Glass in buildings Design and Application
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Lecture - 33
Achieving Acoustics through Glass

Today's session, we will take you through how to achieve or how to understand acoustics when you use glass as a barrier. Because, glass being widely used both for interior application and exterior application. So, it is very important to understand basic acoustics the definition of acoustic and noise.

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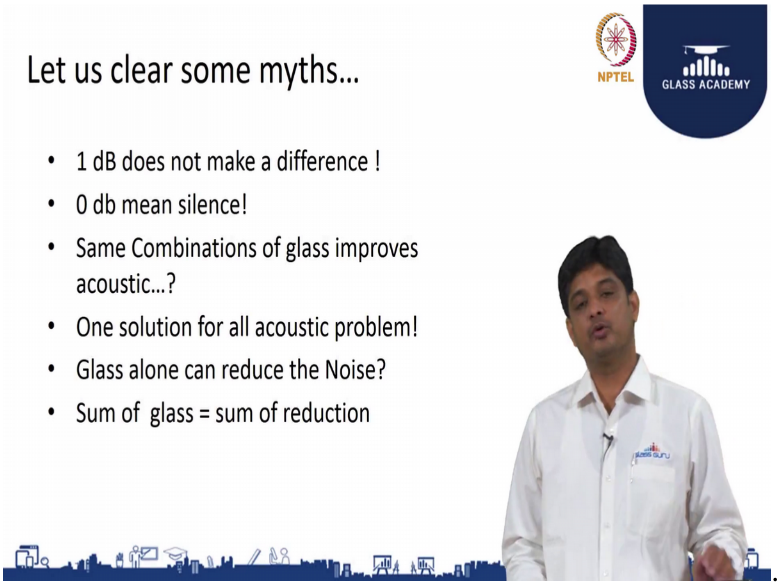

Before getting into generally moment we enter into glass and it acoustics, we always have myths I would say few myths are listed here. We believe that there is a reduction of 1 dB does make any difference.

And we always believe that only 0 means it silence, and if I use same combination of glasses we believe it improves better acoustics or in improves the performance, and always we believe one based on one particular combination and we achieve a particular value, that cannot be used in any other location because of the source value is different. It means the one solution cannot be constant for any acoustic problem because its source can be different, and in a glass you have a glass and framing material. So, glass alone cannot achieve any acoustics.

Whatever the overall acoustic we need to achieve, it has to be through the glass and the system. Some of glass means multi layer of same thickness of glass, it does not mean the reduction that possible by one individual glass versus some of the same thickness of glass is going to be in the same ratio of sum of.

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What is noise? Sound that is loud unpleasant unexpected, unwanted or undesired that is called noise. What is called sound? Vibrations that is are transmitted through an elastic solid or liquid or a gas, with a frequency of approximate range 20 to 20,000 hertz and capable of being detected by human organs of hearing. So, why decibel is a very important question to be understood?

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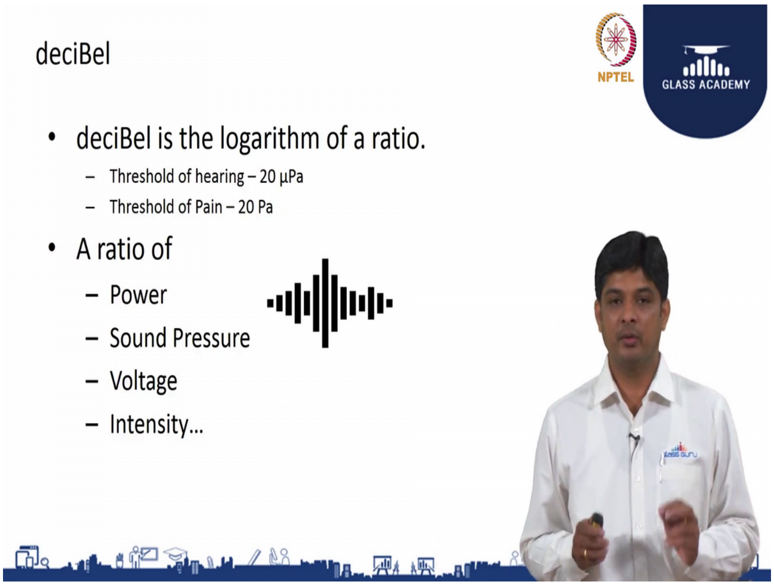

Because our human ear is extremely and it is an amazing a system it has. Because human ear can understand the threshold of hearing for an human hear is about 20 micro Pascal whereas, the threshold of pain it is 20 Pascal. If you convert it to frequency 20 Pascal is approximately at 1000 hertz frequency. What is called decibel? It is a combination or it is a ratio of a power the frequency that is going to hit, the pressure, the intensity and the voltage. The combination of all or the ratio of all it is been measured called and by an individual numbered called decibel.

