green building strategy

Daylighting Design Tips

contents

7group

think integrated

Buildings are the result of the integration of systems and materials. An integrated design process is the key to obtaining a sustainable and energy efficient building. The use of dayighting is one of the most important elements of integrated design. The well designed use of natural light reduces the amount of electrical lighting needed, lowering internal heat gain and reducing the amount of energy needed to cool the building. There are many considerations to using daylighting wisely.

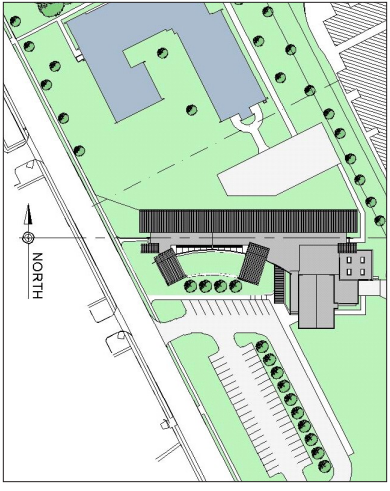
Not only should we let light into our building because it's free, but because people are creatures of light. To be disconnected from the natural environment and being placed in an artificial one is unhealthy both physically and mentally. There are two types of natural light; sunlight is the direct light from the sun (sunbeam) and daylight which is light produced on a cloudy day.

In order to be most effective, daylighting needs to be a high-priority in the design phase. The daylighting systems and the architectural design should be integrated in such as way as to blur the distinction between the two. Daylighting systems added on to the design later in the process will likely be less integrated and aesthetically pleasing.

When developing the program, one should consider which spaces benefit from daylight. A space that is determined to need daylight should also have the amount and quality of light noted. As the program is laid out diagrammatically, placement should correspond to the position on the site that will provide the quantity and quality of light needed for that space.

Effective daylighting design is both an art and a science. The architect, following basic daylighting design principles, creates the daylighting system along with the design of the building, whether intentionally or not. Optimizing the daylighting design's performance requires analysis using computer or physical models to accurately determine if the design criteria for daylight has been met. Working together in an interactive fashion as the design progresses, the architect and daylighting analyst can create a building which performs as well as it looks.

Skylights in an atrium bring light into the interior of this building. The atrium is also a non-visual critical task area.



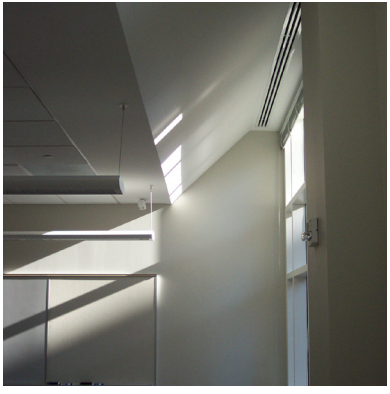
Orientate buildings so that the long axis runs east west. This allows bilateral lighting opportunities in the building.

One of the first strategies employed in the integrated design process is a thorough site and climate analysis. The climate analysis should include temperature range, humidity levels, precipitation averages, percentage of sunny and cloudy days, and prevailing winds. The site analysis should include things like topography, orientation, and shadows cast by man-made and natural objects. These analyses help to assess how the building should be situated to the site and natural light.

A building should be orientated so that the long axis runs from east to west so the north and south facades have maximum exposure. This allows the opportunity for bilateral lighting in the building. An occupancy schedule should be created to determine what time of day and parts of the year that a building will be occupied. This is part of programming and the initial layout of the building.

One of the key elements is to design a building so that architecture takes full of advantage of the daylighting. When the architecture can no longer be manipulated, then other elements can be added to enhance the performance of the building, such as integrated electrical lighting systems and shading devices. The goals are to provide deep daylight penetration and uniform distribution throughout the space, this helps in reducing the need for electric lights. Considering not only the necessary quantity of light but also the quality, and supplying the maximum amount of daylighting to reduce the amount of electric light needed. Daylight analyses performed at each stage of the design process helps refine and increases the daylighting performance.

space design



Sloped ceilings and windows placed as close as possible to the ceiling increases daylight penetration.

Balancing daylight from the north and south produces even illumination.

Space design depends on the program. The activity of the space defines the quantity and quality of light needed. Space design is like carving out a shell. How and where light comes from is a result of the needed light for the activity. Ceiling form and how occupants are able to view to the outside must also be considered.

