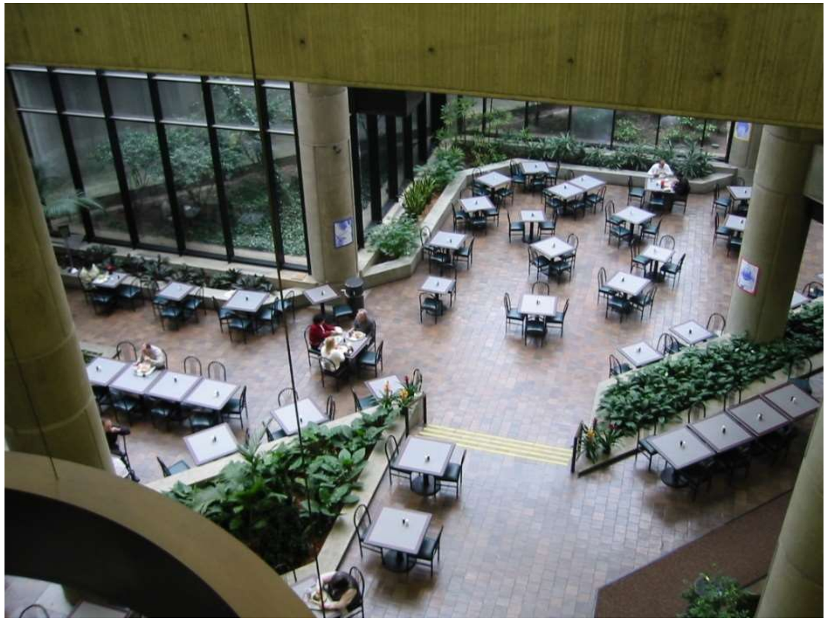
Ch.10 Daylighting

Why daylighting?



Continual variation

Edinburgh airport (2008.06)

A shopping mall in Edinburgh (2008.06)

A shopping mall in Edinburgh (2008.06)

The Orlando Int'l airport (2010.01)

The Orlando Int'l airport (2010.01)

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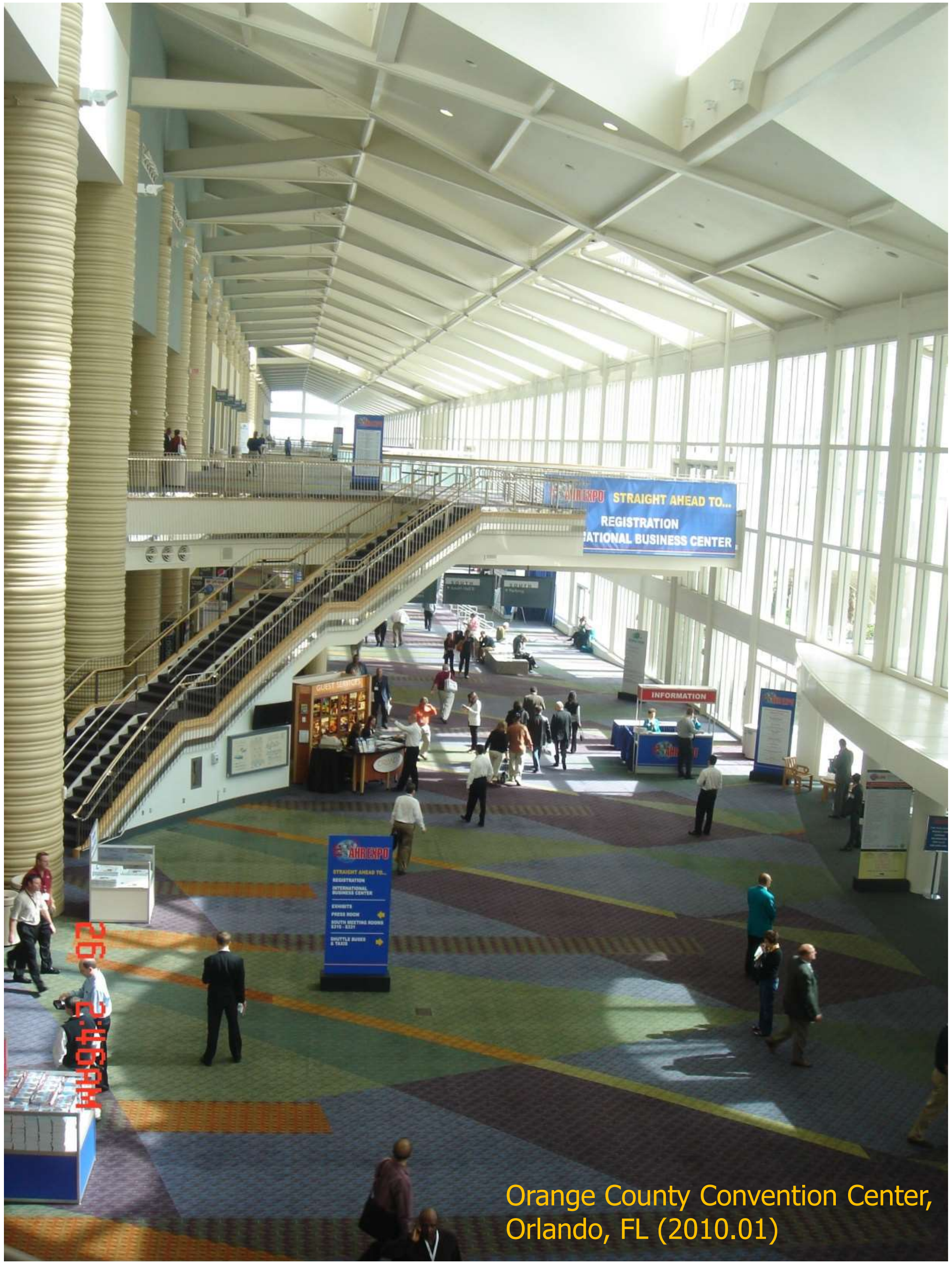
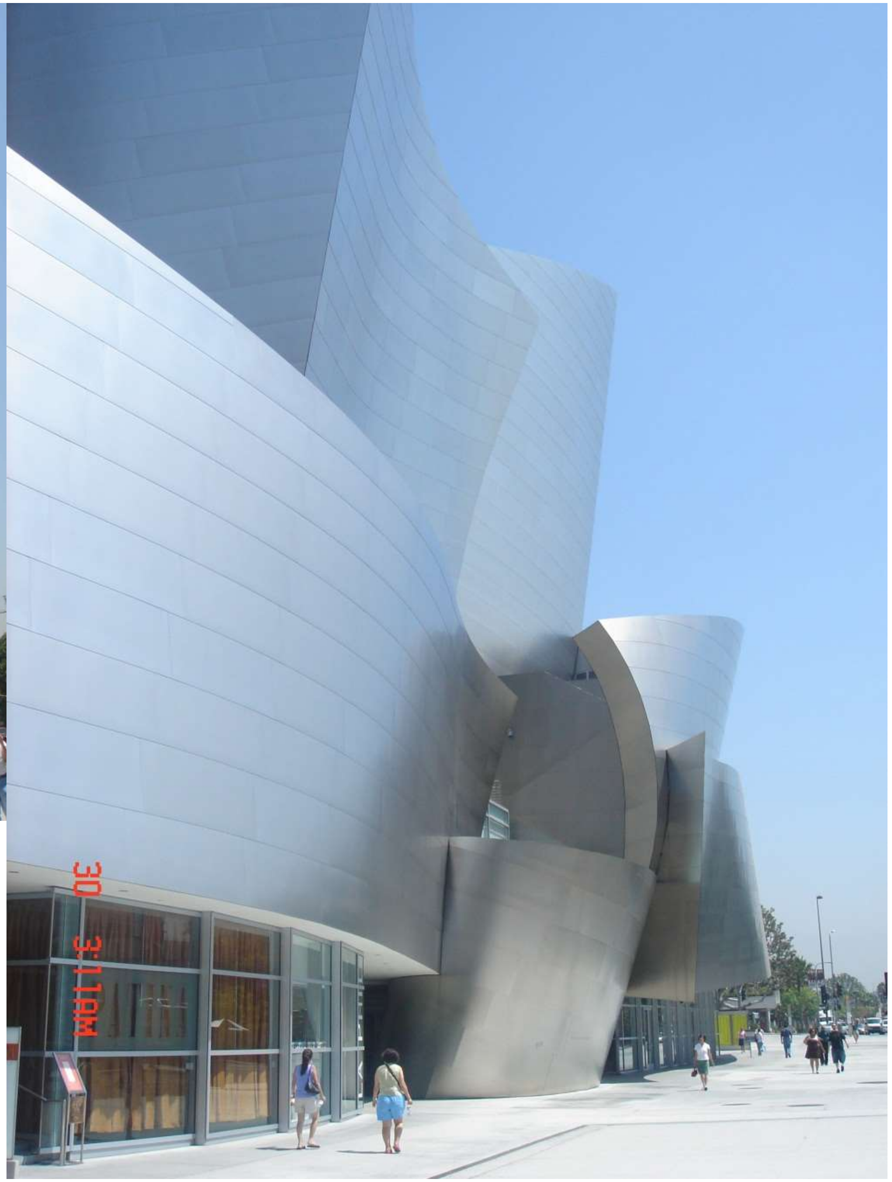
The Orlando Int’l airport (2010.01)

