Noise Management & Its Control

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Lecture - 65
Acoustic Barriers – III

Hello, welcome to Noise Control and its Management. Today is the second last day of this week and what we will discuss today is all about indoor barriers how do we go around designing them.

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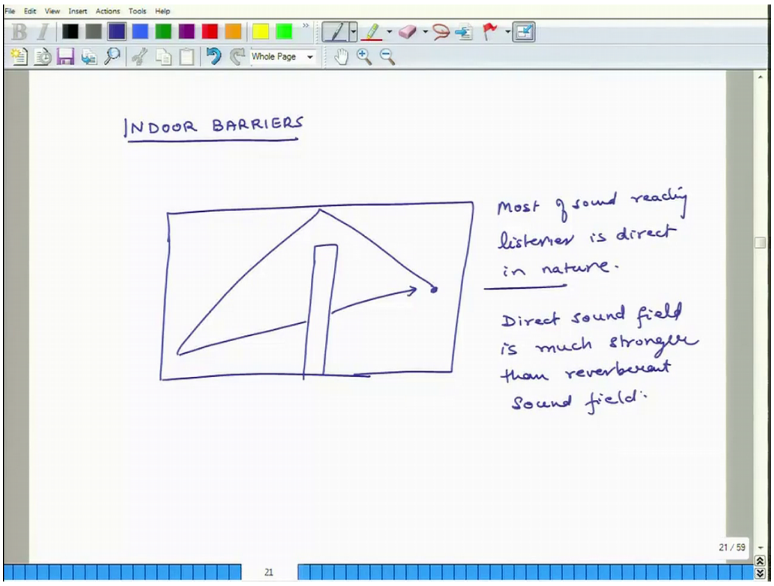

So, unlike outdoor applications for indoor barriers a significant differences that we also have a significant amount of reflected or reverberant sound. So, if you have a large room and this is a barrier, some sound may directly reach the person through reflections and then some sound will get obstructed as it reaches the listening position.

So, indoor barriers are particularly effective if most of the sound reaching listener is direct in nature. Other way we can say is the same thing that indoor barriers are effective when direct sound field is much stronger than the reverberant sound field.

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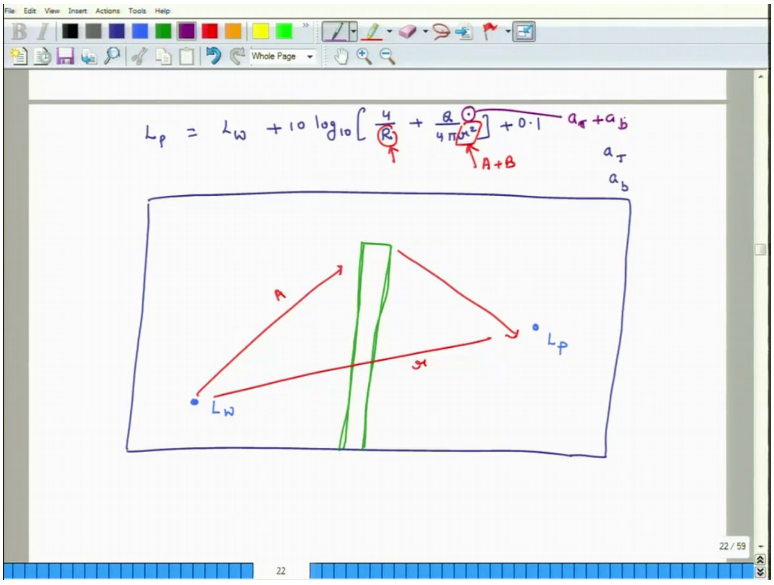

Now consider the situation that we have a large room and there is no barrier. So, this is our sound source this is the listening position this is emitting w watts. So, here the sound power level is L w the sound pressure level is L p and if there is no sound. So, no barrier then how do we predict suppose this distance is r then L p is equal to L w plus 10 log of 10 4 by room constant plus Q by 4 pi r square plus 0.1 right this is the relation we have discussed still so far.

