Noise Management & Its Control
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Lecture – 44
Noise Source: Sound Pressure Level due to a Noise Source Located Indoors -Part – II

Hello, welcome to noise control and its management. Today is the second day of the eighth week of this course and we planned to continue our discussion which we initiated; yesterday is specifically the topic which we started discussing yesterday was what is the sound pressure level at a point of interest inside a closed room when there is a noise source present in the room.

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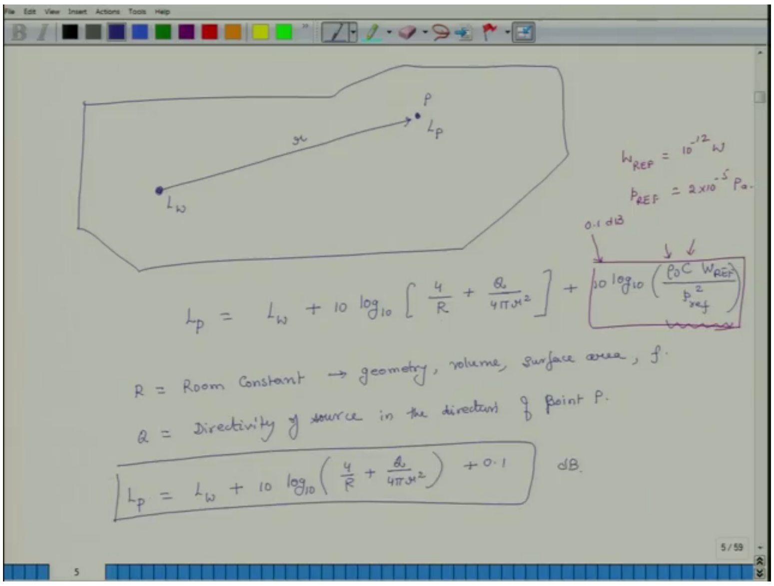

So, I will once again from the close the question using this diagram. So, suppose there is a source which may not be necessarily symmetric spherically symmetric in nature and let us say its sound power level is L p then what we are interested in finding out is the sound pressure level at point p. So, power level is L w and the distance between the source and the microphone is r.

So, based on the discussions which we had yesterday I will directly write down the relation for L w . So, L w and this is based on a lot of mathematics which we are not going to go into. So, I am just going to share with you the results. So, L w excuse me L p equals L w plus 10 log of 10, 4 divided by capital R this R is different than this little r plus Q divided by 4 pi R square plus 10 log of 10 rho C W naught divided by p reference square actually this is not W naught it is W ref and I will explain all of this. So, here what is R? R is a parameter known as room constant, it is a parameter known as room constant it depends on the it is influenced by what it is influenced by geometry of the room its volume its surface area what else and it is also strong function of frequency room.

So, room constant changes with frequency and we will give you an expression for that Q is the directivity of the source it is directivity of the source in the direction of p of point p. So, so it is to directivity index it is directivity. So, a spherical source which is propagating sound uniformly in all the directions its directivity is one and its directivity index will be 10 log of directivity we have discussed this couple of lectures earlier. So, so for a perfectly spherical symmetric source this Q will be one. So, this is there; this parameter. So, C is what C is speed of sound rho is density of air W ref. So, W ref is what it is 10 to the power of minus 12 watts and what is reference pressure p ref is 2 times 10 to the power of minus 5 Pascals.

So, based; so, we know everything in this third component and we can calculate it we know what is C which is about 345 metres per second rho naught is 1.18 W ref is known everything is known. So, if you do all the mathematics it comes to roughly 0.1 decibels. So, we will rewrite this relation and then we will come back to R; what is R. So, L p equals L w plus 10 log of 10, 4 over R plus Q over 4 pi R square plus 0.1 decibels. So, this is the relation.

Now, you would still be wandering what is R? Now Q is will change from source to source, it will depend on the source, but what is R and I said that R is called room constant.

