Energy Efficiency, Acoustics & Daylighting in building
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Lecture – 49
Daylighting (contd.)

So, now, we will look into human eye.

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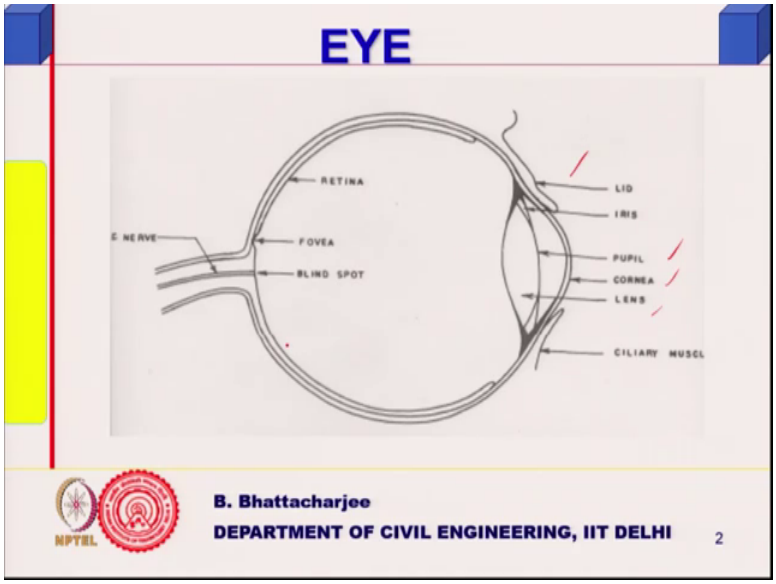

Like noise viewing is also related to human, you know it s the same thing the processing of the images at the brain and therefore, some subjective issues also some subjective issues also, sensitivity depends upon not only wavelength there are other issues also. So, let us quickly look at this, this is a this is a you know transducer again in the light energy it converts into electrical signals and then goes to a brain.

So, you have we will quickly look into this wouldn't go too much into the physiology part of it like we did not do much for the year. So, you have a eyelid oh you have a eye lead, here iris, pupil, cornea and the lens. So, this is the lens basically and you know there are muscles here which can you know close, you can close or open your eyes and then through this lens the light passes and it forms an image onto the retina right and then you have got some nerves here which actually converts this electrical, I mean this optical signal into appropriate kind of electrical signal and sense to the brain. And then brain

does the processing and recognizes the 3 dimensional pattern right it is, it does in a very complex manner.

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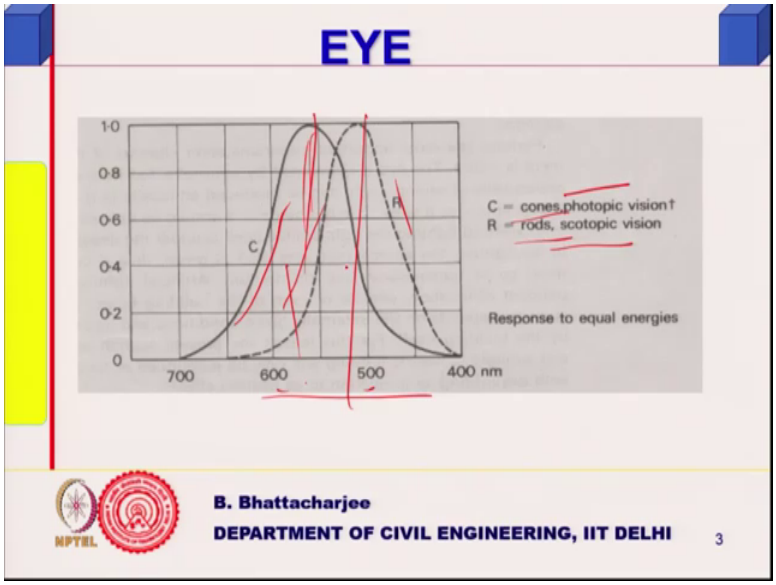

So, basically is a 3D pattern which is which it recognizes although in a retina it will be 2D image. So, finally, it says you know the human eye is able to see all 3D, 3D things right between the light and it is the object lighting of the object the illumination of the object and its surrounding everything put together.

