

PASSIVE DESIGN STRATEGIES



- Passive Cooling Strategies
- Overhang Dimensions
- Shading Devices
- Porous Paving

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Passive Cooling Strategies

Overview

Buildings should be designed in relation to specific climatic conditions, the changed function or the time of use or occupancy levels of internal and external spaces, and in relation to how these decisions will impact parts that remain unaltered. Landscaping can be used to improve both external and internal comfort and energy efficiency. Improvements can also be target specific, such as fitting shading devices over existing openings.

PROTECTED ENTRIES AND OUTDOOR LIVING

- Provide indoor/outdoor transitions with extended roof overhangs and the use of verandas, arcades, and porches to serve as shaded entries and buffers between indoor and outdoor spaces.
- Partially enclose external spaces (e.g. open trellises, walls and/or small courtyards) so that they can be managed by alteration of microclimate with shade, evaporative cooling and airflow.
- Water features such as fountains (evaporative cooling) and vegetation in semi-enclosed spaces can be used to create pleasant and usable outdoor microclimates.
- Incorporate landscape strategies that can alter the surrounding condition of a building: planting to shade a building, a canopy selection that does not restrict air movement, inclusion of water for evaporative cooling and ground cover selection to reduce heat reflection and glare, for example grass instead of paving.
- The function and use of internal spaces should be related to orientation. For example, rooms used in the afternoon and evening can be located facing in an easterly direction.

WALLS

- Consider adding an external or internal layer of insulation (e.g. rigid insulation covered with finish material) as a means of reducing solar radiation impact.
- Investigate the incorporation of secondary wall elements to reduce solar radiation impact such as verandas and colonnades.
- Reduce heat gains (and glare) affecting the walls by a landscaping strategy such as shade planting and groundcover selection.

OPENINGS

- Openings should be designed to minimize eastern and western exposure.

- Exterior shading and protection devices offer a real potential to reduce heat gains and to increase or to direct internal air movement, to reduce glare and maximize internal daylighting.
- Shading devices placed on the outside of openings are the first line of defense against heat gains through openings.
- Shading devices such as louvers can be adjusted and can alter the direction of airflow and lighting.
- Select materials for shading devices that will reflect heat rather than be an added heat source.
- Select high performance windows, such as double pane low-e glazing systems, that can reduce heat gains by reflecting radiate heat.

INTERNAL PLANNING

- Plan and zone according to new building function, occupancy levels and time of use.
- Plan and arrange internal spaces in relation to external facades and their orientation.
- Plan to minimize the number of different thermal zones.
- Plan and zone spaces with particular functions or requirements to reduce energy use or new service requirements.
- Ensure that partitions do not impede air movement such as for ventilation. Ensure that rooms used during the day are related to external facades to maximize daylighting.

VENTILATION AND COOLING PROVISIONS

- Incorporate materials and/or devices for cooling and ventilation.
- Regulate openings to encourage the stack effect.
- Ensure that building elements are sited to encourage air movement to create airflow.
- Investigate the possibility of combination solutions such as use of a staircase to create stack and venturi effects for ventilation by natural convection of air.
- Investigate the need for a means of supplementary natural ventilation or simple mechanical devices that can be used when wind speeds are low and for cooling components of the building envelope.
- Incorporate ventilation devices that direct air movement across desired surfaces such as hot internal surfaces or across the body.
- Use landscaping strategy for evaporative cooling of external and internal spaces.

Source: Koch-Nielsen, Holger (2002) *Stay Cool: A Design Guide for the Built Environment in Hot Climates*, James & James Ltd., London.

