Noise Management & Its Control
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Lecture - 43
Noise Source: Sound Pressure Level due to a Noise Source Located Indoors - Part i

Hello, welcome to noise control and it is management; this is the eighth week of this course and what we plan to do today. And also in the remaining part of this week, we will try to figure out, what is the sound pressure level inside a room. So, if there is a inside a closed room, if there is a noise source and we are let us say 10 meters away from this source then, what is the noise level, we should expect at that point of interest.

So, last week what we had done was something similar, but the noise source was placed outside, the room and first we had idealized that the noise is source is placed in free space, where there are no reflecting surfaces and then later, we also thriven the effects of reflective reflecting surfaces. So, that is what we plan to do and then once we are done, with this discussion then we will actually go and start estimating noise levels, due to specific noisy components. For instance the due to presence of fan or motor and things like that. So, in the last class or last week, what we had discussed was that, if we were outside,

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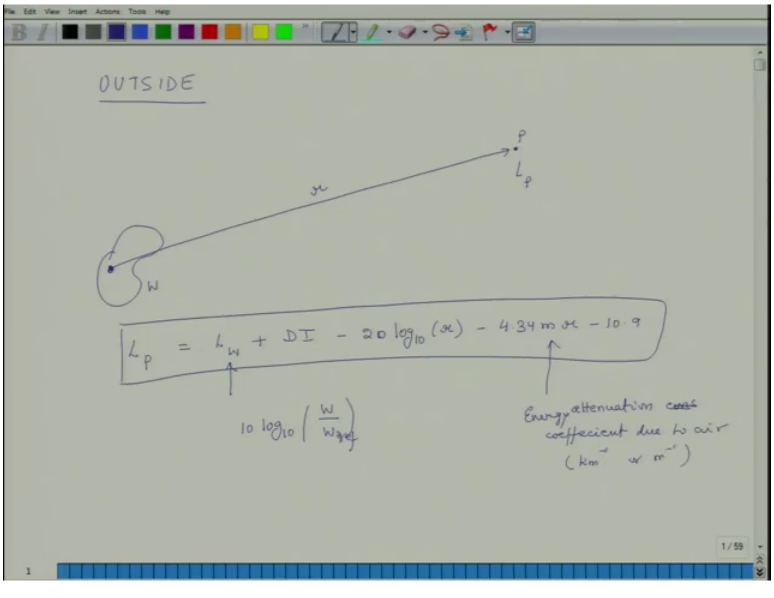

If we were outside and there were no reflecting surfaces then suppose, this is noise source and this is not necessarily a point source, but it could be any arbitrarily shaped source. So, and it is and we are at a distance r away from it . So, this is where we are located and we are interested in finding the value of sound pressure level at this point P.

So, this is point P and it is at a distance r from the noise source, then what we had developed was a relation and it said that Lp in decibels equals Lw. So, what is L W? It is the sound power level. So, this source of noise is emitting w watts of power. So, it is equal to Lw plus directivity index and if it is a perfectly spherically symmetric source, then the directivity index will be 0 otherwise, it will be some non 0 number minus 22 log of 10 of radius minus the effect of air attenuation, which is 4.34 m times r and minus 10.9.

So, this is the expression, we had developed, where Lw, we have explained it earlier also is what it is equal to 10 log of 10 of this ratio w over ref power level, which is W naught or W ref and m is the air attenuation coefficient. So, actually I will not call it air attenuation coefficient. It is energy attenuation coefficient due to air and it is units are in typically kilometer inverse or meter inverse.