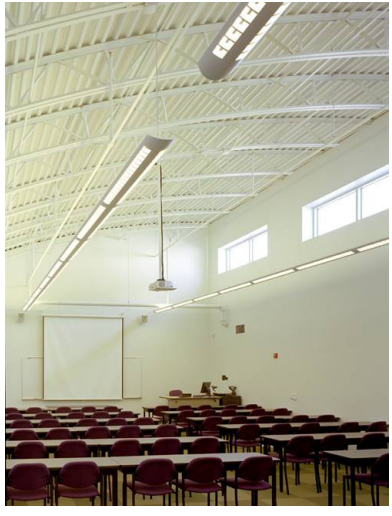
With an office layout design it is best to place the open office are along the window wall and the enclosed offices to the interior. Those who spend the most time at their desk need the most access to light and views.

- ✓ Spaces that require little or no daylight (rest rooms, storage) should be placed in the interior or along the perimeters of the building with little or no glazing; such as the east and west facades.
- ✓ The depth of a room should be 1.5 to 2 times the window head height.
- ✓ A sloped ceiling at the window wall increases the window head height without increasing the floor to floor height.
- ✓ Highly reflective non-specular surfaces will decrease glare and increase daylight performance. (80%90% ceiling, 70%-80% walls, 30% floors)
- ✓ Bring in daylight from opposite sides of a space. This helps to reduce contrast and create more uniform, balanced daylighting schemes.

Windows are a key element in a building. Not only do they allow light in, but they allow occupants to view out. Windows form the connection between the inside and the natural environment. They should not just be considered punched openings in a wall, they are an integral part of the building envelope. The building envelope which contains the windows should be the result of the needed reaction between the interior and exterior environment.

The key element of windows is glass. There are many choices of high performance glass today. It is best to choose a glazing type that has the highest VLT and the lowest SHGC as possible. A glazing type with a VLT of 50% or lower creates and artificial condition. It is like placing dark sunglasses on a building which creates negative effects on the building occupants.

- ✓ Begin with a window to floor area ratio of 10-20%.
- ✓ Place windows as close to the ceiling as possible. This will provide deeper penetration and a more even distribution of daylight. A general rule-of-thumb is that the depth of the effective daylight zone will be 1.5 times the window head height.
- ✓ Place glazing at or above the work plane height.
- ✓ If windows are used on the east or west facades; place the windows as high as possible to reduce direct sunlight problems.
- ✓ Strip windows can help in providing a more even distribution of light.
- ✓ Consider using high visible light transmitting glazing (>0.60 VLT) for daylight glazing. A well designed daylighting system will enable the use of high VLT glazing increasing the solar heat gain, which helps rdeuce energy costs.
- ✓ Consider using different glazing characteristics for different facades of the building. Windows on the east, south, and west facades should have a lower VLT and SHGC.
- ✓ Utilization of daylight analysis will help calculate the best window configurations and glazing selections.
- ✓ Include glazing where it will provide the most benefit. Avoid large amounts of glazing in stairs and other pass-through spaces.



High window placement and even distribution reduces glare and provides a more even distribution of light in the space.

shading

The idea of shading a building is just the same as we shade ourselves by wearing a hat. The hat protects us from direct sunlight which helps in keeping us cool. It also improves our vision by reducing the amount of glare we see. On a clear day the brightest part of the sky is the horizon. By shading the direct solar component of the sun we are still able to use the brightest part of the sky to bring light into the building. On cloudy days the brightest part of the sky is directly overhead (zenith). Shading elements can help bounce light into the building like a light shelf if there is a daylight window.

Consider where and when you shade. It is sometimes beneficial to allow direct solar into buildings especially if thermal massing is used. Shading devices should not block the view of the occupants, this destroys one element in the connection between interior and exterior environments.

- ✓ Different climates and orientations require different shading techniques.
- ✓ Natural and man-made objects on or surrounding the site can provide helpful and unwanted shading. Analysis of the site and surrounding area should be done to determine existing and possible shading opportunities and problems.
- ✓ South facades should be shaded to stop direct solar penetration from March to September with horizontal elements. Daylight analysis will help in determining the depth of the shading devices.
- ✓ Remember to extend the shade's edge beyond the vertical window line in order to shade throughout the day.
- ✓ East/West facades should use awning type shading devices. Fins, vertical elements, and the articulation and deepening of the façade can help in shading.
- ✓ Select a blind which rolls from the bottom up. Consider the blind's color and transparency.
- ✓ Deciduous trees can be very effective shading devices.

