BUILDING DIGEST
CENTRAL BUILDING RESEARCH INSTITUTE, INDIA

CONTROL OF SOLAR HEAT GAIN THROUGH GLASS WINDOWS

Fenestration is generally provided in walls for ventilation, daylight and vision. The current architectural fashion is to provide large areas of fenestration in buildings, particularly in multistoreyed buildings. Glass is most commonly used fenestration material because of certain advantages viz, perfect surface finish, long term durability and visibility from inside to outside.

Glass transmits solar radiation which produces considerable heat inside a building. Solar radiation comprises ultra violet, visible and infrared radiations ranging from 0.3 to 0.38 (6%), 0.38 to 0.76 (40%) and 0.78 to 3.0 (54%) of the total solar radiation. Of all the solar radiation incident on the surface of the glass sheet a part is reflected, part is absorbed and the rest is transmitted through it. In case of plain glass sheet the reflected, absorbed and transmitted fractions are 6% , 14% and 80% respectively.

Calculations for heat gain inside a building through walls, roofs and glass have been made and it is found that the heat gain through glass is much higher in comparison to a solid wall of equal area (Table–1). Therefore, it is necessary to give proper consideration to solar optical properties of glazing materials and shading devices. Based on heat gain calculations the data for evaluation of different shading devices have been provided. From these data a proper selection of shading devices for glass windows can be made.

Table–1

Average Heat Gain Factor in K cal/m$_2$/hr.
Brick Wall with and without 15% Glass Window.

S. No.	Orientation	Solid Wall	With 100% Shaded Window	With 75% Shaded Window	With 50% Shaded Window	With 0% Shaded Window
1.	NORTH	22.0	27.0 28.0	31.0 33.0	35.0 38.0	41.5 49.0
2.	NORTH EAST	25.0	29.0 31.0	39.5 43.5	50.0 57.0	71.0 84.0
3.	EAST	26.0	31.5 34.0	48.5 55.0	65.0 75.0	97.0 117.0
4.	SOUTH EAST	21.0	33.5 37.0	43.0 49.0	52.5 61.5	71.5 86.4
5.	SOUTH	18.0	35.0 40.0	40.0 46.5	47.5 40.0	55.0 65.0
6.	SOUTH WEST	24.0	40.0 45.0	58.5 68.0	76.5 91.0	113.0 129.0
7.	WEST	29.0	43.0 48.0	60.0 68.0	75.5 88.5	108.0 131.0
8.	NORTH WEST	30.0	42.5 46.5	58.0 66.0	73.0 84.5	103.0 124.0

Table- 2 Thermal Performance of Shading Devices

Name of the Materials	U Values K cal/hr°Cm²	Shade Factors for Different percentage of External Shading					Percentage increase in cost in comparison with plain glass sheet windows
		0%	25%	50%	75%	100%	
SINGLE GLAZING							
Plain Glass sheet	4.50	1.0	0.76	0.57	0.37	0.26	—
Heat Absorbing Glass	4.00	0.45	0.38	0.26	0.21	0.16	16.0
DOUBLE GLAZING							
Heat Absorbing Glass Outside and Plain glass inside	2.00	0.38	0.28	0.22	0.16	0.12	24.0
Plain Glass Outside and Heat absorbing glass inside	2.00	0.32	0.20	0.16	0.12	0.09	24.0
Double Plain Glass sheet	2.25	0.65	0.54	0.40	0.28	0.18	16.0
INSIDE SHADING							
Plain Glass Sheet Outside and Curtain Inside	2.50						12.0
(i) Light Colour		0.35	0.28	0.21	0.17	0.12	
(ii) Dark Colour		0.40	0.35	0.28	0.20	0.17	
Plain Glass Sheet Outside and Venetian Blind Inside	2.80						62.0
(i) Light Colour		0.35	0.27	0.21	0.16	0.11	
(ii) Dark Colour		0.40	0.34	0.27	0.20	0.16	
Heat Absorbing Glass Outside and Curtain Inside	2.20						28.0
(i) Light Colour		0.22	0.18	0.14	0.10	0.07	
(ii) Dark Colour		0.25	0.22	0.19	0.15	0.10	
Heat Absorbing Glass Outside and Venetian Blind Inside	2.40						78.0
(i) Light Colour		0.24	0.20	0.16	0.12	0.09	
(ii) Dark Colour		0.28	0.23	0.19	0.15	0.12	

Types of Shading Devices

A wide variety of sun control devices are available for shading windows from direct and diffuse radiations due to sun and sky. Inspite of differences between various shading devices, their functions are alike. They may be broadly classified into two categories :

(i) Internal shading

(ii) External shading

Internal Shading

Different types of glasses, such as painted glass, heat absorbing glass, heat reflecting glass, double glass are generally used for glazing windows.

