Lighting design and calculations

THE LUMEN METHOD

This method is also called: Photometrical Computation and mostly used for interior lighting calculation

To determine the total number of luminaires required to produce a given illuminance by the lumen method we apply the following formula:

Total number of luminaires (N) required to provide a chosen level of illumination (E) at a given surface is .

$$N = \frac{E\ (lx - \ required) x\ Area\ (m^2)}{lumen\ from\ each\ luminaire\ xUFxMF}$$

where

- E = the illuminance level is chosen after consideration of the IES code,
  the area is the working area to be illuminated, the lumen output of each luminaire is that given in the manufacturer's specification and may be found by reference tables.
- MF is maintenance or (the light loss LLF) factor. This factor depends on the maintenance staff of the building, but in general it is taken as 0.8 -0.9.
- Utilization factor (UF)
  The light flux reaching the working plane is always less than the lumen output of the lamp since some of the light is absorbed by the various surface textures.
  The method of calculating the utilization factor (UF) is detailed in lighting design books, although lighting manufacturers' catalogues give factors for standard conditions. The UF is expressed as a number which is always less than unity; a typical value might be 0.9 for a modern office building.

Example 1

It is proposed to illuminate an electronic workshop of dimensions 9 x 8 x3 m to an illuminance of 550 lx at the bench level. The specification calls for luminaires having one 1500 mm 65 W fluorescent natural tube with an initial output of 3700 lumens. Determine the number of luminaires required for this installation when the UF and MF are 0.9 and 0.8, respectively.

The number of luminaire required (N)

$$N = \frac{E\ (lx) x\ Area\ (m^2)}{lumen\ from\ each\ luminaire\ xUFxMF}$$

$$N = \frac{550\ x\ 9x8}{3700\ x0.9x0.8} = 14.86$$

Therefore 15 luminaires will be required to illuminate this workshop to a level of 550 lx.

- Other factors that may be taken into consideration when using the lumen method are :

1. Room Index: this includes

- Room dimensions:
  (i) Length (a)

  (ii) Width (b)

  (iii) Height (h)

- Useful Height - H_k.

This can be calculated as:

$h_k = h - h_d$ or $h_k = h - h_d - h_v$ ……. (1)

where :

h_k = useful height

h = room height

h_d = height of working area, usually taken as : 0.85 m

h_v = height of illumination unit hanging from the ceiling , measured in (m).

$$Room\ \ Index(k) = \frac{a.b}{h_k(a+b)} \qquad (2)$$

2. The reflection factor - ρ

This means the light reflected from ceilings, walls and floors which and depends on the colours, type of floor and ceilings. Table -1 gives the reflection coefficient for various materials.

Reflection coefficient P.U.	Material
0.50	الطابوق (الطوب) الاصفر
0.40	الطابوق(الطوب) الغامق
0.30	الطابوق(الطوب) الاحمر
0.27	الآلسمنت
0.55	الكونكريت (الباطون)
0.40	حجر الكرانيت
0.45	المرمر (الرخام) الابيض
0.70	الصبغ (الابيض الثلجي)
0.5 -0.3	الصبغ الفاتح اللون للجدران
0.70	الزجاج النقي
0.40	الإسفلت
0.1	الكاشي (البلاط) الاسود
0.70	الكاشي الموزائيك الابيض
0.30	الكاشي الموزانيك الاحمر
0.20	الكاشي الموزانيك الاسود والابيض
0.1	الرخام الغامق للارضيات

The reflection coefficients ρ can be used to determine the utilization factor UF for any luminaire from the manufacturers catalogues when the room index is calculated. For example, Table -2 gives the utilization factor UF for a fluorescent luminaire with single 40W lamp and prismatic diffuser1300 mm length for different values of the room reflection coefficients: C – ceiling reflection, W- wall reflection, F- floor reflection. If these values are: (0.5, 0.5, 0.2) and the room index is calculated to be 1.50, then the UF = 0.52.

Table -2

Utilisation factor for fluorescent luminare with single 40W lamp and prismatic diffuser 1300 mm length.

Room Reflection			Room Index								
C	W	F	.75	1.00	1.25	1.50	2.00	2.50	3.00	4.00	5.00
.70	.50	.20	.44	.50	.56	.60	.65	.69	.72	.75	.77
	.30		.38	.44	.50	.54	.60	.64	.68	.72	.74
	.10		.33	.40	.46	.50	.56	.61	.64	.69	.72
.50	.50	.20	.39	.44	.49	.52	.57	.60	.62	.65	.67
	.30		.34	.40	.44	.48	.53	.56	.59	.62	.64
	.10		.30	.36	.41	.44	.50	.53	.56	.60	.62
.30	.50	.20	.34	.39	.42	.45	.49	.51	.53	.55	.57
	.30		.30	.35	.39	.42	.46	.49	.51	.53	.55
	.10		.27	.32	.36	.39	.44	.47	.49	.52	.54
.00	.00	.00	.22	.26	.29	.31	.34	.36	.38	.40	.41
			→				UF	←			

Note: The reflection coefficients for a standard room are: (0.7, 0.5, 0.2)

Table -3 gives the maintenance factors for different types of rooms.

