External shading devices

The use of external shading devices is becoming more widespread in the UK in response to comfort requirements and energy saving requirements set out by the Building Regulations. They may be used to improve the performance of the building or simply to create a certain aesthetic. This Technical Note looks at the practical issues associated with external shading.

This Technical Note should be read in conjunction with:

TN 50 Solar gain and shading
TN 51 Environmental control glasses

Introduction

External shading devices are the most effective way of controlling solar gain in buildings with highly glazed facades. Compared with internal devices they may significantly reduce the internal solar gains within the building. Internal shading devices may however still be required for the control of glare.

The easiest way to control solar gain is through suitable use of glass (in terms of glazed areas and orientation, and glass type). This will not be appropriate for all buildings however so additional measures may have to be taken, particularly when considering highly glazed facades.

Many different shading devices may be used depending on the performance required or the architectural intent. External devices include:

- Horizontal projections
- Vertical fins
- In-plane devices (e.g. louvres with horizontal slats)
- Roof overhangs
- Window reveals

Additionally cavity, or mid-pane blinds may be employed, particular where double skin facades are used.

Many different materials may be used for the shading device depending on the performance and appearance required. Typical materials used include:

- Metals (solid and perforated)
- Timber
- Glass (coated/tinted, fritted, sand blasted, photovoltaics)

An alternative to using external shading is to use a solar control glass. Solar control glasses have the advantage that they are spectrally selective, allowing a higher percentage of visible light transmission compared to shortwave infrared; however in a highly glazed façade they are unlikely to be able to provide adequate shading alone. These are discussed in more detail in TN51.

This Technical Note has been written considering best practice for intermediate latitudes (between the arctic and the tropics) in the Northern hemisphere. Similar principles are applicable in the Southern hemisphere, however it should be remembered that the sun will be due north at 12pm as opposed to due south in the Northern hemisphere.

Building Regulations

Measures to control solar gains in buildings have been in place since 2002 for non-domestic and 2006 for domestic buildings, in order to reduce energy use for cooling. The Building Regulations Approved Documents (AD) were tightened further in the 2010 revision.

To meet AD L1A (new dwellings) there is a procedure given in SAP 2009 Appendix P. The method assesses the risk of high internal temperatures based on a calculation involving ventilation losses, fabric losses and internal gains.

AD L2A (new building other than dwellings) states:

‘reasonable provision for limiting solar gain through the building fabric would be demonstrated by showing that, for each space in the building that is either occupied or mechanically cooled, the solar gains through
the glazing aggregated over the period from April to September inclusive are no greater than would occur through one of the following reference glazing systems:

- For a side lit space, the reference case is an east facing façade with full width glazing to a height of 1m, having a framing factor of 10 per cent and a normal g-value of 0.68,
- For a top lit space (with a height less than 6m), the reference case is a horizontal roof of the same total area that is 10 per cent glazed as viewed from the inside and having rooflights that have a framing factor of 25 per cent and a normal g-value of 0.68,
- For a top lit space (with height greater than 6m), the reference case is a horizontal roof of the same total area that is 20 per cent glazed as viewed from the inside and having rooflights that have a framing factor of 15 per cent and a normal g-value of 0.46.'

This effectively means that some form of shading will be required with highly glazed facades, even if very high performance glass is used.

**Types of external shading device**

In the northern hemisphere, **overhangs, awnings and light shelves** work best on a south, south east or south west facing façade. In general a greater projection blocks more radiation, however if the window is tall and narrow, increasing the width of the overhang so that it extends beyond the sides of the window may be a better strategy than increasing its projection.

![Figure 1 Brise soleil/overhang](image)

Care should be taken to ensure that the radiation blocked by an overhang is not reflected into another part of the building, such as through the glazing directly above the shading device.

**Vertical fins** must extend beyond the top of the window to have the maximum effectiveness. For east, south east, south, south west and west orientations, fins are not particularly effective unless they are very large. Although often recommended for east and west facing windows, they are in fact least effective for these orientations as the sun’s radiation strikes the façade at near normal incidence (low angle). Fins are most effective on north (and north east and north west); however northern orientations usually will not require external shading for solar control due to the position of the sun. Fins on NE and NW facades may be useful at shading the early morning/ evening sun respectively. The colour of the fin is very important. A dark coloured fin will absorb more infrared radiation and therefore reduce the solar gain more than a light coloured fin. A lighter fin will however increase the daylight levels within the room due to the higher reflectance.

