Noise Management & Its Control
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Lecture - 57
Reverberation Time - Example Problem

Hello welcome again to noise management and its control, today is a third day of this week and what we will do today is we will complete our discussion of reverb time which we had initiated in the last class.

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And the last class we were computing the reverb time for this room and we will, what we said was that we will compute the reverb time for this room using both the methods.

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One is when where we use the relation as, an this to compute absorption units.

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And in the second case we use the Fitzroy equation to compute absorption units and see what kind of a difference does it make in terms of r estimate for the reverb time. So, what we had calculated was that alpha bar is 0.236, if we use the first method and using this I compute a to be s naught natural log of 1 over 1 minus alpha bar and s naught we already computed as 150 square meters. So, what I get from this is 40.41 meter square.

So, my reverb time in this is comes out com comes out to be 55.26 times 115.32 divided by 343.8 times 40.41 and that is equal to 0.459 seconds so this is my reverb time. Now, let us computer, but using the other method because we have already said that it is likely that this approach of computation may not be accurate because the rooms reflecting surfaces have significantly different absorption characteristics in different directions. So, if that is the case then probably it is safer to use this Fitzroy equation to compute the parameter a. So, to do that we have to complete all these parameters s x alpha x and all that stuff. So, let us first do that, so what is s x, s x is equal to 2 into 6.2 times 3.1 is equal to 38.44 and alpha bar for the thing is 0.06 ok.

Then s y is 2 times, 6 times 3.1 and that is 37.2 and alpha y bar. So, alpha y bar computing that will be a little tricky. So, we will do that so alpha bar in the x direction is 0.06 why do I say its 0.06 look at this. So, before we do all this let us first let us say this is my x direction, this is y direction and this is z direction actually I used a slightly different convention. So, this is y and this is x. So, the area in the x direction is 6 point 2 times 3 that is how we have computed right and 6.2 times 3 and the surface and the absorption coefficient of this surface 6.2 times 3 and also the back surface is 0.06 and there is no door and anything like that. So, the overall surface absorption coefficient in the x direction remains 0.06 now we will do the calculation for y direction ok.

So, surface absorption coefficient in the y direction is 0.06 times 2 into 6 into 3.1 minus the area of the door, minus the area of the door. So, what is the area of the door 1.2 times 1.1, oh 2 point it is I think. So, that is and then I have to compute the effect of the door. So, it is 0.05 times 1.1 times 2.2 and then I the total area is 37.2. So, that is comes out to be 0.0593 and then s z is 2 times 6.2 times 6 is 74.4 and alpha z bar equals 0.38 or actually will do that computation because again they are different surfaces. So, alpha z bar is 0.21 times 37.2 plus 0.55 into 37.2 divided by 74.4 and that works out to be 0.38. So, if I use the Fitzroy as relation I get a is equal to 16.25 from Fitzroy's relation. So, I just plugged in all this value and get a, but we have still not accounted for the role of people, we have not accounted for the role of people.

So, a with people, is equal to a without people which is 16.25 and then we add the effect of people and that is 0.44 times 6 and you do that so you get 18.89. So, continue this discussion T rev in this case is equal to 55.26 times surface area of volume 115.32 divided by speed of sound 343.8 multiplied by a with people and that comes out to be 0.981. So, you see that the value if I did not used Fitzroy relation would be half and maybe it will be totally of compare to the one which is computed through the Fitzroy relationship and the reason for this is because, the surfaces are significantly different in terms of their absorption characteristics.

If that is the case then we have to use Fitzroy, now we are fairly comfortable with how to compute the reverb time and we have to, but the next step is we have to get an idea that whatever is the reverb for the room which we are calculating is that reasonably short or not, see if it is too long then there will be problem with the noise right.

