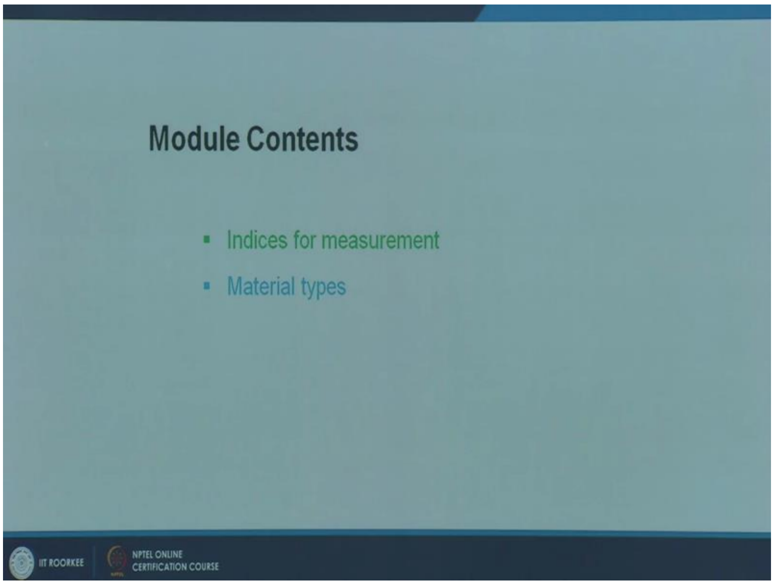
Principles and Applications of Building Science

Dr. E Rajasekar
Department of Civil Engineering
Indian Institute of Technology, Roorkee

Lecture - 18
Acoustic Materials

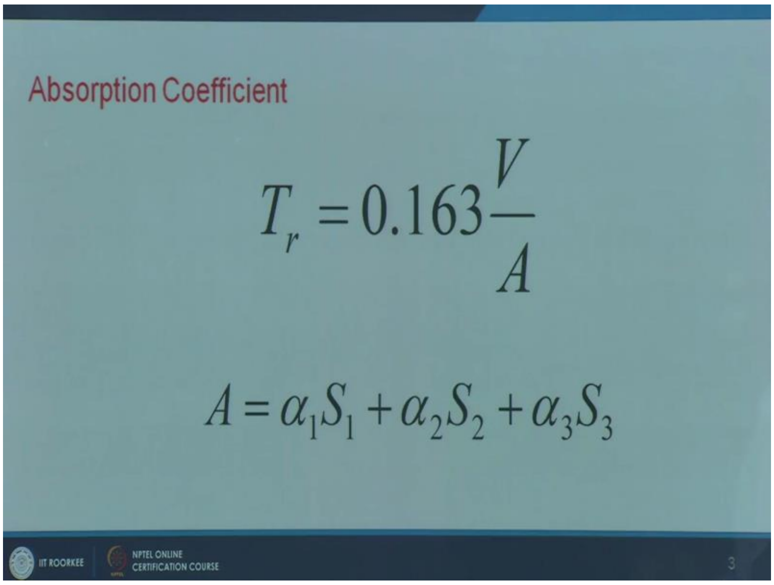
In this module we will be looking at details of acoustic materials. So, far we have been talking about basics of acoustics, and indoor acoustic treatment. You know the last module we were talking in elaborate about considerations for acoustical design in buildings, where material selection is a very crucial part, unless you select a right material your acoustics is not going to be alright. So, this module we primarily focus on types of acoustic material, observing materials, insulating materials. Primarily we will be starting with indices for measuring, what parameter should be look at. Say if you have to select from a list from a seller, what parameter you should be keenly looking for, and then what are the types of materials available and their specific applications.

(Refer Slide Time: 01:10)



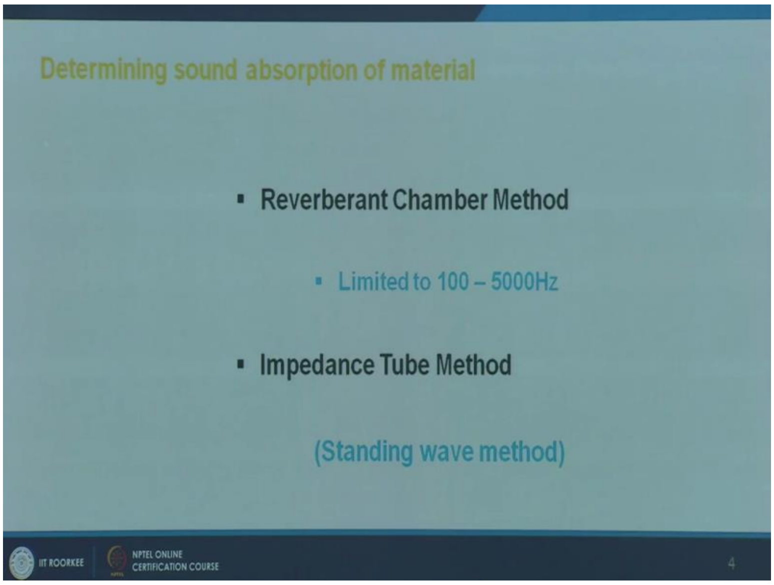
A quick you know recap of what we saw last time, this was a reverberation time equation this is (Refer Time: 01:16) where, you have reverberation time which is equal to 0.163 volume by the absorption; A is alpha that is called absorption coefficient of specific material into the surface area of that particular materials application.

(Refer Slide Time: 01:28)



So, if you have n number of materials spread over specific surface areas, then you can have a sigma that is specific absorption coefficient, which into in the surface area. In this particular number a, is referred in terms of absorption, is referred in terms of Sabin; that is a unit for absorption. Now we will look at more closely about what this alpha actually means

(Refer Slide Time: 01:57)

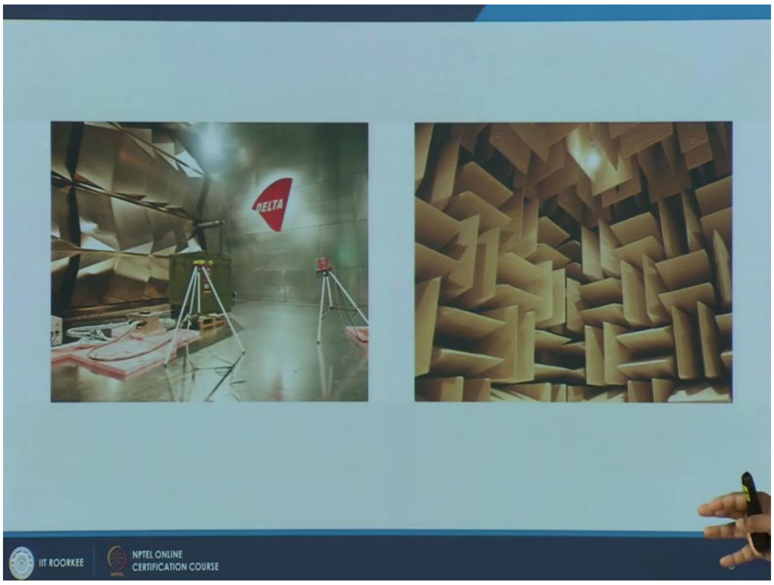


Alpha is the absorption coefficient of a particular material, it ranges from 0 to 1; 0 is 100 percent absorbing 0 is 100 percent reflecting; that is does not have any specific absorption. This particular absorption are alpha absorption coefficient, varies with respect to frequency. So, ideally when you select a material, if you want a real performance based selection. It is rather better to locate at least three specific absorption coefficients; that is absorption in the low frequency, something around 63 or 125 hertz or sometime 250 hertz. You know better is to look at 63 and 125 hertz. Then in the mid frequency range that is around thousand hertz what is absorption coefficient, and in the high frequency range something after 4000, say 8000 hertz is a good indicator of high frequency absorption.

There are two different types of tests through which absorption coefficient itself is determined. First is called reverberant chamber method. We talked about two different types chambers first was a reverberant chamber, other is an anechoic chamber .You know we had this references in the last module; reverberant chamber is a place or a testing room where the acoustic absorption is almost zero. It has infinite reflections or the reverberation time is very large. On the other hand anechoic chamber is something where there are almost no reflections, no absorption is very high, the reverberation time is very low, and this is what makes the difference. So, the first method you place that you know material to be tested, you mount it inside the reverberant chamber, and you test the difference between the original reverberation time, and reverberation time after the material is placed inside the room. Typically test chambers have their own reverberation time, without any material present.