![Figure 2 Vertical fins](image)

The solar transmission through **horizontal louvres** will depend on the slat angle and spacing and their colour. In general horizontal louvres are very effective at blocking solar gain; however they block a similar proportion of daylight. For south, south east and south west orientations, louvres fixed horizontally will block most solar gain, for other orientations the slats need to be tilted. They are not the best option for north facing windows.

Shading devices need not be specific, additional items added to the façade; details such as window reveals, balconies and overhangs may also be effective at reducing solar transmittance.
External Window reveals can significantly reduce the solar radiation admitted, especially for south and north facing windows. The performance is dictated by the colour, position and depth of the reveal. Internal reveals have no impact on incoming solar gain.

An overhang or balcony will work in the same way as a horizontal projection or brise soleil.

Shading performance

The total solar transmittance is the fraction of incoming solar radiation that passes through a window and/or shading device. This is often called the g-value.

For most glazings the g-value is quoted at normal incidence (ie at an angle of 90 degrees to the surface). This does not take into account the lower transmission when the sun hits the window at an oblique angle. The effective g-value allows for this effect.

The effective g-value, $g_{\text{eff}}$, takes this angular distribution into account, and is defined as;

$$ g_{\text{eff}} = \frac{\text{Solar gain in period of potential overheating}}{\text{through window with shading device}} $$

$$ = \frac{\text{Solar gain through unshaded, unglazed aperture for the same period}}{\text{Solar gain through unshaded device}} $$

The period of potential overheating will depend on the building type and use. Littlefair (2005) defines a period from May to August as the basis of his calculations. Solar overheating is most likely to occur on clear sunny days, and therefore only the 2.5 per cent of peak days for radiation availability are used. This information is given in CIBSE Guide A.

The calculation of the effective g-value will depend on the particular glazing/shading configuration. Correction factors used in the calculations can be found in Littlefair (2005) and CIBSE (2006), which is referenced in AD L2A.

Where only glazing is used the normal incidence g-value can be multiplied by a correction term. The factors are less than 1.0 because the glazing rejects more solar gain when the sun is incident at an oblique angle, and depend on the type of glazing and the orientation of the window/ façade.

For a combination of glazing and a shading device the overall effective g-value may be calculated by calculating the individual component values separately and then multiplying them together.

Tables of effective g-values for generic shading and glazing types are available for external, internal and mid-pane devices.

See Appendix 1 for an example calculation.

For all the above cases it should be noted that such values are guides only. Where solar gain is important, it is better to use more advanced techniques, such as specific computer software or by calculating the effective g-value from first principles.

Effective g-values can be calculated from first principles, by combining directional transmittance data for a window, with or without a shading device, weighted by the amount of radiation reaching the window from different directions.
For moveable shading $g_{eff}$ is found from weighting the average of the effective g-value for the window with the moveable shading in place and the effective g-value of the window without the moveable shading.

The fraction of time that the shading device is used will depend on the control and operation strategy, with different values given depending on whether the shade is manually operated, automated with manual override or fully automated.

For all types of solar protection devices parallel to the glazing such as louvres, Venetian, or roller blinds, BS EN 13363 gives both a simplified (Part 1) and detailed (Part 2) method to determine the total solar energy transmittance and other relevant solar-optical data of the combination. This applies to internal, external and mid-pane devices.

**Daylight**

Ensuring adequate daylight in buildings is predominantly a winter issue. All shading devices will block some daylight. This may be reduced by using:

- Adjustable shading,
- Diffusing devices,
- Redirecting devices,
- Devices designed to only block the direct sun, whilst still allowing diffuse light to pass,
- Environmental control glass,
- Deciduous planting.

In order to achieve the optimum performance from a shading device it must be controllable. The major problem with fixed shading is that it always provides shade, regardless of the external conditions. This may provide unfavourable internal conditions which lead to an increased use of energy through heating, cooling and lighting. A device that can move so that it only provides shade when there is direct sun on the façade, and allows natural daylight through at other times will result in a more efficient building with a better internal environment.

Diffusing devices, such as transparent insulation materials (TIMs) or capillary glass reduce direct solar transmission; however they can become bright surfaces which can cause discomfort glare to occupants. In addition they are not actually transparent (rather they are translucent) and therefore cannot be used where a view out (or in) is required.

Redirecting devices such as light shelves can be designed to stop direct sunlight reaching the working plane, instead directing it on the ceiling and therefore increasing the daylight penetration in the room.

