BUILDING DIGEST
CENTRAL BUILDING RESEARCH INSTITUTE, INDIA

SHADING DEVICES FOR GLASS OPENINGS IN AIR-CONDITIONED BUILDINGS*

Introduction

Direct entry of solar radiation through glass openings in air-conditioned buildings causes a large increase in the cooling load. Several types of shading devices have in the past been employed to intercept the influx of solar radiation externally. Such devices are invariably based on past experience or rule of thumb and in quite a few situations mistakes are committed.

It is therefore necessary to evolve a rational system of shading devices for the whole country for the guidance of designers.

Need for a Uniform Design

A study of the types of shading devices likely to be effective reveals that a uniform pattern can be adopted for the whole country. The country can be divided into two regions, viz., (a) Northern region, i.e. North of latitude 20°N and (b) Southern region, i.e. South of latitude 20°N. It is found that the same type of louver system is suitable for a whole region. Even from one region to another, the desirable type of shading device does not alter but in some facades there is merely a nominal change in the dimensions. Such an arrangement therefore has the inherent advantage of uniformity and simplicity.

Why Air-Conditioned Buildings in Particular ?

Direct entry of sunlight into an air-conditioned space implies higher installation and running costs of the cooling plant. It is not so critical in unconditioned buildings where the early morning summer sun can be tolerated. As such the shading system for an air-conditioned building has to be carefully designed to completely intercept direct solar radiation externally throughout the summer months. Of course, similar shading devices can be provided on unconditioned buildings too by judiciously avoiding certain categories which are costly to build or their angles of inclination are large enough to impede daylight or natural air-flow indoors.

Categories of Shading Devices

The following three categories of shading devices are generally used in practice. The required dimensions of either type for individual facades are presented in Tables 1 and 2.

1. Horizontal type (H) (Fig. 1)
2. Vertical type (V) (Fig. 2) and
3. Egg-Crate type (C), i.e. a combination of types 1 and 2 above (Fig. 3).

Several variations of each category, to choose from, in terms of angles of inclination and consequent changes in dimensions, are given in Tables 1 and 2, but the net performance of each variation is not affected thereby. Recommendations for the optimum design are also given in the last column of the Tables.

Inclining of Louvers

The purpose of inclining the vertical or horizontal members is always to reduce the outward projection of an unwieldly louver system but it results in reduced day light indoors. Therefore, if an alternative is available, the angle of inclination beyond 30° should possibly be avoided. Moreover, wherever the feasibility of inclining the louvers in either direction is indicated in Tables 1 and 2, the extreme member in the direction of inclination can be avoided as it does not serve any useful purpose.

Terms and Symbols Used in the Tables

The suggested louver systems for both northern and southern regions are presented in separate Tables. To simplify the presentation, several terms and symbols used in the Tables, here, are explained below :

1. P—It denotes the outward projection of the louver system perpendicular to the wall. All other dimensions are given in terms of 'P' only.

2. B—It is the angle of inclination of the louver away from the normal to the wall. A value of B=o denotes a vertical or horizontal member

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TYPE – H
(FOR ALL FACADES EXCEPT N)