So, there is some amount of, you know beyond also physical lux level there is something else that is therefore, in case of you know like decorative lighting the total light pattern, 3D light pattern that is very important because that gives you the visual you know that finally, gives you the feeling right. So, that is what it is.

So, you have two types of nerves actually we will not go much into this, but two types of nerves ones called cones others are called rods and you have what is called photopic vision and scotopic vision associated with them. So, this particular one, the rods their sensitivities with the wavelength is something like this and for equal energy for example, and for cones this is the sensitivity.

So, you can see somewhere here the eye is most sensitive around this zone somewhere 500 to 600 between them eye is most sensitive that is that is actually where the sunlight

is also maximum no quantity of this proportion, proportion of this colour is maximum in sunlight.

So, we do not go into the details anymore into this physiology aspect of it, but what is important for us is the to know that it is not the object light alone which is required for comfortable vision or comfortably you know visual comfort, the surrounding light is also important right. So, you have some angular range right.

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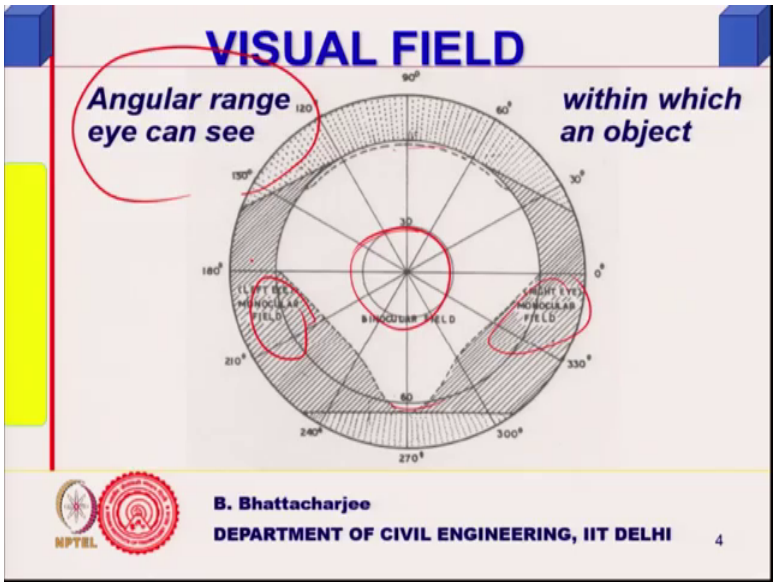

So, we have a binocular field, that means, both eye sees together, other animals you know like one eye is here and one eye is there. They do not have binocular vision, many animals do not have for example, you know many of these birds you will see that they actually you know or even cow, sometimes wants to see detail something cow or they do not have binocular vision, but human binocular vision.

So, this is the overall binocular field this is the central field where you are focusing and I can focus you know it is very, it is a system intelligent system its can change its focal length and you can see the near object or far object can this opening can be adjusted this opening can be adjusted, you know this opening can be adjusted aperture for a camera aperture.

So, aperture can be adjusted right and so that too much of light or less light unit. So, you can it is, it is too bright and area actually aperture will get reduced and it it you know

because. So, it is an intelligent system anyway. So, if senses the surrounding and then accordingly it adjusts itself.

So, this is the main binocular, you know is the main field what you are looking at within 30 degree you see 30 degrees of vision sight, this is the main field then the left eye alone can see this portion, right eye alone can this you know see this portion. So, between this 60 degree here totally 180 degree, this total 180 degree, but you do not see everything you do not see everything, but you see something where you are looking at directly right what are you looking at.

So, this is that 30 degree which you are focusing on and even if you are looking at this something happens from you know something comes here also, something here although you may not be concentrating on this because finally, the processing you know it is important. So, that is that is what it is. So, we define certain things, I mean how much light do I need in order to see a thing it depends upon the size of the object.

So, we define certain terms for example, visual acuity.