The shading used at the BRE Environmental Building has a dual function. When direct sunlight is incident on the façade the external louvres rotate to block the sun. When this has passed, the louvres rotate further and redirect daylight into the building, reducing the use of electric lighting.

![BRE Environmental Building external louvres](image)

Shading can be adjusted according to seasonal requirements, daily weather or occupant requirements. See the CWCT report on automated facades for further details.

The position of a horizontal projection/brise soleil will also influence the amount of daylight that is blocked. On a sunny day there will always be sufficient daylight, however when it is overcast, the reduction in daylight can be significant and result in increased use of electric lighting.

In terms of solar gain reduction, it does not matter which part of the window is blocked (upper, lower etc). Consideration should therefore be given to trying to maximise the natural daylight into the building.

To maximise the daylight penetration into a space it is necessary to admit light from as high an angle as possible, as illustrated in Figure 6.
In addition to this the luminous exitance (brightness) at the horizon is some 40 per cent of that at the zenith (directly overhead).

Brise soleil are traditionally placed at the head of the window. Not only does this effectively reduce the height of the window and therefore reduce the daylight penetration, but it also blocks the part of the sky which is brightest and thus further cuts the overall light level in the space.

A brise soleil placed at the mid-height of a window will reduce the solar gain entering through the window by the same amount as one placed at the head, whilst improving the penetration and amount of daylight.

Fixed vertical fins also offer better daylight performance than horizontal projections. This is because they block the sun from certain azimuths (horizontal angles) rather than certain altitudes (vertical angles) and therefore do not stop high altitude daylight entering a building. This is particularly useful when overall daylight levels are low, such as under overcast conditions.

This can be illustrated on the Waldram diagrams shown below, where the grey areas represent the shading device and the blue areas the sky, as seen through a window. See Appendix 2 for further details.

The Building Regulations do not specify minimum daylight requirements. They point the reader to BS 8206-2, Code of practice for daylighting, which gives guidance on maintaining adequate levels of daylight. Building Bulletin 90 gives advice on daylighting in schools.
A concern with any shading device is that they may significantly affect an occupant’s view out of a building, which can have an effect on satisfaction and wellbeing. The extent of this will depend on the type, size and position of the shading device. This is illustrated in Figure 12 below.

Overhangs/brise soleil, etc. tend to block a view of the sky but still allow vision around and below the horizontal Figure 12(a).

Vertical fins allow a view of the sky but may restrict vision to either side of the window.

Horizontal louvres can block a large proportion of the view out of a window if care is not taken to avoid it, Figure 12(b). If the slats are very closely spaced the view out will be reduced further, as well as giving potential problems of stripes of daylight/shade within the building.

In order to maximise the view out whilst providing sufficient shade the louvres should be placed away from the façade, Figure 12(c). This allows them to be situated above the window, thus allowing a clear view out. This can be seen in the BRE Environmental Building below, where the louvres are approximately 1m from the plane of the façade.

Thermal performance

The use of brackets to support an external shading device may have a significant affect on the thermal performance of a curtain wall. Brackets often bridge the insulation of the wall, bypassing the thermal break in a mullion or penetrating the insulation in a rainscreen.

Brackets are often connected to the nose of a curtain wall mullion where they form a severe
point thermal bridge. The point thermal transmittance (which represents the thermal bridge) may be as high as 0.4 – 0.5 W/K for a simple aluminium bracket, but can be reduced to around 0.1 W/K for more complex designs, that incorporate a thermal break.

![Figure 14 Typical curtain wall brise soleil bracket detail](image)

The brise soleil brackets in a rainscreen should be treated in the same way as the support rails and brackets.

The resulting increase in heat flow (increase in the overall U-value) can usually be compensated for by improving the performance elsewhere, such as thicker insulation in spandrel areas, or a higher specification glass.

However there may be a condensation issue due to much lower frame and glass temperatures. The performance may be improved by using stainless steel as opposed to aluminium brackets, and by the addition of thermal isolators to reduce the heat loss.

Figure 15(a) shows a thermally broken aluminium mullion. The thermal break means that there is little heat flow and the mullion back box remains warm (approximately 15°C).

Figure 15(b) shows an aluminium bracket that penetrates the thermal break. The mullion back box is now much cooler (approximately 8°C) which will significantly increase the risk of condensation formation.