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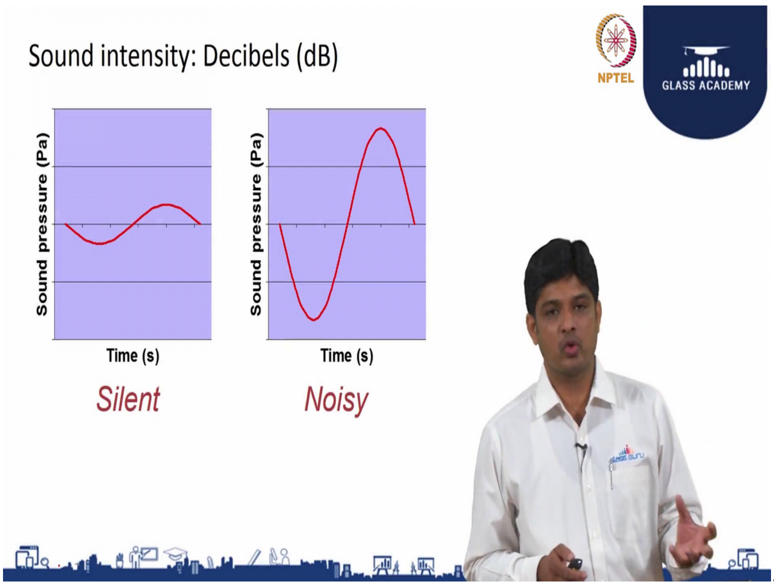

So, when you have a source, source you have a huge range of intensity which is the loudness and there is an medium it going to transfer, and then there is an pitch it is called a frequency pitch, there is a low frequency and there is an high frequency pitches which is going to reach you. So, these three combination is going to decide whether it is going to be a pleasant, noise or it going to be a disturbance. So, the same I said. So, there is a frequency difference, when you see the silent versus noisy, the way it going to reach you with the intensity it is going to be an impact on your ears.

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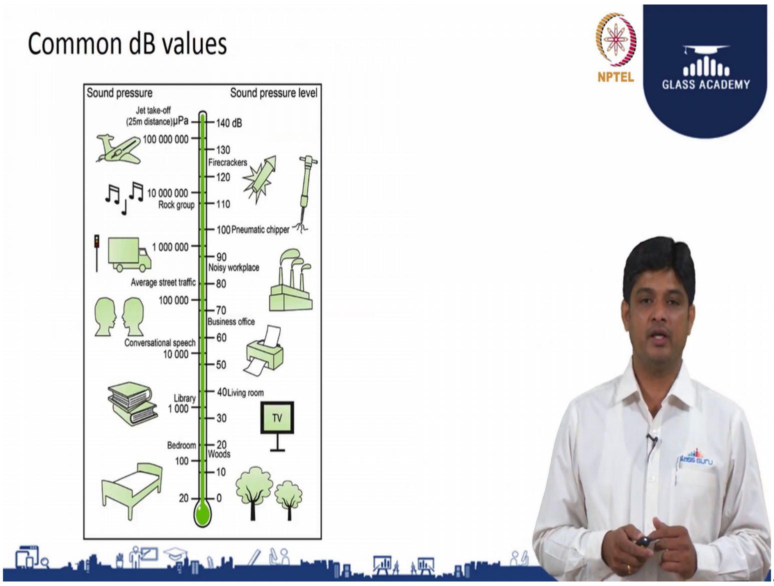

Commonly what you can, how you how much you can able to withstand or where you can have what kind of level of noises? Anywhere in an living space you can be at less than 40 dB, it includes your living and sleeping. So, sleeping usually suggested to be less than 35 dB, where an working station or business offices it can be even up to 60 to 65 dB.

Anything more than 80 dB you call it as an noisy environment and anything more than 100 plus, it will be a really disturbance and more than 120, it became a unbearable. That is where if you connected to my myth even a 1 dB reduction at this scale it is going to be a huge reduction because, the impact of a noise after 40 to 45 dB the impact of noise at every 1 dB the impact will be double; so, which you cannot bear. So, the level what you can be bearable versus non bearable is hardly 1 dB difference.

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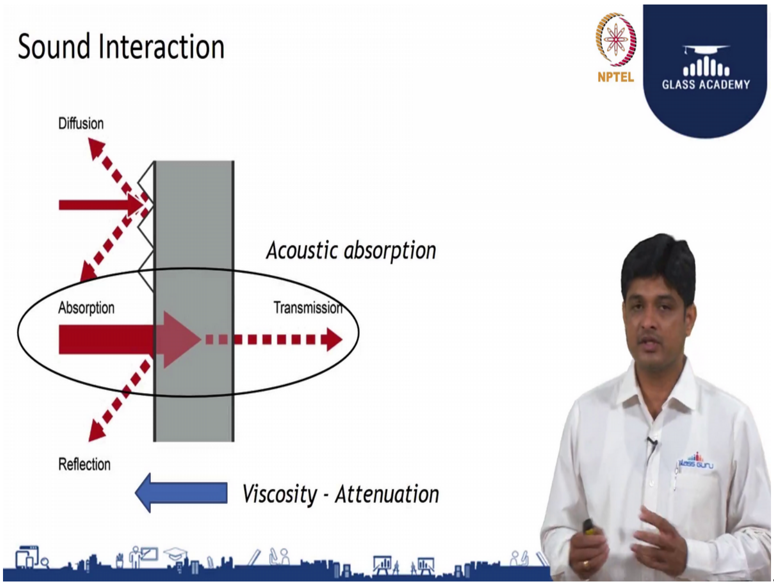

So, how the sound interacts? The sound interacts when there is an source going to hit an element or an object or an layer. So, there is a part it is going to get transferred, part is going to reflected, part it going to get diffused which is because of the surface of your the medium it going to hit and there can be this all can happen based on the mass of your material, because mass again it relates to the frequency filtration process.

