A SEMESTER WRITE UP ON

THE DESIGNS AND EXAMPLES OF HORIZONTAL SHADING DEVICES.

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1.0 INTRODUCTION

Any building surface such as windows, walls, and roofs, that is exposed to the sun can admit solar radiation. To avoid the inflow of heat either direct or indirect. The surfaces on which the sun and rays falls must be protected.

In the tropical climates, the designer should keep the solar radiation off the opaque solid elements of the building's envelope where possible. Special care should be taken to shade the windows to reduce the incoming heat and the risk of overheating.

The design of shading devices reflect various functions including thermal control. There are three types of shading devices which include vertical, horizontal and egg-crate. The design of sun shading devices for thermal comfort involves four steps: Determination of when shading is required, determination of the position of the sun at the times when shading is required, determination of the dimensions and proportions of the required shading devices, and finally the architectural and structural design of the shading devices.

Well planned external shading devices is most effective method of reducing solar heat gain. In addition, it offers possibilities for incorporating day lighting and passive heating some type of external shading interfere with view, while other types make it possible to exploit view that will otherwise be impossible because of solar glare.

Horizontal shading devices is the most suitable form with overhead sun that is, for all north and south façade. It can also be used for southeast, southwest, northeast and northwest facades. The simplest form is the roof overhang, a projecting floor slab
or a balcony. A permanent overhang, fixed to the position of the sun is most frequently used and often combined with projecting building elements. If movable, they are best operated manually using a lever or crank handle.
CHAPTER TWO

2.0 SHADING DESIGN

The design of shading devices can be quite complex. Computer programs exist to accurately shape shades for very specific purposes. However, in their absence, and with a little understanding of the mechanics of sun position and sun-path diagrams, manual methods can be used.

External shading devices are preferable and more effective than internal ones. This includes devices fixed to the outside of the window or attached to building envelope. Among the operable units are louvers made of wood or metal, exterior Venetian blinds, shutters, awnings and fixed or movable overhangs. As you should know from your own personal experience, the most important characteristic of solar position is its seasonal variation.

At the height of summer in the southern-hemisphere the sun rises slightly south-east and sets slightly south-west. In winter it rises slightly north east and sets slightly north-west. It also rises much earlier and sets much later in summer than in winter. In the northern hemisphere, north and south are reversed.
The hourly path of the Sun through the sky in Summer and Winter.

The aim of good shading design is to utilize these characteristics to best advantage, usually complete exclusion in summer and maximum exposure in winter.

2.1 Rules of the thumb

Shading devices should be selected according to the orientation of the window. Whilst some orientations are easy to shade, others are much more difficult as the sun can shine almost straight in at times. The table below indicates the most appropriate type of shading device to use for each orientation in the southern hemisphere. These are guidelines and, of course, there are many variations to these basic types.

<table>
<thead>
<tr>
<th>Orientation</th>
<th>Effective Shading</th>
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<tbody>
<tr>
<td>North (equator-facing)</td>
<td>Fixed horizontal device</td>
</tr>
<tr>
<td>East or West</td>
<td>Vertical device/louvres (moveable)</td>
</tr>
<tr>
<td>South (pole-facing)</td>
<td>Not required</td>
</tr>
</tbody>
</table>

Shadow Angles
When attempting to shade a window, the absolute azimuth and altitude of the Sun are not as important as the horizontal and vertical shadow angles relative to the window plane. These can be calculated for any time if the azimuth and altitude of the Sun are known.

### 2.1.1 Horizontal Shadow Angle (HSA)

This is the horizontal angle between the normal of the window pane or the wall surface and the current Sun azimuth. The normal to a surface is basically the direction that surface is facing its orientation. If the orientation is known,

HSA is given by:

HSA = azimuth orientation

### Vertical Shadow Angle (VSA)

The vertical shadow angle is more difficult to describe. It is best explained as the angle a plane containing the bottom two points of the wall/window and the centre of the Sun, makes with the ground when measured normal to the surface. It is therefore given by:

VSA = \( \frac{\tan(\text{altitude})}{\cos(\text{HSA})} \)