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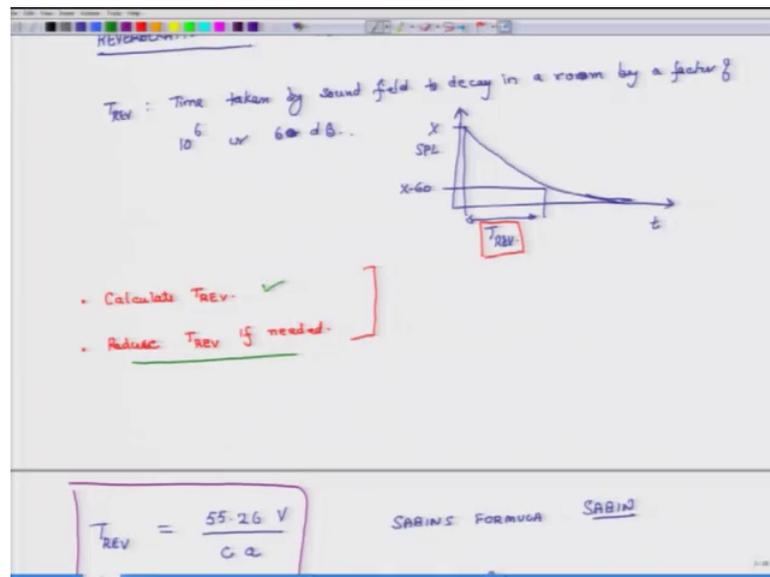
So, as I had discussed earlier calculate T rev, we know how to do that and the second thing is reduce T rev if needed and the only way to understand whether we have to reduce it or not is we have to have a target reverberation time. So, how do we know what is the reverberation time for the room which is desirable.

So, what is optimum T rev, if the reverberation time in the room is too large then the sound becomes unintelligible, you cannot understand it clearly. If the reverberation time is extremely small you will be able to understand what is being said, but you will have a very unnatural experience because our in most of the practical or real life situations we do here some amount of reverberation energy and if that energy is not there then you will have a very unnatural experience of the sound. So, that is also not desirable.

So, we do require some reverberation time, but not necessarily 0 and the amount of reverberation time we require is based upon experience a lot of empirical data and so on and so forth. So, what we are going to discuss in today's class is a very brief discussion on what is a good reverberation time and it has limited applicability, but you can use similar approach to figure out what is the reverberation time in the context of your specific application as well. So, T rev opt, optimum that is given by another empirical relation and the value is can be calculated by a constant k 1 plus 2.3026, constant k 2 log of 10 v and v is the volume of the room in cubic meters. This has relation was developed by Beranek and these constants k 1 and k 2 he had measured and com he had measured

and arrived at their estimates for situations which are particularly specific to western societies. So, I will and he has given us a table. So, I will show you the table which tells us what these constants look like.

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Values of k_1 and k_2 for different rooms/halls

Application	k_1	k_2
Catholic churches	0.098	1/5
Protestant churches	-0.162	1/5
Music studios	-0.352	1/5
Conference rooms, movie theaters	-0.101	2/15
Broadcast room	-0.192	1/9

Source: Date from Table 7-3A, Industrial & Noise Control, Barron, 2003

So, these are the values of k 1 and k 2 for different rooms and halls different types of applications right. So, it is a western society to have, they have different type of churches.

So, for those churches, if it is a catholic church because the internal shape and architecture of churches are different then k 1 he said was should be somewhere close 0.098 and k 2 should be 1 over or 1 divided by 5 and for different types of church protestant churches it was a different number and then for music studios the number is minus 0.3521 by 5, for conference rooms it is a different thing and so on and so forth.

So, these data I have extracted from this book industrial and noise control written by Barron and, but these were originally estimated by Barronic and in this book also he is drawn up on this data from Barronics work. So, the point is at least in our context of our country or in this geographical area, may be these charges and these things may not be that much relevant, but there is data related to other applications for these things also.

So, if you so the point is that knowledge about k 1 and k 2 then you can use this relation to compute what is the optimum reverberation time, let us say that the application of the

example for which we have done all these calculations this is for a conference room, where there are 6 people 6 to 8 people who can sit and have a small conference.

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So, if that is the case then from the table which I had shown earlier k 1 is minus 0.101 and k 2 is 2 by 15 and T rev opt is equal to minus 0.101 plus 2.3026 times 2 by 15 log 10 of the volume of the room 115.32 and that works out to be 0.532 seconds.

So, our goal a good conference room where 6, 7 people can sit and they can have intelligent conversation the reverberation time should be 0.532 seconds in our case t rev is 0.982 seconds, which means that our room is not well designed to meet our goal it is off by the goal by a significant fraction, it is almost ninety percent away from its goal. So, the question is how do you bring down this. So, how do you reduce T rev from 0.982 to 0.532, seconds this is a question. So, the answer to that is you go back and look at the equation.

