Daylighting and Ventilation of Rural Houses

By

B.K. Saxena, Ishwar Chand, G.D. Bansal,
V.K. Sharma and Shree Kumar

Central Building Research Institute, Roorkee (U.P.)

Published in :

"INDIAN PLANNER & BUILDER"
Vol. 3, No. 7—September 1983

Daylighting and Ventilation of Rural Houses

B.K. Saxena*, Ishwar Chand*, G.D. Bansal*
V.K. Sharma☆ and Shree Kumar☆

ABSTRACT

At present, no guidelines are available about design of openings for adequate daylighting and ventilation of rural houses. This paper provides a basis and methodology for designing windows to satisfy required daylight levels for execution of common visual tasks as well as minimum air changes for maintaining hygienic conditions indoors. Design curves for daylighting have been provided for two different sets of room reflectances alongwith ventilation curves for 3 a.c.h. It has been concluded that an unobstructed window opening of about 8 to 9% of the floor area is required in addition to the usual door opening for satisfying minimum ventilation and daylight levels in rural houses.

Introduction

Provision of natural illumination and ventilation are important aspects of building design. So far, there are no guidelines available for design of openings for daylighting and ventilation of rural houses. The norms and guidelines for urban houses are not directly applicable for urban houses, as in rural areas most of the activities are performed outdoors in open spaces and also the type of windows and interior finish are different. The provision of opening in rural houses should be adequate so as to satisfy the minimum requirement of daylight for execution of common visual tasks and that of minimum air changes for maintaining hygienic conditions. Based on findings of survey and research studies, guidelines have been evolved and presented in this paper for daylighting and ventilation design of rural houses.

Requirement of Daylight and Ventilation

Requirement of illumination[1] for performing a task depends upon its angular size, contrast, speed and accuracy involved. The finer the task the higher is the required task illumination. The most common visual activities performed in rural houses are covered under the task illumination corresponding to circulation and reading. Lighting requirement for circulation is of the order of 1% daylight factor or 80 Lux. For more critical tasks such as reading the required illumination is 2% Daylight factor or 160 Lux. As tasks requiring higher illumination can be performed in the vicinity of a door or a window opening, a rational daylighting design of rural house should ensure atleast 80 Lux of illumination throughout and 160 Lux. of illumination in the centre of a room.

Ventilation requirement[2] depends upon the purpose it serves. High rates of air motion are needed to meet the comfort requirement of summer and rainy seasons, whereas minimum of 3 a.c.h are needed to satisfy the health requirements. In rural areas most of the activities are performed in open spaces and main function of ventilation is to provide healthy environment indoors. Therefore, the minimum requirement of 3 a.c h. for average outdoor wind speeds between 2 to 5 Km /hr. should be satisfied.

Design Parameters

Various parameters on which indoor daylight[3] and ventilation[4] depend are window dimension, window location, and obstruction to the window opening by window frame and louvres, etc. A suitable sill height[5,6] of a window above floor level provides a good distribution of daylight and air motion at the working level. For optimum daylighting and ventilation of rural houses a window of height 1.0 m to 1.1 m above sill height of 85-90 cm. is recommended.

Adequate window-width can be determined for any floor area depending upon the percent fenestration required to satisfy the desired task illumination and ventilation. A central location of window is suitable for shorter wall whereas longer wall having a door

* *Scientist,*
Central Building Research Institute, Roorkee.
☆ *Senior Scientific Assistant,*
Central Building Research Institute, Roorkee.

should have a window displaced from the door location.

Reflectance of interior surfaces[6] affect the daylight availability on the workplane. Interreflection of light is better with light colour wash of interiors than with dark colour wash. In rural areas, where room sizes are small the effect of interreflection of light is significant. The reflectance of typical finishes is given in Table 1. Daylight is considerably reduced due to the obstruction caused by window frame, window bars, chhajjas and wooden window panels which act as vertical louvres. These factors have been accounted for in the design curves described in the following section.

