# CONSTRUCTION DRAWING LAYOUT

## INTRODUCTION

The organization and format of drawing packages is a critical element in the professional preparation of construction documents. Early on, the order drawings will appear in a set of construction documents should be determined and distributed to everyone involved in the production process. Most firms have established a standard by which to sequence the documents in a package, by discipline, and then within those disciplines as well. This organization may also be mandated by certain clients, who may have a standard process and expect to see the drawings in a particular progression. The method presented in this chapter is a frequently encountered system for construction document layout.

## NAMING AND NUMBERING DRAWINGS

Before the drawings can be organized, they have to be named and numbered in a logical manner. The diagram presented here shows a typical drawing-naming standard, and explains the importance of each letter and number in that name.

## DRAWING ORGANIZATION

Once the drawings are named, they can be put in order. In all cases, the package setup goes from general and nonspecific information to highly detailed and specific information. A good way to approach this is to put yourself in the contractor's shoes and imagine how you would go about understanding what the project is all about. The package should start by explaining the project location, name, owner's name, and so on—all of this information can be contained on the cover page. Next, the package should explain how the documents are organized and how to read the symbols included in the package, as well as all of the general notes that apply to the entire project. When all of this information is explained, you are ready to begin documentation of the design. Once again, the information in the package should be ordered from the general (large-scale level) down to small-scale details. Starting with overall plans and working through to the individual details, the package organization should be clear and consistent. Remember, the goal is to explain the design intent as efficiently as possible.

In addition to the preceding, the organization of the package is also loosely based on the order of construction of the project. When the contractor installs the project, the hardscape elements will generally be installed first. Thus, the package should present the hardscape plans before the landscape plans. The information is easier to understand in this order—imagine how hard it would be to understand a project if the first drawings were covered with the planting graphics necessary to explain the landscape installation, ahead of the grading, layout, and hardscape information.

The index presented here is a typical representation of the order of drawings in a package.

| Sheet | Contents |
|---|---|
| G-001 | Cover |
| L-001 | Sheet Index |
| L-002 | Notes and Legends |
| LS101 | Site Plan |
| LS201 | Site Elevations |
| LS301 | Site Sections |
| LS401 | Site Plan Enlargement |
| LS501 | Hardscape Details |
| LP101 | Planting Plan |
| LP401 | Planting Plan Enlargement |
| LP501 | Planting Details |
| LP601 | Plant Schedule |

In many cases, the package will include not only the landscape architectural drawings, but also other disciplines, such as architecture; civil engineering; structural engineering; mechanical, electrical, and plumbing engineering (MEP); and so on. The presentation of this information follows the same pattern as above, general to specific, and the drawing order follows the order of construction. For example, for a project with all of the professionals listed above, the following discipline order may most efficiently explain the information:

Civil engineering
Landscape architecture
Architecture
Structural engineering
MEP

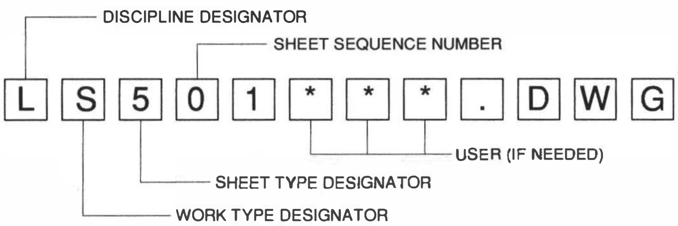
The prime consultant is responsible for establishing and distributing this information to the entire team. This should be done as early in the construction documentation process as possible.

### Drawing Layout

The individual drawings in a package should always have a few basic elements that guide their interpretation, such as the title block, a scale, a north arrow, a key map (if needed), a legend, and so on. This information should be standardized for the project.

## DRAWING CHECKLIST

Many firms will have established checklists to aid in the creation of construction documents. These checklists should be referenced frequently and are a great source of valuable information.




| DISCIPLINE DESIGNATIONS | |
|---|---|
| G | GENERAL |
| H | HAZARDOUS MATERIALS |
| C | CIVIL |
| L | LANDSCAPE |
| S | STRUCTURAL |
| A | ARCHITECTURAL |
| I | INTERIORS |
| Q | EQUIPMENT |
| F | FIRE PROTECTION |
| P | PLUMBING |
| M | MECHANICAL |
| E | ELECTRICAL |
| T | TELECOMMUNICATIONS |
| R | RESOURCE |
| X | OTHER DISCIPLINES |
| Z | CONTRACT OR SHOP DRAWINGS |

| WORK TYPE DESIGNATIONS | |
|---|---|
| S | HARDSCAPE |
| I | IRRIGATION |
| P | PLANTING |
| L | LIGHTING |
| G | GRADING |
| D | DEMOLITION |
| R | RELOCATION |

| SHEET TYPE DESIGNATIONS | |
|---|---|
| 0 | GENERAL (SYMBOLS LEGEND, NOTES, ETC.) |
| 1 | PLANS (HORIZONTAL VIEWS) |
| 2 | ELEVATIONS (VERTICAL VIEWS) |
| 3 | SECTIONS (SECTIONAL VIEWS) |
| 4 | LARGE-SCALE VIEWS (ENLARGEMENT PLANS, ELEVATIONS OR SECTIONS THAT ARE NOT DETAILS) |
| 5 | DETAILS |
| 6 | SCHEDULES AND DIAGRAMS |
| 7 | USER-DEFINED |
| 8 | USER-DEFINED |
| 9 | 3D REPRESENTATIONS (ISOMETRICS, PERSPECTIVES, PHOTOGRAPHS) |

**CONSTRUCTION DOCUMENT DRAWING NAMING FORMULA, FROM A TYPICAL OFFICE STANDARD**

*Thomas Jones, RLA, EDAW*

## GRAPHICS GUIDELINES

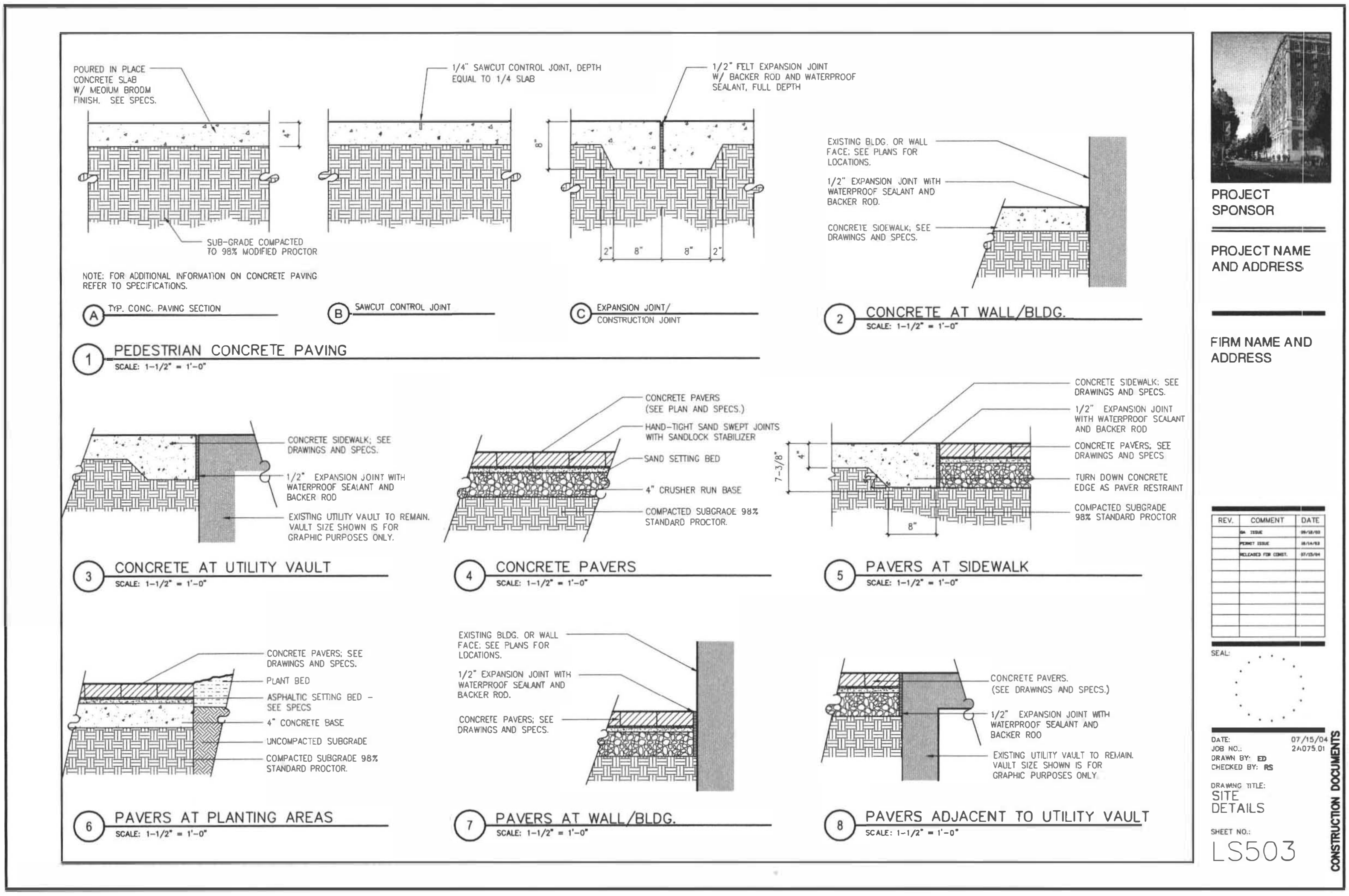
- ☐ Always draw to scale and label drawings as such.
- ☐ Use consistent scale among like details, e.g., all pavements at the same scale.
- ☐ Use common architectural scales
- ☐ Dimension on left; note on right.
- ☐ Use standard material designations; bleed judiciously.
- ☐ Use bold outlines around object in section.
- ☐ Draw object lines medium lineweight; dimension, extension, notation leaders fine lineweight.
- ☐ Align details vertically, including dimensions, object, and notes.
- ☐ Align details horizontally where possible.
- ☐ Keep details, detail enlargements, etc., of a given object or element on the same sheet when possible. This is especially important for a unique element that may be a subcontract, e.g., a garden structure.
- ☐ Always draw typical details first; when drawing unique details, refer back to typical detail note or callout. Do not redraw details.
- ☐ Use standard orthographic projection standards for three-dimensional details with plan on top, section under, elevation to the right. (A detail such as this is considered one detail—not three—in terms of callout designation.)
- ☐ For symmetrical structures, use half-plans and half-garden sections for economy and clarity. For example, on a garden structure, the left half may show the framing plan of the roof, while the right side may show the paving pattern on the floor.

**TYPICAL CONSTRUCTION DOCUMENT GRAPHICS CHECKLIST**

## OVERALL DRAWING GUIDELINES

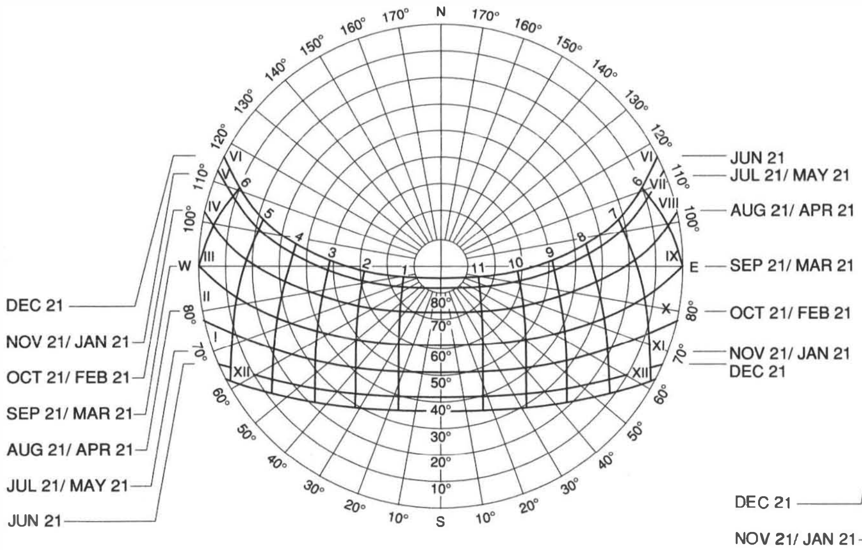
- ☐ Show only what you have to show to build your designs—nothing more, nothing less.
- ☐ Draw all plans at the same scale and orientation.
- ☐ Show the correct information the least number of times. Once is best.
- ☐ Don't draw any other discipline's work except to reference it.
- ☐ Use consistent terminology through the drawings and specifications.
- ☐ Don't draw at large scale what you can draw at a small scale.
- ☐ Don't draw at all what you can note, e.g., catalog items.
- ☐ Don't note what you can spec.
- ☐ Don't label what you can symbolize.
- ☐ Where possible, combine elements, e.g., layout, grading to minimize sheet count.
- ☐ Always proceed from general to specific, large to small, plan to elevation to section.
- ☐ Minimize the use of match lines.
- ☐ Maximize the use of enlargements.
- ☐ Only enlarge if enlargement is two to three times as big as original. Make sure that the enlargement area carries all the content, so that it is not repeated at the smaller scale.
- ☐ Coordinate with utility locations and actual sizes of utility appurtenances.

