BUILDING DIGEST

CENTRAL BUILDING RESEARCH INSTITUTE, INDIA

FENESTRATIONS FOR DAYLIGHTING OF SIDELIT ROOMS : A SIMPLIFIED APPROACH

Introduction

Building Digests 40 and 73 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 very simple design aid. This digest makes an attempt to fulfill 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 luminances and their variations, orientations, 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 could be made.

The 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 the 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 digest.

1. The window sashes may be metallic or wooden, cutting off 10 and 30 percent of the entering light respectively.

2. 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 percent of the expectable daylight.

Table 1. **Recommended Daylight Factors For Interiors**
(Indian Standard Code of Practice IS : 2440-1968).

Location	Daylight factor percent
1. Dwellings	
Kitchens	2.5
Living room	0.625
Bed room	0.313
Study	1.9
Circulation	0.313
2. Schools	
Class rooms	1.9
Lecture theatres	2.0 to 2.5
Study halls	2.0 to 2.5
Laboratories	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
Pathological laboratory	2.5 to 3.75
5. Libraries	
Stack room	0.9 to1.9
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 value 1.25 percent 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. The ceiling height is taken to be between 3.05 and 3.60 metres.

8. The room ratio of length (L) to width (W) is of the order of 5:4.

9. The height of obstructions in front of the window is less than one third of the distance of seperation.

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

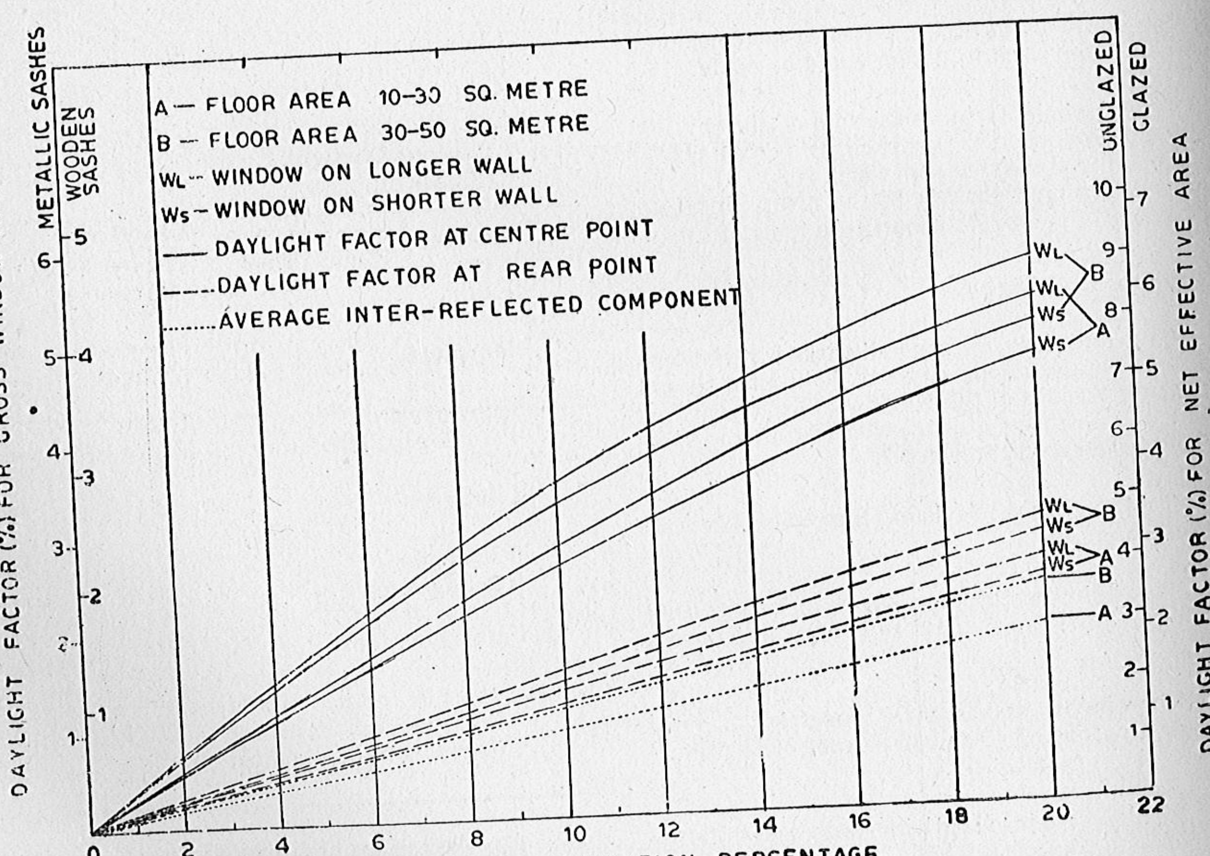
Case I : **To Obtain a window dimension for a given daylight factor**

