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The Sustainable Sun Shading Device for Commercial Building – National Singapore Library

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Abstract

This paper present the aspects of the sustainable sun shading device to building environment. Sun Shading devices affect natural lighting, ventilation, sola gain, to the overall building. Besides, it is used to provide shade, covered for private place and also vary the facade. Using shading devices implementing bioclimatic design concepts can provide maximum comfort to the occupants and the usage of energy minimally. Sun shading device efforts to reduce the energy load have been done by blocking and filtering the sunlight into the building. This is critical for occupant visual and thermal comfortable for minimizing mechanical cooling loads. Direct sun is acceptable in less demanding spaces, such as circulation zones, lobbies, eating areas, etc.

Key-word: - shading device, bioclimatic and energy saving

1. Introduction

The research study base on sun shading devices that believe it can be a parts of a building or separately placed from a building facade, affect the natural lighting and ventilation, solar gain, and overall building performance. Majority commercial buildings serve as new type of urban development, which harmonizing the societal needs for space with the rising concerns of ecological design sensitivity. Special care on sensitivity of natural lighting that should be conserving in spaces. The usage of sun shading in the multi-story building give positive effects (as expected), and also enable the appearance of negative effects, in the comfortable and construction cost. However, it also depend on sun shading type and shape, building mass, building function, geographical position, building site condition, etc. In optimizing of sun shading at the building, in term of comfortable and reduce the incoming heat and the solution risk of overheating and also reducing cost, which implemented in design process.

2. Problem Statements

Overheating has become particularly problematic in the fashion of glass facades in urban ‘sculpture’. This is because adequate attention is not given to balanced daylight design. Large area for glazing to give adequate light levels will then leads too much sun shine falling through the window will cause more heat. So the building overheats, the conventional response is to

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resort to air conditioning. Therefore shading system have to be designed on specifically for each orientation of facade and for the various needs of building occupancy.

3. Shading Design

The design of shading devices can be quite complex. However, in their absence, and with a understanding of the mechanics of sun position and sun-path diagrams, manual methods should 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 we should know, 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 aim of good shading design is to utilize these characteristics to best advantage, usually complete exclusion in summer and maximum exposure in winter.

4. Rules of 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 there are many variations to these basic types.

Orientation	**Effective Shading**
North (equator-facing)	Fixed horizontal device
East or West	Vertical device/louvres (moveable)
South (pole-facing)	Not required

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.

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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. The 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 = atan(tan(altitude) / cos(HSA))

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

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.

Shade Depth
The depth of the shade is given by:

depth = height / tan(VSA)

The width is given by:

width = depth * 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.

6. External vs Internal Shades

Both external and internal shades control heat gain. External shades are more effective than internal shades because they block the solar energy before it enters the window. When using an internal shade, such as blinds or a curtain, the short-wave radiation passes through the glass and hits the shade. Depending on the colour of the shade, some percentage will be reflected straight back out the window, but the rest will be absorbed by the shade itself, effectively heating it up. The energy from the hot blind is given off as long-wave radiation, half into the space and half from the other side back towards the window. As discussed in the greenhouse effect topic, window glass is opaque to long-wave radiation so it gets trapped between the window and the blind and ends up heating the air within this space. This heated air will tend to rise, exiting out the top and drawing in cooler air from below. This forms quite an effective thermo syphon that continually draws cool air from the bottom of the space, heats it up and pushes it out the top underneath the ceiling. Over a whole day this can significantly increase internal room temperatures. Also, as the return-air ducts of most air conditioning systems are in the ceiling, this hot air can add significantly to air-conditioning loads.

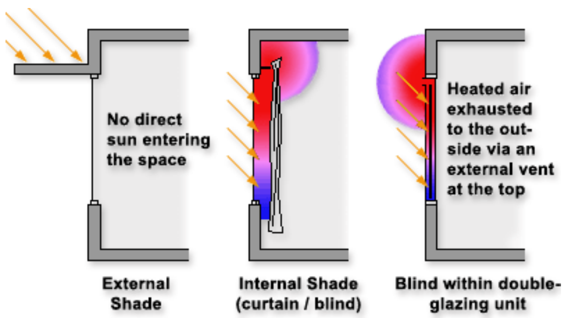


Figure 2 - The effects on internal heat flow of external versus internal shades.