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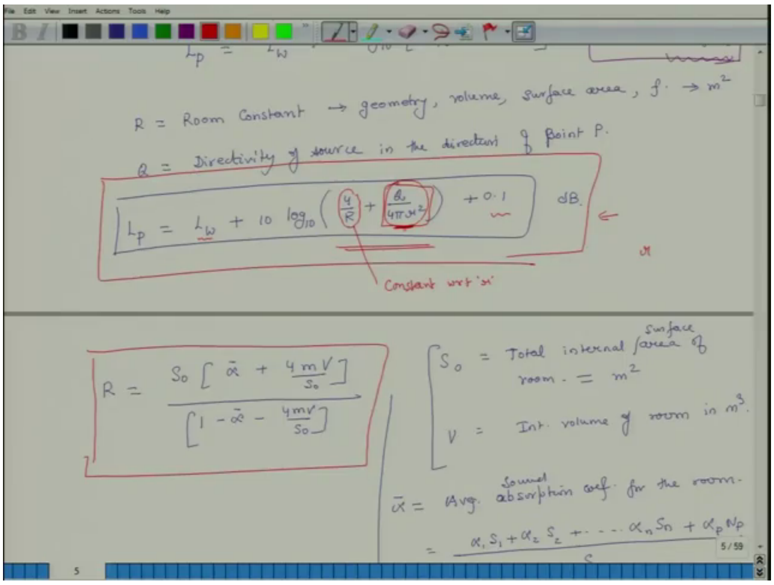

So, function of all these things its unit are metres square and we will give you an expression for R.

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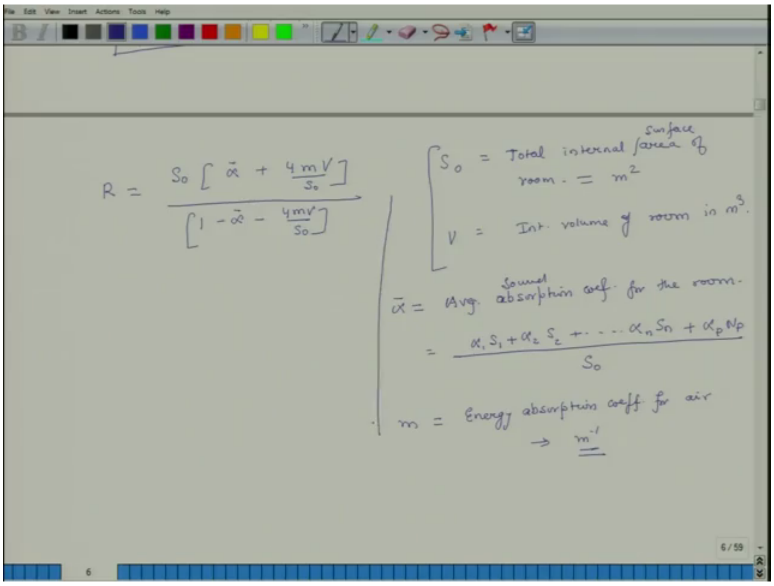

So, R equals S naught times alpha bar plus 4 m V divided by S naught the whole thing divided by one minus alpha bar minus 4 m V divided by S naught where S naught is what it is the total internal area of actually surface area of the room total internal surface area of the room it also should include the area of windows if they are open if you have a large window and it is open does not matter whether its open or close if it is; it should account for all that area.

So, if you have a regular rectangular 6 sided room it will be the area of all the 4 walls plus the roof and the floor. So, that is V. So, this in metres square V is the internal volume of room in meters cube cubic metres and alpha bar is something we have already discussed it is the average absorption coefficient average sound absorption coefficient for the room and we have defined this as alpha 1 S 1 plus alpha 2 S 2 plus all surfaces multiplied by their absorption coefficients divided by S 1 plus S 2 and if you add all of these guys up what you get you get S naught and then of course, there are people in the room then we put alpha P times S N P number of persons I made it clearer.

