Architectural Acoustics
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Lecture – 39
Urban Noise Control : Planning Consideration (Contd.)

Welcome to the NPTEL lecture on Architectural Acoustics. We are in the last week number 8 and this lecture is the numbered as 39. This lecture will be on the urban noise control planning consideration; and this is a second part of that lecture.

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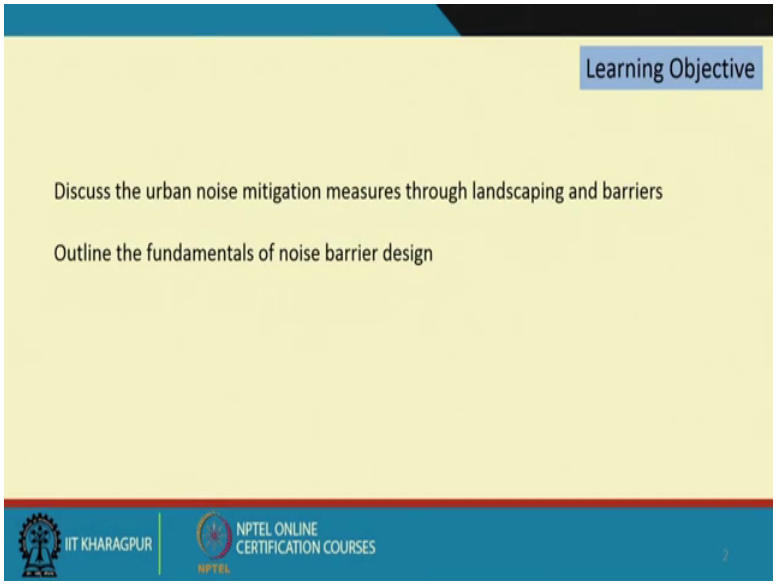

So, in the first part of the lecture, we are discussed about the how the source the sound from the noise source can be mitigated. And in this particular lecture number 39, we will discuss the urban noise mitigation measures through some landscaping or some kind of a barrier developing some kind of barrier what are the different aspect of it. And also we are going to outline the fundamentals of the noise the barrier design noise barrier design an all that is our lecture or the learning objective for today's lecture.

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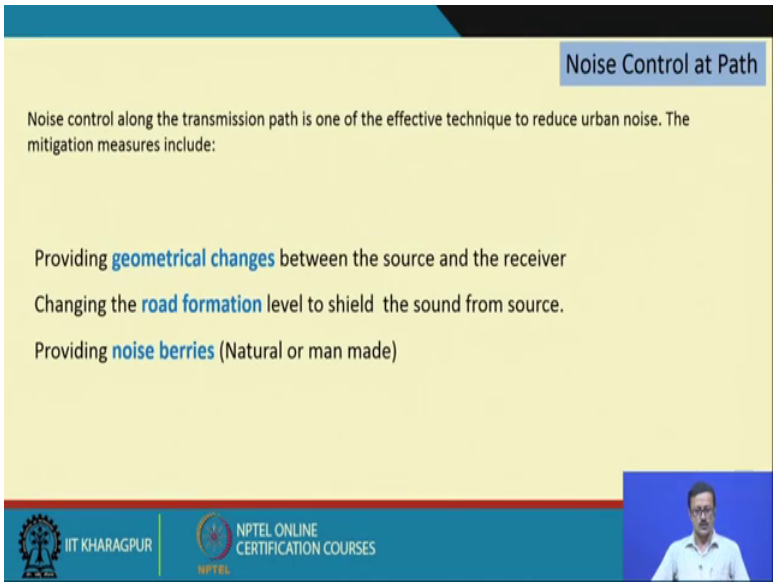

So, go ahead with the noise control. As we know that there are three ways to control the urban noise. The first one is to the mitigate from the source point of view reduce down the noise from the source, and probably that is a one of the best way to reduce the noise. The second one is the control of noise in between, in between in the sense of between the source and the receiver. The source and the receiver this path is another area, where the architect or may be urban designer may play a vital role to reduce down the noise.

So, we will discuss on that particular topic today. So, in that in the noise control at path that is been between the source and the receiver, there are three ways that at broadly it can be classified into three ways the mitigation strategies. The first one is there are some kind of a geometric change we can do we can alter some kind of the dimensional dimensional the properties of the road, and the setbacks, and the vertical up and down from the formation levels or so.

So, those all come under the geometrical changes between the source and the receivers. And then of course, that is basically done in a newly developed area. And some of the cases I mean when there are some kind of a new road has been planned, for a area where there are already road, and the other side of the road there are building is already constructed. This geometrical change may not be that much effective.

So, second one is that the formation of the road. So, formation of the road is that some time we use some kind of a flyover or maybe some kind of a underpass or maybe we put

the road in a different layer or the different level. So, with respect to of course the receiver of the noise. So, those kind of a formation level change in the road can be also useful for the mitigation of the noise. And the third one is also important there may be a natural or may be some kind of manmade berries can be can be installed or can be thought off in between the source and the receiver to make a noise at invasion are the noise shielding.

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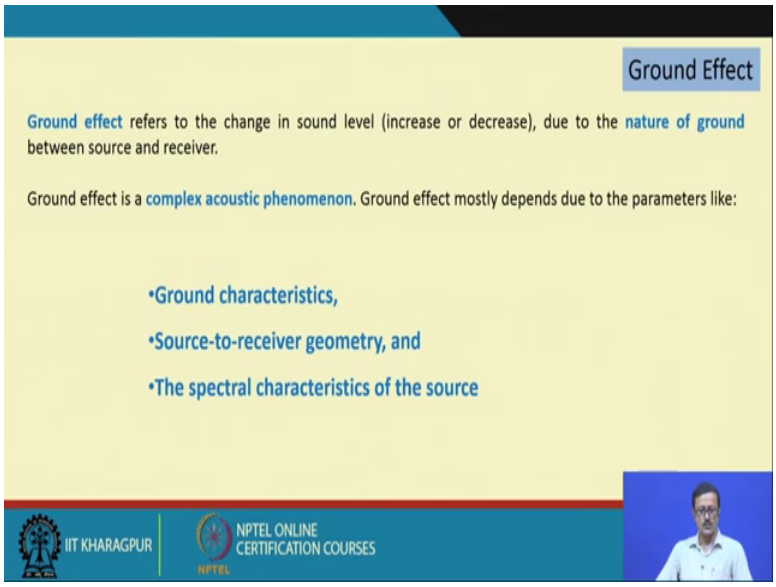

So, in this regard there are two effect we have to discuss in this, if you if you imagine there is a source of sound and there is a receiver of the sound, receiver of the sound is maybe a it is a (Refer Time: 04:04) area. And the source of the sound let us assume that is a road and that is a traffic noise. In this in between these two there are two effects is actually going to play very vital role.

