iJRASET
International Journal For Research in Applied Science and Engineering Technology

# INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

**Volume:** 7 **Issue:** V **Month of publication:** May 2019

**DOI:** https://doi.org/10.22214/ijraset.2019.5090

www.ijraset.com

Call: 08813907089 | E-mail ID: ijraset@gmail.com

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
*ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.177*
*Volume 7 Issue V, May 2019- Available at www.ijraset.com*

# Architectural Design for Day Lighting

Prof. S. K. Gupta[1], Ar. Dilip Singh Kushwaha[2]
[1]*Dean & Director,* [2]*Assistant Professor, Amity University Haryana Manesar, Gurgaon*

***Synopsis: In particular paper the authors put more stress towards the practical orientation of day lighting importance in architectural design. These are two ways to explain the day lighting a) Assess illumination level at different planes & surfaces, b) calculate the size of the window to obtain maximum day lighting in the designed architectural spaces. It is very usefull for the students & professionals to study this paper.***

## I. INTRODUCTION

The grid is based on measurements of sky luminance & day light availability all over India incorporated in **I.S.I. code of Practice :2440 (1968) & new (code NLC 2010)** & is applicable to places all over India.

The publication includes two grids on which are marked a number of dots & stars. The grid represents the window – wall of a room above the working plane. By drawing the plan of the window of the grid & counting the number of dots & stars within the window outline, the illumination can be found. If the desired illumination is known, the size of the windows can also be determined. Fig 1 illustrates the idea in principle.

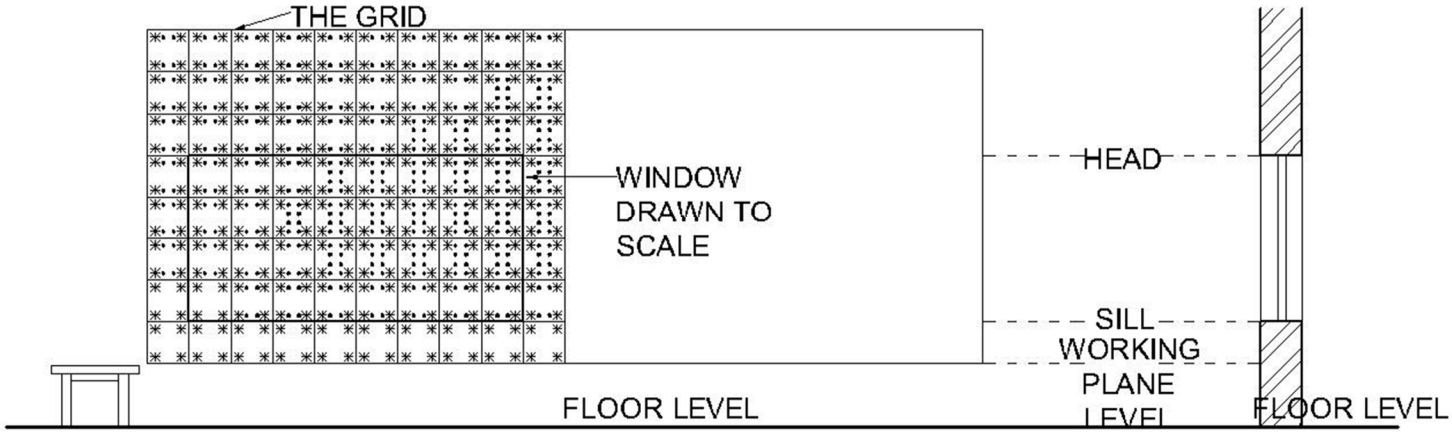



Fig. – 1

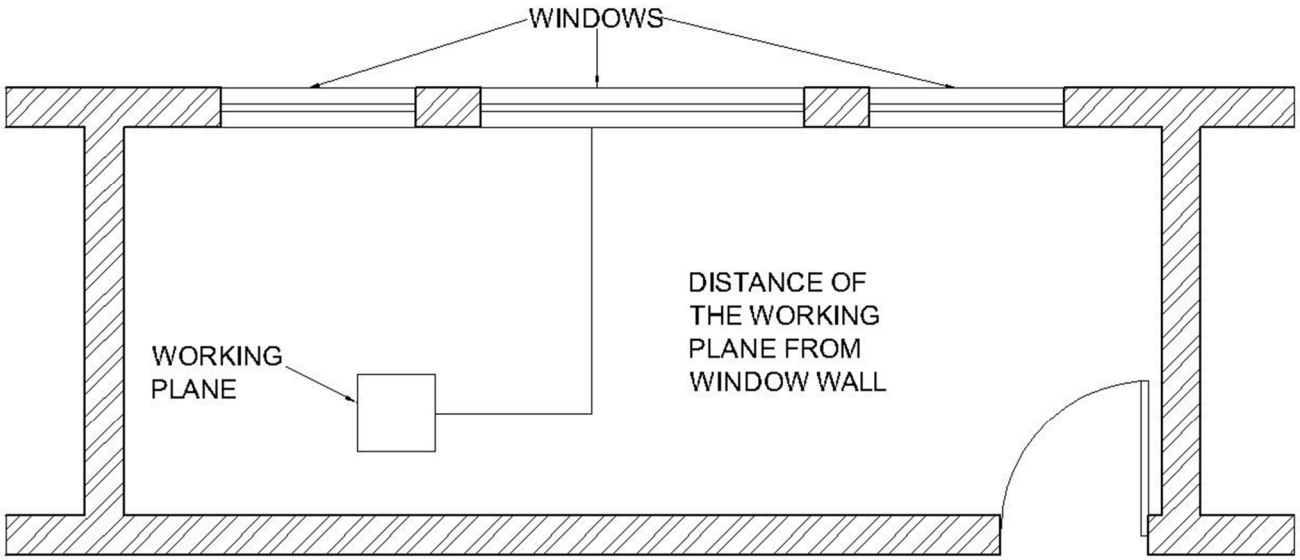
## II. THE GRID

The first step is to decide on the size of one square of the grid so that thw window outline can be workout on it. Table 1 & fig. 2 show how it is workout.

TABLE 1

| Distance of the Working Plane from Window Wall in CM | Width of One Square of Grid in CM |
|---|---|
| 600 | 60 |
| 450 | 45 |
| 300 | 30 |
| 150 | 15 |
| 100 | 10 |

*ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.177*
*Volume 7 Issue V, May 2019- Available at www.ijraset.com*




PLAN OF A ROOM

Fig. – 2

## III. SILL HEIGHT OF THE WINDOW

The illumination on the working plane comes mostly from that part of the window that is above its surface. The sill of the window should therefore be arranged either at or above the working plane height. Where, for some special reason, the sill of the window is below the surface of the working plane, the dots & stars in the grid below the working plane height should not be counted. Fig. 3 explains it clearly.