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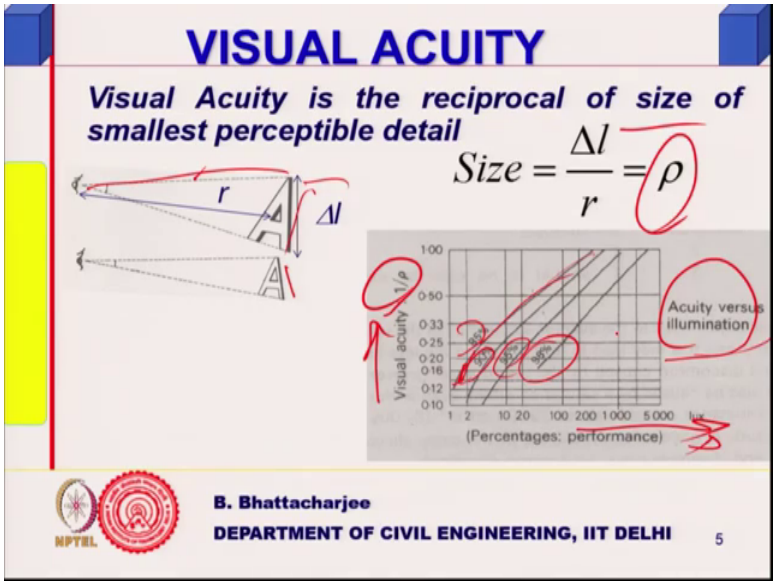

Visual acuity is defined with respect to the smaller size of the object I can see, in an I am doing reading, let us say if I am reading then possibly I keep it a fixed distance from my eye, something like 25 centimetre you know that when you go to an opthalmist they put

you put I one thing, says how good you are reading in there you know your eyes are good to read the close objects and then looks at that long vision also.

Now, visual equity is related to how is you know smaller size object that you can perceive, supposing the size is less than 1, you know 1 millimetre some details are there in 1 millimetre you would not be able to see, distinction will not be there. So, visual equity is reciprocal of the size of the smallest perceptible detail, in a given environment given visual environment that will depend upon the lighting level, you know young people like you might be able to see things, things without much light.

Normal, normal you know 20 to 60 adult, they will be able to see things with much light, but if you are not able to see what you do you increase the light. So, capability of the eye to see is a function of the lighting level that is what we are trying to look at. So, if I have a visual environment whether I am able to see it or not or the smallest detail that I can perceive that is a function of the lighting level, that is a function of the lighting. So, if I want to decide how much lighting level I should add it will depend upon what smaller size of the object I want to perceive.

So, if I am reading the smaller size is a letter it was English, may be small i or small o you know that would be the size of the letter, but then it depends if I want to read I will keep it as close distance, if I want to see something different in a blackboard or you know the distance would increase. So, it is related to the distance and also as a size. So, size we talk in terms of angle, it subtends on the I size of it because that will be the dimension of the object divided by the distance. So, size here we talk in terms of angle.

So, size for example, a this a here this is the size the size will be this distance this height divided by I mean this size divided by length divided by the distance here for example, this length divided by this distance. So, size is talked in terms of d l by delta l by r size we talk in terms of the angle size we talk in terms of delta I by r and we define it by rho the angle and visual equity is 1 over rho visual equity is 1 over rho, visual equity is 1 over rho.

You know what is visual equity, size of the smallest smallest perceptible detail smallest possible detail right. So, size here we define in terms of angle and smallest you know delta l is a smallest length that you can perceive. So, if we are talking in terms of a letter you are reading that will be possibly 2 millimetre, you know at least size of the word that

you read in a book 2 millimetre and you keep it at a distance of about 25 centimetre. So, 2 millimetre divided by you know 25 centimetres 250 millimetre that would be my row, that would be my rho right. So, 1 over rho so if 2 mm I am able to read then one over rho will be if that I am able, but 1 millimetre I will not be able to read. So, smallest perceptible detail that I can read in a given environment I call it visual equity right, visual equity is the size of the smallest perceptible detail in a given environment.