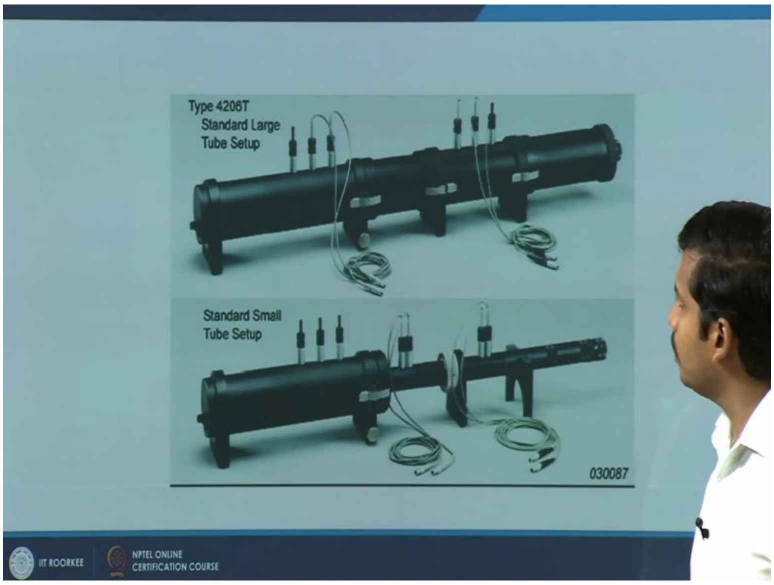
When the material is present there is a second T dash or the second reverberation time, with this you can find out what is a reverberation absorption coefficient of this particular material. This method of testing is more efficient for frequencies between 100 to5000 hertz, and there are lot of other considerations like mounting on what surface you are mounting, edge diffraction, lot of other things are coming. We are looking into those specifications right now. Just for information this is the first method. And the second method is called impedance tube method. We studied about the principle standing waves; this particular principle is applied in this testing. I will quickly show you the chambers and the testing devices.

(Refer Slide Time: 04:33)



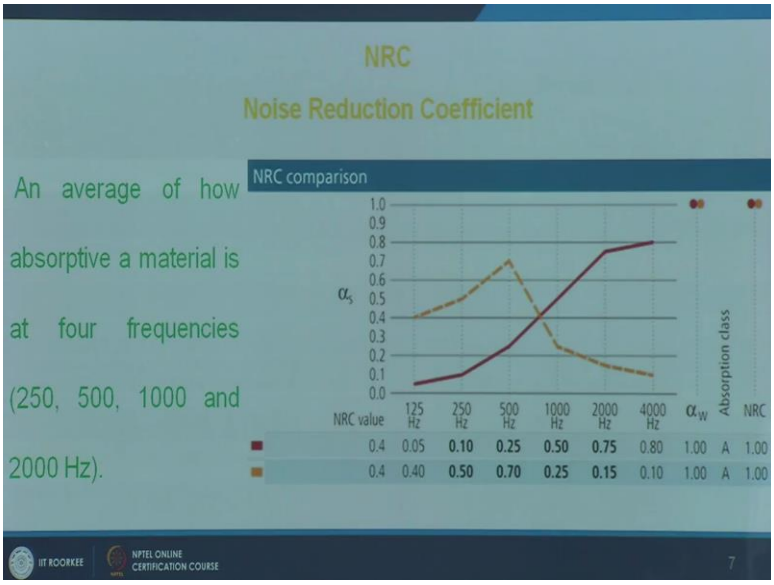
This is a reverberant chamber you place the material inside the chamber, it has infinite reflections, or the reverberation time is very long, without any material the chambers reverberation time is taken, and after the material is mounted, then the absorption is measured. There are various advancements in these method of measurement, this is a anechoic chamber for your information, it has a lot of (Refer Time: 04:58) each one is on absorbing surface. So, the surface area is very high and the absorption is rarely high, the reverberation time will be very low, negligible reverberation time. This is second type of measurement which is called standing wave method, or the impedance tube method this typical experimental setup. It is available as a testing device or you can fabricate your own.

(Refer Slide Time: 05:20)



This diameter of the tube and the length of the tube has a critical you know position to play in terms of the testing efficiencies; say this kind of thinner tubes, you know thin diameter smaller radius tubes are used for high frequency testing, the larger ones used for typically low frequency testing, on one side of it you mount the material. There is a signal generator or a pure tone generator, specific frequency is set in which tones are produced. Principles of standing wave, a standing waves are formed in you know inside this chamber. Then you have a microphone where which is recording in the typical high and low; that is a maxima and minima of the wave length with which a specific calculation procedure, will tell you what is absorption coefficient.

(Refer Slide Time: 06:13)



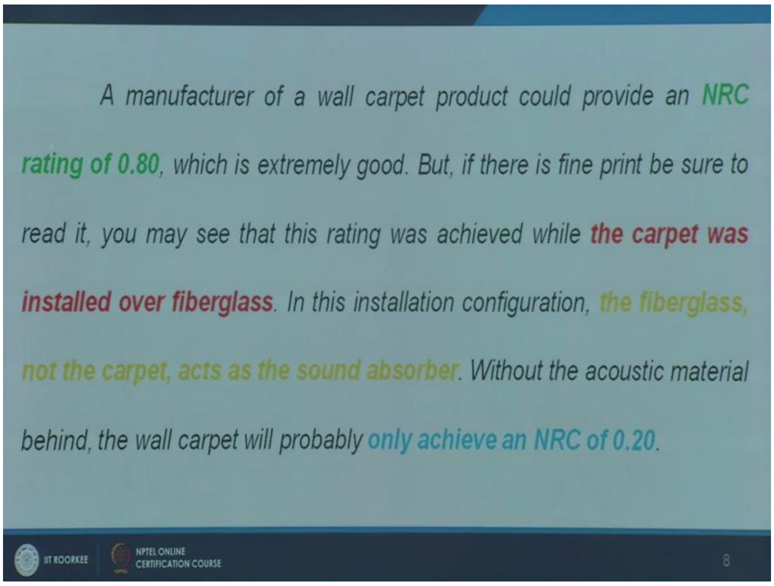
So, this is a second method of testing using these methods typically you determined at specific frequencies, what is a absorption coefficient, this is what we are referring as alpha. So, when we say a specific material is there. Let us take for example, the first the red line here, this is a material x, or says for example we can say it is a cushion, it is a 50 mm cushion, and we are testing this. So, at different frequency, starting from 125 where you are getting about negligible absorption, then you go all way up to 4000, where you are getting about 0.8 alpha, or absorption coefficient. The material is having a good absorption in the high frequency verses; it has a very negligible or low absorption in the low frequencies. You take another material y, where you are mounting it, say for example, it could be glass hole behind a particular panel or a fabric, and you are testing this particular thing. Again it is a 50 to 75 mm which has a different type of alpha value, at 125 hertz it has slightly better absorption 0.4 0.5 mid frequencies close to 500 it is, after mid frequency it has very low absorption.

Commonly when you buy a material you have a value called N R C, or noise reduction coefficient which is nothing, but an average absorption coefficient of four different frequencies, 250 500 1000 and 2000. Any material you chose the first index or the number you get to see, or refer plus a supplier gives you, will be the noise reduction coefficient, then say the N R C value is 0.8 0.94, it is a good absorbing material. Yes, it indicates the materials absorbing performance, but one short note you have to remember, it is an average value. So, take the case of two materials that we were comparing;

material x and material y. Both of them the absorbing pattern is different first material have good absorption in the high frequency, low frequency it is not performing well. Whereas the other material the material y, has the totally reverse type of performance, in the low frequency range it is better, as it gets higher the absorption is coming down, but as you get; see the N R C both have around 0.4 N R C.

