Architectural Acoustics
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Lecture – 22
Introduction to Auditorium Design
(Contd.)

So, in the earlier lecture, that is lecture 21 we have introduced certain matrix to measure or to understand the sound quality or the acoustical quality within an auditorium. So, today in this lecture, we will try to see the different shapes of the auditorium and the seating plan within the auditorium, what from the perspective of an architect, who will only design, but who will also consider acoustics and design.

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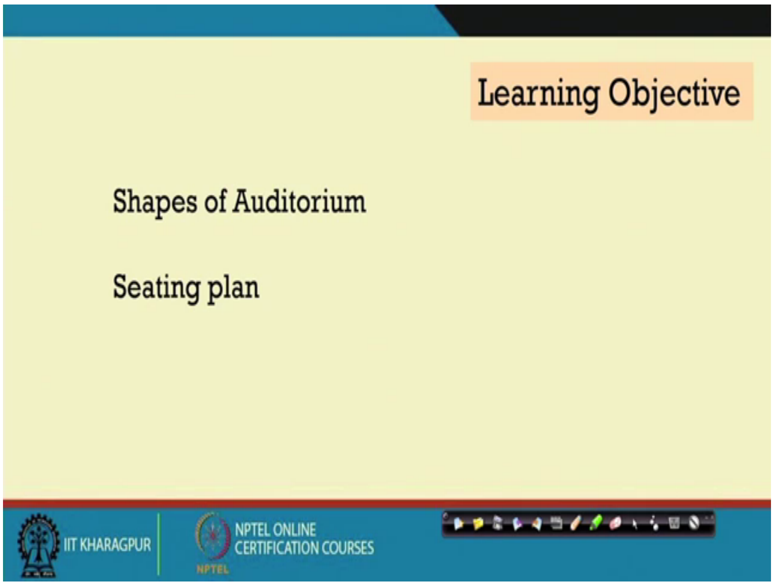

So, we had talked of liveliness we have we had talked of loudness intimacy, clarity, early decay time, we have talked of warmth and brilliants and also intimacy. If, you remember the last lecture, you have seen that all these were measured by the sound pressure level in different forms.

And finally, it was the basic energy, sound energy, which was distributed in the space and was it was and it was it is always desired to spread that sound energy as uniformly as possible and as lively as possible. So, that people have or the audience have a feeling that the sound is all coming from the stage and they are intimate to it. They are getting every portion of the music or the speech very clear and proper to the best achievable possible.

So, as an architect, if you account for all these are all these matrix and try to start your design, then you will always end up with a better acoustical plan, better architectural plan which will serve the best better acoustics also. So, if we start the shoebox halls, which started when with the at the initial times with the classical stages, classical halls you will see that it these were quite successful.

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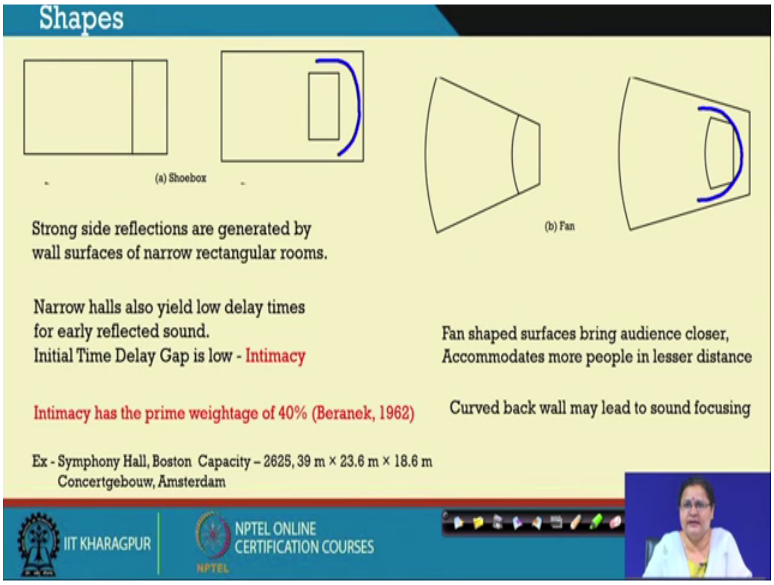

That was because of the strong side reflections these were very narrow rectangular rooms and the side reflections, the lateral reflections, which help in creating the spatial impression were very well achieved. So, these narrow rooms rectangular halls which had a height, good height were actually ruling or were actually felt as the basic form. These narrow halls yielded low delay times for early reflected sound, which led to intimacy. So, the Initial Time Delay Gap that was ITDG, which was around to be achieved around 12 to 25 milliseconds, were really possible in these halls and they became very intimate halls.