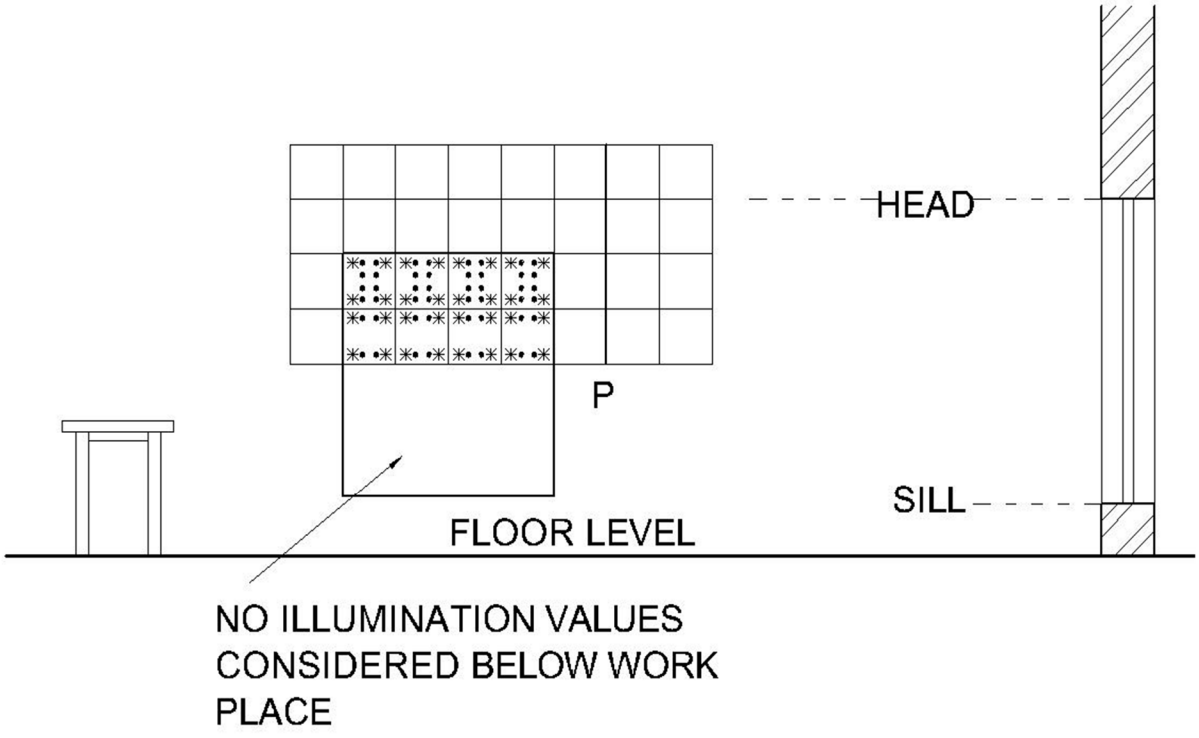



Fig – 3

*ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.177*
*Volume 7 Issue V, May 2019- Available at www.ijraset.com*

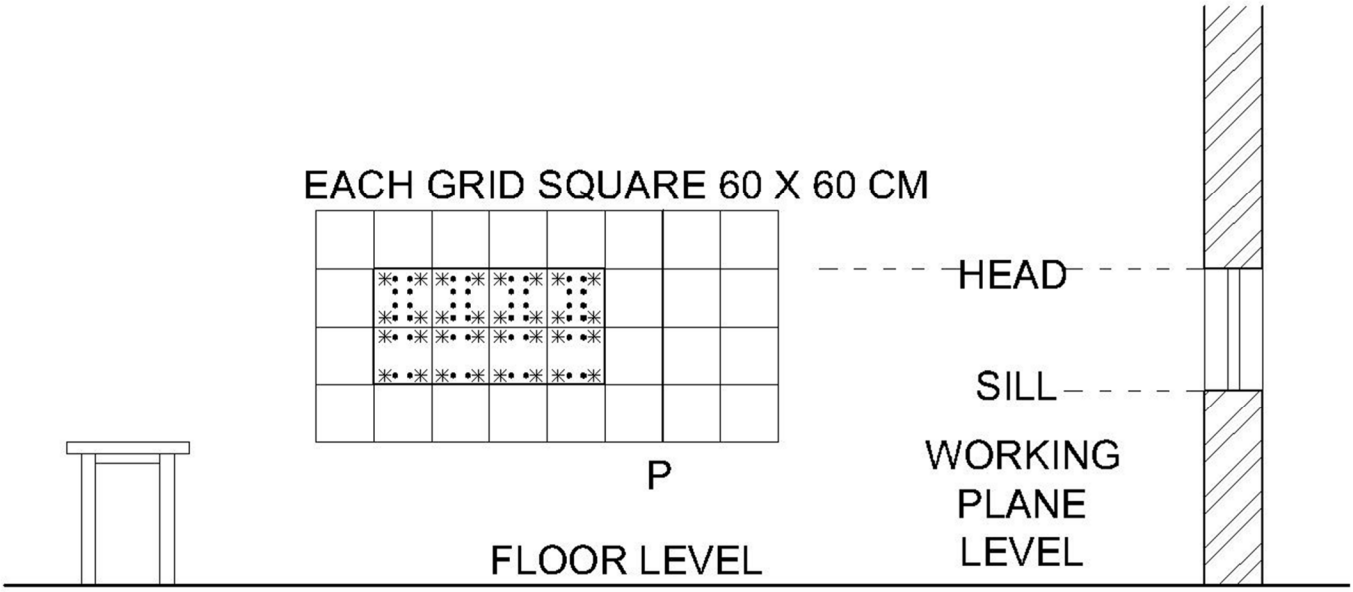



Fig – 4

One dot has a value of 0.5 lux & one star has a value of 2.0 lux. Thus, for point P1 in Fig. 4. the illumination at a point 600 cm from the window wall comprised of:

48 dots = 24 lux
32 stras = 64 lux

Total = 88 lux

Similarly, for P2 in Fig. 4, where the point is 300 cm from the wall in the same room, the illumination is (refer to Fig. 5 )

176 dots = 88 lux
128 stars = 256 lux

*A. Interior Finish Of The Room*

The illumination on an interior surface is affected not only bt the size of the windows but also by inter-reflection of light within the room. If the internal finishes are dull & dark, the inter-reflections will be less & the illumination on a surface some-what lower than if the room is finished with lighter colors. Illumination levels have to be corrected for different interior finishes as indicated in Table 2.

## IV. ILLUSTRATIVE EXAMPLES

*A. Unobstructed Windows (Lux Grid No.1) Illumination From One Window Only*

1) *Ex. 1:* Consider the point P1 (Fig. 4, at 600 cm away) from the window. Assume that the room in which the point is located has "Finish B" & floor area approximately 30 sq. metres.

The number of grid squares enclosed by the outline of the window is 8. The correction factor for Finish B (from Table 2) = -1.9.
Total correction = 8 ( -1.9) = -15.2 lux.
Now add this algebraically to the lux value obtained by counting the dots & stars.

Illumination at point P1 = 88.0 lux
Correction = - 15.2 lux

Total Illumination = 72.6 lux

2) *Ex. 2:* Consider a point P2, 300 cm from the window wall, in the same room as Ex.1.
The number of grid squares enclosed by the windows is 32 (Fig. 5). The correction factor from Table 2 is -6.2.

Total correction = (-6.2 x 32) = -198.4
Illumination at P2 from dots & stars = 344.0 lux
Correction = -198.4 lux

Total Illumination = 145.6 lux

*3) Ex. 3:* Illumination from more than one window.

Fig. 6 shows a room of floor area approximately 42 square metres, with 'A' type interior finish. It is desired to check the illumination levels at two points, P1 & P2 distance 600 cm & 150 cm away from the window respectively.

*a) Consider Point P1:* Fix the scale of the grid from Table 1. Point 1 being 600 cm from the wall, the size of one square on the grid is 60 x 60 cm2. Take a piece of tracing paper & lay it over the grid. Draw the elevation of all the windows on it with the point P1 on the plan coinciding with the heavy line at p on the grid. Make sure that the working plane height, which is the base of the grid, is correct related to the sill height. Fig. 7 shows what should appear on the tracing paper.