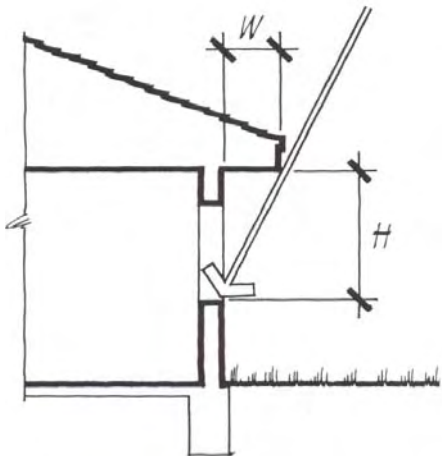
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rev. 9/05



Overhang Dimensions For Summer Shading

The proper size and spacing of shading elements is a function of the orientation of the openings and the time of day and year when shading is needed. The following overhang sizing information comes from *Climatic Building Design* (Watson). For a more accurate determination based on time of year, please refer to sizing tables in *Sun, Wind & Light* (Brown). See reference list for further information.



Roughly appropriate overhang dimension W can be calculated by selecting the shade line factor (SLF) from the table below and inserting in the formula:

$$W \text{ (overhang dimension)} = H / \text{SLF}$$

Shade Line Factors (SLF) for Phoenix region (latitude 33.5°)	
Window Faces	Shade Line Factor
East	0.8
Southeast	1.4
South	3.6
Southwest	1.4
West	0.8

References:

Brown, G.Z. and DeKay Mark (2001) *Sun, Wind & Light: Architectural Design Strategies*, John Wiley & Sons, New York.

Watson, Donald and Labs, Kenneth (1983) *Climatic Building Design: Energy-Efficient Building Principles and Practice*, McGraw-Hill, New York.



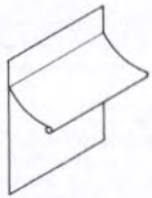
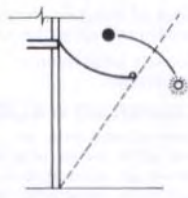

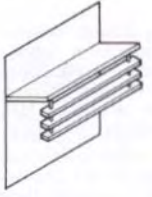
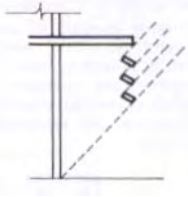
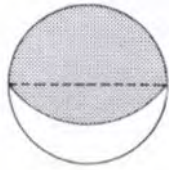
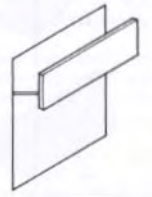
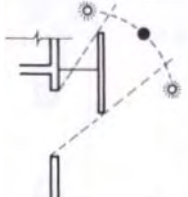

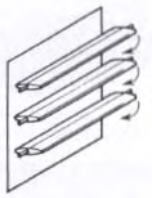
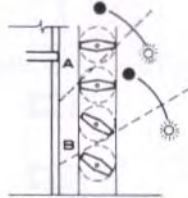
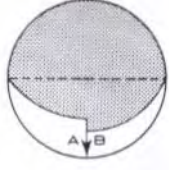
SHADING DEVICES

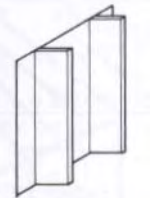
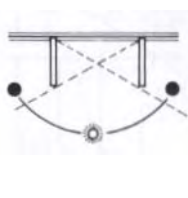

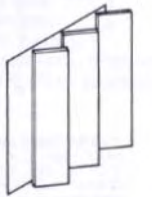
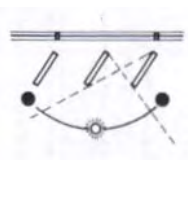
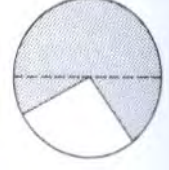
Exterior Protection from Summer Sun

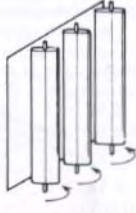
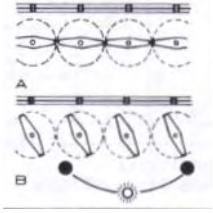
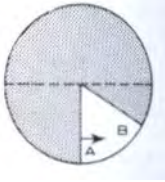
Other than building shape, orientation and location of openings, shading is a fundamental strategy for building in the context of a desert environment. High performance (low-e) windows are paramount but can never match the energy performance of an insulated wall. A typical insulated wall (2x6 framed walls w/ R-19 batts & 1" exterior foam) is 6-8 times better than a double pane low-e window as a barrier against summer heat. Shading provides for the interception of direct solar radiation before it strikes building openings and heat absorbing materials. Interception techniques range from trees and roof overhangs to lightweight ventilated shading panels attached to walls and roofs. Exterior shading devices are the most effective for creating tempered connections and transitions for indoor/outdoor spaces. Shading devices can also provide spatial definition and architectural character.