The first one is called the ground effect. The ground effect is due to the various nature of the ground is nature of the grounds are actually written over here in this slide. The ground characteristics, source to receiver geometry, and the special character of the source. Based on that the particular the ground will sometimes increase the level of the sound or sometimes ground may reduce down the sound or maybe activate that particular sound. So, we have to look into that particular ground effect very curiously.

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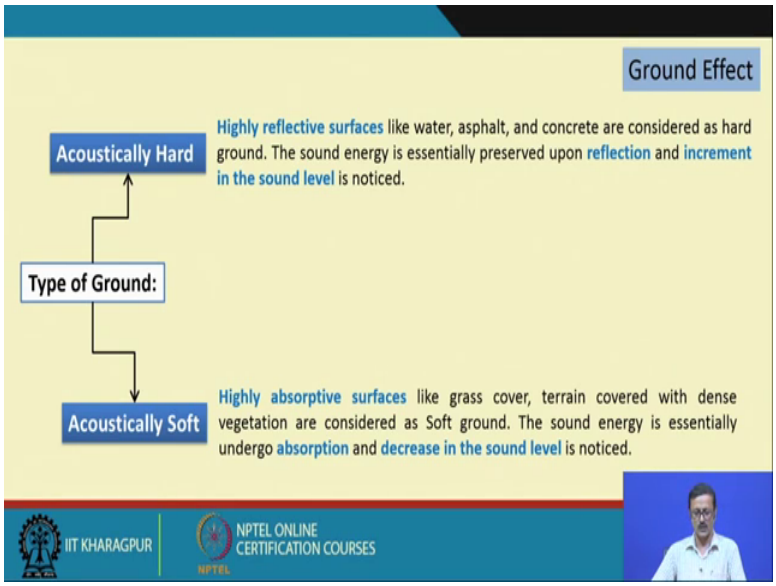

If you want to design based on the ground properties are the ground effect. So, the there are two type of ground as for as the acoustics is concerned. And this particular two type of the ground is always a architect will actually where play within the area where the there is a the this path, this path between the source and the receiver. And this path between the source and the receiver may be a footpath maybe a part of the road or maybe some the grassy area some pavement areas some setback for the building. So there are different character is possible.

Based on that character, and the based on the acoustical properties of those the character of the ground. It can be divided into two part or the two types. The first one is called the acoustically hard surface, which are maybe a concrete pavement or maybe a very asphalt cover, even a water, even a like a lack or some water bodies can also act as a the acoustically hard pavement. And why, it is acoustically hard, because it is actually reflect the sound, because it is hard. It is kind of a be because of the hard is sound is mostly it will be reflected. And as it is reflected the there is a increment in the sound pressure level it is noticed on that

So, the second type definitely it will be acoustically soft, acoustically soft cover, and that was are the absorptive cover. And it mostly absorb the sound by nature, and because of the because of the texture, and the kind of the cavities that form in the surface of the particular softcover. It is considered as a terrain the with a soil terrain or maybe any kind

of a grassy field, and the those are come under that particular or bush kind of a heavy thing bush in, and around a particular building can act as a very highly absorptive cover an acoustically soft cover. And by virtue of the absorption almost of the sound is going to be absorb, and very less proportional of the sound is going to be reflected. And it will be act as a well very well damping the sound damper noise damper kind kinds of a thing.

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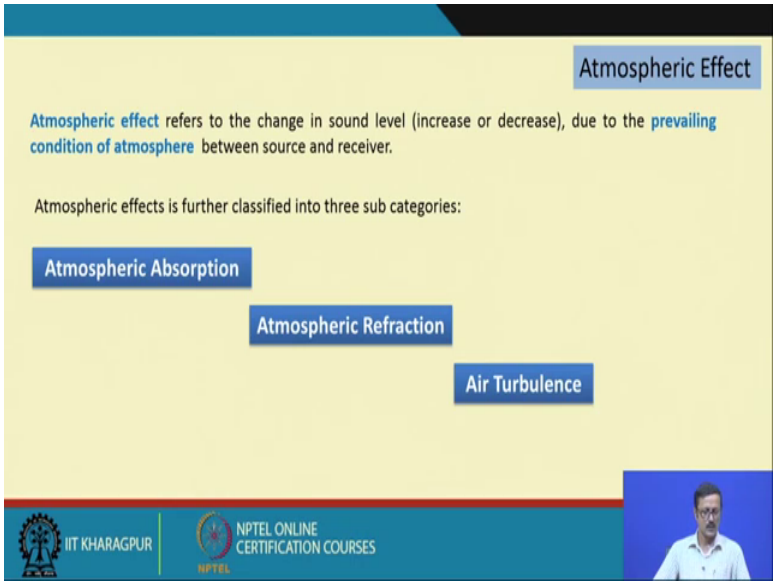

The next effect other than that particular the ground effect is called as atmospheric effect. The atmospheric effect is also sometimes gives you a increment in the sound pressure level, on sometimes it is maybe decrease the sound pressure level. So, the prevailing condition of the wind prevailing condition of the atmosphere the condition of the air, and the presence of the moisture in the air, presence of the some suspended particle in the air is going to give you this kind of the absorptive criteria of the at as atmospheric effect. So, it has actually has three classification, three the sub classification. The one called the as atmospheric absorption; the another called is the atmospheric reflection, and the third one is turbulence.

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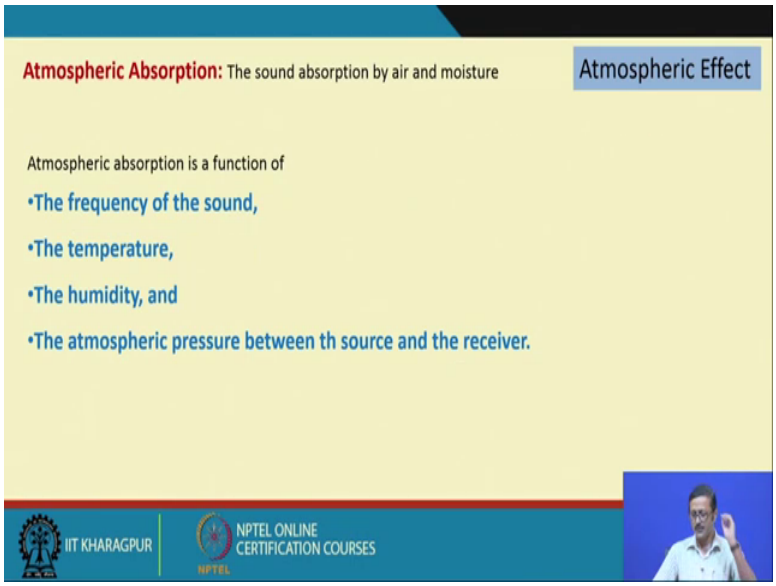

Now, atmospheric absorption is the it is you know it is because of the nature, and because of the air, and the moisture present in the air. And this actually the function of those this particular amount of absorption if you talk about it is actually depend upon the frequency of the sound, it is also depend upon the temperature of the sound. It is I am sorry the frequency of the sound, and the temperature of the wind or maybe the air and also the humidity in the wind or humidity in the air itself. And also it is depend upon the atmospheric pressure between the source and the receiver.