Thus, even though internal and external shades seem to be doing the same job (protecting the occupants from solar radiation), their effect on the performance of the building is quite different. Where possible you should always use external shading devices. If you must use internal shading devices, then:

- The best option is to house them inside a double glazed unit with vents at the top and bottom of the external leaf. This isolates the heat from the blind and makes the long-wave opacity of glass work for you not against you. There are many such products commercially available.

The next best option is to use a sealed unit that, when closed, does not allow the vertical circulation of air. This can be as simple as long curtains that extend down to and rest on the floor (retarding the entry of cool air) with a sealed pelmet at the top (retarding the exit of heated air from the top).

7. Shading Strategy

Exterior Devices

Use exterior shading, either a device attached to the building skin or an extension of the skin itself, to keep out unwanted solar heat. Exterior systems are typically more effective than interior systems in blocking solar heat gain.

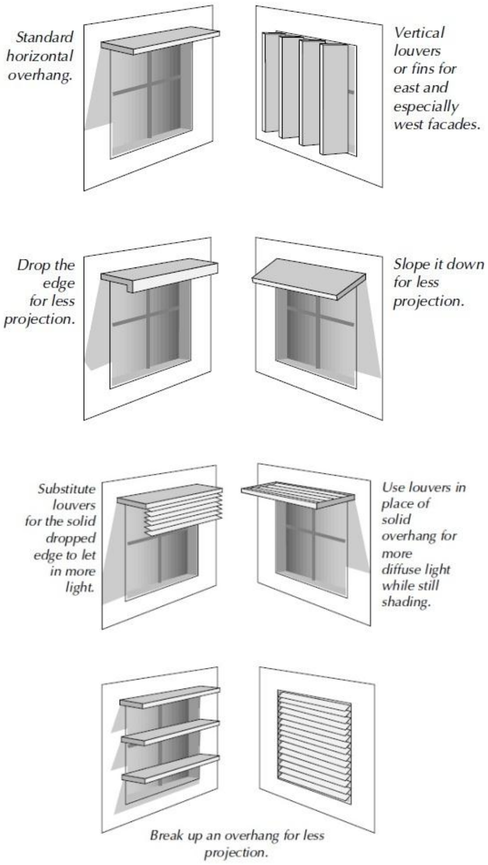
Design the building to shade it. If shading attachments are not aesthetically acceptable, use the building form itself for exterior shading. Set the window back in a deeper wall section or extend elements of the skin to visually blend with envelope structural features.

Use a horizontal form for south windows.
For example, awnings, overhangs, recessed windows. Can be used on the east and west side. No function on the north.

Use a vertical form on east and west windows.
For example, the vertical fins (recessed windows). It is useful on the north to block early in the morning and late in the afternoon when the sun is low.

Give west and south windows shading priority.
Morning sun is usually not a serious heat gain problem. If the client's budget is tight, invest in west and south shading only.

Design shading for glare relief as well. Use exterior shading to reduce glare by partially blocking occupants' view of the too-bright sky. Exterior surfaces also help smooth out interior daylight distribution.



The shade's colour modifies light and heat. Exterior shading systems should be light colour if diffuse daylight transmittance is desired, and dark colour if maximum reduction in light and heat gain is desired.

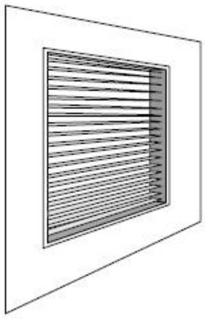
Fixed Shading versus Movable Shading.
Fixed devices are the selection for those budgets is tight. Use movable devices for more efficient use of daylight and to allow occupant adjustment; first cost and maintenance costs are higher than with fixed devices. Use movable devices that are automatically controlled via a sun sensor for the best energy savings. Reliable systems have been in use around the world for years and have only recently become available as cost-effective options in the United States.