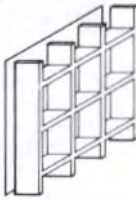
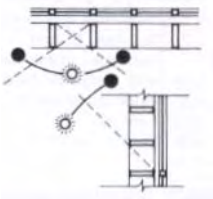

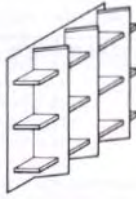
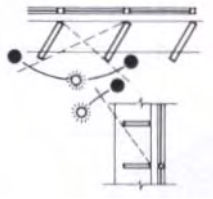

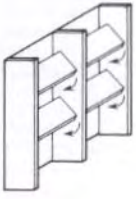
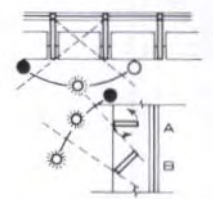
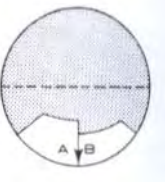
The following illustrations show a number of basic shading devices, classified as horizontal, vertical, and eggcrate types. The dash lines shown in the side view (section) diagram indicates the sun angle at the time of 100% shading. A *shading mask* for each device is also shown with 100% shading indicated by the gray area. A *shading mask* is the shadow cast by a building projection such as an overhang and is helpful in determining the effectiveness of a shading device for a given orientation. Masks of horizontal devices (overhangs) will create a segmental pattern; vertical devices (fins) produce a radial pattern; and shading devices with horizontal and vertical members (eggcrate type) will make a combinative pattern.

Horizontal Types			
Shading Device	Side View	Shading Masks	Comments
			<p><u>Straight overhangs</u> are most effective on southern exposure.</p>
			<p><u>Louvers parallel to wall</u> allows hot air to escape and are most effective on southern exposure.</p>

			<p><u>Awnings</u> are fully adjustable for seasonal conditions and most effective on southern exposure.</p>
			<p><u>Horizontal louvers hung from solid overhangs</u> cuts out the lower rays of the sun. Effective on south, east and west exposures.</p>
			<p><u>Vertical strip parallel to wall</u> cuts out the lower rays of the sun. Effective on south, east and west exposures.</p>
			<p><u>Rotating horizontal louvers</u> are adjustable for daily and seasonal conditions. Effective on south, east and west exposures.</p>

Vertical Types			
Shading Device	Plan View	Shading Masks	Comments
			<p><u>Vertical fins</u> are most effective on the near-east, near-west and north exposures.</p>
			<p><u>Slanted vertical fins</u> are most effective on east and west exposures. Slant toward north and separation from wall minimizes heat transmission.</p>

			Rotating vertical fins are the most flexible and adjustable for daily and seasonal conditions. Most effective on east and west exposures.
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Eggcrate Types			
Shading Device	Plan & Side View	Shading Masks	Comments
			<u>Eggcrate types</u> are combinations of horizontal and vertical types. Most effective in hot climates on east and west exposures.
			<u>Eggcrate with slanted vertical fins</u> (slant toward north). Most effective in hot climates on east and west exposures.
			<u>Eggcrate with rotating horizontal louvers</u> . Most effective in hot climates on east and west exposures.

References:

Brown, G.Z. and DeKay Mark (2001) *Sun, Wind & Light: Architectural Design Strategies*, John Wiley & Sons, New York.

Givoni, Baruch (1998) *Climate Considerations in Building and Urban Design*, Van Nostrand Reinhold, New York.

Hoke, John Ray (2000) *Architectural Graphic Standards*, John Wiley & Sons, New York.