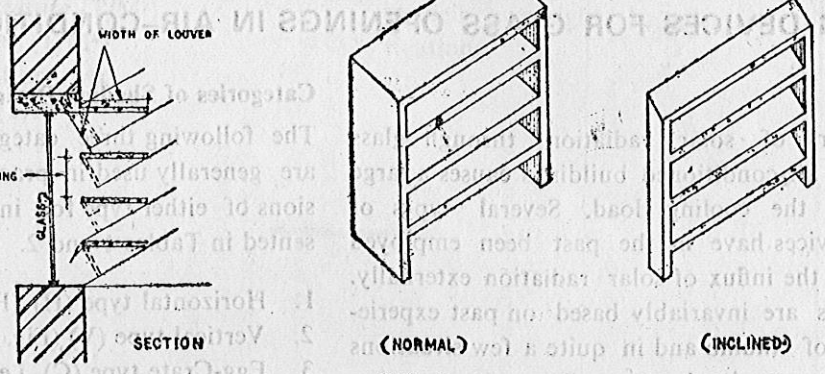
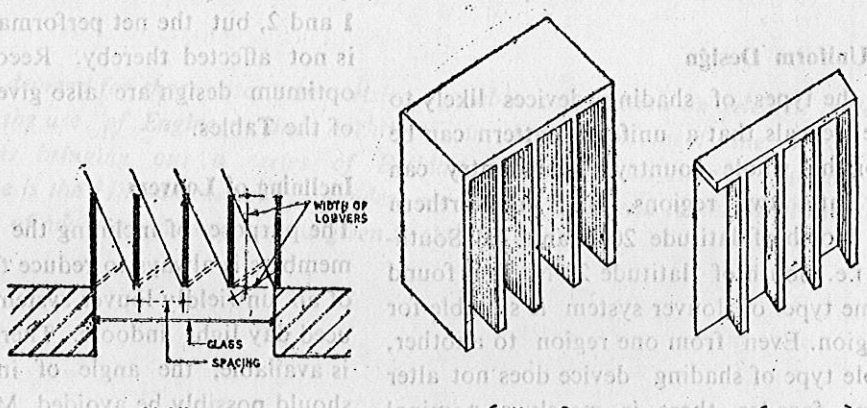


FIG. 1

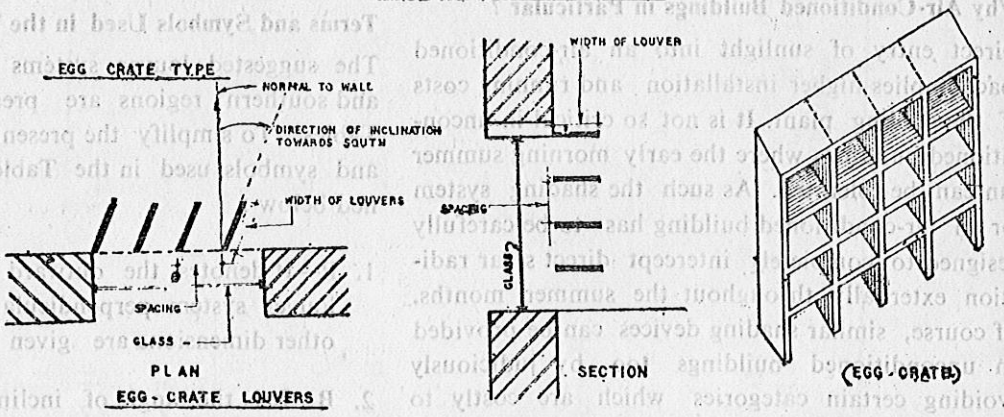
TYPE – V
(FOR ALL FACADES EXCEPT S)



NOTE:- SHOULD IT BE NECESSARY TO INCLINE THE VERTICAL MEMBERS THE LAST MEMBER AT THE EXTREMITY TOWARDS WHICH THEY MAY BE INCLINED, IS NOT NEEDED.

FIG. 2

TYPE – C
(FOR E,W, SE, SW, FACADES)



NOTE:- THE LAST VERTICAL MEMBER AT THE SOUTHERN EXTREMITY IS NOT NEEDED

FIG. 3

TABLE–1

Spacing Distances Between Vertical or Horizontal Members of Louver Systems
(NORTHERN REGION)