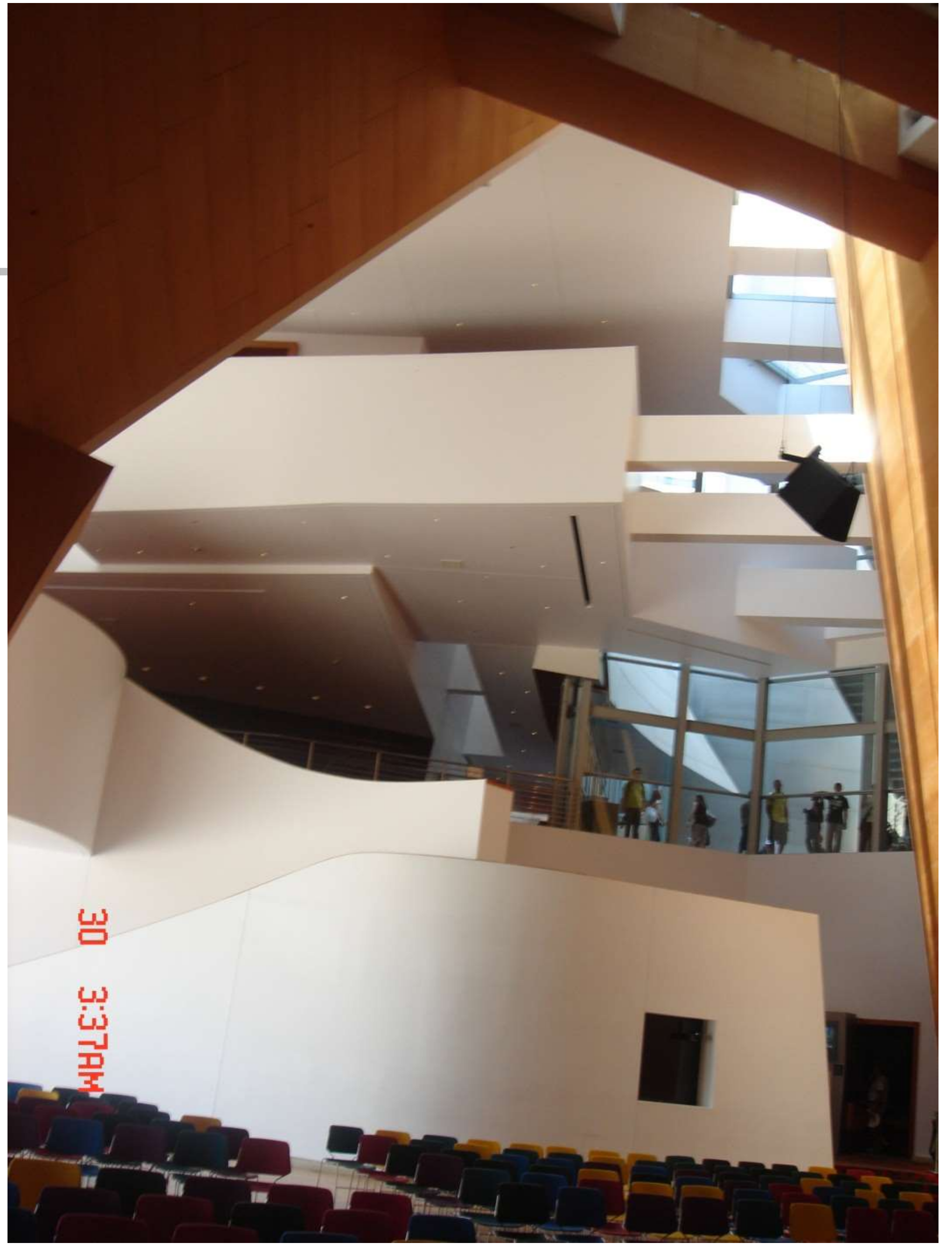


Orange County Convention Center,
Orlando, FL (2010.01)



Disney concert hall, LA

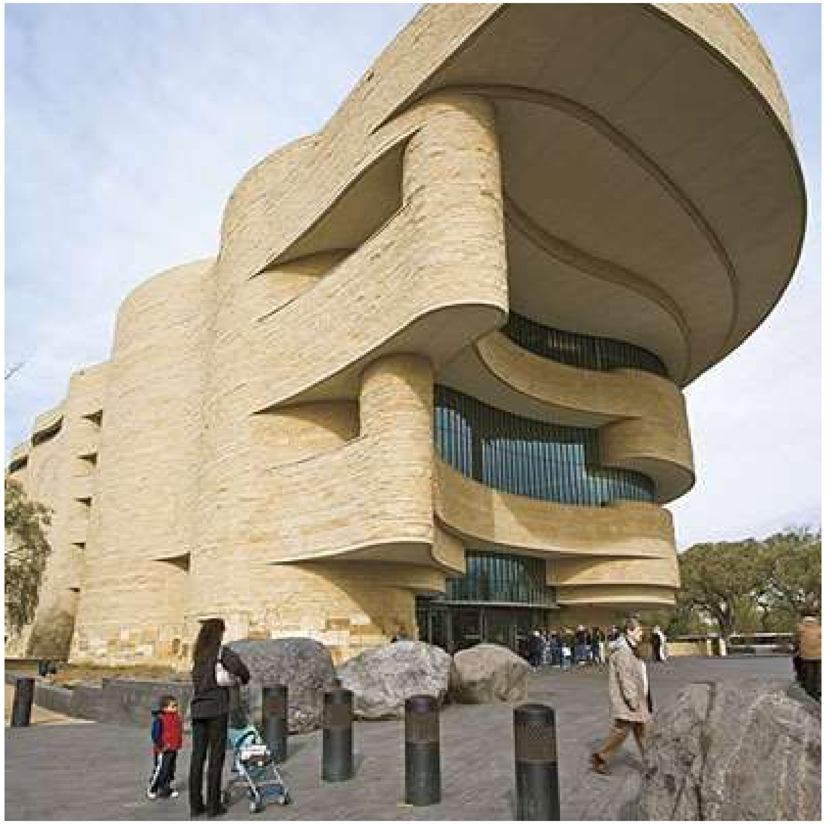
Disney concert hall, LA



Disney concert hall, LA

Architect: Richard Meier
High museum of art (2011.04)