So, in this way N R C as such, simply referring to N R C little misleading, it is rather a good idea or a better strategy, to look at what is the specific absorption coefficient at different frequencies. If you take a closure look, if you want to control reflections or if you want more absorption in the low frequency, if your reverberation time calculations show that your r t at the low frequency needs to be reduced, then you need to go for material y in place of material x. On the other hand if you find that mid and high frequency you need more absorption, or at specific location you need to arrest mid and high frequency sounds, then better go for material x. So, N R C as such is a good indicator for absorption, absorption coefficient of a material, but since it is an average, it sometimes is misleading, because it averages out both high mid and, all the three high mid and low frequencies.

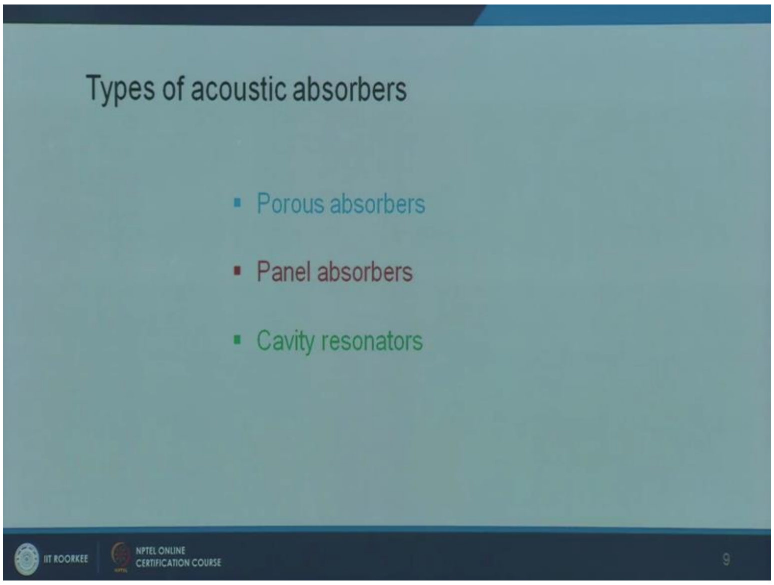
(Refer Slide Time: 09:19)



Another consideration you have to be careful about while you chose a material. For instance I have given an example, you are wanting to buy a carpet, and the you know material suppliers says the carpet has a N R C of 0.8, which means it is extremely good absorbing material. So, typically you will prefer going for this particular carpet, but if you closely take a look at it, the mounting condition, in which the material was tested, was at only the carpet, or was there any backing given to the carpet.

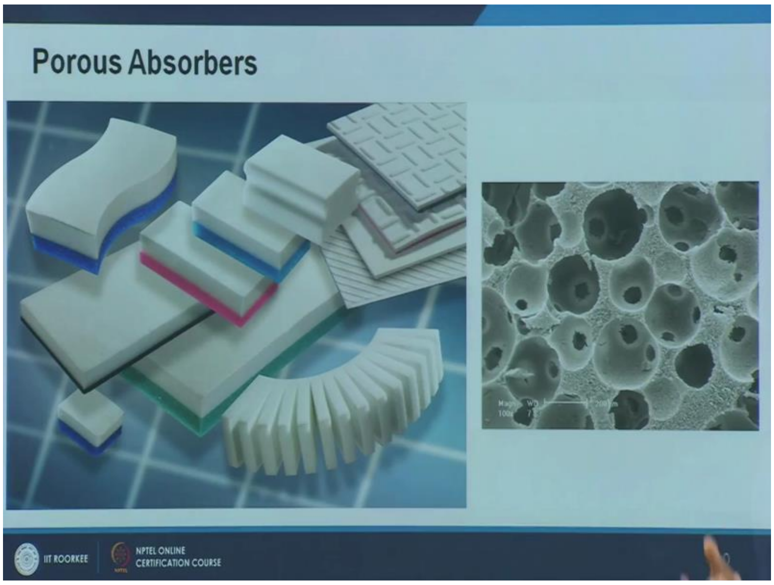
In this case for example, if the carpet where, you know was installed over a block of fiber glass, or a panel of fiber glass then this N R C, particular N R C of 0.8, actually refers to a better absorption not just of the carpet, but it is carpet as well as the backing and the fiber glass you know glass will backing, which is resulting in this 0.8, it is not the sole performance of the carpet alone. So, better you also ask the supplier or check for the data base in the data sheets, what was the mounting condition. If you take a closer look, then your material selection is more economical or more trustable

(Refer Slide Time: 10:31)



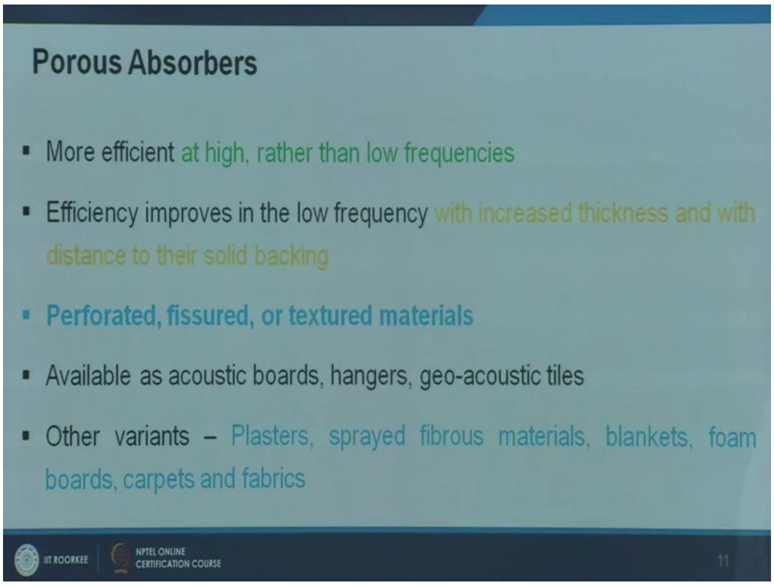
There are three types, primary types of acoustic absorbers; first is porous absorbing material, second is panel absorber, and the last is cavity resonators. Each one has a specific band width or frequencies spectrum, in which they have a very good performance. It can be stretched out to other frequencies, but their primary performance areas are different.

(Refer Slide Time: 10:55)



Take a porous material, any type of cushion glass will you have boards; there are few varieties I will show you now. Simple example is a cushion or a foam acoustic foam, which will have very good absorption in the mid and high frequency range, is a cushion if you take look at microstructure it has lack of air porous in it. So, typically the acoustic signal or the sound energy is getting converted into heat energy inside these porous, because of which you get very good absorption in the mid and high frequency ranges.

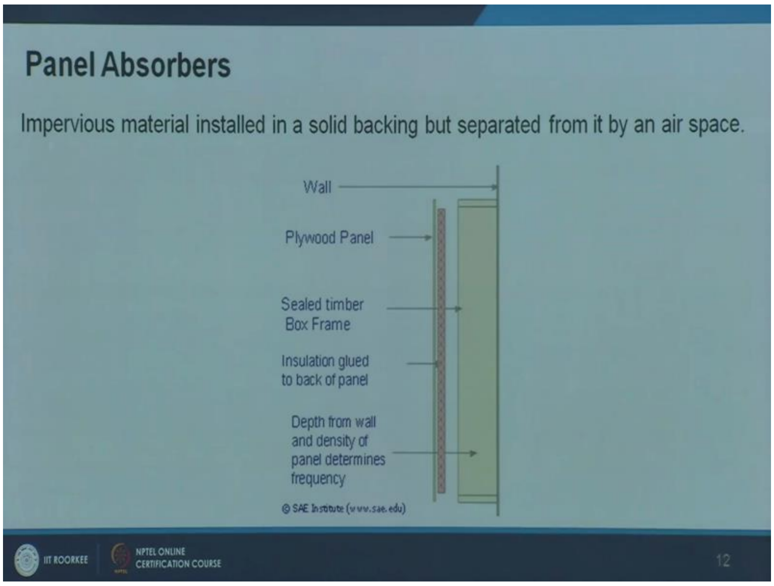
(Refer Slide Time: 11:24)



As I said mid and high frequency is good, but if you take simple 50 mm or 25 mm thick cushion, you know it is absorption or alpha value absorption coefficient, is rather week or low in low frequency, it is not very well performing in the low frequency. If at all you are left with only option of cushion, you do not have any other option you have to go for foam, then if you still want low frequency absorption, then you can increase the thickness or the spacing between the solid backings, solid backing can be your wall. So, probably you should go for a 50 mm or 100 mm space, air gap then mount, instead of a 25 or 50 mm foam, you go for 100 or 150 mm foam with the air gap, then it can be made to or stretched to improve the performance in the low frequency also, but if you are simply mounting it on the wall surface, a thin 50 mm cushion standard panels boards are available. If you are simply going to mount it then you can only expect a very good performance in the high frequency, low frequency you cannot expect much.