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-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 fractions of the floor area. The curves marked A are applicable to floor areas from 10 to 30 sqm and B from 30 to 50 sqm.

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

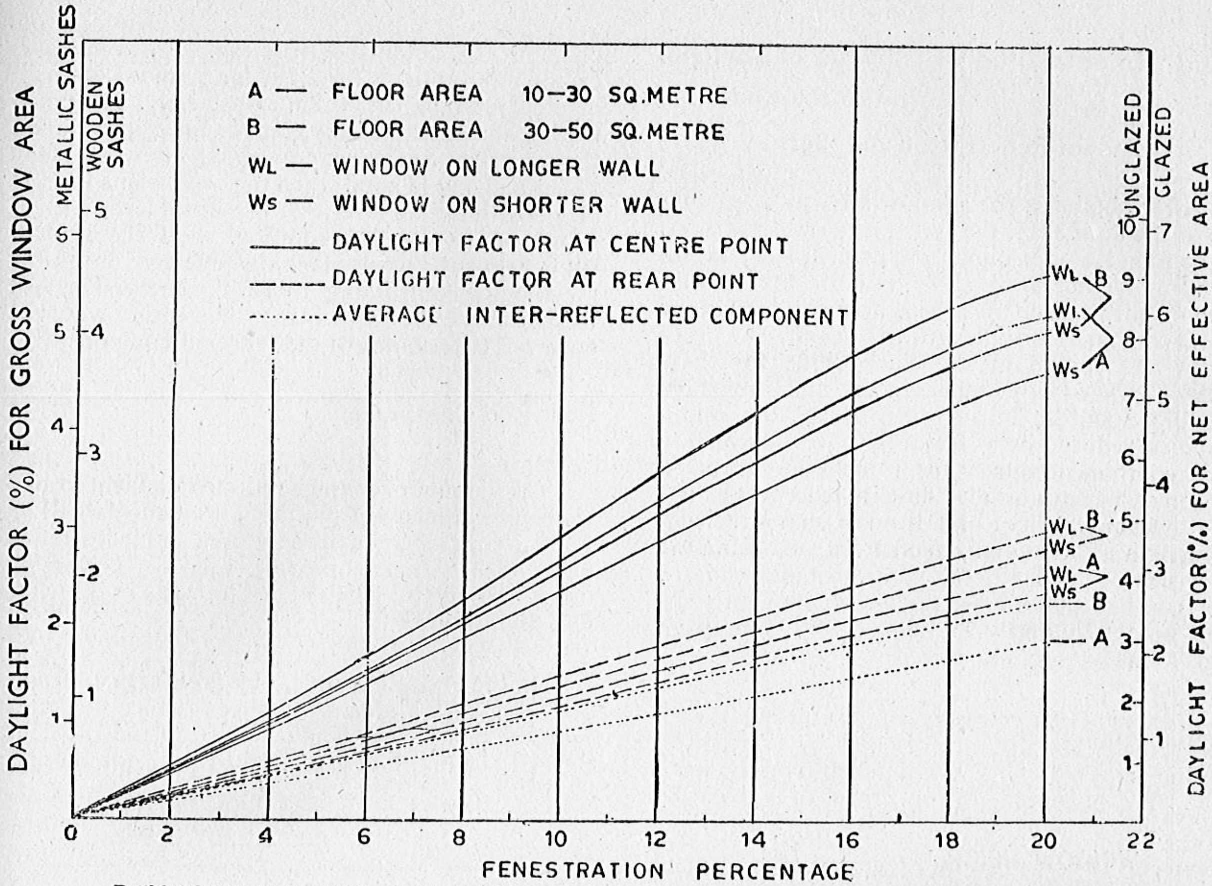
Example : Let a 2 percent daylight factor (for class rooms) be the requirement. The window dimensions will be as shown in table 2.