Olgay, Aladar and Victor (1957) *Solar Control & Shading Devices*, Princeton University Press, Princeton.

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Green Building Program

POROUS PAVEMENT PRODUCTS & RESOURCES

(Adapted from Environmental Building News, Vol.13, No. 9, 9/04)

GRADED AGGREGATE	
Stabilized decomposed granite and soils	
Pre-stabilized Granite - 1/4" minus decomposed granite pre-blended with organic stabilizing compound; Soilshield-LS - liquid copolymer concentrate which bonds decomposed granite	Soil-Loc, Inc. (Scottsdale, AZ) (480) 948-8114, www.soilloc.com
100% recycled pine tree resin mixed with decomposed granite and other aggregates to produce a water repellent surface.	Matrx Industries (Phoenix, AZ) 602-758-2815
Soiltac - polymer-based emulsion used to stabilize soils and decomposed granite	Soilworks, LLC (Gilbert, AZ) (480) 545-5454, www.soilworks.com
Stabilizer Solutions - stabilized binder and reinforcement for decomposed aggregate	Stabilizer Solutions Inc. (Phoenix, AZ) (602) 225-5900, www.stabilizersolutions.com
Soil-Sement – stabilization for decomposed granite	EarthCare Consultants, LLC (AZ) 888-792-4001, www.earthcareconsultants.com
MARLOC – compounded waterborne copolymer emulsion used to stabilize soil materials	Reclamare Company (WA) (206) 824-2385, www.reclamare.com
Trade association software for storm water infiltration structure design	National Stone, Sand & Gravel Assoc. (VA) 703-525-8788, www.nssga.org
BASE SUPPORT FOR AGGREGATE AND GROUND MATERIAL	
Interlocking open grid for stabilizing ground material such as decomposed granite, soil and vegetation for heavy traffic areas and erosion control	
Gravelpave2 – geotextile fabric molded directly to one inch high tubular cells (typically 100% post-consumer recycled content) to provide load bearing support and containment of gravel to create a porous pavement surface for traffic and parking	Invisible Structures, Inc. (CO) 800-233-1510, www.invisiblestructures.com GeoSupply (AZ) 602-305-8094, www.geosupply.com
Netpave 50 for embedment in turf or gravel	Netlon Turf Systems (UK) www.netlon.co.uk (look for US distributors)
TufftrackGrassRoad Pavers8 Plus – interlocking Honeycomb-void panels (minimum 25% post-consumer Recycled content)	NDS, Inc. (CA) 800-726-1994, www.ndspro.com
PermaTurf – interlocking honeycomb-void panels, Sold as a DIY product (100% recycled content, unspecified Source)	PermaTurf Co., Inc. (NH) 800-498-4116, www.permaturf.com
Geoblock – interlocking square-celled panels (minimum 10% post-consumer recycled content)	Presto Products Company (WI) 800-548-3424, www.prestogeo.com