Guggenheim museum in NY

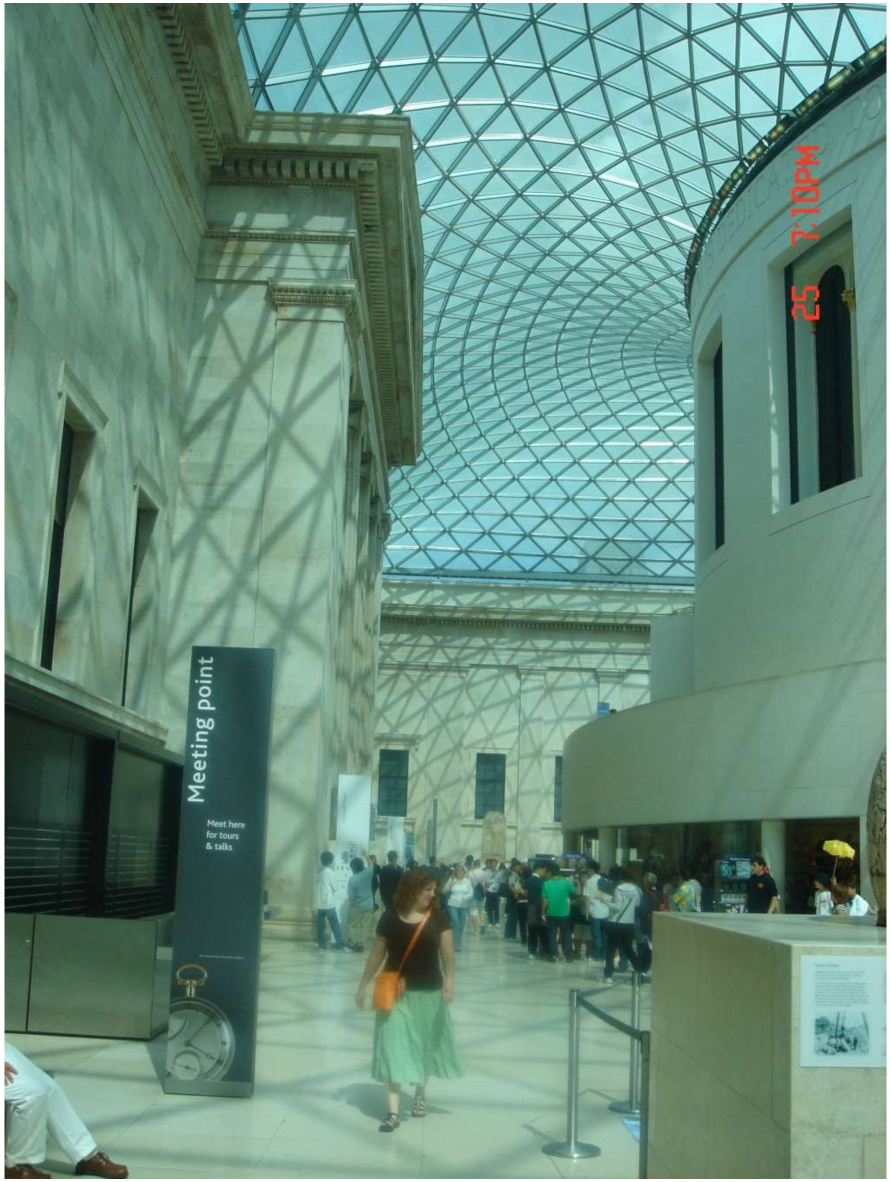


Indian museum in Washington D.C.

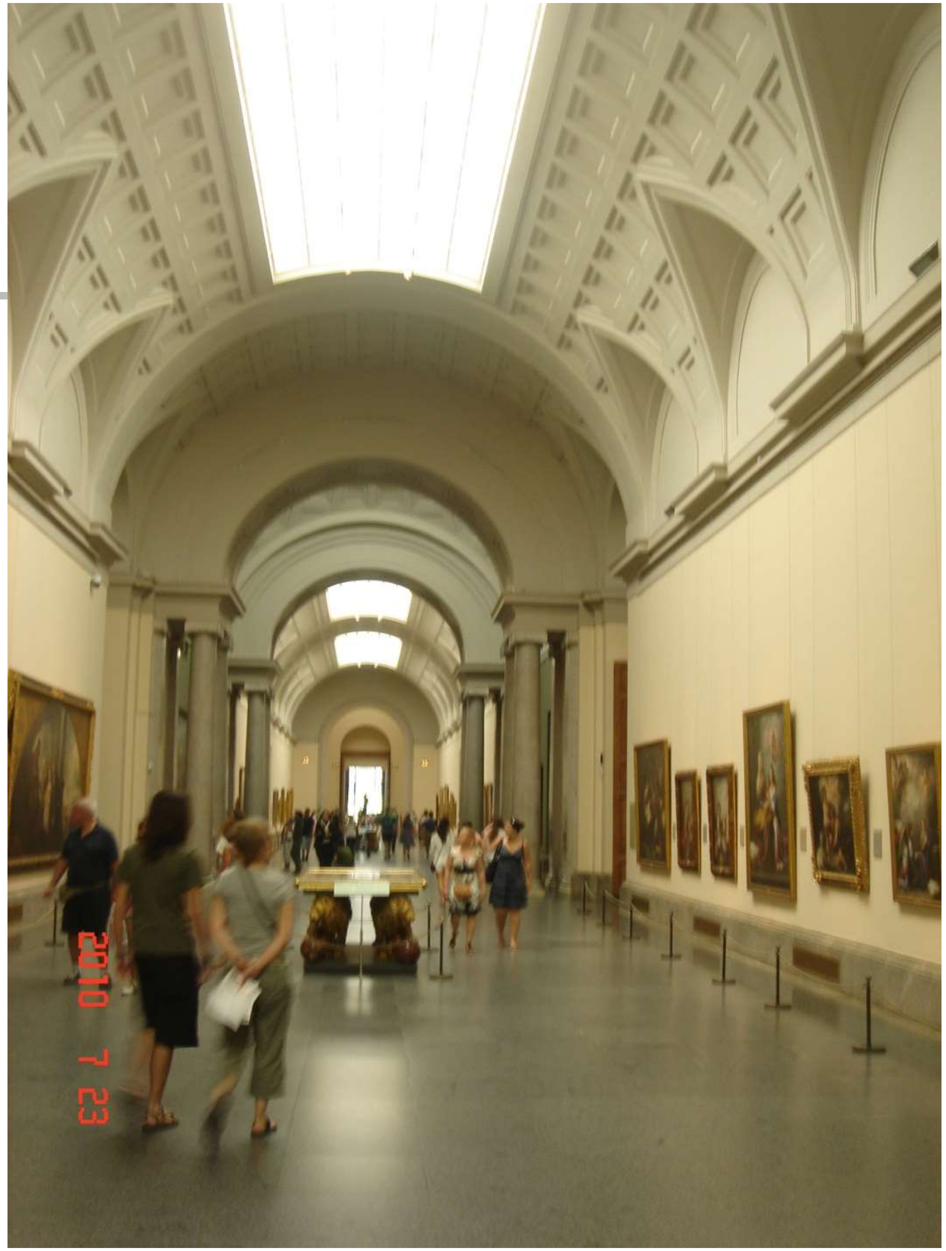
From the Pantheon to the Guggenheim museum: Frank L. Wright called the Guggenheim museum "my Pantheon".