Alternative	Type of Louver	ANGLE OF INCLINATION B = 0°	B = 15°	B = 30°	B = 45°	B = 60°	Direction of Inclination	Performance	Recommended
A NORTH									
1.	Type V	3.73 P	Inclining	not	desirable	—	—	Cuts off after 7 a.m. during June and completely in other months.	Either
2.	Type V	2·15 P	—	—	do	—	—	Cuts off completely at all times.	
B. SOUTH									
1.	Type H	1.73 P	2 P	2.3 P	2.73 P	3.46 P	Downwards	Completely cuts off summer sun and allows winter sun indoors.	Type H (B = 0)
C. EAST/WEST									
1.	Type V	Inclining	not	desirable	.73 P	1.46 P	Towards north away from normal.	Cuts off both summer and winter sun.	Type C Combination of V (B = 30°) and H (B = 0°)
2.	Type H	.27 P	.54 P	.85 P	1.27P	2 P	Downwards	Cuts off only after 7 a.m. in summer and winter.	
3.	Type C								
	Vertical member	—	—	.21 P	.64 P	1.37 P	Away from normal towards south	Completely cuts off only summer sun but allows winter sun to come partially.	
	Horizontal member	.84 P	1.11 P	1.42 P	1.84 P	2.57 P	Downwards		
D. NORTH-EAST/NORTH WEST									
1.	Type V	.36 P	.63 P	.94 P	1.36 P	2.1 P	Towards North away from normal.	Winter sun negligible on this facade and summer sun cut off completely.	Type V (B = 30°)
2.	Type H	.47 P	.74 P	1.05 P	1.47 P	2.2 P	Downwards	Cuts off only after 7 a.m.	
E. SOUTH-EAST/SOUTH-WEST									
1.	Type C								
	Vertical member	.36 P	.63 P	.94 P	1·36 P	2.1 P	Southwards away from normal	Completely cuts off all summer sun and allows winter morning sun partially.	Type C Combination of V (B = 30°) and H (B = 0°)
	Horizontal member	.84 P	1.1 P	1.42 P	1.84 P	2.57 P	Downwards		

Note : In type C above, any combination of the angles of inclination of the vertical and horizontal members can be made.

TABLE-2

Spacing Distances Between Vertical or Horizontal Members of Louver System
(SOUTHERN REGION)

Alternative	Type of Louver	ANGLE OF INCLINATION B = 0°	B = 15°	B = 30°	B = 45°	B = 60°	Direction of Inclination	Performance	Recommended
A. NORTH									
1.	Type V	2.75 P		Inclining	not	desirable	—	Cuts off sun after 7 a.m. during June and completely in other months.	Either
2.	Type V	2.15 P	—	-do-	—	—	—	Cuts off completely at all times.	
B. SOUTH									
1.	Type H	2.75 P	3 P	3.33 P	3.75 P	4.5 P	Downwards	Cuts off all summer sun after 15th March to 30th September.	Type H (B = 0)
C: EAST/WEST									
1.	Type V	Inclining	not	desirable	.53 P	1.27 P	Inclined towards north away from the normal.	Cuts off both summer and winter sun.	
2.	Type H	.27 P	.54 P	.85 P	1.27 P	2 P	Downwards	Cuts off only after 7 a.m. in summer and winter.	Type C
3.	Type C								
	Vertical member	—	—	0.31 P	0.73 P	1·46 P	Inclined towards south away from normal.	Completely cuts off only summer sun but allows winter sun to come partially.	Combination of V (B = 30°) and H (B = 0°)
	Horizontal member	.84 P	1.11 P	1.42 P	1.84 P	2.57 P	Downwards		
D. NORTH-EAST/NORTH-WEST									
1.	Type V	.36 P	.63 P	.94 P	1.36 P	2.1 P	Inclined towards north away from normal.	Winter sun negligible on this facade and summer sun is completely cut off.	Type V (B = 30°)
2.	Type H	.36 P	.63 P	.94 P	1.36 P	2.1 P	Downwards	Cuts off only after 7 a.m.	
E. SOUTH-EAST/SOUTH-WEST									
1.	Type C								
	Vertical member	,58 P	.85 P	1.15 P	1.58 P	2.31 P	Southwards away from normal.	Completely cuts off all summer sun and allows winter morning sun partially.	Type C
	Horizontal member	P	1.27 P	1.58 P	2 P	3.73 P	Downwards		Combination of V (B = 30°) and H (B = 0°)

Note : In type C above, any combination of the angles of inclination of vertical and horizontal members can be made.

normal to the wall.