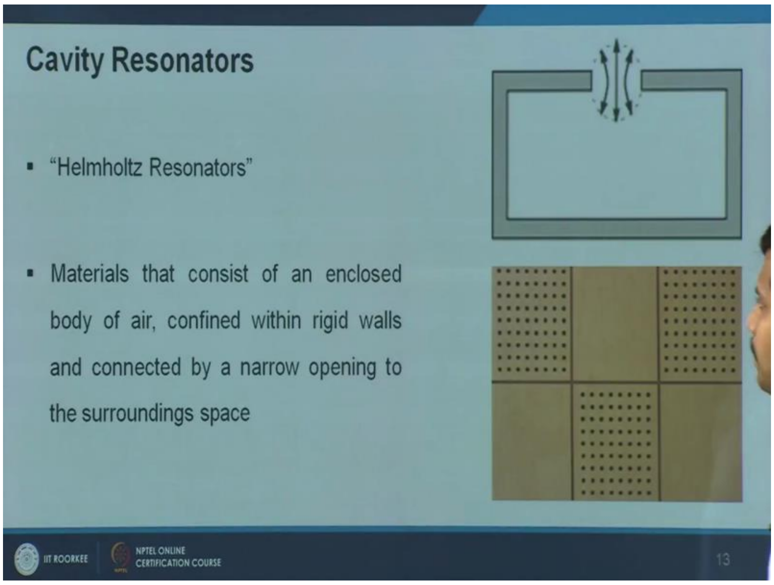
There are different types perforated fissured boards textured materials, different types of patterns textures are available. They are also available in the form of acoustic boards, hangers, geo acoustic tiles lot of you know panels, nice looking you know architecturally, good looking interior you know suited to different themes of interiors panels are available, commercially today. Other variance include acoustic plasters, sprayed fibrous materials, blankets, foam boards, carpets, fabrics are available. So, there is lot of varieties, and this is one of the most predominantly used acoustic absorber as far architectural applications are concerned.

(Refer Slide Time: 13:11)



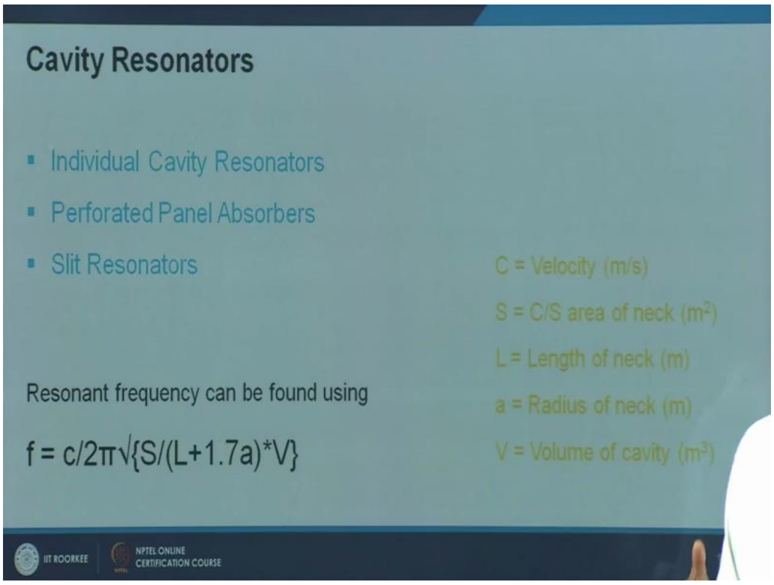
The second type is panel absorber; imagine a thin plywood panel, mounted on a frame, there is air gap you have the wall section here. This also absorbs at a specific particular frequency band width. The absorption is restricted to one or two specific band widths, which depends on the thickness of the panel, the area of absorption, and the air gap which is available behind that is the spacing, depending on these three variables the density of the parallel as well, depending in these three crucial things density, thickness, as well as the mounting distance, the absorption specifically varies. I show you specific examples of how the absorption is; it typically resonates at a particular frequency. I am going to show you some examples.

(Refer Slide Time: 13:58)



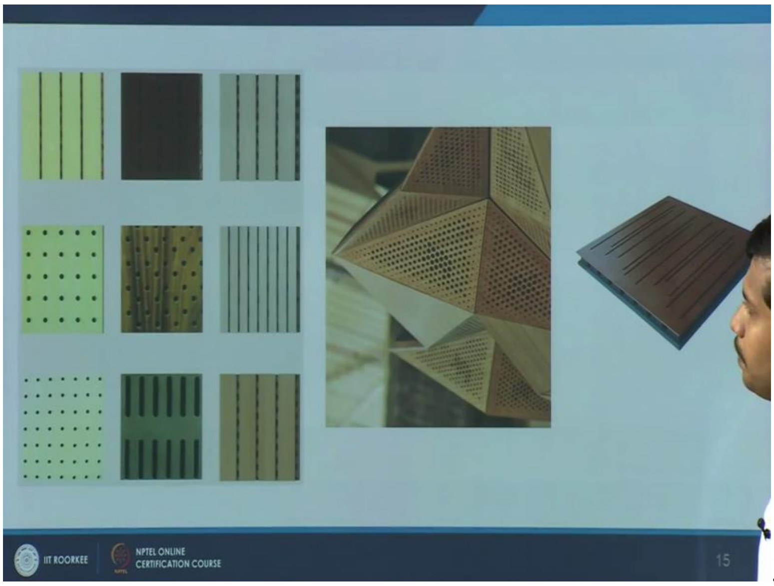
The third type is called cavity resonators, these are typically box shaped absorbers, these are also called Helmholtz Resonators, working principle is they actually trap the acoustic signal, it can be specific boxes like this, or it can be panels with perforated, in which each of these perforations is going to act as an acoustic cavity, inside which the signals or the incoming signals can be trapped. This signal can be, have simple white or this can be lined for improved absorption, and these are typically well performing in the mid and low frequency range. Of course, it depends on the width of the cavity; that is the diameter or the cross section of this whole thing as well.

(Refer Slide Time: 14:46)



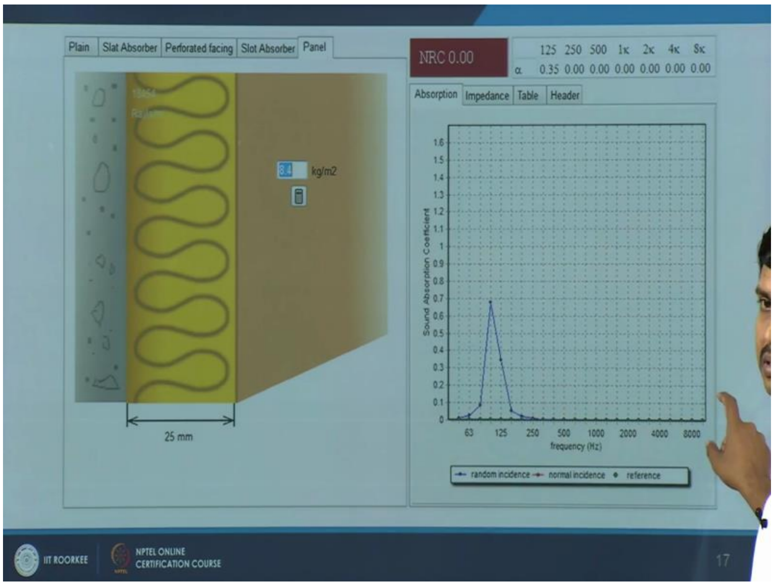
The resonate frequency for example, at which frequency this cavity is going to be effective, or if you have a specific frequency in which you have to address; say for example, your hall or your room is not performing well, or the reverberation time is excessively high at 125 hertz, or 63 hertz. In this case you have a formula, you know the frequency now, and velocity is fixed, now you can determine the dimension and the cross section of the cavity, as well as the volume of the cavity which will be able to arrest frequencies at 63 hertz, frequencies of 163 hertz or 125 hertz. There are different type's individual cavity resonators, or perforated panel absorbers, like I said it can be perforated boards, or it can be slit resonators.