So, it is a function of is a function of lux level, if I increase the lux level visual equity will increase. I can see smaller and smaller object smaller and smaller object, but you see that you know of course, this is the rate at which I can read I will talk about this sometime right, this is rate I can read what is called performance. Performance is the rate at I can read you know you are asked to how fast you can read this, how fast you that will also depend upon lighting levels that will also you will take you know country it. So, easily so you take longer time, but if you are able to read it easily then; So, performance is related to that the rate 98 percent in some scale.

So, you can see that visual acuity increases with the lux level, but initially increase a faster rate than somewhat reduces downright. So, lighting level is important you know acuity of sorry acuity of acuity versus illumination say acuity increases with the illumination level. So, I should increase the illumination level. So, the illumination level I required for watch repair would be quite different for that I had require for reading because you know the distance is important, but then the finest details that one is looking at it would be different.

Then, you know it says like possibly you know I am I am I am doing some other job may be may be something like not reading not reading separating sounds you know removing my papers from my table one piece another and things like that that would require much less level of writing; So, that you can understand right. So, this is one thing, but that is not all, as I said my central field is only 30 degree surrounding next to this is some places I have monocular right vision monocular left vision, but contrast is very important if it is all equally bright you would not see anything.

So, if you are making you know PPTs transparencies and you want to make it very decorative colour and you use yellow or white you would not see anything the person wants to read, cannot read. So, black or blue, dark blue and black on white background

that is what is easily is. So, the contrast between source or object and its surrounding is very important if you do not maintain a contrast you do not see that if you do not maintain across the contrast, you know if this background of my slides are all yellow and you know I just put again orange on top of it you would not see anything.

So, quite often people do this kind of mistakes particularly you know when you are your student and things like they are doing it not many times first time or second time then you like the colour, but actually colours are should be only used the contrast is important black and white or deep blue and colour should be used for only for the purpose of if you want to emphasize something right, want to make a distinct thing. So, one line to another line you might have a colour, but use blue and black. So, contrast is very important contrast sensitivity is important you can.

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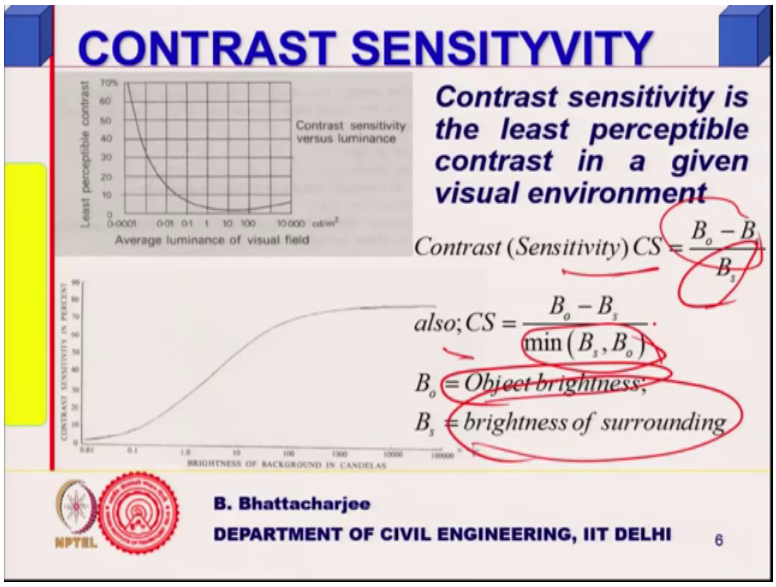

So, what is the least contrast you can identify, maximum contrast see anyway I will see better, but the least contrast I can identify is important. So, contrast sensitivity the least perceptible contrast in a given visual environment, least perceptible contrast in a given. So, what is seen is actually we define it in some manner like this contrast sensitivity is defined at b 0 is the object brightness minus brightness of the surrounding because black letter or white background white paper, black print on white.

So, white is the surrounding black is a object. So, difference between them is this right or if it is black paper white letters then also the same thing, divided by the brightness of the

surrounding that is what we call contrast sensitivity or some places you might find that minimum of this is taken because I can have black background white object or white background black object.

