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BUILDING RESEARCH NOTE 26

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FENESTRATIONS FOR DAYLIGHTING OF SIDE-LIT ROOMS. A SIMPLIFIED APPROACH

Introduction

Studies on daylighting deal separately with the two aspects of interior daylighting viz., the sky component and the reflected component. These form the basis for all daylighting designs. However, there is sometimes a design problem that needs quick answer and the designer wants a very simple design aid. This note makes an attempt to fulfil that need.

Factors that Influence Daylight Availability

A good daylighting design requires careful study of all factors like daylight availability and its variation from time to time, sky luminance and its variation, orientation, facade and ground reflectance, room dimensions, window locations and interior reflection coefficients and brightness balance between adjacent areas in the visual field. If some of the above quantities are treated as constant, a simplified approach to design can be made.

Daylight factor is the sum of the sky and reflected components expressed as percentage of external design illumination which is 8000 Lux for India. When multiplied by 80 the result represents the available indoor illumination in units of Lux.

Problems in Design

Two questions are generally asked by the designer. Given the requirements of light what should be the dimensions of a window? Given a window width and height what is the penetration and spread of a given daylight factor?

Table 1 gives the daylight requirements in some typical interiors.

The following average conditions have been assumed in arriving at the results presented in this note.

1. The window sashes are metallic or wooden, cutting off 10 or 30 per cent of the entering light respectively.
2. The windows are provided with glass panes of transmission coefficient 0.85.
3. The window has a horizontal louver at its top edge about 60 cm wide, cutting off 20 per cent of the expected daylight.

Table 1 : Recommended Daylight Factors of Interiors

(Indian Standard Code of Practice IS : 2440–(1975).

Location	Daylight factor per cent
1. Dwellings	
Kitchen	2.5
Living room	0.625
Study	1.9
2. Schools	
Class room	1.9
Lecture theatre	2.0 to 2.5
Study hall	2.0 to 2.5
Laboratory	1.9 to 3.8
3. Offices	
General	1.9
Drawing	3.75
Enquiry	0.625 to 1.9
4. Hospitals	
General wards	1.25
Pathalogical laboratory	2.5 to 3.75

5. **Libraries**

Stack room	0.9 to 1.9
Reading room	1.9 to 3.75
Counter area	2.5 to 3.75
Catalogue room	1.9 to 2.5

Note : 100 Lux is equal to a daylight factor of 1.25 based on 8000 Lux as the design exterior illumination

4. The glass panes have maintenance factor (depreciation due to dirt) of 0.85.

5. The window sill coincides with the work plane which is at a height of about 85 cm above the floor level.

6. The room interior has reflection coefficients of 0.8 for the ceiling, 0.5 for the walls and 0.3 for the floor surface with white wash, off-white and cement/terrazo respectively.

7. Ceiling height is between 3.05 and 3.60 metres.

8. Height of obstructions in front of the window is less than one third of the distance of separation.

9. The ground opposite the window has a reflection coefficient equal to 0.25 which corresponds to the usual ground with grass, road or pavement, or combinations thereof.

Case I : To Obtain a window dimension for a given daylight factor

Use Fig. 1 and 2 which give daylight factors due to a centrally located and a corner located window respectively. There are three sets of curves viz., solid, broken and dotted. The solid and broken curves refer to the daylight factors at room centre and the room rear respectively and the dotted curves refer to the average inter-reflected components. W_L denotes the window on the long wall and W_S that on the short wall. The abscissae relate to fenestrations expressed as percentage fraction of the floor area. The curves marked A are applicable to floor areas from 10 to 30 sq. m. and B from 30 to 50 sq. m.

If the overall (gross) area of a fenestration is considered, the left hand ordinates indicate the daylight availability (as a daylight factor) through the window with metalic or wooden sashes. When the same opening percentages refer to nett clear area (glazed or open) the right hand ordinates indicate the daylight availability.

Example : Let a 2 per cent daylight factor (for class rooms) be the requirement. The window dimensions are as shown in table 2.

These are obtained from Fig. 1 and 2 by drawing the horizontals from the point corresponding to a 2 per cent daylight factor on either of the four ordinates. For square or near square rooms, the mean of tne results for short wall and long wall windows should be taken. Similarly, for distributed windows or a window in between central and corner position, the mean of the results for central and corner windows should be taken.