**TYPICAL DRAWING CHECKLIST FOR CONSTRUCTION DOCUMENTS**

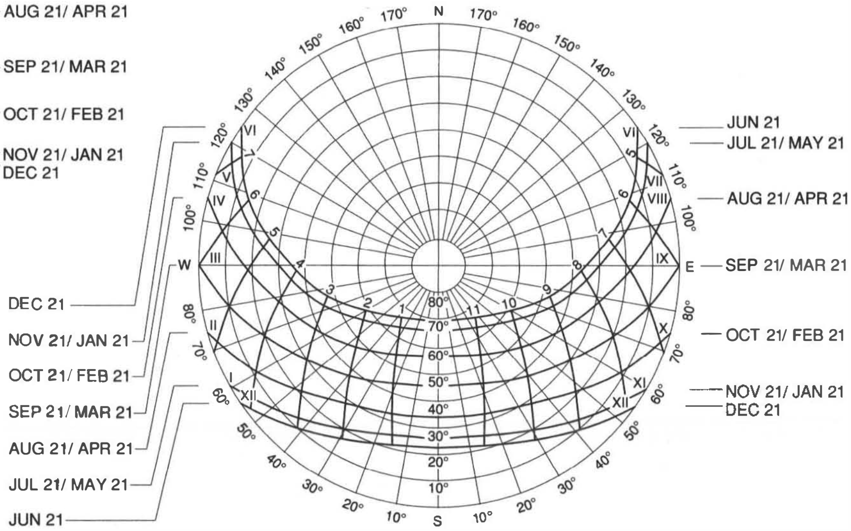



**TYPICAL CONSTRUCTION DOCUMENT DETAIL SHEET**

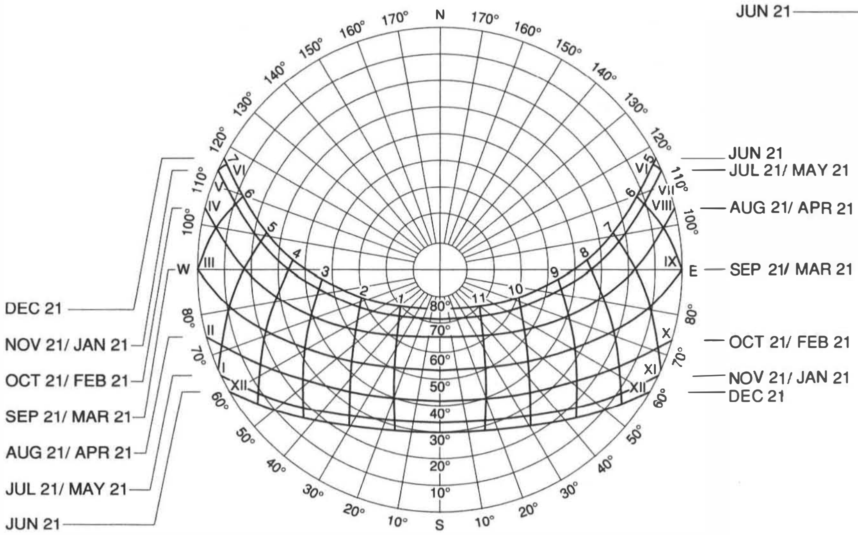
*Thomas Jones, RLA, EDAW*



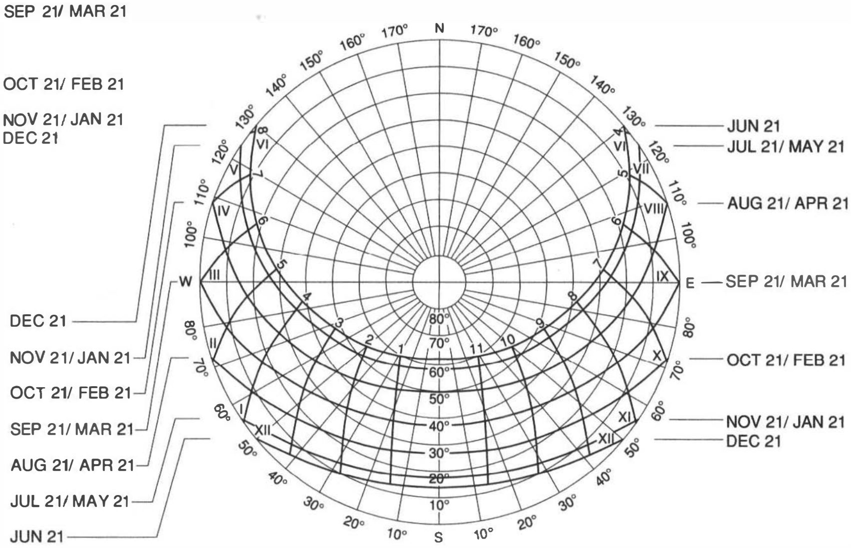

**28°N LATITUDE**




**44°N LATITUDE**



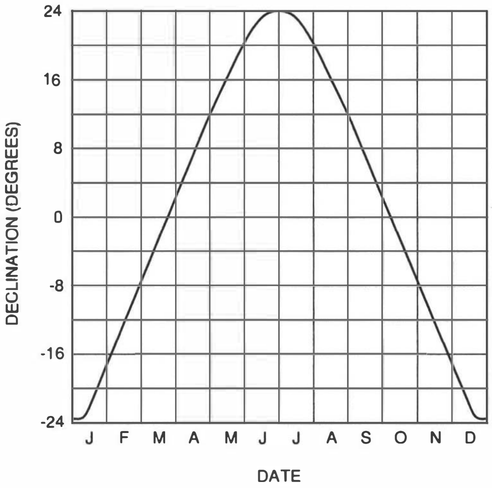

**36°N LATITUDE**




**52°N LATITUDE**

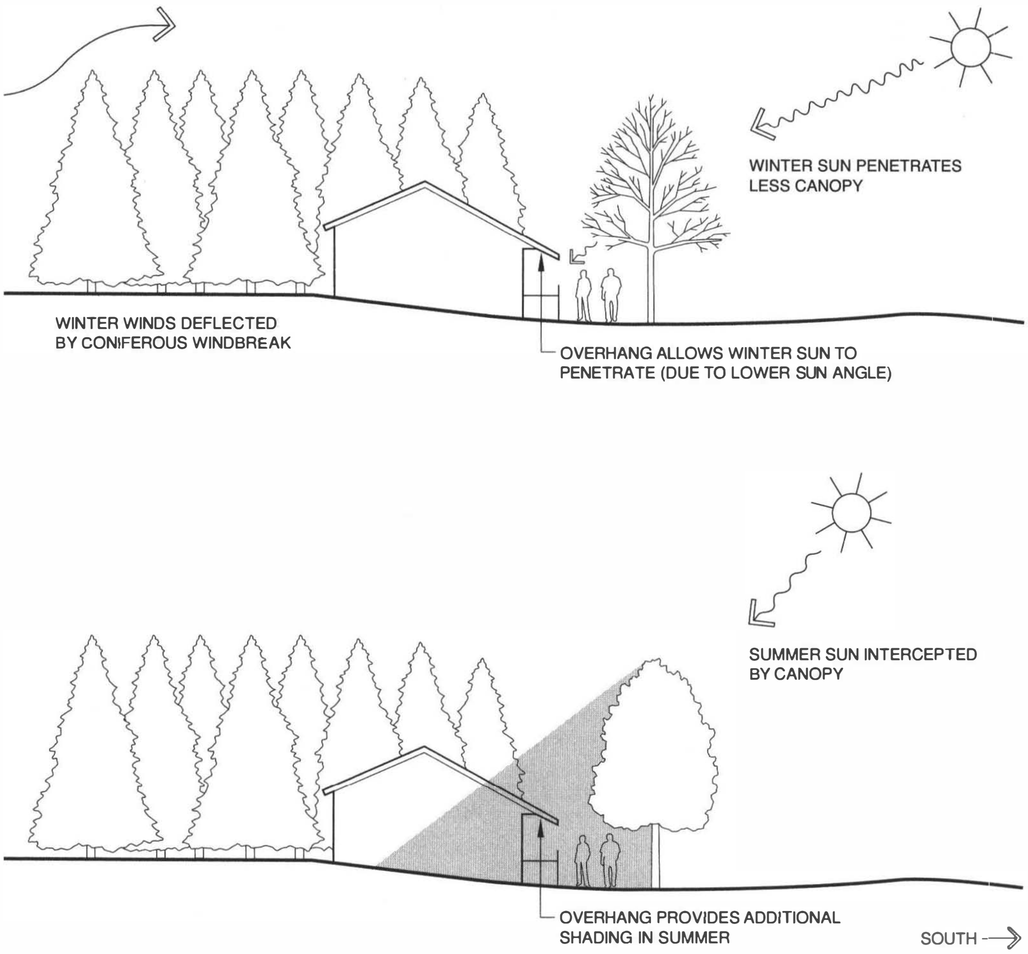
## SUN PATH DIAGRAMS

*Dr. Robert D. Brown, University of Guelph, Guelph, Ontario, Canada; Robert T. LeBlanc, Ekistics Planning and Design, Dartmouth, Nova Scotia, Canada*




The declination of the sun can be determined from this diagram. The first letter of each month is listed across the bottom of the graph, and the declination in degrees is listed along the side. Find the date you are interested in and read the sun's declination angle off the graph.

**SUN DECLINATION**




The amount of solar radiation received by people or objects in the landscape can be increased or decreased through strategic site design. During cool seasons, people will receive high levels of solar radiation in areas that are also sheltered from prevailing winter winds. During warm seasons, people will be able to sit or stand in dense shade, a more thermally comfortable microclimate.

**SEASONAL MODIFICATIONS OF SOLAR RADIATION**

- *June 21.* Summer solstice, when noontime shadows are the shortest of the year, and the sun rises earliest and sets latest in the year.
- *December 21.* Winter solstice, when noontime shadows are the longest of the year, and the sun rises latest and sets earliest in the year.
- *September 21 and March 21.* Fall and spring equinoxes, when there is equal amounts of day and night, and the sun rises due east and sets due west.
- *November 6 and February 6 (same sun angle).* Mid-fall and mid-winter, which are representative of fall and winter shadows.
- *May 6 and August 6 (same sun angle).* Mid-spring and mid-summer, which are representative of spring and summer shadows.

## STANDARD APPROACHES FOR MODIFYING SOLAR RADIATION

### General Guidelines

Standard approaches for modifying solar radiation include:

- Locate objects in the landscape so that their shadows fall on areas that will benefit from a reduction in solar radiation (lower levels of heat and/or light); and allow solar radiation to enter areas that will benefit from the added heat and/or light.
- Select the density of objects to provide the desired level of shade. Generally, the level of solar radiation will be lowest in the shade of buildings and solid objects; low under densely leafed trees; moderate under lightly-leafed trees, and approaching full sun levels under leafless deciduous trees.
- Increase the amount of solar radiation received by an area through reflection. Light-colored and shiny surfaces will reflect much of the solar radiation they receive, and this can be directed toward areas that would benefit from increased solar radiation.
- In designs, consider modification of both solar radiation and wind (see also *Modifying Wind*) to provide the most beneficial microclimates (see also *Modifying Microclimates*).

## LIMITATIONS

Caution must be exercised in interpreting shadow diagrams, because they provide a *static view* of a *dynamic process*. The sun is moving continuously and shadows are constantly changing. Also, due to the unpredictable nature of weather, there are no guarantees that the sun will shine on any given day.

## EMERGING ALTERNATIVE APPROACHES

With increases in computer speed and memory, modeling and simulation are becoming more reasonable alternatives. For complex landscapes (such as one building casting a shadow onto another building, or sloping roofs of buildings casting complex shadows), it is often worthwhile to use computer programs that both calculate the position of the sun and shadows and illustrate the resulting shadows through a time-lapse simulation. This process can be used to illustrate the solar access to an area over a period of time in a way that is very understandable.

## ADDITIONAL APPLICATIONS

Strategic modification of solar radiation can also be beneficial for:

- Active and passive solar heating of buildings
- Survival of plants
- Habitat for animals

## RESOURCES

Brown, G. Z., and M. DeKay. 2001. *Sun, Wind & Light: Architectural Design Strategies* (2nd ed.). New York: John Wiley & Sons, Inc.

Brown, Robert D., and Terry J. Gillespie. 1995. *Microclimatic Landscape Design: Creating Thermal Comfort and Energy Efficiency*. New York: John Wiley & Sons, Inc.

Oke, T. R. 1987. *Boundary Layer Climates*. New York: Routledge.

### See also:

*Modifying Air Quality*
*Modifying Microclimates*
*Modifying Wind*
*Regional Climate*

*Dr. Robert D. Brown, University of Guelph, Guelph, Ontario, Canada; Robert T. LeBlanc, Ekistics Planning and Design, Dartmouth, Nova Scotia, Canada*

# MODIFYING WIND

## INTRODUCTION

Air moves from areas of high pressure to areas of low pressure, and in doing so creates wind. The wind varies in direction of flow and strength throughout the day and through the year. Climate stations record wind speed and direction on an hourly basis, and these values are generally available (see *Regional Climate*). The wind does not normally blow equally from all directions, but often comes predominantly from one direction. This dominant direction is known as the "prevailing wind" or "dominant wind." The amount of time that the wind blows from each direction can be illustrated by a "wind rose." Wind patterns that have been observed in the past generally provide a reasonable estimate of wind patterns that can be expected to occur in future.

As wind moves through a landscape, it is modified by objects that it encounters. Solid objects, such as buildings, affect the wind differently from porous objects, such as tree canopies. The wind will heat or cool objects it encounters (including people, buildings, plants, etc.) depending on the relative temperature. If the air is cooler than a person, for example, the air will have a cooling effect. The greater the difference in temperature between the air and the object, the greater the cooling effect. For this reason, the wind is a very effective cooling agent during winter when the temperature difference between a person and the air is at a maximum. This is often described as "windchill" in weather forecasts. In warmer weather, though, when the air is at or near the temperature of a person, the cooling effect is minimized. This means that designs for areas to be used in cool seasons should focus on reducing wind speed. However, areas to be used in hot seasons will be less substantially improved by increasing the wind. Areas to be used in hot seasons are more effectively cooled by providing shade (see *Modifying Solar Radiation*) than by increasing wind.