Correct for finish: The correction factor for finish "A" from Table 2 is 0. The Illumination at point P1 is thus 155 lux.

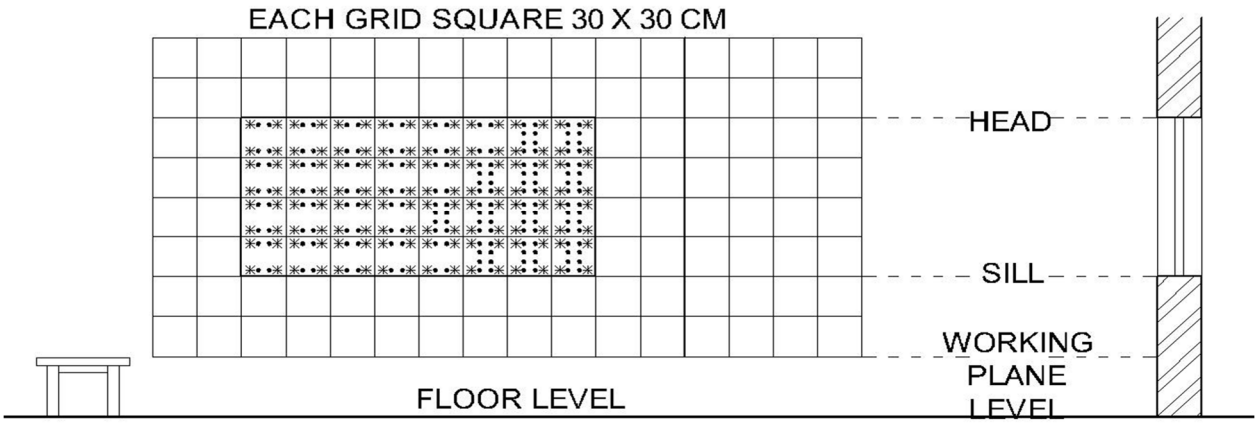



Fig – 5

TABLE 2
Correction Factors For Per Square (axa)- LUX

a = side of one square in the grid
b = distance of point from the window

| d cm | a cm | FLOOR AREA WITHIN 10-25 $M^2$ | | | FLOOR AREA WITHIN 25-50 $M^2$ | | | FLOOR AREA WITHIN 50-100 $M^2$ | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | A | B | C | A | B | C | A | B | C |
| 900 | 90 | +26.6 | +18.0 | +9.5 | +9.5 | +5.2 | +1.0 | +1.0 | -1.2 | -3.3 |
| 840 | 84 | +22.2 | +14.7 | +7.3 | +7.3 | +3.6 | 0 | 0 | -2.0 | -3.9 |
| 780 | 78 | +18.0 | +11.7 | +5.2 | +5.2 | +2.0 | -1.2 | -1.2 | -2.8 | -4.4 |
| 720 | 72 | +14.3 | +8.8 | +3.3 | +3.3 | 0 | -2.1 | -2.1 | -3.5 | -4.9 |
| 660 | 66 | +10.8 | +6.2 | +1.6 | +1.6 | -0.7 | -3.0 | -3.0 | -4.2 | -5.3 |
| 600 | 60 | +7.6 | +3.8 | 0 | 0 | -1.9 | -3.8 | -3.8 | -4.8 | -5.7 |
| 540 | 54 | +4.7 | +1.6 | -1.4 | -1.4 | -3.0 | -4.5 | -4.5 | -5.3 | -6.1 |
| 480 | 48 | +2.1 | 0 | -2.7 | -2.7 | -4.0 | -5.2 | -5.2 | -5.8 | -6.4 |
| 420 | 42 | 0 | -2.0 | -3.9 | -3.9 | -4.8 | -5.7 | -5.7 | -6.2 | -6.7 |
| 360 | 36 | -2.1 | -3.5 | -4.9 | -4.9 | -5.5 | -6.2 | -6.2 | -6.6 | -6.9 |
| 300 | 30 | -3.8 | -4.8 | -5.7 | -5.7 | -6.2 | -6.7 | -6.7 | -6.9 | -7.1 |
| 240 | 24 | -5.2 | -5.8 | -6.4 | -6.4 | -6.7 | -7.0 | -7.0 | -7.1 | -7.3 |
| 180 | 18 | -6.2 | -6.6 | -6.9 | -6.9 | -7.1 | -7.3 | -7.3 | -7.3 | -7.4 |
| 120 | 12 | -7.0 | -7.1 | -7.3 | -7.3 | -7.4 | -7.4 | -7.4 | -7.5 | -7.5 |

Finish A. Ceiling white (reflection factor = .07 to 0.8), walls off white (reflection factor = 0.45 to 0.55) & floor grey (reflection factor = 0.3).
Finish B. Ceiling off white, walls off white & floor gray.
Finish C. Ceiling off white, walls darks (reflection factor =0.25 to 0.3 & floor gray.

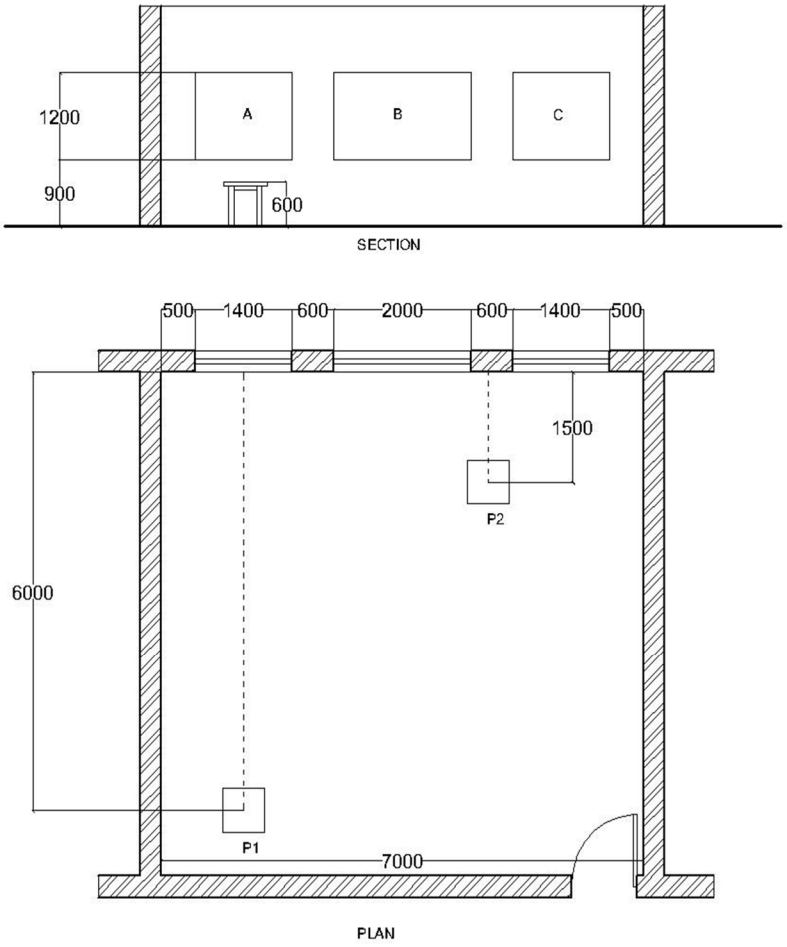



Fig – 6

*b)* *Consider point P2:* The point being 150 cm from the window wall, the size of a square on the grid is 15 x 15 cm2 . Take a piece of tracing paper & lay it over the grid. Draw the elevation of all the windows on it with the point P2 on the plan coinciding with the heavy line at P on the grid. Check that the base of the grid is at the level of the working plane & correctly located in relation to the height. Fig. 8 shows what should appear on tracing paper.