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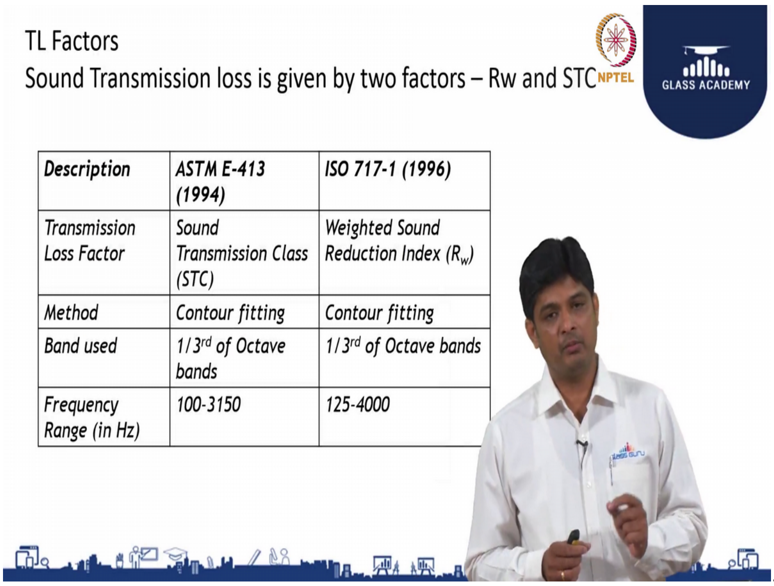

So, when you come to glass and acoustics, you have to be very clearer to important factors which is called your R w and STC. STC is called sound transmission class whereas, R w is called weighted sound reduction index. In both when you when you wanted to measure when you want to plot both has very similar methodology, only the basic difference is the frequency range and the contour standard contour graph, which we are going to plot there is a difference be in that. Whereas, when you measure STC you measure as per ASTME 413, when you go to R w you measure as per ISO 717 plus when the frequency range is for STC is at around 100 to 3150 whereas, for R w it is about 125 to 4000 hertz

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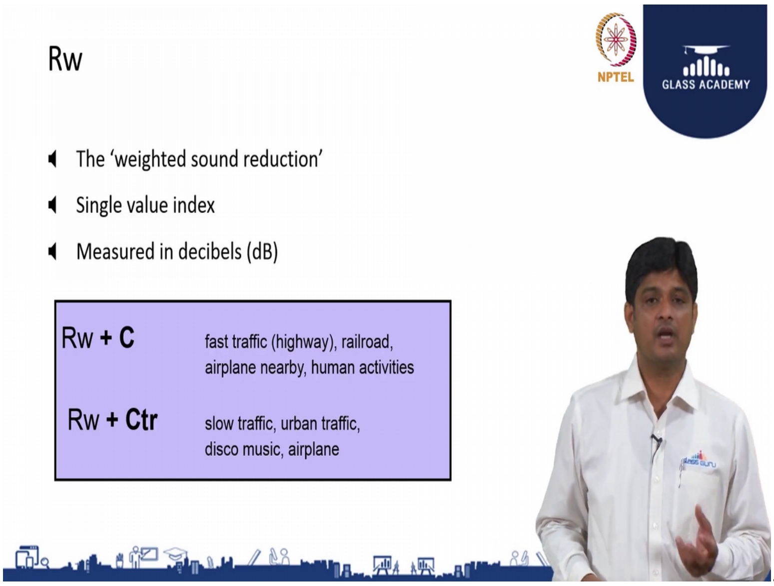

What is called R w? It is an weighted sound reduction, it is simple and single value index which is measured in decibel as we understood, whatever we receive on from the source to the observer side we measure it with the single value index called decibel. In case of specific to a building when you have a when you have a value whether it is R w or even an STC, specifically in case of an R w we need to be very careful based on the type of a source; based on the type of the source you have to understand or you have to have an adjustment factors, which is nothing the which is nothing, but R w C or R w Ctr.

C which is it is an adjustment factor, which relates to very fast high traffic railways or airplane, where the pitch is very high and then whereas, in a case of traffic which is a slow traffic the vehicle movement general public disturbances or very different musics which comes under CTR.