Out of these four the frequency is one of the prime important criteria. The temperature and humidity is also one of the prime criteria. As if you remember, you know all I think in the second lecture we have discussed about that the how temperature plays a vital role in the velocity of the sound, so that is going to give you a more propagation, more velocity means it is quick propagation or the quick the shifting from one source to the receiver. And humidity is also going to give you a way absorption criteria, atmospheric pressure is also plays a role, but atmospheric pressure is it is not that much predominant as why have talked about the other three. So, those are the atmospheric absorption criteria.

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There are atmospheric reflection criteria is also. It is caused by the temperature and the wind gradient. Then the how the wind actually flowing from, which point to the other that means it is from the source to the receiver or from the receiver to the source or in between the receiver of the source, because it may go parallel in that way, so because of that gradient of the wind on also from the temperature of the wind. This particular phenomena of the atmospheric reflection is going to change or it is going to vary.

So, atmospheric refraction or this also is going to give you kind of a the sound the bending of the sound. And it also give some kind of the temperature the gradient an all. And those kind of things also will be depend upon the upwind condition, and the condition for the away from the wind, and that kind of a scenario. And it will going to decrease or increase in case of with this scenarios and the if can in case of the upwind scenario, it will decrease the level of the sound, And if it is a down condition or the downwind condition is prevailing, then the sound is going to be sound level will be going to be increase in the in the point of the receiving source receiving point.

The last one is the, that air turbulence. Air turbulence is sometimes occur in the atmosphere. And this is a very unpredictable scenario. And as it is a very unpredictable scenario. The changes in the sound pressure level because of the air turbulence is going to be fluctuated in the in it is fluctuated I mean the its not may it may not give a kind of a very direct relation the due to turbulence are the type of the turbulence it will increase or

decrease know it is very the unpredicted in nature. So, this refraction of the atmospheric sound, and the absorption of the atmospheric sound place a real vital and the important role in the mechanism between the reduction of the noise from the source to the receiver.

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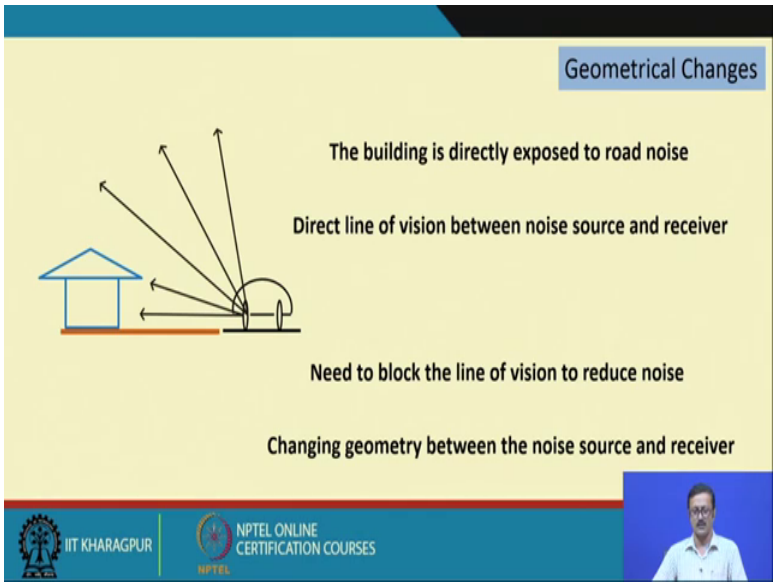

So, this two effect the wind effect, and the effect of the atmosphere is the prime ah prime the parameter for the mitigation. So, now let us discuss about those three things, which I have just talked in the very first slide that the geometric changes and formation level changes and all. So, what happened I have drawn a very small sketch of a house the this blue colour a house habitat, and there is a road, and there is a car are that indicate some kind of the road noise.

So, from the car in the chassis level or the level of the wheel from that particular level the sound is going to propagate I mean that can be take it as a source of the sound. And source of the sound of course, there is a breaking, due to the breaking there is a sound there is a horn that sound maybe it up, but mostly that the friction between the tire and the road, the engine sound and the breaking sound comes from that particular level. So, it is a point source. So, I have drawn the spherical propagation of the sound from that particular source. So, the building is directly exposed to the road noise. And this one is a why it is directly exposed.

So, I have told in the last lecture also it is a vision and sound propagation is very very similar. So, there is a direct line of vision between the noise source and the receiver. So,

there is a direct propagation of the sound. So, somehow we have to nullify this direct vision line or direct the straight line between the source and the receiver. So, it need to you need to block this particular line of the vision so reduce the noise. And this blocking can be a done by various way the formation change, the barrier then the geometric the changes, and there may be a lot of other things can be thought of.

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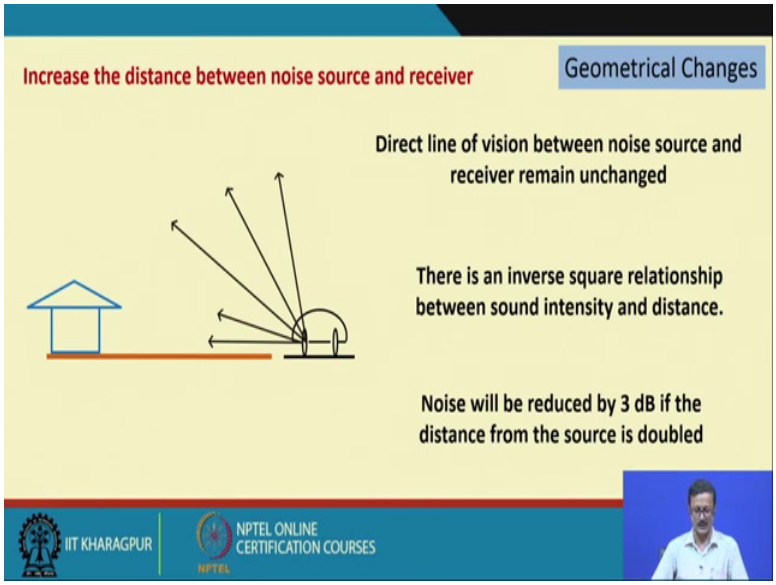

So, what are the geometric changes, the first geometric changes can be occur like direct line of vision can be still here, but we can increase the distance between the noise source and the receiver. So, we push the building little back. And we as for as possible we push the little back.