Beranek at some point in 1962 I have told that intimacy has the highest weightage of 40 percent, that is bringing the audience close as if the performance is happening in a room, not physically bringing them close, but the sound being as if the source is very near to them. So, they will have a room kind of effect. And, that was given that attribute is given

40 percent weightage while design. So, to that is achieved in a shoebox hall and we see the symphony hall of Boston, which was first designed for the acoustics was designed by Clemens Sabine, the father of architectural acoustics was really a rectangle. And, it was you can see the audience size 2625, was the audience size and the hall dimension is 39 meters into 23.6 meters into 18.6 meters height.

So, you can imagine the such a big hall with; obviously, electro acoustical reinforcements other than these lateral impressions, lateral reflections, we also see the concept Tebow hall of Amsterdam many other halls are shaped as a shoebox. Contrary to it you see the fan shaped hall. In the 4 pictures you see 2 of them has their stage at shifted towards the space of the audience, these are surround stages surround halls where even seating's can happen in these areas. So, these halls were fan shaped and the surfaces brought the audience much closer. So, accommodates more people in lesser distance from this stage, that was the advantage. However, there were certain disadvantages the curved back walls led to sound focusing.

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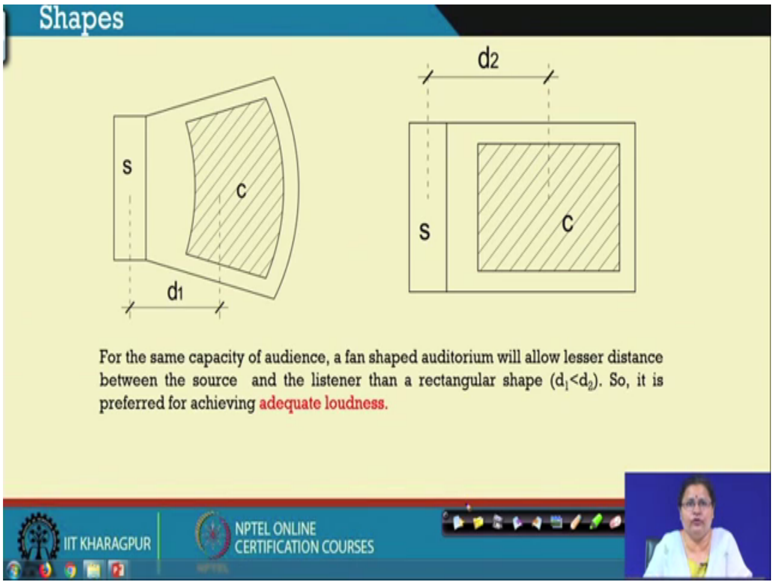

And, led to sound focusing, but if you see that the center of gravity that is center of gravity of a curved or a circular shape has a closer cg towards the stage whereas, a rectangular arrangement has a further cg from the stage. So, adequate from the point of adequate loudness, it is easier or it is easier to achieve adequate loudness in a curved or fan shaped plan.

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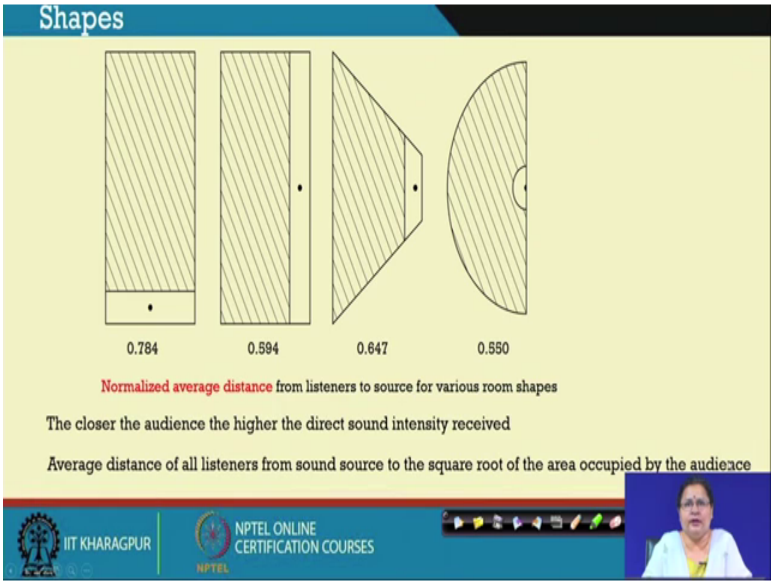