Case II : To obtain the Distribution of Daylight on the Work Plane

Sky Component-Penetration and Spread

After obtaining the window areas as percentage of the floor area, actual window dimensions can be found. For example a 10 per cent fenestration in a room having 40 sq m floor area would mean 4 sq. m. window area. This area can be had by several combinations of length and height. The penetration and spread of sky components for these fenestrations with metallic sashes are obtainable from Fig. 3 and 4. For wooden sashes the values should be reduced by a factor 0.8. The conversion of sky component values from metallic sashes to wooden sashes can also be directly read on the left hand ordinate of Fig. 1 or 2. If one assumes the window length as 2.7 m. and height 1.5 m, choosing the set of curves for 1.5 m.ht. (for mettalic window Fig. 3) we find that a 2 per cent sky component penetrates upto 3.2 m and 0.25 per cent sky component upto 7.3m.

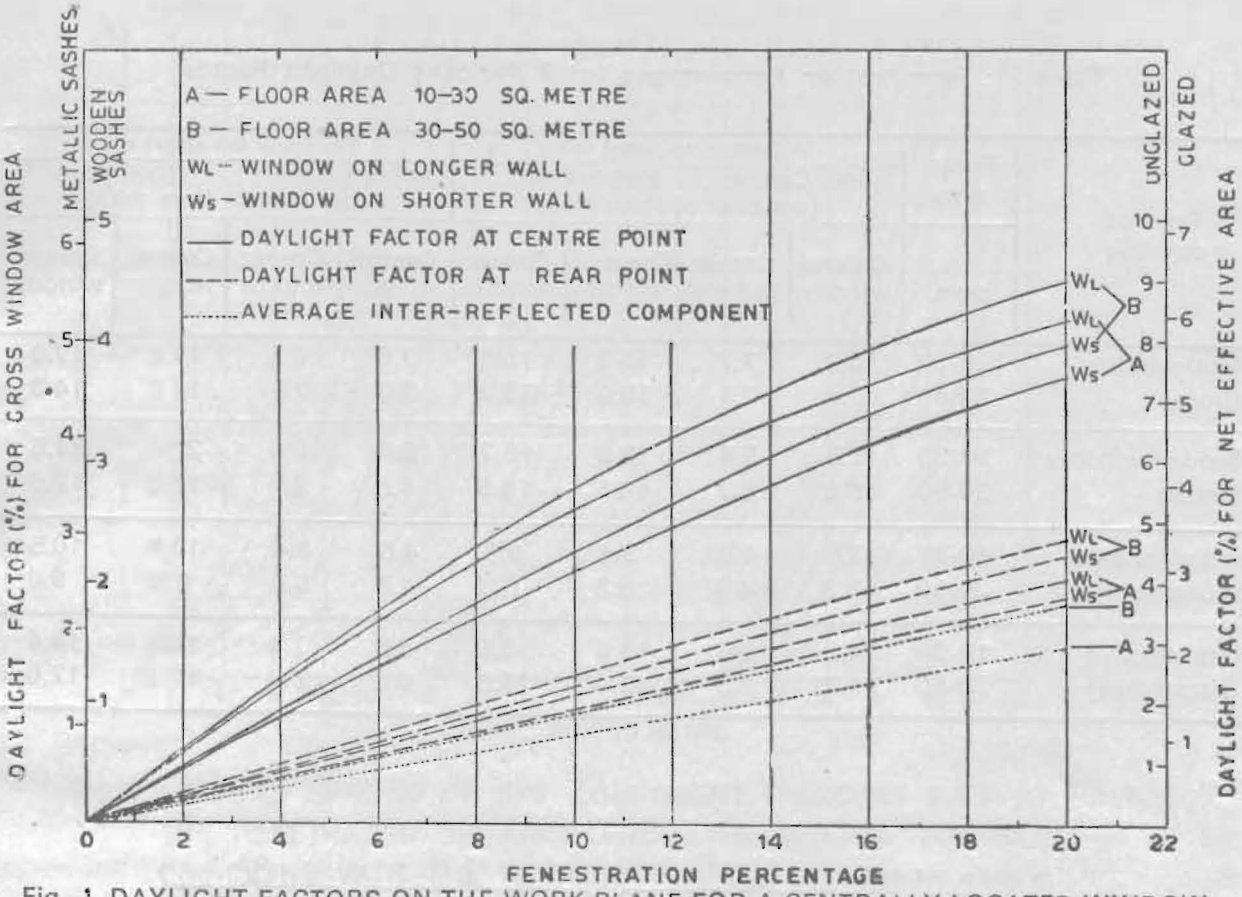


Fig. 1 DAYLIGHT FACTORS ON THE WORK PLANE FOR A CENTRALLY LOCATED WINDOW

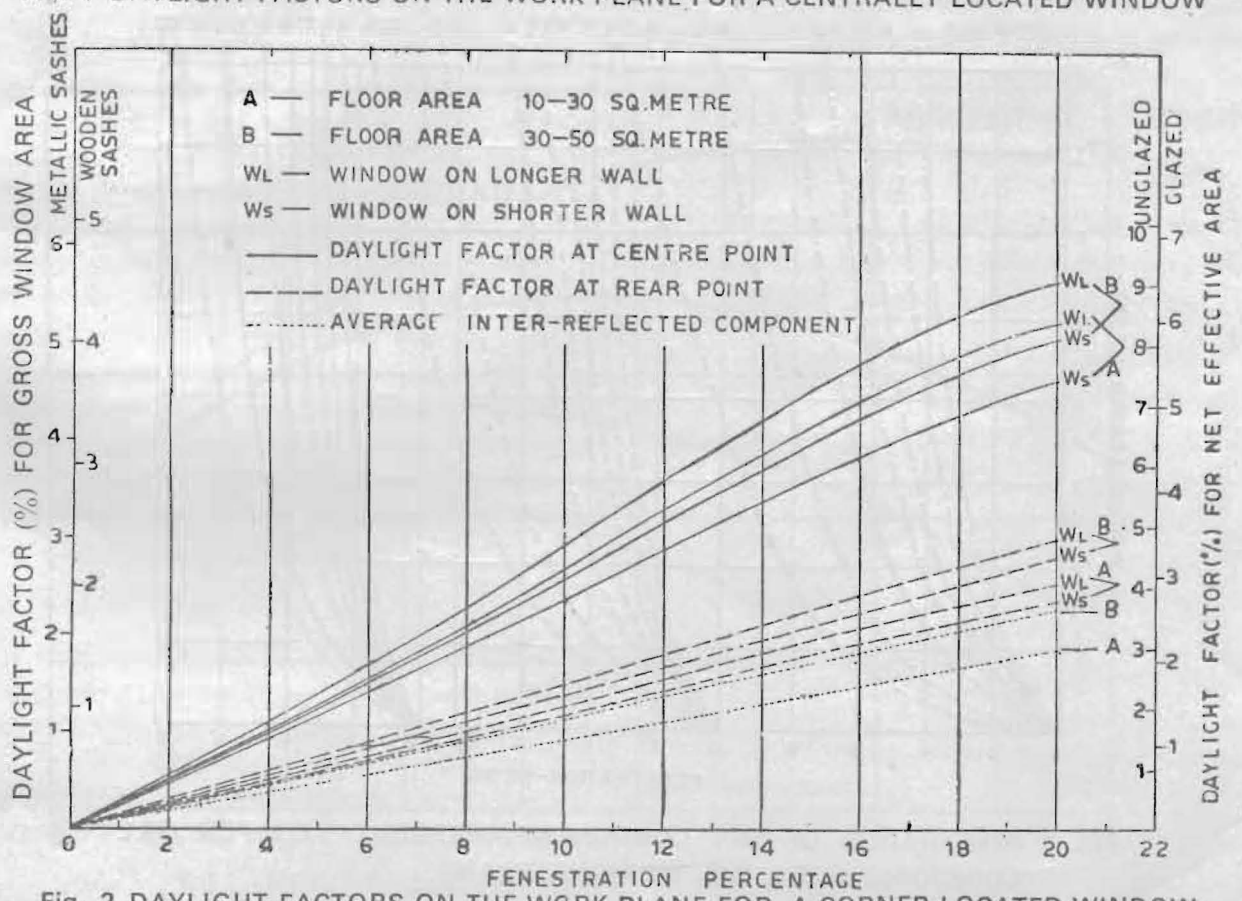


Fig. 2 DAYLIGHT FACTORS ON THE WORK PLANE FOR A CORNER LOCATED WINDOW

Table 2 : **Fenestration Percentages for 2 Per cent Daylight Factor**

Type of opening	Floor area	Window on long wall				Window on short wall			
		Room Centre (per cent of floor area)		Room Rear (per cent of floor area)		Room Centre (per cent of floor area)		Room Rear (per cent of floor area)	