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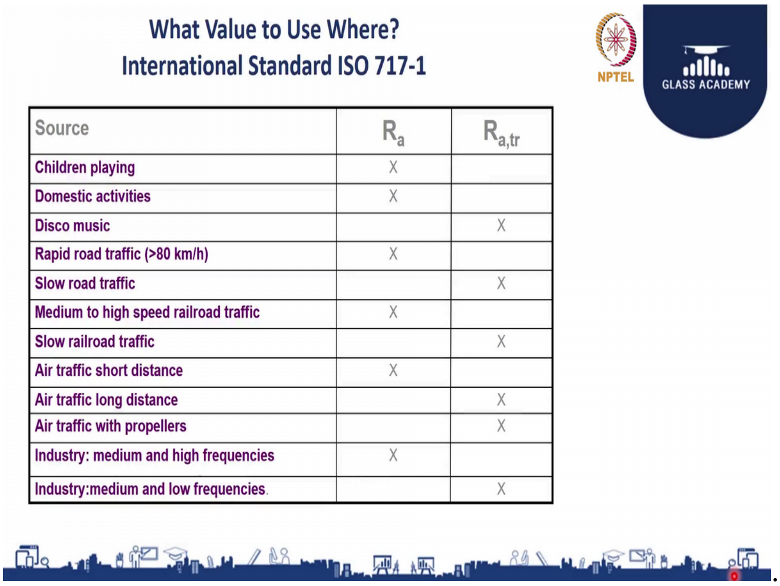

Source	R_a	$R_{a,tr}$
Children playing	X	
Domestic activities	X	
Disco music		X
Rapid road traffic (>80 km/h)	X	
Slow road traffic		X
Medium to high speed railroad traffic	X	
Slow railroad traffic		X
Air traffic short distance	X	
Air traffic long distance		X
Air traffic with propellers		X
Industry: medium and high frequencies	X	
Industry:medium and low frequencies.		X

To make it clear say for example if you take ISO 717, it clearly gives a table what adjustment factor you have to use to achieve your R w inside a building, based on the type of a source. Say for example, if a children is playing outside, you have to take your R w value and you have to apply your R a tr adjustment factor to it.

So, that will be your final achievable or possible noise inside your building, which going to come from the source. So, based on the different sources whether it is from children domestic whether it is a disco tec music or a different types of road traffic, whether it is slow or high or again it is road or airways or again in a industry, what kind of disturbance that comes from industry. So, there very important understand there is something called R w, and there is adjustment factor called Ra and R a tr, which is very specific to internal application.

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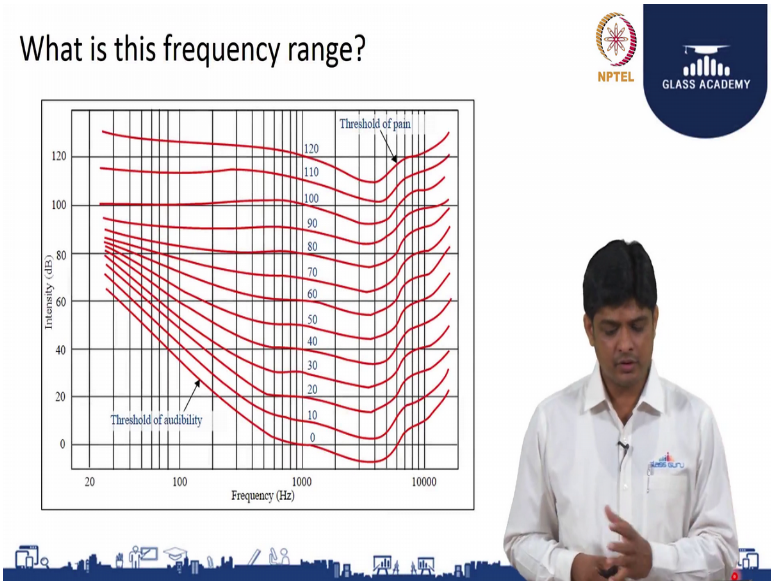

So, this is to show you how the frequency ranges based on different STCS when from 0 to 110 120 whether it is STC or R w this is how your frequency bandwidth will be there. To understand more if you take the lower STC ranges say less than 30, your frequency that lower frequency the intensities are high the intensities are very high in the range of 50 to 60.

Whereas the frequencies slow so, that that the disturbance the noise which is going to enter or which is going to be effecting you as an individual will be very less the impact is very less. Moment you go above 70 and 80, you can see the intensity and the frequency impact are more or less same and which is going to really hit you in your psychological impact.

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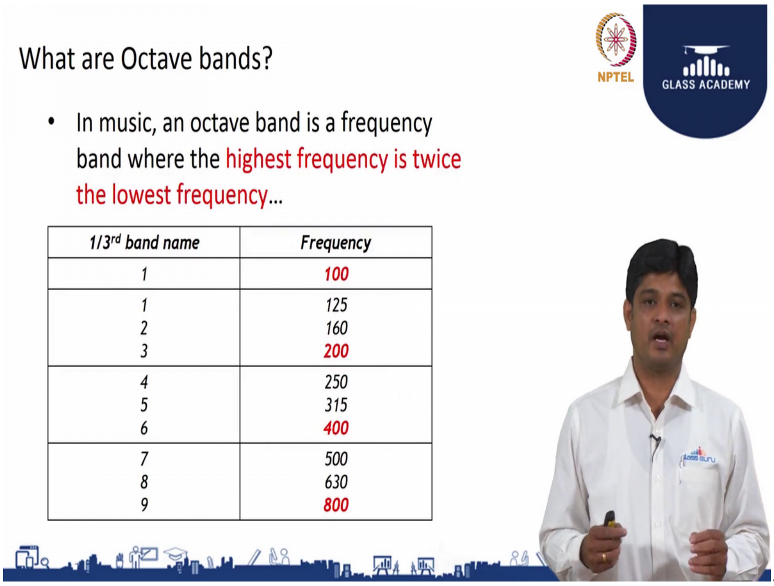