3. Width of Louver :
It is the built-up width of the louver, whether inclined or normal to the wall. For a louver normal to the wall, it is equal to P but it is always greater than P for an inclined member. The width in terms of P is dependent only on the angle of inclination, and for both vertical and horizontal members is as follows :

for B =	0^0	15^0	30^0	45^0	60^0
Width =	P	1.04 P	1.15 P	1.41 P	2P

4. Spacing—It is the horizontal or vertical distance between the adjacent vertical or horizontal members repectively. For the same value of P, it always increases with increase in the angle of inclination of the louver, thereby reducing their number.

A horizontal member can be inclined only downward whereas a vertical member can be inclined either way. It is noteworthy that the vertical members on the northern facade can not be inclined either way, whereas on all other facades, except the South where only a horizontal member is found adequate, the vertical members can be inclined, if at all, towards the north or south away from the normal to the wall, as shown in the Tables

Types of Louvers on Various Facades

1. North

Vertical members normal to the wall, capped by a horizontal member of the same projection are adequate, or the vertical members can be extended to similarly placed windows in upper storeys. If P is pre-decided, spacing can be worked out. If it is desired to provide vertical members on either extremity of the window, spacing should be taken equal to the width of the window and P can be worked out.

The plan and perspective of this type are shown in Fig. 2.

2. South

One or more horizontal members together with vertical members of the same outward projection at the extremities are needed. The vertical members at the extremities can be either rectangular or triangular. These horizontal members can be extended to other windows in the same storey and the vertical members provided only at the two extremes. These can be inclined downwards too. If it is desired to provide only one horizontal member at the top, the spacing should be taken as the height of the window and P can then be worked out.

The section and perspective are shown in Fig. 1.

3. East/West

In these facades, any of the three types mentioned above can be used. The performance of each is given in the respective columns of the Tables. The recommended one is a combination of horizontal and vertical louvers, wherein the horizontal member should have B=0 and the vertical one B=30^0, inclined towards the South away from the normal to the wall. This has the advantage of letting in the winter sun during early mornings on the east facade and late evenings on the west facade and also of completely cutting off the summer sun from morning to evening.

4. North-East/North-West

For these facades, either vertical or horizontal type can be used. The vertical members capped by a horizonal member of the same width will cut off all summer and winter sun completely whereas the horizontal type of louvers will cut-off direct sun only after 7 a.m. throughout the year. Inclining the vertical louvers northwards will reduce the dimensions. The recommended angle of inclination is 30^0.

5. South-East/South-West

For these facades, only egg-crate type of louvers can be adequate without being unwieldly. A vertical member with any given angle of inclination can be combined with a horizontal member of any given inclination from the Tables. The recommended louver system is comprised of a vertical member with B=30^0, inclined towards the South and a horizontal member with B=0. It has the advantage of intercepting all summer sun and permitting winter sun upto around mid-day on the South-East, and late afternoons on the South-West facades.

How to Work Out : Before proceeding to calculate the spacing width and the number of louvers etc., it is necessary to have a rough idea of P, i.e., the intended outward projection. Slight modifications to this dimension may be needed to distribute the louvers evenly over the entire dimension of the window.

For example, if it is desired to shade a window 200 cm wide and 120 cm high in any of the facades in the northern region, reference to Table 1 should be made and the following procedure adopted to obtain the actual dimensions :

1. North

Suppose it is desired to cut off the sun completely and also to provide vertical members only at the two extremities.

From Table 1 A, spacing=2.15 P.
In this case, spacing=200 cm=2.15 P.

$$\text{Therefore, } P = \frac{200}{2.15} = 93 \text{ cm.}$$

Alternatively, if this value of P is considered too large, an extra vertical member may be provided at the centre of the window too. Then the spacing = 100 cm and P=46.5 cm!

2. South

Suppose it is desired to provide only one horizontal member at the top, the spacing becomes equal to 120 cm. From Table 1 B, the spacing for a horizontal member with B=0 is given as 1.73 P.

Therefore 1.73 P=120 cm.

$$\text{and } P = \frac{120}{1.73} = 69.4 \text{ cm.}$$

3. East/West

Suppose it is desired to provide an egg-crate type of louver, where the horizontal member has B=0 and the vertical one has B=30° From Table 1 C, the spacing for the horizontal members is 0.84 P.