And this is the probably in the one of the first thing that comes in our mind that if we segregate or if you make I mean, if you provide a higher distance higher set back from the source to the receiver road to the building, the noise will be reduce definitely it is so, but it is not because of the cutting of or the this direct vision line, but it is as we know that the sound level this is inversely proportional to the distance. And it is reduced by 3 dB by doubling of the distance.

So, normally we can use this particular the fundamentals of the sound physics, and you can go for a larger setback, but students this particular the criteria or this particular solutions is sometimes not feasible, because we may not get that much amount of the setback in the front setback or sometimes you may get. So, it is a chance, it is a depend

on your the site, and the dimension of the side and the what will be the total FER what will be the total ground coverage, what is the demand from the client. So, there are lot of other things you may not get that much amount of the distance.

And number two it is only reduced by 3dB. Let us, assume that the noise is almost 65 dB in the road. So, if you want to reduce it by around 10 dB, we have to go why a huge distance from the source to the receiver, source to the receiver. So, sometimes it is not feasible. And it will only act as an academic kind of an academic kind of a solutions kind of a thing. So, next one is may be a better or feasible solutions is that change the level between the noise source and the receiver. We can make the building little up or maybe we can sung the road little low. Sung thing up are the this depressing the road little low sometimes also may not feasible, because it is not in your hand.

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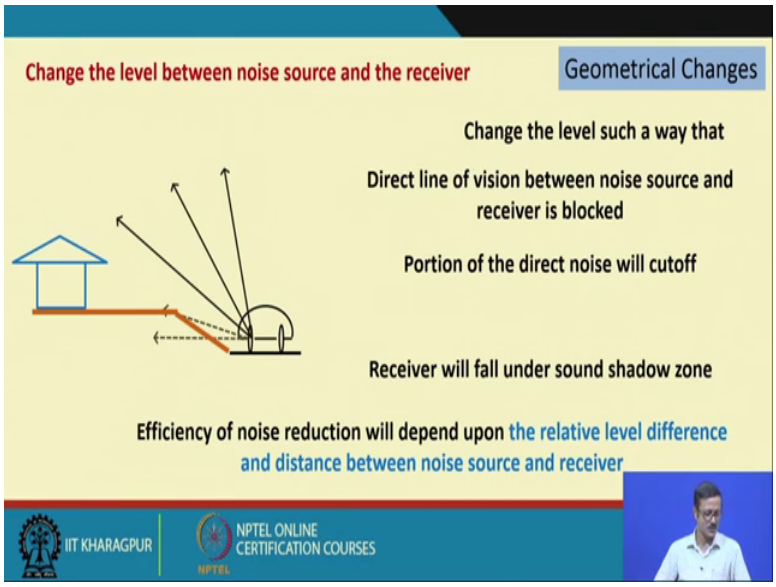

It is the already road is being laid or so, but if you are go I mean go going to have that road layout for a new area, if you are actually working in a terrain area or maybe hilly site, then you can thought of that kind of entry or those kind of a think with a different differential level. And due to this change of the level of the road, this direct line will now going to be little bit pain. So, the lower part of the source in which is very near to the source those is kind of a blocked, of course it is the exposed to the upper portion. And if the building will be under some kind of shadow some kind of a noise shadow or so. And the this particular the efficiency of this reduction how much will going to reduce the

sound is definitely depend upon the depend upon the two things. One is how much is the differential level between the source and the receiver, and also what is the distance between the source and the receiver. So, this is the second one.

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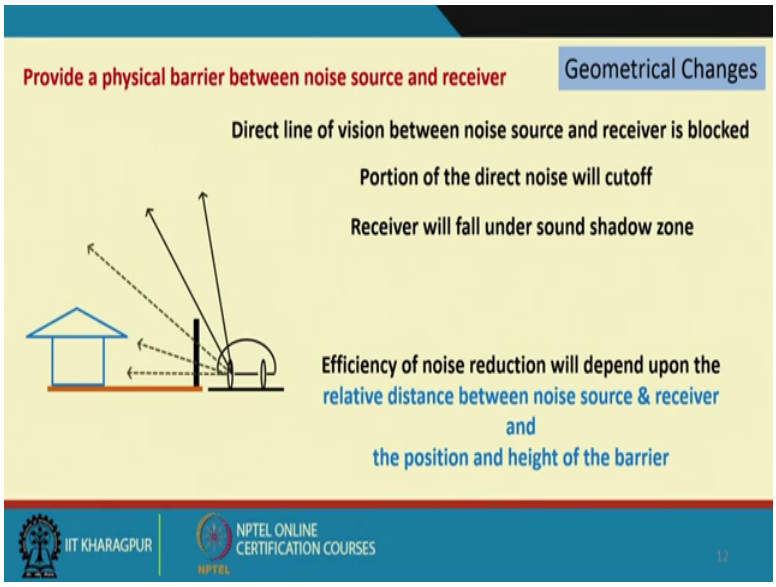

There can be a third thought also or the third solution also. We can go for some kind of a physical barrier, which will talk little later. And this physical barrier may be a tree, this physical maybe an earthbound or maybe a kind of a the manmade wall concrete or break wall. If you provide a physical barrier, then you are going to cut the whole vision line. So, it will be directly nullify your nul noise and the receiver will be under full the shadow condition of the from the noise point of view. And this also depend upon the receiving, I mean the receiver to the source distance and the what is the type of on the height and height and type of the barrier.