So, this is what we had done. So, if we are outside in the space, free space and we are at a distance r away, then this is the sound power pressure level, we would expect to listen to. Now, similarly, the question is that if we are in a closed room. So, what happens

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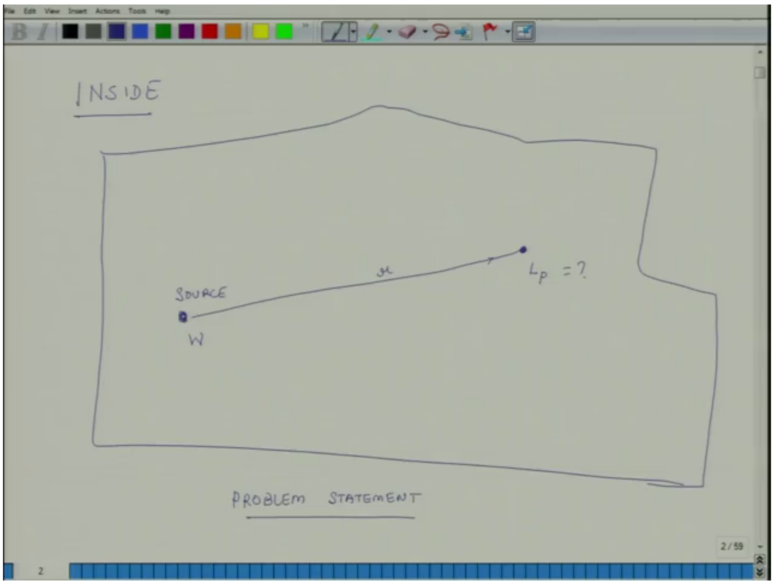

When we are inside a closed room? So, again I will pose a problem. Suppose, there is a closed room and this room may not be necessarily rectangular. So, I am drawing some complicated or arbitrary non rectangular shape and this is a closed room, and let us say there is a source, it could be a fan or a motor or a lath machine or whatever and this is generating noise and let us say, it is generating W watts of sound energy, each w joules of sound energy is seconds.

So, it is sound power level. Here is W and what we are interested in finding out is that I am let us say at a distance r away. So, this is where my microphone is or my ears are then what is the power level at this location. So, this is the problem, we are going to address today or and also may be in the next class. So, that is our power problem statement. So, what is Lp, if W is known. Now, before start addressing this problem, you have to be familiar with an additional concept known as noise absorption coefficient, because we are going to use this term, while we will try to solve this problem.

So, let us understand what is sound absorption or noise absorption coefficient.

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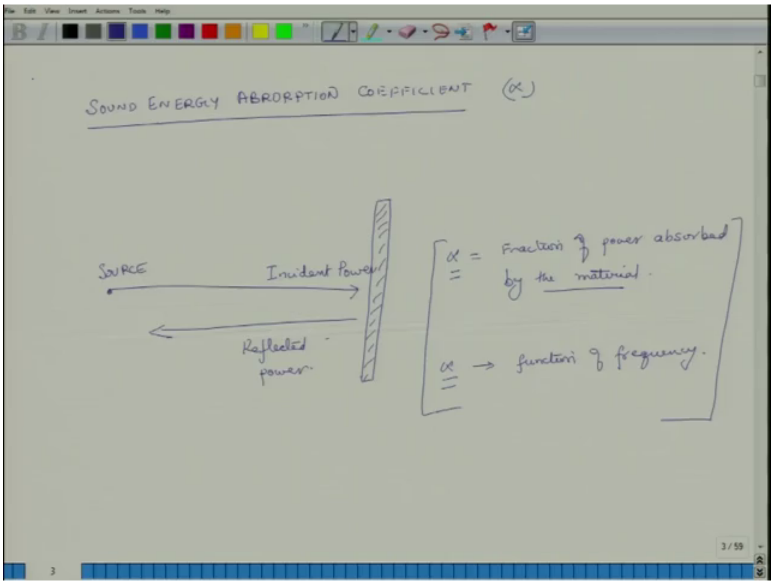

So, sound energy absorption coefficient. So, this is typically written as expressed as alpha. Suppose, I have a plate, let us say the plate is extremely large, infinitely sized and this plate could be of any material, it could be break or it could be curtain or glass whatever and I throw sound at it. So, sound comes from here. So, this is my source and it gets reflected.