(Refer Slide Time: 15:32)



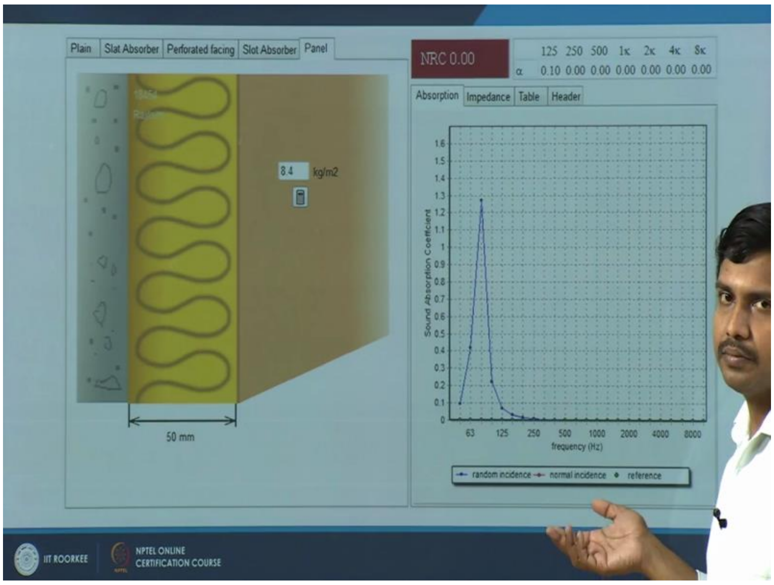
Some examples you can have glass hole backing behind this, you can foam backing behind this. There are different types and the performance whereas, I show you some examples apart from this they can also be separately suspended in the form of specific boxes, which act as resonating cavities; are like I said it can be individual cavities which can arrest, you know very low frequency sounds, typically used in recording studios, where low frequency creates a lot of problem, because of the smaller volume of the room as well as a type of sound signals which are generated.

(Refer Slide Time: 16:09)



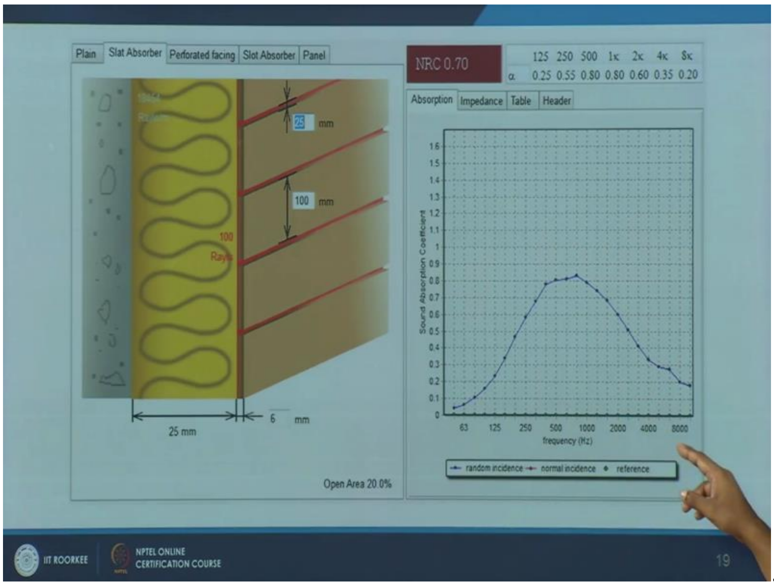
A few examples, first let us start with cavity you know panel resonators, panel absorbers. Let us take an example you have a wall, solid wall, you are mounting 25 mm thick glass hole, then you have a panel, plywood panel which is 8.4 kg per meter square. Typically what you get, you get a sharp absorption around 100 hertz are close to 125 hertz, you have a sharp absorption of around 0.7 alpha, or you know absorbing coefficient of 0.7 close to 125 hertz, but after that the performance is almost, all the alpha values are almost zero. You get very good absorption in this part after that it is dropping down, but if you take a look at the N R C, it will show zero, because it is only taking into account, frequencies after this particular frame, this lower frequency of 63 and 100 hertz is not covered here. If at all you are requiring this particular frequency absorption, sometimes thin panel absorbers, would be really of good help. The absorption also varies for the thickness, as well as the presence is absence or type of material used for the backing.

(Refer Slide Time: 17:23)



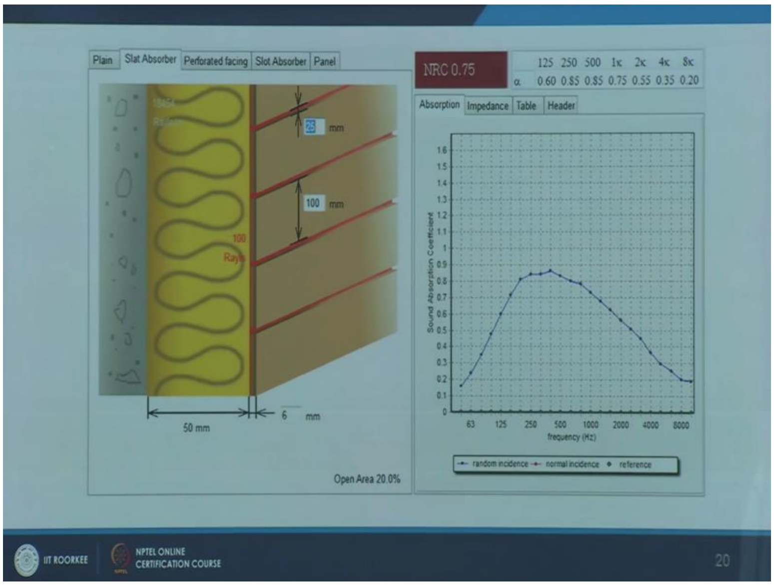
Now, I am increasing this you know glass hole from 25 mm 250 mm. The material is same, wall everything is same, just the thickness has increased. Now you take a look at this, the absorption, sound absorption, the frequency is shifted further lower. Now it is getting much closure to 63 hertz, and the absorption coefficient is also increasing. You also get a very high absorption, it is shifting towards a low frequency, it is a good way of, you know good strategy to use in case you are requiring, very specific frequency in which there is a problem in the room or your hall.

(Refer Slide Time: 18:00)



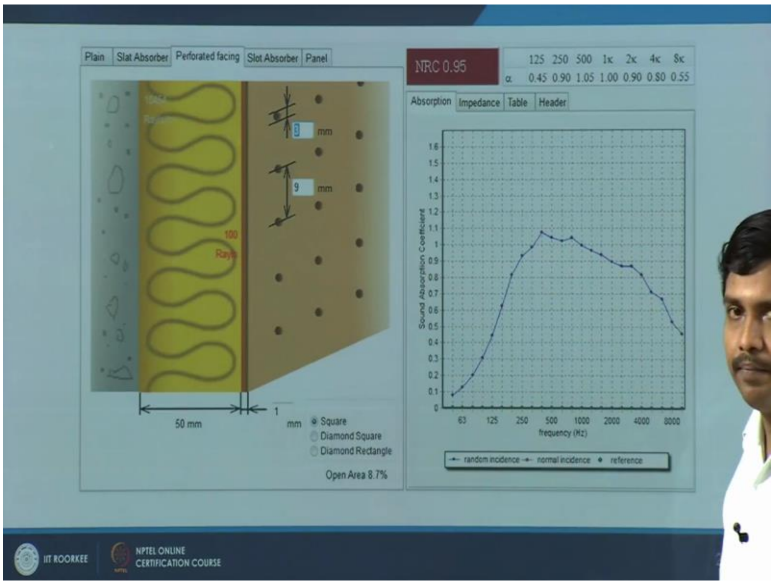
Now, instead of a solid panel if you have a slated panel, you have certain slats here 25 mm thick glass hole backing, same wall material plus you have a 6 mm thin panel and you have slats here. Look at the absorption coefficient; low frequency, like you saw in the previous one, you do not get much in the low frequency range, a proper you know perceivable absorption coefficient you will get somewhere around 250 hertz where it is above 0.5, then you get a better absorption in the mid frequency, and in the high frequency range, it is eventually dropping down. This is with the 25 mm backing.