These are obtained from Fig. 1 and 2 by drawing the horizontals from the point corresponding to a 2 percent daylight factor on either of the four ordinates. It is to be noted that the room ratio of length (L) to width (W) here is of the order of 5:4. For square or near square rooms, the mean of the 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.



DAYLIGHT FACTORS ON THE WORK PLANE FOR A CENTRALLY LOCATED WINDOW

Fig. 1.



DAYLIGHT FACTORS ON THE WORK PLANE FOR A CORNER LOCATED WINDOW

Fig. 2.

Table 2 : **Fenestration Percentages for 2 Percent Daylight Factor**

Type of opening	Floor area sqm.	Window on longwall (percent of floor area): Room Centre, Central window	Window on longwall: Room Centre, Corner window	Window on longwall: Room Rear, Central window	Window on longwall: Room Rear, Corner window	Window on short wall (percent of floor area): Room Centre, Central window	Window on short wall: Room Centre, Corner window	Window on short wall: Room Rear, Central window	Window on short wall: Room Rear, Corner window
Metal window	10-30	5.7	7.7	15.3	15.5	7.5	8.5	17.0	17.0
(Gross)	30-50	5.4	7.1	13.0	13.3	7.0	7.9	14.0	14.3
Wooden window	10-30	7.3	9.4	19.6	19.7	9.5	10.5	21.5	21.5
(Gross)	30-50	6.9	8.7	16.5	16.5	8.8	9.7	17.8	17.8
Nett clear area	10-30	3.5	4.9	9.4	9.8	4.6	5.4	10.5	10.5
(if unglazed)	30-50	3.3	4.5	8.2	8.3	4.3	5.0	8.8	9.0
Nett effective	10-30	4.9	6.8	13.5	13.5	6.5	7.4	14.6	14.6
(Glazed area)	30-50	4.7	6.3	11.4	11.6	6.0	6.9	12.2	12.6

