Sustainable Architecture
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Lecture – 20
Visual and Acoustic Comfort

Welcome back to this new lecture for the online course on Sustainable Architecture. Today's lecture is on Visual and Acoustic Comfort. When we are talking about sustainable buildings and then gradually as we are moving on towards green buildings because, we realize that environmental aspects, environmental parameters are the more tangible ones and hence it is easier to measure, monitor and verify them and also assess the performance of a building as far as the environmental parameters are concerned.

We largely are focusing towards the energy implications, the thermal comfort, how the building performs for a given climate. However, there is an important aspect of it which is the visual and acoustic comfort which also needs to be taken care when we are designing buildings and since we started talking about the sustainability in buildings.

We have discussed that human beings, the occupants, the users are at the center of these buildings and these buildings have to be designed for the human beings keeping in mind the comfort of these occupants. So, only thermal comfort is not the one which should be considered or thought about while designing the buildings, it is also the visual and acoustic comfort.

Visual and acoustic comfort find mention both in our course like NBC and also in our green building rating programs the voluntary rating programs which are available. Let us quickly go over each of these and what are the related concepts and terminologies that we should be looking at.

I am sure most of you have already undergone the courses on lighting and acoustics as part of your curriculum, if you have not some of these concepts are briefly introduced here, but not in great detail. So, let us go over the visual comfort first.

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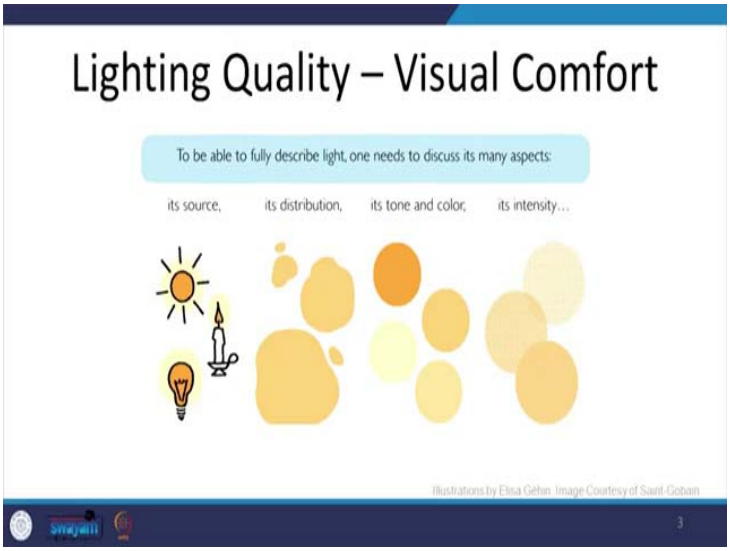

So, what is visual comfort and what comprises of visual comfort? So, there are many components to it. The first one which is essential for visual comfort is the source of light. So, what is the source of light? The other which contributes to it is how is it distributed. So, if it is distributed non-uniformly, so, in one place you have more light in the other place you have less of light then this varying distribution causes discomfort, what is the tone and color of the light that we are using.

So, earlier people were using candles or flames for lighting up the interiors, gradually we moved on to incandescent bulb and then we moved on to tube lights and now we are using CFLs and LEDs. As the technology has progressed the quality of light the tone of light has also changed.

So, earlier we were using yellow light where the color of the light was yellow the tone was such, and gradually we are moving to more sunlit kind of light the light white light that we received from direct sun. It is very similar to what we are able to produce using the artificial light as well.

So, where there is a wide spectrum of colors available where it is a white light or combination results in a white light is what a good color or tone of the light is. Wherever there is a different tone or color which is there in the light, it is not usually comfortable when we are talking about long working hours.

So, suppose assume yourself working in a space which has only red colored lights all around you. You will not feel comfortable for long sitting in that space. The last one is its intensity. So, we need intensity sufficient enough to perform a task. Now that varies from activity to activity space to space, depending upon the activity and the space the intensity has to be there.

Together all these 4 parameters define what visual comfort is. Visual comfort is defined as the ability to fully describe light and understand the space as it should be perceived or as it is. So, it is the absence of discomfort because of its source, distribution, the tone and color and its intensity and the absence of this discomfort is called as the visual comfort.

So, when we are talking about visual ~~comfort~~comfort, we are talking about 2 aspects the quality, as well as the quantity. So, of these 4 parameters 2 are used to define the quality of it.

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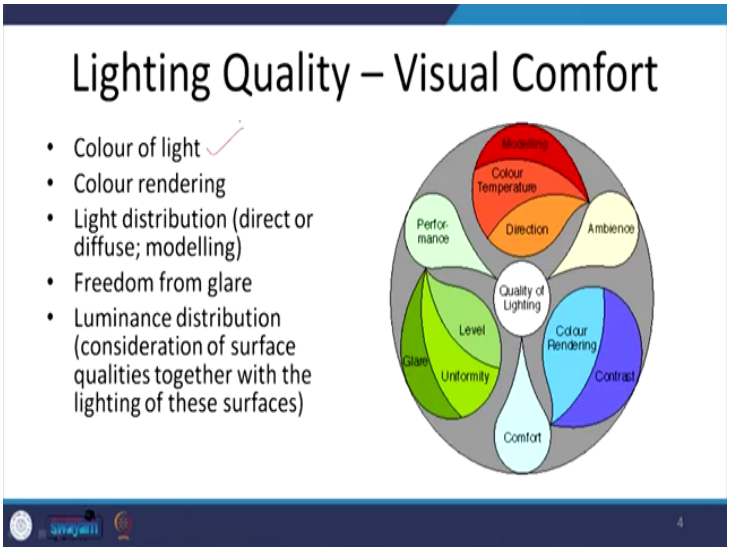

First is the color of light as I just said, that color of light defines how comfortably things can be seen in the given light. Preferably the light's color should be close to what the color of direct sunlight is which is white. We should comprise of all the colors equally and we should be able to perceive the color of any given object as its original color and that is what the color rendering is. So, here we are looking at the light distribution also which is direct or diffuse.

Now, suppose I have a lamp right on top of my head, so, there is direct light there. While if I have a in case of artificial light I am saying in case, of a bulb where I have a diffuser where I have a reflector which reflects it to the ceiling and then I get to diffused light, where I do not get any shadows, I do not get glare, same for artificial as well as natural lighting. So, what kind of light distribution is there, whether it is the direct or diffuse?

In some ~~cases~~cases, direct light is required. For example, for a doctor who is performing a critical operation in the operation theater, there he may want to have there, we may want to have direct light focused onto the operation area where the doctor is able to clearly see things because he is going to perform a critical operation there.

Unlike when we are working or when we are reading in a classroom, there I might not require direct light falling onto my book, onto my notebook. I would prefer diffused light Because, I have to sit looking at my book for long hours and there, diffused light would help keep stress of my eyes.

Another thing that we require here is freedom from glare. We will come to glare what glare is in subsequent slides, but glare is that pinching light directly falling onto your eyes. It is not necessarily that direct light, but it is when there is a great difference between what my eyes are used to and suddenly when I go into a bright light or there is a bright light coming from somewhere.

We are also looking at the luminance~~ous~~ distribution, how the luminance is distributed throughout the work surface. So, these are the qualitative aspects of visual comfort.

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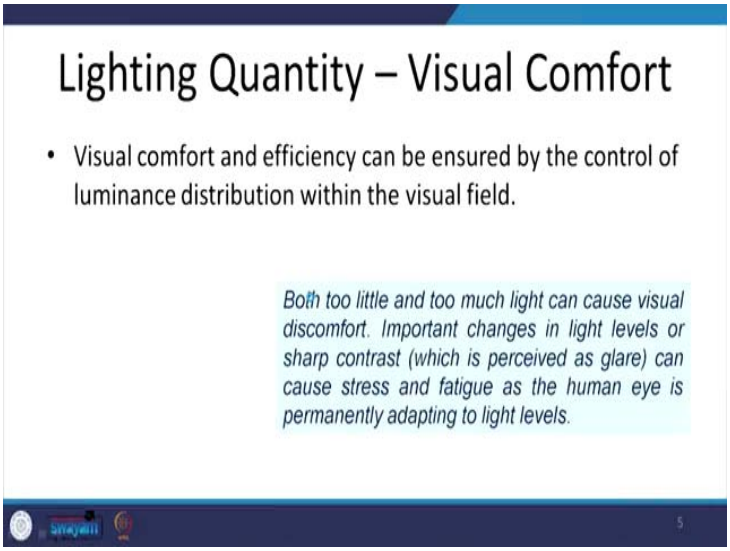

We are also looking at the quantitative aspects of these visual comforts. Some of these qualitative aspects can be converted into quantities. ~~So~~So, first of all we are looking at the illumination, how much of the light the intensity is going to be there. So, when we are talking about illumination we are talking in the units of lux and for different types of tasks from casual seeing to exceptionally severe task with minute detail as I was talking about the operation theater the illumination level goes on increasing.