(Refer Slide Time: 18:41)



Now, if I increase the backing from 25 to 50 mm, then you take a note the absorption slightly gets a shift, you also get realizable values somewhere around 125 hertz, here itself it is crossing 0.5 absorption alpha value, and then you get a good absorption in the slightly low frequency range, around 250 500 you get good absorption, after that 2000 hertz it is eventually dropping down, just the variation in this thickness. Apart from this, the type of slats, the thickness of slats, is there you know thin backing behind this, a cushion backing behind this, are what is a dimension instead of slats if you have porous or perforations, the kind of absorption you are going to get, is going to be different.

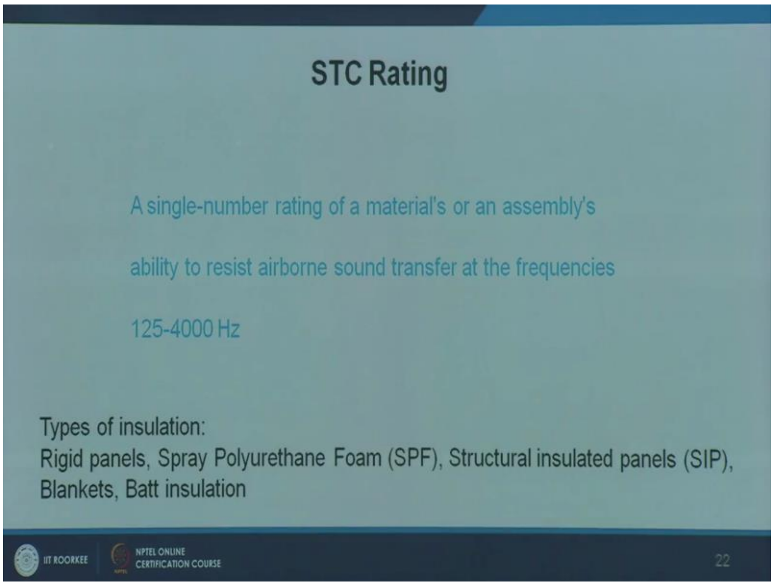
(Refer Slide Time: 19:28)



Take a look at this now instead of a slat you have a perforated facing Now your N R C value is very good, the absorption coefficient pattern you also get a good absorption in the mid and high frequency range. Here the critical thing is, what is a diameter this perforation, and what is a distance between the perforation. So, first I will be defining here it is 3 mm dia and the spacing between center to center spacing is 9 mm, and what is backing, here I have given 50 mm. Now moment I am adjusting you know decreasing it increasing it, or I am varying this perforation type as well as in a spacing and the diameter or dimension surface, then the absorption coefficient or the performance of the material itself is going to vary.

For example in this case, I have a open area of around close to 9 percentage, I can increase this, if I increase this the material is going to give better absorption and the low frequencies, it is kind variable, you have to actually get an understanding of how the material is going to behave, with three different things, in this case spacing diameter and the backing.

(Refer Slide Time: 20:39)



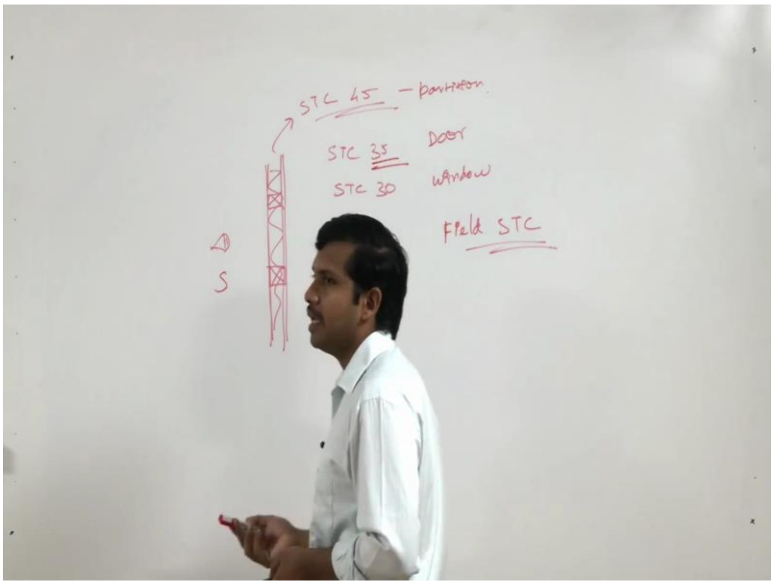
Now, so, far we have been looking at acoustic absorption. So, inside a hall you need an reverberation time, you need specific type of signaled noise ratio and acoustic absorption. For this you are using the factor called noise reduction coefficient, and alpha or the absorption coefficient. Now let us talk about sound insulation, two things we are talking about; first was acoustic absorption inside a room. Now we are talking about sound, you know partitioning and insulating sound between one room to the other room, say if source room to the receiver room, it can be a nice source or it can be a sound source which you want to really arrest, for this similar to N R C we use a term called STC or sound transmission coefficient.

Any particular material says it can be a door, it can be a window, or it can be a wall system. Typically there is a standard which asks you to go for, and STC rating of says 35 40 50. There will be specific STC ratings; say for example, you are designing a board room which is next one open plan office. There will be a specific demand which says that STC rating of the partition used between these two should be say 45, which means if there is, you know the board room requires around 30 or 35 d b as a background noise. Even if the source room that is a next room; that is open office if the sound signal goes to say around 80 d b, which means a 50 d b reduction will be required between these two. In that case the sound insulation or the sound transmission class which we call, is now should be carefully chosen such that it is higher.

It is again a single number rating of a particular material, or an assembly's ability to resist airborne sound transfer. Here we have talking about airborne sound transfer, there are different modes airborne, structure borne sound. Now we are specifically focusing on airborne sound; that is air to air sound transmission, at specific frequencies between 125 to 4000 hertz. There are different types insulation; like rigid panels you can haves you know something called s p f or spray polyurethane foam, then you have s I p structural insulated panels, different varieties variants are available. Then you have blankets batt insulation, specific applications demand different type of sound insulating materials. We refer to a simple term called transmission loss.

You have sound transmission by inserting, you have certain thing called insertion loss or a transmission loss, without this particular material there was, this much amount of sound transmission happening, between the source room and the receiver room. After I insert the particular material there is some amount of transmission loss which is happening, this is determining the efficiency of a particular material. Similar to noise reduction coefficient, this is also determined that different frequencies, and then totally you represented in terms of something called sound transmission class. One important thing you have to notice say for example, there are two rooms, separated by a partition simply the partition itself might have a very good sound transmission class, see you have a gypsum board two sets of gypsum board, with some glass hole insulation material inside, it may have a very good sound insulation.

(Refer Slide Time: 24:01)



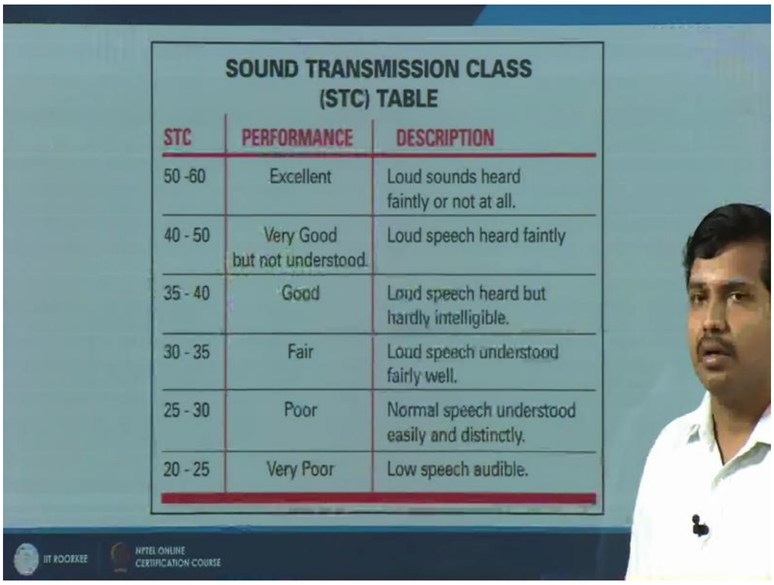
Say there is source room and there is a receiver room, you have gypsum you know partition plus, you have a glass hole, then you have a second gypsum panel. This has a simple partition is available. Now source room to the receiver room, you may have this particular thing can have an STC of for example, 45, a good STC value sound transmission class is available. Moment you insert a particular window or a door the STC of a door this is STC of partition. Now, you insert a door and a window, this is not openable just a see through window.

