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BUILDING RESEARCH NOTE

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THE REFLECTED COMPONENT OF DAYLIGHT IN THE DESIGN OF FENESTRATION

General Considerations

Fenestrations in walls or roofs allow the entry of daylight, in direct proportion to their dimensions. In India, where sunlight is available for greater part of the year, daylighting of building interiors should normally be resorted to. This would ensure economy in electrical power consumption. Seasonal and daily variations of daylight make the problem of daylight design slightly complicated. To fulfil the need for an unfailing supply of daylight indoors for most of the working hours in a day, a design sky has been proposed for India, which has since been accepted by the Indian Standards Institution. (Indian Standard; Guide for Daylighting for Buildings. 2440, Second revision, 1975).

Reflected Component of Daylight

Reflected component of daylight consist of two parts, external and the internal. The former consist of the light reaching an indoor point after reflections from external ground and opposite facades and it depends on the availability of daylight outdoors on the ground or on the facades, as well as their reflection coefficients. The Internal Reflected Component is governed by reflection coefficients of interior surfaces and initial illumination on these surfaces, area of the room surfaces (hence the room dimensions), the reflectance of these surface and the dimensions of the fenestrations contributing to the Inter-reflected illumination.

Method of Calculation of Inter-reflected illumination

For computation of reflected illumination several methods have been developed. These are based on the assumption that the room acts as Ulbricht's sphere. The lower and the upper parts of a room, about a plane passing through the mid-point of fenestration, receive external flux from the sky and the ground. These fluxes when weighted and averaged over the respective surfaces, given an idea of their intial luminous emittance, (Reflection coefficient X incident Illumination). Since there are six room surfaces, each one of which successively reflects and receives light from other surfaces, the two parts finally achieve luminous emittance which is higher than the initial value. The ultimate reflected illumination can be obtained by projection method.

In Fig. 1 the average Inter-reflected light is based on the assumption that the reflection coefficients of ceiling, walls and floor are 0.8, 0.5 and 0.3. respectively. These values are normally recommended for daylit interiors. Using Munsell's colour charts and following relation, it is possible to find out suitable reflection coefficient for any choice of colour scheme or vice versa.

R (reflection coefficient) $= V(V-1)$
where V is the value of colour in Munsell's notation.

Reflection coefficients of some typical finishes are given in Table 1. However, if surfaces having different values are used, an appropriate correction for the expected reflected Illumination may be made from Fig. 2. The values of reflected Illumination in Fig. 1 assume the working plane at a height of 75cm to 90cm above floor level. These value hold good within an accuracy of 10%.

The values in Fig. 1 cover all possible room sizes for ceiling heights between 3.05 and 3.6 m. In Fig. 2 the length of the window wall is designated as L and room depth as D and the length and height of the window are denoted by l and h respectively. This figures yields the expected Inter reflected Iliumination in Lux for l=L. The graph applies only to unobstructed windows having glass panes and normal sashes, bars and louvers.

Windows generally have sashes, bars, glass and louvers. The values plotted in Fig. 1 have taken into account the reduction factor due to glazing as 0.85. Because light transmission factor for 3 mm plain glass is 0.85. If glass of some other thickness or plastic sheet is used as glazing material, its actual transmission factor must be taken into account. Transmittance of a few glazing materials is given in Table 2. Sashes and bars reduce the amount of luminous flux entering through windows in proportion to the obstructed area. The reduction factor due to sashes and bars etc. for steel window is taken here as 0.9. For other types of windows the illumination values obtained from Fig. 1 should be correspondingly corrected.