Next, count the dots & stars enclosed by the outlines of all the windows & and them together.

| | Dots | stars |
|---|---|---|
| Window A | 0 | 304* |
| Window B | 328 | 434 |
| Window C | 320 | 304 |
| Total | 648 | 1042 |

Illumination = 324 + 2084 = 2408 lux.

Correct for finish: The correction factor for finish A from Table 2 is (-7.3 + 6.9) /2 = -7.1

*what is to the left of A in Fig. 8 & just outside the grid squares contributes negligible to the illumination m, at P1. The effective contribution per grid square may be treated as 4 stars per square.

The number of grid square enclosed by all the three windows is:

Window A = 76
Window B = 108
Window C = 76
Total = 260 grid squares

Thus the total correction is

= (-7.1x260)
= - 1846.0

Total illumination at $P_2$ is thus

24-08-1846 = 562.0 lux

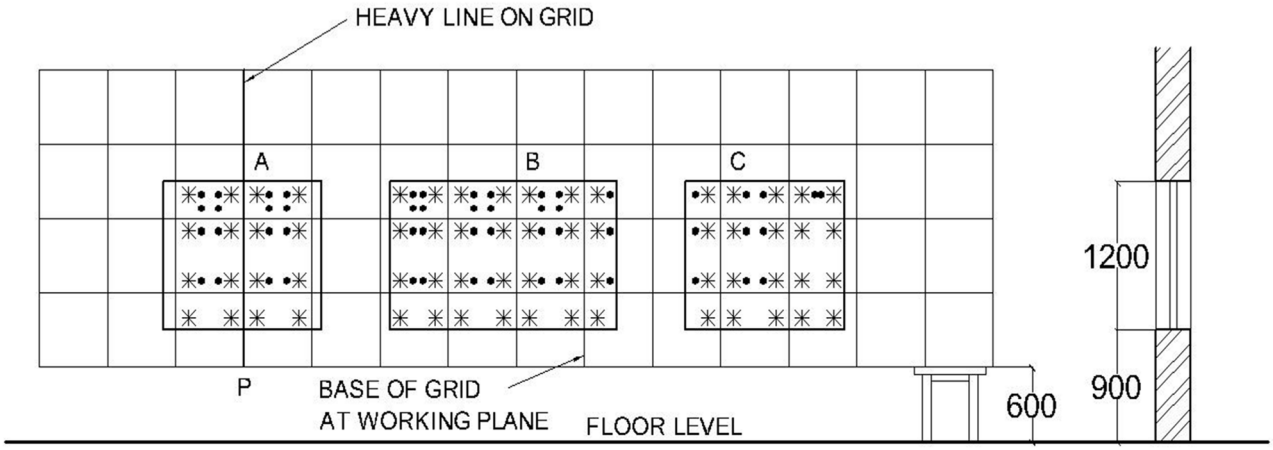



Fig – 7

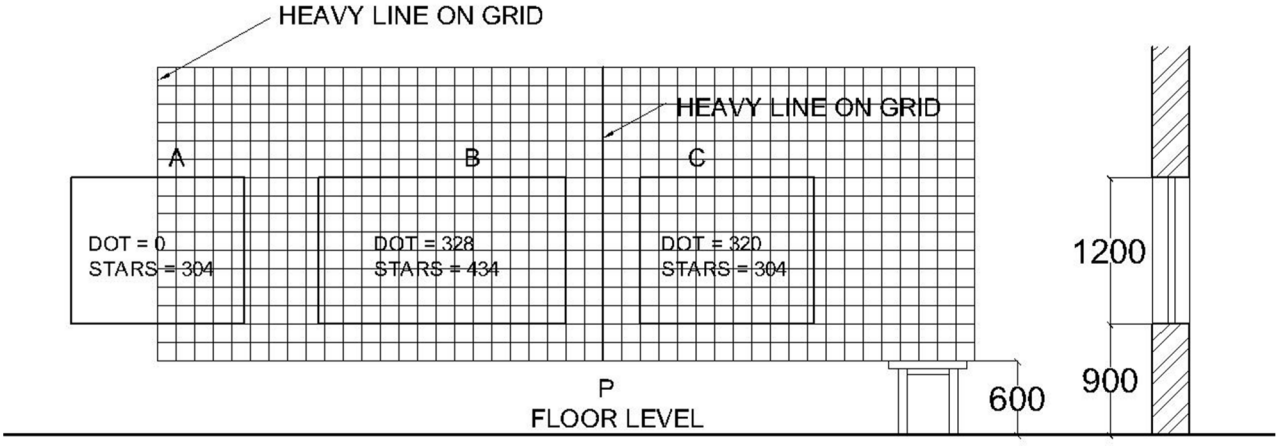
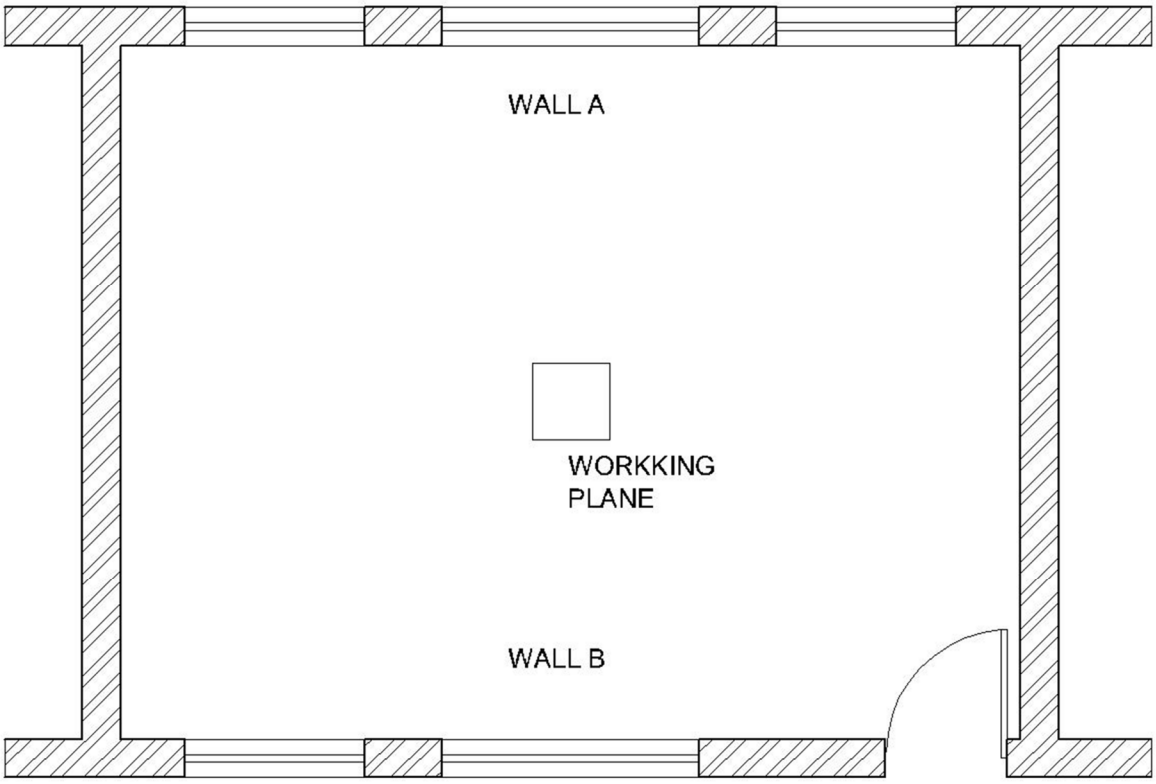



Fig – 8

*B. Windows in Two Walls*

Sometimes, in a room one may receive illumination from windows in opposite wall as shown in Fig. 9

In such cases, the illumination on the selected point is calculated by adding together the illumination obtained from windows in wall. A is to the obtained from window in wall B. The method of calculation is similar to that explained in the examples above.




