The

Architecture

Reference + Specification Book

Updated + Revised

Everything Architects Need to Know Every Day



Julia McMorrough

ROCKPORT

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INTRODUCTION

ARCHITECTURAL DESIGN is a complex activity that involves multiple levels of knowledge, communication, and production, even on a small project. Architects often speak their own language, both in terminology and through conventions of drawings, models, and diagrams. Moreover, to make a piece of architecture requires following countless rules of which an able practitioner must remain ever knowledgeable: building codes, human dimensions, drawing standards, material properties, and relevant technologies. Familiarity with so many issues comes with schooling and long years of experience, but even the most seasoned architect must avail him- or herself of a vast and exhaustive array of resources, from code books to graphic standards, from materials libraries to manufacturers' catalogs.

The Architecture Reference + Specification Book is a unique compilation of essential information for architects, students of architecture, and anyone contemplating an architectural project. Included here are the tables, charts, diagrams, dimensions, standards, codes, and general data that many architects need on a daily basis. This book is not a replacement for other sources that architects might consult regularly, but rather a handy "first-stop" reference that is always at the ready, on a desk or in a bag.

Part 1, "Materials," provides a detailed catalog of the most common building materials—wood, masonry, concrete, metals—as well as various interior finishes. Parts 2, 3, and 4, "Systems," "Measure and Drawing," and "Codes and Guidelines," address the major aspects of undertaking an architectural project. Topics include basic measurements and geometry, architectural drawing types and conventions, parking, building codes, accessibility, structural and mechanical systems, and building components. Parts 5 and 6, "Proportion and Form" and "Context," bring together the human scale, architectural elements, a glossary, and a timeline of key moments in the history of architecture. Finally, because such a compact book cannot possibly contain everything, a directory of resources offers an extensive guide to the most helpful publications, organizations, and websites.

For every project, architects must take into account an endless number of external forces, not least of which are the codes and standards of design and construction. But these codes and standards should certainly not be viewed as limiting: Knowledge of them and their creative use can, in fact, liberate and empower.

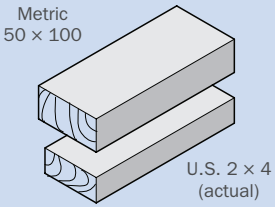
MATERIALS 1.

A NOTE ON METRIC AND CUSTOMARY UNITS

This book acknowledges the two primary measurement systems used in the world today: the metric system, also known as the Système International d'Unités (SI), and the U.S. customary units system, referred to in the United States as English units or standard units. While the metric system has become the universally accepted system of units in science, trade, and commerce, in the United States, federal laws have yet to mandate SI as the official system.

In this book, every attempt has been made to accurately represent the relationship between customary and SI units. Except where noted, soft conversions are used throughout and, due to constraints of space, are usually written as follows: 1'-6" (457), with the numbers in parantheses representing millimeters.

See Chapter 10 (page 100) for more details on metric conversions, and Chapter 1 (page 10) for more details on wood.



As an example of the factors that might influence translation from one system to the other, consider the North American 2 × 4:

Nominal dimension: 2" × 4"

Metric "soft" conversion
50.8 mm × 101.6 mm

Metric "hard" conversion
50 mm × 100 mm

Actual dimension: 1½" × 3½"

Metric "soft" conversion
38 mm × 89mm

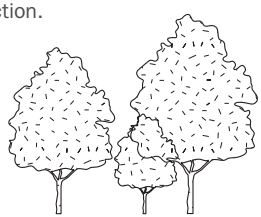
Metric "hard" conversion
40 mm × 90 mm

Metric preferred dimension:
50 mm × 100 mm

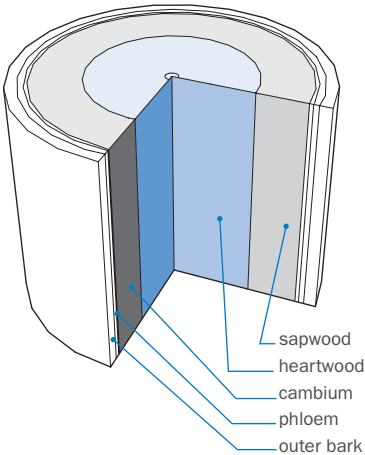
Gum pocket: Excessive accumulation of resin or gum in certain areas of the wood.

Hardness: Ability of wood to resist indentation. See Janka hardness test.

Hardwood: Wood from deciduous trees (which lose their leaves in the winter months). Oak and walnut constitute 50 percent of all hardwood production.