Renaissance hotel, Atlanta

The British Museum


Meeting point
Meet here
for tours
& talks

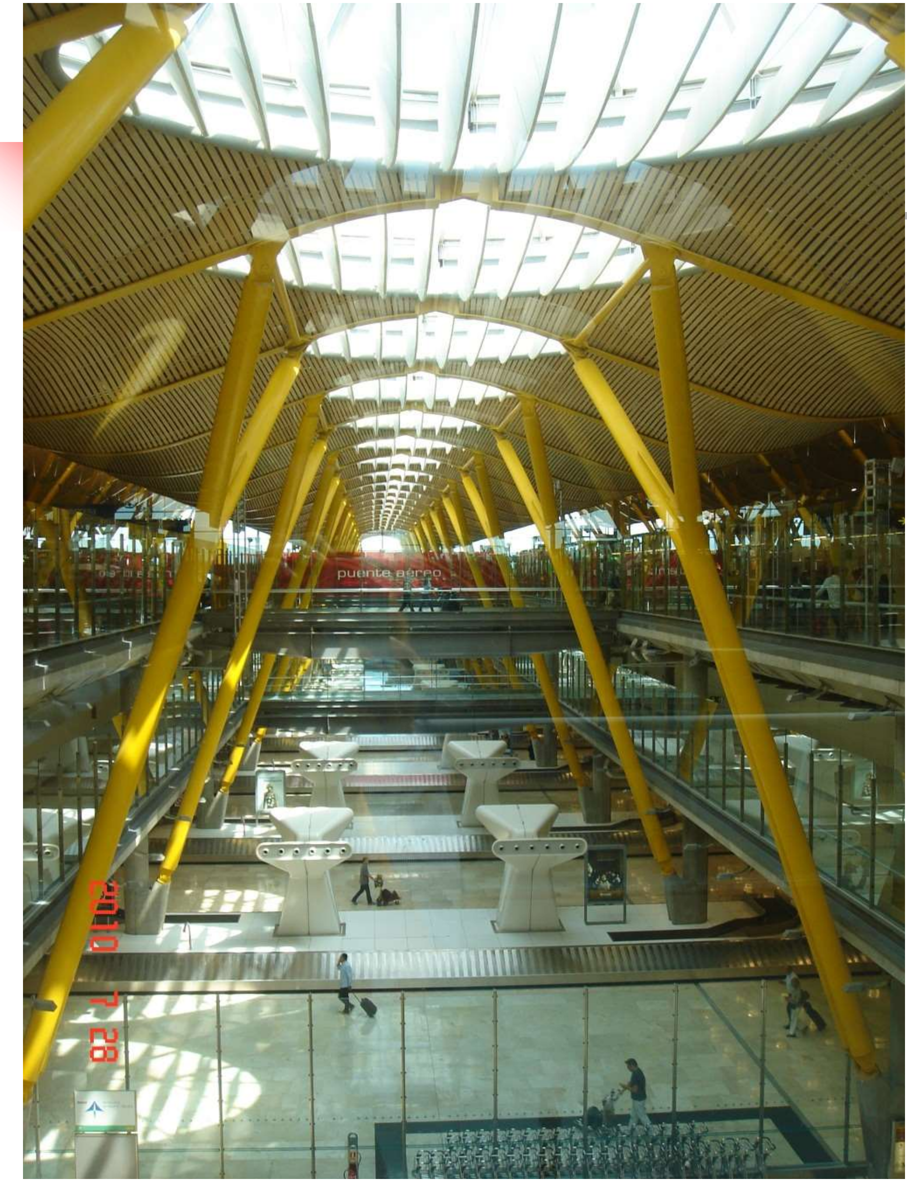

Eating
Shopping
Tickets

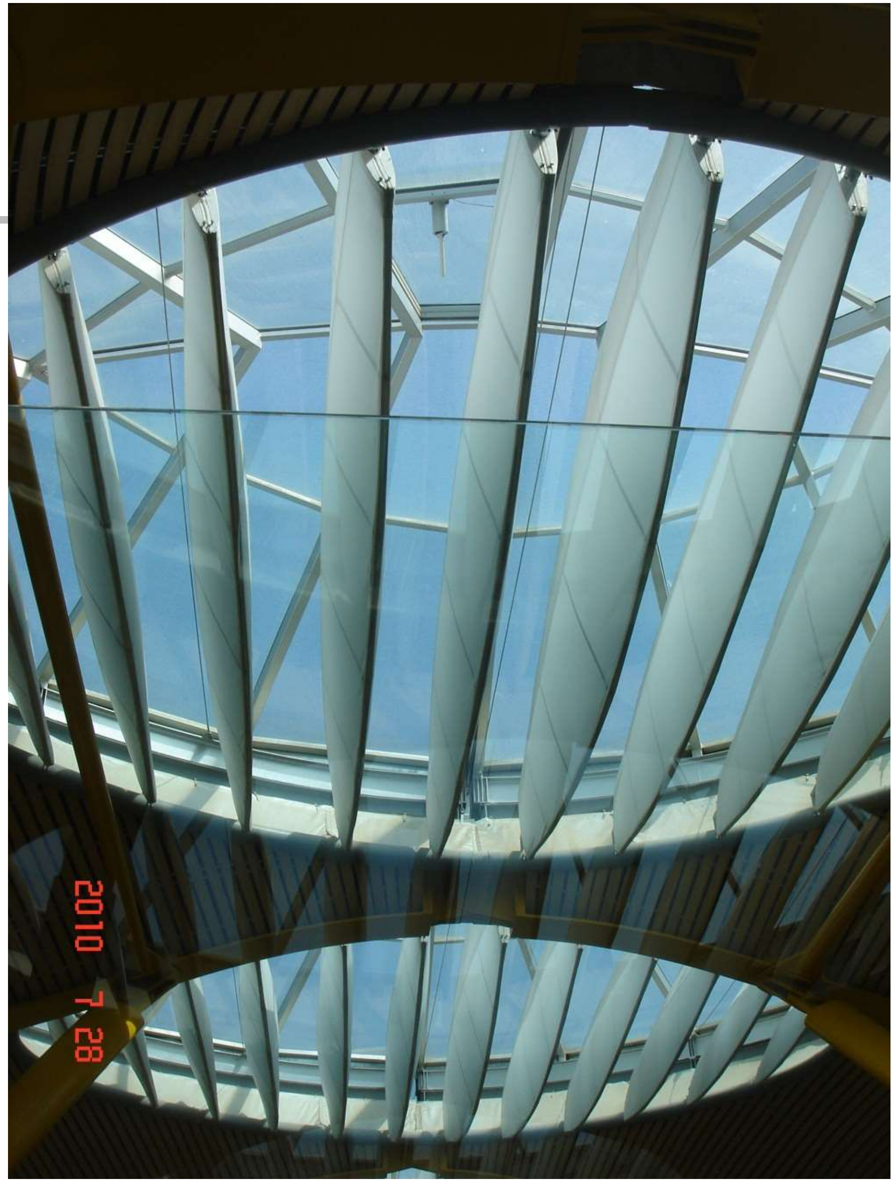


Museo Del Prado, Madrid

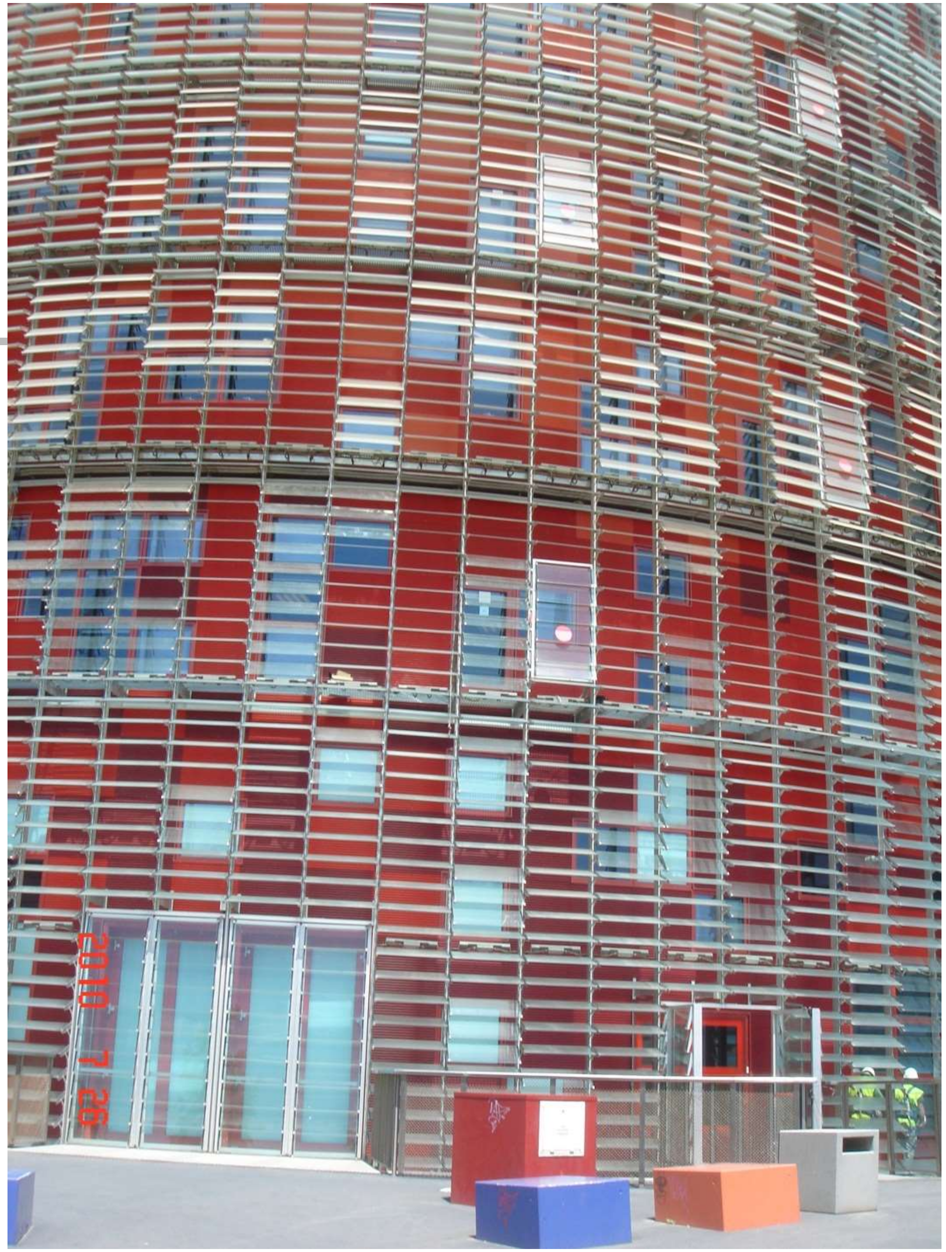
Barajas Airport (Madrid, Spain)

Barajas Airport (Madrid, Spain)

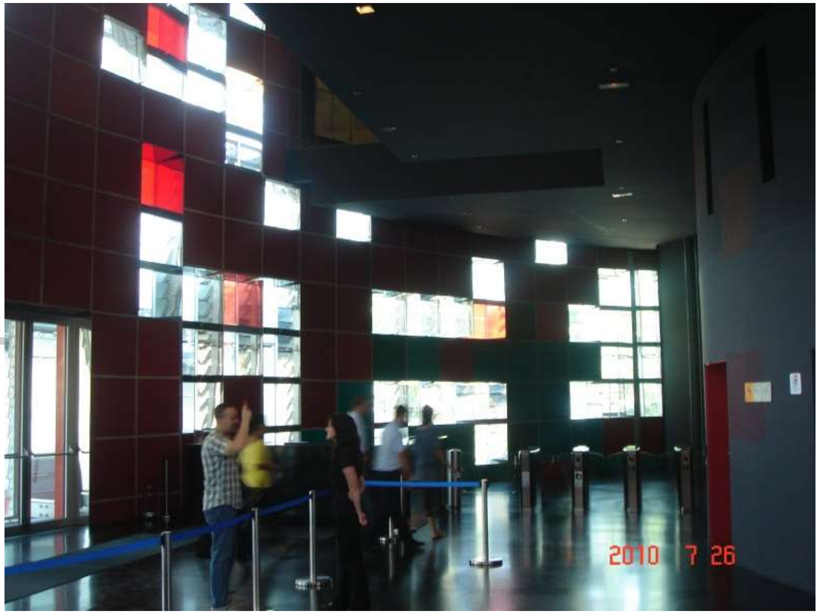




Sagrada Familia, Barcelona



Architect: Jean Nouvel
Torre Agbar, Barcelona



Torre Agbar, Barcelona

Fernbank museum. Atlanta

CNN center, Atlanta

Air space museum, Washington D.C.

Taichung city center, Taiwan


2011 5 31


2011 5 31


Gabriel Metsu
2011 5 31


Metsu
2011 5 31


Gabriel Metsu
2011 5 31

National gallery of art, D.C.


27 1:26AM

High Performance Buildings deliver

Productivity Improvements

A healthy, comfortable work environment may be the best perk to offer office workers

It may be the smartest financial choice too!

Look at some Case Studies to see why

What makes a building high performance?

- daylighting
- daylight control to reduce HVAC loads
- light shelves for shading
- glass type varied by orientation and location
- light sensors to control electric lighting
- occupancy sensors
- narrow floor plans to optimize natural daylight
- high benefit lighting upgrades
- under floor air distribution
- occupant control of heat, light and air
- displacement ventilation
- exposed thermal mass of building structure
- night flushing of buildings
- operable windows and mixed mode HVAC

http://www.seattle.gov/light/conserve/sustainability/studies/

Friday, May 29, 1998

`Daylighting':Does it improve office productivity?

