Basics of Noise and Its Measurements
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Lecture - 47
STC, NRC, Sound Attenuation

Hello. Welcome to Basics of Noise and its Measurement. Today we will be introducing a couple of new terms which are very widely used in noise reduction industry and academia, and some of these terms are like transmission loss, mass attenuation, sound transmission class, noise reduction coefficients and things like that.

So, I just wanted to introduce these terminologies because once you are done with this course and if you encounter these things in your work place or in your college, you should have some idea as to what they mean.

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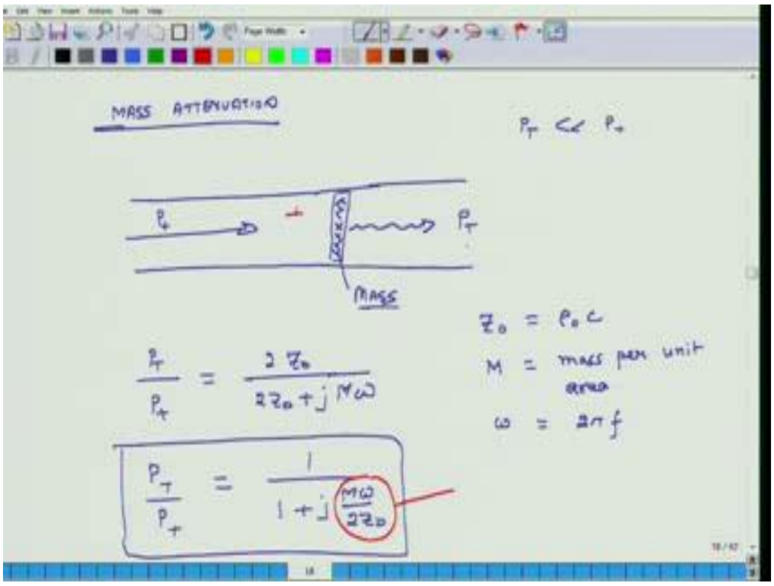

So, the first thing is mass attenuation. So, whenever I have some sound which is traveling across in a medium and I want to reduce the level of noise at the other end, then I can do it in 2-3 different ways. The first way is that I look up put a heavy piece of mass as an obstacle for this sound and then, less amount of sound gets transmitted across this block of mass. So, this way of reducing noise level at the other end is known as mass attenuation, where I rely on just mass and it is not rigidly fixed. It is actually free to move because it is mass and the sound pressure wave has to move this mass. So, that consumes a lot of energy. So, the other side experiences less sound level. So, we will explain this little bit more.

So, suppose I have sound which is traveling like this and I have mass here and this is some mass. This is my incident wave P plus and because of this, there is some transmitted wave P T and what I am interested in this is that P T should be very small compared to P plus. That is what I want and here I am actually relying on its mass to do that. So, without going into the mathematics of it, there is a relationship which connects P T to P plus and that relationship is this Trans complex amplitude of transmitted sound wave divided by P plus. So, this is the complex number is equal to 2 z naught over 2 z naught plus j m omega. What is z naught? This is characteristic impedance of air is rho naught c and then, m is mass per unit area.

So, if I am putting a panel here and the panel ways 100 kilo grams and if the area of the panel is 5 square meters, then the value of m will be 20 over or 100 over 5 which is 20 kilo grams per square meter. So, that is mass per unit area and then, omega is equal to 2 pi f or I can also express this in a different way which is 1 plus j times m omega over 2 z naught. This is another way.

