

Shading: A Simple Technique For Passive Cooling And Energy Conservation In Buildings

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Learning about different methods employed to shade a building leading to natural cooling and energy conservation.

Buildings consume significant large amount of energy for cooling, heating, ventilation and lighting to create desirable thermal comfort conditions. In warm and tropical climates, excess solar gain may result in high energy consumption. The depletion of conventional energy and high cost of non-conventional energy enforces a demand for energy conscious designs of buildings. Natural and passive cooling uses non-mechanical methods to maintain a comfortable indoor temperature. Natural cooling can be achieved by proper layout and orientation of building, appropriate shape, insulation, high thermal capacity and resistance of the building materials, good landscape design, proper shading devices, overhangs, external surface finish.

The most effective method to cool a building in summer is to keep the heat from building up in the first place. The most important passive cooling strategy, regardless of mass, is shading. Shading is a simple method to block the sun before it can get into the building. The primary source of heat buildup (i.e., gain) is sunlight absorbed by the building through the roof, walls, and windows. Secondary sources are heat-generating appliances in the building and air leakage. Shading can reduce the peak-cooling load in buildings, thus reducing the size of the air conditioning equip-

ment that will run fewer hours and consume less energy. Shading minimizes the incident solar radiation and cools the building effectively and hence dramatically affect building energy performance. Energy savings can range anywhere from 10 to 40 percent. In this paper different methods that can be employed to shade the buildings, which provides natural cooling and finally helps in energy conservation in buildings have been discussed.

SHADING OF BUILDINGS

The performance of solar passive cooling techniques such as solar shading, insulation of building components and air exchange rate was evaluated. In the study a decrease in the indoor temperature by about 2.5°C to 4.5°C is noticed for solar shading. Results modified with insulation and controlled air exchange rate showed a further decrease of 4.4°C to 6.8°C in room temperature. The analysis suggested that solar shading is quite useful to development of passive cooling system to maintain indoor room air temperature lower than the conventional building without shade [1]. Although shading of the whole building is beneficial, shading of the window is crucial. The total solar load consists of three components; direct, diffuse and reflected radiation. To prevent passive solar heating, when it is not wanted,

a window must always be shaded from the direct solar component and often so from the diffuse and reflected components.

Decisions on where and when to include shading can greatly affect the comfort level inside a closed space. Shading from the effects of direct solar radiation can be achieved in many ways:

- Shade provided by the effect of recesses in the external envelope of the building.
- Shade provided by static or moveable external blinds or louvres.
- Transient shading provided by the orientation of the building on one or more of its external walls.
- Permanent or transient shading provided by the surrounding buildings, screens or vegetation.
- Shading of roofs by rolling reflective canvass, earthen pots, vegetation etc.

The different criteria of shading of buildings for various climatic zones have been given by Bansal [2]. They are given in the following table.

Table 1: Criteria of Shading for Various Climatic Zones (Bansal et. al. 1988)

CLIMATIC ZONES	REQUIREMENTS
Hot and Dry	Complete year round shading
Warm and humid	Complete year round shading, but design should be made such that ventilation is not affected
Temperate	Complete year round shading but only during major sunshine hours
Cold and cloudy	No shading
Cold and sunny	Shading during summer months only
Composite	Shading during summer months only

SHADING BY OVERHANGS, LOUVRES AND AWNINGS ETC.