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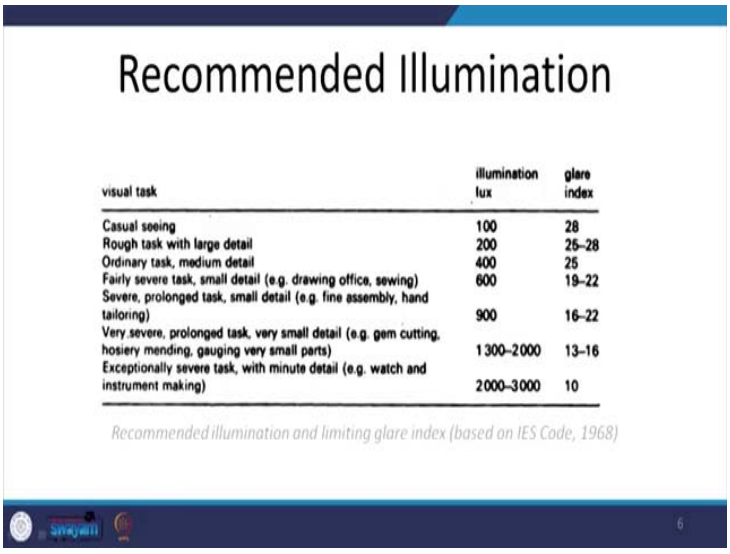

So, if we are casually walking around seeing things a ~~100 lux~~100-lux illumination is sufficient enough and of glare index as high as 28 is also fine because, we are casually seeing around things. However, when we go high on the intensity of the visual tasks for example, we look at the ordinary task or medium detailed task which is where our classrooms and offices come in.

We look at ~~a an~~an illumination level of around 400 lux, 400 to 500 lux is what we would want in our offices and classrooms and a glare index of around 25. We will come to what glare index is. If we look at where is severe or prolonged tasks which require minute detail for example gem cutting there the lux levels are quite high, but though the lux levels are high we are not promoting a very high, we are not accepting a very high glare index, the glare has to be less.

So, the entire workspace has to be highly lit along with the task table, along with the task work plane. And the maximum it goes up to 2000 to 3000 lux which is in case of operation theaters or instrument making, watch making which is very minute very small parts go in and the glare is further reduced.

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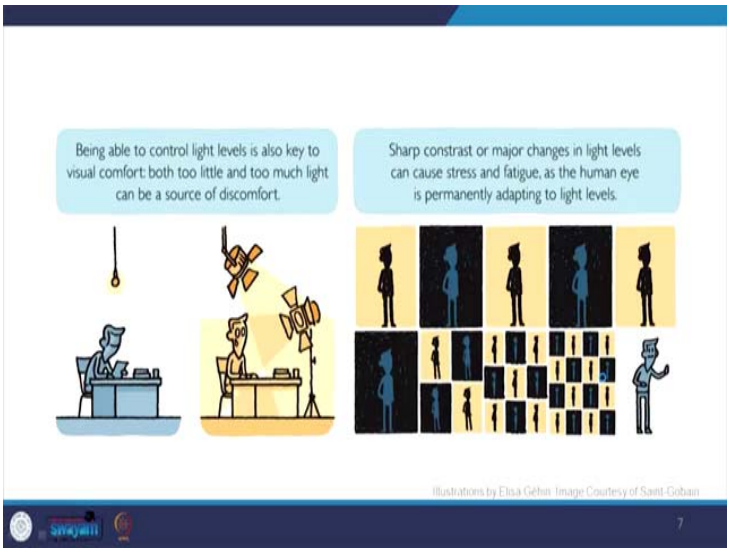

If I look at beyond the quantity quantitative aspects of visual comfort in general, the ability to control the light levels by the occupant is key to this satisfaction. So, suppose I am in an office area where I cannot control the illumination around, today I might ~~to~~ be

feeling a little low and I might require more light to perform a task the same task as compared to some other days where I might want to work with less of the light depending upon my mood, depending upon my comfort that ability that flexibility in the built environment is also a key to satisfaction.

So, it is both for thermal comfort, for visual comfort equally. If I am able to control my thermal environment and, if I am able to control my visual environment, the researchers have proven that the occupant is more likely to feel comfortable be at comfort.

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Now, we come to glare. So, glare as defined is a subjective human sensation that describes light within the field of vision that is brighter than the brightness to which the eyes are adapted. Now, this brightness to which the eyes are adapted is the overall brightness of the place, the general illumination level luminance of the place and the light within the field of vision.

So, suppose I am sitting here if you look at this picture, so, if somebody who is sitting here is usually looking at this wall this is the work side, this is the work desk and this side is where the bright light comes in. So, the difference between the brightness coming from this side versus the brightness which is prevailing in this larger area this room is what is perceived as glare and there are quantified formula to define what glare is, but glare is often harmful.

Because, it injures the eye, it disturbs the nervous system and at times it when we are talking about injuring the eye it almost blinds a person you cannot see. It is a cause of annoyance, discomfort and fatigue. So, if you are constantly, for example, if you are driving during the night and there are vehicles coming from the opposite direction, so, your eyes are used to a much lower level of brightness because it is night and suddenly when the light from the vehicle which is coming from opposite side hits your eyes that is what causes a discomfort because of glare.

Now, constant exposure to this glare causes fatigue; it is mental fatigue, it is fatigue to eyes, it is fatigue to body. So, ~~its~~it reduces the efficiency of work and it interferes with a clear vision which is what I say that people are almost blinded when there is glare when there is high glare and thereby increasing the risk of accidents.

So, a lot of accidents happen because of this glare on highways. So, I am giving example of glare from highways, but when we are talk about the ~~buildings~~buildings, we experience a lot of glare coming because of surrounding buildings. So, suppose I have a window and there is a reflection coming from the building which is adjacent because of the ~~light colored~~light-colored finish of that building a lot of reflection of light is coming onto my window and onto my eyes. So, that is how the glare inside a building often comes in.

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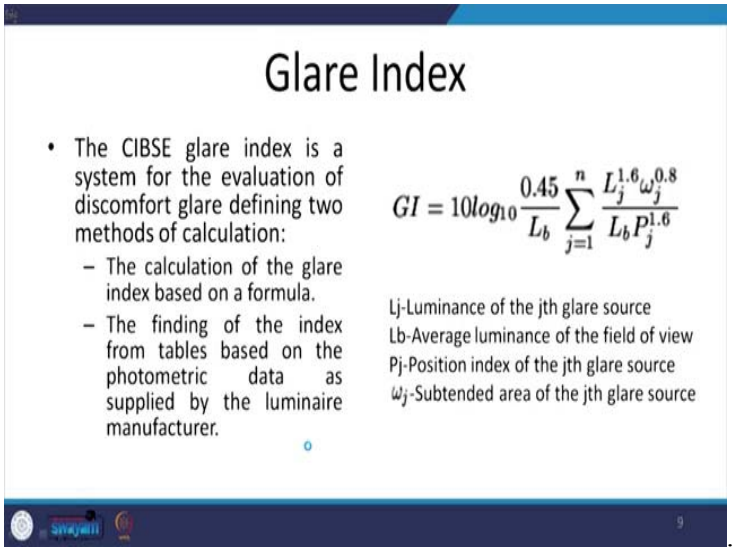

So, to define glare the glare index has been defined which is what we just saw when we were defining the illumination level and the glare indices. So, the formula inn corporates largely the luminance of the glare source which is under question, the average luminance of the field of view to which the eyes have adjusted, the position index of the glare source how far or how close it is to the object to the area under study subject under study and the subtended area of the glare source.

Put together in a formula it gives us the glare index. With the help of this glare index as we have already seen we can define how much of glare is ok. So, up to 25 is maximum that can be seen that can be accommodated this is as per CIBSE glare index, but there is a new glare rating which is unified glare rating or UGR.

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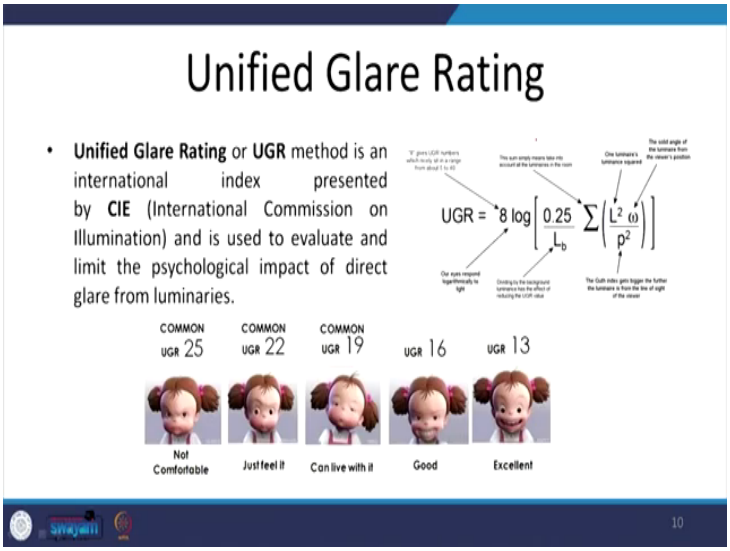

And it is defined by this formula again where we are taking into account the background luminance, we are taking into account the luminance of the source and the luminary, and putting together in an formal in a formula to get the UGR as per the UGR we are looking at a limit of UGR 16 which is good enough for the human eyes beyond 16 it is not advisable to have the glare. Now when we have talked about the illumination level the luminance and the glare index always whenever we are talking about visual ~~comfort~~comfort, we are talking about 2 things.

We have to look at strategies to control glare and to allow for this minimum illumination which is desirable besides these 2 the qualitative parameters where we were talking about the color of light and we are talking about the uniform distribution the tone of the light, the tone color and uniform distribution also comes into a picture and one more thing which is the direct access to views. So, how much can we view.