![Figure 15 Temperature distribution of a mullion](image)

### Cleaning/access

External shading devices, particularly horizontal brise soleil may obstruct access for construction and maintenance. They may also increase the need for maintenance as they may collect dirt and moveable devices may require adjustment and lubrication. Some shading devices can provide ideal nesting sites.

Access equipment may need to be modified, for example cradle supports may need to be extended to project past horizontal shading devices. Counterbalanced cradles may be provided to reach below projections, as shown in Figure 16.
An alternative solution would be to use the brise soleil themselves as the access platform. This obviously puts additional loads both on the shading device and the wall, and therefore both must be designed accordingly. If the shading device obstructs the façade then consideration must be given to how it will be cleaned and maintained. The figure below shows a series of vertical fins used as shading. In this example the glass is cleaned by squeegee working through the vertical blades. This may be both difficult and time consuming.

Some external shading devices are moveable, allowing closer access to the façade; however this may not be sufficient to carry out all necessary cleaning and maintenance. Inward opening windows may be used to gain access to the external façade for cleaning, however this leads to other issues such as increased costs, higher U-values, and reduced useable floor area around the perimeter of the building.

External shading devices lose heat to the outside by convection currents and through longwave radiation. Longwave radiation emission can be a particular issue in hot climates where the shading device may store a large amount of heat, which can then radiate into the building, adding to the internal gains. It is therefore vital that there is a suitable means of removing the heat build up within the cavity.

Walls may be designed to allow glazing replacement from inside. However this may not be possible and limits the size of glazing unit that can be used. Otherwise it is necessary to have demountable shading devices to allow for replacement from the outside.

**Double facades**

Placing external shading devices within the cavity of a double skin façade façade removes the projections, thus eliminating some of the access problems mentioned above. This allows cleaning of the outer façade. It does not obviate the need to clean (dust etc) within the façade cavity.

A further advantage of placing external shading within the cavity of a double skin façade is that the components required to automate them will also be protected. The reliability of actuators when positioned outside of the building is a concern to many clients. A double façade goes some way to improving durability and reliability so alleviating those fears. Shading devices within the cavity will also be protected from the wind, which may be important for taller buildings.
This may be supplied by either natural or mechanical ventilation.

**Structural considerations**

Brise soleil/external shading devices have to be either integrated with the curtain wall or a free standing structure. This requires discussion between the architect, specialist contractor and structural engineer.

Loadings on any external shading device include:

- Self-weight
- Wind load
- Snow load

A horizontal shading device may also have to withstand access loads if they are to be used as work platforms for cleaning and maintenance of the façade.

**Wind loading**

It should be noted that wind moves across the surface of a façade. When this flow impinges on a shading device it causes forces on the shading device that may be upwards or downwards on a horizontal shelf. Vertical fins will have a horizontal force on them.

- The building geometry,
- The position on the building,
- The design of the shading device (e.g. open slats, mesh or solid shade).

If considering a design whereby the shading is pinned and then tied back to the mullions, it is essential to ensure that the moment connection between the bracket and the frame is sufficient to resist the upward wind load.

There are no specific test methods/standards that deal with the structural performance of external shading devices. A dynamic pressure test (aero engine test) may be specified to ensure that the system (shading device, fixings, wall etc) are able to withstand the imposed dynamic forces and movement.

**Structural solutions**

Horizontal shading devices may be attached to the building in various different ways including:

- Cantilevered from the floor slab,
- Cantilevered from mullions,
- Pinned to mullions and tied back,
- Cable supported,
- Free standing.

If the horizontal brise soleil are cantilevered from the floor slab the bracket will penetrate through the wall and may form a severe thermal bridge. In addition the brise soleil may not be at the optimum height to provide the best shading performance, and the risk of air or water leakage may be greater.

![Wind direction](image)

**Figure 19** Flow patterns around rectangular buildings

The precise load will depend on a number of factors including:

- The wind speed and direction,
- The wind direction.

If the horizontal brise soleil are cantilevered from the mullions the rigid connection required may also introduce a point thermal bridge. This will also place an additional bending load on the mullion. The advantage of this method of construction is that the height of the brise soleil...
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is flexible so they can be placed in the optimum position.

Figure 21  Horizontal brise soleil cantilevered from the mullions

In order to reduce the bending moment in the wall the devices may be pinned to the mullions and then tied back to the wall. This results in a small additional load on the mullions, as well as having the potential to reduce the point thermal transmittance due to the smaller pinned connection. The height of the brise soleil is flexible and they may also be hinged so that they can be retracted for cleaning and maintenance purposes.