Once the barrier is introduced think about it what happens suppose I introduce a barrier here what I have effectively done is that I have introduced 2 more I have done 2 things, I have introduced 2 more reflecting surfaces this is the first reflective surface this is the first reflecting surface right. So, sound will come here and it will get reflected and it may bounce and it may still reach here that is one thing that I have done. So, once I have added a reflecting surface this R will change which is room constant right, their value of R is going to change. So, I can use the small relation may be if I can adjust for the room constant.

The second thing which I have done is that the diffracted sound directs a diffracted sound goes like this which is distance A and it comes like this. So, a original distance was r, but now instead of r I have to replace this by A plus B because the sound which goes directly to which goes directly to the listening position a travels a distance of A plus B. So, this r becomes A plus B. The third thing is that not all the sound goes to the other end, but only a portion of it goes to the other end right, and how much of it goes the amount of sound which reaches the other end is some of the sound is transmitted and that fraction is 80 and some of it is diffracted and that is A b. So, instead of this thing in the numerator I also introduce a new term right and that is a T plus a b.

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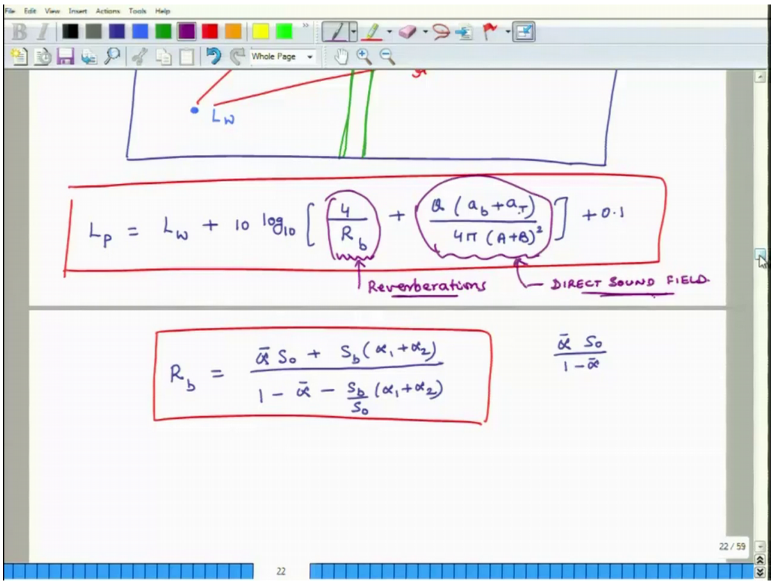

So, if I have barrier then the value of L p can be calculated by L w plus 10 log 10 of 4 over room constant, but the room constant with the room with the barrier. So, I will call it R b plus directivity of the source times a b plus a T if all the sound was getting transmitted to diffracted then this number will become 1 right, but only a fraction of it is going to the other end divided by 4 pi times A plus B whole square plus 0.1.

So, the other question is that we know how to calculate a b through the relations which we had discussed earlier we know how to calculate a T we know what is a and b, how do we calculate the revised room constant. So, the answer to that is simple. So, R b is equal to, the original relation was what R was equal to alpha bar S naught divided by 1 minus alpha bar this was the original relation, but now we have some extra reflective surfaces. So, I have to account for that. So, it is now alpha bar S naught plus I have some more surface. So, let us say the surface of barrier is s b times alpha 1 plus alpha 2, and what are alpha 1 plus alpha 2? Let us say alpha 1 is the absorption on this surface and alpha 2 is absorption coefficient on the second surface because they are 2 surfaces which are going to absorb sound.

So, it is, this is the total area times their absorption coefficients and when the numerator also I introduce these things. So, first I compute R b and after I compute R b then I can use that R b to compute L p. So, this is there. I have to make couple of other observations. This term is because of reverberations because of repeated reflections, this term is because of direct sound field I mean when I say this term this it means this entire thing and same thing here also.