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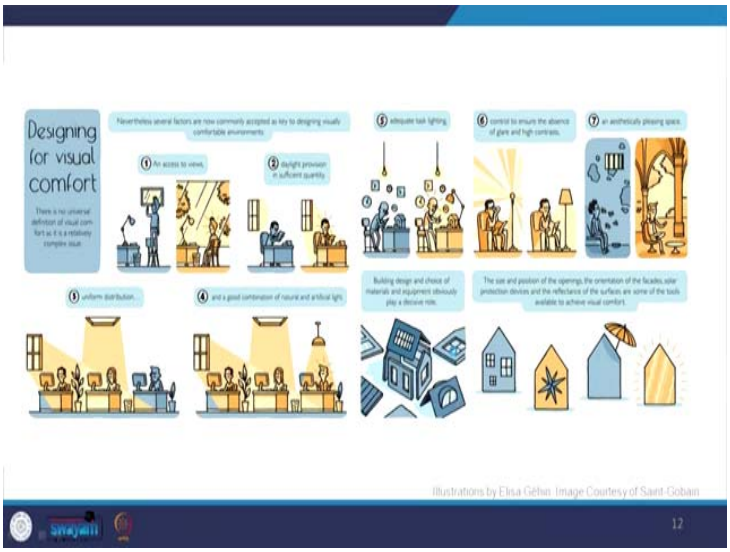

So, this is a beautiful illustration which is put up by Elisa Gehin and it is available in public domain at the Saint Gobain website. So, there are 6, 7 strategies or indicators to assess visual comfort. First of ~~al~~all, which we of a neglect is an access to views this is very well taken care in green buildings in sustainable building where each workplace should have an access to views.

If every workplace cannot be connected to the outdoors outside the building, punctures or green areas natural areas within the building have to be created in order to provide for these views. The next is provision of sufficient day light every workplace should be day lit as much as possible. Though we may have sufficient light available artificially yet the provision of daylight has a lot of impact now we may not be able to perceive that immediately.

But if human beings are continuously exposed to controlled environments where they cannot see the daylight there are psychological changes which start to happen which are

visible and a lot of medical research has proved that. So, direct provision of daylight in sufficient quantity is required for visual comfort. The next is uniform distribution of that we cannot have some workplaces with limited daylight availability and others with less of that.

If it is a uniform distribution that is what will lead towards the visual comfort then we are looking at a good combination of natural and artificial light for some for the entire year for all the working hours it is very difficult almost impossible to provide for provision of day light to all the workspaces. So, we have to have a good combination of artificial and natural light preferably day lit areas which are which are receiving good amount of diffused light daylight, day lit combined with provision of artificial light in addition to that we should have adequate task lighting.

So, there may be general lighting in a space and then specific task lighting depending upon an individual's need which also fulfills the need of an individual to control his own environment. Maybe I need more light to work and there is someone who prefers low levels of light to work. So, that personalization of a space giving individual controls is what can be fulfilled through provision of adequate task lighting.

The next is the ability to ensure the absence of glare and high contrast. So, we should use such fixtures such luminaries where we are able to control the glare the next is an aesthetically pleasing space this is a very qualitative aspect, but any space which is if esthetically pleasing, beautifully designed interiors and environments enhance the productivity of people they become they feel more energetic they feel more activated to work. So, these are few parameters which we can keep while designing any space for visual comfort.

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And this is based upon a lot of socio psychological research where it has been established that ~~good~~good ~~we~~ visual comfort, good amount of light, but type of light, quality of light, amount and intensity of it. Actually, has a significant effect on how we feel how we experience in a space and in time both consciously and subconsciously. So, we have to provide for good visual comfort now some of the visual comfort strategies which can be employed to bring in visual comfort passively are shown here on this slide.

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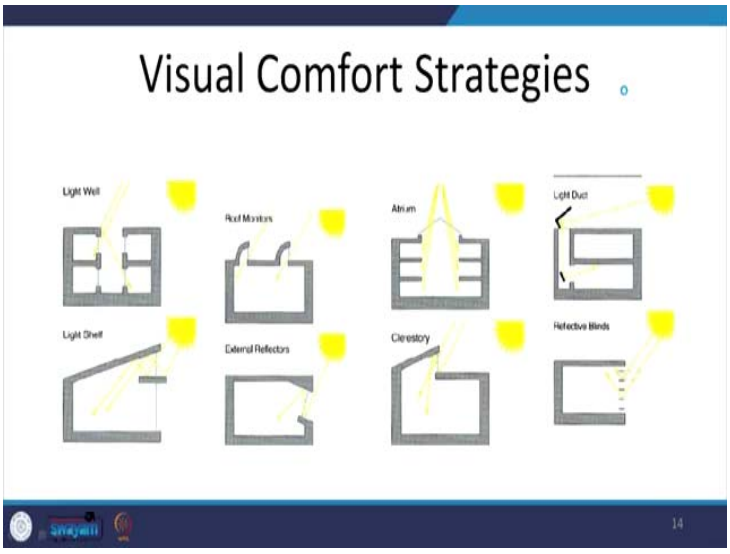

So, we can use light well we can use roof monitors and atriums where a lot of daylight can be brought into the atrium the courtyards actually served such a purpose there are light ducts. So, this is the reflective side of the material where the light is actually reflected it is mirror and if you remember, if you have seen some of the old photos and traditional buildings, mirrors were used to bring in light to the deep corridors to the deep areas inside the buildings.

Light shelves we have discussed again this top surface of the light shelf is a reflective surface and it reflects and this light which has received indoors is actually a diffused light similar to light shelf we have a shelf here. So, it is slightly different from this light shelf, but serves the same purpose of reflecting the light and then diffusing it.

We have clear story again reflective surface here direct as well as diffused penetrates inside and we have reflective blinds here which are serving similar purpose as the light shelves smaller light shelves as we can see here. Another very interesting strategy which is utilized in case none of these is working is to divide the window in such a manner.

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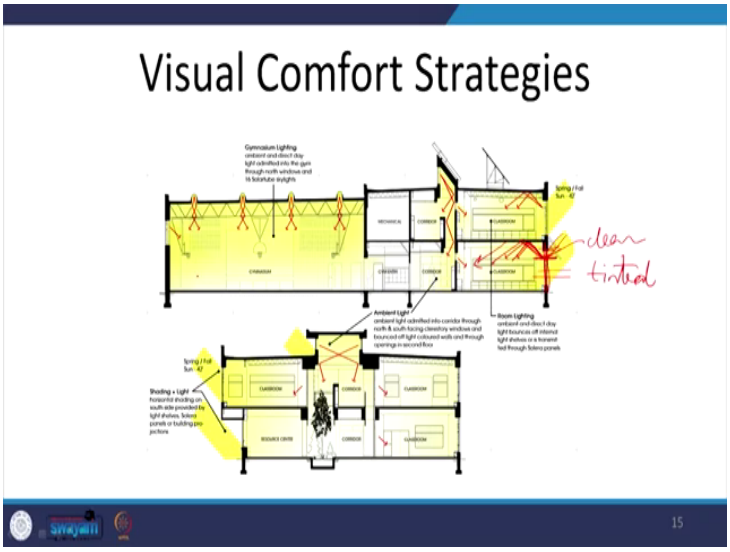

That a large window where we have a large window we can divide it the portion above the visual part of the window is where the clear glass is used and that part is used to reflect the light to bring in light and penetrated deeper while this part of the window ~~we~~ will use a tinted glass now this will help in cutting down the glare. So, there will be no

direct light falling onto the eyes of the occupants and there is; however, there is sufficient light which is brought in through the clear glass which is above.

So, the window very clearly can be divided into 2 parts and just by choice of the color of glass interesting combinations and overall a uniform distribution of light can be achieved. So, this particular case study shows how different day lighting strategies have been used to day lit almost the entire school. So, this is the case study of a school where different strategies have been used to bring in diffused daylight into the habitable rooms.

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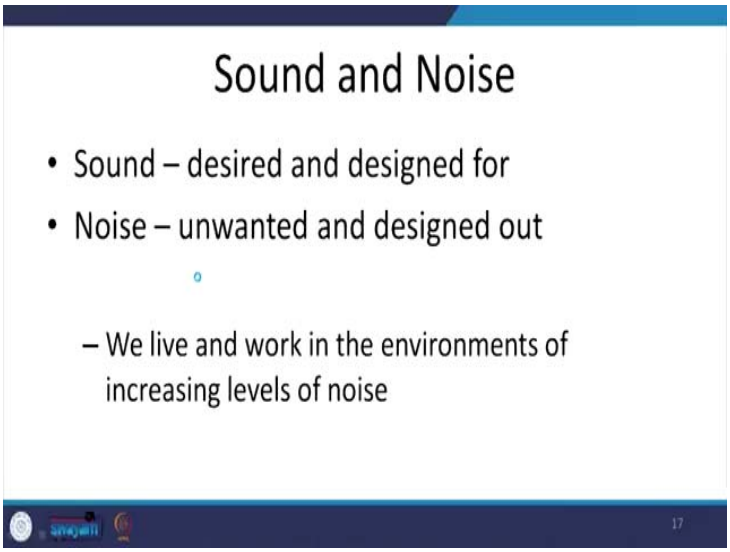

~~Next~~Next, we have acoustic comfort. Now when we are talking about acoustic ~~comfort~~comfort, we must very clearly understand the difference between sound and noise. So, sound is what we have desired and we have designed for while noise is something which is unwanted and we have to design out. For example, I often take this example of a classroom. So, when as a teacher I am in the classroom what I am saying the lecture that I am delivering and what my students are able to hear is what the sound is.

I should be hear able to hear what my students have to say they have to ask and the students should be able to hear me what I am delivering. While noise is something which is what we do not desire in this space for example, somebody walking in the corridor

outside my classroom, a vehicle going by the side of the classroom on the road. So, all these noises are unwanted.

So, we want to hear each other clearly while in a classroom, but we do not, do not want any of the noises coming from outdoors to inside of this room that is nice for me. Now how do we know how much of the sound is available or should be allowed? How much of the noise should be cut?