In the Window Plane
Use exterior shades for a smooth facade. Exterior shade screens are highly effective on all facades and permit filtered view.

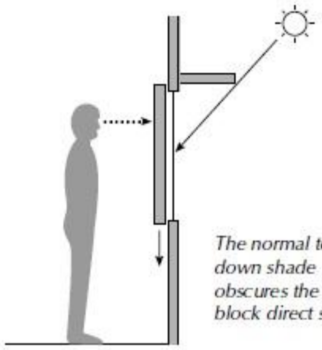
Use roller shades for a movable alternative. Open weave exterior shades are not as effective, but acceptable.

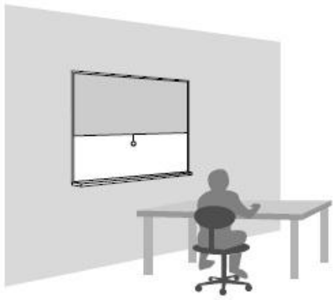
Don't rely on dark glazing.
Glazing treatments (reflective coatings, heavy tints, and reflective retrofit film) can be effective at reducing heat transfer. They allow direct sun penetration but with reduced intensity. This may not be an effective shading strategy from an occupant's perspective unless the transmittance is very low to control glare, e.g., 5-10%. Fritted glass, with a durable diffusing or patterned layer fused to the glass surface, can also provide some degree of sun control, depending upon the coating and glass substrate properties, but may also increase glare.

Within the glass systems. Several manufacturers offer shading systems (e.g. blinds) located between glazing layers. Some are fixed and others are adjustable. See the related comments on interior devices.

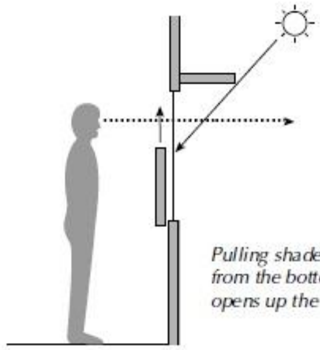


An exterior shade screen fits neatly within window framing, a bit away from the glass. Design for easy removal for cleaning.





Shades, blinds, and draperies are the categories of interior shading products.



Interior Devices

Interior shading alone has limited ability to control solar gain.
All interior systems are less effective than a good exterior system because they allow the sun's heat to enter the building. They also depend on user behaviour, which can't be relied upon.

If interior devices are the only shading, specify light colours
in order to reflect the sun's heat back out. Light-colored blinds or louvers are best. Light-colored woven or translucent shades are acceptable, but may not control glare under bright summer conditions.

Interior shading is best used for glare control and backup shading.
Supply user-operated devices that occupants can adjust to their individual comfort needs.

Use devices that still allow daylight in. Blinds and open weave shades are good choices for filtering but not blocking all light.

Don't use dark devices unless exterior shading is used.
Dark colour interior devices offer only small energy savings. Open weave shades are easiest to see through if their interior surface is dark, but perform best if their exterior surface is light colour.

8. Integration Issues

Architecture
-Projections work well with an articulated or layered facade and can integrate well with structural members.
-Exterior screens can make windows look dark.
-If interior devices are the only shading, many occupants will always keep them closed. This can mean the window is permanently no longer transparent.
-Use exterior shading to avoid the facade clutter of variously adjusted interior coverings.

Interior
-Choose light-colour window coverings for -best energy savings and comfort.

-Choose interior window treatments that allow occupants to make adjustments for individual comfort needs.

HVAC

-Good shading provides cooling load reductions. The mechanical engineer should perform calculations that include shaded windows, but acknowledge that not all shading systems will be deployed when needed.

Lighting

-Shading devices modify the intensity and distribution of daylight entering the space. Lighting design scheme and placement of control zones may be affected.