Well-designed sun control and shading devices, either as parts of a building facade, can dramatically reduce building peak heat gain and cooling requirements and improve the natural lighting quality of building interiors (Fig. 1). The design of effective shading devices will depend on the solar orientation of a particular building facade. For example, simple fixed overhangs are very effective at shading south-facing windows in the summer when sun angles are high. However, the same horizontal device is

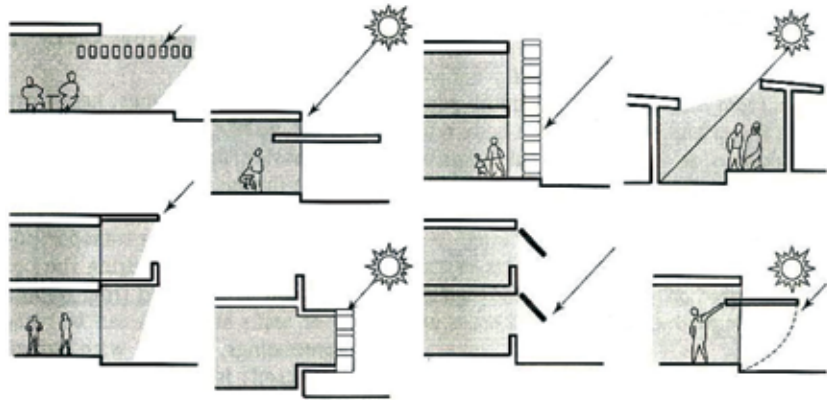


Fig. 1: Different types of shading devices.

In a research conducted at Division of Energy and Building Design at Lund University, it was investigated that the performance of various internal and external shading devices in offices compared to outdoor measurements by using the simulation software ParaSol version 2.0. ParaSol is a dynamic energy and solar transmittance simulation software for comparison of various solar shading devices. One study showed that both the cooling load and the annual cooling demand could decrease by a factor of two by using external solar shadings. For internal solar shadings the cooling load and the cooling demand decreased only by one third. The general conclusion of this study is that external

shadings are much more efficient than internal shadings. This can also affect the design of the HVAC-system, leading to smaller installations. The result of another study showed that the efficiency of the solar shadings increased with decreasing window absorption [3]. Givoni analysed the efficiency of various types of fixed shading devices in different orientations and concluded that in all orientations, horizontal shading is more effective than a vertical one. Other advantages of horizontal projections over vertical projections are; (i) vertical device is not applicable for shading the whole length of facade (ii) vertical device reduces daylight penetration more than horizontal projection (iii) vertical projections will reduce the extent of external view [4].

Given the wide variety of buildings and the range of climates in which they can be found, it is difficult to generalize the design of shading devices. However, the following design recommendations generally hold true [5]:

1. Study of the sun angles is important for designing the shading devices. An understanding of sun angles is critical to various aspects of design including determining basic building orientation and selecting shading devices.
2. Fixed shading devices, using correctly sized overhangs or porches, or design the building to be "self-shading" should be installed. Fixed shading devices, which are designed into a building, will shade windows throughout the solar cycle. Permanent sun shades may be built into the building form and this is often given the French terminology of - brise soleil (Fig. 2). They are most effective on the south-facing windows. Awnings that can be extended or removed can also be considered for shading the windows. The depth

and position of fixed shading devices must be carefully engineered to allow the sun to penetrate only during predetermined times of the year. In the winter, overhangs allow the low winter sun to enter south-facing windows. In the summer, the overhangs block the higher sun.

3. Limit east/west glass. Glass on these exposures is harder to shade from the eastern morning sun or western evening sun. Vertical or egg-crate fixed shading works well if the shading projections are fairly deep or close together; however, these may limit views. The use of landscaping can also be considered to shade east and west exposures. North-facing glass receives little direct solar gain, but does provide diffuse daylight.
4. In hot and dry climates, the movable blinds help to reduce the convective heat gain caused by the hot ambient air. In warm and humid climates where the airflow is desirable, they impede ventilation. In composite climates, the light colored/ reflective blinds block the solar radiation effectively.
5. Internal shading, in the form of blinds or curtains, is often used to block the unwanted solar gains coming through a window. The effectiveness of any shading device located inside the window is a function of how well it reflects short wave radiation back out through the glass. Darker blinds or curtains may reduce solar penetration into the space and may be helpful, but not as effective as exterior shading because it still convert most of the sunlight into heat within the building envelope since heat has already penetrated the building [6].
6. Any shading device will affect the view out of a window and this



maybe a crucial factor in favouring one form of shading over another form. If shading devices are used, they will have a major, if not an overwhelming affect upon the external appearance of a building, and therefore they need to be considered at the outset if they are to be used [7].