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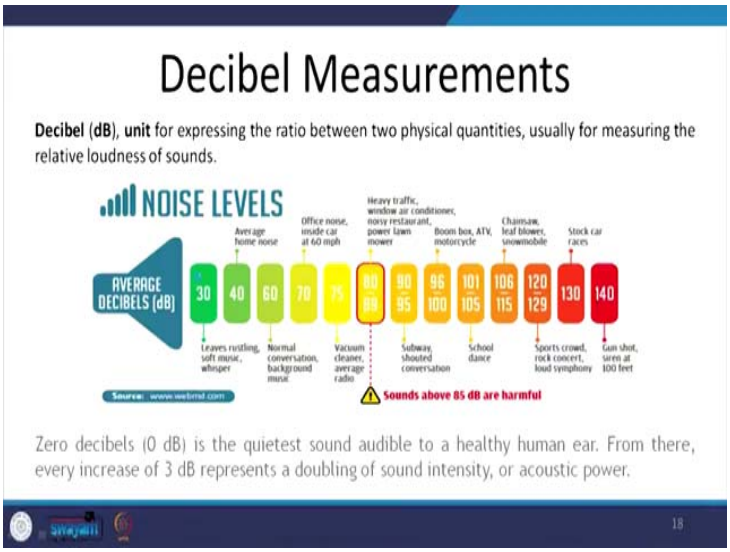

So, first of all we have to measure I am sure you have already read the course on acoustics where you know how we measure. So, we measure using decibels. So, Decibel is the unit for expressing the ratio between the 2 physical quantities for measuring the relative loudness of sounds. If you look at the average decibels which are required in an office and in a classroom around 60 decibels is what we would normally require that is, that is what should be maintained extremely low decibels spaces which are too quiet are also not comfortable we might be comfortable in those spaces for a very short while.

So, there was an experiment which was conducted and one of the universities in a United States where they were able to bring down the decibels in a space down to 0. So, an absolutely quiet space and at 0 decibels the human beings we can hear our own blood flowing through our body and it is quite disturbing. So, we need a little sound around us

which is around 30 decibels is good. 30 decibels ~~is~~is where you have the leaves rustling, you have the sounds of the nature, little bit of whisper and it is quite comfortable.

If we look at 40 decibels this is what we require for sleeping. So, around 30 to 40 decibel we can comfortably sleep. 60 is what we would look at what we want in the classrooms slightly higher than that is what we would look at of we would be comfortable when we are in an office space where people are moving, people are talking.

There are little discussions going on. When we have ~~a some~~some average radio being played little bit of music, vacuum cleaner and all that is around 75 decibels. Now 80, 85 is the limit beyond this it is harmful for the ears. So, any sound above 80, 85 decibels is noise, ~~–~~beneath this also depending upon the space it is it may be qualifying as noise above this it is definitely harmful and noise.

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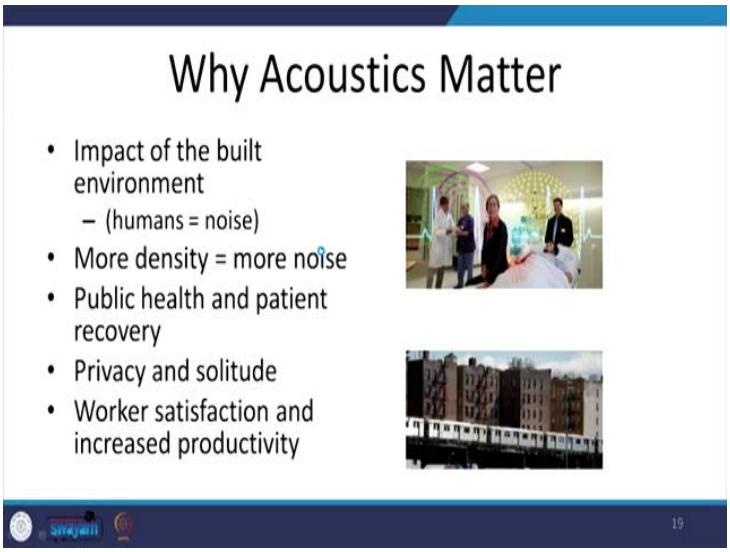

So, depending upon the quietness that you require or the amount of sound that you require the space has to be designed it will impact the health of the occupants the amount of sound which is present amount of noise which is present it depends upon waiting levels of privacy. So, in areas which are more private suppose I want to have a private discussion in a conference room even when I am in an office such areas would require more acoustic treatment.

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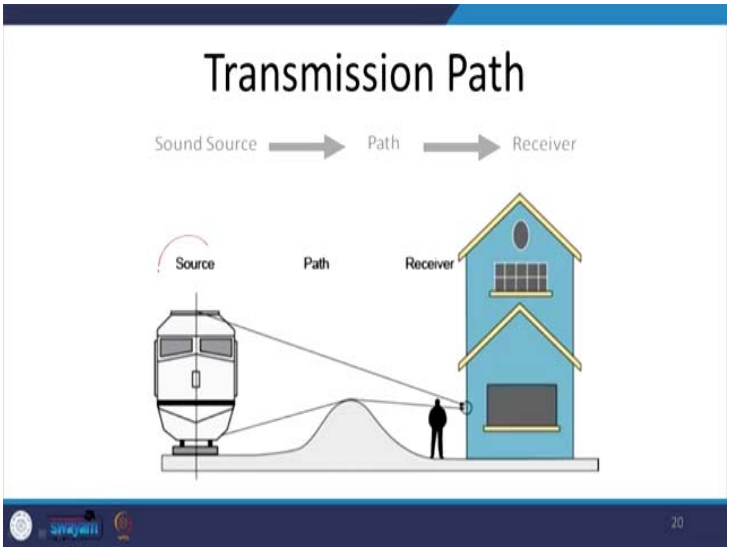

For example, the theaters they require more sound acoustic treatment to provide for the sound quality. So, when we are looking at the design of buildings for acoustic ~~comfort~~comfort, we should look at the transmission path we should identify the source, we should identify the receiver and we should look at how what the path of this sound travel is from source to the receiver.

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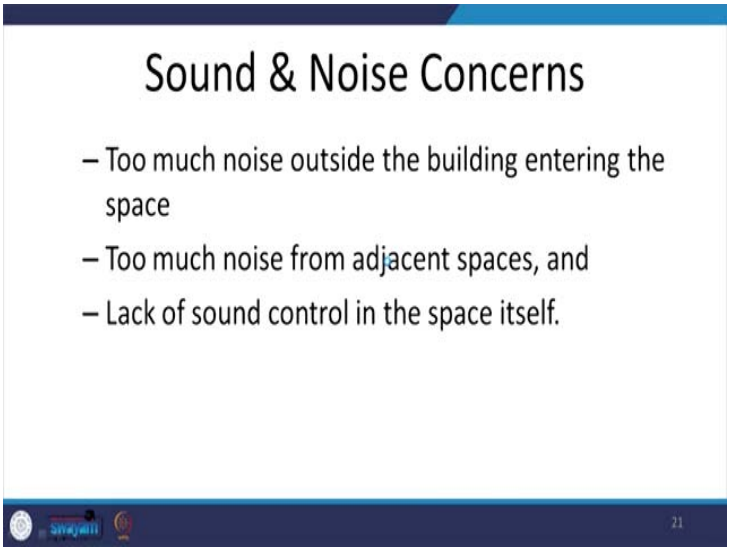

Based upon this we have to identify the strategies we have to look at these strategies for designing these buildings. The impact of this environmental noise can be direct as well

as indirect on human health and wellbeing people ~~expe~~experience~~diency~~ sleep disturbances, speech interferences and annoyance.

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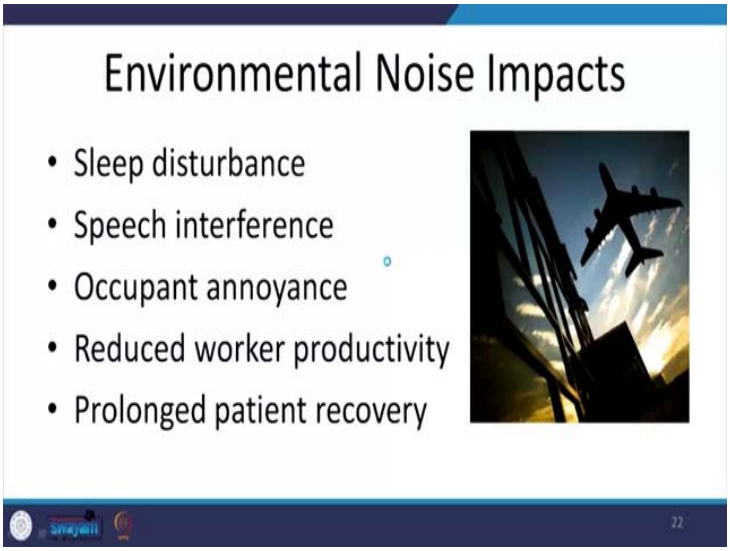

Because of the environmental noise there is a reduced productivity and there is a prolonged patient recovery that is why in all the hospitals where patients are, people are there with illnesses, sicknesses. The hospitals are supposed to be maintained quiet. Since it reduces the retention, concentration of occupants those classrooms and work areas like offices are also required to be maintained at low decibel levels.