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

Sky Component-Penetration and Spread

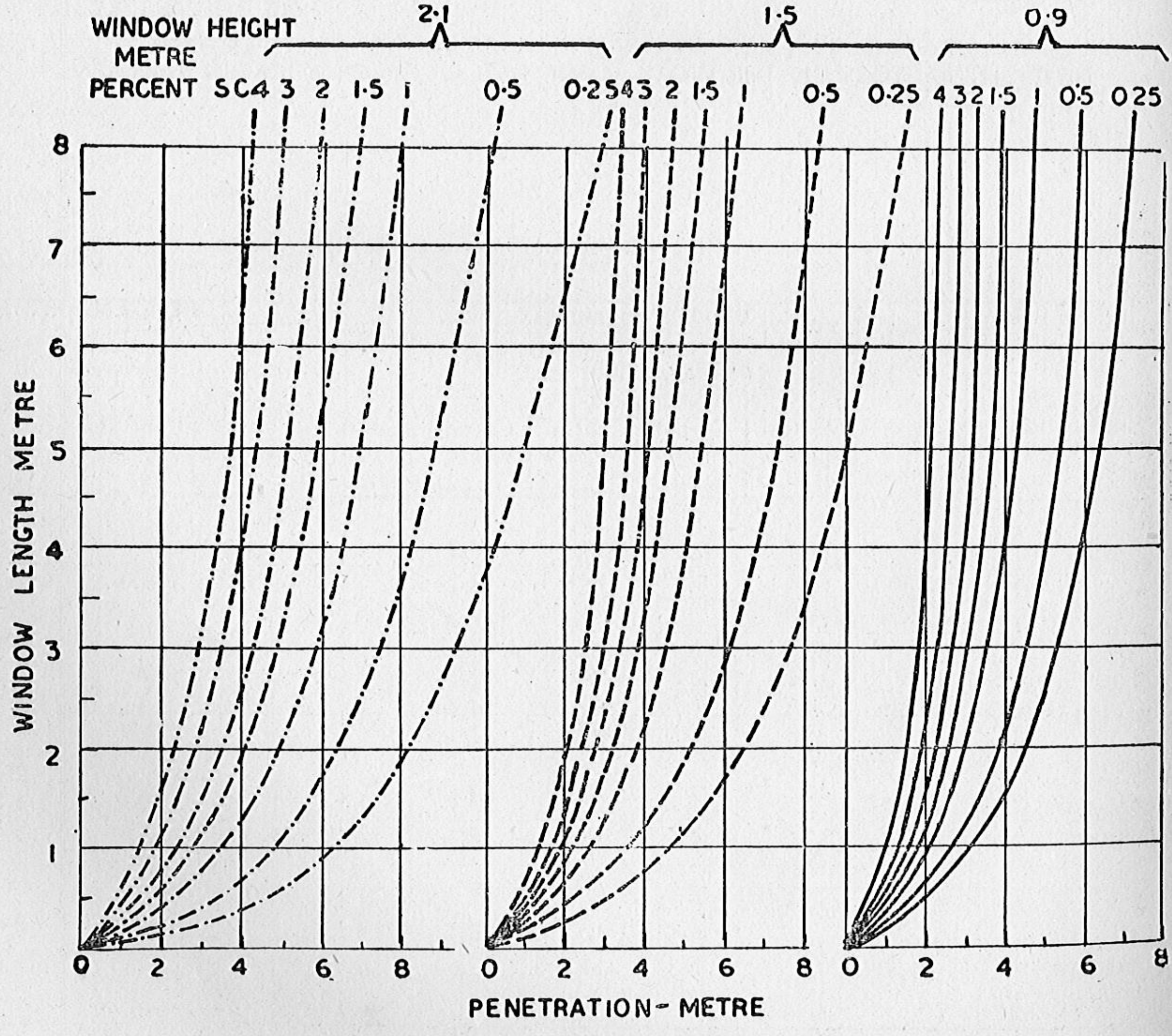
After obtaining the window area as a percentage of the floor area, the actual window dimensions can be found. For example a 10 percent fenestration in a room having 40 sqm. as its floor area would mean 4 sqm window area. This area can be had by several combinations of length and height. The penetration 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 2.7m and height 1.5m, choosing the set of curves for 1.5 m ht. (for metallic window Fig. 3) we find that a 2 percent sky component penetrates upto 3.2m and 0.25 percent sky component upto 7.3m.

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 a given sky component is obtainable from Fig. 4. In the above example the spreads for 2.7m long .and 1.5m high window are 5.0m and 9.8m 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 component 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 in white, walls in off white and floor in grey.

In the above example, the floor area is 40 sqm and fenestration area is 10 percent hence the inter reflected component is obtained from the left hand ordinate of Fig. 1 or 2 as 1.15 percent for metallic sashes.