Other reasons to modify wind in the landscape include strategic diversion or deposition of snow or sand carried by the wind, dissipation of air pollution (see *Modifying Air Quality*), and energy conservation in buildings.

Wind in a landscape can be readily modified by design. It is quite easy to reduce, but difficult to increase, wind speed in an area. Wind diagrams can be generated to illustrate areas that are inherently appropriate for use in different seasons.

## STANDARDS

### General Guidelines

General guidelines for modifying wind for design purposes include:

- Orient outdoor areas away from prevailing cool season winds.
- For areas to be used in cool seasons, provide upwind barriers perpendicular to prevailing seasonal winds.
- For areas to be used in warm seasons, do not block, and if possible increase, prevailing seasonal winds.

### Regional Winds

Wind data from a climate station (see *Regional Climate*) can be tabulated for different time periods. Yearly data will often yield patterns that are different from seasonal patterns.

These tabulated data can be illustrated as a wind rose by drawing the length of each line proportional to the amount of time the wind blows from that direction. These patterns often change with the season, and in general it is the wind patterns during cool to cold periods that are the most important when designing outdoor areas.

### Local Winds

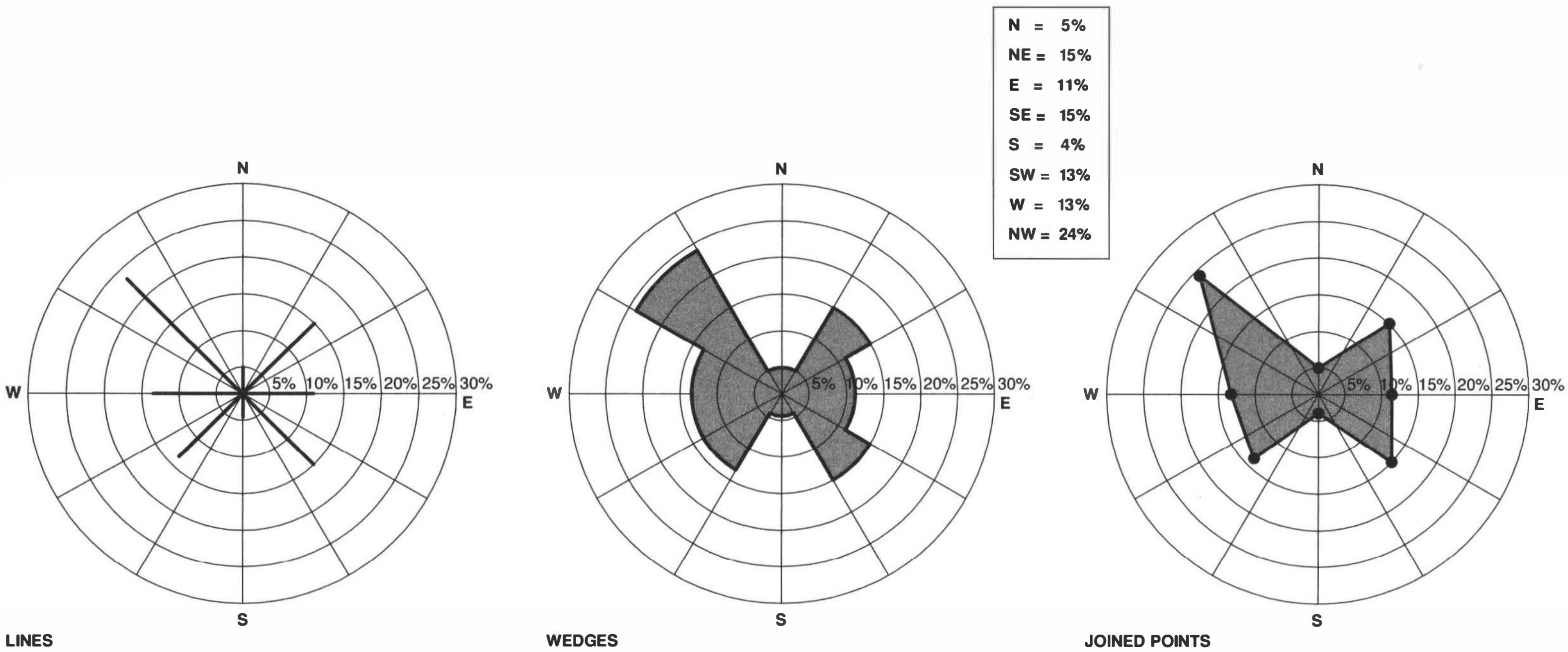
The wind that has been measured at a climate station provides a view of the general wind patterns of a region, but these patterns are modified at a local scale by elements of a landscape. At present, the most effective way to determine local winds in a landscape is to build a scale model and test it in a wind tunnel; however, this can be expensive and time-consuming. Computer models currently are not available for use in simulating wind in a complex landscape.

A less expensive, but also less accurate, approach to estimating local winds in a landscape is to use empirically based diagrams. Over time people have

**TABLE OF CLIMATE STATION DATA**

Wind data from a climate station can be tabulated in a format that is useful in design. Some standard approaches include the percentage of the time that the wind blows from each direction by season (columns 1 through 4) and throughout the year (column 5).

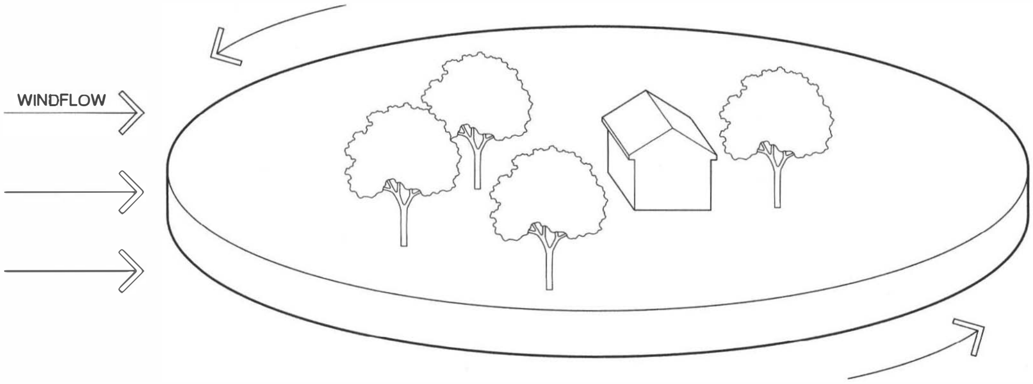
| | PERCENTAGES | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| | Winter | Spring | Summer | Fall | Year |
| N | 19.3 | 19.8 | 15.5 | 17.6 | 18.0 |
| NE | 4.7 | 5.6 | 3.5 | 4.5 | 4.6 |
| E | 4.9 | 5.4 | 3.1 | 4.6 | 4.5 |
| SE | 8.6 | 11.9 | 8.2 | 8.4 | 9.3 |
| S | 12.6 | 20.6 | 25.7 | 14.9 | 18.5 |
| SW | 11.7 | 13.2 | 20.1 | 15.2 | 15.1 |
| W | 17.6 | 10.8 | 12.1 | 16.8 | 14.3 |
| NW | 20.6 | 12.6 | 11.8 | 18.1 | 15.8 |




A wind rose diagram can be used to illustrate the amount of time that the wind blows from each compass direction. In this example, the prevailing wind is from the northwest.

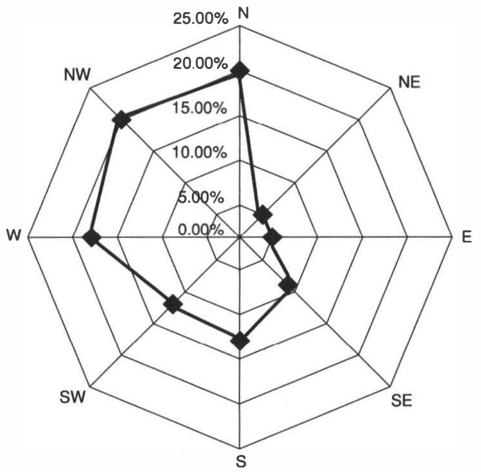
**THREE ALTERNATIVES TO SHOWING THE AMOUNT OF TIME WIND BLOWS FROM EACH COMPASS DIRECTION**

Dr. Robert D. Brown, University of Guelph, Guelph, Ontario, Canada; Robert T. LeBlanc, Ekistics Planning and Design, Dartmouth, Nova Scotia, Canada

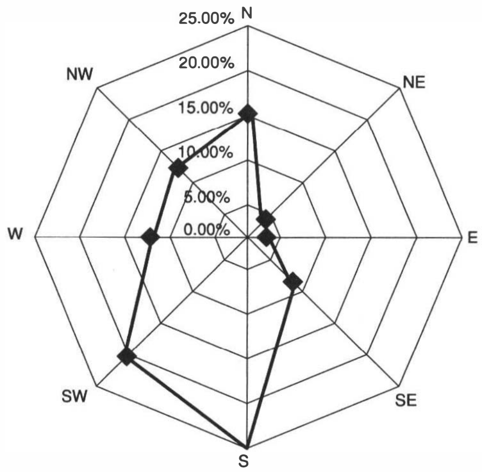



A scale model of a landscape is constructed, typically on a circular base, and set into a wind tunnel. The fan is turned on to generate wind, and sensors can be used to measure the wind speed at various locations around the model. When considering outdoor areas for use by people, the sensors measure the wind speed at about chest height in the landscape. The model is turned periodically so that each direction of wind is allowed to flow over the model. The model can be modified according to the proposed design, and the design can be tested for the effect on the wind. This approach can identify and alleviate problems before construction.

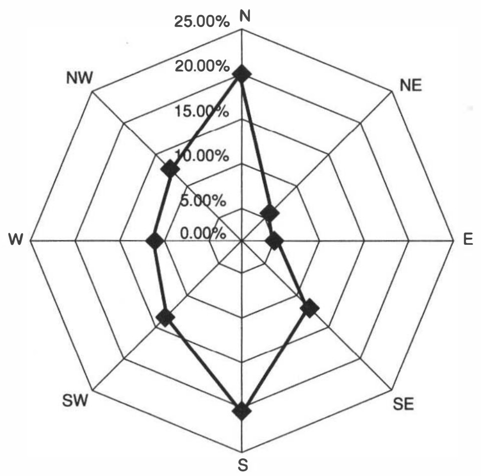
**ROTATING WIND TUNNEL MODEL**



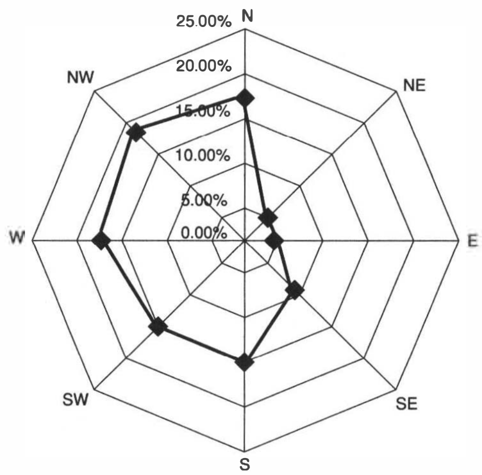

**WINTER**




**SUMMER**




**SPRING**




**FALL**

Wind data from climate stations can be illustrated through the use of wind roses. The data from "Table of Climate Station Data" has been used to generate seasonal wind roses.

**WIND ROSES TO SHOW SEASONAL DIFFERENCES**

observed and measured patterns of wind flow around standard elements in a landscape. These patterns can be used to illustrate both approximately how the wind will flow across a landscape and how the design of the landscape will affect future wind patterns.

## STANDARD APPROACHES FOR MODIFYING WINDS

### General Guidelines

Standard approaches for modifying winds can be summarized in these general guidelines:

- Locate objects in the landscape so that their "wind reduction zones" will occur in areas that will benefit from a lower wind speed (less cooling when air is cooler than an object); and allow wind to enter areas that will benefit from the increased convective cooling.
- Select the porosity of objects to provide the desired amount of wind reduction and size of wind reduction zones. Generally, the wind speed will be lowest behind buildings and solid objects, but the wind reduction zone will be very small and will probably experience turbulence; wind speed will be low behind trees with approximately 50 percent porosity and whose branches extend to the ground, and the wind reduction zone will be relatively large; and wind speed will be nearly the same as in the open when behind lightly leafed and leafless deciduous trees and coniferous trees whose branches don't extend to the ground.
- The amount of wind received in an area can be increased through deflection and/or channeling. "Conservation of mass" requires that air must go somewhere, even when it encounters a solid object. Air moving as wind over a landscape is analogous to water flowing in a channel. When the water encounters an obstruction, the water flows over and around and keeps going. Similarly, when wind meets a solid object, it has to go somewhere, so it flows over and around. The air can be deflected, through design, to flow through areas that would benefit from increased wind. Also, just as water will increase in speed when flowing through a constricted channel, air will also increase in speed if channeled between two solid objects such as buildings.
- Designs should consider modification of both wind and solar radiation (see *Modifying Solar Radiation*) to provide the most beneficial microclimates (see *Modifying Microclimates*).

## LIMITATIONS

Of all the biological and physical elements in a landscape, the wind is probably the most difficult to characterize and control through design. The standard approaches and patterns described here provide only an estimate of the general conditions of wind on a site. Reality can be quite different. As noted, the complexity of wind flow in the landscape has yet to be effectively modeled by computers.

