B. ARCHITECTURE

BUILDING SERVICES-II (AR6511)

LIGHTING DESIGN: INSTALLATION AND APPLICATION IN BUILDINGS

Lecture-05

Artificial Light Sources-1:

Artificial Light Sources are the light sources where they are used to compensate the natural light. So this artificial light sources they have different frequencies and wavelengths and from that you have various colours of light you get. Based on that we have something called spectral distribution. Distributions represent the energy radiated at different wavelengths produced by an artificial light source. It is for every type of light source you have a different type defined. Now when you take this image the first image here, this is a high-pressure sodium lamp. Spectral distribution of a high-pressure sodium lamp. If you see here, the light is concentrated here. So this is because the main energy, part of energy radiated in this type of lamp is radiated in Yellow and orange colours. So you can see the wave length concentrated here. Whereas when it comes to metal halide lamps. It generated in all parts. So you almost get white light, so when you the white light emission all the spectrum colours will be visible here which is distributed all over the visible spectrum. This determines the efficiency of your luminar. **Luminar efficiency** is a measurement commonly used in the lighting industry. So this will decide the ability of the light source to emit. So now we are talking about the ability of the light source to give off the light required. So the source is a product of how well it can convert, see the input that is given is an electrical signal, so electromagnetic radiation should be converted to radiations or waves which is detected by the human eye. So the efficiency of the luminaire or light fixture will determine the luminous efficacy of the emission.

Now coming to **colour temperature**. This is the temperature of an ideal black body radiator. So the waves that has been radiated that is given a temperature

values and that is what we call it as colour temperature. So this is compared to the light source. So generally, the colour temperature we say like warm to cool. We say warm will be starting from the yellowish and the cool will be bluish. So the measurement is also in degrees as in temperature. So this is the colour spectrum the colour temperature ranges you can see. The temperatures over 5000 Kelvin are called cool colours. You see this blue shade is over 5000 Kelvin it is called cool colours. And the things lower than that we call it as warm colours that is starting from yellow to red. Now this colour temperature why we need to know is when you are designing a building interiors and when you have to design the lightings and light fixtures, you have to consider the colour temperature that is going to be the result of the design. So if you need a warmer ambience, light should be used in public areas so that it will give a relaxed atmosphere. Same way when a cooler light is used it will give a concentrated or an effort task lighting effect will be given. So depending on the colour temperature, you can also decide the type of lighting is required for that particular purpose.

Then comes **colour rendering**. This is actually a general term; this is actually a comparison of a light source by the observer actually. So if you see these two pictures this one is brighter than the one on the left. It is because of the properties of a light source cannot accurately assess it, only by visual inspection we are doing it, it is not physically done. So for that what we do is we do a calculation procedure and that is called colour rendering index. So this will measure the sources' ability to reveal the colours of the object, how well the colours will be revealed and that is rated on a scale of 1::100. When the rating is lower, the accuracy of the colours will be less. So that is why this picture you can see the colours of these vegetables the greens and red is more clearer and pronounced in the right hand side than your left hand side. This is what we call it as colour rendering index and this is also a crucial factor when you decide on the lighting fixtures. Now when you take incandescent radiators they have a CRI that is the colour-rendering index of 100, because they give only white light so everything will be rendered equally. So when you have a high CRI those kind of things will be used for only critical application like neonatal care, photography, and cinematography, there they will be using higher CRI light sources.

Then coming **to additive colour mixing**. So when you already know about colours and colour mixing and all those things, how this works in lighting is, we have primary colours. Red, green and blue. Same way these 3 mixing

together with each other we get the secondary colours magenta, cyan and amber. Now Varying the colour, slightly you get the third colours. So that is the hues of all the primary colours. Now what happens in additive colour mixing is, when you see this picture, you can when all the things are put together, the secondary colours and primary colours, when they come together you get a white light. So the actual light that we see is all the colours mix together and the source is emitting that light and we see a white light. So this is what is being used in your computer monitors and televisions. It is the process of additive colour mixing is used. So they have dots, little dots, if it is LED all the LEDs will be like Red, blue and green dots. All when they come together with all their hues, you will get the white light.