So, the equation says, this is our equation for reverberation time, the equation says that reverberation time equals 55.26 times volume divided by c divided by a, now the room you cannot make it smaller. So, if you have to reduce reverberation time either you reduce v or you increase c or you increase a, you cannot change c because it is speed of sound you cannot reduce the volume of the room because the room is fixed. So, the only thing you can play with is absorption units a.

So, we have to somehow increase a if I increase a by a factor of 2 my reverberation time will become half. So, how do I increase a? So, I have computed my a, based on this relation Fitzroy equation and we see that inverse of a depends on s x, s naught and all these things right alpha x bar, alpha y bar and what we are seeing is that alpha x bar and alpha z bar we have calculated it, this is alpha x bar, this is alpha y bar and this is alpha z bar. So, alpha z bar is reasonably large, see I will go back here, if alpha.

So, think about it as alpha approaches 1, as alpha approaches 1 the term in the bracket becomes close to 1 minus 1 which is 0, as alpha approaches one this becomes closer and closer to log of 0 which means this term becomes, overall this term becomes very small. So, as I n f because log of as you increase. So, what is log of 0.1 is minus 1, log of 0.01 is minus 2 right, log of 0.001 is minus 3 right. So, as this term in the parenthesis is becoming small the denominator is becoming larger and as it becomes larger the overall

term which I have answered it becomes smaller, if this becomes smaller 1 over a will also become small, which means a will become large right.

So, if I have to increase a I have to increase 1, I have to increase my alpha bars I have to increase my alpha bars. Now, alpha bars are already reasonable large as it is already reasonable large for the z direction, but for y direction and x direction it is small. So, if I can use appropriate material on these 4 walls. So, this is so alpha. So, this is y, this is x, on the 4 walls if I somehow increase a more you know sound absorbing material then I should be able to reduce this 0.982 to 0.532. So, if I use heavier curtains or more better sound absorbing materials or having some false panels behind which there is some air gap all those types of techniques can help me reduce alpha ak help they will help me increase the value of alpha x bar and alpha y bar significantly up and that will cause this T rev to go down. So, I have to again engineer and see what kind of materials I can use to improve.

So, that my reverberation time goes down from 0.982, 0.532 seconds. So, this concludes our discussion on reverberation time and what we will do starting tomorrow is we will start discussing about enclosures because in our earlier class the first week we had said that can reduce the airborne noises especially by abstraction and by abstraction I can either enclose it or I can put walls or partitions and so on and so forth.

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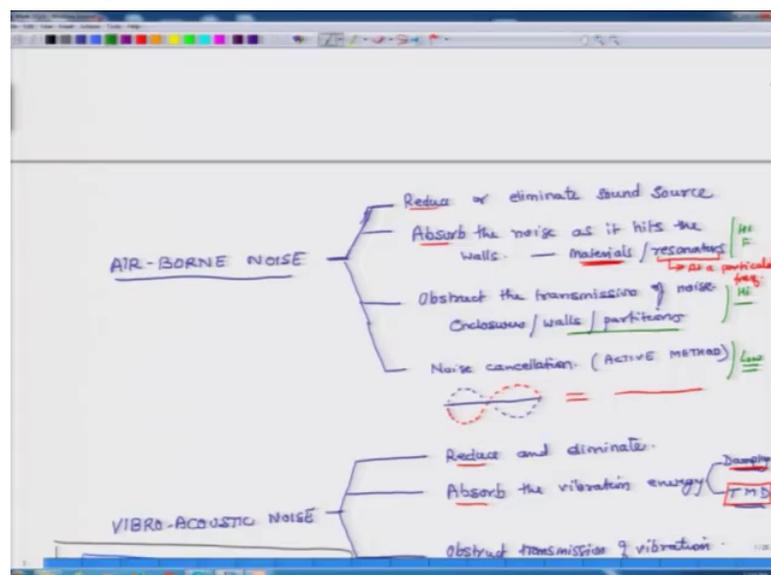
So, what we will start looking at is how can we create enclosures around sound producing objects and what kind of noise reduction they can lead. So, that concludes our discussion for today and I look forward to seeing you tomorrow.

Thank you very much.