For example, the door which you chose has a STC of 35, the window which you chose has an STC of 30. Then you have to tally or account for all the three things together, which is referred as composite sound transmission class, when you have three four or n number of different elements across the wall or a partition, then each of it is sound transmission properties, or sound insulating properties have to be accounted, which we commonly refer as sound transmission class or composite sound transmission class of a particular partition. Now this is a weaker link, if you have to really improve the sound transmission of the whole partition system, then you have to really address this particular window; say instead of a single glass you go for a double glass unit, or you go for a laminated window panel which will be slightly more sound insulative.

Then you address the door, you check whether it is a single door, double door, led line doors, led line doors typically give you a better sound insulation in the low frequencies, you can go for acoustic gasketing sound, you know insulating gaskets then you can improve the acoustic performance of the door. There is another component here say particular supplier might give you STC of the door as 35. This is something which you find in the materials catalog. This is a laboratory tested value.

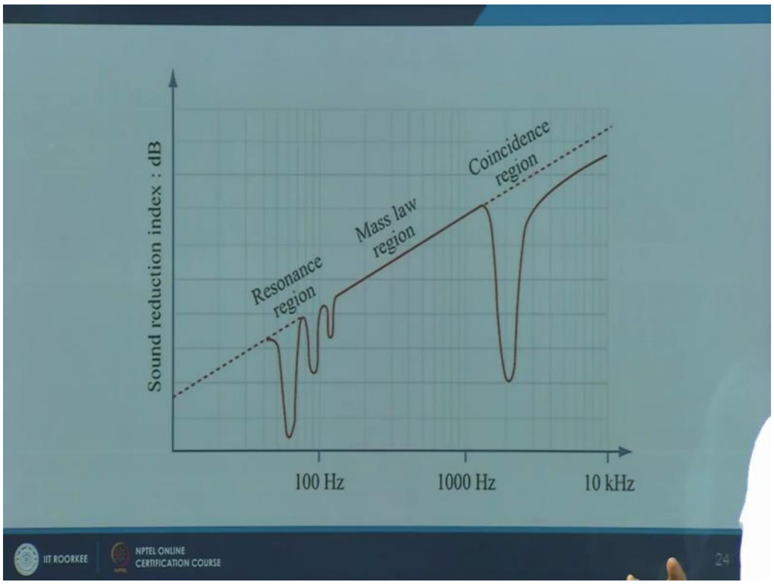
You also have something called field STC. This is a laboratory tested value. So, you have to actually give certain concessions for it is performance in the field, moment you have certain installation related things. You cannot do such a fine installation, like they do a testing in the laboratory. So, accounting for all that if you are doing it practical design, go for a slightly higher STC rating, instead of 35 it is suggested or advisable to go for 38 or 40 STC, so that you can actually achieve an STC of 35.

(Refer Slide Time: 26:58)



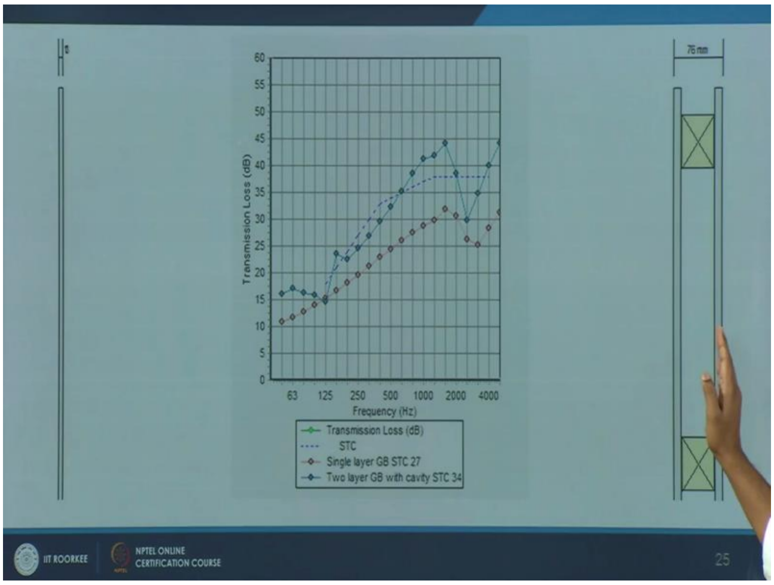
It is a general design consideration which any acoustic designer typically does. Simply putting it a sound transmission class between; say forty to 50 is considered to be very good, higher it is, say higher it above forty it is considered to be typically good between the rooms; that is even if you have above say 80 d b sound in the other side you are going to get 35 to 40 decibels if you have a STC in this range. Below that is fair and it is very poor if the STC ratings are 20 to 25. I am going to give you some specific examples of this as well. If you have STC between 20 to 25, it also means that the speech between these two rooms, source room and the receiver room is going to be audible with each other. Typically STC of the panel, say you have gypsum board you have a plywood panel.

(Refer Slide Time: 27:43)



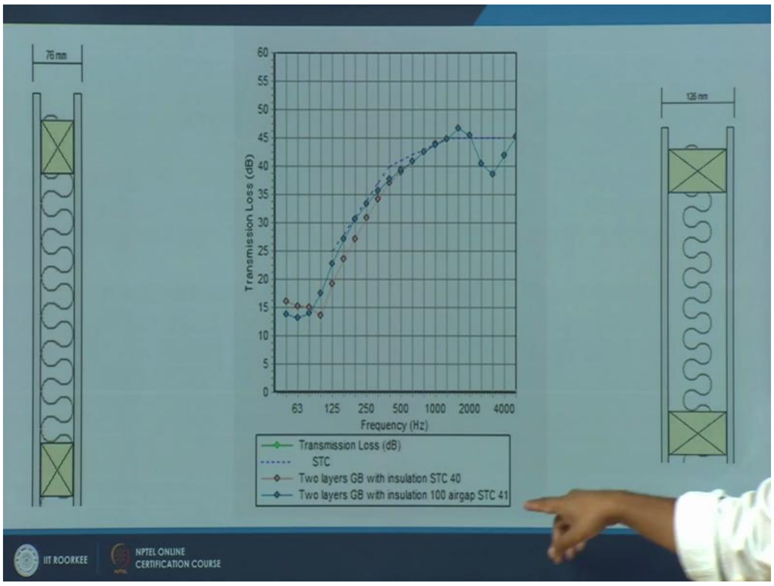
There are different types; you know ranges or regions in which the sound reduction is more effective. There is a specific range called mass law region, where the density of the material increases. So, the higher density material and thickness you go for, the insulation properties increase, but there are two ends to it in the lower end, you have something called resonant region, where the materials start resonating to low frequencies. Typically it happens below 100 hertz, again it depends on the material and it is dimensions, typically in the lower side it happens. In the resonance region this is not proportional, whatever thick, whatever density it is when resonates the acoustic insulation is very poor, and you cannot interpolate or extrapolate in this region. Again in the higher end you have something called coincidence region, where different planes of acoustic signals coincide with each other, and again the insulation property drastically drops down.