So, contrast sensitivity is defined like this, difference between them divided by the least of the 2 least of the 2 right and least contrast you can perceive in a visual environment it is better right, because you see I am talking of blackboard and book that is fine, but not always it is blackboard and book, if you are doing something some task elimination somebody is doing a surgery.

So, bodies colour is not what do you want the contrast you will not be what one would be wondering wanting right, the human body or whatever it is so. So, therefore, how much lighting level do you need or for the least contrast that you can process. So, light that is what we think. So, contrast sensitivity related to least contrast I can perceive the difference should be least.

So, so this is seen that if you increase the average illumination level average brightness level sorry average brightness level, it the contrast least perceptible contrast you know least perceptible contrast because the expressed in percentage ratio difference between them difference the list is b 0 minus b s right b 0 minus b s. So, smaller becomes b 0 minus b s divided by b s that is what the equation, was equation was it.

So, it can be expressed in percentage, it can be expressed in percentage. So, as I increase my brightness sorry as I increase my brightness, as I increase my average brightness level the smaller contrast I can actually perceive, I can perceive smaller contrast I can perceive smaller contrast, but beyond a level it starts actually. So, there is an optimal level somewhere right average luminance level in candela per meter square beyond a point I mean you increase the brightness too much everything becomes equally bright, you increase the light too much everything will become after all the reflection you know when we talked of value.

So, bright what you see is also depends upon you know if we put too much of light reflectivity or you know both can become very very bright and you do not see contrast at all. So, as a result control sensitivity there is an optimal brightness level or if you see it in this manner brightness of the background in candelas, contrast sensitivity in percent. So,

it one by its in apostilb actually this is in yeah. So, he puts in apostilb 2 candela that is why 1 by pi.

So, it increases contrast sensitivity increases, but becomes steady, defined in a slightly different manner not exactly using this formula not exactly using it slightly 1 you know it is 1 minus that. So, the contrast sensitivity increases right because here it was constant or reducing down, here it is showing that it is constant.

So, that some experiment some people have done, but the point that we take is continuously increase of brightness level may not give me a better contrast sensitivity result I may not be able to perceive the lower you know contrast difference between the two would actually I may not be able to perceive.

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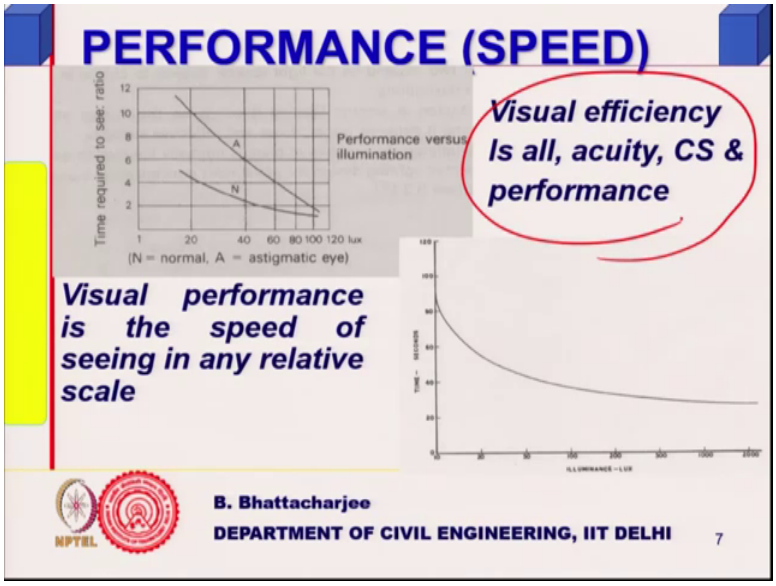

Performance is related to speed, a rate at which you can read right. So, time required to read say it is in some sort of ratio. So, you have standard number of words or letters. So, at what rate you can so qualitatively we understand. So, performance is rate, contrast sensitivity is difference between the object and the surrounding their brightness difference I should be able to perceive the least difference and other one is a size, performance is rate.