Fig. 2: Brise soleil – shading devices integrated with the building facade

SHADING OF ROOFS

Shading the roof is a very important method of reducing heat gain. Roofs can be shaded by providing roof cover of concrete or sheet or plants or canvas or earthen pots etc. Shading provided by external means, particularly a roof, should not interfere with nighttime cooling. A cover over the roof, made

of concrete or galvanized iron sheets, provides protection from direct radiation. Disadvantage of this system is that it does not permit escaping of heat to the sky at nighttime.

A cover of deciduous plants and creepers is a better alternative. Evaporation from the leaf surfaces brings down the temperature of the roof to a

level than that of the daytime air temperature. At night, it is even lower than the sky temperature.

Covering of the entire surface area with the closely packed inverted earthen pots, as was being done in traditional buildings, increases the surface area for radiative emission. Insulating cover over the roof impedes heat flow into the



Fig. 2: Brise soleil – shading devices integrated with the building facade

building. However, it renders the roof unusable and maintenance difficult.

Another inexpensive and effective device is a removable canvas cover mounted close to the roof. During day-time it prevents entry of heat and its removal at night, radiative cooling. Painting of the canvas white minimizes the radiative and conductive heat gain.

SHADING BY TREES AND VEGETATION

Proper Landscaping can be one of the important factors for energy conservation in buildings. Vegetation and trees in particular, very effectively shade and reduce heat gain. Trees can be used with advantage to shade roof, walls and windows. Shading and evapotranspiration (the process by which a plant actively release water vapor) from trees can reduce surrounding air temperatures as much as 5°C. Different types of plants

(trees, shrubs, vines) can be selected on the basis of their growth habit (tall, low, dense, light permeable) to provide the desired degree of shading for various window orientations and situations. The following points should be considered for summer shading:

1. Deciduous trees and shrubs provide summer shade yet allow winter access. The best locations for deciduous trees are on the south and southwest side of the building. When these trees drop their leaves in the winter, sunlight can reach inside to heat the interiors.
2. Trees with heavy foliage are very effective in obstructing the sun's rays and casting a dense shadow. Dense shade is cooler than filtered sunlight. High branching canopy trees can be used to shade the roof, walls and windows.

3. Evergreen trees on the south and west sides afford the best protection from the setting summer sun and cold winter winds.
4. Vertical shading is best for east and west walls and windows in summer, to protect from intense sun at low angles, e.g. screening by dense shrubs, trees, deciduous vines supported on a frame, shrubs used in combination with trees.
5. Shading and insulation for walls can be provided by plants that adhere to the wall, such as English ivy, or by plants supported by the wall, such as jasmine.
6. Horizontal shading is best for south-facing windows, e.g. deciduous vines (which lose foliage in the winter) such as ornamental grape or wisteria can be grown over a pergola for summer shading.

SHADING BY TEXTURED SURFACES

Surface shading can be provided as an integral part of the building element also. Highly textured walls have a portion of their surface in shade. The increased surface area of such a wall results in an increased outer surface coefficient, which permits the sunlit surface to stay cooler as well as to cool down faster at night.

CONCLUSION

Different methods that can be employed to shade the building, which provides natural cooling and finally helps in energy conservation in buildings, have been discussed in this paper. This technique minimizes the incident solar radiation and cool the building effectively and hence affect building energy performance. Using any or all of these strategies will help to keep the

building cool. Sometimes we need to supplement natural cooling with mechanical devices. Fans and evaporative coolers can supplement our cooling strategies and cost less to install and run the air conditioners. Shading reduces the peak-cooling load in buildings, thus reducing the size of the air conditioning equipment that will run fewer hours and consume less energy.

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