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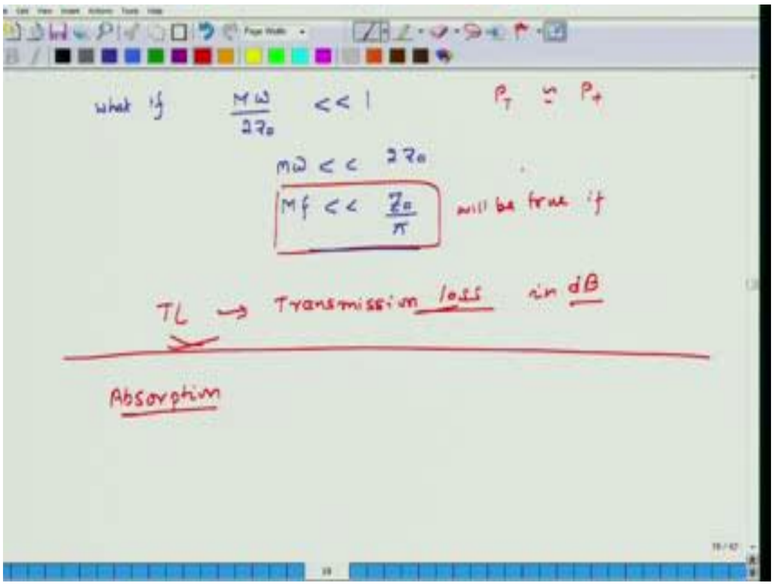

So, what does this relation tell us? So, what it says is we will look at 2-3 possibilities. One is what if M omega over 2 Z naught is extremely small compared to 1. What does that mean? Let this term is extremely small compared to 1, then in that case PT is a proximately equal to P plus. So, if M omega over 2 Z naught is extremely equal to small compared to 1 or I can also say M omega is extremely small compared to 1 or M times F times 2 pi is extremely small compared to 2 Z naught or I can bring this thing 2 pi or I can simplify this further, then if this condition is true, then whatever I will be hearing on the transmitted side will be pretty much same in amplitude as to what it is being incident on this thing.

So, what does this mean? This will be true if either M is very small or F is very small or both of them are very small and when I am talking small in this sense Z naught over pi. So, what this means is that if I have a low frequency sound, then I have to really put a very heavy mass to stop it from getting transmitted to the other side because it is the multiple of M N of which matters or if I have very small mass when most of the frequencies will easily pass through it unless frequencies are extremely high. So, if I have to make these mass attenuations effective, I have to keep on and if I want to be at moderate frequencies and high frequencies.

Even moderate values of M can do the job, but for low frequencies I have to make mass really large and it is not specifically mass, it is mass per unit area, it is mass per unit area and using this PT plus over P plus relation, we can also calculate something known as TL which is called transmission loss and we can calculate in decibels. How do you do that? If you take the magnitude of this thing and you square it that will be the ratio of energy which is getting transmitted. So, whatever is the ratio of energies which is not being transmitted, that is your TL and then, you can calculate it in decibels. So, that is your transmission loss.

So, this is one important way to attenuate sound as it is propagating in a medium. So, if I am talking and I place a wall at the other end, then it will be for less values of M. Most of the low frequencies sounds will still get transmitted high. Well, high frequency sounds will get attenuated to a larger extent. So, this is one way to attenuate sound.

The second way in this approach I did not assume that sound is getting actually absorbed by the mass. All what is happening is that this pressure wave is causing motion of this mass back and forth. When the pressure is high here, the mass moves on the other way you know positive X direction. When it is low, then it gets set back. So, the only thing which is happening is that this energy due to pressure is getting transmitted, translated in to kinetic energy of the system, but there is no dissipation happening in this system, but we can also have sound attenuation through dissipation.

So, this energy could enter into the material and because of internal friction and viscosity or whatever, it can get converted into heat and it can get lost. So, that is another absorptive way. So, this is another mechanism through which energy can be absorbed and if more of it gets absorbed, then less of it is getting transmitted to the other side. So, there are the two mechanisms through which a lot of attenuation of sound happens.

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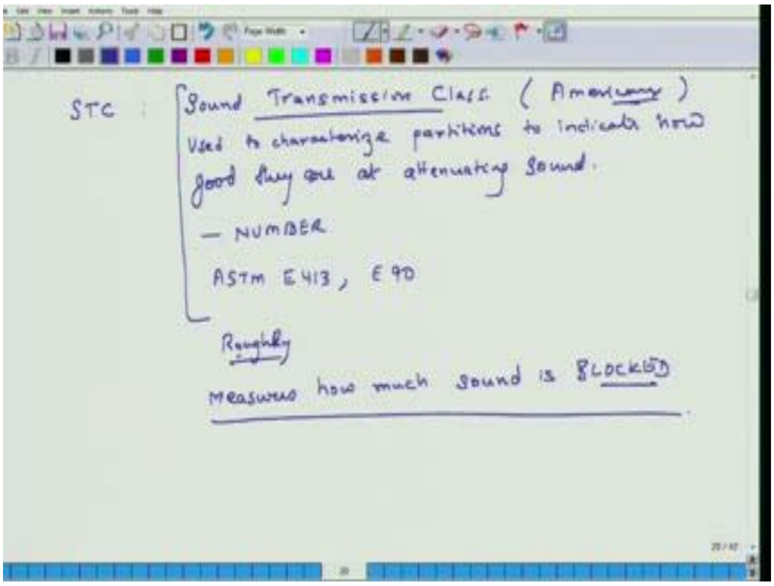