If, you see 4 of these pictures, you see in a shoebox kind of hall the distance from the center of the stage, to the center of the hall varies. And, the normalized average distance from the listener to the source, for the various shapes is given below. So, for a shoebox hall it is highest. Whereas, in case of a fan shaped semicircular plan it is the least. And, closer the audience the higher is the direct sound in say intensity reaching the receiver. So, loudness that was one of the objectives could be achieved in compact halls.

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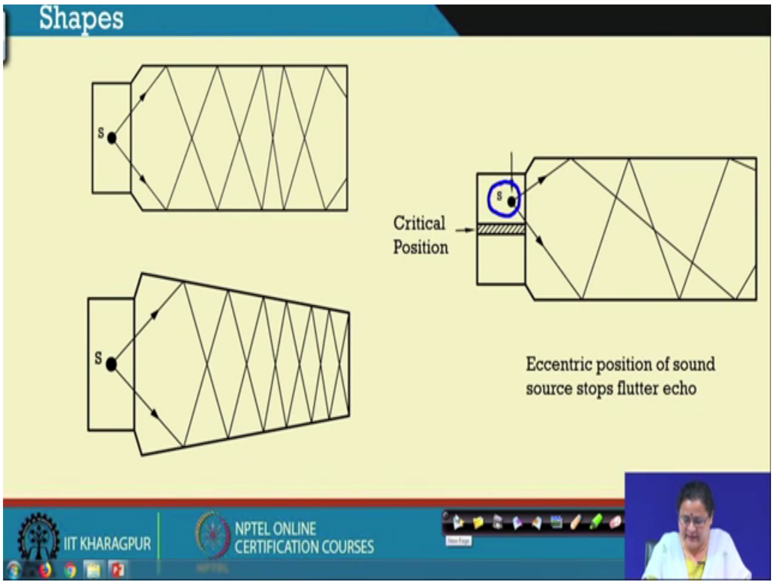

Now, coming to the rectangular shape, we see we had already covered in our lecture 6 flutter echoes. In such kind of shapes, you may encounter flutter echoes if the source is exactly at the center. So, you may end up with flattery codes, which needs to be treated, but at the same time we have to remember that these walls, which are creating flutter echoes can give helpful lateral inflection.

So, if we can modify the source location or seek a source location, which is just shifted or it is eccentrically located, then the sound movement across the parallel walls may not be exactly like what the flattery echo actually happens? So, you can check such flutter echoes in shoebox kind of hall or rectangular hall, if necessary just by changing the source position.

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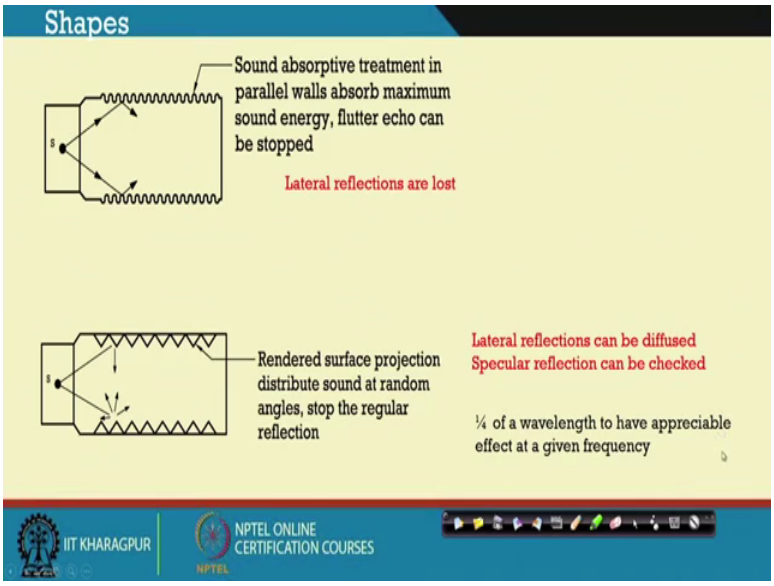

Now, let us see in that rectangular shape, how we can stop echoes? We had told at some point of time in lecture 6, that you can put absorptive surfaces. So, that the sound energy gets absorbed, but if the sound energy gets absorbed the lateral reflections are lost. And, that was one of the reasons one of the causes of getting a good sound in a hall. So, you cannot really welcome absorptive surface all along the side walls, where it is necessary which where sound reflection is necessary towards the audience.