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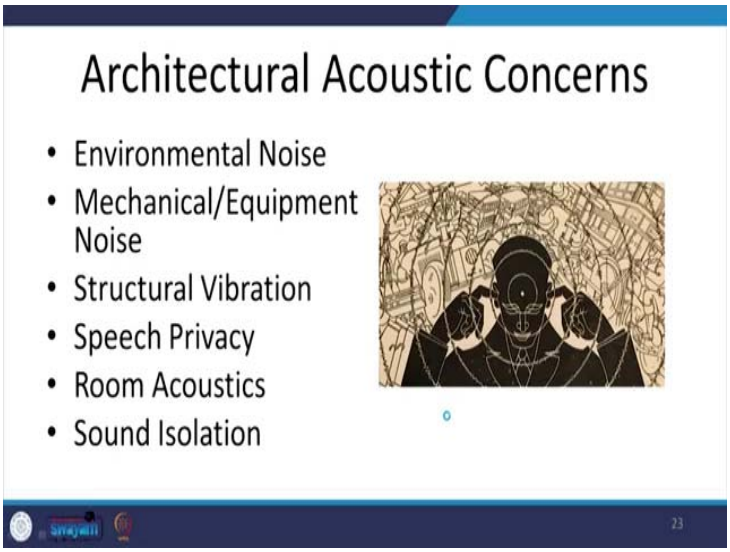

When we are talking about buildings, we are talking about many concerns, we are looking at environmental noise; we are looking at mechanical and equipment noise which is often a very high noises a major concern. We have HVAC systems, we have air conditioners, on our windows and inside our rooms we have water coolers, we have fans, we have different equipment which is there.

So, a lot of noise is because of these mechanical or other equipments we also have structural vibrations which are passing from the; which are passing through the structure of the building into the space. We have concerns for speech privacy as I would just mentioning for conference rooms, meeting rooms we have requirements for room acoustics and sound isolation is what we require we need to isolate the source where the sound is coming from the noise is coming from.

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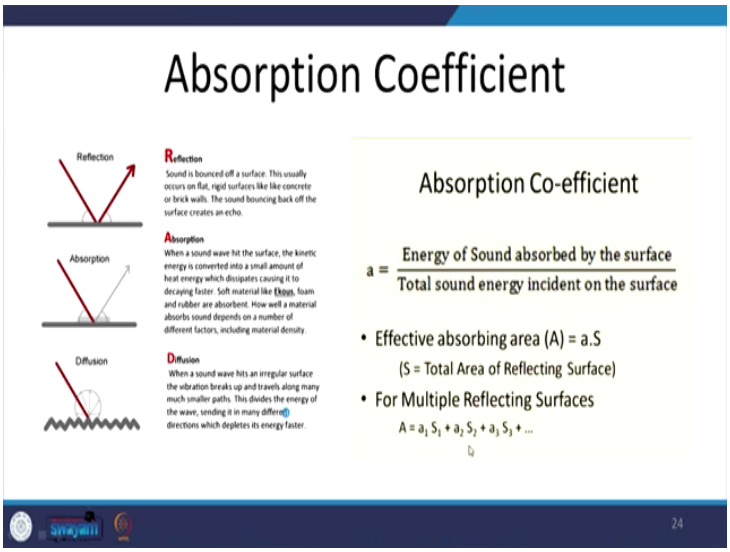

For doing that we have to understand very quickly some of the phenomena some of the quantities parameters that we use one most important is absorption coefficient. Now what is the absorption coefficient very simply if I put it is the proportion percentage of the not percentage. It is the proportion of the sound which is absorbed by a surface versus its total incident sound energy which is incident on the surface. So, the more amount of sound which is absorbed by it out of the incident sound is what its absorption coefficient is higher is that amount, higher is the absorption coefficient.

Maximum it can be 1 because 100 percent of the sound is absorbed and least would be 0 where all the sound is transmitted. For example, an open window so, an open window ~~have,~~ will have all the sound transmitted through it. So, that is where the comparison would be just as we have ~~light~~light, we have the phenomena for sound. So, the sound is reflected from the surface the harder the surface is the more is the sound which is reflected then we have absorption by the surface. So, the more porous the material is the more is the amount of sound it absorbs.

So, a material such as wool ~~voile~~ or fabric because it is porous absorbs more amount of sound and then there is diffused. So, based upon the shape of the; shape of the material the amount the sound when it is incident on this it is diffused. So, it is broken into sound of reduced intensity, but it is there it is still there it is reflected that is what diffusion is the next concept that we have to keep into mind is reverberation.

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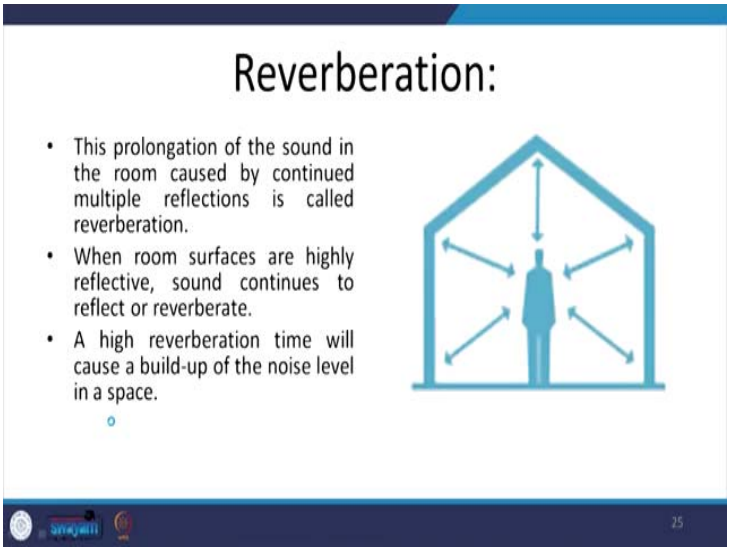

So, reverberation is prolongation of the sound in the room caused by continued multiple reflections which is what we would see in case of different shapes. So, it gets reflected from one surface goes onto the other surface and then further reflected and comes back. So, it will happen only when we have hard surfaces and there are multiple reflective surfaces present in any room.

That is what will also cause the echo now based on reverberation and the formula we can calculate the reverberation time.

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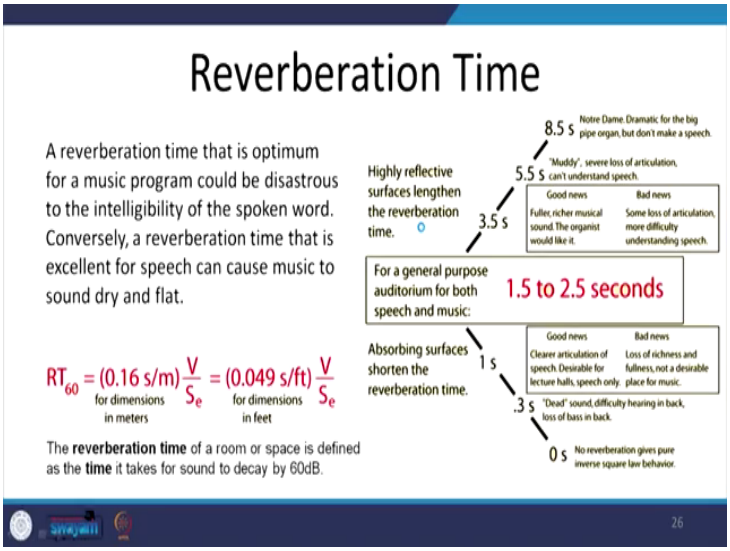

Now this reverberation time decides for how long the sound is going to be present in that space for any ~~general purpose~~general-purpose auditorium which is both for speech and music now there are different reverberation times which are proposed good for music and separately for speech. So, for any music to be enjoyed for a theater where musical performances are going to be a reverberation time of around 2.5, 3.5 is good. So, when we have a reverberation or time of 3.5.

Because, there are different types, different intensities, different notes, different musical waves which are hitting our ears that is where the musical sound will sound fuller, richer, if we have less reverberation time less than 1 it will it will be perceived as a very dead space it will be perceived as a very dead sound while it may be good for speech. So, around 1.5 seconds of reverberation is good for speech it is a little bit of hard surfaces should also be there that is when it sounds good.

Now that is this reverberation time is calculated on the basis of the total surface area ~~equa~~equivalent~~l~~ and surface area which takes into account the absorptivity, the absorption coefficient of the surface and the surface area. All the different surfaces and

~~there~~their absorption coefficients put together and also the volume of the space so together these 2 result in a reverberation time.

So, whenever we are designing for auditoriums, theaters reverberation time becomes very important, but often we forget about it when we are designing classrooms when we ~~are~~are ~~we~~ designing offices, but we should take into account take care of the kind of surfaces which are being used. Here we are also talking about reflections.

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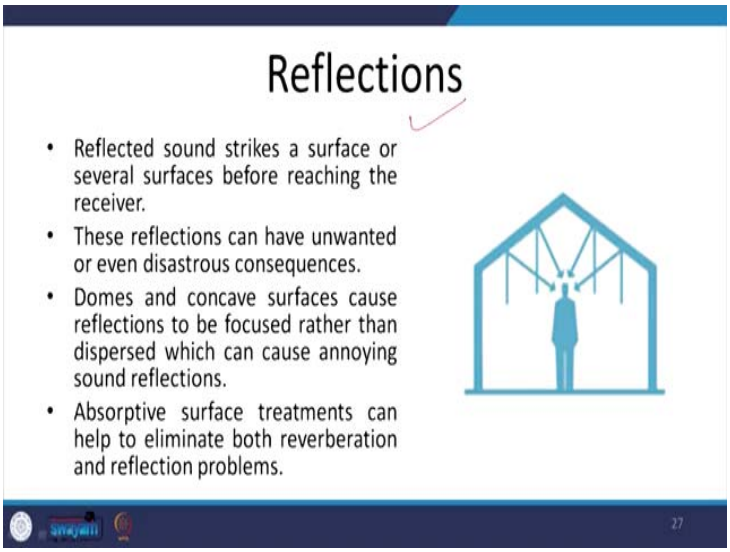

Now, reflection results in reverberation. So, how the sound is going to be reflected? So, it depends upon the material as well as design. So, how the sound is going to be reflected? How many times will it be reflected will result in reverberations. So, for any good classroom or office a reverberation time of around 1.5 is a good reverberation time and we should choose materials effectively.