(Refer Slide Time: 28:41)



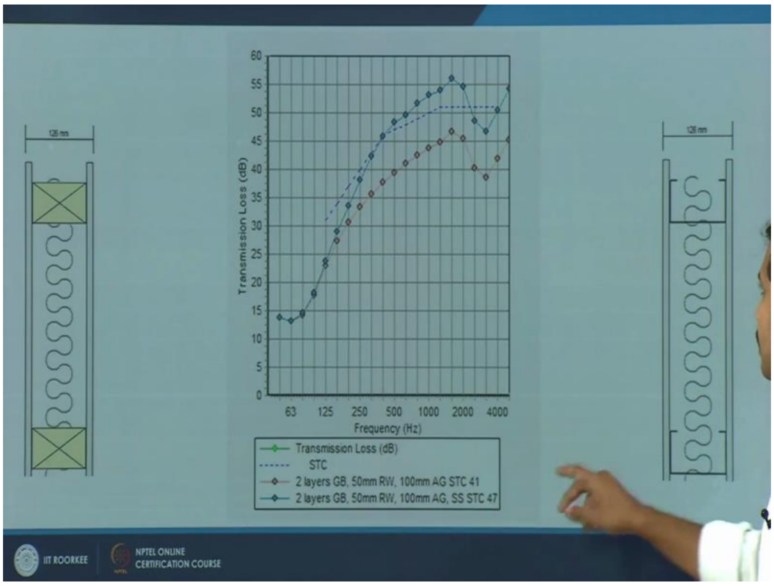
Getting certain specific examples, let us take a single layer of gypsum board, a thin gypsum panel; say around 30 in mm or 50 in mm gypsum panel, this is a absorption you know sound transmission class, or the sound insulation property at different frequency, the red one, this is what you are going to get. Now if you add a cavity at two specific gypsum boards, you are trying to increase this particular number; the STC value from 27 you are able to achieve 34.

(Refer Slide Time: 29:14)



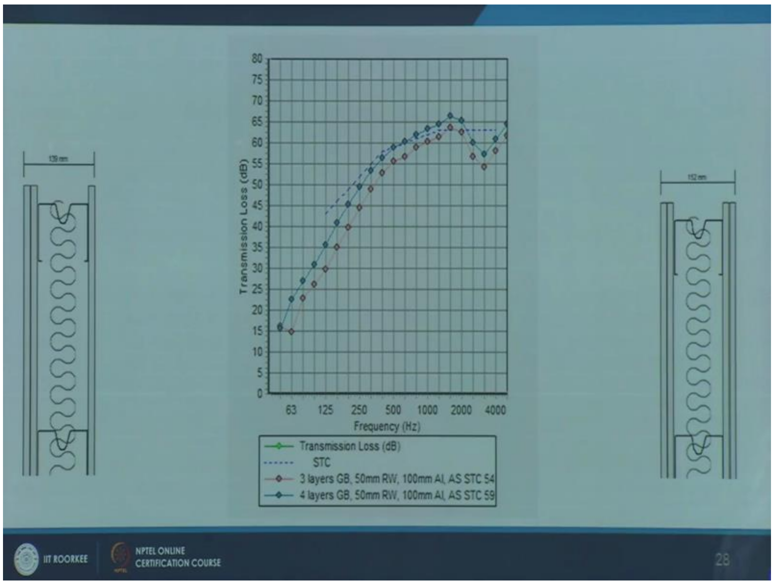
Now, you have a glass hole associated with it, you can raise it to forty, you can increase the width of it from say 75 mm, you are getting it to 125 mm. Now from 40 you have a slight increase, you have a air gap that is, you know you have a air gap here air gap here the same 50 mm insulation glass hole is put up here, you are getting a marginal increase in STC, we can take a note of the curve here.

(Refer Slide Time: 29:44)



Now, further to increase, this is what we had in the previous graph, we had 41 STC. You can actually replace these wooden studs with specific metal studs with gasketing. You will have a very good increase in sound transmission class. In this example instead of this particular wood, if I am going to introduce a metal stud with certain gasketing in both sides, and kind of isolating both the things, I am actually arresting the sound transmission path, with which I am able to get from 41 I am trying to improve, I am able to from 41 I am trying to improve I able to improve it to 47 STC.

(Refer Slide Time: 30:22)

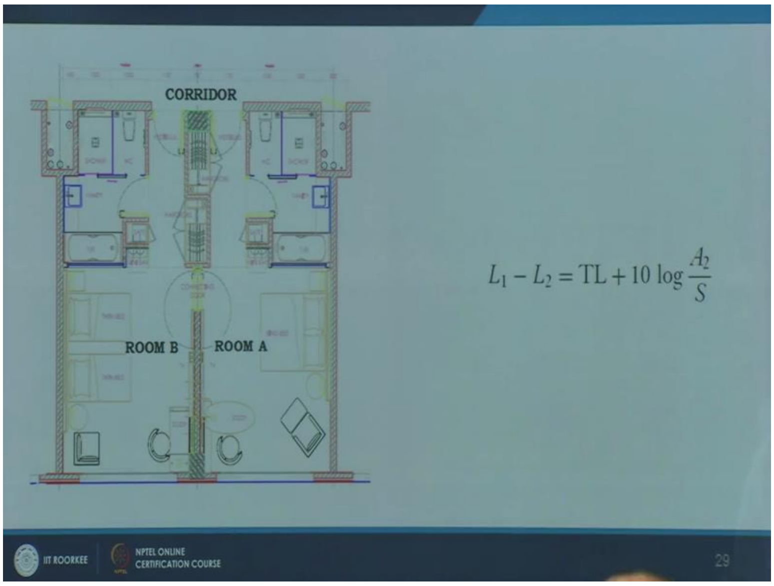


Further to it, there are specific types of studs, metal studs which are further good at isolating the sound transmission path; that is airborne sound transmission path; it would be able to arrest further. So, we will be able to achieve; for example, with two lines of gypsum on both sides with the specific type of acoustical, you know stud with the insulation of 50 mm and air gap on both side, we can raise it to up to 59 STC, which is really a good STC to achieve between the rooms.

So, typically you have to understand as the type of STC requirement increases, the amount of STC is essential, higher STCs are essential. There are various strategies like going in for thickener panels, adding another board, two three boards, or introducing an air cavity, introducing insulation material, changing the stud types, or adding panels on both the sides, increasing the total air cavity. Depending on these things you can actually attain an improvement in terms of STC. Common mistake which people do in the industry when you have fall ceiling, typically people stop this particular panel at the fall ceiling level.

Ideally when you need a perfect insulation between both the rooms, it is suggested that you raise this partition up to the ceiling, clear ceiling height, do not stop it at the fall ceiling level, these are certain common things mistakes which are done. So, you have certain thing called you know to the ceiling, ceiling at a (Refer Time :31:51) class where through the ceiling fall ceiling it gets in, passes through this and goes to the receiver room. So, it is a good practice to get it further. Other common you know considerations are like. So, you have two panels; there is one board here, there is one more board here, this is a source room, this is a receiver room, if you are placing a switch boxes on both these things. Certain common things like you know do not place it side by side, it is a better you know advisable thing to place it in a staggered manner, anything like you know staggering these, some principles common principles logical things can be apply, so that an effective STC can be attained.

(Refer Slide Time: 32:33)



How do you calculate the level difference between these rooms? This is a simple example see you have a room a room b; source room and receiver room, typical example in hotels or you know apartment buildings. Typically in hotels the problem is more, because some of the rooms have connecting doors, sometimes they make use of is as suit's they can open up this double doors. So, they become suit's together this whole room is rented out, but when they close it, there is a typical problem of sound transmission from one room to the other room. So, when you have to calculate this for example, you have the transmission loss of this particular partition here. You have different types of wall section, there is wardrobe here, there is a door double door here, then there is a simple wall section thin wall section, there is a thicker wall section here. Accounting for all this you takes the composite transmission loss.

Then you take into account the absorption, which is present in the second room, divided by the surface area of the partition. Together if you take then we will be able to determine what is a level difference. Ideally what happens you will not in practice, you will not be required to calculate the difference, but you will know what difference you need to achieve, you know that the source room is going to produce something like 90 db, whereas here you want to ensure 35 db. So, you know what is a delta t required. The possible options are you increase the transmission loss, you take a look at each of these elements and increase the transmission loss, or you increase the absorption in the receiver room. You make the receiver room more absorbing then you will also find an associated improvement in terms of the overall sound transmission, or the sound reduction which is attained.

(Refer Slide Time: 34:18)

Closing this section, so far we looked at different indices of measurement, we looked at two key things one is acoustic absorption, where we started with reverberation time and talked about noise reduction coefficient, and specific absorption at different frequencies how it is important. Other thing we looked at the different type of materials; porous absorbers, panel absorbers, and cavity resonators. And the second thing we looked at is sound insulating material, where we talked about transmission loss, and sound transmission coefficient or STC, how do we calculate, and how do we calculate the transmission loss between two different rooms. We also looked at few examples of, how do we increase the STC of a particular partition system.

Thank you.