So, if there are persons also times N P and n is something we have already discussed earlier it is energy absorption coefficient for air and it changes with respect to temperature and humidity. So, you have to put it get the right number corresponding to temperature humidity from standard tables and this is measured in this case in this case because we are in meter land we provide it in meters inverse. So, this is my expression for L p and to calculate L P, I have to know the room constant and this is room constant. So, please remember R is a function of frequency and because R changes its frequency this L p also will change with frequency L p will also change with frequency.

So, you have to remember this and we will underrated this expression more we will do an example, but look at this relation and what you see is that if R is very large this little R if it is large then this term becomes very small this 4 divided by capital R; capital R is a constant. So, that does not change with R radius. So, this is this entire thing remains constant. So, this is constant with respect to R, but as I go further away from the room source this term in the box it becomes progressively smaller.

So, when I am very far away from the room may be this becomes insignificant this term becomes insignificant and the only thing which influences the sound pressure level is 4 over R 4 over R as I am very far away from the room Q over 4; 4 pi divided by R square has no influence then what does that mean what; that means, is that when I am very far away in the room see L w does not change with R this does not change with R the only thing which is going down with respect to R is this term and this also, it does not change then you are very far away right compared to 4 divided by capital R. So, when I you are very away in the room, then the sound pressure level appears to remain as constant why does that happen why that happens is and we will actually do some calculations also to show that.

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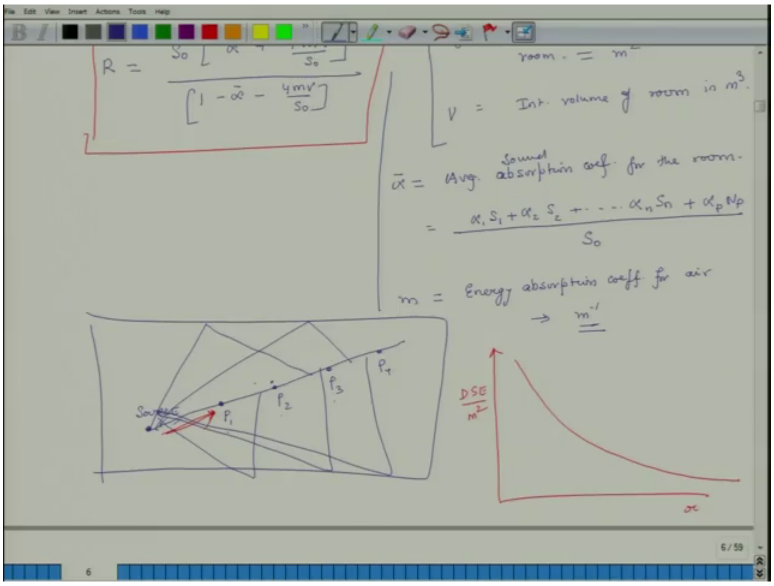

But physically what happens is that when you are here this is your source and let us say you have these are several locations.

So, this is the first point of interest, then you go away further P 2, then you go away further P 3, then you go away further p 4 physically what happens that when you are closed to the to the source close to the source you get more of direct sound energy as you are going further away and away the amount of direct sound energy which you get it keeps on becoming less because the direct sound energy it decays by a factor of 1 by 4 pi R square, right, I mean that is something we have seen in when there are no reflections also. So, direct sound energy at p 1 is highest at p 2 is small at P 3 is even smaller and if I plot with respect to R, this direct sound energy I will draw it the direct sound energy per unit area. So, sound interest is it goes like this and it decays.

So, the direct sound energy becomes negligible when you are far away, but what happens to the reflected sound energy. So, reflected sound energy is all over the place and its influence is virtually homogenous in the entire room because it is bouncing at all frequencies and it is reaching all the places. So, its presence is more or less constant in the whole room. So, what this equation tells us is that when I am very far away from the room this term becomes negligible and this is the term which is due to the presence of reflections and that stays constant. So, that is what dominates the overall system, but when we are very close to the source this becomes very important and this does not dominant any more. So, what we will do is we will also look at an example to understand this better.