Grassy Pavers – honeycomb-shaped voids (minimum 97% post-consumer recycled content)	RK Manufacturing, Inc. (MS) 800-957-5575, www.rkmfg.com
GridTech Hex Panel – reusable, interlocking hexagonal panels, approximately 3 ft ² . (0.3 m ²) each, particularly good for sand; also available in aluminum (100% recycled HDPE)	Grid Technologies, Inc. (RI) 800-959-7920, www.gridtech.com
OPEN-JOINTED CONCRETE PAVERS Pavers with inherent voids between blocks	
Bio-Aquifer Storm System- engineered system of Z-pattern, square, or X-shaped pavers over well Prepared base	Advanced Pavement Technology (IL) 877-551-4200, www.advancedpavement.com
Eco-Perm Pavers – square interlocking pavers; Different installation patterns achieve different void percentages	Air Vol Block, Inc. (CA) 805-543-1314, www.airvolblock.com
Ecologic Pavers – wide range of concrete pavers that can be installed in porous applications	Capitol Ornamental Concrete Specialties, Inc. (NJ) 732-727-5460, www.capitolconcrete.com
ECO 1 Pavers have a brick look; Monoslabs have a raised “waffle” pattern	EP Henry Corporation (NJ) 800-444-3679, www.ephenry.com
Environpave Spacers – polyethylene and polypropylene pipe-style spacers for use with almost any paving block	Pave Tech, Inc. (MN) 800-728-3832, www.pavetech.com
SF Rima are square pavers; SF Matoro-Drain is a two Dimensional, T-pattern, interlocking system for heavier Loads	SF Concrete Technology, Inc. (ON) 905-828-2868, www.sfconcrete.com
UNI Eco-Stone – high-load interlocking pavers with Diamond-shaped corner voids	UNI-Group U.S.A. (FL) 800-872-1864, www.uni-groupusa.org
Aquaterra – Z-pattern pavers for driveable surfaces	Unilock, Ltd. (IL) 800-864-5625, www.unilock.com
Trade association information for design professionals, contractors, and homeowners	Interlocking Concrete Paver Institute (DC) 202-712-9036, www.icpi.org
OPEN-CELLED CONCRETE PAVERS Pavers with integral voids for grass or drainage material	
Grass Paver – made from clay (not concrete); square, 5-hole pavers for use in dry and moderate climates	D’Hanis (TX) 800-299-9399, www.dhanisbricktile.com
Turf Pavers – lattice-style grid in a large paver format	EP Henry Corporation (NJ) 800-444-3679, www.ephenry.com
EcoGrid Pavers – square pavers with four square voids. Appropriate for moderate vehicle traffic.	Hanover Architectural Products (PA) 800-426-4242, www.hanoverpavers.com
Checker Block – steel reinforced, 2-foot-square (0.2m ²) Waffle-type tiles	Hastings Pavement Company, LLC (NY) 800-669-9294, www.hastingspavers.com
Turfstone – lattice-style containment for turf or aggregate	Nicolock (NY) 800-669-9294, www.nicolock.com
Grasstone – Z-shaped, 8-void containment block for turf or aggregate	Pavestone (TX) 800-580-7283, www.pavestone.com

POROUS CONCRETE No-fines concrete	
Grasscrete – similar to open-celled concrete pavers but cast-in-place as monolithic porous concrete pavement; the voids are filled with topsoil and turf	Bomanite (CA) 559-673-2411, www.bomanite.com
Ecocrete – specialized admixture for porous concrete	Ecocrete of Texas, Inc. (TX) 512-312-5901
StoneyCrete – porous concrete produced with proprietary admixture	Stoney Creek Materials, LLC (TX) 512-261-0821, www.stoneycreekmaterials.com
Portland Cement Pervious Pavement Manual - porous concrete introduced by the trade association in the U.S.	Florida Concrete & Products Association 407-895-9333, www.fcpa.org
POROUS ASPHALT “open-graded,” no-fines asphalt with less tar	
Trade association information on porous asphalt	National Asphalt Pavement Association (MD)888-468-6499, www.hotmix.org
RUBBER PAVEMENT AND PAVERS Flexible/cushioned pavement surfaces, often made from recycled tires	
PlayTiles –interlocking porous tiles made with recycled rubber, sold as playground surfacing (up to 90% post-consumer recycled material)	Dinoflex Manufacturing, Ltd. (BC) 877-713-1899, www.dinoflex.com
Flexi-Pave and Flex-Path – site-installed porous urethane bonded crumb rubber pavement (rubber from used auto tires)	KB Industries, Inc. (FL) 727-647-2307
Sport Track – site installed poly-bonded rubber and EPDM granules, sold as running track surfacing	Hellas Construction Inc. (TX) 512-250-2910, www.hellasconstruction.com
Safety Deck II – interlocking high-void tiles of recycled rubber and PVC; sold as trail and playground surfacing	Mat Factory, Inc. (CA) 800-628-7626, www.matfactoryinc.com
DuraPaver and PlayBound Tile – recycled-rubber/polyurethane pavers and tiles for walkways and playgrounds	Surface America, Inc. (NY) 800-999-0555, www.surfaceamerica.com

rev. 10/5/05