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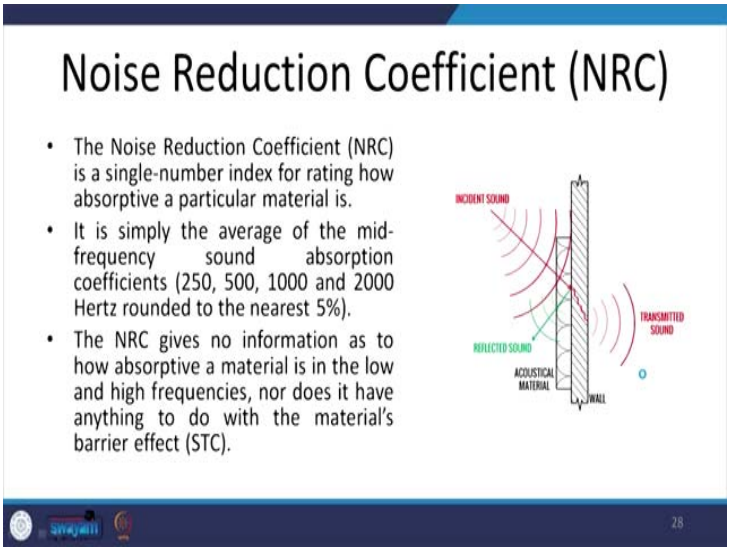

Here we are also talking about noise reduction coefficient this is an, this is a measure of the material individual material where we know how much of the sound can be absorbed by the material. So, on higher number of noise reduction coefficient implies that larger is the amount which can be absorbed or diffused by the material. Lower is that number, lower is the amount of sound which can be reduced the reduction of the sound. So, of the incident sound which is their how much is transmitted to the other side ~~other side~~ is the measure of NRC noise reduction coefficient.

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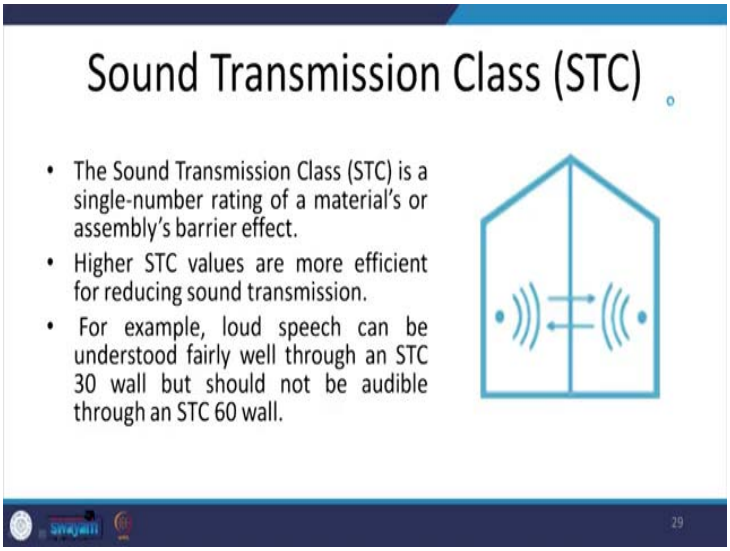

Lower is that number the better is this material for sound insulation the same is further taken to understand or classify the materials in different classes. So, there are, there are sound transmission class STC. So, higher this STC values are the more efficient is the material for reducing sound transmission. So, it is an inverse of NRC in a way.

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Once we understand what these materials are and what our requirements from design ~~is~~is, we can look at the different strategies for sound barriers we can use the sound rated walls which are STC and we can look at these windows which are also sound rated windows.

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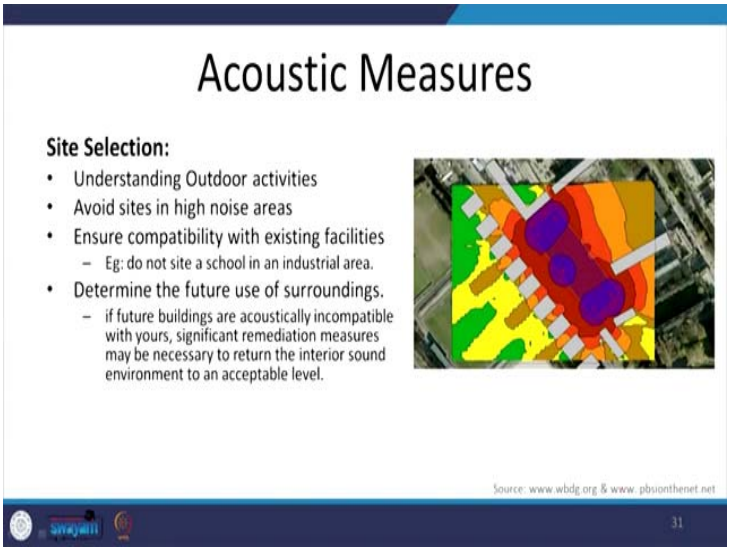

There are design measures which we can use for example, the selection of site. So, understanding from where the sound comes to a site organizing activities in such a manner that noisy activities which can be performed with high noise amount placed in the high noise areas and the quieter activities are placed in the quieter areas.

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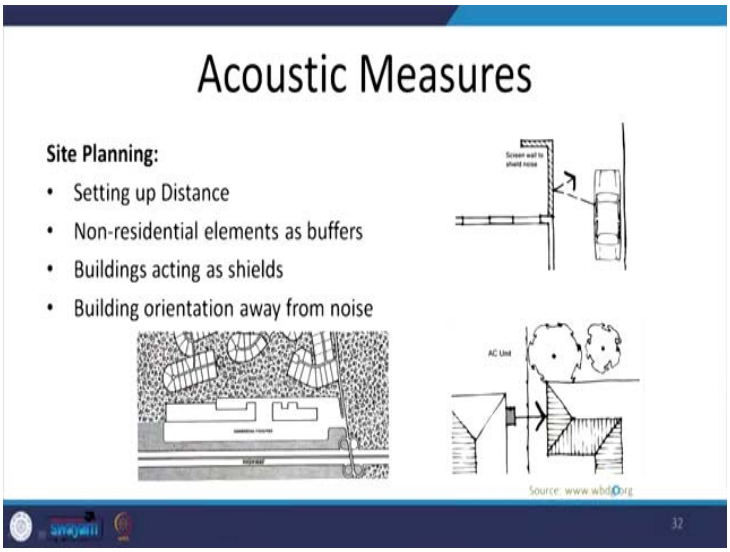

We can look at the distance of the site we can look at different elements non residential elements for example, commercial facilities. So, this is a highway going and this is the residential area. So, between the highway and the residential area a huge commercial

facility has been developed where it acts as a barrier of sound to the residential area. So, this is building acting as shields and also orienting the building away from the noise. So, we can orient the building in such a manner that the noise is cut away.

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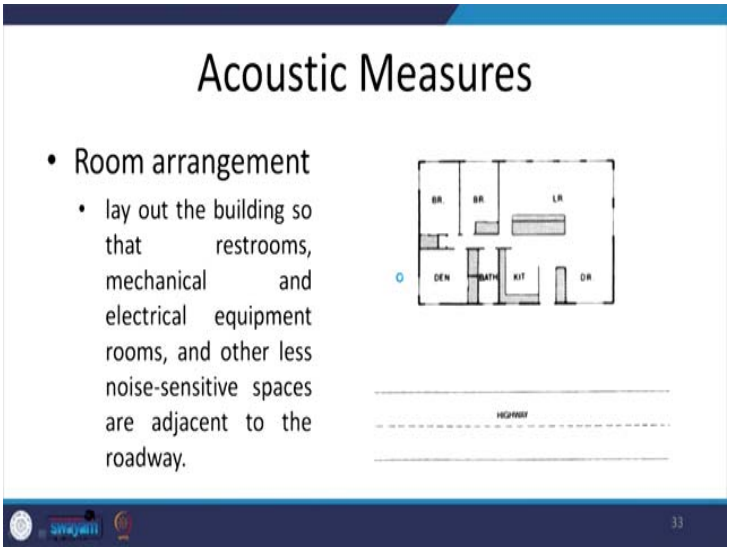

We can also look at the internal arrangements now bedrooms are the quieter areas where people sleep during night. So, they can be kept away from the noise creating side the source of the noise. So, more active areas for example, the drawing rooms, and kitchens and bath areas they can be used as a buffer as an acoustic buffer and the bedrooms can be at towards the quieter side.

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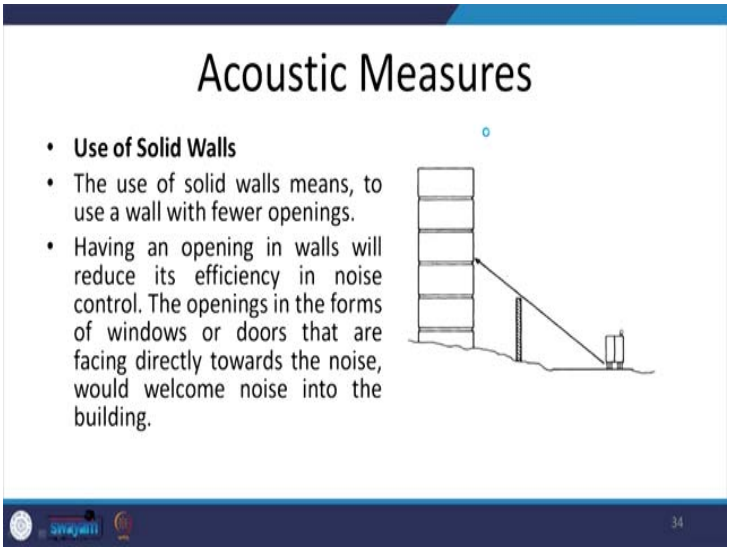

There are multiple other measures for example, using walls, solid walls as acoustic measures. So, this is a highway going and this actually acts as an acoustic measure besides was trees can also act as acoustic measure.