To derive these graphs first we need to understand, what is called octave bands. Octave bands is nothing, but we need to understand the one third values, you have to plot your graph or you have to measure your impact of any barrier and you have to plot it in this octave band width, which is nothing, but the highest frequency is twice of the lowest frequency. So, this is given in an ISO. So, based on it whenever you measure any material, you have to plot your graphs as per your one third band bandwidth then you align it to your standard contour graph so, that to understand your STC or R w.

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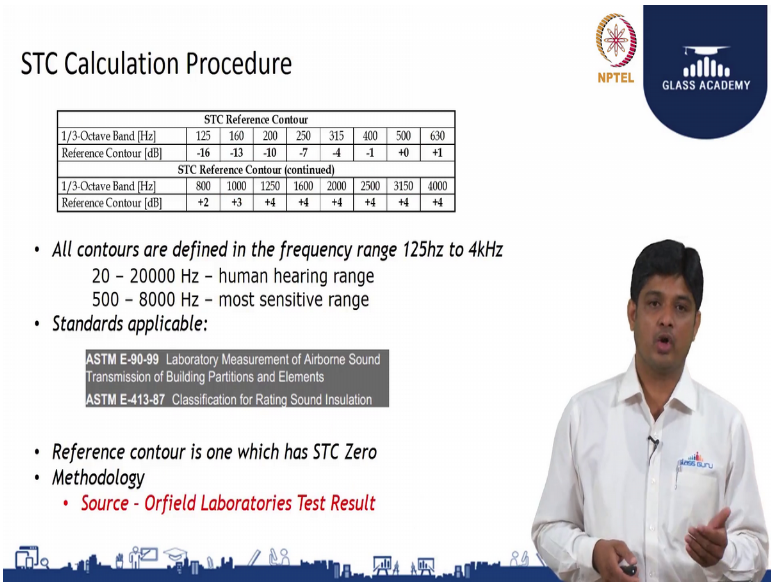

I will take you through how to calculate after you measured something, because measurement usually cannot be done at a at a regular standard locations you need a laboratory setup condition or you need a very specific setup to measure acoustics based on from different frequency say from 100 or from 125 to 4000, then you have to plot completely the graph and then you have to assign it to a contour.

So, when you when you plot a graph, it is very important that the measurement values are very important because you are human here ranging frequency starts from 20 to 20000 hertz. But whereas, it is very its became very critical when it has became 500 to 8000 hertz usually that is why STC values are R w values are calculated at the frequency bandwidth of 500.

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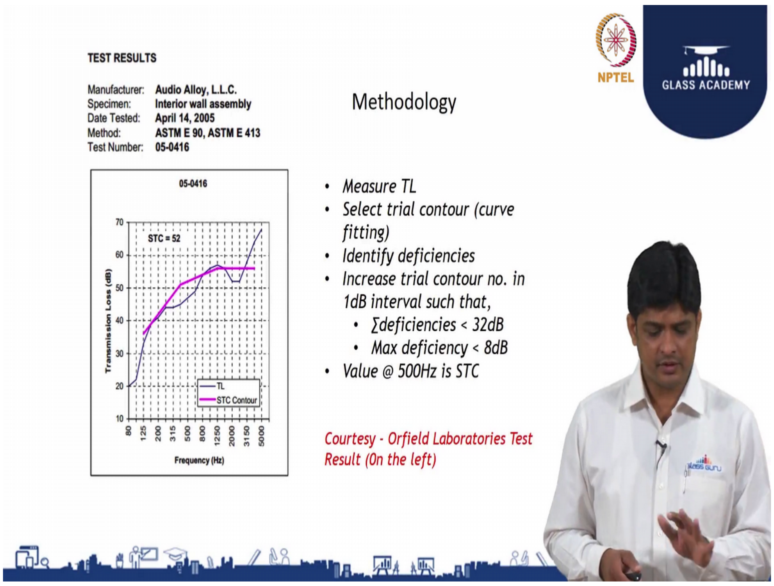

So, this is the standard graph you can plotted graph you can see for a particular STC say 52, you have an STC contour line which is drawn, and there is an measurement line which is called the TL the transmission line which is drawn. So, the methodology to do this is first I have to measure the transmission loss. So, I have a source and I have a receiver, there is a different frequency been emitted there is an barrier and there is an receiver. So, based on the different frequency being measured inside the transmission loss curve been plotted from say a 125 to 3150 or even up to 4000 hertz.