PLAN OF A ROOM

Fig – 9

*1) Ex. 4:* Determination of window size to achieve a required level of daylight on the working plane.

Fig.10 shows the outline plan of a room in which it is desired to provide an illumination level of 216 lux at the point $P_1$ on the working plane. Before fixing the size and location of the windows, one should have an idea of the maximum possible daylight expectable at the point as shown below:

Let us assume: Room ceiling height = 3.05m.
Sill height = 72 cm.
Distance of point
From window = 3.6 m.
Room interior finished = "A"

The sill of the windows is assumed to be in level with the working plane.

The maximum expectable daylight is obtained by opening out the whole wall above the working plane. The maximum window height can be only 3.05-.72= 2.33 metre. The location of the point from the window wall is 3.6 m. Hence, each square on lux grid is 36x36 $cm^{2.}$ Using the method of counting already described, the number of dots and stars will be

| | Dots | Stars | Total |
|---|---|---|---|
| Window portion On left of $P_1$ | 180=90 lux | 130=260lux | 350lux |
| Window portion On right of $P_1$ | 316=151lux | 390=780lux | 938lux |
| Total | | | 1288lux |

The correction factor for finish 'A' is determined as under:

Left of $P_1$ = 32.5 grids
Right of $P_1$= 97.5 grids

Total 130 grids

Correction from Table 2, at a distance of 3.6 m, for the given room (floor area = 34.56 sq. meter), having interior finish 'A' is – 4.9 per grid.

The total correction= - 130 x 4.0
= - 637.0 lux

The net illumination at $P_1$ will be = 1288-637- 651.0 lux.
This is more than the required 216 lux. Illumination due to window on right side of P 938 lux.
No. of grids on the right side = 97.5
Hence total correction= - 477.75 lux
Nett illumination at $P_1$ due to right side along = 938-477.75
= 460.25 lux

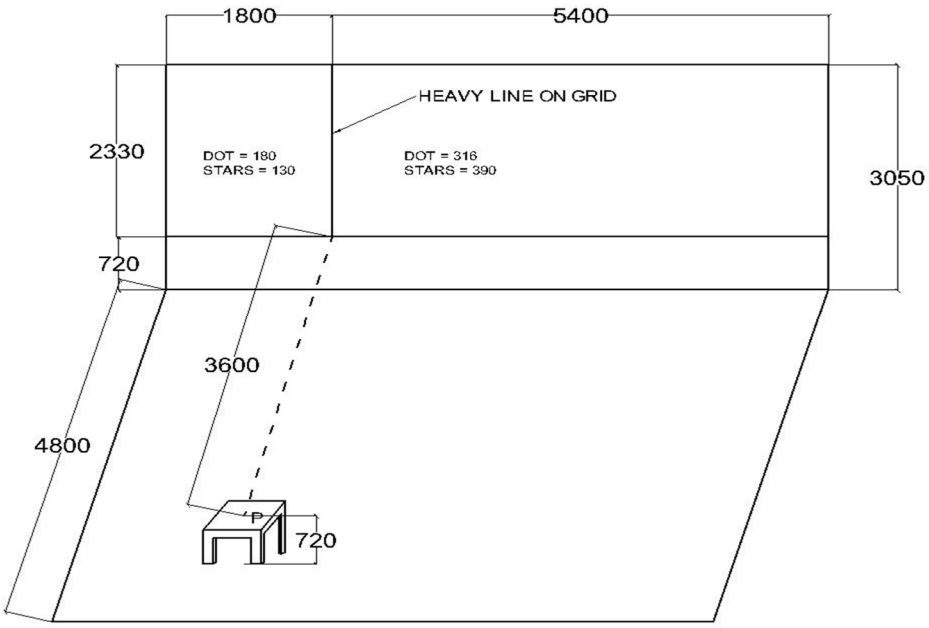



Fig – 10

Hence, windows extending up to ceiling, but only on the right side of $P_1$
The size of the window can be adjusted further, keeping in view the reductions in daylight due to the relative positions of grid squares with respect to the point in question.

*C. Limitations of the Method*

*1)* It is assumed that the ground outside the windows has a reflection factor of 0.20, that is, grass with some brick or concrete paving.
*2)* The ceiling is from 2.75 to 3.05 meters above the floor level, pitched or flat.
*3)* Obstructions outside the windows can be ignored if they are at distant more than 3 times their own height from the window. For obstructions that are closer, the method given ahead should be used.
*4)* In designing the grid, it is assumed that the window has a 60 cm sunshade around or a 60 cm horizontal louver is incorporated in the window, which supported to be glazed.

*ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.177*
*Volume 7 Issue V, May 2019- Available at www.ijraset.com*

If there is a verandah or other large overhang outside the window, the size of the window for the purpose of counting the dots and stars should be reduced appropriately (Fig.11).

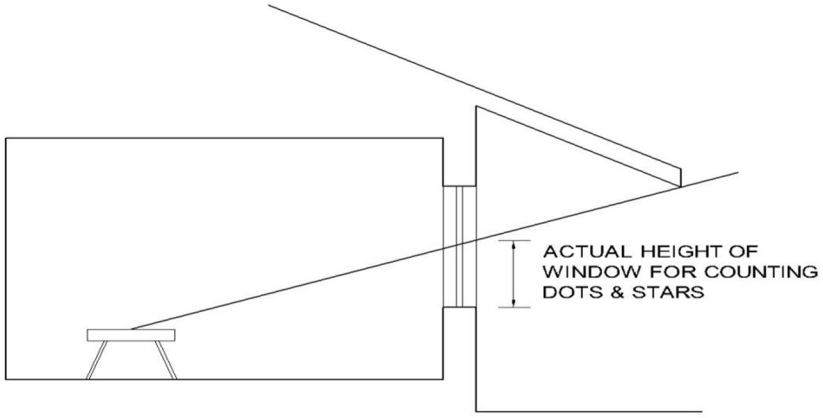



Fig – 11

*D. Window with External Obstruction (lux grid No.2)*

When obstructions outside the window (having a reflection factor lying between 0.4 & 0.6 restrict the entry of daylight, lux grid No.2 together with its correction Table No. 3 has to be used. Here one finds in addition to the dots and crosses inside each grid, a circle enclosing a few dots and crosses. The dots and crosses within the circle correspond to the daylight contributed by obstructions, while those outside the circle represent the contribution due to the unobstructed window including inter reflections. One cross is equal to 1.0 lux.

To estimate the available daylight at a point, the outline of the window and the obstruction are projected on the lux grid using proper scales corresponding to the distances of window and obstruction from the point in question.