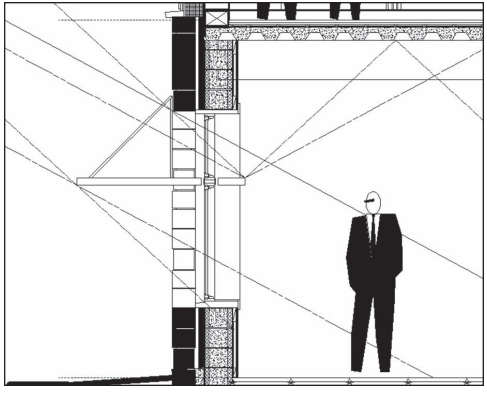
Vertical shading on the east and west facades handle low sun angles in the morning and evening.

Shading devices are designed based on solar analysis. They should not block any views to the exterior.

Interior lightshelves stop direct solar penetration onto work surfaces and also increase daylight penetration.

The sun travels in an arc through the sky, therefore, shading devices and lightshelves should extend past the window for full shading.

Light shelves are both shading and illuminating devices. They work by shading the view window and bounce light through the daylight window. The key element when using light shelves is a direct solar analysis. This will determine the size and location of the light shelf. A daylight window under 12 inches in height is somewhat inefficient.



Lightsheves are designed based on when and where you want daylight to penetrate the building.

- ✓ Lightshelves are most effective on the south facade.
- ✓ Do not place lightshelves on the north facade, they will reduce the daylight and provide no benefits.
- ✓ Lightshelves are effective at stopping direct light from the daylight windows onto to work surfaces.
- ✓ Lightshelves can be an integrated element, such as large window mullions or HVAC ducts.
- ✓ The reflecting surfaces should be highly reflective with semi-specular characteristics. (i.e. brushed metal)
- ✓ Lightshelves allow the use of a higher VLT in the view window, improving illuminance and quality of view.
- ✓ The glazing above the light shelf, the daylight window, should have a higher VLT than the view window.

toplighting

This strategy allows daylight to penetrate the interior of buildings. This strategy is especially useful in urban environments. Creating an open atrium in the center of the building creates a bilateral lighting condition. This is especially useful in buildings with large floor plates. If its not possible to place top lighting in the space you are wanting to daylight, it is possible to place them in the hallways and allow the light to penetrate the spaces through clear or translucent walls. Top lighting strategies can also be integrated into the natural ventilation plan or stack ventilation system.

Evenly distributed toplighting provides ample lighting for large spaces.

skylights

- ✓ Consideration for using skylights should come early in the design process so that structure and mechanical systems can be coordinated with the openings.
- ✓ Analysis should be done to determine the feasibility of skylights in spaces with critical viewing tasks and the effects on the cooling loads.
- ✓ Space skylights within 1 to 1.5 times the ceiling height.
- ✓ Use highly reflective and specular materials in skylight wells. The wells should also be free building obstructions (i.e. HVAC, piping, structure).
- ✓ Roof mounted equipment should not be mounted near skylights. This causes unwanted shading.
- ✓ Use of software that considers weather data, lighting levels, and skylight construction is recommended to achieve a balance between HVAC and lighting concerns.

light tubes

Light tubes can be used in place of skylights when structure and mechanical systems limit placement and size. They are also a consideration for retrofitting existing buildings.

clerestories

- ✓ A basic rule-of-thumb is a clerestory window to floor area ratio of 10%.
- ✓ Clerestories will create less glare and heat gain than skylights.
- ✓ A series of north facing sawtooths can be used to receive reflected southern light off the roofs of the other clerestories.
- ✓ South facing clerestories admit more light and heat than north facing clerestories. However, proper shading and placement will reduce the direct light and heat gain.

South facing clerestories can be shaded with large exterior overhangs.

monitors

- ✓ Allow both north and south light, therefore shading must be considered when used.
- ✓ Daylight analysis should be used to determine proper configuration and placement of clerestories and monitors.