Now there is something called **subtractive colour mixing**. Here cyan, yellow and magenta these are all primary colours when you consider subtractive colour mixing. Actually subtractive mixing works in reverse order. So cyan, yellow and magenta will be the primary colours. So how this works is, light is reflected off a surface. So when that happens it gets filtered through another object. You see in the picture you have a light spectrum all the colours are coming here. It is reflected off a surface, which is red in colour. So what happens is this medium, this filtering medium will absorb all the colours other than red and it will emit only the red back. So it appears that this medium subtracts all the things that are not red. So whatever medium you are putting your light to, the colour of that medium alone will not be absorbed, the rest will be absorbed. That is how you actually see colours. So when you want to do subtractive colour mixing, this actually works well when you are going for printing or publishing or when you are trying to paint in a paper. So what happens is you are putting a colour on a surface. When you are putting that colour if you need red, what we have to do is, it has to absorb green and blue. Only when it absorbs green and blue it will emit red. For that what we will do is, we will have to print yellow to absorb blue and you have to print magenta to absorb the green. Then you will get red as the result. So when you combine the yellow and magenta pigments then we are left with red. This is what subtractive colouring is, we are going from backwards.

Artificial Light Sources-2: Outdoor Lighting

Then it comes to **outdoor lighting**. We saw various types of luminaries and lightings and various classifications we saw. And one of the classifications is indoor lighting and outdoor lighting. And when it comes to outdoor lighting, the types of light fixtures are the main difference that you will note. Again here depending on the light location and function there is a category and the lamp type. Lamp type again comes under what we saw in the earlier lectures they are incandescent light, electric discharge and LED lights. So we will be looking into the location and function alone now.

So **based on the location and function** you have so many categories. You have **floodlights, sport lighting, street and roadway, pathway, parking lot and garage, security, landscape, and signage** all these types of classifications we have.

So **what is flood lighting**; - You would have seen in huge stadiums you will have huge lights which give so much of lighting to the place. This is actually one thing. Billboards - You would have seen on the roadsides huge billboards, at nights if you see lights will be out. It is not glowing from inside, actually lights are fixed in front of them and it is projected on to it. So this flood lighting will be used in that billboard lighting and in stadiums. So mostly **HID lamps will be used in flood light luminaries** and this also illuminates **outdoor playing fields** and the **most common type is metal halide and high-pressure sodium lights.**

Then comes your **sport light**;-This also is similar to your flood light but the **main advantage is it is provided with a special aiming and locking gear.** So the focusing will be towards the sports area or the court or whatever it is. So the focusing will be like a directional lighting. This is typically mounted to the side or sides of the play area and it will be of greater height also. Now this is how in an indoor stadium you see or in any stadium at nights, you can see lights like this. This lighting sometimes they also provide louvers- **internal and external louvers** so you could control the glare. It is of so much of high intensity of light you might have to control the glare so that it does not disturb, if it is a sports stadium, it does not disturb the players**. Wattage will be like 1000-3500 W** will be the wattage for sport lighting.

Then **street and roadway lighting**; - This is you would have seen in streets. There would be a **long pole and on top of that lights** would be mounted on top. For this, also we use **HID lamps**. **High-pressure sodium lamps are very common for road way application.** The shape would be like something like a drop dish, oval, or refractors. They are the commonly used shapes. Because of these appearances, they are also called as cobra head luminaries.

Then pathways: - If you go for some beautiful garden areas, you can find the pathway alone will be well lit. That is what we call pathway lighting. Walkway and grounds lighting will be done by bollards. These will be like mounted on the ground, something to your street lighting but will be of a **very smaller size**. **The height will be very less.** Short thick post similar to that of a ship or wharf will be there. This is used for a localized lighting, only for that path it will be lighting. And this will be placed above the grade level. The grade level in the sense the road level. **Along the sidewalks** you can see this if they have to highlight the path it will be done like that. Or the **informal parts in a landscape**. This is done so that you can **safely lead a person from one location to another in the nighttime. Pathlight fixtures are generally low to the ground; they emit light in a spread out fashion.**

Now coming **to parking lot and garage**, we use **cut off or semi cut off luminaries with flat-bottomed lens.** This is something similar to your street lighting but it has special features like the luminaries will either be cut off or semi cut off. Like you have posts here and the brackets will be there. This will be very short. It will not be as long as your street lighting. This can be like one side or twin sided depending on the cars to be parked on both the sides you can have both the things. Now wall-mounted luminaries can also be used in the parking lot garage. If there is going to be basement parking, then you can have these luminaries fixed on the walls. These kinds of things we are calling as **wall packs or wall mounted luminaries**.

