A basic guide to lighting and lighting design explaining variables such as working plane, mounting height; depreciation factors; coefficient of utilisation and reflectance factors.

Fundamentals of lighting design

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The following basic design concepts should generally be considered when designing a lighting solution for either indoor or outdoor applications:

- Whether the lighting will be installed in a safe or hazardous area.
- The required illumination level for the tasks to be performed in the area.
- The working plane level at which the recommended lux level is to be achieved.
- Types of lamp to be used and their lumen outputs.
- Mounting height available.
- Uniformity of illumination to be achieved.
- The colour rendition required for the task to be performed in the area.

Closed vs. open areas

The amount of protection required for the luminaires against factors such as weather, corrosion or water or dust ingress depends on whether the lighting installation is done indoors or outdoors. It is not advisable to use indoor luminaires where there are no side walls but only a roof at the installation.

The interiors in old industrial plant used to consider maximum possible natural lighting in their designs to optimise lux and energy savings. This, however, seems no longer to be the case. Nevertheless, the reflectance factors of the luminaires can play an important role in improving lux levels.

It is important to ensure that the light fittings in outdoor applications are enclosed and made of materials which can withstand weather conditions and corrosion. The focus here is on focused and localised lighting in areas where specific tasks are to be performed.

Working plane, mounting height

The working plane in a reading area or assembly shop is generally at desk-top level (750 to 900 mm from floor level) whereas, on a verandah or in an indoor stadium, it can be at floor level. The mounting height of the lamps determines the light falling on the working plane.

Indoor lighting is affected by the cavity above the mounting height, (the ceiling cavity) and below the working plane, as well as by the walls surrounding the work area.

Reflectance factors

The reflectances are given the abbreviations *L, M* and *D* to signify light, medium and dark reflectance respectively. The average values of these factors for ceiling, walls and floor are generally as shown in Table 1.

The coefficient of utilisation (CoU) factors provided by the lighting manufacturers are generally based on these reflectance factors for different room indices, for use in indoor lighting calculations.

Coefficient of utilisation

This is the ratio of the luminous flux which reaches the working plane and the total flux emitted by the mounted lamps, taking into account the floor and ceiling cavities, as well as reflectances.

In a closed room, CoU is based on the room's internal dimensions (length,

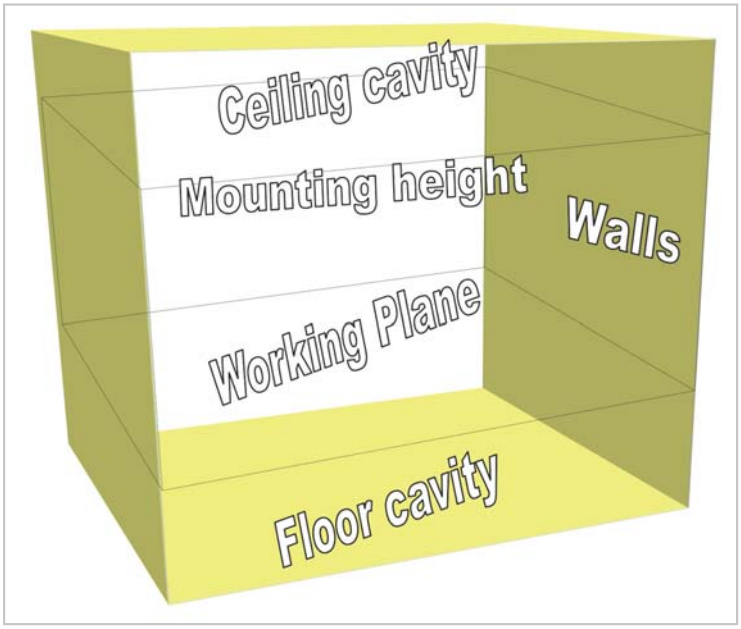

Fig. 1: Working plane and mounting heights.

width and luminaire mounting height) and is governed by the formula:

$$\text{Room Index} = \frac{Length\ x\ Width}{Hm\ x\ (Length + Width)} \quad [1]$$

CoU factors are provided by luminaire manufacturers for each type of luminaire with different room indices and reflectance factors. These are used in the lighting calculations to determine the number of luminaires required.

Depreciation factors

Luminaire depreciation factor refers to the depreciation in the amount of light output of the luminaire as it ages and as a result of dirt accumulation, degradation of materials etc. The lamp output also reduces gradually with age because of factors such as filament evaporation. This is referred to as the lamp depreciation factor.

Separate factors are sometimes considered in lighting calculations to determine depreciation and to take care of any possible reduction in light output over time. The designer must, however, be able to justify the values considered.

The maintenance factor (MF) can also be assumed to cater for reduced light output by the luminaires or lamps. An MF of 0,7 – 0,8 is commonly assumed in the design calculations where information on the maintenance plan or the luminaire or lamp type to be used is not available.

Luminaire spacing

The design should also take into account the ratio of spacing between successive luminaires to their mounting height to ensure aesthetics and uniformity of the luminaire layout.

For vertical downlighting, this spacing will be on the two horizontal axes of the room along the 0 – 180°and the 90 – 270° axis, considering vertically downward light Maximum Recommeneded spacing

$= S \times (H_m - H_w)$

where:

S = Recommended spacing.

H_m = Height of the luminaires above the work plane.

H_w = Height of the work plane above the floor.

It is recommended that the spacing between adjacent luminaries be no more than 1,5 times their mounting height, i.e. luminaire spacing < 1,5 H_w, as a rule of thumb.

Simple calculation

The IES zonal cavity method, also known as the lumen method, is used to decide the number of luminaires needed for the required lux on a work plane in an interior space, taking into account the room index, CoU and MF.

Surface reflectance	Light	Med	Dark
Ceiling cavity	0,70	0,50	0,30
Walls	0,50	0,30	0,10
Floor cavity	0,30	0,20	0,10

Table 1: The average values of the reluctances for the ceiling, walls and floor.

Typical steps involved

Decide the type of luminaire you plan to use in the application, as well as the number of lamps the luminaires can hold. Determine the room's dimensions and decide the CoU based on the manufacturer's luminaire catalogue.

Next, determine the reflection factors of the ceiling, floor or walls. It is common to assume some nominal factor based on experience and knowledge. Determine a suitable maintenance factor on your previous experiences or assume it to be 0,7 – 0,8.

Use the formula in Eqn. 2 to determine the number of luminaires required (the integer) and make a practical and feasible layout for the luminaires. Recalculate and check the actual illuminance achievable with the planned layout.

Decide on a proposed luminaire type based on the average lux level required at the work level with the formula:

$$\text{Number of Luminaires} = \frac{(Desired\ average\ lux)\ x (work\ plane\ area)}{(lamps\ per\ luminaire) x (lumens\ per\ lamp)\ x\ COU\ x\ MF} \quad [2]$$

Determine the luminaire layout with uniformity of spacing and aesthetics in mind and recalculate the achieved lux for the proposed layout to ensure that it provides the desired lux level using the formula:

$$\text{Average lux achieved} = \frac{(lumens\ per\ lamp) x\ (lamps\ per\ luminaire) x\ (number\ of\ luminaires) x\ COU\ x\ MF}{Workplane\ area} \quad [3]$$

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