It is the VSA that determines the depth of the required shade. The diagram more adequately describes the derivation of the VSA

### 2.1.2 Shade Dimensions

These two angles, HSA and VSA, can then be used to determine the size of the shading device required for a window. If the height value refers to the vertical distance between the shade and the window sill, then the depth of the shade and its width from each side of the window can be determined using relatively simple trigonometry.
2.1.3 Shade Depth

The depth of the shade is given by:

$$\text{depth} = \frac{\text{height}}{\tan(VSA)}$$

The width is given by:

$$\text{width} = \text{depth} \times \tan(HSA)$$

The width simply refers to the additional projection from the side of the window. Exactly which side is a matter of the time of day and which side of the window the Sun is on.

2.2 Design Requirements

The design requirements for a shading device depend entirely on a building’s use and local climatic conditions. In a multi storey open plan office building, the occupancy and equipment gains are such that heating is rarely required. In this situation, to avoid unnecessary loads, shading may be designed to completely protect the windows all year-round.

In a domestic building or one that is occupied 24 hours, the release of stored heat during cold nights in winter can be important. In this case, the shading would be designed to fully protect the windows during the summer months, but to expose them as much as possible to direct sun in winter so that they have a chance to absorb heat during the day. In climates where summers are also relatively cold, the requirement may be to allow full solar access all year round.

If you look at outdoor air temperature and the intensity of solar radiation at different times of the year for Perth, Western Australia, it is clear that the transition to colder weather really begins in mid to late March. Thus, in order to take advantage of
solar heating, the transition from shaded to exposed should really begin at the same time. This means that the window should remain completely shaded up until mid to late March, with maximum exposure occurring at the winter solstice in mid June.

A convenient date, by happenstance, is the 21st of March. This has the advantage of being the autumn equinox. One characteristic of the equinox is that, for a north-facing wall, the VSA is exactly the same throughout the day. This is an important piece of information as, in summer, the lowest daily VSA occurs at noon, whereas in winter noon sees the highest VSA.

Thus, if the cut-off date for a north-facing shade occurs on or before the autumn equinox, its depth will be defined by the noon VSA. If the cut off date occurs after the 21st of March, the VSA at either the start or end times will determine its depth.
3.0 DESIGN STEPS

To design a horizontal shading device, simply following the following steps.

1. Determine cut-off date. This is the date before which the window is to be completely shaded and after which the window will be only partially shaded.

2. Determine Start and End Times. These represent the times of day between which full shading is required. Keep in mind that the closer to sunrise and sunset these times are, the exponentially larger the required shade.

3. Look up Sun Position. Use solar tables or a sun-path diagram to obtain the azimuth and altitude of the sun at each time on the cut-off date.

4. Calculate HSA and VSA. Using the formulae given above, calculate the HSA and VSA at each time.

5. Calculate Required Depth and Width. Once again, using the formulae above, calculate the depth and width of the required shade on each side of the window.

3.1 Design and Selection Issues

Exterior shading requires more thought and innovation than most energy conservation techniques because you have many choices, but not a well established doctrine for using them. A wide variety of prefabricated shading devices have appeared on the market. For most applications, external shading is fabricated on a custom basis by a manufacturer who specializes in particular materials and fabrication techniques. Shading devices can be made from metal, wood, fabric, or any opaque material. There are well established companies that can fabricate almost anything you want, but they
cannot tell you the best solution for your building. You have to design the installation. As you do, consider the following factors.

3.2 **Shading Effectiveness**

Simply hanging shading devices over windows may not provide much benefit, as shown in Figure 18. Overall shading effectiveness depends on the performance of the device at all sun positions. For example, a window awning on 221a south face may provide complete shading at noon, but poor shading in the morning and afternoon.