So, there is an incident energy or incident power and there is reflected power. So, the incident power and reflected power. They may not necessarily be same, it if this panel, if this wall or panel absorbs sound, then the reflected amount of power will be less than incident power alpha is defined as fraction of power absorbed by the material of interest. So, you can either express a 10 percent or you can just express it in some fractional numbers 0.1 0.2.

Now, alpha changes with frequency. So, it is a function of frequency. So, different materials, the same material may absorb more sound at high frequency and may be less sound energy, at lower frequency and there are standard people have done lot of lots and lots of experiments to characterize different materials, and a very large number of materials have been characterized, for their values of alpha sound energy absorption coefficient.

So, what we will do is, we will look at a chart to get a feel of what kind of values are these.

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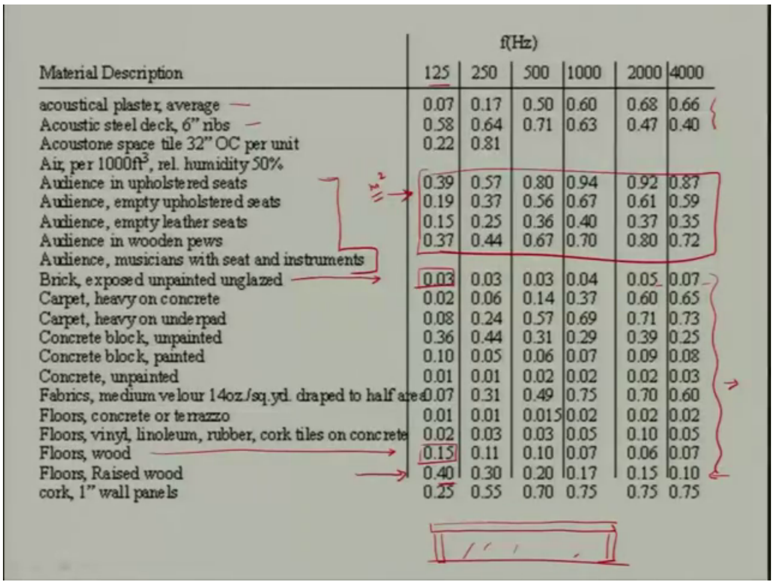

Material Description	f(Hz) 125	250	500	1000	2000	4000
acoustical plaster, average	0.07	0.17	0.50	0.60	0.68	0.66
Acoustic steel deck, 6" ribs	0.58	0.64	0.71	0.63	0.47	0.40
Acoustone space tile 32" OC per unit	0.22	0.81				
Air, per 1000ft^3, rel. humidity 50%						
Audience in upholstered seats	0.39	0.57	0.80	0.94	0.92	0.87
Audience, empty upholstered seats	0.19	0.37	0.56	0.67	0.61	0.59
Audience, empty leather seats	0.15	0.25	0.36	0.40	0.37	0.35
Audience in wooden pews	0.37	0.44	0.67	0.70	0.80	0.72
Audience, musicians with seat and instruments						
Brick, exposed unpainted unglazed	0.03	0.03	0.03	0.04	0.05	0.07
Carpet, heavy on concrete	0.02	0.06	0.14	0.37	0.60	0.65
Carpet, heavy on underpad	0.08	0.24	0.57	0.69	0.71	0.73
Concrete block, unpainted	0.36	0.44	0.31	0.29	0.39	0.25
Concrete block, painted	0.10	0.05	0.06	0.07	0.09	0.08
Concrete, unpainted	0.01	0.01	0.02	0.02	0.02	0.03
Fabrics, medium velour 14oz./sq.yd. draped to half area	0.07	0.31	0.49	0.75	0.70	0.60
Floors, concrete or terrazzo	0.01	0.01	0.015	0.02	0.02	0.02
Floors, vinyl, linoleum, rubber, cork tiles on concrete	0.02	0.03	0.03	0.05	0.10	0.05
Floors, wood	0.15	0.11	0.10	0.07	0.06	0.07
Floors, Raised wood	0.40	0.30	0.20	0.17	0.15	0.10
cork, 1" wall panels	0.25	0.55	0.70	0.75	0.75	0.75