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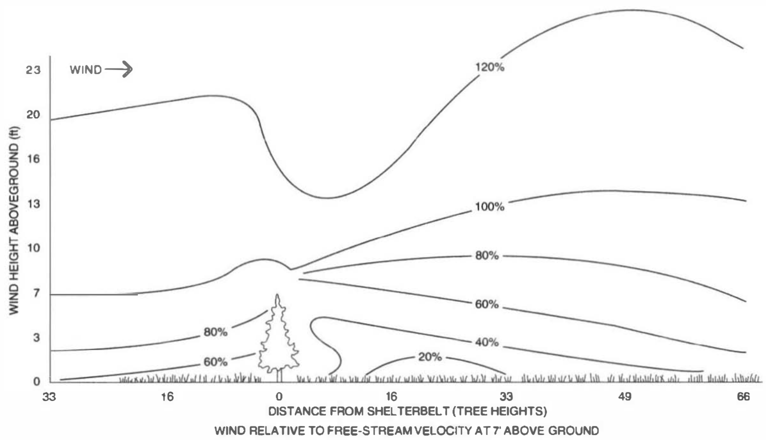



ILLUSTRATION OF WIND PATTERN AROUND A PERMEABLE WINDBREAK SUCH AS A THUJA OCCIDENTALIS HEDGE

Over time people have observed patterns of wind flow around buildings and plants in the landscape. These diagrams can be used in conjunction with the wind rose diagrams to estimate local winds on a site. They can also be used strategically to modify the wind on a site to achieve design goals. Note: the numbers across the bottom represent multiples of windbreak height. For example, if the windbreak is 5 feet tall, the value 16 represents 5 × 16 = 80 feet downwind of the windbreak.

## STANDARD PATTERNS OF WIND FLOW IN THE LANDSCAPE

## EMERGING ALTERNATIVE APPROACHES

Although computer modeling of wind is still not practical for complex landscapes, there are encouraging developments of programs that model and simulate wind in the landscape.

## ADDITIONAL APPLICATIONS

Information about winds can be useful in many different kinds of design decisions, including:

- Human thermal comfort
- Energy use in buildings
- Effects on plants and animals
- Deposition of snow or sand

## RESOURCES

Brown, G. Z., and M. DeKay. 2001. *Sun, Wind & Light: Architectural Design Strategies* (2nd ed.). New York: John Wiley & Sons, Inc.

Brown, Robert D., and Terry J. Gillespie. 1995. *Microclimatic Landscape Design: Creating Thermal Comfort and Energy Efficiency*. New York: John Wiley & Sons, Inc.

Oke, T. R. 1987. *Boundary Layer Climates*. New York: Routledge.

**See also:**

*Modifying Air Quality*
*Modifying Microclimates*
*Modifying Solar Radiation*
*Regional Climate*

*Dr. Robert D. Brown, University of Guelph, Guelph, Ontario, Canada; Robert T. LeBlanc, Ekistics Planning and Design, Dartmouth, Nova Scotia, Canada*

# REGIONAL CLIMATE

## INTRODUCTION

The climate at a site is an integration of daily weather events over a selected period of time. The World Meteorological Organization of the United Nations recommends that climate normals be computed for 30-year periods and updated at the beginning of each decade. The currently recommended climate data are for the 1971–2000 period.

Two main drivers of climate will be reflected in the data for a site:

- Proximity to a significant body of water
- Latitude

Regional climate must be considered in the landscape design process. Location and orientation of landscape elements will affect such things as human comfort, energy consumption by buildings, and convenient use of outdoor spaces. Consideration of climate data will improve the landscape architect's design of any site, regardless of whether he or she has lived there and is familiar with the climate or not.

The most widely available climate variables are temperature and precipitation. Fewer stations record other useful elements such as wind, solar radiation, and humidity; that said, such data can still usually be found for a location that is sufficiently close to a design site.

The weather elements most easily modified in the design process are wind and solar radiation. The table "General Climatic Categories for Different Locations" suggests the first broad overview of climate that should be considered at the outset of the landscape design process.

Modification of solar radiation is given priority over modifying the wind in a warm, dry (sunny) situation. This is because providing four times deeper shade obeys a direct proportion rule and reduces solar overheating by exactly the same factor of 4; but cooling by the wind usually obeys a square root rule, so enhancing the wind by four times only increases the cooling by a factor of 2. However, in cold, dry (sunny) situations, available solar energy is often still not sufficient to cope with heat losses due to windchill, so attention to wind is given top priority.

Four examples of locations with seasons that fit into the four categories from the table "General Climatic Categories for Different Locations" are illustrated in the table "Monthly Degree Days for Selected Regions." Summer at the Southwestern Desert station fits into the Warm-Dry box, with very little rainfall and a very high percentage of sunny days. In contrast, summer at the West Coast Mexico station is quite cloudy and fits the Warm-Wet category. Winters at the Great Plains and Great Lakes stations have similar temperatures, but the western station has significantly less winter precipitation and more sunshine (Cold-Dry) than the eastern one (Cold-Wet). There is very limited potential for utilizing solar radiation in the lee of the Great Lakes in winter.

### GENERAL CLIMATIC CATEGORIES FOR DIFFERENT LOCATIONS

The climate attributes are given in the top row and left column; then, within each table cell, the elements to consider are listed in order of priority. The climate attributes may apply to a whole year or to a season when most use of a site will occur:

| | DRY | WET |
|---|---|---|
| **WARM** | 1. Minimize solar heating using shade (since dry climates or seasons are usually sunny)<br>2. Maximize cooling by wind | 1. Maximize cooling by wind<br>2. Minimize solar heating (but wet climates or seasons are usually already cloudy) |
| **COLD** | 1. Minimize cooling by wind<br>2. Maximize solar heating (since dry climates or seasons are usually sunny) | 1. Minimize cooling by wind<br>2. Maximize solar heating (but wet climates or seasons may have little solar energy available) |

### MONTHLY DEGREE DAYS FOR SELECTED REGIONS

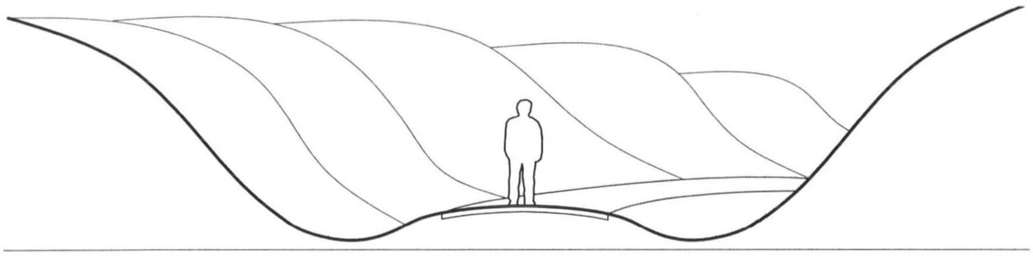
This table illustrates climate data for four representative North American regions. These summary statistics are useful in providing a general sense of the climate issues that should be addressed in design.

| DAYS IN MONTHS | 31 | 28 | 31 | 30 | 31 | 30 | 31 | 31 | 30 | 31 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **JAN.** | **FEB.** | **MAR** | **APR.** | **MAY** | **JUNE** | **JULY** | **AUG.** | **SEPT.** | **OCT.** | **NOV.** | **DEC.** |
| **WARM-DRY: SOUTHWESTERN DESERT** | | | | | | | | | | | | |
| Avg. temp. (C/F) | 10/50 | 12/53 | 16/61 | 20/68 | 25/77 | 30/86 | 33/91 | 32/90 | 29/84 | 22/72 | 15/59 | 11/52 |
| Precip. (mm./inches) | 19/.75 | 22/.87 | 17/.67 | 8/.31 | 3/.12 | 2/.08 | 20/.79 | 28/1.10 | 19/.75 | 12/.47 | 12.47 | 22/.87 |
| Precip., days | 2 | 4 | 2 | 1 | 1 | 0 | 3 | 4 | 3 | 1 | 2 | 3 |
| Percent sunny | 77 | 79 | 83 | 88 | 93 | 94 | 84 | 85 | 89 | 88 | 84 | 77 |
| CDD | 0 | 0 | 0 | 60/108 | 217/391 | 360/648 | 465/837 | 434/781 | 330/594 | 124/223 | 0 | 0 |
| HDD | 248/446 | 168/302 | 62/112 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 90/162 | 217/391 |
| GDD | 155/279 | 196/353 | 341/614 | 450/310 | 620/1116 | 750/1350 | 868/1562 | 837/1507 | 720/1296 | 527/949 | 300/540 | 186/335 |
| | **JAN.** | **FEB.** | **MAR** | **APR.** | **MAY** | **JUNE** | **JULY** | **AUG.** | **SEPT.** | **OCT.** | **NOV.** | **DEC.** |
| **WARM-WET: WEST COAST MEXICO** | | | | | | | | | | | | |
| Avg. temp. (C/F) | 26/79 | 26/79 | 27/81 | 27/81 | 28/82 | 29/84 | 29/84 | 29/84 | 29/84 | 28/82 | 28/82 | 27/81 |
| Precip. (mm./inches) | 8/.31 | 1/.04 | 0 | 1/.04 | 36/1.41 | 325/12.80 | 230/9.06 | 236/9.30 | 353/13.90 | 170/6.70 | 30/1.18 | 9/.35 |
| Precip., days | 1 | 1 | 0 | 1 | 3 | 13 | 12 | 12 | 15 | 9 | 2 | 1 |
| Percent sunny | 69 | 77 | 73 | 69 | 58 | 49 | 40 | 41 | 41 | 51 | 60 | 63 |
| CDD | 248/446 | 224/403 | 279/502 | 270/486 | 310/558 | 330/594 | 341/614 | 341/614 | 330/594 | 310/558 | 300/540 | 279/502 |
| HDD | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| GDD | 651/1172 | 588/1058 | 682/1228 | 660/1188 | 713/1283 | 720/1296 | 744/1339 | 744/1339 | 720/1296 | 713/1283 | 690/1242 | 682/1228 |
| | **JAN.** | **FEB.** | **MAR** | **APR.** | **MAY** | **JUNE** | **JULY** | **AUG.** | **SEPT.** | **OCT.** | **NOV.** | **DEC.** |
| **COOL-DRY: GREAT PLAINS** | | | | | | | | | | | | |
| Avg. temp. (C/F) | -6/21 | -5/23 | 0/32 | 6/43 | 12/53 | 17/63 | 22/72 | 21/70 | 15/59 | 9/48 | 1/34 | -3/27 |
| Precip. (mm./inches) | 16/.63 | 19/.75 | 36/1.41 | 55/2.17 | 65/2.56 | 65/2.56 | 30/1.18 | 23/.91 | 30/1.18 | 29/1.14 | 20/.79 | 16/.63 |
| Precip., days | 5 | 5 | 8 | 8 | 9 | 8 | 5 | 3 | 5 | 5 | 5 | 4 |
| Percent sunny | 57 | 57 | 61 | 58 | 57 | 61 | 76 | 74 | 66 | 65 | 53 | 53 |
| CDD | 0 | 0 | 0 | 0 | 0 | 0 | 124/223 | 93/167 | 0 | 0 | 0 | 0 |
| HDD | 744/1339 | 644/1159 | 558/1004 | 360/648 | 186/335 | 30/54 | 0 | 0 | 90/162 | 279/502 | 510/918 | 651/1172 |
| GDD | 0 | 0 | 0 | 30/54 | 217/391 | 360/648 | 527/949 | 496/893 | 300/540 | 124/223 | 0 | 0 |
| | **JAN.** | **FEB.** | **MAR** | **APR.** | **MAY** | **JUNE** | **JULY** | **AUG.** | **SEPT.** | **OCT.** | **NOV.** | **DEC.** |
| **COOL-WET: GREAT LAKES** | | | | | | | | | | | | |
| Avg. temp. (C/F) | -6/21 | -5/23 | -1/30 | 7/45 | 12/53 | 18/64 | 21/70 | 20/68 | 16/61 | 10/50 | 3/37 | -3/27 |
| Precip. (mm./inches) | 58/2.28 | 52/2.05 | 65/2.56 | 63/2.48 | 81/3.12 | 61/2.40 | 74/2.91 | 67/2.64 | 66/2.60 | 62/2.44 | 56/2.20 | 55/2.17 |
| Precip., days | 16 | 13 | 14 | 12 | 12 | 10 | 10 | 9 | 11 | 10 | 13 | 14 |
| Percent sunny | 27 | 35 | 38 | 42 | 48 | 56 | 61 | 60 | 53 | 45 | 29 | 27 |
| CDD | 0 | 0 | 0 | 0 | 0 | 0 | 93 | 62 | 0 | 0 | 0 | 0 |
| HDD | 744/1339 | 644/1159 | 589/1060 | 330/594 | 186/335 | 0 | 0 | 0 | 60/108 | 248/446 | 450/810 | 651/1172 |
| GDD | 0 | 0 | 0 | 60/108 | 217/391 | 390/702 | 496/893 | 465/837 | 330/594 | 155/279 | 0 | 0 |