The Business Journal of Milwaukee - by Robert Mullins

A statewide program seeks to promote daylighting and its energy-saving, productivity-enhancing qualities. The Daylighting Initiative trains architects and building engineers on uses of daylighting, provides design assistance to builders and generally promotes daylighting, said Scott Pigg, senior project manager for the Energy Center of Wisconsin, Madison.

Pushing daylighting

The Energy Center is a private, nonprofit group that researches effective use of energy. It is funded in part by electrical utilities.The Daylighting Initiative was established in 1994 by the state Public Service Commission, which directed state-regulated utilities to jointly push daylighting, Pigg said.

"Daylighting brings more light into a building with less heat than artificial lighting," he said. If a building uses less artificial light, less energy will be expended on cooling systems to offset the added heat from light fixtures.

Also, daylighting reduces the number of light fixtures and, thus, a building's total energy bill, he said. The cost of lighting accounts for from one-third to one-half of the total cost of electricity for a building, Pigg said.

But energy savings are a remote concern to employees. For them, a comfortable workplace is a higher priority.

"Morale improves. It's an intangible," said Bruce Lynch, another Kahler/Slater architect. "If they don't have as much eye strain from daylight as from artificial lighting, people will be more efficient and make fewer mistakes."

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Daylighting design

- Mistakenly understood to mean an abundance of light should fill the space.
- Good design → careful balance and control of heat gain and loss
  - Manual vs. energy & lighting simulation
  - Energy, lighting (illuminance), visual comfort (luminance ratio, daylighting glare)
- Strategies: shading devices, light shelves, glazing, atria, courtyards, material finishes (both interior and exterior)

Daylighting in LEED

- A minimum daylight factor of 2% in 75% of all occupied spaces

Importance and planning of daylighting design

- Daylighting influences human behavior, health and productivity
- Planning for daylight throughout building design process
  - Conceptual stage: building form, orientation, layout, major apertures
  - Design development: materials and interior finishes, zoning for integration with electric lighting and other services, control systems
  - Occupancy: fine tuning and maintenance of the system

Energy savings with daylighting

- IESNA RP-5-99: recommended practice of daylighting
  - Plan interior space for access to daylight
  - Minimize sunlight in the vicinity of critical visual tasks
  - Design spaces to minimize glare
  - Zone electric lighting for daylight-responsive control
  - Provide for daylight-responsive control of electric lighting
  - Provide for commissioning and maintenance of any automatic controls

Goals of daylighting

- Advantages of daylighting: improved aesthetics, provision of human biological needs (circadian rhythms and visual relief), reduction of electric lighting energy usage
- Goal: to provide sufficient illuminance, minimize the perception of glare and provide for overall visual comfort.

Human factors in daylighting design

- View: outside (sky, horizon, ground)
- Productivity and satisfaction
  - Classrooms: better progress on math and reading
  - Retail stores: increased monthly sales
- Controlling daylight in interior spaces
  - Daylight provides psychological well-being
  - Provision of adjustable shades must be made to exclude sunlight.
- Minimize glare

daylighting

Toronto Eaton mall (2014.10)

Site strategies for daylighting buildings

- (1) orientation: southfacing is preferred in terms of:
  - prevention of excess solar heat gain (summer)
  - passive solar heating strategies (winter)

(2) Zoning

- Thermal and (luminous) lighting zoning
- Zoning is one of the first steps to passive heating and cooling design.
- Zoning facilitates later decisions about sizes of equipment as well as fenestration and thermal mass.
- The more carefully zoning is considered →
  - the better lighting and thermal performance will be.
  - the lower the annual energy use will be.
  - The less likely it will be that all sides of a building will have an identical appearance.
- Factors: function, schedule and orientation

Zoning is most often influenced by…

- Function:
  - Important because of the variations in internal heat gains between functions
    - Sports facility vs. office (room set-point temperature differs!!)
  - Comfort conditions may vary considerably between functions; air temperatures can be lower for a strenuous activity than for a sedentary activity, or heat tolerance may be greater for some activities (restaurant kitchens) than for others.

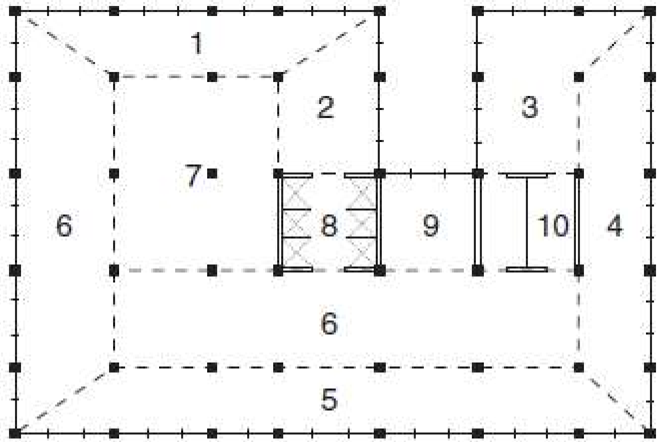


Fig. 10.4 Daylight zoning for a mixed-use building with perimeter and internal zones as well as varying types of use. Scheduling and/or internal load differences within any one of these zones could require division into additional zones. (Drawing by Amanda Clegg.)

Zoning is most often influenced by…

- Schedule:
  - An activity between 9:00 a.m. and 4:00 p.m.: can be entirely daylit when the outside temperatures are the warmest of the daily cycle.
  - An activity that takes place only from 9:00 p.m. to 4:00 a.m.: entirely dependent on electric lighting → heat from lights can be used to overcome the chill of the outside temperatures in winter. (In summer, such heat can be flushed away with the cool outside night air in many U.S. locations.)
  - If one activity has operating hours different from those of the remainder of the building, a separate mechanical system is often provided. → This saves energy, because large equipment will not be underused to provide heating or cooling for only one zone.

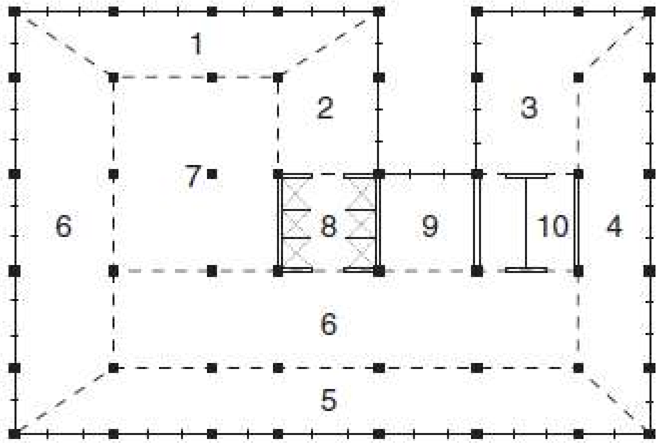


Fig. 10.4 Daylight zoning for a mixed-use building with perimeter and internal zones as well as varying types of use. Scheduling and/or internal load differences within any one of these zones could require division into additional zones. (Drawing by Amanda Clegg.)

Zoning is most often influenced by…

- Orientation:
  - Case I: Perimeter spaces with direct sun through the windows may gain more heat than is lost and thus need cooling.
  - Case II: Perimeter spaces without direct sun may have a net heat loss due to heat loss through glass, infiltration, and a lack of electric lighting (because daylight is adequate). These spaces will need heat from a mechanical support system.
  - Case III: Interior (no-daylight) spaces are often overheated by electric lighting because they cannot lose heat. These spaces will need cooling from the support system.