So, all 3 are called visual efficiency all 3 are called visual efficiency all 3 put together are called visual efficiency. So, visual efficiency you know performance. So, it is a time

what we have seen is again this one increases, but does not you cannot see time to read a fixed number of word. So, after that it does not reduce number, supposing I have a fixed number of letters or words standardized which I want to read. If the time required to read this initially increases initially decreases, as I increase the lux level, but beyond a point it does not.

So, all that point I am trying to make is that increasing the lux level in the room very large amount I mean just continuously does not make much sense, while visual acuity increases somewhat performance level may increase up to some point then I mean beyond that it does not improve and contrast sensitivity also improves up to certain point beyond that it does not improve.

So, there is an optimal lux level for every type of task, optimal lux level for every type of task and that is given in the code or similar sort of situation, but there is a formula. So, visual performance is speed of seeing in some relative scale and visual efficiency is all 3 of them.

So, visual efficiency improves with lux level, but do not improve continuously that is what qualitatively you should understand, all right qualitatively you should understand that and therefore, there is an optimal lux level for every task optimal lux, lux level for every task and that is given in the code, that is given in the code.

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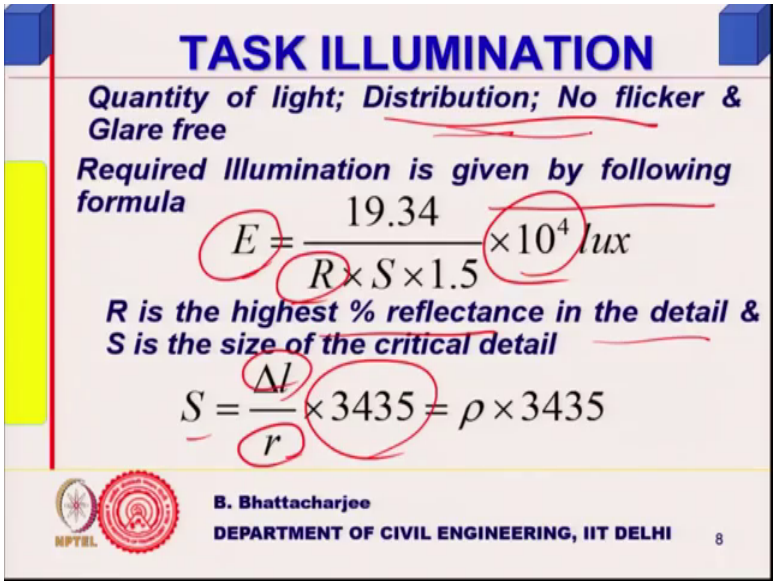

So, quantity of light its distribution all rights is important and I think there is a formula and I hope I have kept that formula yeah there is a formula. So, I will come back to this statement later on. So, required illumination is given by this formula, required illumination for a given task is given by this formula where R is the highest percentage reflectors of reflectance of all the details, highest reflectance right.

Because it will depend up on reflectance of this one whatever light falls in how much it comes out and s is the size of the critical detail. For example, I was talking of the word if you are reading the size it to be in terms of angle actually size will be in terms of angle it is given in this manner delta l by r and 3435 this our conversion unit conversion etcetera etcetera in terms of radians because 19.34 is also a kind of an m p you know it is a saying we unit conversion.

So, E is the illumination required for a size which is given as the smallest length supposing you want to read word in a book, delta l is the length of the smallest letter or least dimensional smallest letter R is the distance at which you want to keep your book and this is for radians and equivalent conversion in minutes actually it will be in minutes and all those.

So, some unit conversion time and this is 10 to the power 4 lux you know this multiplied by this gives us 10 to power 4 lux this is the reflectance of thus details the is a highest reflectance. You know in other words if it is white and very clean white new paper not old paper, old paper tends to lose their colour this would be possibly close to one, in old paper it would be in black print. So, old paper it would be somewhat lesser and this value is given in terms of lux this value is given in terms of max. So, one can calculate this out depending upon tasks.

So, in case of watch repair this size will be different in case of in case of you know seeing now you can think in dramatics facial expressions 22.5 meter. So, things are different or if you are seeing blackboard things would be different, surgery it could be different right office it could be different.