TABLE 1

Reflectances of common interior finishes

Finish	*Reflectance*
White wash :	
(i) Good maintenance conditions.	0.7—0.8
(ii) Poor maintenance conditions.	0.5—0 6
Light green	0.5—0.6
Light pink	0.5—0.6
Light blue	0.4—0.5
Mud Plaster, Gobri, Thatch	0.25—0.3
Cement terrazo	0.25—0.35

Design Curves

Fig. 1 and Fig. 2 respectively provide design curves for rural houses for two different sets of reflectances viz. ceiling and floor as dull grey ($r_c = r_F = 0.3$) with walls as off white ($r_w = 0.5$), and ceiling and walls as off white ($r_c = r_w = 0.5$) with floor as dull grey ($r_F = 0.3$). Following average conditions have been assumed in arriving at the results :—

(i) Windows consist of wooden frame and bars cutting about 20-30% of the entering light.

(ii) Chhajjas and wooden window-panels acting as louvres cut off 15-20% of the expectable daylight.

(iii) Workplane is between 60-85 cm. above floor.

(iv) Rooms have a ceiling height of 3 m. and floor area upto 25 sqm.

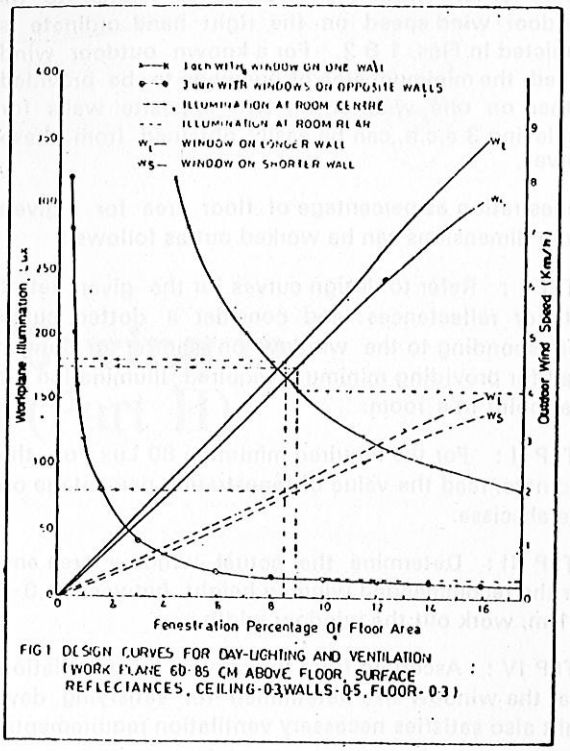

FIG 1 DESIGN CURVES FOR DAY-LIGHTING AND VENTILATION (WORK PLANE 60-85 CM ABOVE FLOOR, SURFACE REFLECTANCES, CEILING-0.3,WALLS-0.5, FLOOR-0.3)

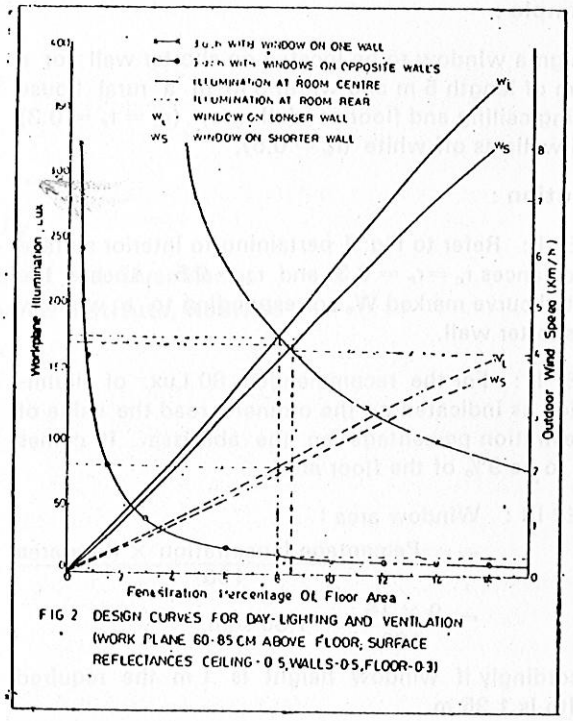

FIG 2 DESIGN CURVES FOR DAY-LIGHTING AND VENTILATION (WORK PLANE 60-85 CM ABOVE FLOOR, SURFACE REFLECTANCES CEILING-0.5,WALLS-0.5,FLOOR-0.3)

In these curves, the asbscissa corresponds to fenestration as percentage of floor area and the left hand ordinate corresponds to illumination in Lux. The solid and dotted curves refer to the illumination at room centre and the room rear respectively. W_L denotes the window on longer wall and W_s that on the shorter wall.