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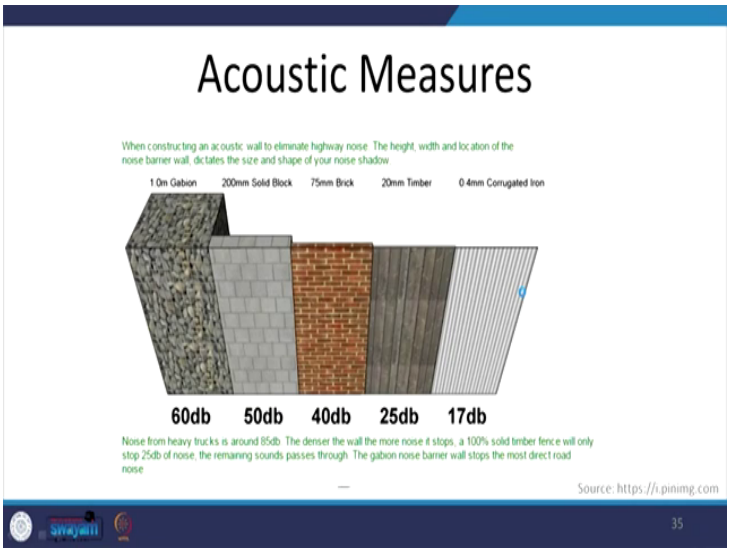

If you are looking at ~~materials~~materials, we should understand the difference between each material and the amount of sound reduction, insulation that each of these materials provide. So, the walls the regular walls provide around 40 Decibel of a sound insulation

difference from the source to the sink side. If you want around 60 Decibel around 1 meter of Gabion is a useful strategy or useful material.

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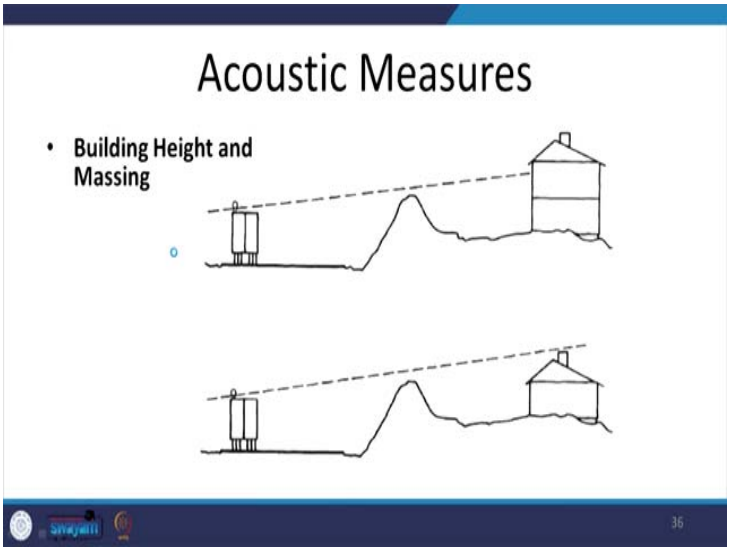

But it is a very thick wall and we should also see that it is porous and that is what causes a lot of sound reduction to happen through this wall. There are other design measures for example, adjusting the building height depending upon the topography and the site features which are available.

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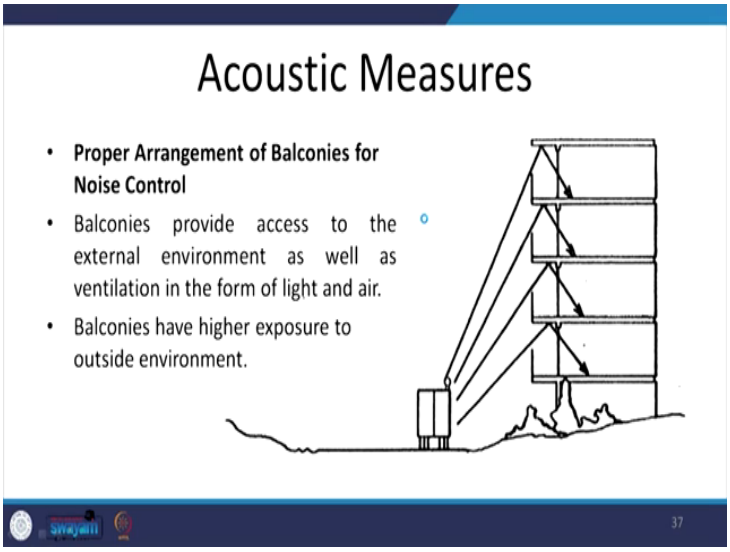

For ~~example~~example, designing the balconies such a way that is known direct noises hitting into the space it is coming into the space.

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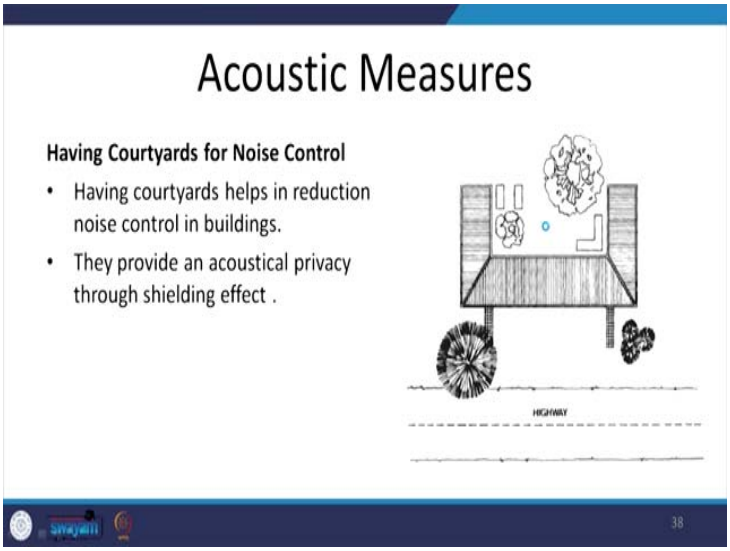

Having courtyards for noise control, so, for example, in this building the courtyard is facing away from the highway and this side would be a blocked side. So, the sound because its travels straight. So, there will be less of sound which will be available in this courtyard.

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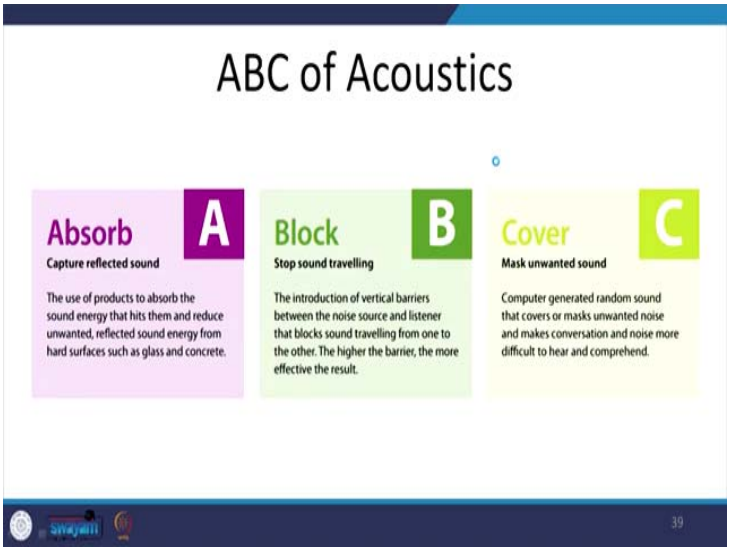

To conclude it all we can say there are 3 fundamental ways in which acoustics of a place of a space can be designed that is ABC absorb, block and cover. So, first is to capture the reflected sound by using appropriate material absorptive material. Second is to block the sound from traveling by introducing the vertical barriers the barriers to this sound which can be possibly disturbing and. The third is to cover the unwanted sound to mask that sound by providing certain covers.

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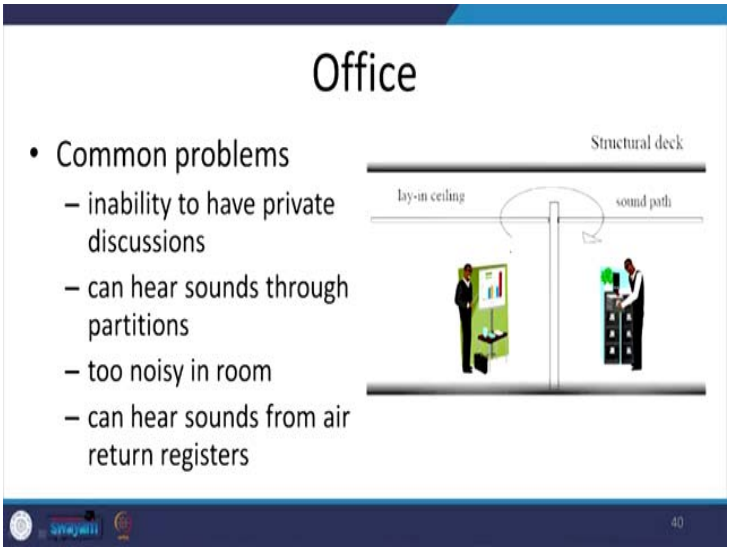

So, which is what we see in our buildings happening very quickly going over the kind of problems that we have we often see in our offices and our classrooms is we have a lot of noise traveling through the ceiling, through the ducted area there is inability to have private discussions and ~~we can~~ the partitions are so thin that we can hear through the partitions and there is no privacy and it also becomes noisy. So, if there is a n lot of noise happening in this area the area which is supposed to be quiet also receives a lot of noise.