For **security** reasons we provide outdoor luminaries to visually secure an area. **From a distant, you can see that it is secure. It is also for visual surveillance and security camera surveillance** we use security lighting. This will be generally **mounted on inaccessible places**. Because anybody else by accident also people should not knock it off, they should not break it. Security lighting will be provided in places where it is not easily accessible.

Now coming to **landscape:** - This is similar to your garden lighting. Garden lighting is only going to highlight your paths were you are going to walk. **Landscape will be even lighting your plants, water features like water bodies, fountains, swimming pools** whatever you have as part of landscape everything **will be highlighted** using this landscape lighting. This again will be mounted on poles from the ground. We have also lighting which is under water or which can be used in trees. This type of lighting, landscape lighting will have special housing, the cover of the lamp will have a special housing, which will be harder than your normal housing. it will have a gasket and lenses, an electrical wiring hardware will be so that it is protected from water and corrosion. When you say landscape lighting whenever we water the plants or trees, the water is going to affect these luminaries also. So we have to make sure that the water and corrosion will not affect these luminaries.

Then finally we come to the **signage:** - We already saw in the types of luminaries about exit signs. This is similar to that and it will also be equipped with **asymmetric reflectors**. Asymmetric reflectors in the sense the reflectors inside will not be of any symmetry so that if it is asymmetry it will emit light in an evenly manner. This must be given only **for outdoor use** and it will orient towards the position, if you say like it is going to show a pathway depending on that it will be positioned. It **should be designed to shed water and resist ice buildup.** The design of the luminaire the housing should be so that water will not stagnate if it rains or if it snows ice should not build up on it. It should fall off. Some kind of an inclination should be there. An external mount should be mounted on top of the sign. If a sign board is there and you are going to highlight it with this, luminaries should be on top of the sign and then it should aim downwards so that the light will be shown on that and pollution will not be there.

Lighting For Various Buildings:

Now coming to **lighting for different buildings**, we will see a few buildings in detail**: Lighting For offices:** - The basic principle is it should be **flexible and energy saving.** Because flexible in the sense you have to use a different combination of lamps and luminaries because you have different tasks happening in an office depending on the area. So when you take up, even here itself you can see, this is a top view of an office. You see here this is a workstation. So **work station will require a task lighting** and if there is going to be a conference or something that will require a different type of direct lighting. So **optimal lighting** for an office will depend on the **visual task** that is whatever work they are going to do and there should be a **balance between the direct and indirect lighting** that you provide. Also a balance should be there **between the daylight and artificial light** because working hours is going to be predominantly on the day light type. So we should not waste the day light and use excess of electrical or artificial lighting. It is said that 500 lux is required for ideal computer workstation, but if you provide an illuminance between 500 to 1000, it is considered as stress free. It says that if you increase the illumination level, it will boost the visual performance. So there will be a positive influence on the people working there. Appropriate bulbs have to be used depending on the task. If you look at here there are some concepts given. If it is **room related lighting, we require a direct lighting and an equally direct and indirect lighting. If it is going to be a task area lighting direct lighting, direct and indirect lighting**, and then you can also have a track lighting and this is task lighting. And **work surface lighting will be like track lighting and particular to a particular space you can have that type of lighting. So it depends all on the task that is going to happen that you have to design your lighting.**