Depending on the height (H) and distances (D) of the obstruction from the point and window-wall respectively, four cases arise:

TABLE -3 CORRECTION PER SQUARE (AXA)-lux

a = side of one square in the grid

d = distance of point from the window

| d cm | a cm | FLOOR AREA WITHIN 10-25 $M^2$ | | | FLOOR AREA WITHIN 25-50 $M^2$ | | | FLOOR AREA WITHIN 50-100 $M^2$ | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | A | B | C | A | B | C | A | B | C |
| 900 | 90 | +10.6 | +7.2 | +3.8 | +3.8 | +2.1 | +0.4 | +0.4 | -0.5 | -1.3 |
| 840 | 84 | +8.9 | +5.9 | +2.9 | +2.9 | +1.4 | 0 | 0 | -0.8 | -1.6 |
| 780 | 78 | +7.2 | +4.7 | +2.1 | +2.1 | +0.8 | -0.5 | -0.5 | -1.1 | -1.8 |
| 720 | 72 | +5.7 | +3.5 | +1.3 | +1.3 | 0 | -0.9 | -0.9 | -1.4 | -1.9 |
| 660 | 66 | +4.3 | +2.5 | +0.6 | +0.6 | -0.3 | -1.2 | -1.2 | -1.7 | -2.1 |
| 600 | 60 | +3.0 | +1.5 | 0 | 0 | -0.8 | 1.5 | 1.5 | -1.9 | -2.3 |
| 540 | 54 | +1.9 | +0.7 | -0.6 | -0.6 | -1.2 | -1.8 | -1.8 | -2.1 | -2.4 |
| 480 | 48 | +0.9 | 0 | -1.1 | -1.1 | -1.6 | -2.1 | -2.1 | -2.3 | -2.6 |
| 420 | 42 | 0 | -0.8 | -1.6 | -1.6 | -1.9 | -2.3 | -2.3 | -2.5 | -2.7 |
| 360 | 36 | -09 | -1.4 | -1.9 | -1.9 | 2.2 | -2.5 | -2.5 | -2.6 | -2.8 |
| 300 | 30 | -1.5 | -1.9 | -2.3 | -2.3 | -2.5 | -2.7 | -2.7 | -2.8 | -2.9 |
| 240 | 24 | -2.1 | -2.3 | -2.5 | -2.6 | -2.7 | -2.8 | -2.8 | -2.9 | -2.9 |
| 180 | 18 | -2.5 | -2.6 | -2.8 | -2.8 | -2.8 | -2.9 | -2.9 | -2.9 | -3.0 |
| 120 | 12 | -2.8 | -2.9 | -2.9 | -2.9 | -2.9 | -3.0 | -3.0 | -3.0 | -3.0 |

1) *Finish A:* Ceiling white: P = 0.7- 0.8
Wall off-white: P = 0, 45 - 0.55
Floor grey P = 0.3

2) *Finish B:* Ceiling - off white
Wall – off white
Floor - grey

3) *Finish C:* Ceiling - off white
Walls - dark (p=0.25-0.30)
Floor – grey

*a)* *D > 3 H:* This case can be treated as unobstructed as far as daylighting is concerned & grid no. 1 should be used.

*b)* *1.5 < D ≥ 3H*

*i)* *Step a.* Find the contribution due to unobstructed portion of the window using lux grid No. 1 & No.2 separately & take the mean value.

*ii)* *Step b.* Find the contribution due to the obstructed portion by counting the dots & crosses within the enclosed circle ( in the obstructed part) using lux grid No. 2 & multiply the value so obtained by a factor = 1.8.

*iii)* *Step c.* Add the two values.

*c)* *0.5 H < D ≤ 1.5 H:* Find the contributions of the unobstructed & obstructed portions of the window separately using lux grid No.2 & add the value.

*d)* *D ≤ 0.5 H*

*i)* *Step a.* Find the daylight due to unobstructed part using lux grid No. 2

*ii)* *Step b.* Find the daylight due to obstructed part using lux grid No. 2 but reduce the value obtained by 50 percent.

*iii)* *Step c.* Add the values.

Ex. 5. Consider Fig. 12, a point P1 at 6 m away from the window wall. Assume that the room in which the point is located has finish B, & floor area approximately 43 sq. metres. The room has two windows each of size 2.40 x 1.50 sq. m at a sill level of 30 cm above the working plane symmetrically located with respect to point P1. The windows face an infinitely long parallel obstruction (reflectance = 0.5) located at a distance of 18.0 m

This corresponds to case (ii) where 1.50 H < D ≤ 3.0 H.

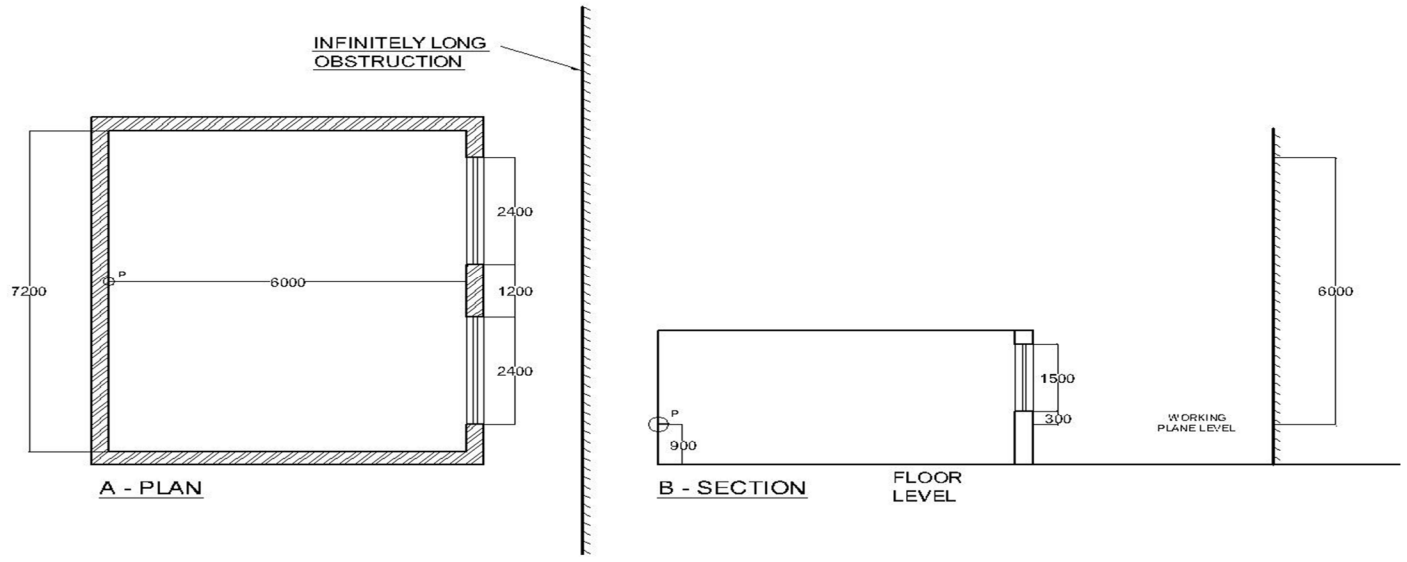



Fig – 12

Step a. Projection of the obstruction on the lux grids 1 & 2 are shown in the Fig. 13 (a) & (b). The contribution due to unobstructed portion of the windows using lux grid 1 (Fig. 13 a) & grid 2 (Fig. 13 b) are determined as follows:

*ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.177*
*Volume 7 Issue V, May 2019- Available at www.ijraset.com*

*4) Use grid No.1 (Fig. 13 a)*

The number of grid squares for unobstructed parts of windows = 4.
Correction factor for interior finish B (Table 2) = - 1.9 lux.
Total correction for 4 squares = 4 x (- 1.9) = -7.6 lux.
Illumination at P1 from Fig. 13 a.
Stars 16 = 32.0 lux
Dots 32 = 16.0 lux

Total = 48.0 lux
Correction = - 7.6 lux.
Net Illumination = 40.4 lux.

