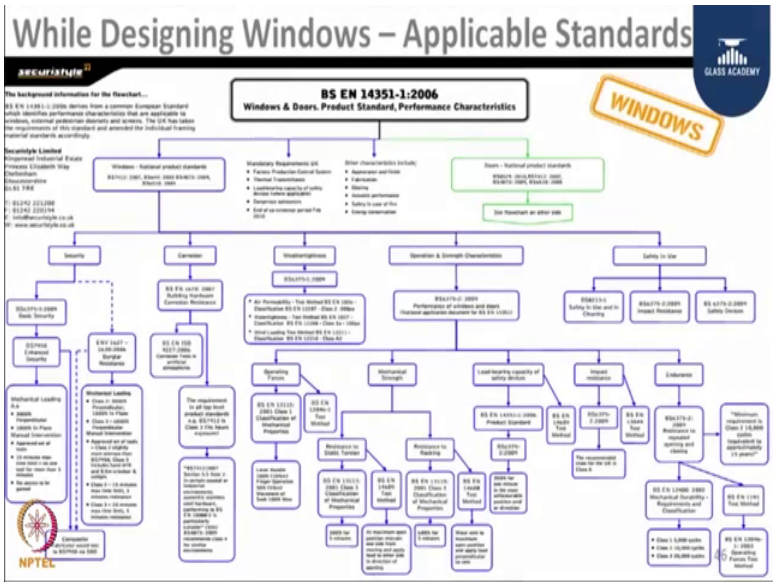

We talked about window performances, problems of window, how to design window, what parameters to look at windows. What are the practical aspects of frame materials, glass, how to select windows between slider and casement or double windows for sound. There is another part of it that window also needs to be tested, and in India though we do not have much of standards applicable for window industry. But, in the international arena if look at there are huge range of the standards for testing window, framing materials or applications or opening closing pressures, wind load performance and so on so forth. I am sure India will also catch up on this. At Fenesta we do lot of test which are based on the European guidelines, but modified to the Indian context, that is it.

Thank you.