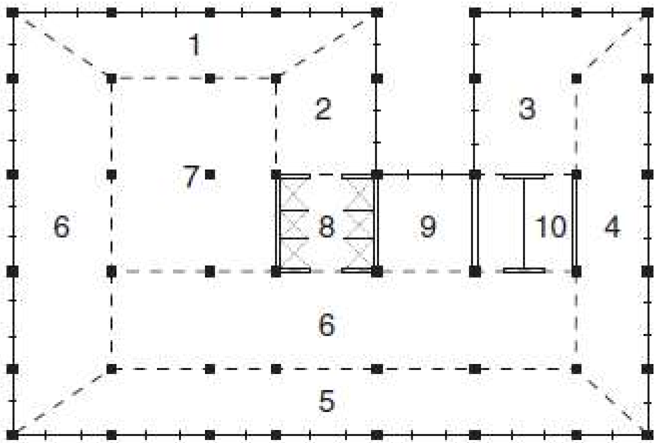


Fig. 10.4 Daylight zoning for a mixed-use building with perimeter and internal zones as well as varying types of use. Scheduling and/or internal load differences within any one of these zones could require division into additional zones. (Drawing by Amanda Clegg.)

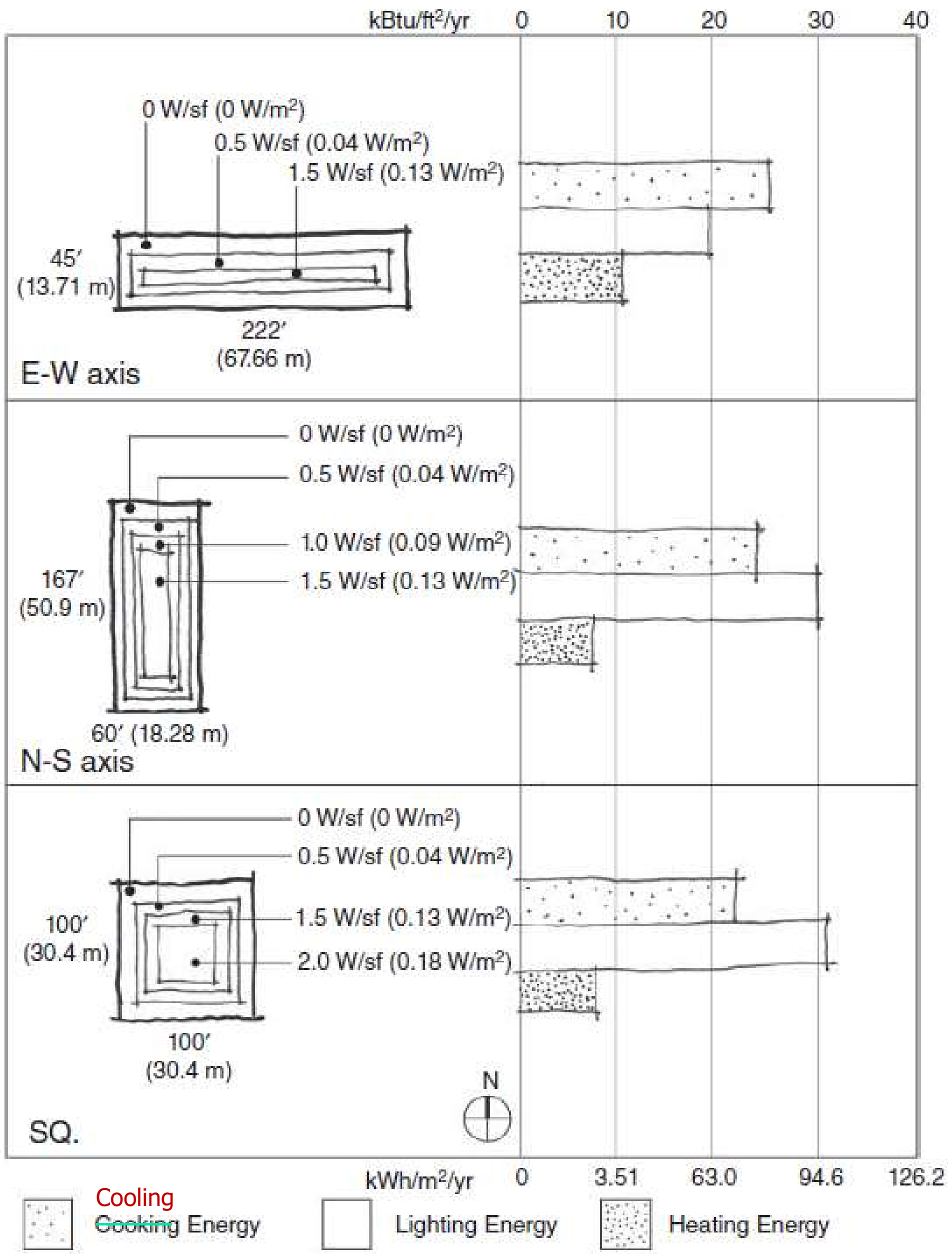


Fig. 10.3 *Effect of building orientation on energy consumption. (Drawing by Erik Winter after Moore,* Environmental Control Systems, *1993.)*

Site strategies for daylighting buildings

- (3) Form
  - At its simplest, form can be reduced to questions of tall or short, thick or thin.
  - 15 ft (4.5m) perimeter zone: completely daylit
  - 15-30 ft (4.5-9.0m): partially daylit
  - 30 ft (9.0m): electrically lit

Thicker, taller buildings: more space away from climate influences → internal load dominated (ILD)

Thinner buildings: need heating in cold weather and cooling in hot weather; skin-load dominated (SLD).