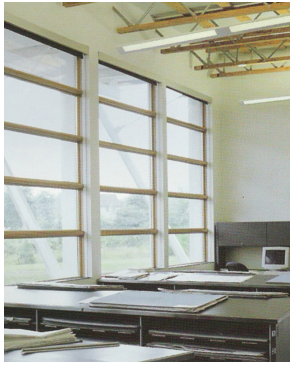
Monitors provide an even distribution of light into the space.

electric lighting

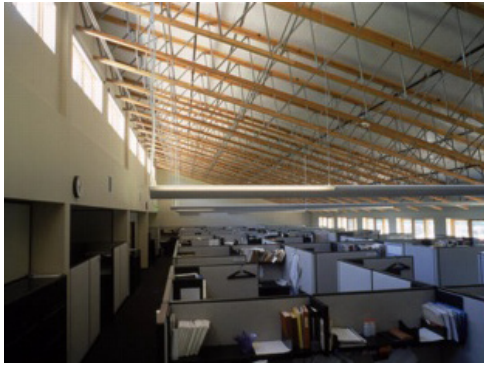
The key element with electric lighting is its integration with the daylighting strategies. This will produce the best lighting conditions for each space. The use of direct, indirect, and dimmable fixtures provide an effective combination to help compliment the different daylight conditions and interior activities. The space activity determines the amount and type of light needed so an electric light analysis is helpful so that the space does not become over lighted.

- ✓ Continuous dimming produces the most energy savings and the least complaints in most cases.
- ✓ An effective daylighting scheme will reduce overall energy use. Energy modeling should be performed in conjunction with daylighting analysis to optimize the performance of the entire system and not just the daylighting component.
- ✓ Cooling loads should be reduced with an effective daylighting system.
- ✓ Take advantage of dimming to reduce the peak lighting loads used to calculate the cooling loads. This can contribute to the downsizing of the HVAC system.
- ✓ Direct/Indirect lighting will reduce glare and simulate the diffuse distribution of daylight.
- ✓ Use occupancy sensors to turn off lights when the space is not in use.
- ✓ If possible, run electric lights in rows parallel to the window wall. This compliments the distribution of daylight into the space.
- ✓ Use daylight analysis to verify that daylighting is providing sufficient illuminance to justify dimming. Use the same analysis to determine dimming zones.
- ✓ Circuit the fixtures so that they can be dimmed parallel to the window wall. Even if dimming is not used, the lights can be turned off manually in circuits according to daylight conditions near the windows.

Light fixtures and circuiting parallel to the window walls allows dimming systems to better compliment the natural daylight.



Placement of low-height furniture perpendicular to the window wall allows deeper light penetration into the space.



Furniture color should be of light color as to not absorb any light entering the space.

This is a critical task that can easily ruin everything achieved through the daylighting strategies. Coordination must be made so that the furniture layout does not produce negative effects. Cubicles may help with noise reduction but if they are needed it is best to use clear or translucent walls so that light and views penetrate the entire space.

- ✓ Consider color and reflectance of furniture. Dark colors and low reflecting materials absorb light.
- ✓ Heights of partitions can effect daylight distribution. Low furniture height near the windows is best.
- ✓ Do not place bookshelves, files, or full-height partitions near windows. If necessary, place them perpendicular to the window wall which would allow daylight to penetrate through the aisles.
- ✓ Orient desks, especially ones with computers, perpendicular to the windows. A desk which faces the windows will cause the occupant to receive direct glare. Desks facing away from the windows will cause reflections of the window on the computer screen.

additional resources

Books and Manuals

Concepts & Practice of Architectural Daylighting, Moore, Fuller

Daylighting: Design & Analysis, Robbins, Claude L.

Daylighting for Sustainable Design, Guzowski, Mary

Sun, Wind, Light: Architectural Design Strategies 2nd Edition, Brown, G.Z., Dekay, Mark

Heating, Lighting, Cooling, Lechner, Robert

Tools

Sketchup

EcoTec

Radiance

Spot

Skycalc

AGI-32

Websites

Windows & Daylighting
http://windows.lbl.gov

Whole Building Design Guide
http://www.wbdg.org/design/daylighting.php

U.S. Dept of Energy: Energy Efficiency and Reneweable Energy Building Technologies Program
http://www.eere.energy.gov/buildings/info/design/integratebuilding/passivedaylighting.html

Energy Design Resources
http://www.energydesignresources.com/category/daylighting/

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