So, this is what I got from internet. So, what you see is we will look at couple of things. So, what you see here are different materials. So, first one material is acoustic plaster, then acoustic steel deck, but there are even common materials bricks. Suppose, you have a brick wall and you strike it with a 100 and 25 hertz, sound energy in this band 125 hertz band. Suppose, you strike it with that then about 3 percent of that energy gets absorbed and the remaining gets reflected.

So, then in that case it is alpha is 0.03 and it remains same up to 250 500 hertz, but that, but at 1000 hertz. It becomes higher at 2000 hertz. It becomes 5 percent and at 4000 hertz. It becomes 7 percent. Let us look at some other number. So, let us look at wooden floor. Suppose, you have floor, which is made up of wood. Now, wood it looks like is very good in terms of absorbing sound energy at low frequencies, it absorbs about 15 percent.

But as you go higher in the frequency, it absorbs less and less amount of energy. So, low frequency energy wood is good at absorbing it, but at higher frequency, it has problem. So, if you make a floor, if you make a floor and it where you have raised wood, what does raised wood, it is like this and then you have some gap here. So, there is some hollow stuff, here then this type of wooden floor absorbs 40 percent energy at low frequencies and at higher frequencies, that absorption coefficient becomes 10 percent.

It also happens that when there are people in a room. So, you can have an empty room or you can have people in a room and depending on, whether they are sitting in upholstered seats or simple plastic seats, people also absorb a lot of sound. So, these are absorption coefficients, for people audience. So, this is per person, this is per person, but the units of these things. So, these guys all these, here the units are dimensionless, but here the units are somewhat different, it is actually meter square the dimension is meter square.

For people the dimension is meter square. So, it is alpha times, the area of a person and we will explain that a little later more precisely, but this is. So, people also absorb sound and.

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Material Description	f(Hz)					
	125	250	500	1000	2000	4000
Geoacoustic tile, 32" OC	0.13	0.74				
Glass, heavy plate 32" OC	0.18	0.06	0.04	0.03	0.02	0.02
Glass, ordinary window	0.35	0.25	0.18	0.12	0.04	0.04
Gypsum board 1/2" on 2"by4" stud 16"OC	0.29	0.10	0.05	0.04	0.09	0.09
Plaster/Gypsum/Lime on brick	0.013	0.015	0.02	0.03	0.05	0.05
Plaster/Gypsum/Lime on concrete block	0.12	0.09	0.07	0.05	0.04	0.04
Plaster/Gypsum/Lime on lath	0.14	0.10	0.06	0.04	0.03	0.03
Plaster/Gypsum/Lime on lath with airspace	0.30	0.15	0.10	0.05	0.05	0.05
Plywood, 1/4" with 3" airspace and 1" insulation	0.60	0.30	0.10	0.09	0.09	0.09
Brick, unglazed and painted	0.01	0.01	0.02	0.02	0.02	0.03
Panels, 1.5" fiberglass	0.86	0.91	0.80	0.89	0.62	0.47
Panels, perforated metal 4" thick	0.70	0.99	0.99	0.99	0.94	0.83
Panels, perforated metal and fiberglass 2"	0.21	0.87				
Panels, perforated metal and mineral wool 4"	0.89					
Panels, 3/8" plywood	0.28	0.22	0.17	0.09	0.10	0.11
Polyurethane foam, 1"	0.16	0.25	0.45	0.84	0.97	0.87
Tile, mineral fiber ceiling	0.18	0.45	0.81	0.97	0.93	0.82
Tile, marble or glazed	0.01	0.01	0.01	0.01	0.02	0.02
Wood, solid 2"	0.01	0.05	0.05	0.04	0.04	0.04

Then there are some more materials. So, you have tiles, thick plates for glass, different types of plasters, bricks, polyurethane foam and so on and so forth. May be this is relatively smaller list, but there are very exhaustive list. So, if you are interested in figuring out, if you have a particular material, you can browse over the internet or approach some specialized agencies, who deal with sound and they will be able to provide you sound absorption coefficient for different materials and what do we do with this

So, of course, I mean we get a feel how good are poor a particular material is, but when we work inside rooms, what we are trying to what we try to figure out is what is the overall sound absorption, coefficient for the entire room. So, how do we calculate it?