So, the barrier will be in particularly more efficient if this direct sound field term is much larger compare to the reverberation term and we will actually do an example and we will see that because there is only so much you can change R b, but this you can significantly influence. So, if the direct sound field is strong in the room to begin with a barrier can do a very good job in terms of reducing the overall sound pressure level. So, we will do an example.

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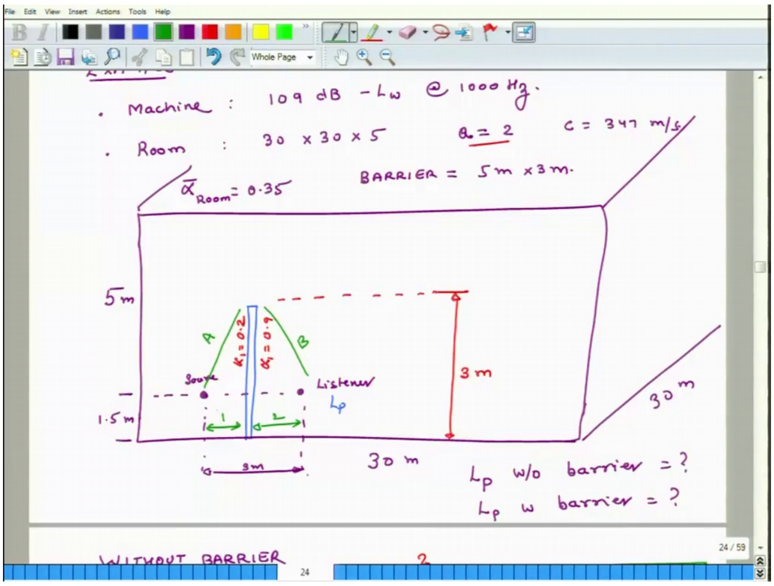

So, here there is a machine and it is generating 109 decibels this is the sound power level at 1000 Hertz. So, for 1000 Hertz band it is generating 109 decibels. And this machine is in a room the dimensions of the room are 30 by 30 by 5 meters. So, we will actually draw it. So, this is 30 and this is 30 meters wide. So, it keeps on continuing on the back and the height is 5 meters, and let us say the machine is somewhere here. And then there is a person who is operating it and the person is he is remotely controlling the machine or he sits there and whenever he has to change he comes and changes the machine, but he is hearing a lot of noise coming from this machine. So, this is the machine source and this is the listener and both of these guys are at a height of 1.5 meters away from the floor.

So, person is standing and maybe he is also sitting on some erased platform. So, his ears are 1.5 meters above the ground. And the overall distance between these 2 individuals is 3 meters. The directivity of the machine is 2, directive factor is 2. So, the question is if I introduce a barrier, if I introduce a barrier what will be the sound pressure level and if I do not have the barrier what will be the sound pressure level that is at this location. So, to know that I have to give some details of the barrier also, so on this surface alpha 1 is 0.2 and on the other surface alpha 1 is 0.9 and the barrier is overall 3 meters tall, the height of the barrier is 3 meters and the speed of sound is 347 meters per second.

Finally, the dimensions of the barriers, so this barrier is 3 meters tall and the size is 5 meters by 3 meters. So, it is 5 in the depth direction normal to the plane of your television screen or laptop and its 3 meters tall. So, these are all the data on the problem and the question once again is what is the value of L p without barrier, what is this value an L p in presence of barrier with barrier, you have to compute these. So, what we will start with without the barrier condition.