Once the transmission loss graph is been drawn, then I have to find a trial contour line I have to fit that contour line into the graph. How to fit I have some basic methodology to be followed? Usually I have to start fitting the contour mapping at 500 considering at 500 it is 0. So, when I plot it the because of the shape of the contour mapping, because of your transmission losses graph based on your different frequency pitches, there will be ups and downs. So, there is a particular condition I have to achieve that, the maximum deficiency or that distance between the transmission loss curve and your contour graph contour line, cannot be go beyond eight 8 dB.

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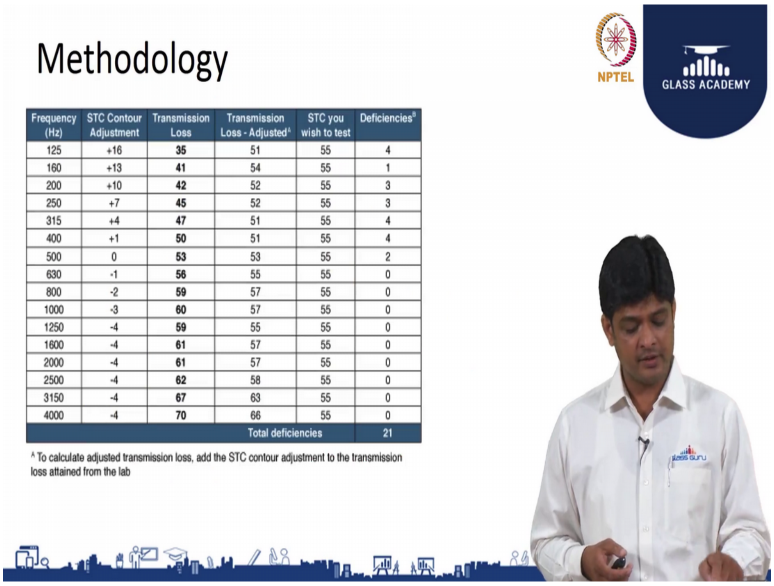

Frequency (Hz)	STC Contour Adjustment	Transmission Loss	Transmission Loss - Adjusted[A]	STC you wish to test	Deficiencies[B]
125	+16	35	51	55	4
160	+13	41	54	55	1
200	+10	42	52	55	3
250	+7	45	52	55	3
315	+4	47	51	55	4
400	+1	50	51	55	4
500	0	53	53	55	2
630	-1	56	55	55	0
800	-2	59	57	55	0
1000	-3	60	57	55	0
1250	-4	59	55	55	0
1600	-4	61	57	55	0
2000	-4	61	57	55	0
2500	-4	62	58	55	0
3150	-4	67	63	55	0
4000	-4	70	66	55	0
				Total deficiencies	21

[A] To calculate adjusted transmission loss, add the STC contour adjustment to the transmission loss attained from the lab

So, when I plot this at 0 when I assume that it has 0, then I have both the positive and negative which I have to sum it up in these two important parameters to be considered is. The total deficiency cannot be greater than 32 even in this case if you see there is a plus 16. So, this contour line has to be further adjusted so, that the maximum gap has to be 8 dB.

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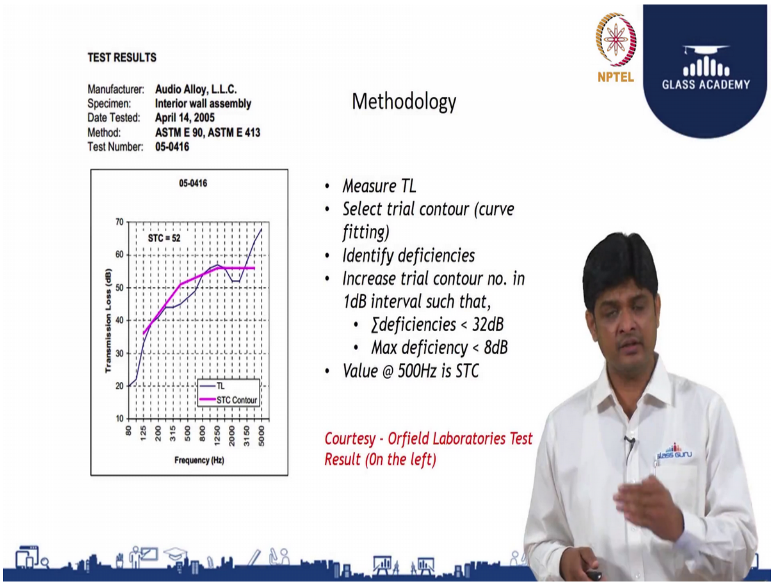

When I plot that considering this two criteria, then I will be able to achieve the contour and my trail, then whatever it is at 500 is my STC value, which is the whatever value in my contour line at 500 hertz will be my STC or R w value.