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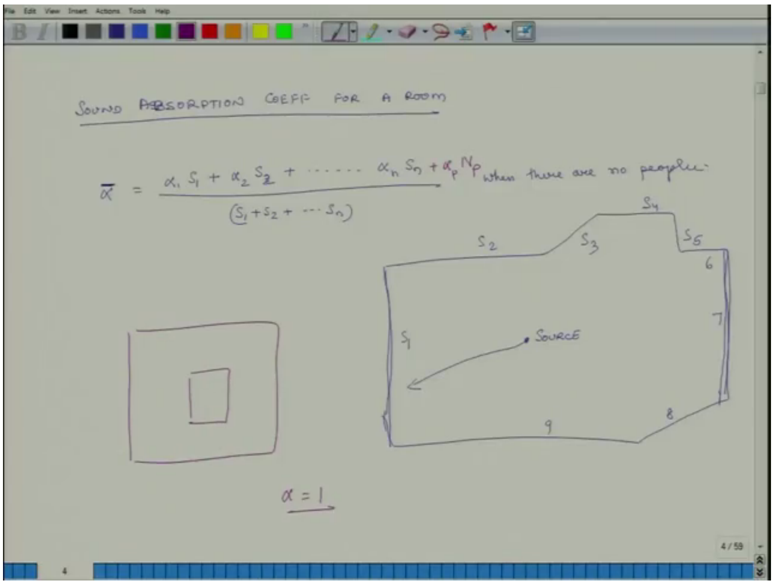

So, sound absorption coefficient for a room. So, this is some sort of an average entity and we call it alpha bar. So, suppose, you have a room, we have a room and it has different surfaces. So, this is surface 1, this is surface 2, surface 3, surface 4, surface 5, 6, 7, 8, 9.

There may be other surfaces also, this wall and the other wall. So, each. So, suppose, I have a sound source and I throw sound on this surface and let us say each surface is made up of different material, maybe this is made up of a brick wall, this surface could be having a brick wall, but it is also having very heavy curtains, in front of it. So, each surface may be different then what is the average sound absorption coefficient for this room, what it is sound absorption coefficient for the first surface times area of that first surface plus absorption coefficient for second surface times area of second surface and we keep on adding this, till we account for all the surfaces.

So, this is a sum of all the multiples, of all absorption coefficient and their respective areas divided by the sum of areas. So, that gives us average absorption coefficient for the room and this is for the case, when there are no people. So, when there are no people inside it. If there are persons inside the room, then what do we do? We just modify it a little bit and remember the chart we showed. So, we pick up those absorption coefficients for people, but suppose there are 100 people in the room.

So, then we add alpha p, p is for a person and we do not multiply it, by surface area of an individual, but rather we multiply it, by number of persons. So, if there are 100 persons, because this alpha p already accounts for some rough surface area of an individual. So, this is how we account for the presence of individuals for a window. Suppose, you have a room and there is an open window in it, what will be the value of alpha for that thing well whatever sound energy goes towards the window, it just goes out. So, nothing gets reflected back.