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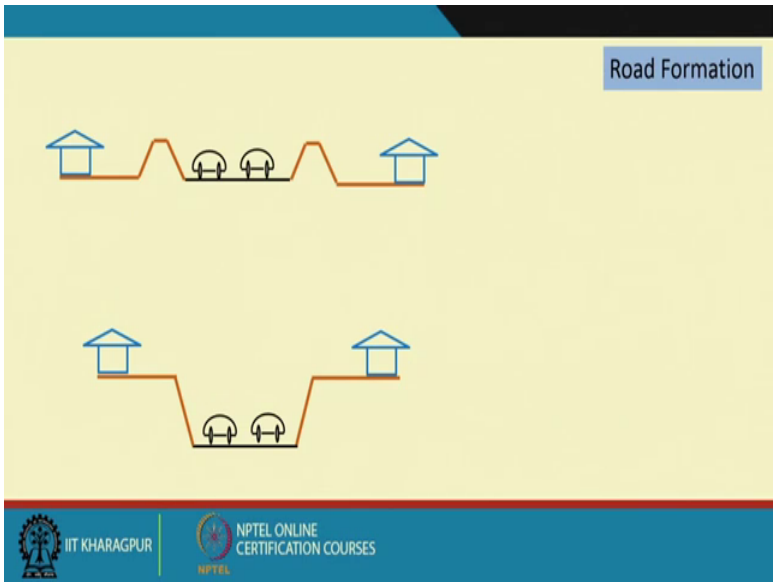

So, these are common that this particular the geometric changes or so. So, next let us discuss about the road formation. So, road formation is again I must tell you this road formation is another way of another sub category of the geometric changes, because again I am going to change the levels, change the heights and whatever. And then try to put my buildings and the habitats under a sound shadow zone.

But again another disadvantage of this particular the methods of reduction is that. It is not possible for an area where there is already a road is laid it say already there are building is under construction or building is constructed on you think of doing some changes no may not be possible. But yes it say some newly developed area you are creating some kind of a the are in a particular site is self you are doing some kind of a level changes in the movement for the vehicular entries or may be some kind of a service entry for the lories, truck and all then it is in your in your scope of your work. And you can also go for this kind of a road formation change.

So, whatever I have drawn here a small sketch. Two sketches are giving you a kind of a road formation. The first case the upper one there is no such change in the level. So, suddenly I thought these two buildings are has to be shield or that invited from the noise. So, I can create some kind of earthbound or some kind of a the earth berm, and that is going to give you kind of a shielding. And sometimes we can sunken down the road level is sunken down with respect to the with respect to the sides.

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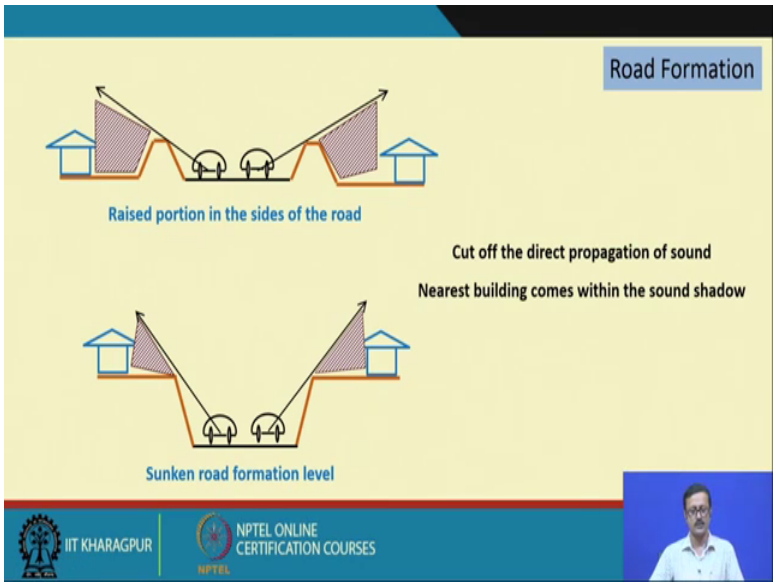

Where there are the building plots and definitely it can create a shadow it can create a shadow to the building to that in the habitat area.

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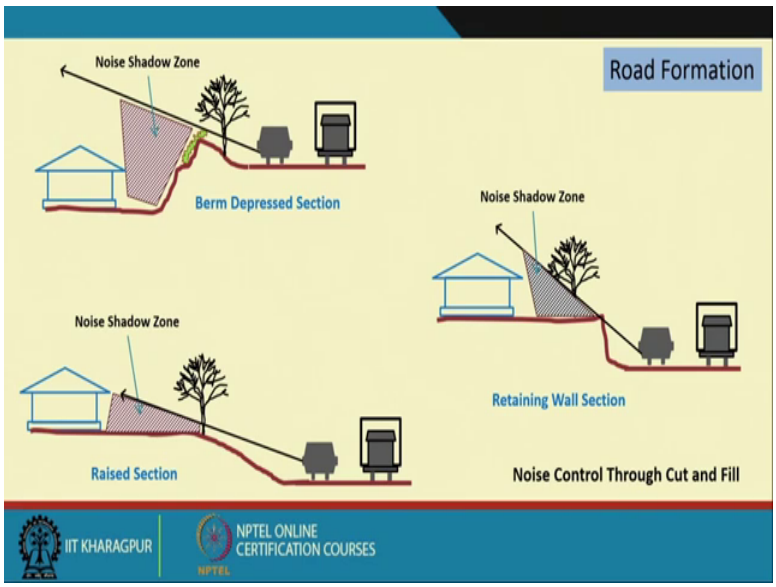

There are another three the sketches. So, in this first top one the top one the noise shadow has been created, but kind of a the berm and the depressed section kind of a thing. So, some of the areas in the, where there is a terrain development or so or maybe there are some area is, where there can be a kind of the design required, some kind of a

sunken kind of the habited to be developed. There we can also integrate that with the noise reduction criteria.

These trees are also going to be very very important. I already told about this pai particular area, where there is a grassy field or the grassy cover, which actually going to at in way it, because of the ground coverage. Here also it is a retaining wall sections in the see this figure. A retaining wall sections is can be thought of and then the this level of the rode level of the habitat area can be lifted above and create a kind of sound shadow. And the raised sections is also possible, and by virtue of the distance and raised sections can also sound shadow can be created.