Cost-effectiveness

-Proper shading devices can be partially or fully paid for by reduced cooling equipment and cooling energy costs. However the likelihood of proper use by occupants must be accounted for Mechanical engineer should calculate these savings. Compare to any additional construction costs for the shades and calculate simple payback for the shading.

-Automated movable systems can have an added maintenance cost and a higher first cost relative to other shading schemes. However, the operation should be more reliable than with manually operated systems.

-Careful calculation of expected energy savings are needed to determine cost-effectiveness for this approach.

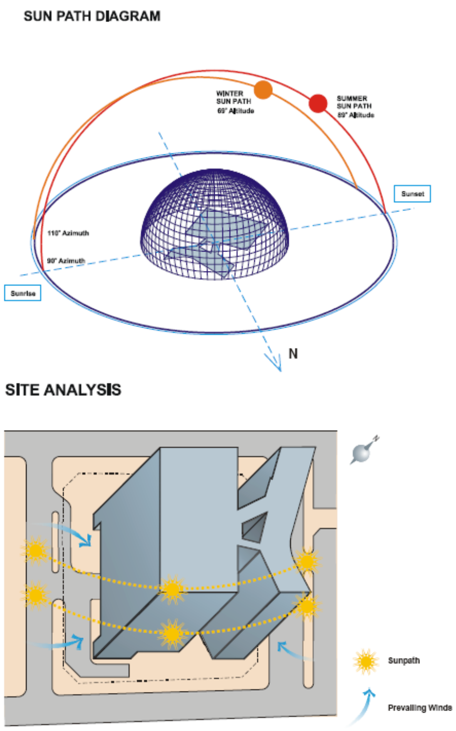
Occupant Comfort

-Direct sun in the workplace is almost always a comfort problem. Uncomfortable occupants will be less productive, close their window coverings, bring in energy-using portable fans, and reduce thermostat setting if possible. Good shading means occupants will have minimal complaints.

-Shading reduces glare. Exterior elements partially shield occupants' view of the bright sky. Screens, glazing treatments, and shades reduce the brightness of the window. Exterior elements and venetian blinds reduce contrast by sending some light deeper into the space (improving distribution).

9. Case Study

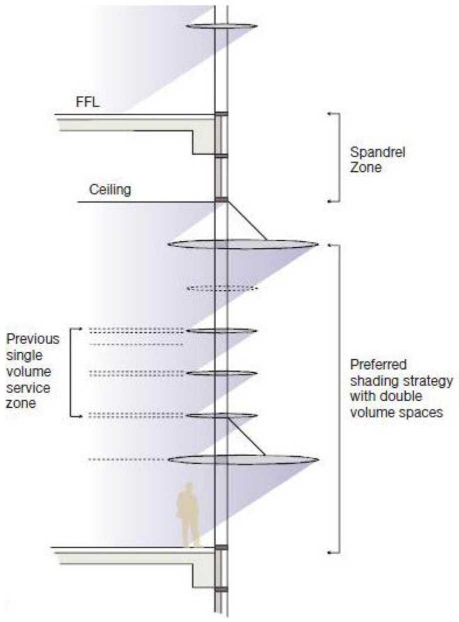
Singapore's National Library embraces innovations in information and communications technology, building physics, fire, and façade engineering to create a knowledge hub for the 21st century.

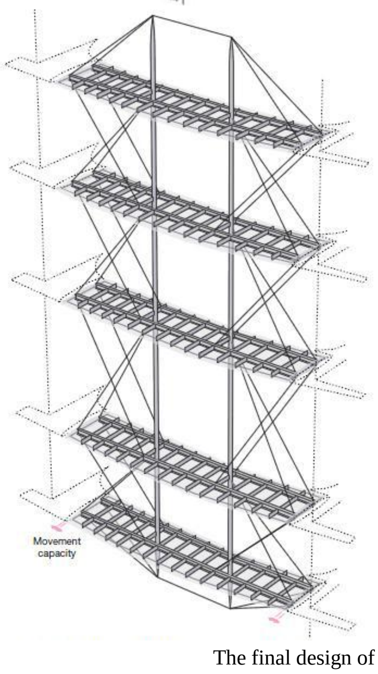


Singapore is hot and humid. It's warm and humid year round, with the temperature almost never dropping below 20°C , even at night, and usually climbing to 30°C during the day. Recent times, it even reached till 35°C. Humidity is high, mounting over a 75% mark.