So, you can actually create diffused surfaces, which will help in spreading out sound or scattering sound, within the hall and lateral reflections can be welcome that way. We had given information on the relationship of the diffused surface lengths and that could be adapted here.

So, if you know what kind of performance is happening, you can actually plan for diffuser dimensions and one-fourth of the wavelength to is appreciable to get the effect of diffusion at given frequency range. So, it should be less than lambda, that was told and if you can achieve even lesser than that then you can actually cover a range of frequencies in that across that particular area, where the in which the performance is going to happen.

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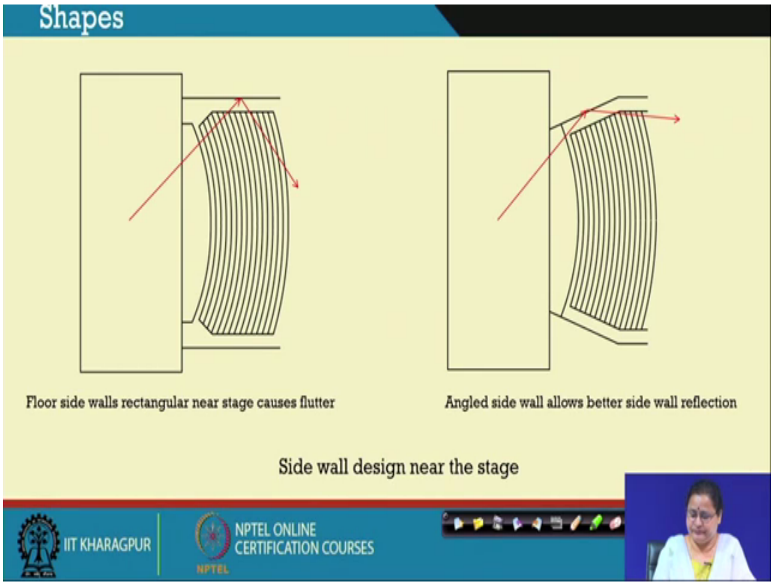

Now, if you really go for a rectangular plan, you have to see the changes in these 2 plans patterns. Here in this first one you see the wall is straight and here is the stage whereas, in this hall the wall is played and then it is straight. So, this could be this playing could be done with any additional member and foregoing few number of seats at the edges, which can give you a better reflection towards the hall. You see the red arrows, you can see the sound is being spread in the second case or in the right hand side, it is spread more towards the hall.

So, the source from the source the first reflected sound can get scattered to a further length giving a better sound quality. So, you can adopt rectangular shape considering the number of audience, considering the constraints of structure, you can carry on with such a shape, but keeping in mind all these constraints.

So, you can achieve a good hall with adding diffusers on the sidewalls, splaying the side wall on the front where the stage or the where the source is you can actually end up in a good design for small to medium multiple purpose halls.

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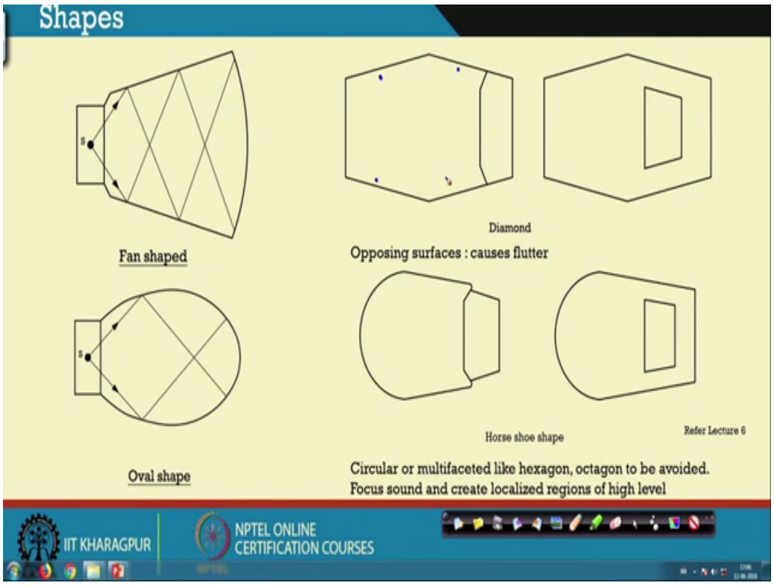

What could be the other shapes? We have discuss the fan shape, we have disc we have talked about the rectangle, here is one oval where also you can experience flutters and flutters inside it, but yes you can have diamond kind of shape, but remember flutter echoes can happen, because these 2 are opposing surfaces, again these 2 are opposing surfaces. So, flutters can happen here.