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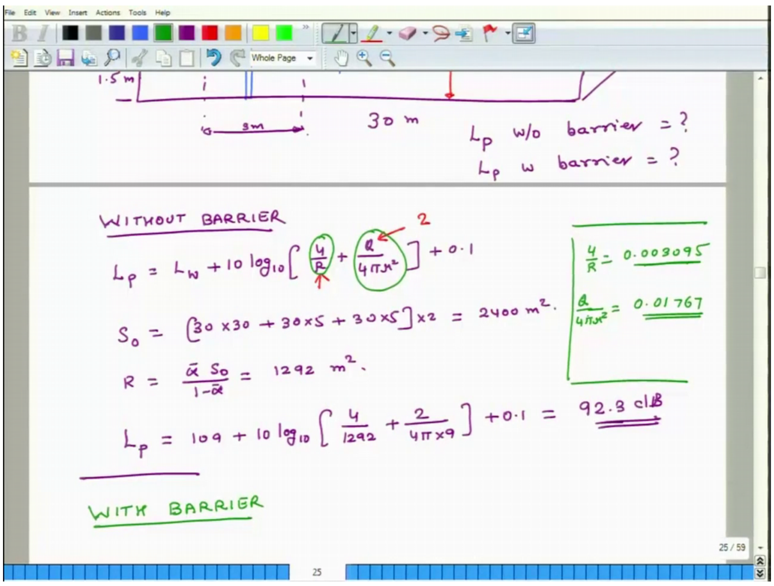

So, without barrier I know that for a closed room L p equals L w plus 10 log of 10 divided by 4 over R plus directivity index divided by 4 pi r square plus 0.1, but I do not know the room constant. So, I have to calculate the room constant. So, to calculate the room constant I have to know the internal surface area. So, surface area of the room is how much? 30 times 30 plus 30 times 5 plus 30 times 5 times 2 is equal to 24000 meter square and then I forget to add one data which was is also given is that the average surface absorption coefficient of the room is 0.35. So, with that understanding the room constant is what alpha bar times S naught divided by 1 minus alpha bar and that works out to be 1292 square meters.

So, now I know R. So, I know this value, Q is the specified as 2 it is given Q is equal to 2. So, L p sound pressure at the location of the listener is L w L w is 109 decibels plus 10 log of 10 4 by 1292 plus Q 2 divided by 4 pi into 9 plus 0.1 and that is equal to 92.3 decibels. So, again this is a very high sound pressure level you do not like this at all, a person will go deaf if he gets exposed to this pressure level for extended periods of time. So, you want to reduce it. So, our next job is with barrier.

So, before we compute this I also wanted to show you some numbers. So, if you do this 4 over R you calculate you find that its value 0.003095, 4 divided by basically 1292 it comes to 0.003095 and Q divided by 4 pi r square, this if you do the calculation it works out to be 0.01767. Now, we had said earlier that this term is related to reverberation and this term is related to direct sound and we see that the magnitude of the reverberation component is very small compare to the direct sound field. So, because we are seeing we think that if we put a barrier in this situation it will work. If these numbers were close to each other or if the direct sound field was weaker than the reverberant field then we would not consider barrier as a potential solution. So, now, we go back and we compute R b.

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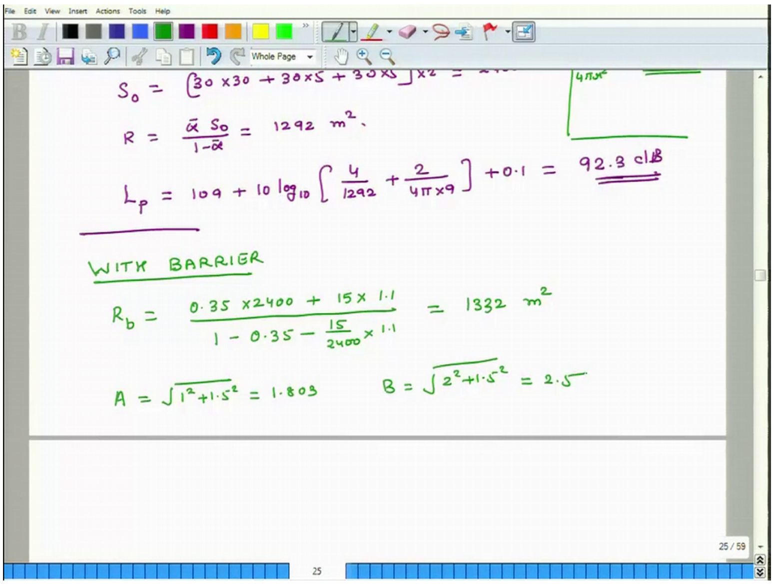