Table -3 Maintenance factor

Room classification	**Lamp maintenance factor**	**Maintenance factor for dirty lamp**	**Total maintenance factor**
very clean	0.09	0.85	0.85-0.9
clean	0.9	0.9	0.8
average	0.9	0.8	0.7
dirty	0.9	0.7	0.6

Example 2

It is proposed to illuminate a class room of dimensions 6 x 8 x 2.85 m to an illuminance (E) of 400 lx at the bench level. The specification calls for luminaires having one 1050 mm 40 W fluorescent natural tube with an initial output of 3200 lumens with white metal base and prismatic plastic diffuser (its UF is given in Table -2) . Determine the number of luminaires required for this installation when the MF is 0.7, respectively. The reflection coefficients are: (C= 0.70, W= 0.3, F=0.2)

Solution

From the room dimension we can calculate the room index (*k*)

assuming the working table height is 0.85 m. Hence,

$$h_k = 2.85\text{-}0.85 = 2\text{m}$$

$$Room\ \ Index(k) = \frac{a.b}{h_k(a+b)}$$

$$k = \frac{6\,x\,8}{2\,x\,(6+8)} = 1.71$$

From Table -2 , UF = 0.57

$$N = \text{No. of luminaires} = \frac{lumen\ required\ x\ Area(m^2)}{lamp\ lumen\ x\ U.F\ x\ M.F}$$

$$N = \frac{400\,x\,48}{3200\,x\,0.7\,x\,0.57} = 14.58 \approx 15$$

Since 15 luminaire are large number that can be installed in the ceiling, so we suggest to use luminare with 2x40 W fluorescent lamps with prismatic diffuser. Hence, the number of luminaire required will be,

$$\frac{15}{2} = 7.5 \Rightarrow 8 \quad \text{luminaire}$$

Luminaires distribution:

Distance between two adjacent luminaire s is

$$= \frac{Room\ length}{No.of\ luminaire\ in\ a\ single\ row} = \frac{8}{4} = 2m$$

Distance between the luminaire and its adjacent wall = (½ to ⅓)x(room height):

or $\frac{2.85}{2}$ = 1.425 ≈ 1.50 m

Note: Usually we take the factor ½ when the dimensions of the room are such that the ratio of the length to the width is less than 1.6, otherwise we take the factor of ⅓ .

The distribution of the luminaires are shown in Fig.A

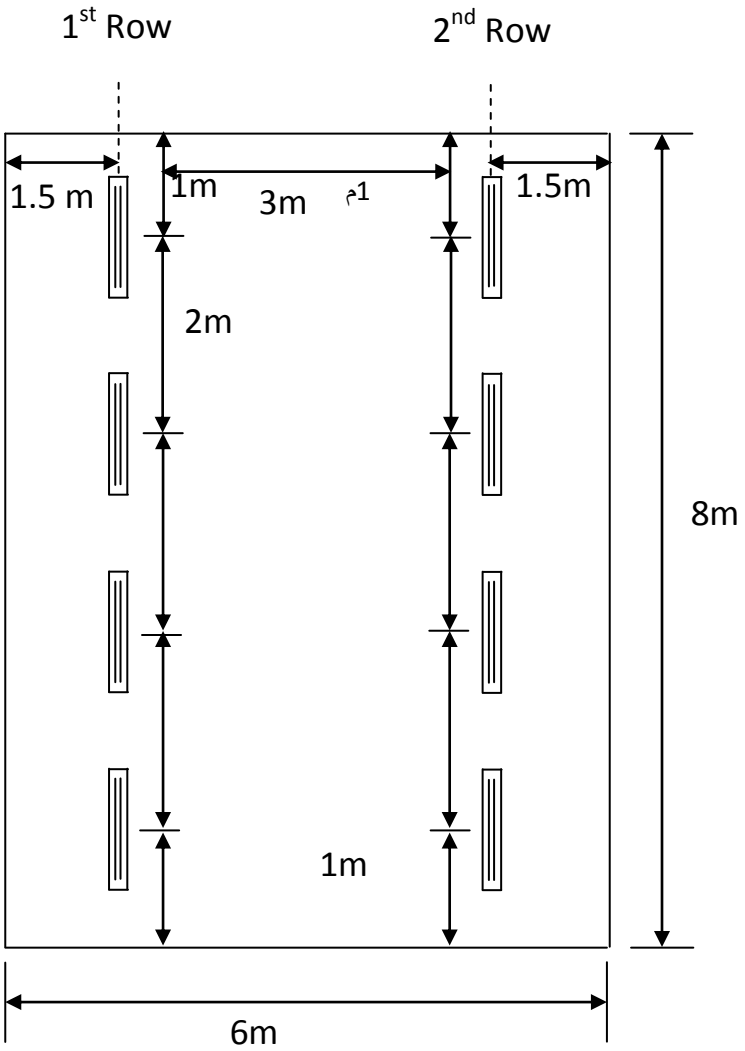

Fig.A Luminaires distribution on room ceiling