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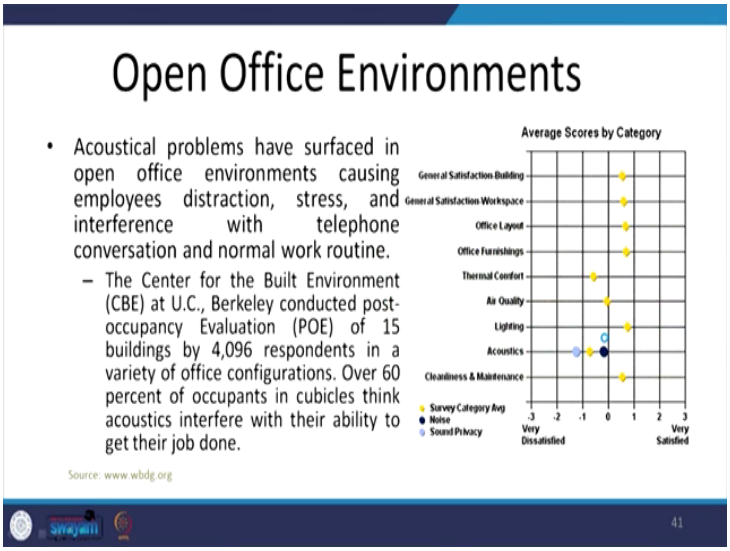

So, these are some common problems which are there in the office environments and there was a research conducted by center for built environment at UC Berkeley and there people felt dissatisfied, uncomfortable only because the acoustics was not good for everything else they were quite comfortable satisfied, but because of acoustics because this was. So, noisy in an open plan office.

So, this research was largely on open plan office environments and people felt dissatisfied simply because the acoustics was not comfortable.

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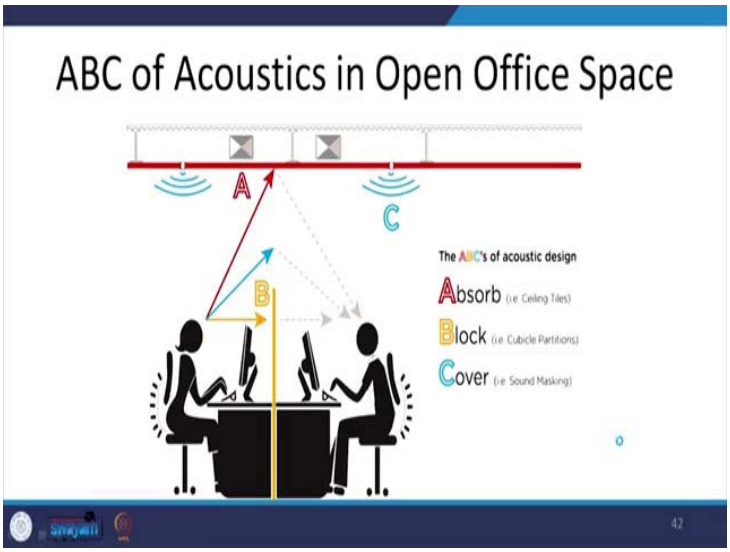

So, when we are looking at strategies in an open office space we are again looking at the ABC we are looking at the ceiling material which is reflect, which is absorptive we are looking at the partitions which block, we are looking at the masking of the sound through provisions of absorptive material here.

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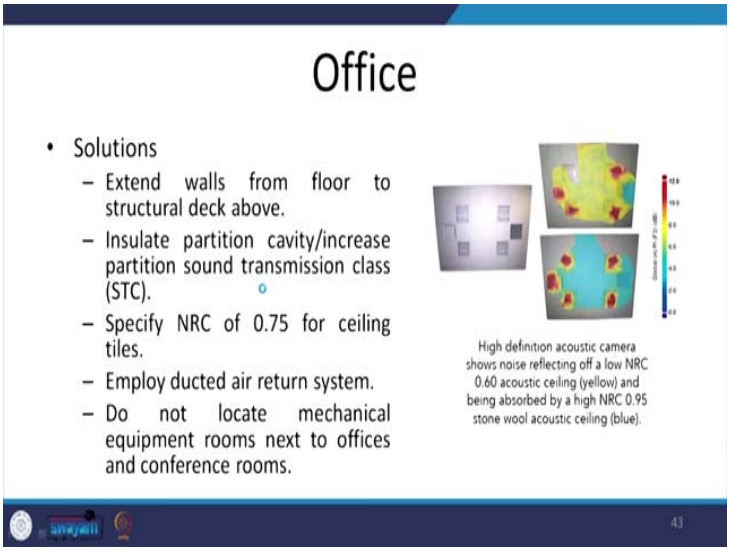

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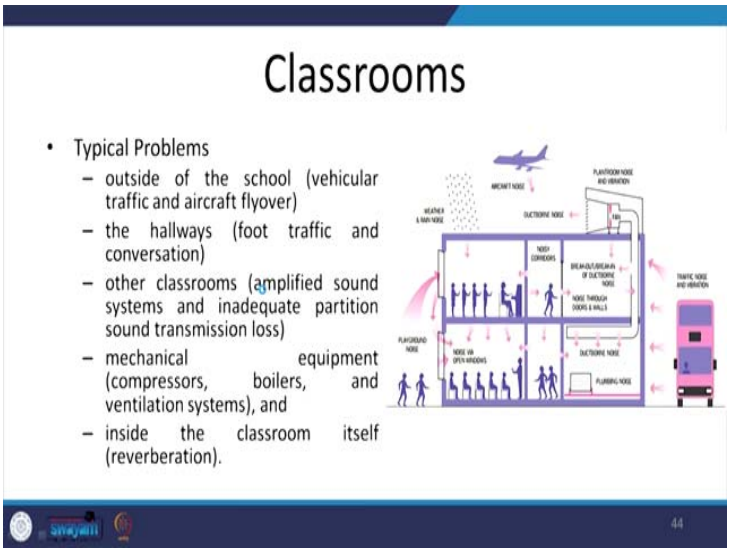

Similarly, we have problems for classrooms where there is outside sound maybe the noise of traffic or the noise of children playing in the playground, inside the room. So, one room might be noisy room while the other one might be a quieter room. So, how the

sound is transferred from one to the other noisy corridors? So, that is ~~the~~ of the usual acoustic problem inside a classroom.

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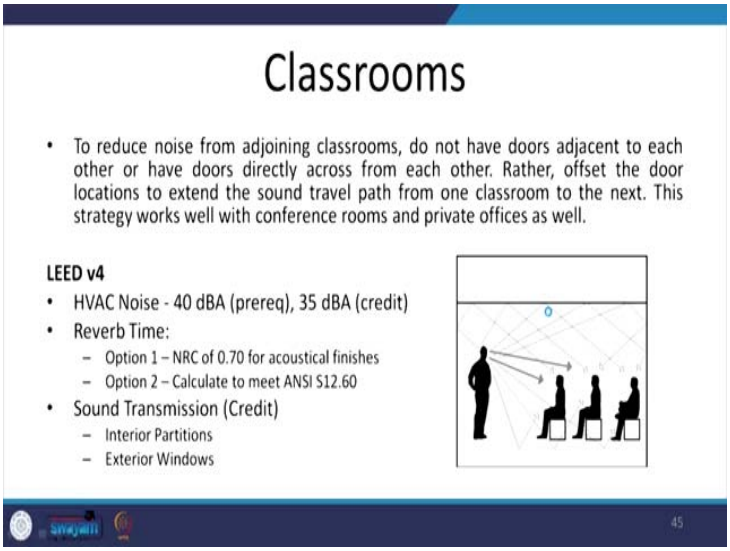

And what we have to look at when we are looking at classroom is again the ABC we have to use the absorptive materials and if you look at the lead criteria, lead prescriptions it also prescribes the amount of HVAC noise which is the reverberation time for class rooms and also the sound transmission class of the material that should be used for interior partitions an exterior windows to ensure that all these different types of noises and sounds are not there inside the classrooms.

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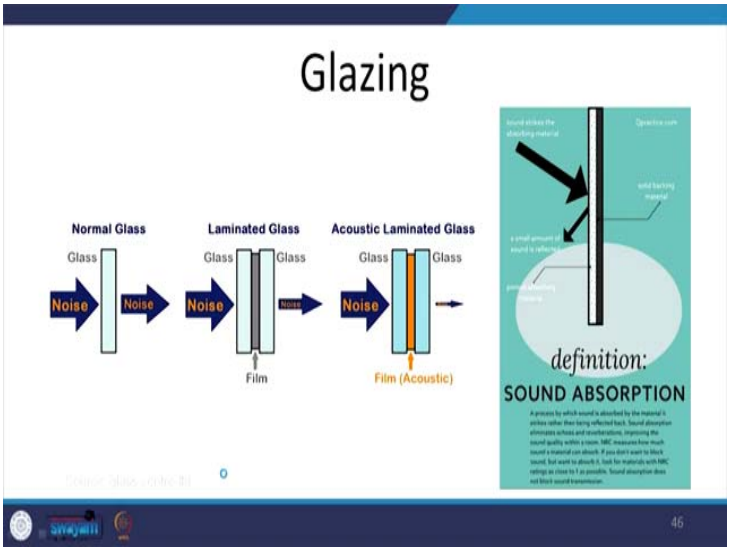

Glazing, in today's times has leapfrogged~~lead~~ (Refer Time: 46:05) there are different types of glazings which are available. So, we have acoustic laminated glass which is available where there is an acoustic film which is added and the 2 glass sheets, pins help to reduce the amount of sound which is transferred from one side to the other. So, with the choice of correct material with the correct selection of design strategy and special design of a building visual and acoustic comfort of a building a sustainable building is possible that is all for todays lecture. See you in the lecture next week.

Thank you.