So, depending upon the type of task the sizes will vary and reflectivity of the detail will also vary one can view, but then this calculation you can do this is the basis values are given most of the code gives you this value for example, you know that in classroom general lighting level should be one fifty lux right.

So, this is given in codes moves to the course illumination codes or building codes will give you these values. So, this this is this and this statement I did not make. So, far I am going to make this.

So, you have to have illumination level as desired you have to have illumination level as desired in a given space, in a given space right as desired and this is calculate basis is this the values are tabulated and you use the tabulated values right you use the tabulated.

For example, in corridor it would be different in your working plane on the bench or table where you were writing it would be different and you know somewhere it is around of the order of from 300 lux for reading or like reading or similar sort of thing may be general corridors etcetera 150 lux for where I want to walk and see and this values are given this value given right.

Now, this statement I did not mean the important thing is distribution of the light is important only on the tasks if you keep 300 lux on the table and surrounding is not good the contrast could not be you know the brightness. So, its distribution is important, not only the object its surrounding is also important next thing it should be should not be there should be no flicker of light if it is artificial illumination no flicker is uncomfortable, flickering should not be there as far as the lamp is concerned well if it is of course, that kind of effect you want to get with this strobein a stage that is a different thing you know in drama they use.

Of course, in dance like Michael Jackson's they would use strobe tag Dum dug Dum whatever it is or in drama sometimes they do it you know like a like some ghost, ghost dancing and things like that; So, somebody on white and making all sorts of things. So, strobethat's a purposeful flicker that is not a problem, but otherwise even if its artificial lighting flicker should be avoided the next thing is glare, now I am not sure if I am defining glare yes I am defining glare here.

Now, what is glare when too much light falls on to your eye, you do not see anything just do not see anything you know that somebody puts a torch light onto your eye you do not say anything right. So, that is actually called disability glare, this you just do not no ability to see. So, this ability glare, but we are not much interested in disability glare anyway in a classroom or in an operation theatre the doctor is not going to put light on you know the person's eye itself.

So, this ability glare is not the thing, but there is something called discomfort glare, discomfort glare comes from the contrast difference between the object and the surrounding for example, some classrooms you know where the you know like blackboard and there is a window there, blackboard is on the corner you do not see the you cannot distinguish them the letters in some corner you just do not see them or even if you see you have to really struggle yourself to see that is called discomfort glare.

So, discomfort disability glare light is totally scattered it does not form an image in the retina right, too much of light coming in it does not form an image it gets you know. So, it actually scatters like headlight of a car coming in you know people driving you know this is these people driving in this campus or small areas put their what he call yeah high beam light in the night that should not be done.

I am sorry that this is a this is kind of driving culture is not very good, this will not happen, but in highway you are supposed to because there is no light and you want to see the longer distance. So, it is a high beam it throws quite off, but in local neighbourhood areas as we call it neighbourhood areas actually you should use a deeper, you know you dip it down only locally you see your front.

So, that kind of a high beam a cyclist coming from the other side or a motorcycle is coming from other side or a car coming from other side their face what is called disability glare, you do not see anything you go total blind right, but in a room this is not the issue, in a room discomfort glare is more of an issue.

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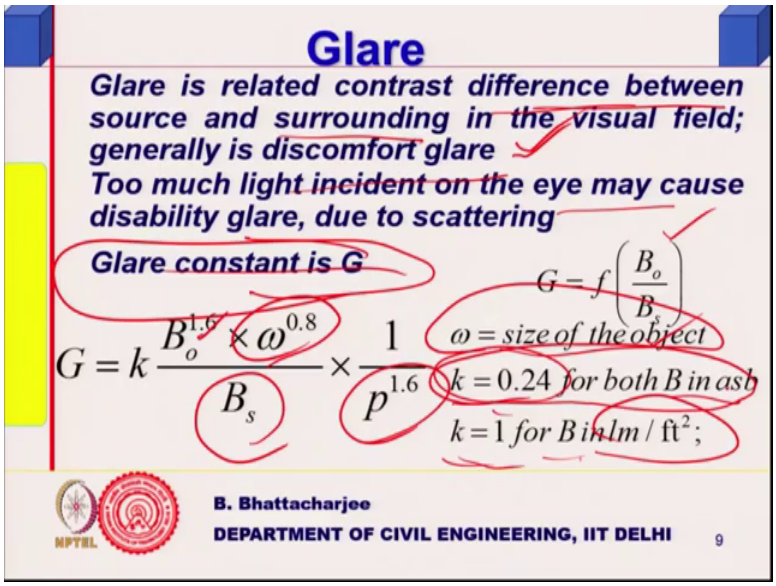