So, for a window alpha is 1, because it absorbs all the sound, nothing gets reflected back. So, alpha is 1. So, this is what I wanted to explain, in context of sound absorption coefficient. Now, we will go back to our original problem and the original problem was that suppose, I have a big room and in this room I have a machine or a place, where lot of noise is getting generated and

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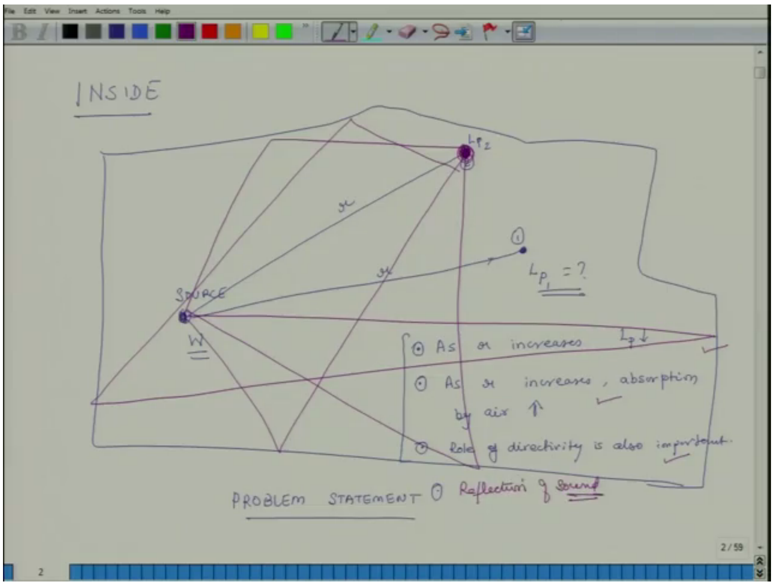

Let us say if the source is generating w watts of noise power and then I want to find out at a distance r away, what is the sound pressure level, this is what I want to figure out.

So, intuitively what do you think is going to matter. See, suppose there were no walls, then we could have calculated the value of Lp using the earlier formula, where we had, we could have used this formula right, but now we have. So, in this formulas there is the role for directivity index, because sound which is being emitted, it may be stronger in one direction, compared to other directions and if we are far away then the sound pressure level will be less and also you have the role of absorption of sound by air.

So, in this case what are different factors? So, let us first list down factors, then we will talk about a mathematical relation, how they are all connected. So, as r increases you would expect Lp to go down, you would expect Lp to go down, second thing is as r increases absorption by air that should also go up. So, when you are going away from the source, even if air did not absorb any sound, even then the sound pressure level will go down and in case air absorbs, then sound pressure will go down even faster. So, that is the second thing, third thing is what you would expect is that if the sound being emitted is uniform, in all the directions then the directivity has no role.

But if this source is emitting more sound in this direction and let us this distance is also r, then you would expect Lp 2, at the second location and this is first location, if the sound being emitted in this direction is stronger, then you would expect Lp 2 to be higher than Lp 1. So, role of directivity is also important. So, whatever mathematical relation, we have it should also account for role of directivity, but there is 1. So, all these factors were present in our earlier case, when there were no reflecting surfaces right, when there is a reflecting surface sound is not only reaching these locations directly, but it also goes to these walls and it reaches the point of interest like this and it is not that it just gets only reaches the point of interest.

So, some once some sound reaches the point of interest directly and some sound reaches there after getting reflected. If it reaches this point of interest, after only one reflection, the reflected amount of sound will be absorbed by lesser amount, but then it will again go and hit another wall, it will again get reflected. So, each successive reflection, the amount of sound which reaches the point of interest becomes less and less. So, based on this physical understanding people have used knowledge of statistics and ray mechanics, some things like that and people have come up with a relation that relation accounts for all these effects, the role of r, the role of sound absorption by air, the impact of directivity, but it also accounts for reflection of sound, because the sound which is being received at the point of interest is partly direct in nature, and it is partly reflected in nature and we have to account for both of those.

So, in the next class, what we will do is, we will actually have a detailed discussion on that particular relation and also using that how can we calculate sound pressure level at the point of interest. So, that concludes our discussion for today and with this I hope that you have a great evening and I look forward to seeing you tomorrow.

Thank you.