Table 1 : Reflection Coefficients of Some Common Interior Finishes

Surface	Reflection Coefficient
Lime Wash	0.70 – 0.75
Distemper white	0.75 – 0.80
Distemper grey	0.40 – 0.45
Distemper Cream	0.65 – 0.70
Distemper Yellow	0.60 – 0.65
Mosaic Tiles	0.25 – 0.30
Three ply	0.25 – 0.30
Light blue	0.40 – 0.50
Light Pink	0.50 – 0.60
Light Green	0.50 – 0.60

Table 2 : Transmittance of glazing materials

Material	Thickness (mm)	Transmittance
Clear glass	3.0	0.85
Wire cast glass	6.0	0.67
Heat absorbing glass	3.2–3.5	0.62
Prismatic glass	3.6	0.76
Glass fibre reinforced Polyester Plastics	2.0–3.0	0.60-0.40

Example—1

A room has length (L)=3.6 m, depth (D)=4.8 m. with a ceiling height=3.05 m. Interior reflection is 0.8 for ceiling, 0.5 for walls, and 0.3 for floor. A steel window having a gross fenestration of 12% of floor area (window length l=2.3 m. and height h=0.9 has been provided. Sill height coincides with the working plane. Calculate Inter-reflected illumination.

Solution

The value of inter-reflected illumination as read from Fig. 1 for a window height of 90 cm is 120 Lux. This is true for l/L = 1.0. Since here l/L = 0.639, the inter-reflected value reduces to 120 × 0.639 (76.7 Lux).

Example–2

In the above example, if the steel window is replaced by a wooden one where in the ratio between clear and gross area is 0.7. What is the expected inter-reflected illumination ?

Solution

The inter-reflected illumination given in Fig. 1 presumes 0.9 as the ratio of clear area to gross area, which is true for steel windows. Since wooden windows have a clear to gross area ratio of 0.7, the value of reflected illumination obtained from Fig. 1, should be corrected by a factor 0.7/.9 = 0.78.

The illumination finally reduces to 76.7×0.78=59.8 (=60.0 Lux)

Example–3

Consider a room of length (L) = 4.8 m, Depth (D) = 6.0 m, with a ceiling height = 3.0 m, provided with a steel window having a gross fenestration of 7.5% of floor area (window length l = 1.8 m, and window height h = 1.2 m). The room has interior reflectances 0.8 for ceiling, 0.8 for walls and 0.3 for floor. Find the inter-reflected illumination.

Solution

The value of inter-reflected illumination as read from Fig. 1 after interpolation for a window of 120 cm height comes to

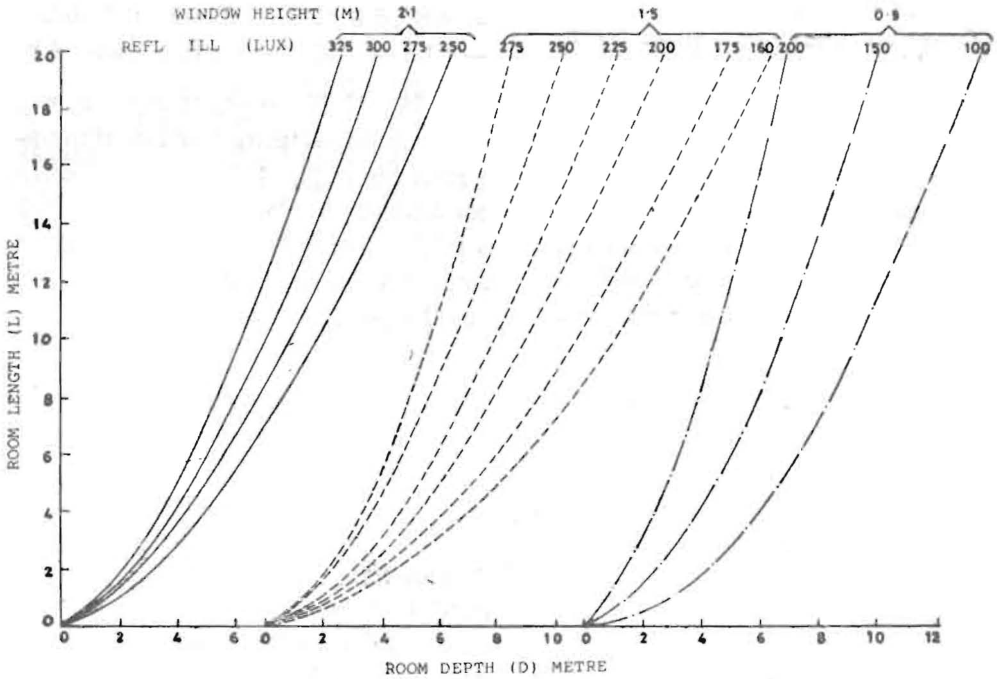

Fig. 1 Percent Av. Inter-Reflected Illumination for Various Room and Window Sizes. (Refl. Coef, Ceiling 0.8, Walls 0.5, an Floor 0.3)