	sqm.	Central window	Corner window	Central window	Corner window	Central window	Corner window	Central window	Corner window
Metal window (Gross)	10-30	5.7	7.7	15.3	15.5	7.5	8.5	17.0	17.0
	30-50	5.4	7.1	13.0	13.3	7.0	7.9	14.0	14.3
Wooden window (Gross)	10-30	7.3	9.4	19.6	19.7	9.5	10.5	21,5	21.5
	30-50	6.8	8.7	16.5	16.5	8.8	9.7	17.8	17.8
Nett clear area (if unglazed)	10-30	3.5	4.9	9.4	9.8	4.6	5.4	10.5	10.5
	30-50	3.3	4.5	8.2	8.3	4.3	5,0	8.8	9.0
Nett effective (Glazed area)	10-30	4.9	6.8	13.5	13.5	6.5	7.4	14.6	14,6
	30-50	4.7	6.3	11.4	11.6	6.0	6.9	12.2	12.6

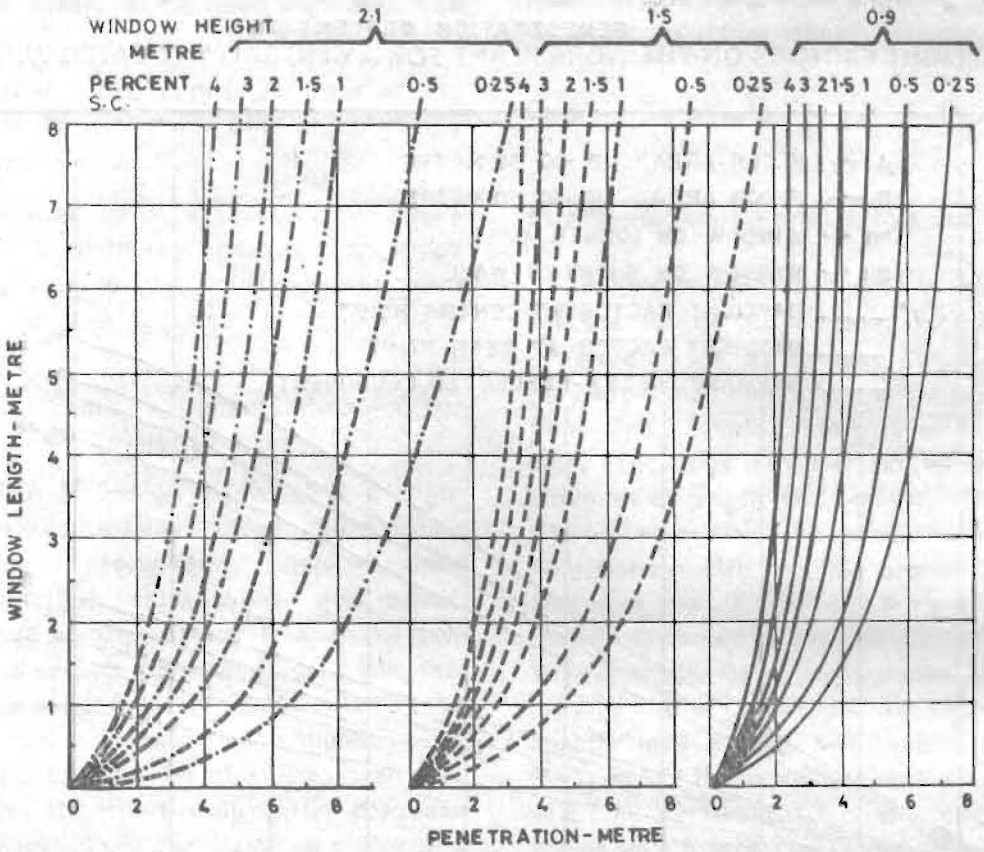


FIG. 3 PENETRATION OF SKY COMPONENT (PERCENT S.C.) FOR SILL COINCIDING WITH THE WORKING PLANE.