3.3 **Effect on View**

Shading always blocks a part of the view. As a minimum, it blocks portion of the sky where the sun travels. On south faces, you can usually arrange window shading in a way that preserves the view of the surrounding landscape. On east and west faces, fixed shading may eliminate the view toward the south, or they may limit the view to a downward angle. Movable shading on the east and west can restore views during the portion of the day when the sun is on the other side of the building.
Fig. 2 Horizontal shelves integrated with windows These are effective cooling load control devices on a south face. Otherwise, they are mainly a decorative touch. This building must be at a southerly latitude for shelves this shallow to provide much benefit.
CHAPTER FOUR

4.0 SHADING METHODS

External shading is a general technique that you can accomplish with many different types of hardware or architectural features. Shading may be fixed or movable. These are most of the types of external shading that you will encounter today:

• **projecting horizontal shelves.** These can be a primary method of shading south faces. They have little value elsewhere. They must be built into the building’s structure, and hence they are limited to new construction. To be effective, they must be much wider than the windows, in the direction along the wall, to account for the sun’s motion from east to west. Typically, they are installed above the level of the windows. If the windows are closely spaced, shelves typically are installed along the full width of the south face. They are vulnerable to strong wind forces, and in northern climates, to snow loads. Smaller shelves can also be built into tall windows at various levels.

• **Balconies.** These have the same effect as horizontal shelves, but more so. They are deep enough to provide significant shading even if they do not face in a southerly direction. They provide major additional value as usable space and as an ambiance feature. The shelves also serve as balconies. They are limited to new construction.
• **Eaves and overhangs,**

Which can provide effective shading for the floor level directly under the eave? They merit strong consideration as shading devices, and they can provide major additional value in protecting the wall finish and reducing below-grade moisture problems. A typical residential installation, an installation for a public library. They are limited to new construction.
Fig. 4 Eaves and porches  Roof overhangs have long been used to keep buildings cool in warm climates. The trees help, also.

Fig. 5 Roof overhang  The shadow pattern shows that the roof overhang of this library is effective in keeping direct sunlight out of the windows. The open windows show that natural ventilation is cooling the building, assuming that the air conc
• **Inset windows.** In effect, the entire wall acts as shading device around the window. This is obviously a feature that is limited to new construction. It is usually done as a stylistic element, rather than as a rational approach to controlling sunlight. As a method of shading, it is very expensive and wasteful of occupiable space.

However, it can be effective if it is used properly, namely, on southerly exposures at low geographic latitudes.

![Inset windows](image)

**Fig. 6 Inset windows** The shadow patterns show that deeply inserting windows reduces solar heat gain. However, it cannot create satisfactory daylighting by itself.

• **Fixed louvers** may be useful on any exposure of building, except north. The best orientation for the louver blades depends on the direction that the glazing faces. On the south side, the blades should be horizontal. For the north side, louvers are vertical. For other directions, they may be tilted. Louvers can be arranged in a horizontal array, like
a shelf. Or, they can be arranged in a vertical array, like a Venetian blind. Or, they can be installed at an angle, like an awning. The choice of installation geometry depends on the issues discussed below, and perhaps on additional considerations, such as using the shading devices as storm shutters. Louver blades can take many forms, including flat blades, airfoil shapes, and egg crates. They are easier to install than shelf-type shading because they have less wind resistance and they accumulate less snow load. Therefore, they can be much lighter and easier to attach. They can be attached to the wall, or they can be mounted on columns that carry their weight to the ground, Louvers interfere with the view if they are installed in the line of sight, but they may not block the view entirely. For example, a vertical stack of horizontal louvers in front of a window interferes with the view upward and horizontally, but they are not too bad when viewing downward.
• **Vertical fins** are useful for shading north faces from summer sunlight early and late in the day. A building with fins molded into the wall surface.

• **Awnings**, which project downward over the windows. These may be fully effective on south faces, and provide partial shading of windows on east and west faces. A common mistake is making awnings to fit

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**Fig. 1 Horizontal shelves**  These can be very effective for reducing cooling load on the south side of a building. As seen here, sunlight gets under the shelves on other orientations. These also serve as balconies, a nice touch that is rare in office buildings. They make window washing much easier, protect the glazing, and protect the surroundings from falling glass.
4.1 Day lighting Potential

External shading provides the potential of day lighting in perimeter areas, provided that the shading never allows direct sunlight to fall inside the space. If the shading method allows direct sunlight to enter the space even occasionally, occupants will resort to closing curtains or blinds. Day lighting is difficult to accomplish effectively, and it requires automatic light switching.

4.2 Appearance

External shading has a major effect on the appearance of a building. If the building is highly stylized (e.g., neoclassical or glass cube), it may be impossible to reconcile external shading with the original style. In such cases, the style of the building has to change. A stylistic advantage of external shading is that you can make it have any color or surface finish without increasing heat gain. Very little of the heat that is absorbed by the shade is transmitted to the building interior by thermal conduction. Because of its exposed location, the shade is cooled by the atmosphere.

4.3 Longevity

Try to make external shading device last as long as the building. Generally, it is a mistake to use materials that have limited life outdoors, such as fabric and plastic.
Fig. 7 **Horizontal louver shading**  This building is located at a latitude of 30 degrees. The louver arrays greatly reduce the cooling load. On the south side, they also provide effective daylighting by keeping direct sunlight out of the windows at all times.
4.4 Passive Heating Potential

Early in the project, Passive Solar Heating Design. Effective shading kills passive heating. You can reconcile shading and passive heating by moving or removing the shading device when passive heating is desirable. For example, movable louvers and roller blinds provide shading when needed while allowing passive heating at other times. On the south face of a building, you can achieve passive heating even with fixed shading. This is an important opportunity. The sun’s path through the sky is much lower in winter. As a result, you can design horizontal shading over southerly windows so that it shades the windows in summer but allows sunlight to enter in winter.

This fact has long been exploited in the architecture of various cultures, including pueblo Indians and the Zulu. For example, at a latitude of 40° (Philadelphia, Denver, Beijing, Madrid, Ankara, Wellington), the noonday sun is about 70° above the horizon in the middle of summer, while the noonday sun is about 30° above the horizon in the middle of winter. You can shade south faces either with a single shelf installed over the window, or with a set of louvers in front of the window. If you use a single shelf, it must project outward a distance that is proportional to the height of the windows. Therefore, this method is easiest to accomplish with windows that are not tall. In new construction, you can exploit this shading possibility by installing balconies along the south face.

Fixed shading used in this manner gives only crude control of solar heat input. It cannot adjust to changes in the intensity of sunlight or to internal heat gains. Also, the outside temperature lags behind seasonal solar motion, typically by four to eight weeks.
4.5 The Effects of Shading

The above method will provide a precisely shaped shade that will provide full protection over the time period selected. However, we have not yet looked at how much Sun we will get in winter, when some penetration is usually desirable. Unfortunately, a shading device will not suddenly stop working after a certain date (unless it is retractable). It will usually partially obscure the window year round, more so in summer and less so in winter.

This is where the trade-off begins the amount of which depends on the relative heating and cooling stresses in the environment. In a very hot climate you may not actually need solar gains in winter, whereas in a very cold climate solar gains even in summer may be desirable.

In order to understand the full effect of a shading device, we really need to turn again to the sun-path diagram and a percentage overshadowing graph. It may be that, whilst we want 100% shading throughout most of summer, we could probably live with only 80 to 85% shading in early Autumn in order to gain extra solar gains in winter. You will notice that the shading patterns displayed in the diagram below all display "fuzzy" edges. This is because we are dealing with a large window surface, not a single point.
A combination of external and internal shading devices can offer efficient solar control. Ideal solution is to have shades that can be moved, either seasonally or on a daily basis.
CHAPTER FIVE

5.0 CONCLUSION

External shading is useful in almost all situations where direct sunlight through glazing increases the cooling energy requirement substantially. Shading can be adapted to virtually all sizes of windows and skylights. The most common limitations are high cost and the effect on the building’s appearance. Effective external shading blocks all or most direct sunlight, although it admits indirect light from the sky. It typically reduces solar heat input by 80% to 90%. In buildings where solar load dominates the cooling requirement, shading may reduce a building’s total cooling load by as much as half.

Each face of a building requires a different shading treatment because sunlight strikes each side from different angles. A south face is best shaded with horizontal shading. East and west faces require shading that blocks sunlight entering at low angles. A north face can often be left unshaded.
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