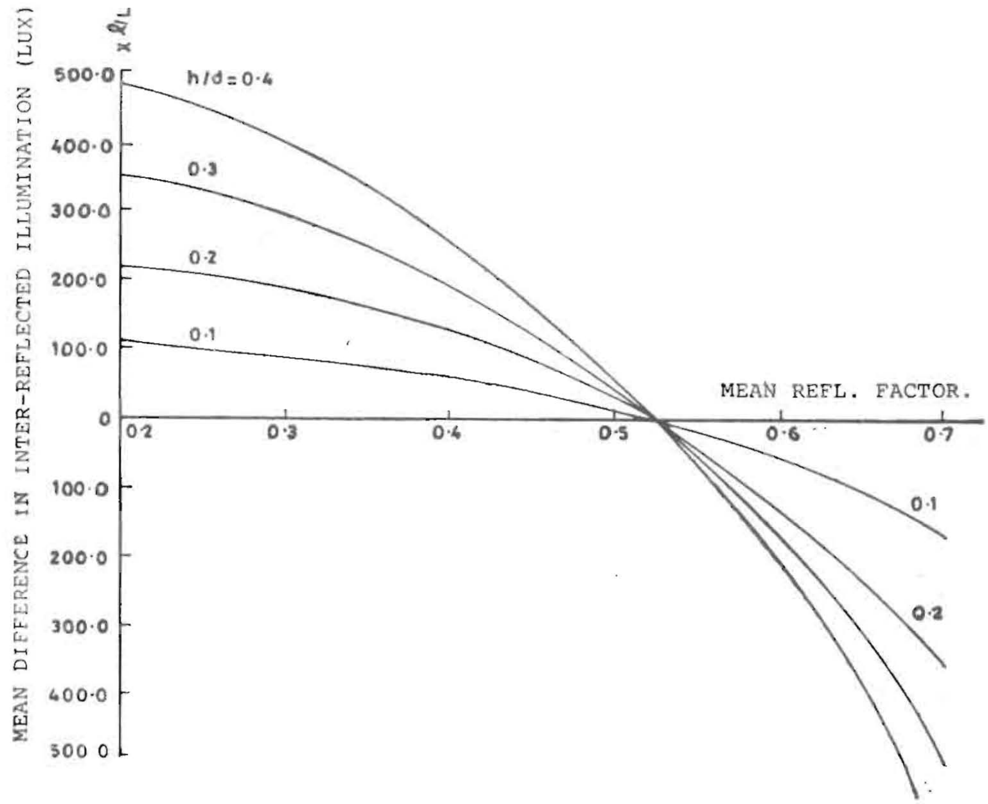

Fig. 2 Correction Curve for Mean Reflection Factor

$\frac{200 + 120}{2} = 160$ which when multiplied by the proper l/L viz. = 0.375, reduces to $160 \times 0.375 = 60.0$ Lux. To this a correction of mean reflection factor is to be applied from Fig. 2.

The mean reflection factor of the room = (ceiling area × ceiling refl. coef. + wall area × wall refl. coef. + window area × window refl. coef. + floor area × floor refl. Coef.)/ Total room surface area

$= 4.8 \times 6.0\ (0.8+0{,}3) + 2 \times 0.8\ (6.0 \times 3.0 + 4.8 \times 3.0) - (0.8-0.15)\ 1.2 \times 1.8/2\ (6.0 \times 4.8 + 6.0 \times 3.0 + 4.8 \times 3.0) = 0.67$.

The correction factor (Mean difference to be subtracted) from Fig. 2, for a mean reflectance 0.67 and corresponding to $h/D = 0.2$, is $-296 \times l/L = -296.0 \times 0.375 = -111.0$. Hence the reflected illumination value after correction due to mean reflectance will be $60-(-111.0) = (171$ Lux).

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