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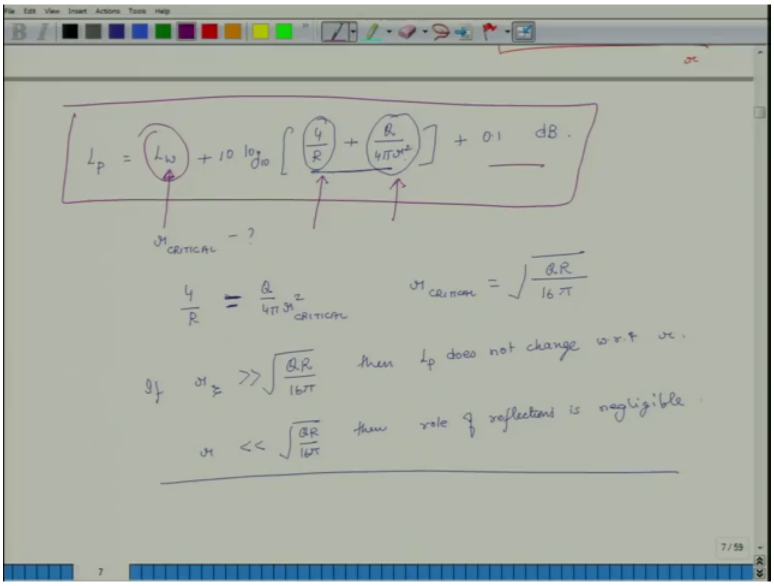

So, but before we do that we will just write this equation one more times. So, we have seen that L p equals L w plus 10 log of 10 4 over R plus Q over 4 pi R square plus 0.1 decibels. So, there is a particular value of R beyond which reflections become more important than direct sound energy and when does that happen when this term becomes smaller than this term. So, we will find out that R critical we will find out the value of R critical. So, when does that happen when 4 by R becomes larger or equal to Q over 4 pi R it equal to one of this thing critical. So, this and this R is where. So, r. So, you do the math you get critical equals Q R divided by 16 pi.

So, if R is very large compared to Q R divided by 16 pi, then L p does not change with respect to R and if R is very small compared to this then what happens role of reflections is negligible and yeah I think I will just stop it right there that point. So, this is what all this means. So, what we will do is we will do an example.

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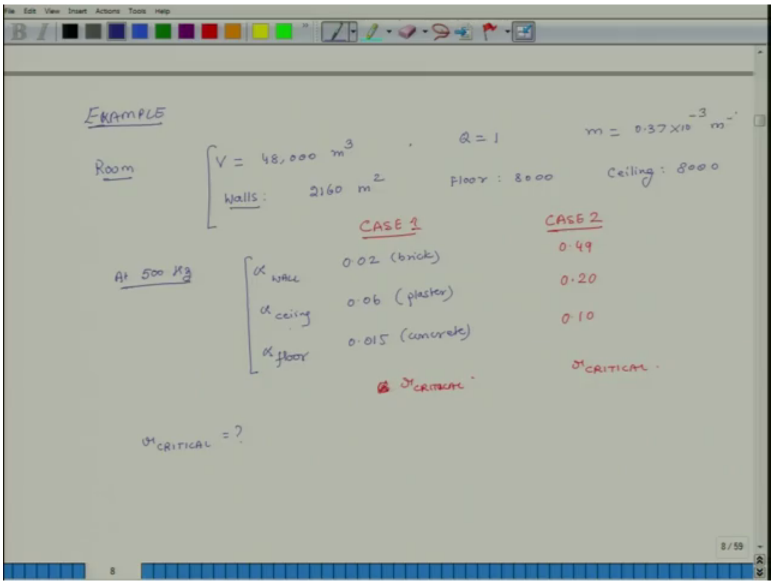

We will do an example and we will say that suppose there is a room and this room is such that its internal volume is 48000. So, these are we are talking specifically large rooms we are not talking about small rooms like we have in drawing rooms because we are typically interested in finding out what happens to the noise level when we are in a shop floor or in a factory where the rooms are very large.