Now coming to **hospitals:**-In hospitals, you have to make sure that so many people will be coming and patients are there. Different categories of people are going to come in and go out. Mostly examination will be a predominant factor in a hospital whether they are the outpatient or in-patient. So for examination purpose mobile type of luminarie is used. So when you see halogen lamps they can be used in surgery. In operation theatres, again you will have a mobile lighting system. So depending on the type of surgery, they will be using the lighting system. But care should be taken in an **operation**

theatre the light bulb that you are going to provide the lamp should have **a soothing and a comfortable feeling to the patient**. A **brilliant blue white light is recommended** for that. The lux, the lighting required, the illuminance required for the **lighting of operation theatre is 70,000 lux**. This is some of the lighting that you can find in hospitals and clinics. This is mobile type luminaire, this is fixed to the ceiling and this can be moved to wherever they want. So this is required in labour wards, orthopedics, neurology, gynecology as an additional lamps in an OT. And this is like in other places you have this kind of fixed lighting. For **an inpatient ward, a luminaire of 150 to 200 lux is enough as a maximum limit, and 20 to 50 for a minimum. Reception and nursing stations will require 300 lux more of a task work will be going on. For corridors and circulation areas 150 to 200 lux is enough. In corridors and circulation areas it is better to use FTL, CFL that is chloro- fluro lights and LED lights can be used.**

Coming to **lighting for schools**, now schools have a different type of **variety in spaces and different types of activity in the spaces and they are used at different times of the day.** You cannot say these spaces are used only in the morning. It is the case in an office environment, you go in the morning and till the evening it is going to be the same. It is not going to change for that place. But in a school it is a very difficult task, so appropriate activities should be considered before you go for the lighting design. **Ceiling mounted luminaires** are the most appropriate when you consider school applications. If you see here, the classroom looks well lighted and good for studying. If you go for recessed ceiling lighting, it will give a dull appearance and larger rooms will be made to look smaller. Therefore, mood lighting is not required for a school. Then for a general-purpose classroom, we require 300 lux but you have to make sure that the lighting will not shine on the white boards when they are taking class and so whatever they are doing on the board will be totally washed out. If they have a special subject room maybe we can take it as **labs.** If they are going to make some detail metre readings or some observations are going to happen there, you need more lighting, so we are taking **500 lux**. In **computer rooms and general-purpose halls, 300 lux** is enough, for **corridors 120 lux. In library**, you need **300 for reading and sports hall if it is going to be an indoor unit you will need 400 lux.** And particularly in schools **suspended luminaries are not encouraged because health and safety issues are there. Kids might get hurt.** In the same way when there is diffuser, enclosed diffusers are

preferred so that the lamps by accident also may not get shattered and harm the kids.

Lighting Design for Physically Challenged and Elderly:

Now coming under **lighting design for physically challenged and elderly**. Lighting is a very important thing we have seen all along. Now when it comes to physically challenged and elderly, in any part of the design we see, we are giving special requirements for them. When it comes to lighting certain points have to be kept in mind like **ease of operation, visibility, height and freedom from obstruction.** These are the main factors that are required for a person with a disability. So when you talk about lighting controls, you make sure that **the controls have a minimum contrast, whatever controls are there it has to contrast with the background finishes.** If it is going to be a wall, the wall and the switch whatever control you have, should have a 30 % difference of contrast. The controls that you are providing should not be too tight or grasping or twisting, a push kind of a structure is effective. Now when you take a person with a **wheel chair, the height restrictions** we have, 400 mm everything is in mm. so if you **require telephone and TV sockets** for those to access it should be **400**. **Any other controls needing precise hand movement will be 750 to 1000. For light switches you have to make sure it is between 1100 to 1200mm that is 1m to 1.2m, 1.2m will be the maximum for any control for that matter.**

Now coming to **illumination,** with illumination people will feel the surroundings. So the **basic illumination** you will have to follow. **If it is ground floor entrance lobby and lift, 120 lux has to be maintained. Lift lobby in the upper floors can be reduced to 85, corridors and accessible paths and stairs should be 45.** So this artificial lighting wherever you are going to give, you should ensure there is uniform lighting. You do not create any recess lighting or shadows or anything. It has to be of optimal illumination and any glare is also not present.

When you are coming to **fire alarm systems**, this system should emit both audible and visible signals. Because people who cannot see will be relying on audible signals and people who cannot hear will rely on visible signals. So whatever fire alarm system you are going to take, you should be able to **provide both audible and visible signals**. Now this **fire alarm call points**

also activation controls should be accessible to wheel chairs. This kind of height measurements should be followed even for that. Then the **push buttons in emergency alarm** should be conveniently **accessible**. Like push buttons in the sense we can have **emergency alarms in toilets, or in case of emergencies in corridors, near to the stair case lifts** we'll provide that. That again should be **accessible;** it should not be way high up.