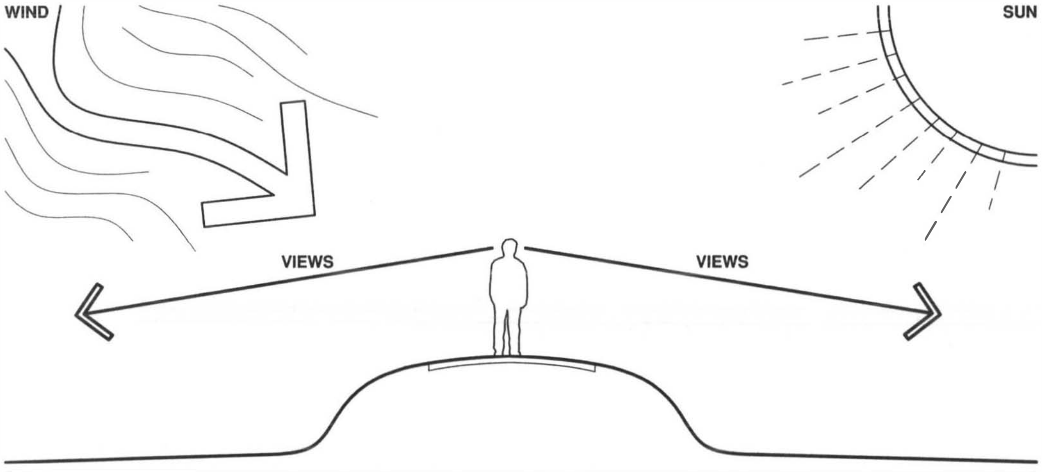
## STANDARDS

A standard approach to including climate in landscape design can begin by locating the site on a map that shows the basic temperature and moisture attributes, and then using the table "General Climatic

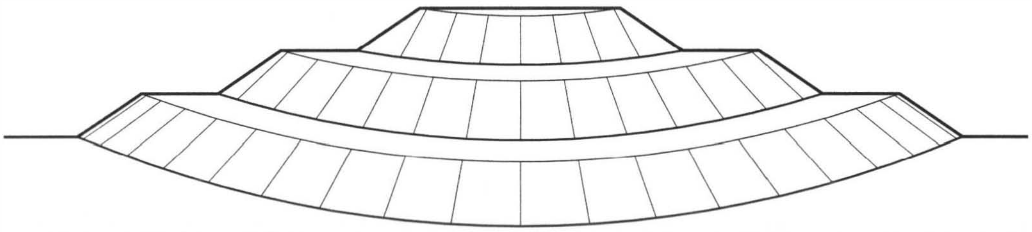
*Dr. Terry J. Gillespie and Dr. Robert D. Brown, University of Guelph, Guelph, Ontario, Canada*



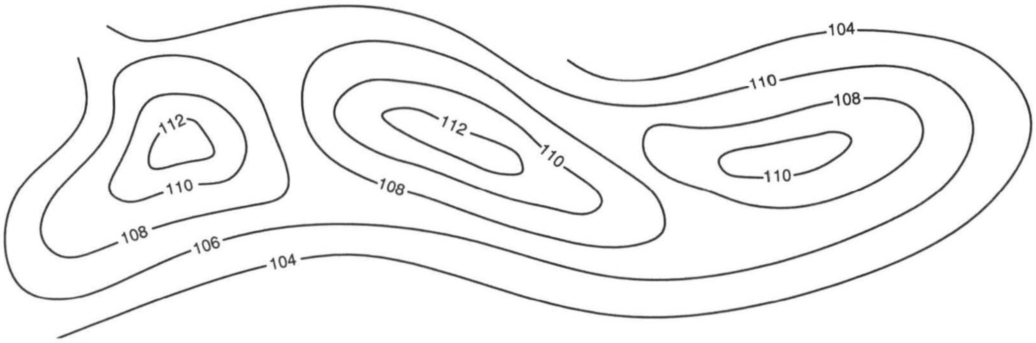
SENSE OF ENCLOSURE



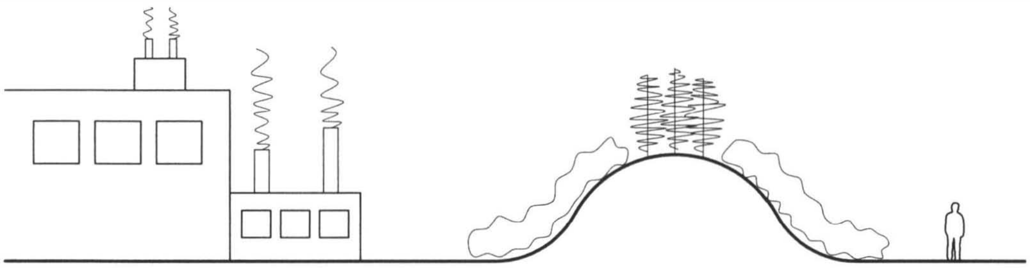

SENSE OF EXPOSURE/ISOLATION



TERRACING




BERM WITH "PEAKS" TO MIMIC MOUNTAIN RANGE



BERMS FOR SCREENING

## CONTOURS

Topographic changes in the landscape are represented on two-dimensional maps using the convention of contours. A contour is a horizontal plane slicing through the earth at a constant elevation above sea level or some other known reference elevation. A contour line, as illustrated on a topographic map, represents the edge of the contour plane as it meets the surface of the landform. The shoreline of a pond best represents the image of how a contour's edge meets the surface. If the surface of the water represents the contour plane, and water seeks a constant elevation, then the water's edge on a still pond could be illustrated as a contour line. If after a few dry days in summer the water elevation drops, then the surface represents a new contour elevation, and the still-moist shoreline retains evidence of the higher elevation.

The contour interval, or the vertical distance between two contours, is always the same throughout an entire drawing. Intervals of 1, 2, 5, 10, 20, 50, 100, 500, and 1,000 are common. The smaller the interval, the greater the degree of accuracy on a map and the greater the number of contours represented. Selection of the interval is a function of the scale of the drawing, the steepness of the terrain, and the use intended for the property. A section drawn through several contours appears to represent a stacked configuration, but in reality, the change between contours represents a gradual transition, like the fluid landforms of the earth.

Like the shoreline of the pond, every contour is assumed to be a continuous line that closes on itself, somewhere on earth, even if it is not contained on the drawing. Contour lines never cross each other, except in an unusual circumstance, such as a natural bridge or overhanging cliff. Contour lines may appear to coincide, or stack, at vertical walls, but in axonometric view, the path of the lines becomes clear. Contours never split.

The steepest slope on a topographic map is where the contours are closest together. Because water flows downhill at the steepest slope, it will always flow perpendicular to the contour lines.

One of the trickier landforms to read is at a transition between an uphill and a downhill slope. If an elevation is crossed moving uphill, then when a downhill turn is made, the same elevation must be crossed again.

*Sarah Georgia Harrison, ASLA, Assistant Professor, School of Environmental Design, University of Georgia*

### Settling

Compare wall foot pressure with the bearing capacity of the foundation soil (see the table "Bearing Capacities of Common Soil Types") and apply safety factor of 1.5.

$$f = W/A\left(1 + \frac{6e}{b}\right)$$

$$= \frac{4{,}650 \text{ lbs}}{5.5 \text{ sq ft}}\left(1 + \frac{6 \times 0.396 \text{ ft}}{5.5 \text{ ft}}\right)$$

Note:
W = weight of wall (1 foot length) lbs
e = distance from wall to centerline to intersection of the line of action of R with the bottom of the f footer, ft
A = bearing area between wall footer and soil (one foot length), sq ft
b = footer width, ft
Soil-bearing capacity of:

$$\frac{\text{Foundation soil (wet sand)}}{f} > \text{Safety Factor } 1.5$$

$$\frac{4{,}000 \text{ lbs/sq ft}}{1210.7 \text{ lbs/sq ft}} > 1.5$$

3.3 > 1.5 Check: Wall is resistant to settling.

### Investigation of Wall with Surcharge

*Example*: Test a given concrete gravity wall that is 4 feet above grade and has a total height of 7.62 feet. The backfill is assumed to be at a slope of 33 degrees.

#### General Stability

a. Find W:

| | Volume of 1-ft Section (cu ft) | × | | Weight of Material lbs/cu ft | Wall Weight = (lbs) W |
|---|---|---|---|---|---|
| 1 | 0.5 x 0.5 x 6 | | = 1.5 | 150 | 225 = $W_1$ |
| 2 | 1 x 6 | | = 6.0 | 150 | 900 = $W_2$ |
| 3 | 0.5 x 2.5 x 6 | | = 7.5 | 150 | 1,125 = $W_3$ |
| 4 | 0.5 x 2.5 x 6 | | = 7.5 | 100 | 750 = $W_4$ |
| 5 | 0.5 x 2.5 x 1.62 | | = 2.03 | 100 | 203 = $W_5$ |
| | | | | | Total: 3,203 |

b. Find location of wall centroid:
Note: For sections that are right triangles, the centroid is found at one third the length of the base from the 90 degree angle.

| Section | Weight (lbs.) | × | Moment Arm from Point O (ft) | Moment = (ft-lbs) |
|---|---|---|---|---|
| 1 | 225 | | 3.67 | 825.75 |
| 2 | 900 | | 3.00 | 2,700.00 |
| 3 | 1,125 | | 1.67 | 1,878.75 |
| 4 | 750 | | 0.83 | 622.50 |
| 5 | 203 | | 0.83 | 168.49 |
| | | | | Total: 6,159.49 |

Arm R = total moment/W
= 6,195.49 ft-lbs/3,203 lbs
= 1.93 ft from point O

c. Find the horizontal component, p:

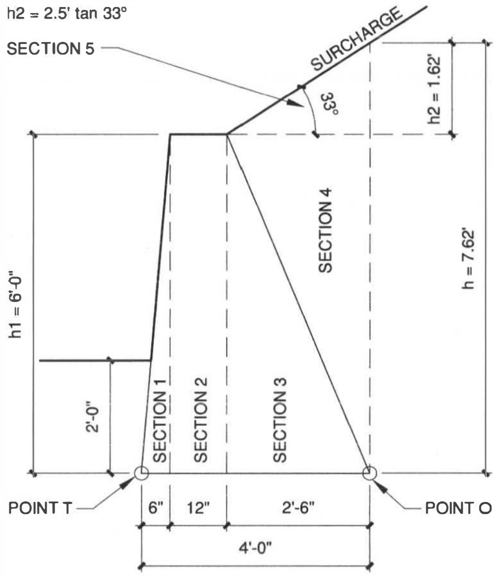
$$h = h_1 + h_2 = 7.62 \text{ ft}$$

$$p = {}^{*}0.833\,\frac{Wh^2}{2}$$

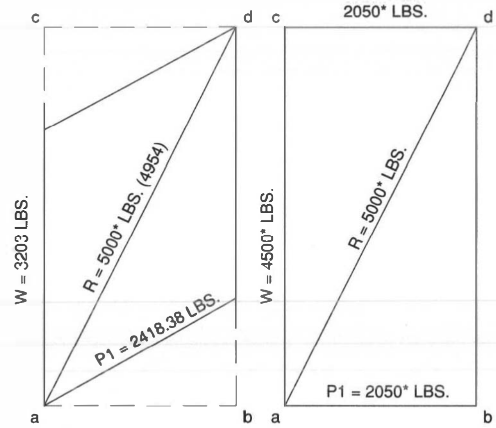
$$= 0.833 \times 100 \times (7.62)^2/2$$

$$= 2{,}418.38 \text{ lbs}$$

*Note: The constant (0.833) changes for surcharged walls.




EXAMPLE 3: SURCHARGED GRAVITY WALL DIMENSIONS AND WEIGHTS BY SECTION

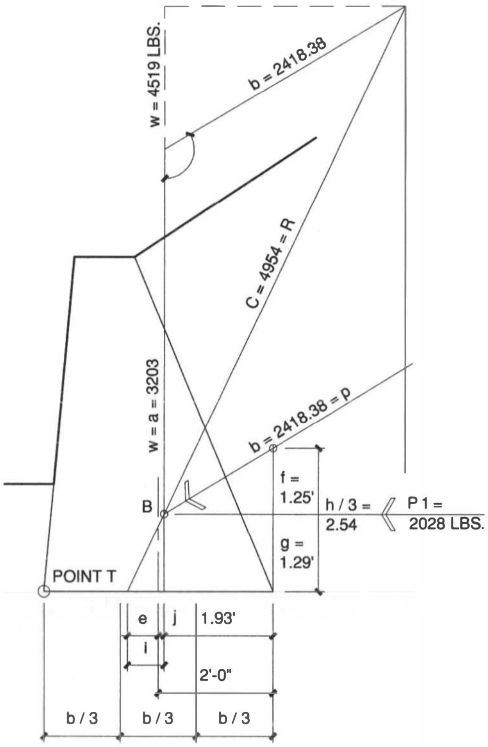



W = 3203 LBS.
P = 2418 LBS.
R = 5000 LBS.
W1 = 4500 LBS.
P1 = 2050 LBS.
* VALUES HAVE BEEN SCALED

EXAMPLE 3: SURCHARGED GRAVITY WALL EQUIVALENT FORCES

Note that with a surcharge, the line of action of the horizontal component, P, lies parallel to the surface of the backfill soil, or at a slope of 33 degrees. With the horizontal component at a slope, the force parallelogram is not a rectangle. The equivalent rectangle is constructed, as shown in the figure "Example 3: Surcharged Gravity Wall Parallelogram of Force by the Trigonometric Methods" and equivalent values determined and used in the later checks for overturning, sliding, and settling.

W = 3,205 lbs $\quad$ $W_1$ = 4,500 lbs
P = 2,418.38 lbs $\quad$ P1 = 2,050 lbs
R = 5,000 lbs $\quad$ R1 = 5,000 lbs
e = 0.6 ft = 7.2 in




EXAMPLE 3: SURCHARGED GRAVITY WALL PARALLELOGRAM OF FORCE BY THE TRIGONOMETRIC METHOD

### Overturning

Compare $M_O$ with $M_R$ and apply a safety factor of 2.