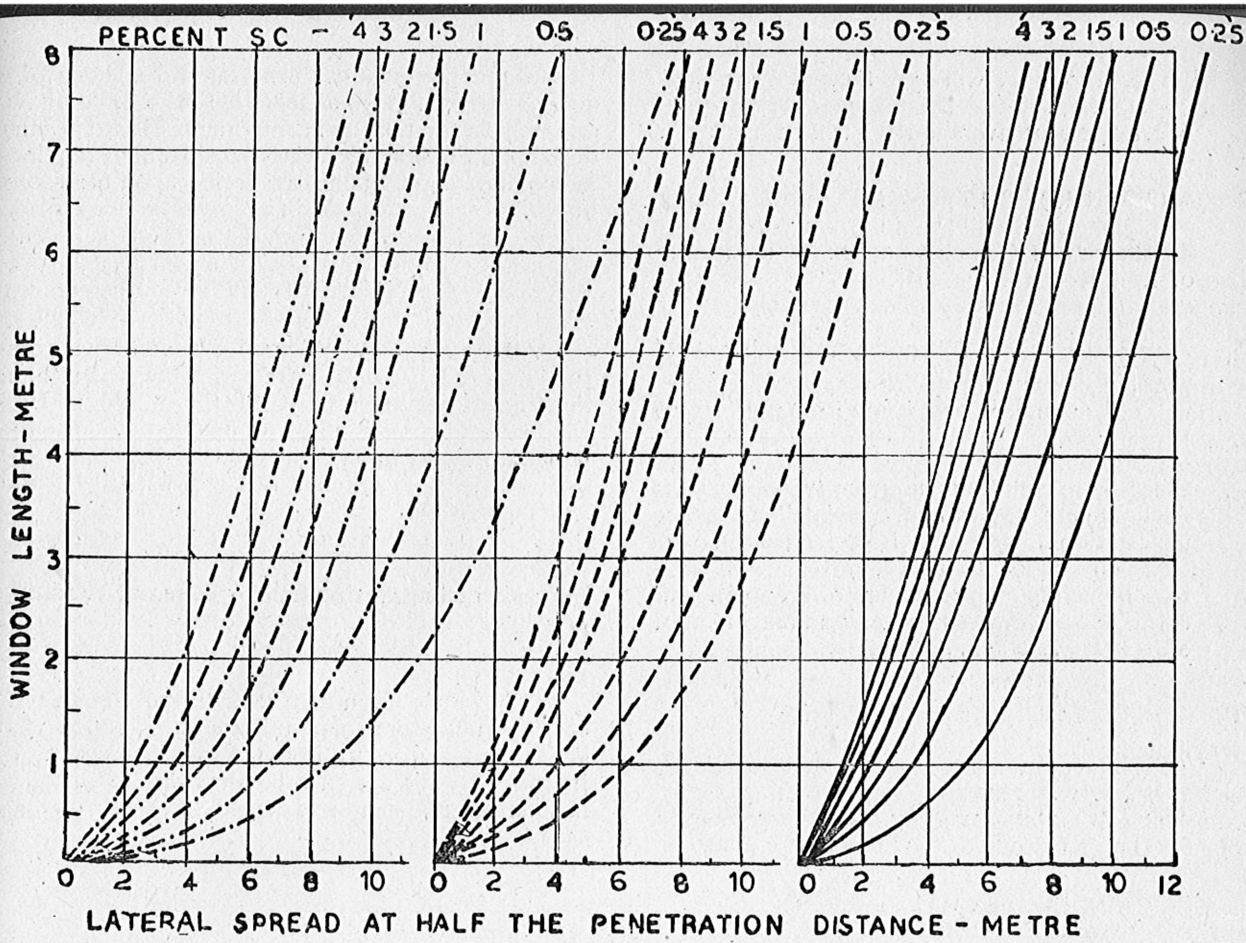
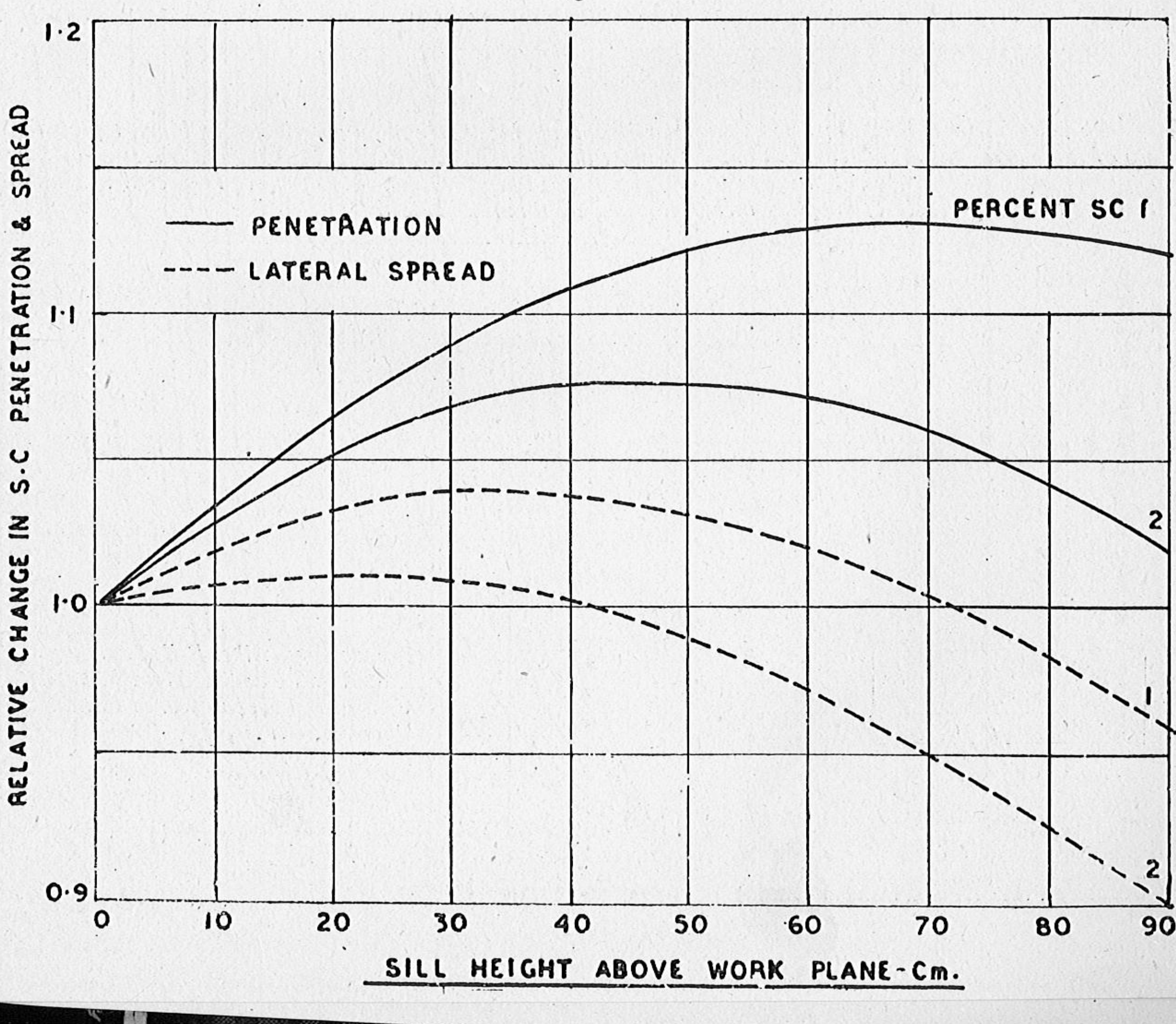