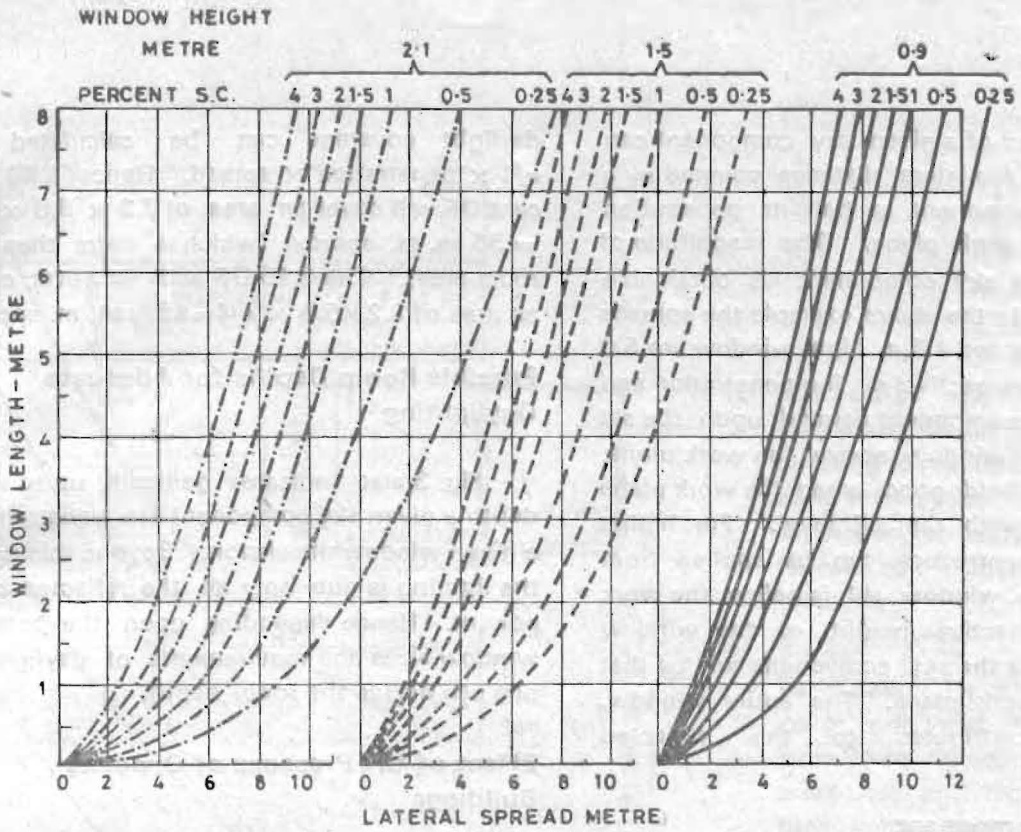


FIG. 4 LATERAL SPREAD OF SKY COMPONENT (PERCENT S.C.) AT HALF THE PENETRATION DISTANCE FROM THE WINDOW FOR SILL COINCIDING WITH THE WORKING PLANE.