Arm O = g = 1.29 ft
$M_O$ = $P_1$ x Arm O
= 2,028 lbs x 1.29 ft
= 2,616 ft-lbs
Arm R = 2.07 ft
$M_R$ = W1 x Arm R
= 4,519 lbs x 2.07 ft
= 9,354 ft-lbs

$$\frac{M_R}{M_O} > \text{Safety Factor } 2$$

$$\frac{9{,}354}{2{,}616} > 2$$

3.6 > 2 Check: Wall is resistant to overturning.

### Sliding

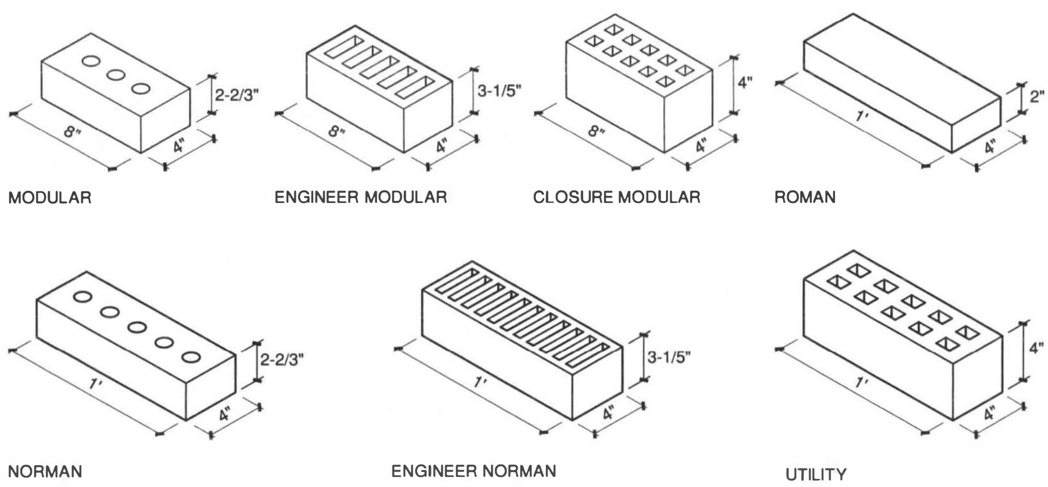
Compare lateral soil pressure, P, to shear strength created by the frictional resistance between the footer and soil and apply a safety factor of 1.5:

$$\frac{W_1 \times \text{coefficient of friction ("Average Coefficient of Friction of Common Soils" table)}}{P_1} > \text{Safety Factor } 1.5$$

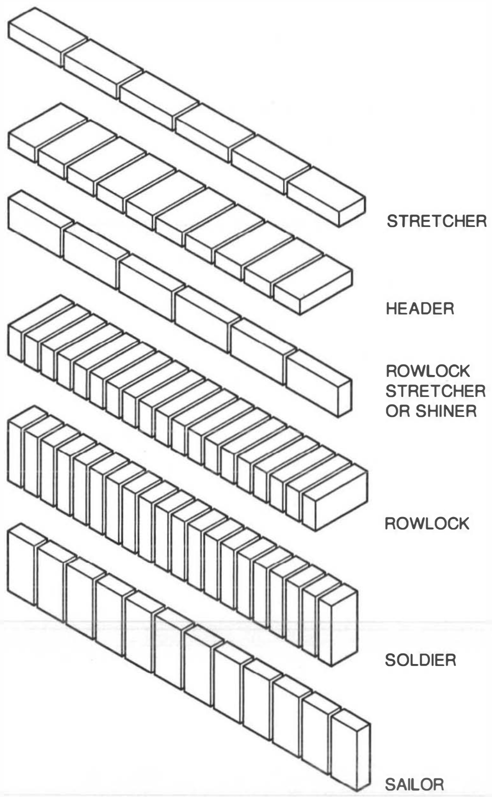
$$\frac{4{,}519 \text{ lbs} \times 0.5}{2{,}028 \text{ lbs}} > 1.5$$

1.11 > 1.5 Does not check: Wall does not meet the factor of safety of 1.5; therefore, a redesign of the wall is required. Measures must be taken such as increasing wall weight, soil replacement with gravel, or the addition of keys.

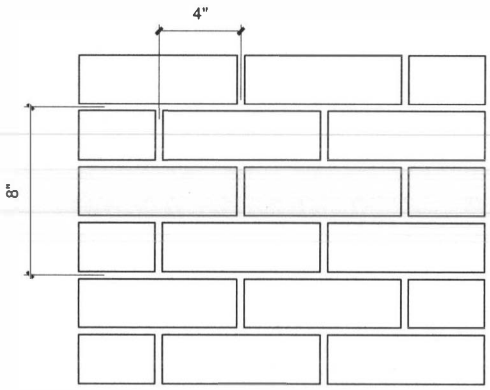
*Janice Cervelli-Schach*
*Credits: Thanks to R.V. Cervelli for his assistance on the structural mechanics calculations.*




**NOMINAL SIZES OF MODULAR BUILDING BRICK**




**NAMES OF BRICK POSITIONS IN WALLS**




**MODULARITY IN BRICKWORK**

**MODULAR BRICK SIZES**

| UNIT DESIGNATION | NOMINAL DIMENSIONS (IN.) W | H | L | JOINT THICKNESS | SPECIFIED DIMENSIONS[1] W | H | L | VERTICAL COURSING |
|---|---|---|---|---|---|---|---|---|
| Modular | 4 | 2⅔ | 8 | ⅜ | 3⅝ | 2¼ | 7⅝ | 3C = 8 in. |
| | | | | ½ | 3½ | 2¼ | 7½ | |
| Engineer modular | 4 | 3⅕ | 8 | ⅜ | 3⅝ | 2¾ | 7⅝ | 5C = 16 in. |
| | | | | ½ | 3½ | $2\frac{13}{16}$ | 7½ | |
| Closure modular | 4 | 4 | 8 | ⅜ | 3⅝ | 3⅝ | 7⅝ | 1C = 4 in. |
| | | | | ½ | 3½ | 3½ | 7½ | |
| Roman | 4 | 2 | 12 | ⅜ | 3⅝ | 1⅝ | 11⅝ | 2C = 4 in. |
| | | | | ½ | 3½ | 1½ | 11½ | |
| Norman | 4 | 2⅔ | 12 | ⅜ | 3⅝ | 2¼ | 11⅝ | 3C = 8 in. |
| | | | | ½ | 3½ | 2¼ | 11½ | |
| Engineer norman | 4 | 3⅕ | 12 | ⅜ | 3⅝ | 2¾ | 11⅝ | 5C = 16 in. |
| | | | | ½ | 3½ | $2\frac{13}{16}$ | 11½ | |
| Utility | 4 | 4 | 12 | ⅜ | 3⅝ | 3⅝ | 11⅝ | 1C = 4 in. |
| | | | | ½ | 3½ | 3½ | 11½ | |

*[1] Specified dimensions may vary within this range from manufacturer to manufacturer.*

*Source: Brick Industry Association.*

support, as well. Pier-and-panel walls use structural piers to support relatively thin brick wall panels that span from pier to pier. In the landscape, masonry columns provide adequate support for vertical loads without internal reinforcing. Piers and pilasters require additional reinforcing to resist lateral forces. Foundations for brick piers and pilasters are typically reinforced cast-in-place concrete. Foundations must extend to recommended structural depths or to the local frost depth, whichever is greater. Like walls, the topmost surface of columns, piers, and pilasters must be capped for water resistance.

## DESIGN CONSIDERATIONS

### Brick Sizes

For efficiency and consistency in production, design, and construction, a set of standardized modular dimensions has evolved for the production of brick. The dimensioning of modular brick accounts for the width of the mortar joints, and adheres to multiples of 4 inches. Modular brick is sized to coincide with concrete block coursing. Brick dimensions are specified using the sequence of width, height, and length (i.e., W × H × L). Modular brick is referred to by its nominal size, which varies from its actual and its specified dimensions. The "nominal size" refers to its modularity relative to the 4-inch grid and actually describes the distance between the centerlines of a wall's mortar joints.

### Brick Orientation

A brick's position designation relates to the orientation of its exposed face within a wall. There are six possible brick positions: stretcher, header, rowlock stretcher, soldier, sailor, and rowlock. A brick in the rowlock stretcher position is sometimes called a "shiner." The stretcher is the most common position in brick masonry. Headers are frequently used to provide bonding between wythes. Rowlock, soldier, and sailor courses are commonly used to create interest and detail in brick walls.

### Texture

In the stiff-mud manufacturing process, brick finishes are applied as the brick is extruded. The wire-cut, or velour, finish is achieved as extruded brick is sliced into individual units by a wire-cutting tool. Other popular finishes include rug, stippled, striated, molded, sand, smooth, and bark. Ironspot refers to small metallic

*Rob W. Sovinski, ASLA*

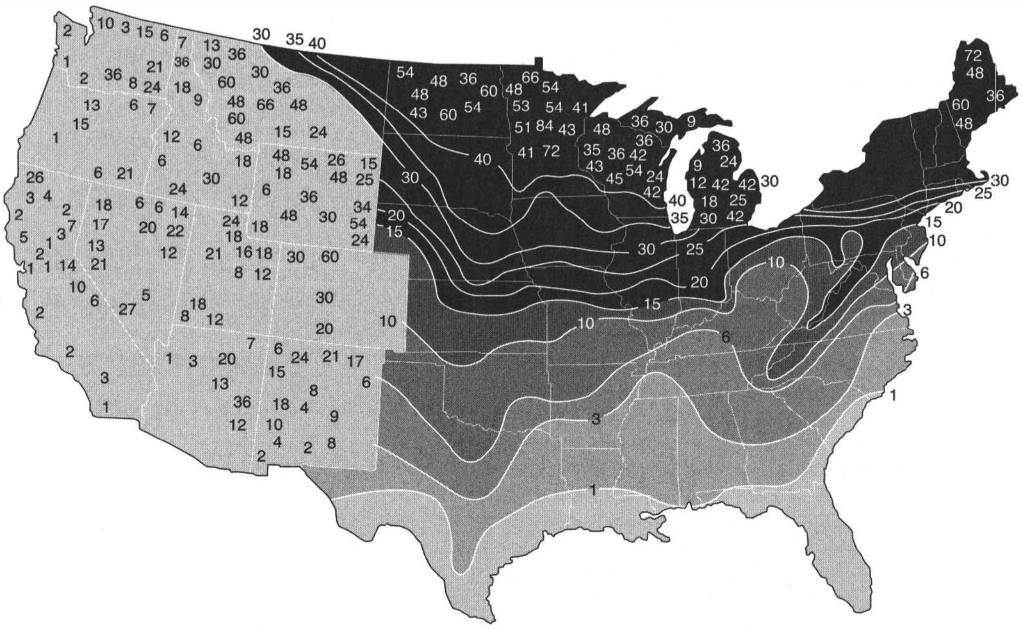
fragments embedded in the clay. Many brick manufacturers offer unique finishes of their own design. Soft-mud-processed brick may be sand-struck or water-struck. Glazing imparts an impervious, smooth coating—available in a range of colors and gloss—onto a brick's face. Glazing, however, may curtail the venting of moisture from bricks, and their lack of traction make glazed brick inappropriate for use as pavers.

## Bond and Bonding

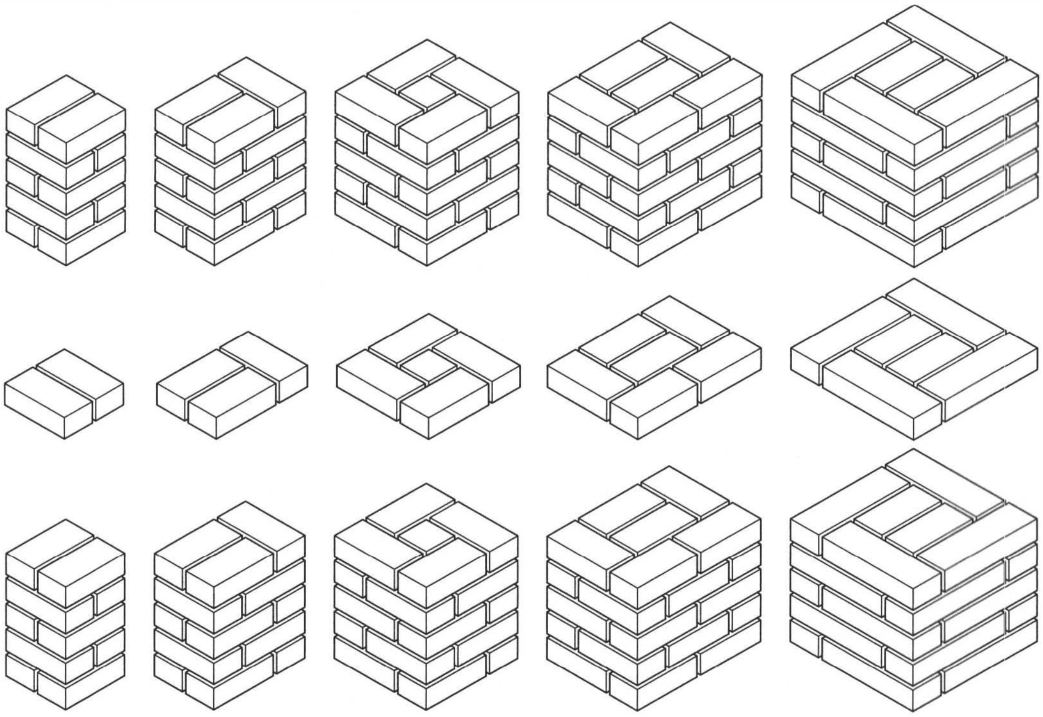
Although it creates opportunities for visual interest, the primary function of bonding is structural. Bonding ties multiple wythes together and distributes vertical loads diagonally. Bonding is achieved through the front-to-back placement of header bricks. Mechanical ties may be used when bond patterns don't include headers, such as the running bond. Among the most widely used bonds are: stack bond, running bond, common bond, English bond, Flemish bond, Dutch bond, and garden wall. Soldier and rowlock courses are commonly used to add interest, especially at a wall's cap.