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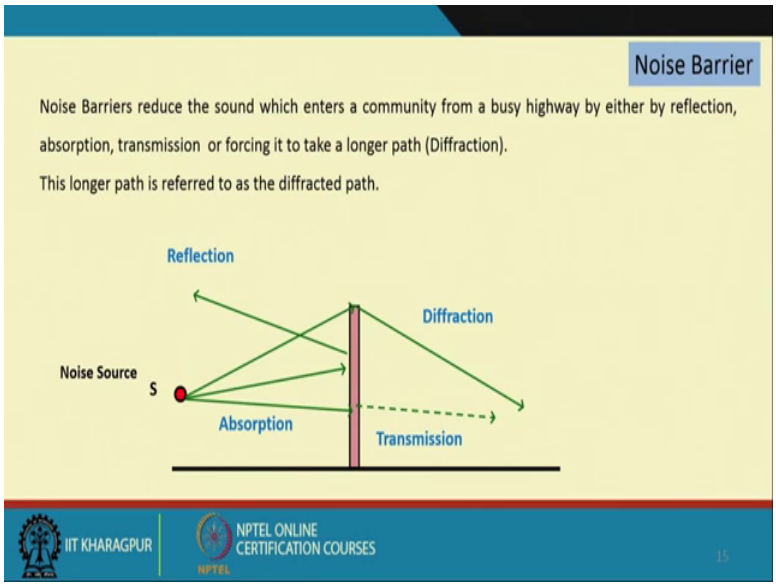

The next and last one is the noise barrier. A noise barrier as I told you that it is a kind of a barrier, which a community the boundary wall kind of a thing. It may be manmade or it may be some kind of the vegetation the group of vegetations and the trees and all, so that can be also thou thought of this noise barrier. It is a wall, particularly it is a wall it may be a soft wall or maybe a very hard wall by virtue of its nature of its the density, and the weight has been constructed and over material has been taken for that construction and all.

So, these walls suppose this is a source this red the colour dot is the source of the noise. So, there are lot of phenomena I will going to occur. The first is the reflection. So, this is a reflection can be occurred. If it is very hard, if it is soft, may not be reflected much.

Then there is an absorption the things will be absorb, the sound will be absorb. Some sound may transmitted also in the other part of the wall. And the one of the interesting criteria is that the sound which will move at the top of this wall can be diffracted. And this diffraction is depend upon the atmospheric conditions, and some other properties also.

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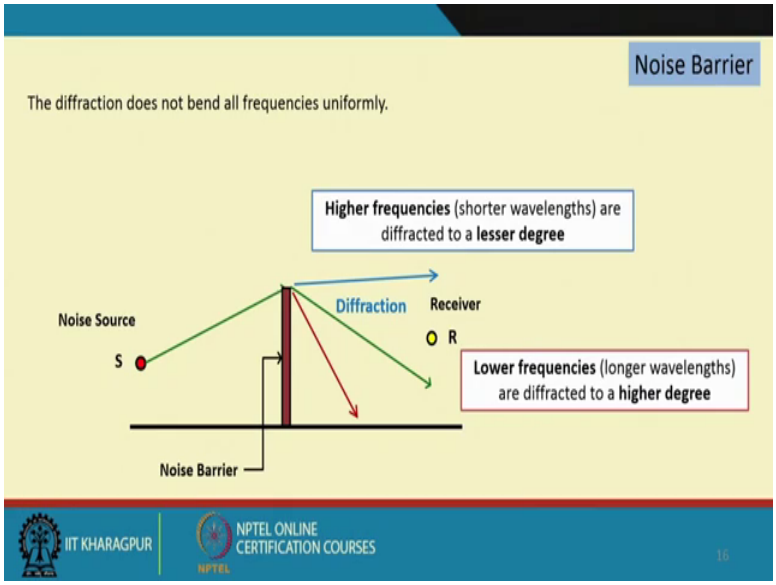

So, here let us talk about this diffraction, because that is the important criteria to design a the noise barrier or a wall also. So, I have put a road. And there are two sides of the road one side is probably the noise source and other side of the road is my building or whatever are the noise sensitive zone. So, there is a sound source or the noise source, which is marked as S and there is a receiver is R receiver. What is a receiver? Receiver point may be a window, receiver point may be a kind of a balcony, receiver point may be a kind of a open area, where people are seating for cup of tea or may be in relaxing for some kind of a part of the day.

So, those are the areas or those are the point it can be consider as a receiver of the particular the sensitive zone. So, the sound will be going to diffract sound will be going to diffract. And this diffraction is basically due to the densi; it is a governing by the density of the air layer, the temperature, the humidity, and the gradient of the winds also, so but this diffraction will also not very the equal amount for the frequencies.

For the higher frequency this diffraction angle will be very less. So, it will be re diffract very less. Just a slight diffraction will occur, it will fly through. Almost it will going to fly through. But if the frequency of the sound is low frequency sound, which is probably the sound comes from the road noise mostly the noise from the engine, the friction from the tyre, and all.

And there are another noise that actually comes from the any kind of a operations are the those kind of a things, automobile operations those are basically a the low frequency sound. And those low frequency sound is going to be diffracted much and that is a higher degree of the diffraction. And this higher degree of the diffraction will bend the sound from the top to lower.

So, is this particular sound this low frequency sound, which actually comes from the automobile source will be diffracted much, and the receiver may come under that particular sound. So, this sound shadow is created by the noise barrier will not be same for the high frequency sound or the low frequency sound. Low frequency sound has a much more wider appearance much more wider the domain, but the high frequency sound S. There are some sound high frequency sound also comes from the road side the automobile, the hunk, the horn, and the breaking sound or the high peak sound. Those will be fly away from the top.

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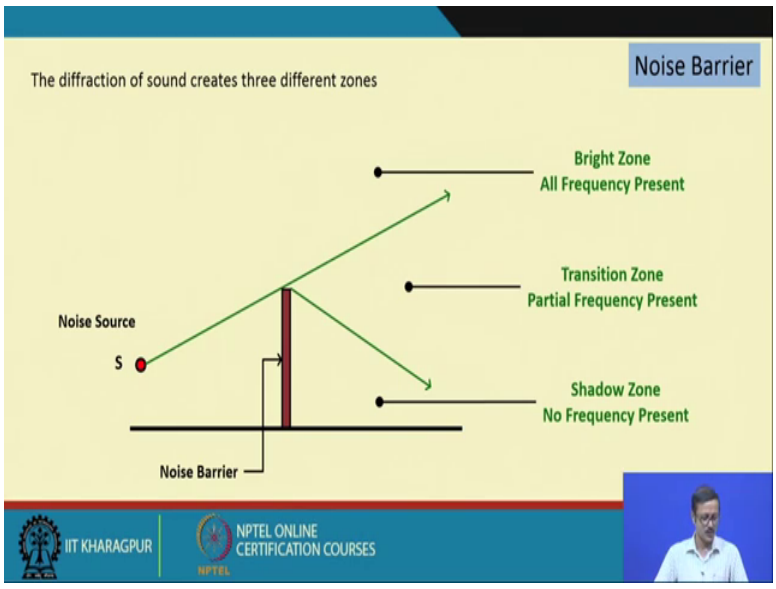

So, from that I can understand that this is the first one, which is flying away from the top of the this noise barrier, which is high frequency. And this is the low frequency is tending back tending towards the ground. It is divide the whole area in the side of the noise source into 3 zone. The first zone this called bright zone, which is above that particular flying line or the line of the side. Why it is bright zone, because all the frequencies are present here.