*5) Use grid No.2 ( Fig. 13 b):* The number of grid squares for unobstructed part of windows is again 4, but these include now 28 crosses & 4 dots giving a total illumination at P1 = (28 x 1.0) + (4 x 0.5) = 30.0 lux. This value has to be corrected using Table No. 3.

From Table 3, for interior finish B, this correction factor (per square) is – 0.8 lux & the total correction = 4 x ( - 0.8) = -3.2 lux. Hence net illumination as given by lux grid No.2 (30.0 – 3.2) = 26.8 lux.
The mean of values obtained from grid 1 &2 = !/2 (40.4 + 26.8) = 33.6 lux.
This is the net illumination from the unobstructed part of the windows.

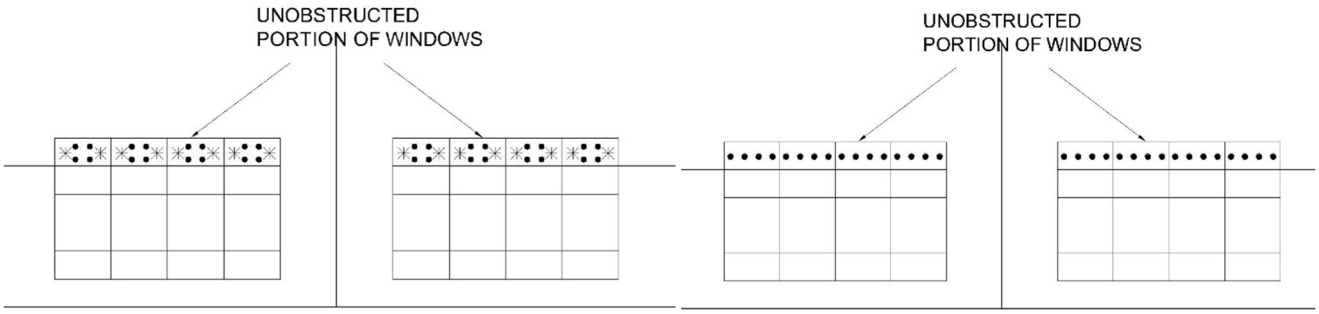



Fig – 13a, 13b

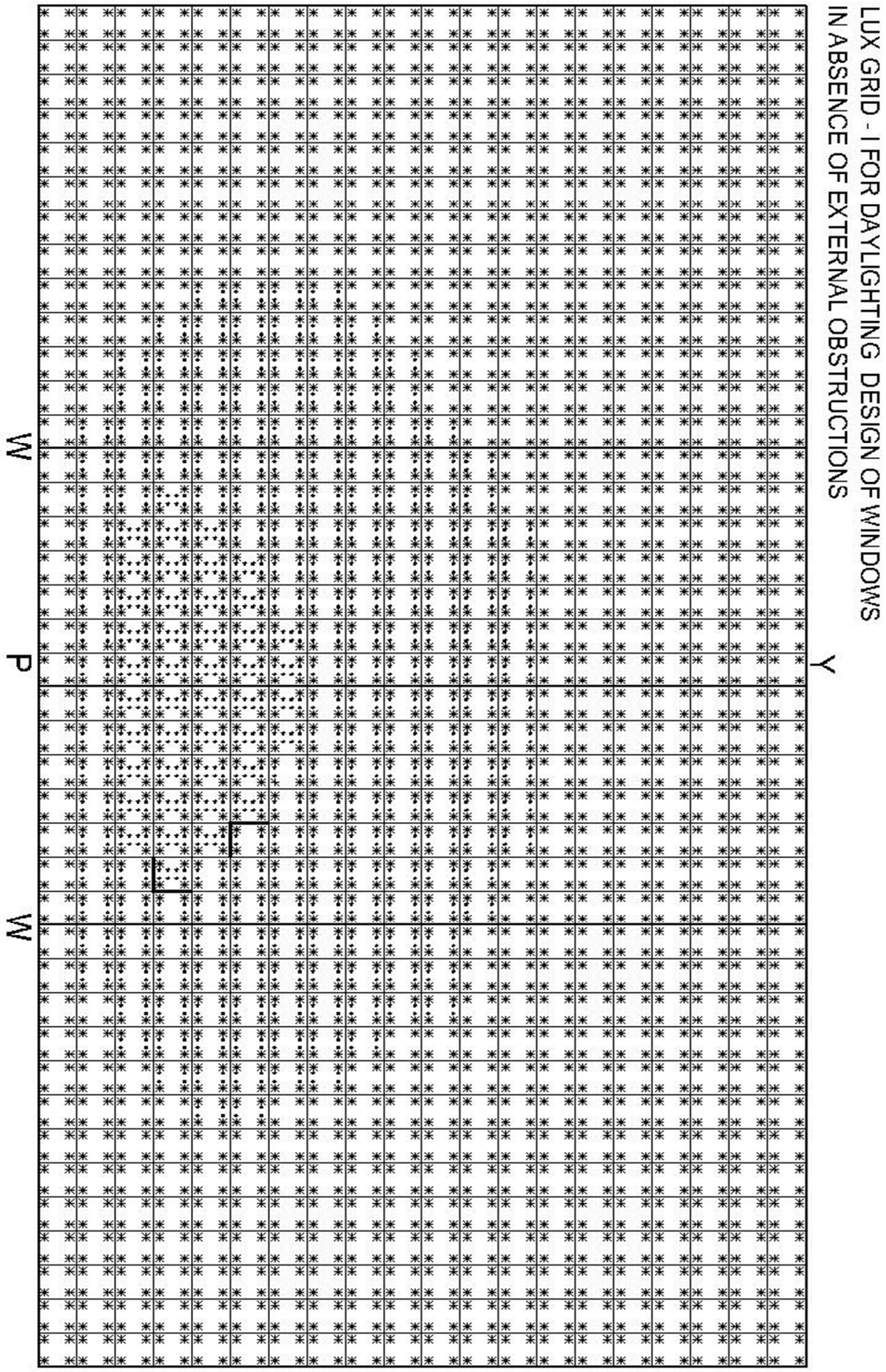
Step b. The number of squares enclosed by the obstructed part of the windows (Fig. 13 b) = 16. The correction factor from Table 3 is – 0.8 lux.
Net correction = 16 x (- 0.8) = - 12.8 lux.
Total illumination at P1 from Fig. 13 (b), (counting the dots & crosses inside the circle).
Cross 48 = 48.0 lux
Dots 16 = 8.0