Aplot of fenestration percentage as related to the outdoor wind speed on the right hand ordinate is depicted in Figs. 1 & 2. For a known outdoor wind speed, the minimum area of openings to be provided either on one wall or on two opposite walls for achieving 3 a.c.h. can be easily obtained from these curves.

Fenestration as percentage of floor area for a given room dimensions can be worked out as follows :

STEP I : Refer to design curves for the given set of interior reflectances and consider a dotted curve corresponding to the window on shorter or longer wall for providing minimum required illumination at rear point in a room.

STEP II : For the required minimum 80 Lux. on the ordinate, read the value of fenestration percentage on the abscissa.

STEP III : Determine the actual window area and for the recommended window height between 1.0—1.1 m, work out the window width.

STEP IV : Ascertain from the curves for ventilation that the window size determined for satisfying daylight also satisfies necessary ventilation requirements.

Example :

Design a window to be located on shorter wall for a room of length 5 m and width 3 m in a rural house having ceiling and floor as dull grey ($r_c = r_F = 0.3$) and walls as off white ($r_w = 0.5$).

Solution :

STEP I : Refer to Fig. 1 pertaining to interior surface reflectances $r_c = r_F = 0.3$ and $r_w = 0.5$. Locate the dotted curve marked W_s corresponding to a window on shorter wall.

STEP II : For the recommended 80 Lux. of illumination as indicated on the ordinate, read the value of fenestration percentage on the abscissa. It comes out to be 9% of the floor area.

STEP III : Window area :

$$= \frac{\text{Percentage fenestration} \times \text{floor area}}{100}$$

$$= \frac{9 \times 15}{100} = 1.35 \text{ sqm.}$$

Accordingly if window height is 1 m the required width is 1.35 m.

It may be noted that window dimensions as worked out will provide 175 Lux. at the room centre which is enough for performing critical tasks such as reading.

STEP IV : It is seen that when fenestration is provided only on one wall, the desired area of opening for 3 a.c.h. varies from 17.5 to 8% of floor area for average outdoor wind speed between 2 to 5 km/hr. respectively. Alongwith a door of usual size, a window opening of about 9% of floor area as required for daylighting is also adequate for ventilation. When an opening of equal size is provided on the opposite wall, the minimum requirement of ventilation is satisfied even for almost still outdoor wind speed. As cross ventilation also enhances air motion for thermal comfort, a window of size equal to 9% of floor area with an equal opening on the opposite wall may be considered as optimum for adequate daylight and ventilation.

Recommendations

1. An unobstructed window opening of about 8 to 9 per cent of the floor area is required in addition to the usual door opening for satisfying minimum ventilation and daylight levels in rural houses.
2. For good distribution of daylight and ventilation, window height of 1.0 m to 1.1 m and sill height of 85-90 cm. above floor level is recommended.
3. Openings of nearly equal size, located on opposite walls are recommended to facilitate cross ventilation for thermal comfort. Door may be treated as one of these openings.
4. Whereever window opening is on the same wall as the door, or on the adjacent wall, it should be provided in a location displaced from the door.
5. To admit good daylight and breeze indoors, window opening should not be obstructed by trees and sheds etc.

Acknowledgement

The work reported in this paper forms part of regular programme of research of the Central Building Research Institute, Roorkee and is published with the permission of the Director.

The authors wish to thank Shri Narendra Verma, Scientist Coordinator, Rural Buildings Division, for useful discussions.

References

1. IS : 2440-1975 Guide for daylighting of buildings (second revision) Indian Standards Institution, New Delhi.
2. IS : 3362-1977 Code of practice for natural ventilation of residental buildings (first revision).
3. Narasimhan, V. and Saxena, B. K., Design of windows for adequate daylighting of buildings—CBRI Publication : Functional Aspects of Building Design. Lecture programme organised by CBRI and NBO at New Delhi ; 26-28 April, 1976.
4. Ishwar Chand, Bhargava, P. K. ; 'Guidelines for design of airy buildings' CBRI Building Digest 121 Oct. 1976.