So, then there is this term call STC - Sound Transmission Class. What is it? It is used to characterize partitions. So, what could be a partition? A door is a partition, a wall is a partition, and window is a partition. You can even put a plank of wood between I am say it is the noise source and the other side that is also a partition. So, they are used to characterize partitions to indicate how good they are at attenuating sound. What is that C? It is a single number. So, I can have a partition, a wall and I can say its STC rating is 25 and it means something we will talk about it later, but it means something and there are some international standards used to determine the STC rating of any partition and there are some. So, there is one standard STM E 413 and then, there is another one E90.

So, these are roughly if the roughly if the STC number is N, then you can say that if the incident sound is 100 decibels, then the sound which has been heard on the other side will be 100 minus N roughly. It is not an exact mathematical relation. So, that is what in a broad sense STC number means and this is basically used by Americans and you see this number a lot of times even on some of the Indians stuff which we see. The STC rating of this door is 80 which been roughly if you have 100 decibels outside. Then, it will be 20 decibels inside roughly.

So, another thing to look at it is that STC measures how much sound is blocked. It does not tell you how much sound is being absorbed is some of sound may be getting reflected also, some sound may be getting reflected, some sound may be getting absorbed and only whatever is left is getting transmitted. So, it tells you how much sound is getting blocked, but it does not tell you how much sound is getting absorbed. So, it is a very fundamental thing because there is another thing called NRC. So, this tells you how much sound is getting absorbed and I will show you some values of STC.

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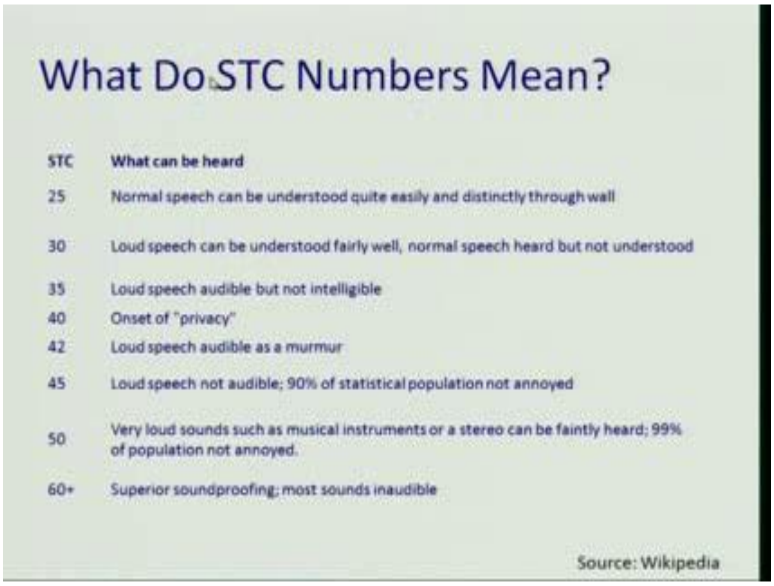

So, what do these STC numbers mean? So, if there is some door let say and we say that its STC is 25, it means that if I am talking on one side of the door, the other person on the other side of the outgoing may be he will be able to clearly understand what is going on in the other side. So, that is the meaning of STC 25. If you go to STC 35, then the same door if there is loud speech on this side, then the person inside the room will be able to hear something, some discussion is happening, but may not be able to necessarily figure out what is being discussed. If STC 40, then you say not much is being heard. So, whatever conversation is happening in this room, it remains private.