## Joints and Joint Design

Joints account for approximately 17 percent of the visible surface of a brick wall. The primary role of mortar joints is adhesion, but they also play a significant visual role, thus designers need to consider both the color and the profile of the mortar joints. Since the majority of masonry failures occur at the joints, sound joint design must facilitate rapid drainage. The process of tooling a joint serves to compress the mortar, much like the crust on a loaf of bread, enhancing its water-resistant capacity. Concave, V, and weathered are the best joints to use when water intrusion is a concern. Flush joints offer an effective profile to resist water, but aren't compressed by tooling during installation. Colored mortar is widely available and can dramatically impact the visual aspect of a brick wall.

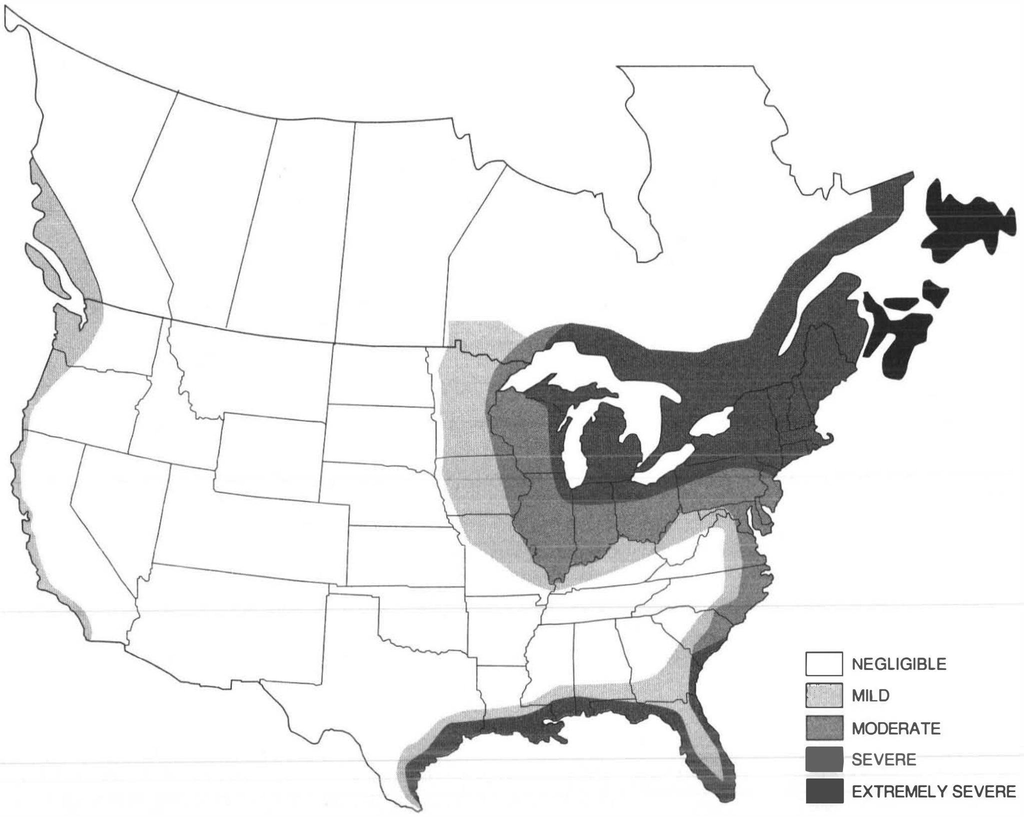


**AVERAGE DEPTH IN INCHES OF FROST PENETRATION**



**CONFIGURATIONS FOR SOLID BRICK COLUMNS**

Rob W. Sovinski, ASLA




**MAP OF CHLORIDE CONCENTRATIONS IN RAINFALL**

*Source: Courtesy of Specialty Steel Industry of North America (SSINA).*

sion. In particular, acid rain can cause the erosion of the oxide layer. This contribution to erosion has been blamed for the loss of features on bronze statues throughout northern Europe.

In addition to these broader pollution effects, localized pollution can have a major impact. A factory or highway can deposit sulfuric acids and other harsh chemicals on metals nearby. Environmental chemicals that can affect metal include cleaning products. A common concrete cleaner is muriatic acid, which has a strong corroding effect on stainless steel. The metal selection should not be based on the cleaning products; rather, the maintenance protocols should be established based on the metals present on a project.

### Surface Area

An increased surface area means that there is a greater quantity of material exposed to the chemical reaction. The rougher the surface of a metal, the more surface that is exposed to the elements. Conversely, the smoother the surface, the less base metal is available to the chemical reaction. Hence, a smoother surface is less susceptible to oxidation and corrosion.

On a larger scale, a rougher surface will tend to trap water, salts, and other pollutants that accelerate oxidation. This allows more time for the chemical reaction to occur, increasing the amount of oxidation. Smoother surfaces are often referred to as self-cleaning, meaning that they tend to shed water, and with it the dirt and pollutants that accelerate the oxidation.

### Abrasion

All metals form a "protective" outer coating of oxide as the first step in corrosion. While many companies claim a metal to be corrosion-free after the formation of this oxide layer, the amount of further corrosion depends on the abrasive nature of the environment and the metal's natural tendency to erode. Abrasives are omnipresent, and include rain, hail, condensation (water), road grit, driven sand, and countless others.

### Alloy (Metal Chemistry)

The raw, unaltered forms of any metal tend to be the most chemically reactive forms. Therefore, the alloying or mixing of metals with each other and other chemicals results in a more chemically stable product.

### Coatings

Coatings serve as a barrier between the base metal and the environment. There are essentially two types of barrier: nonreactive and reactive. Nonreactive barriers such as paints and powder coats all have a life span based on environmental weathering, but do not have an active chemical feedback with the environment. Conversely, reactive barriers such as galvanizing and thermal sprays are referred to as "sacrificial" barriers, themselves corroding in protection of the base metal.

### Design

In the same way that poor design causes failure in other applications, so it does with metals. A design that allows water to collect, with all of the pollutants, acids, and salts that it may carry, will cause an increase in corrosion. This is particularly notable at connections such as bolts and welds. Cracks, crevices, and holes should be avoided, or provided with a water-shedding curve or radius where exposed to the weather or where water may be conveyed toward it by the design of the element itself.

The creation of areas that collect water is a particular concern, as oxygen-deprived areas of metal can cause a strong electron-exchange reaction that will speed corrosion even further than simply due to the presence of water.

Weep holes are an important, and often overlooked, aspect in designing hollow metal objects, including tube railings and fences. Condensation and collection of water on the interior of the hollow can cause unseen corrosion.

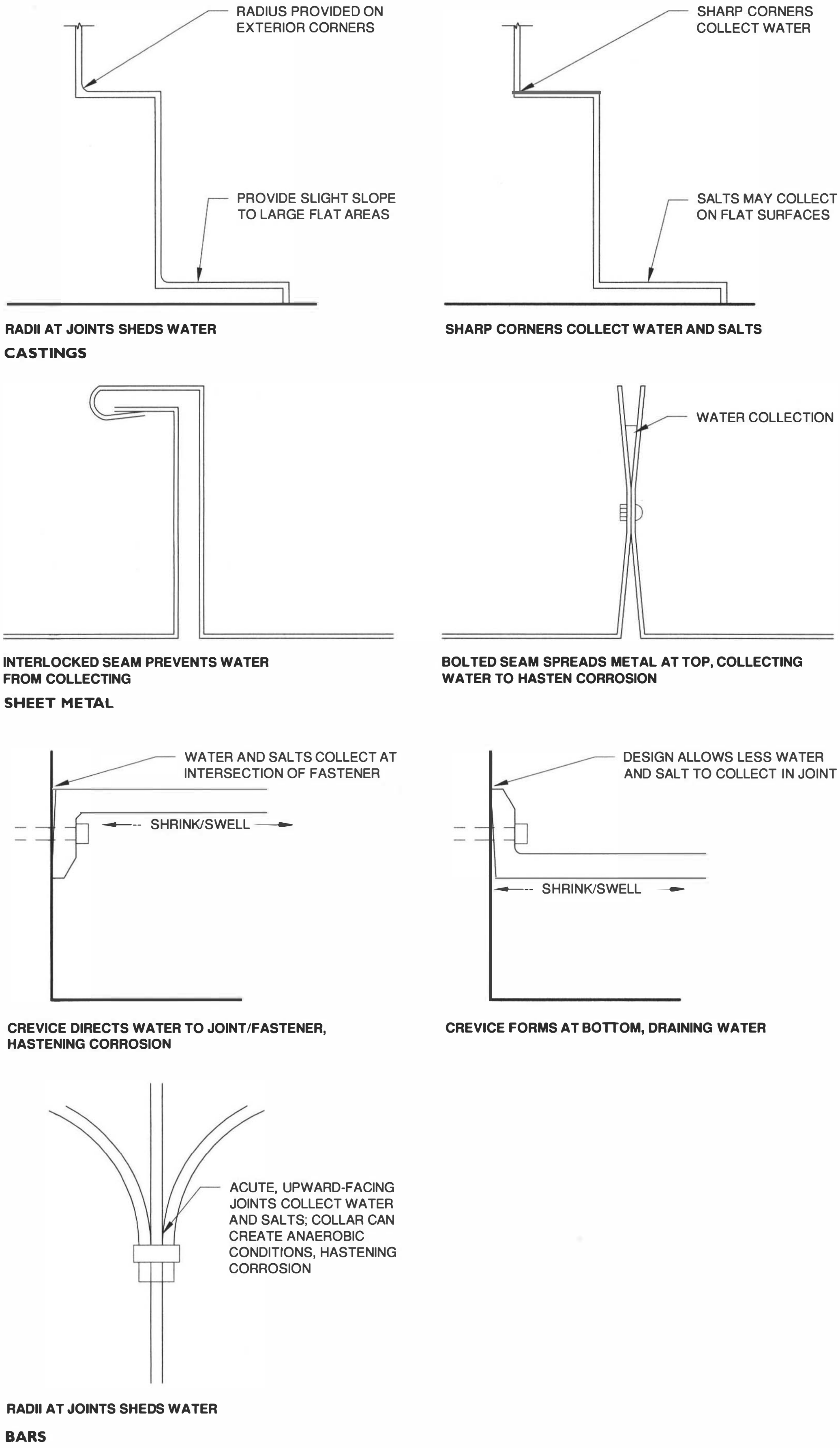
Where metal elements are directly embedded in a concrete foundation, water will find its way into the hole and corrode the metal within the concrete. A design that prevents water from reaching the interface between the concrete and the metal is the best solution. This can be accomplished through the provision of metal flares, caps, or similar devices that direct water away, or through the proper slope and chamfer of the concrete.

Poor design that can cause corrosion can be seen at a larger scale as well. Placement of metals in poorly drained areas, roof drain leaders directed toward metal elements, and the placement of planter drains above metals are all easy-to-avoid mistakes.

**ANODIC INDEX OR GALVANIC SCALE OF METAL COMPATIBILITY**

| METALLURGY | INDEX (V) |
|---|---|
| Nickel, solid or plated; titanium as an alloy; Monel | 0.30 |
| Copper, solid or plated; low brasses or bronzes; silver solder; German silvery high copper-nickel alloys; nickel-chromium alloys | 0.35 |
| Brass and bronzes | 0.40 |
| High brasses and bronzes | 0.45 |
| 18% chromium-type corrosion-ant steels | 0.50 |
| Chromium-plated; tin-plated; 12% chromium-type corrosion-resistant steels | 0.60 |
| Tin-plated; tin-lead solder | 0.65 |
| Lead, solid or plated; high-lead alloys | 0.70 |
| Aluminum, wrought alloys of the 2000 series | 0.75 |
| Iron, wrought, gray, or malleable; plain carbon and low-alloy steels | 0.85 |
| Aluminum; wrought alloys other than 2000 series aluminum; cast alloys of the silicon type | 0.90 |
| Aluminum; cast alloys other than silicon type; cadmium, plated and chromate | 0.95 |
| Hot-dip-zinc-plated | 1.20 |
| Zinc, wrought; zinc-base die-casting alloys; zinc-plated | 1.25 |

*Nathan Imm, RLA, EDAW, William B. Kuhl, RLA, Saratoga Associates (formerly with EDAW)*




**EXAMPLES OF DESIGN IMPACTS ON CORROSION**

### Corrosion versus Staining or Oxide Layer

As a definition, corrosion is the unabated oxidation of a metal: it will continue until all of the unoxidized metal is consumed. The term "corrosion" is also generally used to indicate the concentrated erosion of the metal, in particular providing a structural threat to the metal object.

Corrosion is the most extreme mode of oxidation. On the other end is staining or the creation of an oxide layer. The term "staining" is generally used in reference to stainless steels or similarly highly resistant metals. This is a surficial oxide that tends not to form a complete layer or covering, rather appearing as blotches or spots. A stain is less susceptible to erosion as well, as the oxidized metal is surrounded even at the surface by unoxidized metal. Conversely, an oxide layer is a skin of oxide that forms on the metal surface. Copper patina is the best example of this.

In examination of an existing metal object in the field, or a weathered sample, it is important to determine where in this continuum the oxidation lies.