So, what is R b? R b is 0.35 times 2400 plus the area of the barrier an area of the barrier is 5 times 3 into alpha 1 plus alpha 2. So, that is 1.1 divided by 1 minus alpha bar minus area of the barrier 15 divided by area of the room 2400 times alpha 1 plus alpha 2 1.1. So, that works out to 1332 square meters.

The next thing we compute is A. So, what is A? A is this distance and this is B. So, A is basically this distance is 1 meters, a 2 meters. This is 1 it is given and this is 2. So, this is 1 square plus 1.5 square the whole thing square root. So, A is equal to 1 square plus 1 point square is equal to 1.803, A equals 2 square plus 1.5 square equals 2.5. So, now, we have computed A and B and where do we use this A and B, we use A B in this relation, but we also have to compute barrier coefficient and the barrier coefficient we compute by first finding out Fresnel's number which we discussed in the context of barriers outside and then you use that tan hyperbolic relation to compute the barrier coefficient.

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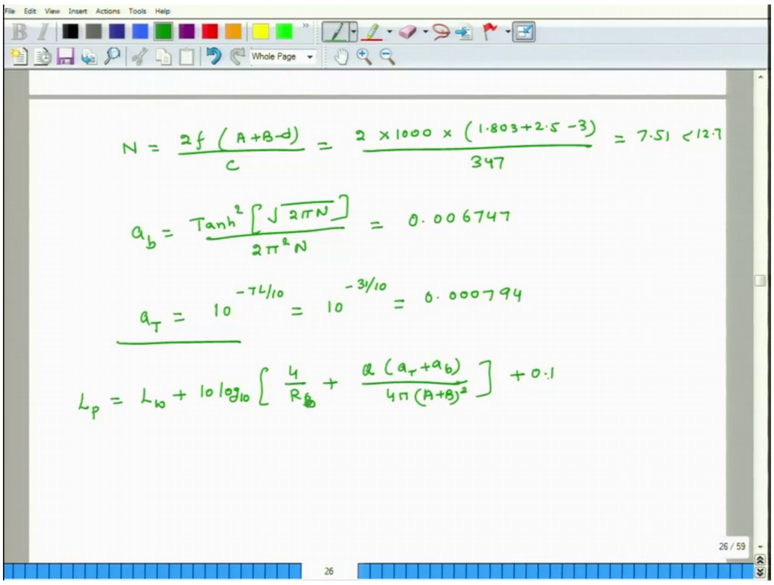

So, Fresnel’s number N equals 2 f times A plus B minus D divided by C and that is equal to twice of 1000 Hertz times 1.803 plus 2.5 minus 3 divided by C, C is 347 and that is equal to 7.51. So, again it is less than 12.7. So, A B equals tan hyperbolic square of root of 2 pi N divided by 2 pi square N and if you do all the math you get 0.006747.

And then a T which is the transmission coefficient for the barrier is what 10 to the power of minus transmission loss by 10 and the problem tells us may be I did not specify earlier which is my mistake transmission loss for this barrier we are specifying it as 31 decibels at 1000 Hertz. So, this is one data I had omitted I am sorry. This transmission loss number will help us compute a T. So, this is equal to 10 to the power of minus 31 divided by 10. So, that is equal to 0.000794.

So, now with all this data we compute L p, L p equals L w plus 10 log of 10 4 over, R B plus times a T plus a b divided by 4 pi times A plus B whole square plus 0.1.