And this is contrast difference because count coming out from the contrast difference source and surrounding, in the visual field generally this is discomfort glare this is discomfort right, this is discomfort glare.

Too much incident eye on the eye may cause disability glare due to scattering. So, this we are not interested in as much, but this is very important for us, we do not want discomfort glare which occurs let us say as I said because the contrast for example, if ever black, black board white chocolate on the corner and too much light coming onto it what happens is because reflectivity is you know the even black ones tends to become bright because too much lighter has fallen to do.

So, contrast reduces so you do not see. So, this is what it is. So, there we define something called glare constant, glare constant and there is an empirical formula which relates it to the brightness of the object and brightness of the surrounding right. Ratio of brightness of the object and brightness of the surrounding and the formula given is something like this, it is an empirical formula B 0 is the object, brightness B s is the surrounding brightness and this is something related to your position because light might be coming from somewhere else and you are being you might be the object might be somewhere around another distance.

For example, say the screen here if the light focus from somewhere there or the light that is here it was focused towards the screen itself right that can cause glare, you are not

looking at the light itself, but the you are looking at the object where the light is coming from somewhere the source is somewhere which is making an angle with your eye as well as the object that you are looking.

So, that is the position, relative position of your object with reference to the light and you your eye. So, that is called that depends upon that position and this is size of the object, size of the object in solid angle size of the object in solid angle.

So, this is a this empirical formula omega is the size of the object this is a constant because of unit because the formula was empirical. So, done on good subjects and etcetera etcetera and this earth must have been done in the appear system when they wanted to convert in on. So, this is related to unit and k f is one in f s apostilb, when it is when it is lumen per feet square. So, when it was lumen per feet square k is equals to 1 k is 0.24 for b in apostilb, where B in apostilb right for B in apostilb all right.

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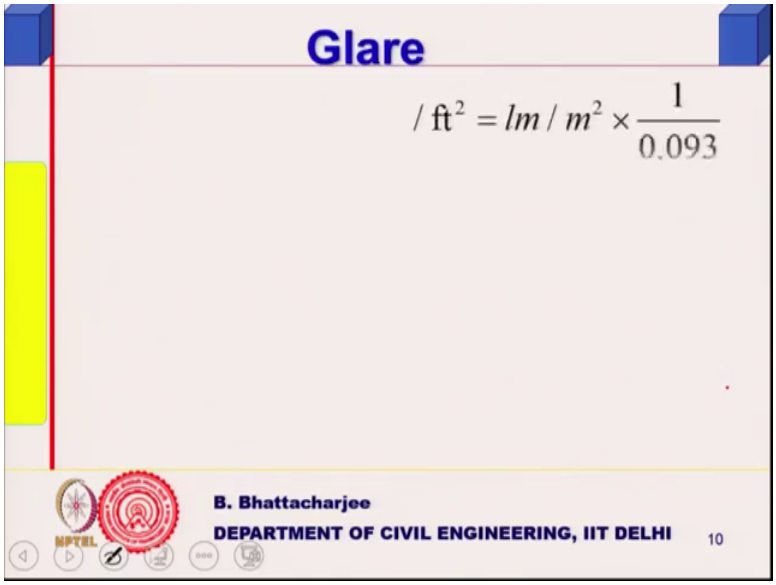

So, that is glare I think we will look into this, we will look into this we will break for a while if you have some questions we will, we will answer and then look back into the glare this why this 1 and 0.24 more in details.