So, it says sound transmission class I would have thought that more this number, more sound gets transmitted, but it is actually the other way round. The more the number, the less sound is getting transmitted. STC of 60 plus superior sound proofing most sounds are inaudible so on and so forth. So, you can look at this and you can get a general flavor of, qualitative flavor of what is the meaning of different STC numbers and suppose you want to purchase a readymade window for your room and you can specify the manufacture, especially if you are designing it from an acoustical stand point that I want this window should have a STC rating of 40 or 60 or 70 or whatever. So, that is how you specify.

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STC	Partition type
27	Single pane glass window (typical value) (Dual pane glass window range is 26-32)
33	Single layer of 1/2" drywall on each side, wood studs, no insulation (typical interior wall)
39	Single layer of 1/2" drywall on each side, wood studs, fiberglass insulation
44	4" Hollow CMU (Concrete Masonry Unit)
45	Double layer of 1/2" drywall on each side, wood studs, batt insulation in wall
46	Single layer of 1/2" drywall, glued to 6" lightweight concrete block wall, painted both sides
46	6" Hollow CMU (Concrete Masonry Unit)
48	8" Hollow CMU (Concrete Masonry Unit)
50	10" Hollow CMU (Concrete Masonry Unit)
52	8" Hollow CMU (Concrete Masonry Unit) with 2" Z-Bars and 1/2" Drywall on each side
54	Single layer of 1/2" drywall, glued to 8" dense concrete block wall, painted both sides
54	8" Hollow CMU (Concrete Masonry Unit) with 1 1/2" Wood Furring, 1 1/2" Fiberglass Insulation and 1/2" Drywall on each side
55	Double layer of 1/2" drywall on each side, on staggered wood stud wall, batt insulation in wall
59	Double layer of 1/2" drywall on each side, on wood stud wall, resilient channels on one side, batt insulation
63	Double layer of 1/2" drywall on each side, on double wood/metal stud walls (spaced 1" apart), double batt insulation
64	8" Hollow CMU (Concrete Masonry Unit) with 3" Steel Studs, Fiberglass Insulation and 1/2" Drywall on each side
72	8" concrete block wall, painted, with 1/2" drywall on independent steel stud walls, each side, insulation in cavities

Source: Wikipedia

Lot of times people sell partitions and you know there in big offices, there are cubicles and there is a partition. They also have a STC rating and they tell you how much sound is getting blocked but they do not tell you how much sound is getting absorbed.

So, this is from Wikipedia and this is another list from Wikipedia and we range of different types of materials, not materials, but partitions. So, I am not talking about material. So, this is partition and different STC ratings and in general if you have a single plate pane glass window like the window there, then it has a very low STC rating 27 and then, if you have double wall, then STC rating goes up significantly in Aircrafts, the windows are double walled because you do not want a lot of sound from outside to go in and inside to go out and also, you want to remove because the engines are running outside. They are very noisy. So, they have very high STC ratings that designed in such a way that their STC ratings are extremely high. So, this is what STC rating is all about.

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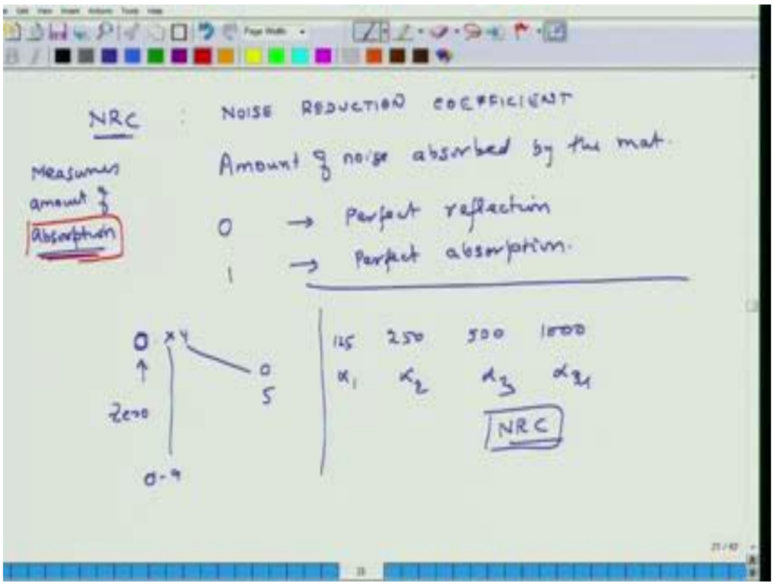