So, V is equal to 48000 cubic meters and then the walls have an area of 21600 meter square and then there is floor its area is 8000 and ceiling or roof is also 8000, we assume that we are putting a Omni directional source in it. So, for an Omni directional source Q is equal to 1 and the directivity index is 0 the additional log of that and then at 500 hertz what we are doing is that at 500 hertz, we are defining specifying the absorption coefficient for different materials. So, alpha wall is equal to 0.02. So, this is for basically brick alpha ceiling is 0.06 this is our regular ceiling which we have some plaster with line and then alpha floor alpha of the material for the floor is 0.015 and we are assuming that it is made up of concrete.

So, and this; these are the material properties for wall ceiling and floor at 500 hertz you can you can do similar mathematics for different frequencies. So, then the question is what is R critical; what is R critical? So, this is case one and then we will do another case where we apply some sound absorbing materials on different surfaces. So, instead of having brick walls of course, we are having brick walls, but we are also putting some curtains on the walls. So, in that case this 0.02 it becomes 0.49 because once you hang curtains this I am getting from the table it becomes point 4 nine and then the second case alpha ceiling what is the situation.

So, I am lining up my ceiling with some false roof and in that case this sound absorption coefficient for the roof at 500 hertz becomes 20 percent and the floor I start using some I start putting some this plastic sheets linoleum sheets. So, this becomes 0.1. So, I have to find alpha critical R critical for this case and R critical in this case and we are interested. So, let us do the math. So, if I do. So, first thing what do I have to do I have to calculate Q is one it is given I have to calculate this room constant then I divided by 16 pi and then take the square root, but then what is R? R is S naught times alpha bar plus 4 m V by S naught divided by this entire thing. So, I have to alpha bar as a first step oh by the way also I am I have given that m equals actually it is a very small number 0.37 into 10 to the power of minus 3 meters inverse. So, given m is also needed.

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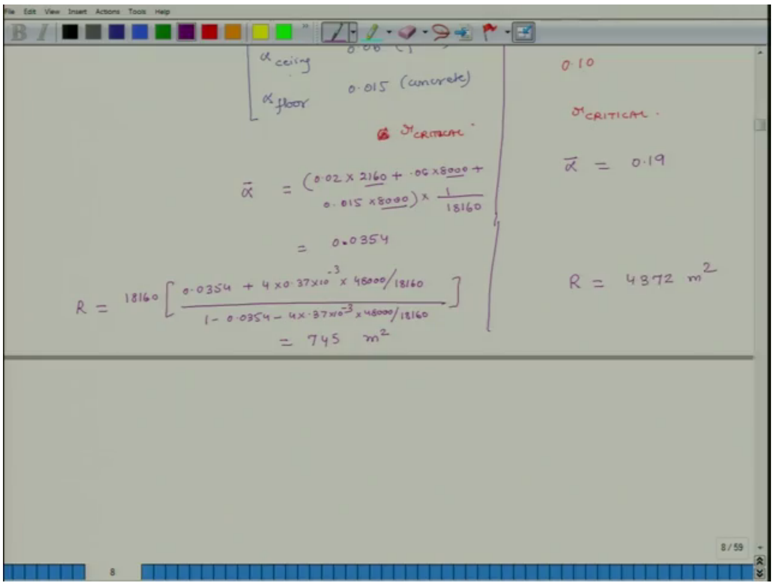

So, first we calculate alpha bar. So, alpha in this case is what it is equal to 0.02 times area 2160 plus 0.06 times 8000 plus 0.1 015 times 8000 into one by sum of 2160 80; 8000, 8000. So, it is 18160 and you get alpha bar to be about 3.5 percent 0354 and in this case if you do the math similarly the value of alpha bar comes to 19 percent 0.19. So, the next thing is we calculate our room constant. So, room constant in the first case is what it is; S naught. So, S naught is 18160 into alpha bar; so, that is 0.0354 plus 4 m V divided by S naught.