Design for tropical conditions

The building had to be able to respond to the tropical climate. Solar heat, humidity, and light could potentially make it very uncomfortable for its occupants and threaten the important collection. The facade design was crucial in both respects. The building had to be heavily shaded to reduce solar heat gain through the facade, and so a 30˚ solar cut-off was adopted, ie there should be no direct sunlight visible in the building when the sun was 30˚ and more above the horizon. Though almost no direct sunlight should enter the building between 10am and 4pm, as much useful daylight as possible still had to penetrate so as to allow artificial light to be reduced. Sunshades on a curtain wall, projecting up to 1.8m from the face of the glass. These wrap around the building and control solar radiation and glare, yet maximize daylight. These wrap around the building and control solar radiation and glare, yet maximize daylight. To speed installation and to avoid the difficulty of fixing in mid-air, they were attached to the curtain wall before erection. The need to support the sunshades and the 5.4m storey height led to the curtain wall mullion being 250mm deep - the maximum available for most aluminium extrusions. It was accepted that part of the shades could be located inside the building as these would also cut the sunlight, but any energy in the radiation that had passed through the solar selective glazing would still enter the building. For the typical curtain wall panels, these shades were supported by deep steel plates projecting out of the aluminium mullions, in combination with tie rods. These were added at site, allowing the panels to be transported flat. Each shade had the same basic construction but the form was modified to create the intended sweeping lines. Clear double-glazing completes the facade, coated to cut down on energy transfer from solar radiation and ambient temperature.





The final design of the laneway sunshades recalls a World War One trip lane

Some areas of the building have automated drop-down blinds that engage when the sun is too low for the sunshades to be effective. The pattern of shades continues around the building. Between the two main blocks, they span up to 6m wide and 14m long, but only 400mm deep. Together with natural breezes, the shades here create a dramatic enclosed environment which, though in a humid tropical climate, remains comfortable. From the start, the architect conceived these shades as being tied together by pairs of vertical tubes that do not reach the ground; and, as the shades are a continuation of the main shades for the curtain wall; they need to be as thin as possible. The structural concept developed into a floating framework of steel frames supported on bearings on the main blocks each side of the laneway.

Laneway Sunshades

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The beauty of glass versus the challenge of light

The main contractor undertook a comprehensive study in which the visual light transmission of the glass in combination with the position of the shades was checked using a complete three-dimensional model of the building. The library needs to be a quiet place, so the curtain wall was also subjected to acoustic testing, both for transmission of sound into the library spaces and to review the noise from rain falling on the aluminium sunshades. Ensuring a good indoor environment quality for their users.

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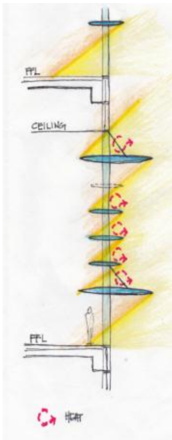
This section describes about the analysis of the building without sun shading devices. It will make a lot of heat in the building and the rate of energy use will getting higher. If propose the sun shading device for the building, it will protect the sun heat direct go in to the building and the building can save more energy example like electrical and it was enough of day lighting. The ventilation is getting better when the green landscape let the wind flow come in to building and make the building more comfortable with the environment.



Conclusion

As a result, Dr. Yeang reduced projected energy consumption to 185 kilowatts hour per square meter per year, well below 230 kW / m ² per year, the amount used by a typical office tower in Singapore. (The research according to the Leadership In Energy and Environment Design (LEED))

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