It is more common to use some indoor shading devices for light and glare control. Types of internal shading used generally are : curtains, venetian blinds etc. These shading devices also provide some relief to people against heat.

External Shading

External shading devices are the most effective means of reducing solar heat gain through fenestration.

Light colour venetian blinds of aluminium, installed outside, are effective in reducing heat ingress. Curtains can also be equally effective but it is not practicable to use them externally.

Horizontal projections formed by balconies or porches are also quite effective. Fixed or movable vertical or horizontal louvers constitute another type of shading devices.

Shading by obstruction such as trees, herbs are effective in reducing solar heat gain through glass windows.

Thermal Evaluation of Shading Devices

Effectiveness of these shading devices is evaluated from their performance which is given in terms of shade factors. Shade factor is defined as the ratio of total heat transmitted through glazing with or without shading device to that through an unshaded plain glass sheet of 3 mm thickness. The measured shade factors, U-values and increase in the cost for various types of shading devices are given in Table-2.

I.S.I. has recommended maximum shade factor and U-values of windows for unconditioned and conditioned buildings. For unconditioned buildings, the recommended U-value and shade factor are 4.5 K cal/hr^{0}C m^2 and 0.5 respectively. For conditioned buildings these recommended values are 4.5 K cal/ hr^{0}C m^2 and 0.3. The required shade factors can be obtained by a judicious combination of both internal and external shading devices. From Table-2 it is possible to work out the type of shading devices to satisfy the I.S. requirement. External shading to the extent of 100% will not be suitable because it will cut down solar radiation during winter. From this point of view the external shading, even for air conditioned buildings and West orientation, should not be more than 50%.

Design of External Shading

Design of external shading devices for a given size of window and the amount of shading can be worked out from solar chart and shadow angles. These can be taken from the climatic and solar data published by C.B.R.I. For the sake of convenience the length of vertical and horizontal louvers for a few sizes of windows with different percentages of shading has been worked out in Table-3.

Normally horizontal projections are needed for South orientation whereas, only vertical projection is needed for North. Both horizontal and vertical projections will be necessary for other orientations.

In many cases it is not possible to provide the desired amount of vertical projections due to high cost and structural requirement. In such cases the vertical projections can be designed in combination with the horizontal projections to provide a given amount of shade factors. It has been observed that the effective shading for orientation other than North and South will be an average of the horizontal and vertical projections. The effective shading for various percentage combinations of horizontal and vertical projections are shown in Table-4.

Table—3 Size of the Louvers for Different Sizes of Windows

S. No.	Window Size	Type of Louvers	Size of Louvers for 100 per cent of Shading for Different Orientntion				
			N	S	E/W	NE/NW	SE/SW
1.	240×90 cm	H	—	1 (55)	1 (107)	2 (95)	1 (107)
		V	1 (105)	—	9 (107)	7 (95)	6 (107)
2.	200×120 cm	H	—	1 (69.4)	1 (143)	2 (127)	2 (71.5)
		V	1 (93)	—	6 (143)	4 (127)	7 (71.5)
3.	120×90 cm	H	—	1 (55)	1 (100)	2 (90)	1 (100)
		V	1 (55)	—	5 (96)	4 (82)	4 (82)
4.	120×150 cm	H	—	1 (88)	2 (90)	4 (80)	4 (80)
		V	1 (55)	—	5 (96)	4 (82)	4 (82)
5.	150×90 cm	H	—	1 (55)	1 (100)	2 (90)	1 (100)
		V	1 (67)	—	6 (100)	4 (100)	4 (100)

Table-4 Effective Percentage of Shading by the Combination of Horizontal and Vertical Louvers

S. No.	Orientation	Percentage of Shading Required for					
		100% Shading		50% Shading		25% Shading	
		H Horizontal Louver	V Vertical Louver	H Horizontal Lauver	V Vertical Louver	H Horizontal Louver	V Vertical Louver
1	E/W	100%	100%	100%	30%	50%	15%
2	NE/NW	100%	100%	70%	30%	50%	15%
3	SE/SW	100%	100%	70%	30%	50%	15%

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 126th 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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