Circular multifaceted like hexagons octagons are really to be avoided. They can focus sound and create localized concentration of sound energy and that can distort or that can make a design unsuccessful. So, just by getting dominated by the shape, you cannot really achieve a good acoustics in a octagonal or hexagonal plans.

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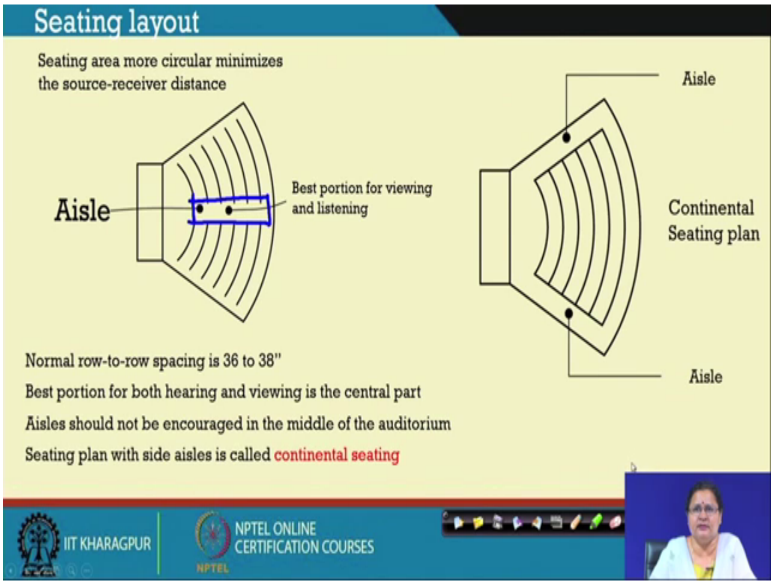

Now, coming to the seating layout, in starches way back starting from the b cs we had covered much of the starches in the introduction lecture. They are from the entry gate people move in congregation, they come in a position through the center, but in case of auditoriums it is not. So, the arrangement should not be so. We have seen that the fan shaped location, fan shaped plan, brings the audience more closer. And; obviously, that has a lot of advantages, but the best portion for the people or the listeners is the central portion. It is best for viewing to as an architect you also have to think not only sound, but you need to see the performance what is happening?

So, gradually we will also come to that and with that how acoustics is also related. So, we can actually reserve the central part of an auditorium for the best viewing seats, the best acoustically performing seats. So, we are never going to place our aisles in this location, this is not accepted. Rather I should be encouraged on the sides and you can see this where the aisles are on the site sides and it is called a continental seating plan. So, you may not get the opportunity to have continuous stretches.

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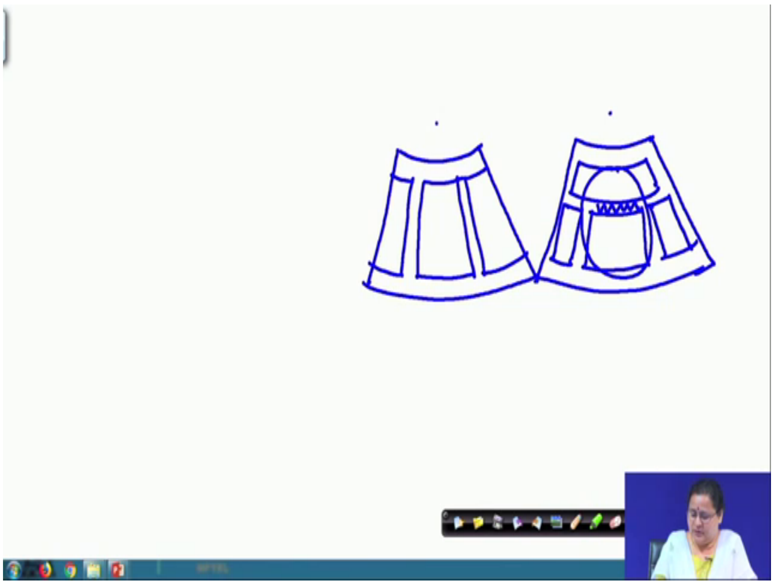

But, you can break with some middle eye, you can have arrangements like this, you can have arrangements like this. So, here you are foregoing a small portion of the front of the middle area, but yes you are trying to give maximum number of seats in the central portion, which is best for viewing as well as for listening. So, this is called the continental seating plan arrangement and this is to be followed.