All the high frequency and the low frequencies are present here. So, suppose if you design a very tall building like this, so the upper part of the tall building will be under this bright zone. And those balconies, and all in the maybe in the 5th floor, 4th floor, 6th floor level will be exposed to all the sound. There is no vision cut, there is this is that particular bright zone.

Next is there is a transition zone, where the partial frequencies are present. So, it is a partial shadow kind of a scenario, because the high frequency will tend like this it is not going to diffract. Some will go like this. And as in when the frequency increases, it is moves back. So, here in the 3rd 4th or maybe the second floor level, there are some partial frequencies will be available over there, but some frequencies definitely will be will be takeoff will be eliminated from the zone.

And then probably this is the last frequency or the smallest frequency or the lower lowest frequency that travels, and it is deflected much higher amount of diffraction, so I can get a third zone, which is the lower part of that this triangular triangulation, which is called the shadow zone, and almost low frequency in present over here. And it is a truly reduced area, and the that can be the ground floor area or maybe any kind of the outdoor area, which can be under that particular shadow zone also.

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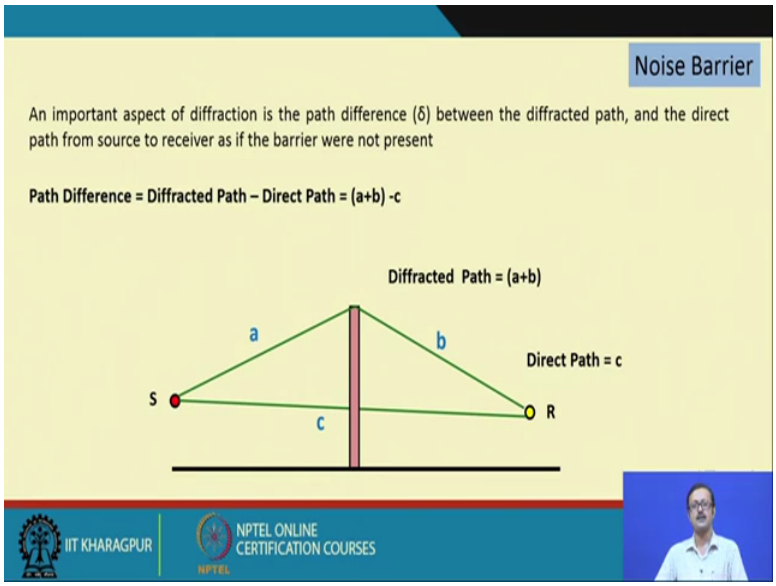

So, next is you must thing that how can this design can be formulated. So, again if I go back to this particular fundamentals of the vision line and the sound line goes as in the same direction, so what we can do is that, we can calculate the differential path or the path difference. This path a plus b is your diffracted path, because of the diffraction. And suppose if there is no barrier, so this S to R this path c this is your direct path. Of course, this direct path the sound cannot me, because if there is a barrier.

So, what is the path difference the diffracted path minus the direct path that is a plus b minus c, and this a plus b minus c this path difference are delta plus very vital role. Our role will be as being a architect or maybe a urban designer. We have to increase this path difference by any means we have to increase this path difference. As even when increase the path difference you will going to get more amount of area as a sound shadow area. You will be able to hide more amount of frequency. And we will get the most of the best benefit in the receiving end. So, this is the path difference is one of the criteria.

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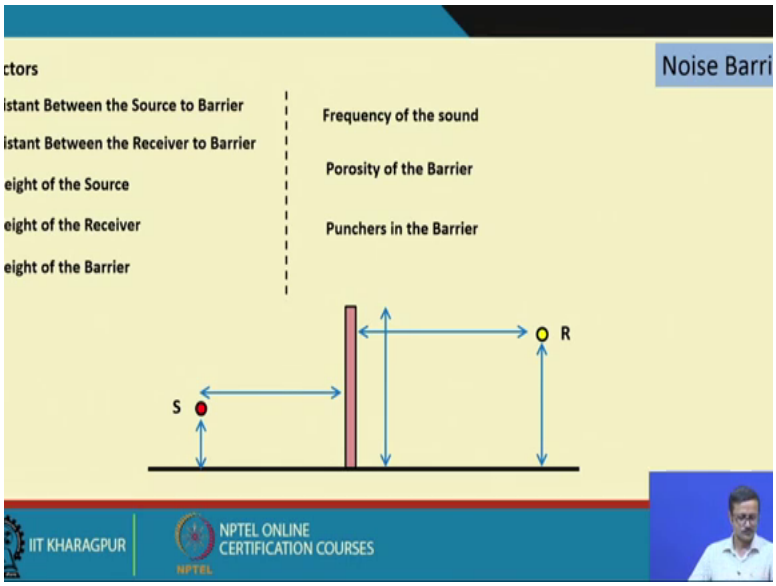

Now, there are two reduce are increase this path difference. Of course, we will try to increase the path difference always to mitigate the noise, there are sound factors. Let us discuss those 5, 6 factors. Source is that red colour. S and the receiver is in the right side that is R receiver yellow colour. So, first factor is the distance between the source to the barrier S. If you change the distance, if you just move the source away from the receiver, if you go very close to the receiver, this particular barrier is very close to the receiver or so, there will be change of the in the path.

What is the next, next is definitely to the distance between the receiver and the barrier, source and receiver and the barrier. These two the mutual distance are very much important to get a particular path difference or maximize the path difference. The next one is the height of the source from the road level. The next one is the height of the receiver from the level, of course from the road level. These are four from the point of view of the source and the receiver.

And the last one is the height of the barrier that is also true, because if the height of the barrier smaller, suppose all distance are same. Now, the height of the, this is very small, so the direct path and this the other diffracted path will be same, so maybe the less or so. So, you would not get any kind of the benefit. So, and these are all geometric property that plays a role in this particular noise barrier. There are so other factors.

Also I have already told you that frequency of the sound matters, because it is diffract the sound, and it is the high frequency sounds is fly away or may not go that. And the porosity of the barrier, whether it is a solid barrier, whether is a green cover, whether is a only a fens, so those porosity is actually going to be important. And as and we know that this if it is a solid, this definitely give you a lot of sound reflected back. Poros will again allow some kind of this, and also the punchers in the barrier, which is may be a solid wall, but there are some punchers that also give you some kind of a noise leak.