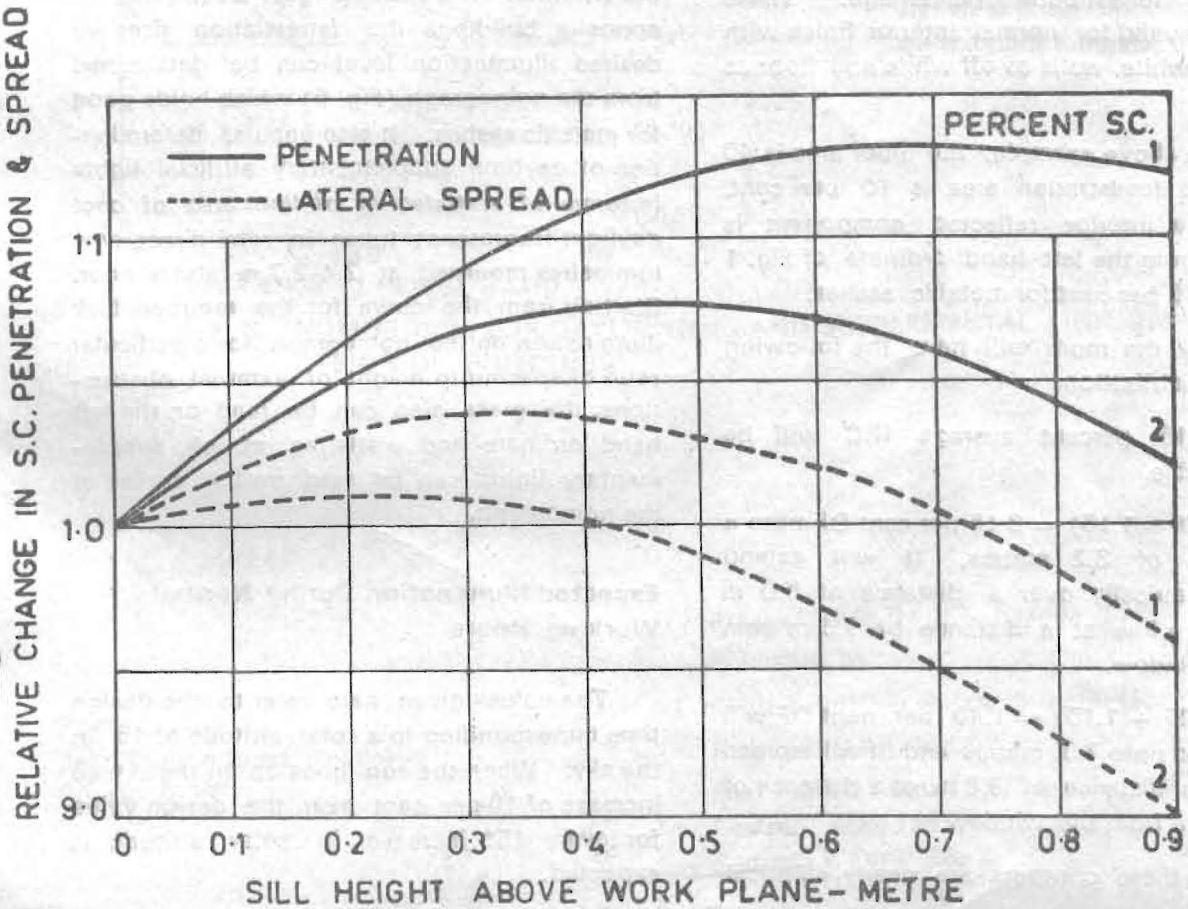


FIG. 5 VARIATION OF THE PENETRATION AND SPREAD OF SKY COMPONENT (PERCENT S.C.) WITH SILL HEIGHT ABOVE THE WORKING PLANE.

The spread of a given sky component can be defined as the lateral distance covered by a given sky component at half its penetration depth on the work plane, The magnitude of the spread of sky component is obtainable from Fig. 4. In the above example the spreads for 2.7 m long and 1.5 m high window are 5.0 m and 9.8 m respectively. The penetration and spread of sky component depend upon the sill height of the window above the work plane. Fig. 3 and 4 hold good when the work plane is coincident with the sill level. For higher sill levels a correction can be applied from Fig. 5. If the window sill is below the work plane, the effective height of the window contributing to the sky comyonent will be that above the work plane. The entire window, however, contributes to the reflected component.

Reflected Component

The amount of average reflected daylight available can be estimated from the dotted curves of Fig. 1 or 2 depending upon the floor area and fenestration percentage. These curves are valid for normal interior finish with ceiling as white, walls as off white and floor as grey.

In the above example, the floor area is 40 sq. m. and fenestration area is 10 per cent. Hence, the interior reflected component is obtained from the left hand ordinate of Fig. 1 or 2 as 1.15 per cent for metallic sashes.

Finally, the room will have the following daylight distribution.

1. A 1.15 percent average IRC will be available.
2. A (2.0 + 1.15) = 3.15 per cent DF upto a depth of 3.2 metres. It will extend symmetrically over a distance of 5.0 m along a line at a distance of 1.6 m from the window.
3. A (0.25 + 1.15) = 1.40 per nent DF will extend upto 7.3 metres and it will spread over a distance of 9.8 m. at a distance of 8.65 m from the window.
4. Since these contours are nearly elliptical

daylight coverage can be calculated as $\pi/4 \times$ penetration $\times$ spread. Hence 1.40 per cent DF will cover an area of $7.3 \times 9.8 \times \pi/4$ = 56 sq. m. approx. (which is more than the room area). The 3.15 DF will however, cover an area of $3.2 \times 5.0 \times \pi/4 = 12.5$ sq. m. approx.