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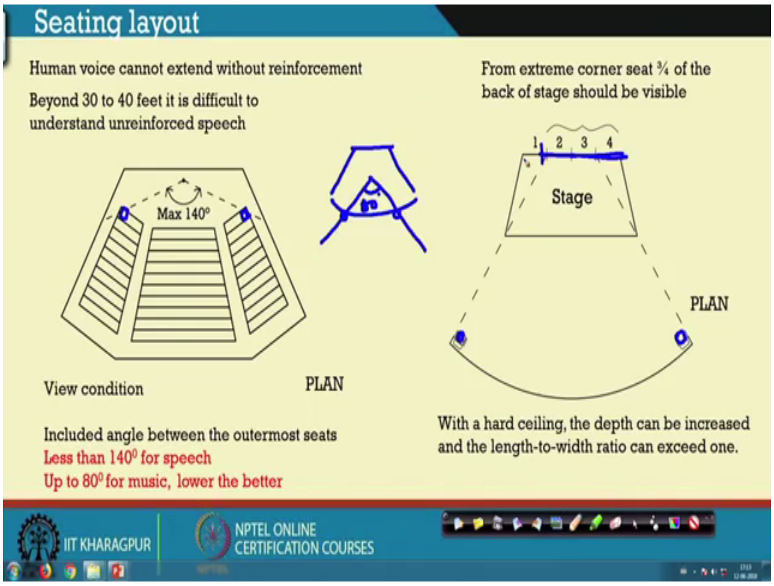

Now, coming to the viewing of the stage, if it is a speech the person who is giving a speech from here, should view the stage, view the audience with a maximum of 150 140 degrees. So, the included angle between the outermost seats, that is if you have a seat here which is the outermost seat you have a seat here, these 2 actually when projected you make a maximum of 140 degrees. But, this is in case of speech, but in case of music it should be much. So, your person should sit here and it is said that it should be 80 degree. So, you are actually closing the view closing the view, when it is music and making it more intimate, in case of speech you can spread it out.

Coming to how much from the end one needs to see the stage. So, if this is the back wall of the stage, you see this person here at the end or this person here at the end should actually see three-fourth of the stage back of the stage. So; that means, he is having a good enough view of the stage almost the complete view. Similarly, from this end it should be worked out that way. So, you have to know what is the purpose, you have to know geometry and these angles, you have to know what is the stage dimension, and then you can actually work out what best would be your boundary conditions of sitting? And, once you know your boundary conditions of sitting, you know your aisle dimensions, your distribution and you can plan accordingly.

Now, how far will the sound go? As you know unreinforced sound cannot go beyond 40 30, 30 to 40 feet. At the same time you have to remember how much you can view clearly, that is if you are looking at a performance. Even the eyebrow movement of the person should be visible and that requires a distance. So, you can go up to 80 feet with your vision you can see all details, what is happening that is facial expressions etcetera on stage. So, if you have a reinforced sound or an electro acoustical reinforced sound, you can go up to 80 feet to take care of the facial impressions facial expressions that the performers are included in the performance. So, if you get all these constraint conditions or the boundary conditions, you can start your auditorium design in which will be performing well in viewing as well as acoustics.

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So, here you see a picture taken from the center of the stage of Kalidas auditorium, it is a Kalidas hall of IIT Kharagpur. So, it is just the day after a performance had taken place. So, from the center of the stage I have click the picture. And, see from the point of view of a performer he can get encouraged from all the seats of the audience.

Though you I should not criticize this, but you see the central part is occupied with the door, that could have been avoided, but this is a hall which has multipurpose use, it has performances, it has lectures, it has dance programs many other things. So, all events are actually taking place here and you can also have a glimpse of the ceiling and the back which is circular. You can also see the seat here and this may recall you of the seat deep effect, we will carry on with those in further lectures.

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So, I request you to revisit lecture 6, 7, 16 some particular slides and then you can actually recall the principles, and you can come back and revisit auditorium design, and you will find it is really not to avoid, but to take up courageously auditorium design and we usually start with plan and I think this will; obviously, encourage you to carry on or take up a project on auditorium design and start with these basics.