Total = 56.0 lux
Correction = -12.8 lux

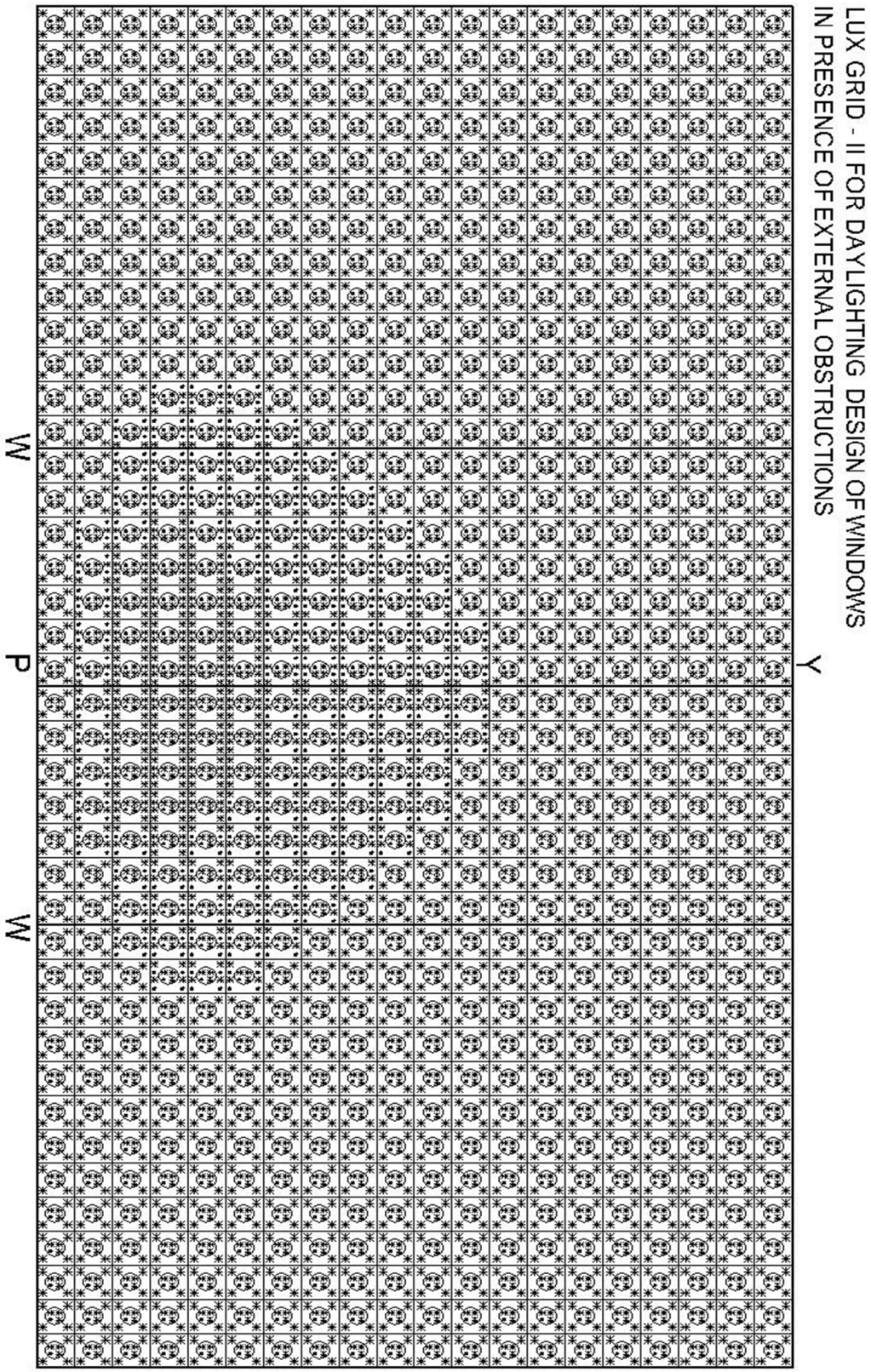
Net illumination = 43.2 lux
To get the illumination due to obstructed portion of the windows, multiply the above value by 1.8.
Here this value becomes = 1.8 x 43.2 = 77.76 lux.
**Step c**. Finally, the total illumination due to these windows is
= 33.6 + 77.76 = 111.36 lux round off 111.0 lux.

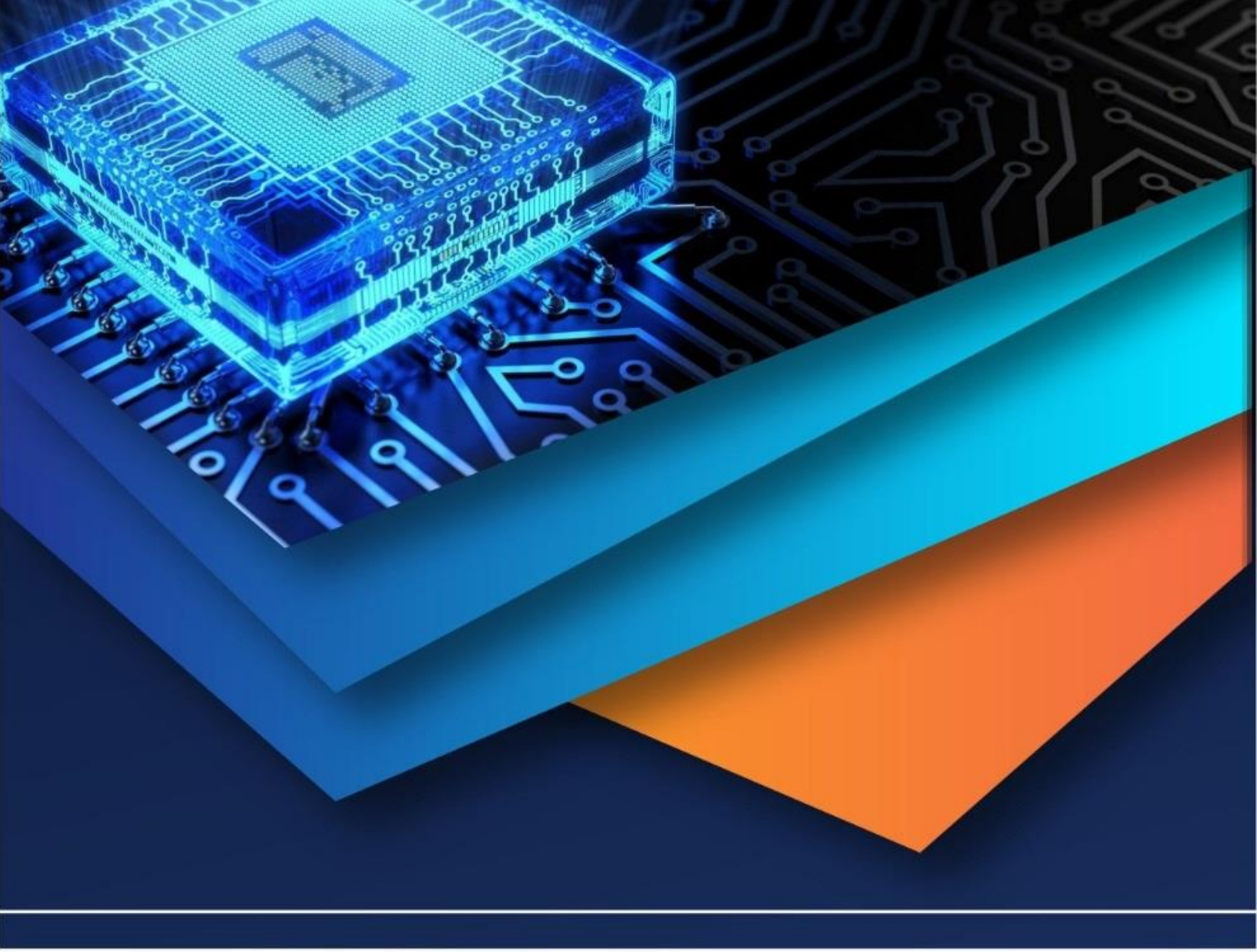
## V. SUGGESTIONS & RECOMMENDATIONS

Through various examples the solutions are very clear to understand themselves. The students can use it for their respective design, thesis work. The methods & calculations are very easy to under- stand & good for learning.



*ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.177*
*Volume 7 Issue V, May 2019- Available at www.ijraset.com*





10.22214/IJRASET

45.98

IMPACT FACTOR: 7.129

IMPACT FACTOR: 7.429

# INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY