MEASURE 8.1.1 Install external shading devices appropriate for each exposure of the glazing.

RATINGS

New Facilities	Retrofit	O&M
B	C	

SUMMARY

The most effective method of controlling solar heat gain. Each orientation must be designed separately. All new buildings should have it. In retrofit, it is expensive and often impractical.

SELECTION SCORECARD

Savings Potential	$	$	$	$
Rate of Return, New Facilities	%	%	%	%
Rate of Return, Retrofit	%	%		
Reliability	✓	✓	✓	✓
Ease of Retrofit	☺	☺	☺	

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

External shading is much easier to integrate into the design of a new building than it is to retrofit. External shading has a major effect on the appearance of the building, and it must be anchored strongly to the building structure to resist wind loads. In retrofit, both of these factors are serious challenges.

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.

Where to Consider External Shading

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.

If an existing building has glass that is treated to reduce solar heat gain, adding external shading is not likely to be economical from the standpoint of energy efficiency. External shading does reduce the temperature of the glass, improving comfort in some cases. (Exposed absorptive glass may become quite warm in the absence of wind.) See Measure 8.1.3 for details.

Energy Saving Potential

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.

In new construction, this large reduction of cooling load may allow the capacity of the cooling equipment to be reduced by a similar amount. The saving in cooling equipment cost may pay for the shading, or a large part of it.

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, as in Figure 1. 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, as in Figure 2.
- ***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. Figure 3 shows a variety of examples. They provide major additional value as usable space and as an ambiance feature. The shelves in Figure 1 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. Figure 4 shows a typical residential installation, and Figure 5 shows an installation for a public library. They are limited to new construction.

- ***inset windows.*** In effect, the entire wall acts as a shading device around the window, as shown in Figure 6. 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.
- ***fixed louvers*** may be useful on any exposure of a 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. Figures 7, 8, and 9 show examples.

  Or, they can be arranged in a vertical array, like a venetian blind. Figures 10 and 11 show examples.

  Or, they can be installed at an angle, like an awning. Figures 12 and 13 show examples.

  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, as in Figure 14, or they can be mounted on columns that carry their weight to the ground, as in Figures 9 and 15.

  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. Figure 16 shows a building with fins molded into the wall surface.
- ***awnings,*** which project downward over the windows. Figure 17 shows a typical installation. 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 every 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.

the width of the window. Such awnings are too narrow, allowing an excessive amount of sunlight to enter from the sides.

- ***miniature fixed-louver materials*** are supported in frames and installed directly over glazing. They are useful on all faces. One product is made from aluminum sheet punched to create tiny louvers. Another product consists of tiny bronze strips woven into a louver with wires. Within limits dictated by the manufacturing process, the manufacturer may offer a variety of louver spacings and tilt angles. Some fixed louver materials can be oriented vertically for use in east-west shading, or to any other angle.
- ***mesh materials*** are loose weave fabrics made of materials such as glass fiber and plastics. They are largely non-directional, although some directional characteristics can be achieved by altering the pattern of the weave. The principal merit of these materials is low cost.
- ***movable louvers,*** which operate like venetian blinds. They are expensive because they must be rugged enough to survive the outside environment. They may be controlled manually or with sun tracking controls. Movable louvers can be installed in any orientation for shading of any face.
- ***roll-up external blinds,*** which typically are made of aluminum. These are widely used in Germany, for example. They provide security as well as sunlight control. Like internal roller shades, they are non-directional, and they do not offer good lighting quality.

Vistawall Architectural Products

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.

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.

■ 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 a south face may provide complete shading at noon, but poor shading in the morning and afternoon.

■ Effect on View

Shading always blocks a part of the view. As a minimum, it blocks the 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.

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Fig. 3 Balconies Buildings in this summer resort use many kinds of balconies to reduce the cooling load and to provide pleasant space for occupants. These buildings face the ocean toward the east, so the balconies are effective for controlling sunlight mainly around the middle of the day.

■ Daylighting Potential

External shading provides the potential of daylighting 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. Daylighting is difficult to accomplish effectively, and it requires automatic light switching. See Subsections 8.3 and 9.5 for details.

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Fig. 4 Eaves and porches Roof overhangs have long been used to keep buildings cool in warm climates. The trees help, also.

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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 conditioning has been turned off.

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

■ Passive Heating Potential

Early in the project, read Reference Note 47, 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. See Reference Note 24 for more about solar motion.

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.

■ 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.

■ 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.

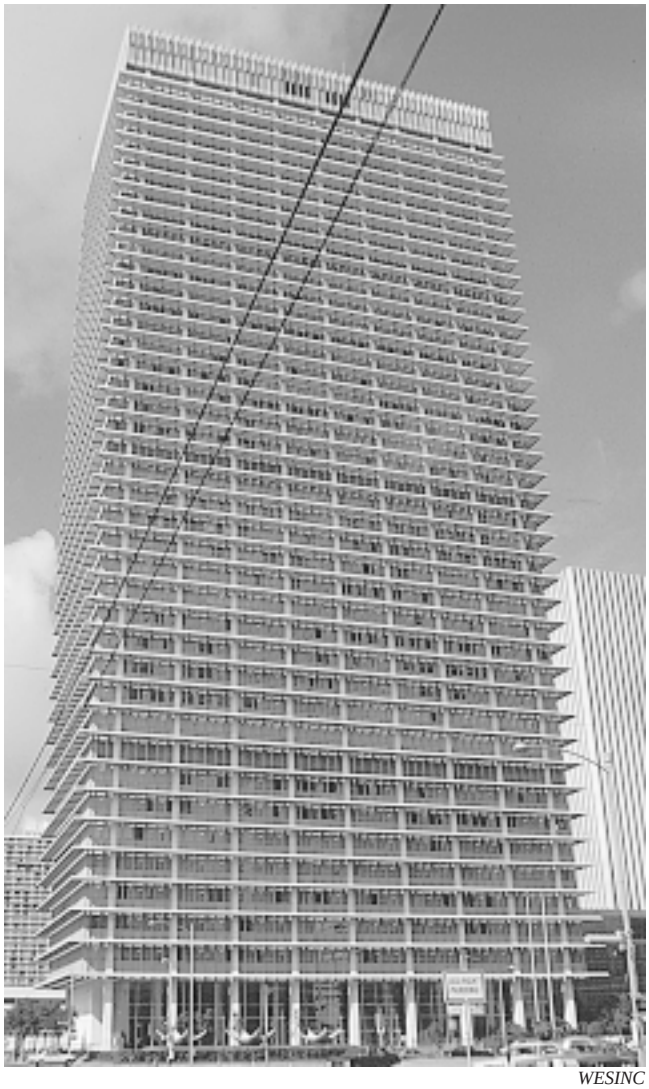

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Fig. 7 Horizontal louver shading This building is located at a latitude of 30 degrees. The louver arrays greatly reduce the cooling load. On the south side, they also provide effective daylighting by keeping direct sunlight out of the windows at all times.

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Fig. 8 Shadow pattern of horizontal louvers These are working well, except at the corner. We infer that the wall at right faces in a southerly direction. A double row of louvers is used to reduce the outward distance required. The louvers are attached to vertical stringers, which are bolted to the wall.

Airolite Company

Fig. 9 Egg crate louvers The egg crates block sunlight from all directions. They are supported by the columns, rather than being attached to the wall. This rather massive construction and the irregular placement of the louvers may have been motivated by an appearance concept as much as by sunlight control.

Why inflict the cost and effort of periodic replacement on future owners and operators? Also, such materials soon lose their sparkle and start looking shabby.

■ Attachment to the Building

Attaching external shading devices to the building can be a design challenge. Shading devices are subject to strong wind forces because they have a large surface area. Some shading is subject to snow loads. If the building envelope does not have easily accessible strong points for attachment, you have to create them.

In new construction, you can make some of the shading features described previously an integral part of the structure. This is generally very strong.

Separate shading devices can be bolted to the wall. However, do not assume that an existing wall is strong enough to withstand the weight and wind loads. You may have to reinforce the wall at the attachment points, and doing this may be awkward.

You can also attach shading devices to columns or vertical stringers. If the latter are attached to the wall, as in Figure 8, they distribute the weight of the devices along the wall, while minimizing bending loads that tend to tear attachments out of the wall.

If the attachment columns can extend to the ground, they can relieve the gravity load on the wall. In some installations, the columns are freestanding, except for a steadying attachment at the top.

■ Removable Shading

Try to avoid shading devices that have to be removed on a seasonal basis. Stowage is a major problem, and operating personnel hate to bother with this kind of chore. Such shading tends to be abandoned within a few years.

■ Method of Control

Movable shading may be operated manually or automatically. Automatic control is necessary to achieve efficient results in most applications. Controls based on some form of sun position sensor can be simple and reliable. Such controls are unconventional, so you have to make sure that they are installed properly.

Manual control is reliable only if people become uncomfortable in an obvious way when they fail to control the equipment efficiently. For example, manual control may work for a louver shade that allows glare when it is not adjusted to keep out sunlight. However, this method of control is not pleasant for the occupants, and it is not effective for exploiting passive heating.

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Fig. 10 Vertical array of louvers These provide effective shading of full-height windows across a narrow walkway. They are high enough to avoid obstructing the view.

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Fig. 11 Vertical louvers for a house These provide effective light and ventilation for the southeast side of a house located in southern Florida. Provides a limited downward view.

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Fig. 12 Louvers installed as awnings These simple louver assemblies on the south side of a modest commercial building provide effective shading, along with a moderately good view of the street below. They have been lengthened to hide air conditioners installed below the windows.

Construction Specialties, Inc.

Fig. 13 Louvers arranged in a curved array The curvature is strictly for appearance. The designer has to work a little harder to figure out the louver dimensions that keep direct sunlight from striking the window.

Airolite Company

Fig. 14 Shading louvers attached to wall by brackets

■ Envelope Penetrations

Avoid actuators for movable shading that require significant envelope penetrations. These become sources of air leakage.

■ Fire Egress

Windows may be potential escape routes in the event of fire, or points of entry for firefighters. Do not install shading devices in a way that interferes with emergency use of windows.

■ Property Lines and Setbacks

If a sun shading device would extend beyond a property line or beyond the limit of a construction setback, make arrangements beforehand to use the adjacent air space.

Orientation is Critical

Some shading methods are extremely specific to compass orientation (azimuth). For example, fixed horizontal shading may leak sunlight into the building during the morning or afternoon unless it is used on a face that is oriented almost exactly due south. The same is true of vertically oriented shading that is installed on east and west faces.

Do not assume that a north face does not require shading. See Figure 16. In summer, the sun rises and sets well to the north of due east and due west, respectively. Shading of the north side is simplified by the fact that the sun is low by the time it gets around to the north face, except at low latitudes. North faces that are oriented slightly toward the east or west experience a significant increase in solar gain during summer mornings or evenings, respectively.

Construction Specialties, Inc.

Fig. 15 Shading louvers supported by columns

■ Determine the Azimuth Accurately

If you are going to retrofit shading to an existing building, you need to know the actual orientation of the building faces within an accuracy of about 10°. The compass roses on most building drawings are not precise, and hence are worthless for shading design. Instead, work from a surveyor's plot plan that has an accurate north arrow. Use directions based on true north, rather than magnetic north. True north and magnetic north may differ by 30° or more. If you cannot find an accurate plot plan, use a surveyor's magnetic compass and set it up away from any ferrous objects (including buried pipe, pavement reinforcement steel, and the magnetized screwdriver in your shirt pocket). Correct the magnetic compass reading to find the true orientation.

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Fig. 16 Vertical fins Fins are cast into these concrete wall panels. They are too shallow to keep sunlight off the north windows during summer. They do keep the wall cool by shading most of the surface area.

Account for Reflection from Surrounding Features

Reference Note 24, Characteristics of Sunlight, points out that a substantial amount of solar radiation may arrive by reflection from features that surround the building. Some of these features may be too big to ignore, such as the lake on the south side, or the glass box building next door. Reflected sunlight that arrives from an unexpected direction is likely to get past your shading devices. So, don't assume that all sunlight comes directly from the sun. Take a careful look around your property.

Account for Shading by Surrounding Features

The lower portions of tall buildings may be shaded effectively by adjacent buildings and other features. Don't spend money unnecessarily to shade these portions of the building. However, external shading may still be desirable in such cases to eliminate glare for the purpose of preserving a good view.

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Fig. 17 Awnings Canvas awnings provide effective shading for the rooms of this hotel in a warm, sunny climate. The wall to the right faces east. As you can see from the shadows, the narrowness of the awnings allows some direct sunlight to enter the windows. This could be minimized by tapering the sides of the awnings outward. The awnings provide an important decorative accent for this plain rectangular building. However, fabric has a rather short service life.

Airolite Company

Fig. 18 Shading or deco? Look at the shadow patterns. The windows on the right face southeast, and most of the sunlight is getting into them now, at mid-morning. Fixed horizontal shading works well only on a south face. If horizontal shading wraps entirely around a building, only a part of it will be very useful. Given the limited outward reach of these shades, how far south must the building be located for the shading to be effective, even on the south side?

ECONOMICS

SAVINGS POTENTIAL: *70% to 95% of the cooling load caused by the shaded glazing.*

COST: *$2 to $20 per square foot of window area.*

PAYBACK PERIOD: *In new construction, may be immediate if the cost of shading reduces the cost of the cooling equipment by an equal amount. May be several years, in other cases. In retrofit, the payback period is several years or longer.*

TRAPS & TRICKS

PIONEERING: *If you want to attract attention, this will do it. For better or worse, sun shading radically changes the appearance of a building. A major decision is whether to use fixed or movable shading. Fixed shading cannot completely block direct sunlight while preserving an open view unless it faces directly south. Movable shading requires custom engineering, custom fabrication, and maintenance. Make sure that the structural attachments have sufficient strength to withstand the strongest wind loads. Consider the effects on fire safety, window cleaning, etc. Make a study of other facilities that use sun shading, but do not expect to find perfect shading performance on all sides of a building. If you achieve it, you will be making architectural history.*

EXPLAIN IT: *If you install movable shading devices, tell the staff how it is supposed to operate. Describe the system in the plant operating manual. Install effective placards at the controls.*

MAINTENANCE: *If you install movable shading devices, maintenance is critical. Schedule periodic checks of operation in your maintenance calendar. If you have an energy management control system, use it to monitor the operation of the movable shading devices.*