The next term which I am going to mention is NRC. So, this is noise reduction coefficient. So, STC rating it could be for a structure, it could be for panel, it could be for window, it could be for a door, it is not for a material. You understand? Material is different. A door could be made of 20 different materials. The outer lining could be steel, inner could be some word, then inside could be glass wool, but a window could have glass outside on it and you may have some gaskets and things like that. So, STC is for the whole system. This is NRC for specific materials and this is basically amount of noise absorbed by the material when sound strikes it.

So, when NRC is equal to 0, it is perfect reflection. When NRC is equal to 1, it is perfect absorption and this NRC in this format, NRC is in this format. So, the first number is 0. When you over decimal place, then this X could be anywhere from 1 to 9 or actually 0 to 9 and then, Y is either 0 or 5. So, you can have NRC or point of 0.00 NRC of 0.05 NRC of 0.1 NRC of 1.5 and so on and so forth, but you would not have NRC f 0.27.

How do you calculate NRC? So, you take the material and find its absorption coefficient at different frequencies. So, you measure it at 255, 100, 1000 and 2000 hertz. These are the standard frequencies and then, you find it alpha 1, alpha 2, alpha 3, alpha 4. For the same material, you may have four different values and somehow average them up and you come up with the final NRC rating. I am sorry. So, you start a 125 hertz. So, this is how you compute NRC. So, this is noise reduction coefficient.

So, what is noise reduction coefficient? It measures amount of absorption. This is different than STC which is amount of sound which is getting blocked. This is only about absorption.

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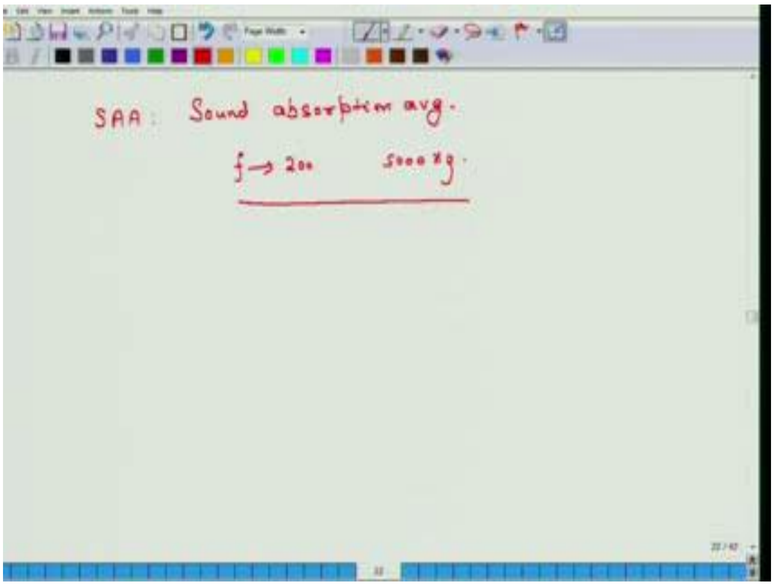

Then, there is another term called SAA. It is sound absorption average and it is pretty much similar to NRC, but the only difference is that here the frequencies which we used to calculate NRC or SAA is from 200 to 2000 hertz. This is being been more prevalent because a lot of sound which we hear in practical applications, they do not limit themselves to 1000 hertz. They go up to 5000 hertz easily. So, this is becoming more prevalent. This is the limitation that it stops at 1000 hertz. It may be for some general music or things like that, but not for the regular sounds. This is more practical. So, these are some of these important parameters about sound absorption and sound attenuation.

We will close this discussion today and tomorrow, we will discuss two topics. How do you measure absorption coefficient of a material and then, in that context we will introduce another tool for acquisitions and that is called a Reverb Chamber. So, that is all I wanted to discuss today.

Thank you very much and I we will meet tomorrow again. Bye.