### Bimetallic Corrosion

Otherwise known as galvanic corrosion, this corrosion process is caused by the exchange of electrons between significantly dissimilar metals. The "Anodic Index or Galvanic Scale of Metal Compatibility" table lists a variety of metals in order of galvanic action: the further apart two metals are on this list, the greater the corrosive reaction; conversely, the closer the two metals are on the list, the safer or less corrosive they will be.

One of the most common solutions where two different metals are utilized is to separate the metals by a gasket or similar. The selection of the gasket becomes very important in this case, as its life span will directly impact the life span of the metals. Gaskets should also be nonabsorbent, as the water collecting in the gasket can convey the electrons as efficiently as if the two metals were in contact.

### Metal Corrosion

Corrosion, which is caused by galvanic action, occurs between dissimilar metals or between metals and

**THE GALVANIC SERIES**

| | |
|---|---|
| Anode (least noble) + | Magnesium, magnesium alloys |
| | Zinc |
| | Aluminum 1100 |
| | Cadmium |
| | Aluminum 2024-T4 |
| | Steel or iron, cast iron |
| | Chromium iron (active) |
| | Ni-Resist |
| | Type 304, 316 stainless (active) |
| | Hastelloy "C" |
| | Lead, tin |
| Electric current flows from positive (+) to negative (–) | Nickel (Inconel) (active) |
| | Hastelloy "B" |
| | Brasses, copper; bronzes, copper-nickel alloys, monel |
| | Silver solder |
| | Nickel (Inconel) (passive) |
| | Chromium iron (passive) |
| | Type 304, 316 stainless (passive) |
| | Silver |
| | Titanium |
| Cathode (most noble) – | Graphite, gold, platinum |

*Nathan Imm, RLA, EDAW, William B. Kuhl, RLA, Saratoga Associates (formerly with EDAW)*

# OTHER MATERIALS

## GREENHOUSES

### INTRODUCTION

Developments in ventilation, glazing, and horticulture have helped achieve satisfactory plant growth in greenhouses to make the practice economical. Site selection considerations include: topography (flat is advisable), drainage, quantity and quality of water supply, air quality, direction and average wind speed, and, most important, the amount of available light. Orientation for optimal solar gain is east-west except in conditions where shadow casting obstructions outweigh the orientation rule. Once a site has been selected, development of a plan for growth (even if only one greenhouse is built at first) is essential, factoring in access, mechanical room locations, and circulation of materials and labor. Heating and cooling needs will vary with latitude, plant type, skin or glazing, and growth period.

### HEATING SYSTEMS

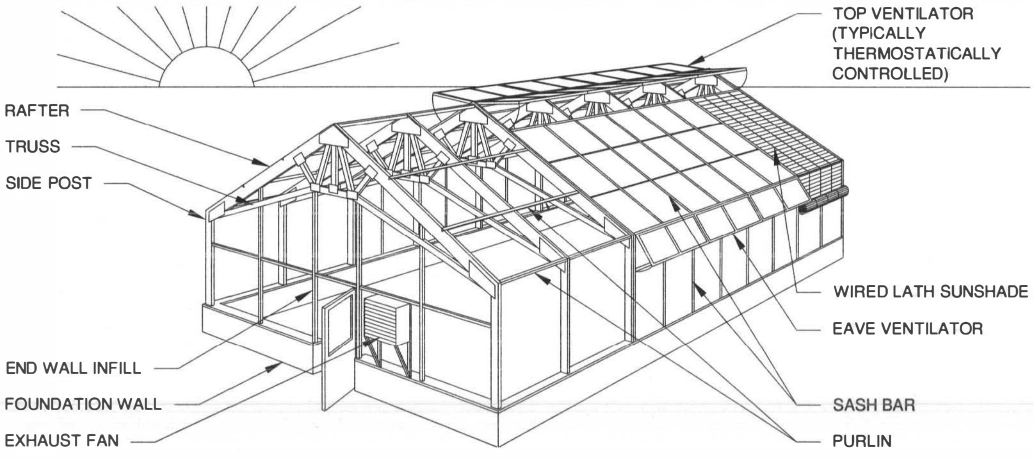
Heat distribution is achieved through use of solar, hot air, or radiant pipe systems. Solar heating will usually need the augmentation of the two latter systems at the coolest or windiest part of the year.

#### Radiant/Hot Water Pipe

Systems use a boiler to heat and distribute water. Pipes located at the greenhouse perimeter are the most convenient and efficient method of achieving uniform temperature.

### INSULATION

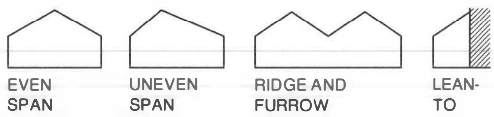
Insulation augments heating systems and helps reduce heat loss from convection and radiation. Three basic systems are most widely used: movable night curtains, plastic covering over glass, and permanent reflective insulation of north wall and roof.




### GENERIC GREENHOUSE

**FRAME TYPES**

| MATERIAL | FEATURES |
|---|---|
| Pipe frame | Economy/simple connections |
| Steel frame | 50' span (installation by professionals) |
| Aluminum frame | No rust, deeper sections than steel |
| Wood frame | Pressure treated lifespan: 10–15 yrs. |



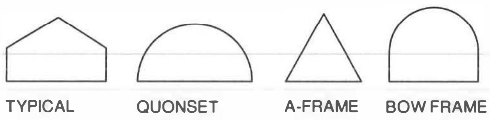

When properly maintained, a glass greenhouse will last 40 to 50 years. Structural design of a greenhouse is similar to curtain wall design with live loads of wind, snow, piping, and hanging basket plants.

### GLASS-SHEATHED GREENHOUSE

**PLASTIC TYPES**

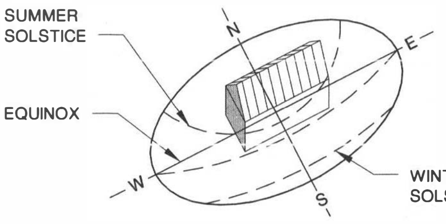
| MATERIAL | FEATURES |
|---|---|
| Flexible | Polyethylene, mylar |
| Rigid | PVC, acrylic, fiberglass |

NOTE
The size of a plastic greenhouse is limited only by the width of a single sheet of plastic.



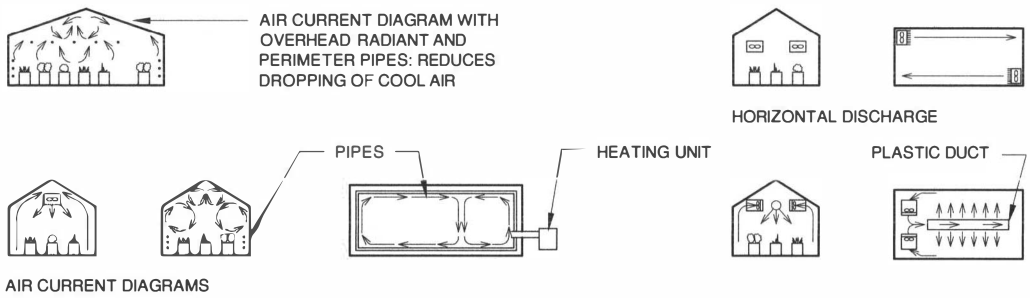

Rigid or flexible plastic greenhouses feature economy, ease of fabrication, and flexibility of form making. Plastic's liabilities are its poor durability, reduced light transmission over time, and discoloration or brittleness.

### PLASTIC-SHEATHED GREENHOUSE




Use of an uneven span greenhouse allows for optimal solar orientation. Slope of glass is determined by latitude.

### OPTIMAL SOLAR ORIENTATION




### HEATING SYSTEMS

Eric K. Beach; Rippeteau Architects, PC, Washington, D.C.

# EVALUATING THE ENVIRONMENTAL AND HUMAN HEALTH IMPACTS OF MATERIALS

## LIFE-CYCLE PHASES OF A MATERIAL OR PRODUCT

All phases in the life cycle of a material/product impact the environment, as inputs and outputs are generated from "cradle to grave." Therefore, any approach to decision making based on environmental impacts must consider the full spectrum of upstream and downstream impacts. Additionally, human health impacts can occur during any phase of a material's or product's life cycle.

### RAW MATERIALS ACQUISITION

Raw materials acquisition includes all processes and activities required to obtain the raw materials and associated energies. These processes can include drilling, mining, dredging, logging, processing, refining, and transportation.

### MANUFACTURING/PROCESSING

Manufacturing activities include conversion of natural resources, fabrication, assembly, packaging, and distribution. Manufacturing uses energy and water, produces waste by-products, and can contribute harmful pollutants to air, water, and soil. These pollutants can also affect the health of people in and around the manufacturing facility. Levels of processing vary widely by material/product. Some materials such as stone are minimally processed and have low embodied energy, while others such as aluminum are extensively processed using large amounts of energy and producing waste products.

Some manufacturers take steps toward minimizing the environmental and human health impacts of their materials/products by incorporating recycled materials and by-products into their products; minimizing energy and water use in manufacturing processes; burning waste as fuel; using alternative energy sources and containing toxic releases.

### TRANSPORT

Transport of building materials/products in all phases uses energy and natural resources, and releases pollutants that negatively affect the environment and human health. Materials/products are transported from the extraction point to the manufacturer, then to the distributor and site, and after use, to the disposal point. Transport fuel uses nonrenewable resources and releases by-products (VOCs, CO2, carbon monoxide, and sulfur and nitrogen compounds) from internal combustion engines, which contribute to air pollution and global warming.

Transport may be one of the most important considerations for landscape architects because materials/products used in the landscape are heavy and bulky. Energy used in transport, especially by less efficient trucks and airplanes, can be greater than energy used in production if the manufacturer is located far from the site. Use of local materials can significantly reduce resource and pollution from transportation.

### INSTALLATION, USE, AND MAINTENANCE

Installation, use, and maintenance can be the most important phases when considering the environmental and human health impacts of building materials/products, as they tend to be in use for very long periods of time. Durability of the product is, therefore, one of the most important concerns because the longer the installation lasts, the less need for replacements that use more resources. Therefore, it is important to match the expected life of the product with the expected life of the landscape.

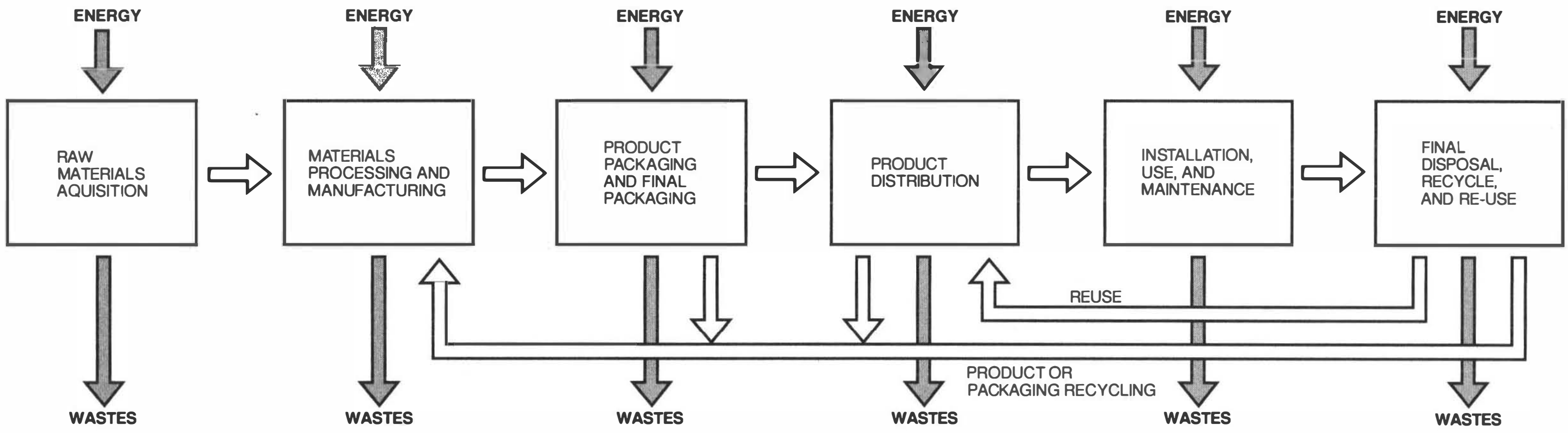
An ideal building product or assembly will improve and support, or at least not damage, the ecological functions of the project site. For example, paving can have a negative effect on the site, in that it is usually an impermeable surface that speeds stormwater and pollutant runoff, causes erosion, and damages the soil underneath. In contrast, permeable paving would allow for some infiltration of water and air to the soil below.

Maintenance and repair of materials and products can have environmental and human health impacts as well. Adhesives, finishes, sealants, and maintenance products can contain hazardous chemicals, including volatile organic compounds (VOCs). Steps should be taken to specify materials and products that require few chemicals to maintain; or low-VOC and nontoxic cleaners and sealers should be used.

### DISPOSAL, RECYCLING, AND REUSE

The end of the use phase sometimes results in disposal and release to the environment, but it can also include reuse, reprocessing, or recycling. Building materials can outlast the life of a landscape, so planning for their reuse is an important consideration. "Deconstruction" is the term used to refer to the disassembly and salvage of materials from a building or site, as opposed to "demolition," whereby everything is destroyed and hauled to a landfill.

Although deconstruction takes more time and incurs higher labor costs than demolition, it may ultimately be less expensive than paying landfill costs. Resale of the materials, either whole or ground, can generate additional income. Where the demolition contractor is also responsible for new construction, materials can be stockpiled for reuse on-site.




**LIFE-CYCLE CHART**

*Source: Charles George Ramsey, Architectural Graphic Standards (New York, John Wiley & Sons, Inc.), 2000.*

*Meg Calkins, Ball State University, "Environmental and Health Considerations"*