So, m is 0 point how much. So, 3; 7 into 10 to the power of minus 3 times the volume of the room which is 48000 divided by the area of the room 18160 and this entire thing is divided by one minus 0.0354 minus 4 into 0.37 into 10 to the power of minus 3 into 48000 divided by 18160 and if you do all this calculation. So, the units of R will be in square meters 745 meters square and here if you do the math you find that R comes out to 4372 meters square.

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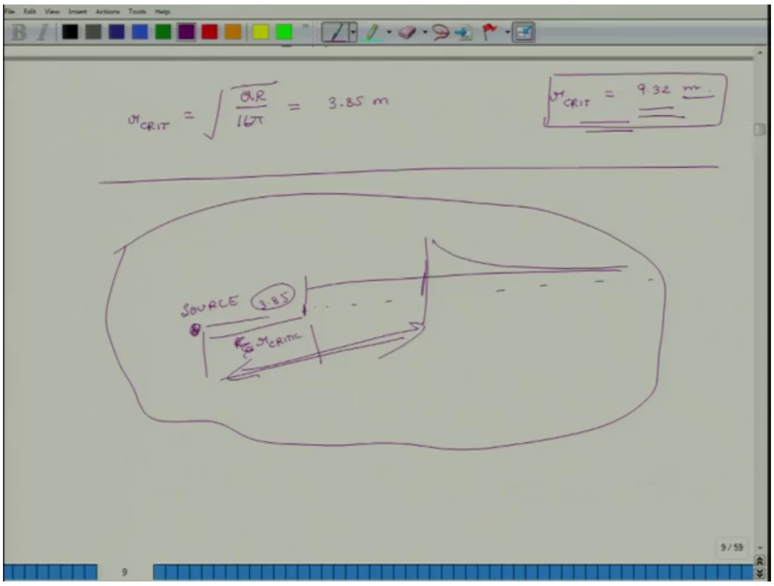

So, R critical R critical equals Q R divided by 16 pi, then what does that come out to if you put plug in 745 you get 3.85 meters and here it is equal to 9.32 meters.

So, what does that mean what; that means, is that in this room at 500 hertz in this room. So, suppose this is complicated room with all the surface area and volume which we have discussed and this is your source at 500 hertz if I do not put all these curtains and all these sound absorbing materials sound field. So, this is R critical; R critical excuse me R critical. So, this is just 3.85 meters. So, beyond this as you move away from it sound field becomes more or less increasingly constant it changes rapidly in this zone, but beyond this it starts becoming more and more constant, but if I have more sound absorbing material if I have more sound absorbing material which is the second case then this 3.585 meters becomes 9.32 metres and why is this happening you should understand this.

When R critical becomes larger; what is happening R circuital has become larger why because I have more sound absorbing material when things are more sound absorbing material the materials are more sound absorbing then reflection become less and the situation becomes more and more like outside and as situation becomes more and more like outside and what happens on outside you keep ongoing further and further sound level keeps on decaying every time you double it; it decays by 3 decibels. So, same thing is happening in the room also if you have more sound absorbing materials then the room then the noise level beyond a certain this R critical it rapidly becomes constant and this R critical becomes longer and longer it becomes larger.

So, this is an important thing and I think this concludes our discussion for today starting tomorrow we will start going into now another direction because now that we have learnt how to calculate sound pressure level in room and also outside room now we will start trying to figure out how to estimate the value of L w .

So, because in this relation we know how to calculate this parameter we know how to calculate this parameter this is already known this L w depends on the sound source and based on different types of sources the value of L w is different suppose you have a motor what will be a typical value of L w suppose you have a compressor or an industrial fan what will be a typical value of L w. So, we learnt how to estimate not exactly calculate, but get a ballpark figure of the value of L w. Now once we have L w , then we can calculate L p and then we can figure out if we want to reduce this L p or we are comfortable with this L p because this is what we will be listening. So, that concludes our discussion for today and we will once again meet tomorrow.

Thank you.