Let us first try with only one horizontal member at the top, so that the spacing is equal to the height of the window.

Thus spacing=0.84 P = 120 cm.

$$\text{or } P = \frac{120}{0.84} = 143 \text{ cm, which}$$

appears too large an outward projection.

Alternatively, we think of providing two horizontal members, one on top and the other at the middle and hence the spacing=60 cm and thus P= 71.5 cm. So we now know the likely outward projection of the louver system.

Now for the vertical members the required spacing is 0.21 P and knowing P to be 71.5 cm, the spacing of the vertical members=0.21×71.5=15 cm. In order to determine the number of vertical members needed to cover the 200 cm width of the window when the spacing works out to be small, the likely thickness of the louvers should also be added to the spacing. If then, the thickness of each vertical member is say 5 cm, the total separation between corresponding edges of the louvers is 15+5=20 cm and so the number of spaces needed between vertical louvers is 200/20=10, and actually 11 louvers would be needed. But as mentioned earlier, the extreme louver on the southern extremity is not necessary, only 10 vertical louvers inclined by 30° towards the South would be adequate.

4. North-East/North-West

Suppose it is desired to provide vertical members inclined by 30° towards north. Also suppose it is decided to provide only 60 cm of outward projection. From Table 1-D, it is seen that spacing =0.94 P.

Hence spacing=.94×60=56 cm.

Considering the thickness of the louver equal to 5 cm, the total distance required for each spacing is 56+5=61 cm and the number of spaces needed =200/61=3.3 But since this is not a whole number, some changes in the dimensions are needed.

Suppose now it is desired to find the outward projection of the louvers for four spacings. This gives a spacing width of 50 cm between the adjacent members. Reckoning 5 cm as the thickness of the louver, the clear spacing distance associated with each member is 45 cm Therefore spacing = 45 cm = 0.94 P.

$$\text{or } P = \frac{45}{.94} = 48 \text{ cm. nearly}$$

In a similar way, the outward projection for only three spacings can also be worked out.

Alternatively, if it is decided to provide horizontal type of louvers, projecting by say, 60 cm beyond the wall, the spacing from Table 1 (D) for B = 0 is 0.47 P.

Hence spacing = 0.48×60 = 28 cm and the total distance between the corresponding edges of adjacent louvers

= spacing + thickness of louver
= 28 +5 = 33 cm.

The required number of spacings = 120/33, 120 cm being the height of the window. This gives a value slightly less than four. In order to have exact four spacings, the outward projection can be slightly modified. Each spacing will be 120/4 = 30 cm and

since 5 cm is the thickness of the louver, the clear spacing distance = 25 cm, which gives

$$0.47\ P = 25 \text{ cm}$$

$$\text{or } P = \frac{25}{.47} = 53 \text{ cms. nearly}$$

Therefore, for four spacings, the outward projection should be 53 cms.

5. South East/South West

Suppose it is decided to employ the recommended type C system of louvers, where the vertical members are inclined by 30° towards south away from the normal to the wall and horizontal members have B = 0. Also suppose the intended outward projection, P, is around 70 cm.

For the horizontal members from Table 1-E, the spacing is given as .84 P. Therefore, spacing = .84 × 70 = 59 cm nearly. As the height of the window is 120 cm, two horizontal members, one at the top and one at the middle are necessary.

For the vertical members (B = 30°), the spacing shown is 0.94 P = 0.94 × 70 = 66 cm nearly. For a total width of 200 cm, roughly 3 spacings are indicated and so 4 vertical members are necessary. The last vertical member on the southern extremity of the window is not needed as discussed earlier. Therefore, only 3 vertical members will suffice.

The built-up width of the vertical members, as given earlier = 1.15 P = 1.15 × 70 = 80.5 cm.

Concluding Remarks

The decision for choosing the type and size of the shading device is left entirely to the designer. A little familiarity with the use of Tables 1 and 2 can easily enable the designer to evolve a fool-proof shading system for any orientation of the building anywhere in the country.

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 119th 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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