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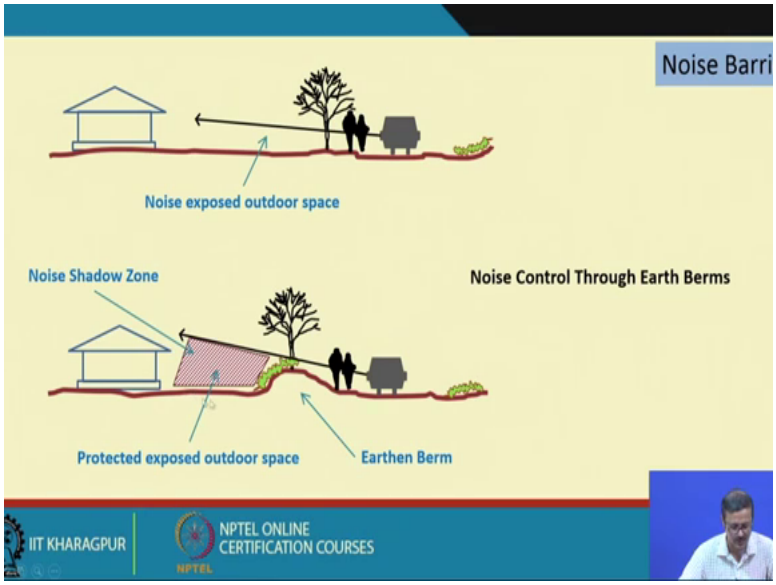

So, there are some control on the barrios. Also so here there maybe expose sound in the first figure, what I have drawn just exposed to the building, noise expose to the building. And the second figure you see there are some barriers, which is earth berm or maybe a kind of a the soft barrier like the trees, and all which can create some kind of a sound shadow zone. In the this is outdoor space can be very enjoyable from, and that will cut of the noise from the sound source also.

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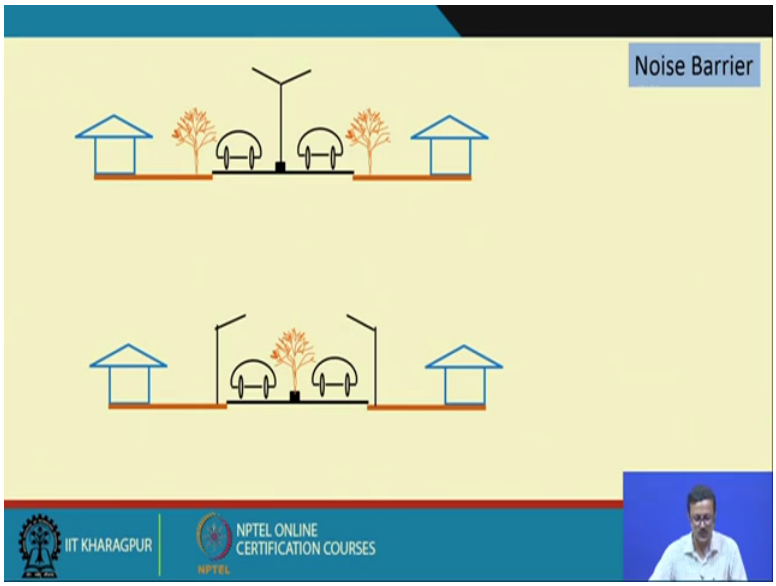

There are some kind of a guidelines also may be there are two type of the road the this light, road light the street light, and the tree maybe placed. One cases, the tree may be placed in the side, an another cases trees maybe in the central path that is the road median. And the in the side there are definitely the in the side there are in the street lights in the sides, so which one is good, which one you thought that is good, definitely, the first one, because that will give you some kind of a barrier of sound, because of the vegetations and landscaping screen.

And another one I must say that if you want to provide some trees the rows of trees in a like a boundary wall between the road and the building, you must plan different type of tree one plan same type of tree, because the amount of the sound observe by the foliage of the tree is depend upon the texture of the foliage. And also it is depend upon the how much cavities it is form by the leaves. So, if you go for the same type of tree, the texture of the trees will be same, and the cavities created by the leaves also will be the same or of same nature.

So, a particular band off sequence will be observed. So, and if you change the type of the tree maybe in two layers or maybe zigzag in that way, and then the different foliage and the different cavities formation will be there, and because of that your the a higher band of frequency can be observed, because you know the texture, and the absorption of the frequency has a vital role or the cavities has a vital role.

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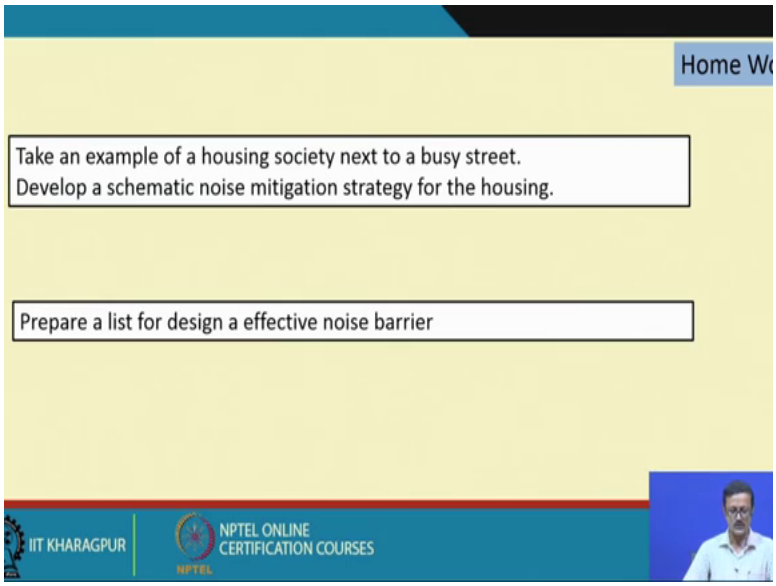

So, we are in the end of this lecture. And the as usual I have some homework for you. I will give you a small exercise like are take an example of a housing society was in a you may stay in the housing society or maybe your friend is staying in that is kind of society, society where visited lot many times. And you know about that society take a particular real life situation of a housing society.

Try to draw the plan of that particular society housing society and develop a schematic noise mitigation strategies for the housing, so what can we can do for reduce the noise from the road to the particular housing society that is one. And second one you prepared a list of list for design an effective noise barrier, what are the things you will be thought when somebody will ask you to do a effective noise barrier. So, these two are the homework.

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And that is all for this lecture number 39th, which was on the urban noise control the planning consideration. And this is a second part, and the last lecture will be on the architectural consideration.

Thank you.