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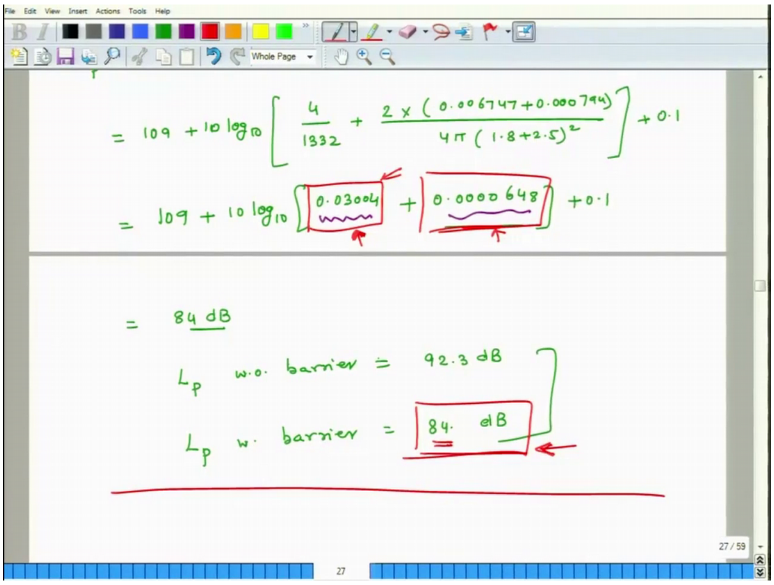

So, this equals L w is how much 109 watt decibels plus 10 log of 10, 4 divided by 1332 square meters that is the room constant with the barrier plus directivity index is or directivity factor is 2 times a T 0.006747 plus 0.000794 divided by 4 pi times 1.8 plus 2.5 square plus 0.1.

So, we will I can directly write the answer, but I wanted to show you something extra. So, I will actually compute these numbers. So, 4 by 32 it works out to be 0.03004 and this other term it works out as 0.0000648 plus 0.1. Now you see this term Q over 4 pi r square was attributable to the direct sound field it was 0.01767, this number has gone down very significantly almost 99 percent of that thing has vanished because this is the direct sound field term. This number is the reverbing field term it was 0.03004 and it was 0.003095, so not a whole lot of difference between these two.

So, once again we are seeing that the barriers are do a good job in reducing the direct sound field, but not such a great job in reducing the reverberant sound field. So, finally, I do is 84 decibels. So, L p without barrier was how much 99.3 decibels, an L p with barrier is how much its 84 decibels and most of this reduction has come because of reduction in this term. Now if I reduce this term even further this 84 decibel will not go down any significantly because it is already pretty close to 0 right its already pretty close to 0, but the barrier will do a bad job will not do a such a great job in reducing this term.

So, if I want to significantly go down below 84 decibel level then I have to do something different than just a barrier the barrier this is probably my limit up to which we can go down to in close doors. In open doors situations this term will not be there, so does not matter, but in close doors this term does not change much and this is probably the roughly the lowest possible value which I will get in terms of L p. So, we do get good amount of sound reduction in case of barriers located inside a room, but the magnitude of this sound reduction from barriers which are located inside the room is not that large as compared to the if you place the same barrier outside it is a much larger reduction.

So, that is all I wanted to discuss for today and with this I conclude our discussion we will meet once again tomorrow which is the last day of this class. And till so far we have been thinking of how to control and reduce noise levels by either stopping them or reducing the overall sound power level. Starting tomorrow we will start looking at different ways some other ways is specifically how we can suck in not necessarily absorbed the sound, but suck in a particular frequency by using some specific resonators and things like that and specifically we will use this term called Helmholtz resonator.

So, if you have a particular sound in a room or outside and it is dominated by one single frequency then probably you can use something known as a Helmholtz resonator to reduce that sound by significant fraction because that resonator has an ability to absorb or suck in a particular frequency very effectively. So, that concludes our discussion and I look forward to seeing you tomorrow, bye.