PERCENT SC - 4 3 2 1.5 1 0.5 0.25 4 3 2 1.5 1 0.5 0.25 4 3 2 1.5 1 0.5 0.25
WINDOW LENGTH - METRE
LATERAL SPREAD AT HALF THE PENETRATION DISTANCE - METRE

Fig. 4


PENETRATION
LATERAL SPREAD
PERCENT SC 1
2
1
2
RELATIVE CHANGE IN S.C PENETRATION & SPREAD
SILL HEIGHT ABOVE WORK PLANE - Cm.

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 percent DF upto a depth of 3.2 meters. It will extend symmetrically over a distance of 5.0 m along a line at a distance of 1.6m from the window.

3. A (0.25+1.15)=1.40 percent DF will extend upto 7.3 meters and it will spread over a distance of 9.8m at a distance of 3.65 m from the window.

4. Since these countours are nearly eliptical the daylight coverage can be calculated as $\pi/4 \times$ penetration $\times$ speread. 1.40 percent DF will cover an area of $7.3 \times 9.8 \times \pi/4 = 56$ sqm approx. (which is more than the room area). The 3.15 DF will however, cover an area of $3.2 \times 5.0 \times \pi/4 = 12.5$ sqm approx.

Possible Room Depths for Adequate Daylighting

Fig. 3 also indicates generally 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 upon the room depth.

Effect of the Presence of Opposite Buildings

All these figures hold good when external obstructions are located at distances more than three times their height in front of the window. If a window gets obstructed by opposite buildings the reduction factor in daylight will be 0.2,0.45,0.6 and 0.7 for the distance/height ratios of 0.5,1.0,1.5 and 2.0 respectively.

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 percent over the design value for every 15° increase in solar altitude can be expected.

There is a demand for short notes summarising available information on selected building topics for the use of Engineers and Architects in India. To meet the need, this Institute is bringing out a series of Building Digests from time to time and the present one is the 82nd in the series. Readers are requested to send to the Institute their experience of adopting the suggestions given in this Digest.

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