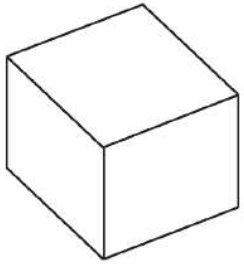
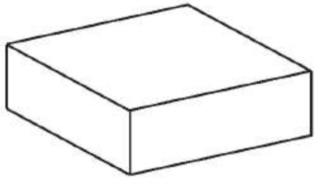
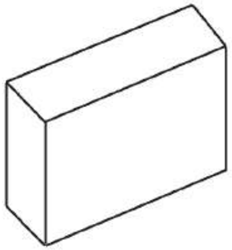
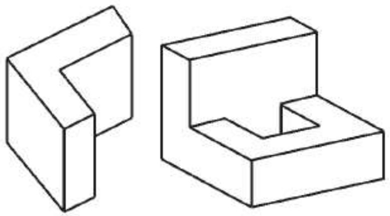
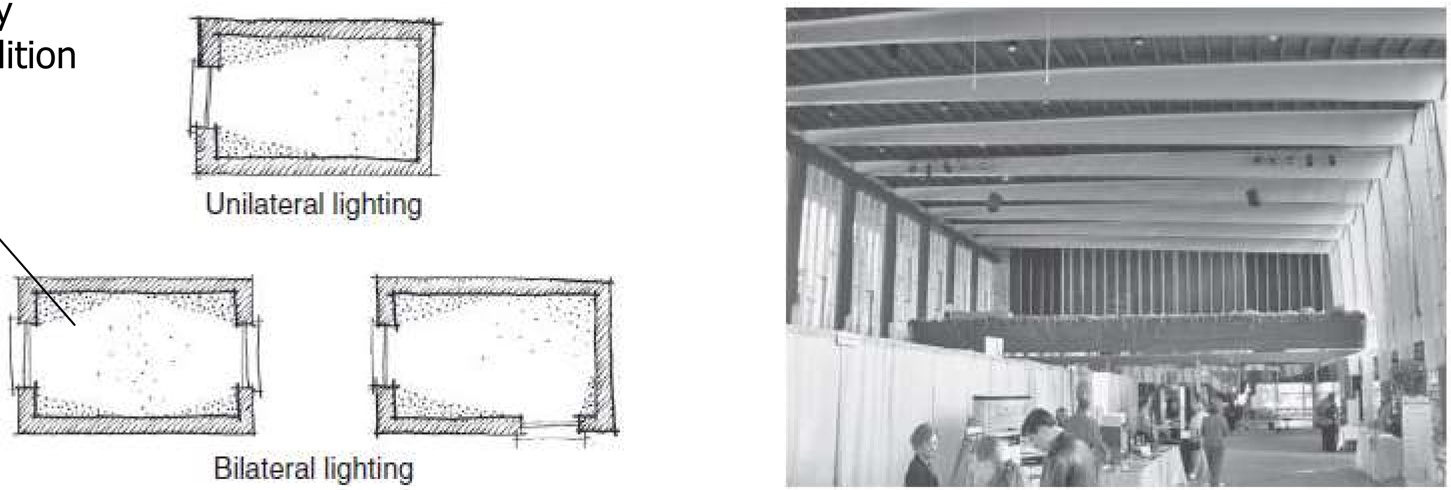
BUILDING TYPE	DAYLIGHT	HEATING	COOLING
 THICK TALL BUILDING	✓− Core is dark. Perimeter lighting is unidirectional	✓− Unbalanced solar gain makes perimeter zoning and control critical	✓− Large core requires mechanical cooling. Perimeter ventilates poorly
 THICK SHORT BUILDING	✓ Toplights and perimeter windows can provide adequate daylighting	✓ Passive heating systems may be implemented although somewhat limited and unbalanced	✓− Passive cooling possible but costly. No cross ventilation
 THIN BUILDING, TALL OR SHORT	✓+ Complete sidelighting for all spaces can be achieved	✓+ Passive heating and solar heat gain mitigation possible	✓+ Natural ventilation is easily accomplished
 THIN COMBO BUILDING	✓ Complete daylighting for most spaces	✓+ Passive heating and solar heat gain mitigation possible	✓+ Natural ventilation is easily accomplished

Fig. 10.5 The effect of building form on environmental control strategies. The illustration shows how building layout affects cooling, daylighting, and heating opportunities. (Drawing by Nathan Majeski.)

Aperture strategies: sidelighting

- (a) Design for bilateral lighting: even distribution

The most evenly distributed condition

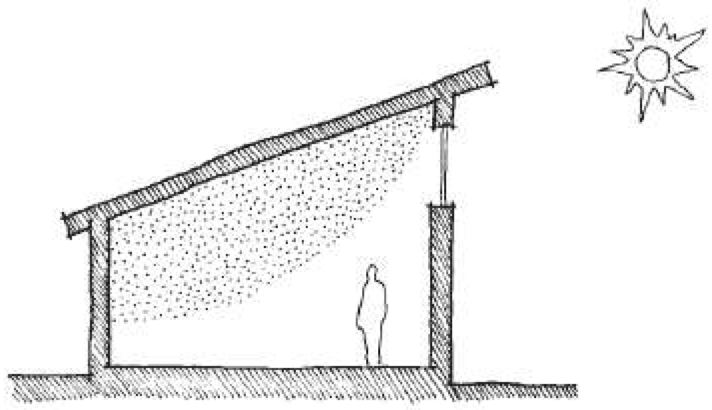


(a) (b)

Fig. 10.7 *(a) Plan diagrams of unilateral and bilateral daylighting. (b) Windows on two sides (a bilateral approach) at the Crystal Cathedral campus, Anaheim, California. (Drawing by Erik Winter; photo by Alison Kwok; © Alison Kwok; all rights reserved.)*

(b) Place windows high on a wall

- Provide more uniform distribution
- Use the ceiling as a reflecting surface by placing window heads as close as possible to the ceiling



(a)

(b)

Fig. 10.8 (a) With higher windows, daylight extends farther into a space. (b) High windows in a classroom at the University of Oregon. (Drawing by Erik Winter; photo by Nathan Majeski.)


30 6:39AM


30 7:20AM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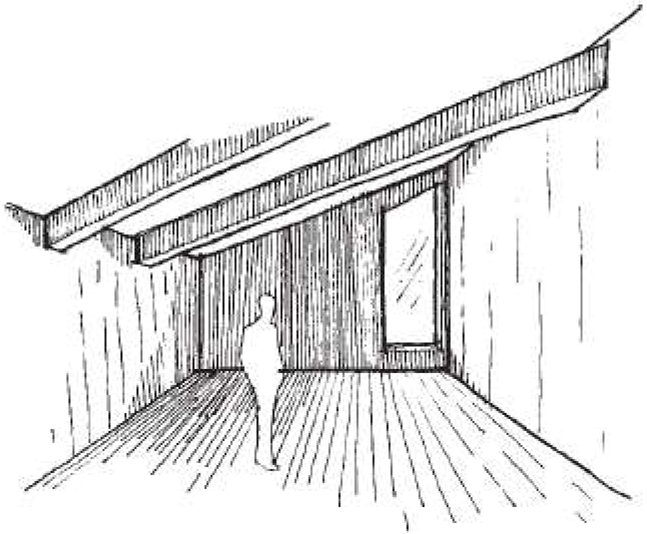
(c) use adjacent walls as reflectors

- Additional reflector, reducing the contrasting edge around the window



(a)

(b)

Fig. 10.9 *(a) Windows adjacent to a wall provide an additional reflecting surface. (b) Reading carrel adjacent to a window at the Graduate Theological Union Library, Berkeley, California. (Drawing by Erik Winter; photo by Alison Kwok; © Alison Kwok; all rights reserved.)*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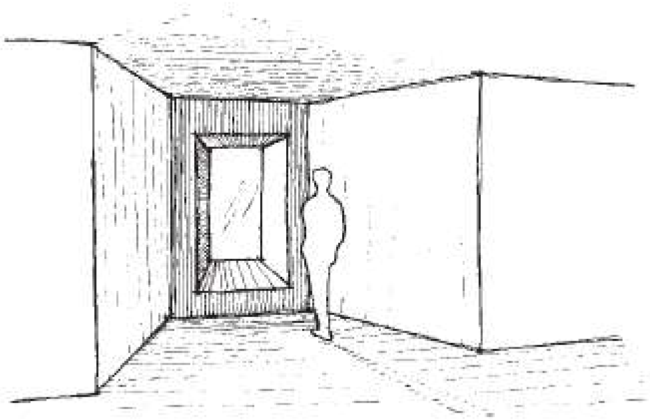
(d) Splay the walls of aperture

- visual comfort by reducing contrast and the potential for glare



(a)

(b)

Fig. 10.10 (a) Splayed window and wall provide additional reflecting surfaces. (b) Splayed window opening to increase visual comfort and reduce glare potential at the 2011 Solar Decathlon EMPOWER House by the New School and Stevens Institute of Technology. (Drawing by Erik Winter; photo by Alison Kwok; © Alison Kwok; all rights reserved.)