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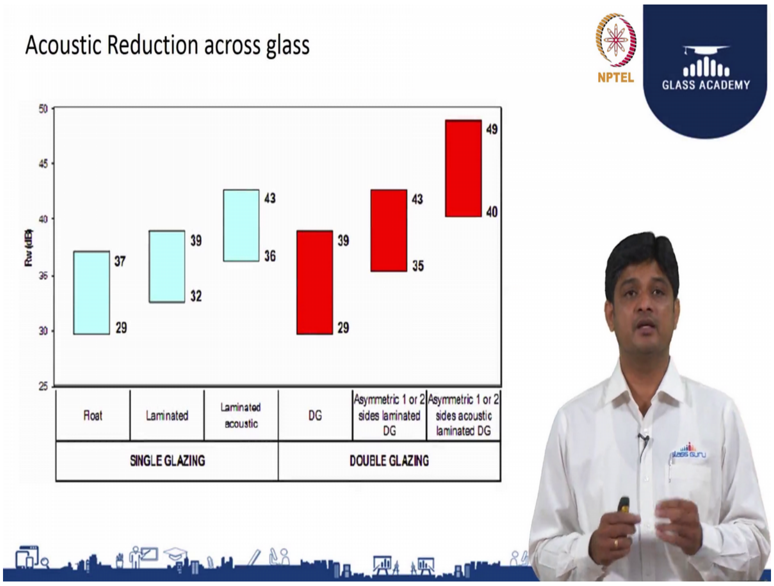

So, to understand how it respect to the glass and normal floored glass, based on different thicknesses whether it can be from 5 mm to 12 mm, then it is a single unit the ranges will be from 29 to 37 dB because from 4 mm. So, every next glass thicknesses there will be improvement in your performance. Moment I laminate it moment I laminate means I am going to sandwiching two glasses, with a material called PVB or it can be with the sentry.

Based on the number of layers type of bonding element I will use, the ranges can be from 32 to 39 dB. The same combination for a lamination I can even use an acoustic at material, which is used which can be which can further improve efficiency or which can further reduce the noise transferring. So, which can improve from 32 to 36; so, it can reach up to even 43 dB

To further achieve, if I have to further reduce my noise level coming into my building from my source then the next option available for me is to make a double glazing unit. In the double glazing unit I can go for symmetric glass asymmetric glasses, where based on the kind of thickness of glass combination are used there can be reduction varied or I can use a laminated glass in a double glazing format, which can further increase my acoustic performance.

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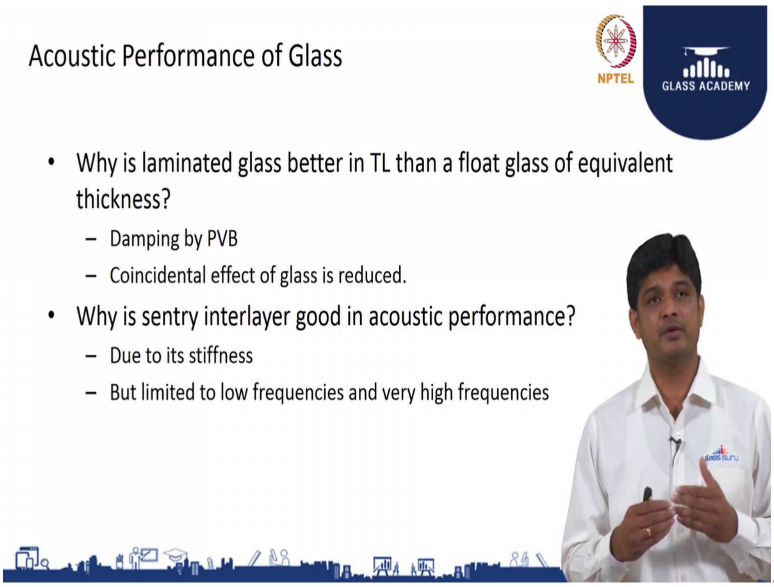

How the acoustic glasses going to perform? It going to perform on basically based on two important parameters. One is the thickness of the glass which is going to be an major factor second one is the PVB which is actually behaving like a dampering material. Whereas, there as other option called sentry interlayer which can further improve the acoustic performance, because it is the stiffness of the material the dampening property of the material is further enhanced, which can have a better impact on the overall acoustic.

So, to recap it; so, we have gone through what is called the basics of acoustics mean it has to be measured in a decibel, which is a single unit for number it varies based on the type you do or the kind of standard you refer to whether it is to as per ISO or as per ea. So, there is two parameters called R w and STC; when you go very deep into it the STC and R w the range will be within the deviation of 1 to 2 dB you can derive it is only a matter of the standard and the frequency you take through.

So, based on the source again you have to use an adjustment factors, which is called rac and R a tr. Moment you are able to understand the basic terminology, then you should be able to understand how to plot it. So, to plot it we need to plot first the transmission loss graph, then I have to plot a contour, the maximum difference between the contour and my transmission loss is has to be 8 dB, after plotting it I have to calculate the overall deficiency, which cannot go more than 32. So, once it is done at five hundred whatever is the contour that will became my its STC value

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So, specific to glass more thicker is better because it is heavy. So, the if there is less tendency to vibrate or to resonance. So, but in a single glazing maximum available is will be 12 mm thick in a single glaze you can use it in an architecture application. So, maximum you can achieve is about 36 dB to 37 dB.