Possible Room Depths for Adequate Daylighting

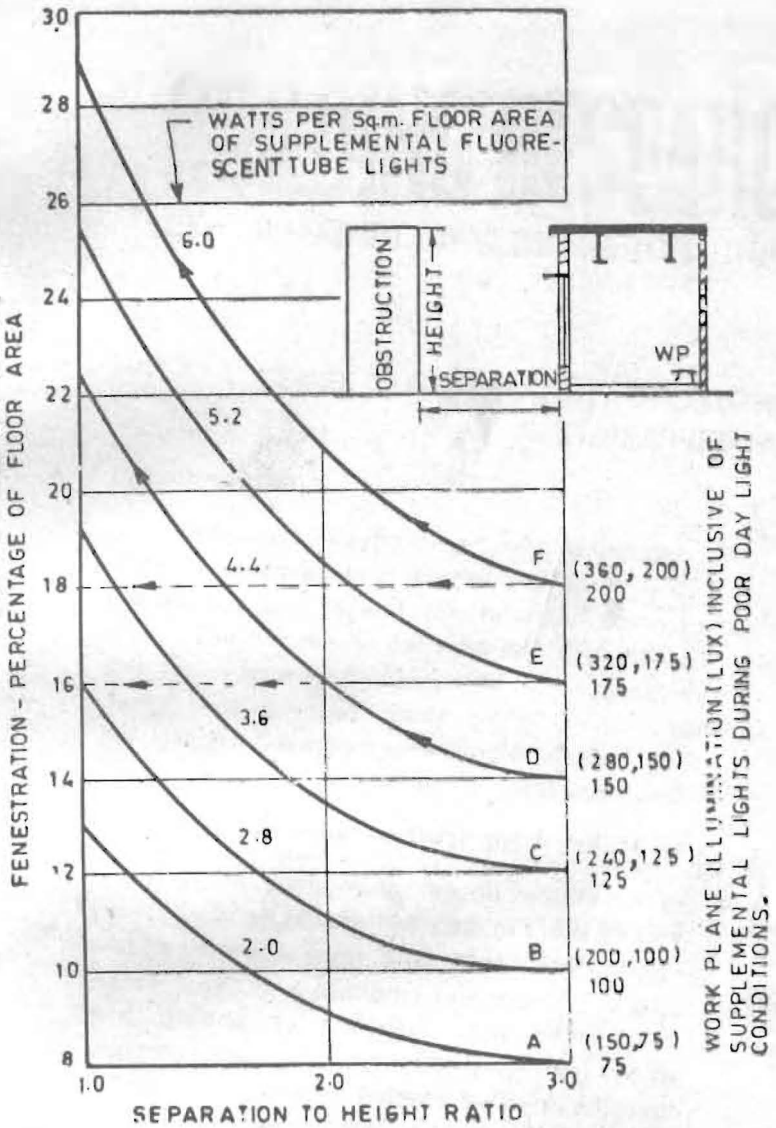
Fig. 3 also indicates generally up to what depth a given sky component can penetrate for a given window dimension. Beyond this depth the lighting is due only to the reflected component. Hence depending upon the possible window sizes and requirements of daylighting one can decide the room depth.

Effect of the Presence of Opposite Buildings

All these figures hold good when external obstructions are located at distances more than tnree times their height in front of the window. If a window gets obstructed by opposite buildings the fenestration sizes for desired illumination level can be determined from the nomograph (Fig, 6) which holds good for metallic sashes. It also enables determination of daytime supplementary artificial lights in terms of watts/sq. m of floor area of cool daylight fluorescent tubes in semi-direct type luminaires mounted at 2.4–2.7 m above floor. Starting from the curve for the required task illumination on the nomograph for a particular ratio of spacing to height of external obstructions, the glass area can be read on the left hand ordinate and watts./sq. m. of supplementary lights can be read on the curves of the nomograph.

Expected Illumination During Normal Working Hours

The values given here refer to the design time corresponding to a solar altitude of 15° in the sky. When the sun goes up in the sky an increase of 10 per cent over the design value for every 15° increase in solar altitude is expected.



1. **Method of use :** Read supplemental lights on curve corresponding to required illumination. From intersection of curve and separation to height ratio, read fenestration percentage on left ordinate.
2. **Floor Area Correction :** Fenestration per cent and watts/sp. m, are valid for floor area from 30 to 50 sq. m. For floor areas less and more than this, these values are to be multiplied by 1.15 and 0.85 respectively.
3. **Parenthesis Values :** Daylight at room centre and room rear for Indian sky conditions are given on the right ordinate.

FIG 6. NOMOGRAPH FOR DAYLIGHTING AND SUPPLEMENTAL LIGHTING DESIGN OF BUILDINGS

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