Figure 22  Horizontal brise soleil pinned to mullions and tied

To eliminate any additional bending loads in the mullion the brise soleil may be supported by a cable from the top. This has all of the advantages listed before and may also be anchored to the ground to resist wind uplift.

Figure 23  Horizontal brise soleil pinned to mullions and cable supported

A free-standing structure may be used. This places no additional loads onto the mullions. This solution may be more expensive and may be more difficult to procure since a separate contract package may be required.

Figure 24  Free-standing structure

In addition to the bending moments induced in the mullions, deflection of the mullion and brise soleil must also be considered.

Vertical shading devices

The self-weight of a vertical shading device can be transferred to the wall, for instance to a mullion, using relatively small connectors to transfer the vertical and a small horizontal secondary load.

Wind load caused by wind movements parallel to the wall and particularly around corners acts orthogonal to the plane of the shading device. If this is resisted by connecting the shading device to a mullion the wind load will cause torsion in the mullion and high stresses in the
shading device bracket, connectors and walls of the mullion.

An alternative solution may be to connect the shading device to the transoms. The shading device connectors can now be spaced further apart to reduce the stress in them. An additional moment will be created in the transom but this does not always mean that a deeper transom profile is required.

**Brackets**
The bracket may be pinned to the nose of the mullion or screwed through. Reinforcement, in the form of a spigot or insert may be required in the back box of the mullion in order to provide sufficient stiffness, and to avoid deformations.

![Bracket connection to mullion](image)

**Design and specification**
Outline design must be done at an early stage as it will affect planning.

The shading may be fully detailed by the architect, whereby the required performance would be specified and drawings of the system produced.

Alternatively the specialist contractor may be responsible for the design of the external shading. An effective g-value should be given by the architect/services engineer, with the exact details left to the specialist contractor.

Increasingly systems companies are producing their own shading components. These have the benefit of ensuring compatibility and will complement the rest of the wall.

Alternatively a pick-and-mix approach may be taken whereby off-the-shelf products are used. With this method it is vital that the components selected are compatible and all interfaces are detailed correctly to ensure that the overall performance of the wall is not affected. Approval from the curtain wall contractor/supplier may be required where alterations to the original system need to be made.

Specification and calculation are covered in TN50.

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CWCT
The Studio, Entry Hill, Bath, BA2 5LY

T: +44 (0) 1225 330945
cwct@cwct.co.uk
www.cwct.co.uk
Calculating effective g-values

The following example shows how to calculate the effective g-value of a combined window and shading device. The calculation is carried out for the south and west facing facades to demonstrate the effect that the orientation has on the final result. The values are taken from Littlefair (2005).

South and West facing windows, clear glass, overhang at the head of the window (full width, depth equal to 0.6 times the height of the window).

\[ g_{\text{glass}} = 0.76 \text{ (normal to the glass)} \]

Factor to convert normal g-value to \( g_{\text{eff}} \):

- South: \( g_{\text{eff}} = 0.828 \)
- West: \( g_{\text{eff}} = 0.923 \)

Correction factor for overhang:

- South: \( = 0.531 \)
- West: \( = 0.717 \)

Therefore

\[ g_{\text{eff (south)}} = 0.76 \times 0.828 \times 0.531 = 0.334 \]
\[ g_{\text{eff (west)}} = 0.76 \times 0.923 \times 0.717 = 0.503 \]

The above calculation reinforces the knowledge that an overhang/brise soleil is most effective at providing shade on a south elevation as the sun is higher in the sky.
Using Waldram diagrams

Sophisticated computer simulations can tell the designer the daylight reduction caused by a brise soleil/shading device, however such software is not available to all. The Waldram diagram is a quick and easy way to investigate the affects of a shading device.

The scales on a Waldram diagram are such that illuminance is proportional to area, and therefore by measuring the area of the shading device on the diagram (which can simply be done by counting squares) the reduction in daylight can be estimated.

In the example below the window, excluding any shading had an area of 25 squares. The brise soleil at the head of the window covered an area of 8 squares, resulting in a 32 per cent in the daylight available. The same brise soleil 0.5 m below the head of the window covered an area of 6.5 squares and therefore reduced the daylight available by 26 per cent.

Figure A2  Brise soleil at the head of a window (left) and 0.5 m below the head of a window (right)