So, further if you want to improve you have to go into a lamination format, again in lamination as always thicker is better, but here because of the benefit of the PVB or your sentry, which behaves at can acoustic barrier, which helps you to decouples your individual glasses. So, there is two layer of glass and there is an PVB. So, there is and suggested to always go with an asymmetric glasses because every thickness of the glass, because sound travels with the mass. So, every different mass behaves like a different filters.

So, when you use a asymmetric glasses, the frequency the frequency capacity to pass through will be varying. So, when you use an asymmetric glass with a PVB. So, the glass 1 able to block particular frequency and the PVB and then the glass 2 will be able to block a particular frequency or different frequencies. So, when it is sum of this all there will be a positive or there will be a better reduction.

Whereas, when you do a simple lamination, you can achieve maximum is about 37 to 42 dB. When the really the source level is about 80 dB outside your building, and you wanted to achieve something less than 40 dB or even 35 dB where it is in case of an hotel, where you wanted to have a complete silence. Mean complete silence here means anything less than 25 dB it is very tough to understand, I can take in one classic example is the normal air conditioning noise what you are used to it which is in the range of 35 to 37 dB.

So, in a hotel, which where you have to achieve less than 35 dB from a source of 80 so, you have to reduce more than 45 dB. So, 45 dB cannot be achieved only through glass; so, glass and a system. So, when you select a glass it better to suggest or better to take 2 or 3 dB at higher R w STC so, that even there is a possibility of loss through your system or leakages still you will be able to achieve that 45 dB.

So, to achieve anything more than 40 to 43 dB, you have to go for a double glazing unit where you have to have the outer light laminated or if you wanted to achieve anything more than 45 to 46 dB, it is suggested to have even both the lights laminated. Again to achieve a particular STC range, you have to find that the different glass thicknesses has very huge impact on your different frequency.

So, again it is coming back to what is the purpose and for what source we are going to reduce it that is where your TL graph is very important to understand based on your source you have to plot your graph, and based on your source you have to understand your contour and then derive your STC considering your source and your adjustment factors. One we are able to understand this three important parameters your R w your adjustment factors and your source which is very important so, that you can play well within acoustics.

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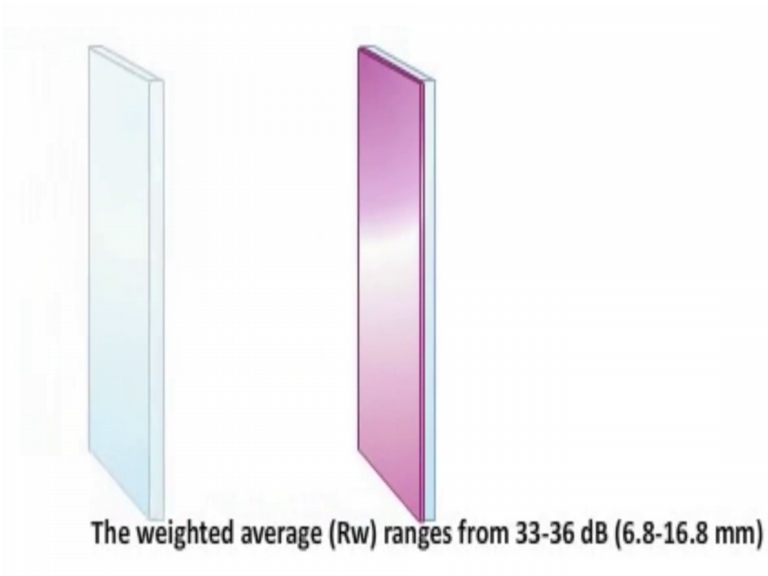

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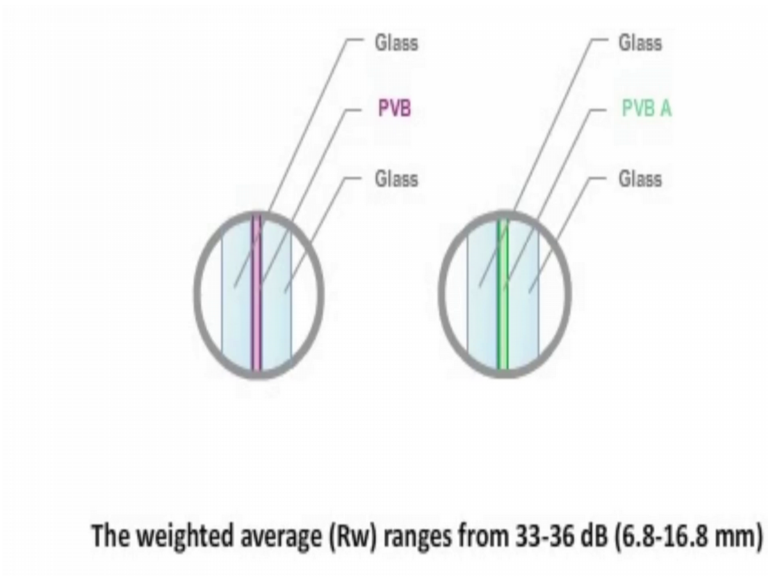

Thank you. I hope this session will help you understanding very basics about acoustics; terminologies acoustics and how to understand glass, and how to take it positive, how to reduce the noise transferring into your building.

Thank you.