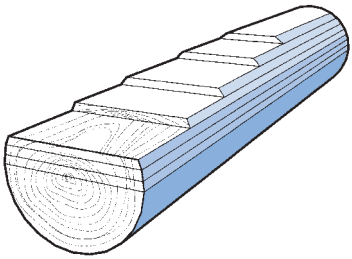
Heartwood: Harder, nonliving innermost layers of a tree. It is generally darker, denser, more durable, and less permeable than the surrounding sapwood. Good all-heartwood lumber may be difficult to obtain, and, depending on the species, it is common to find boards with both heartwood and sapwood combined.



Janka hardness test: Test that measures the pounds of force required to drive a 0.444" (11 mm) -diameter steel ball to half its depth into a piece of wood.

Moisture content: Percentage that represents a board's ratio of water weight to the weight of oven-dried wood.

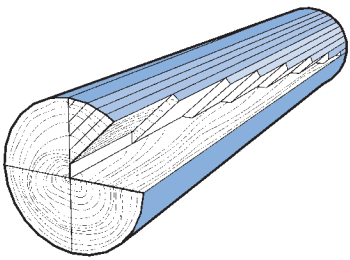
Plainsawn: Lumber cut with less than a 30-degree angle between the face of the board and the wood's growth ring.



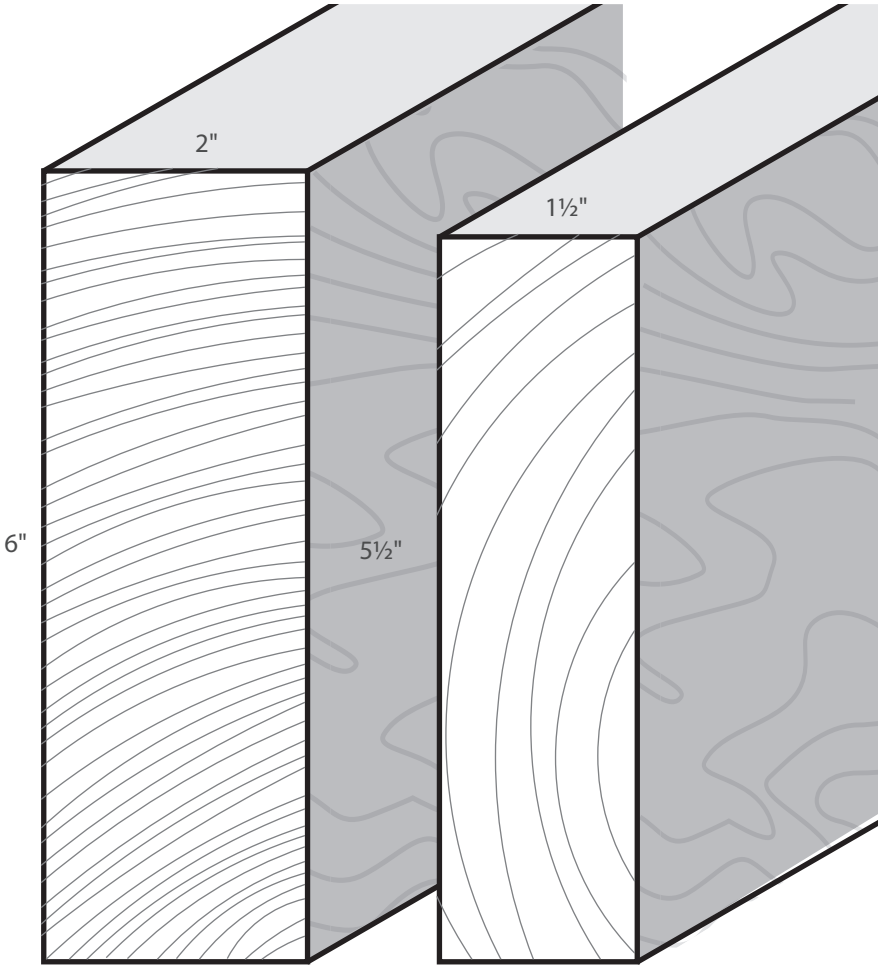
Plywood: Large sheet of wood made up of several layers of veneer that are glued together so that the grain of each layer lies perpendicular to the grain of the previous layer. There is always an odd number of layers, enabling the grain direction of both faces to run parallel to one another.

Pressure-treated lumber: Wood products that are treated with chemical preservatives to prevent decay brought on by fungi and to resist attack from insects and microorganisms. Under pressure, the preservatives are forced deep into the cellular structure of the wood.

Quartersawn: Lumber cut with a 60- to 90-degree angle between the face of the board and the wood's growth rings.



Dimensional Variations of a 2×6 Stud



2×6 Old Growth
Typically, older growth wood is denser, stronger, and more dimensionally stable than younger wood. Before aggressive logging, older growth trees grew more slowly, as they competed for sunlight in more densely forested conditions, resulting in more rings per inch.

2×6 Farmed Wood
By contrast, farmed wood grows bigger faster, due to more aggressive watering, fertilizing, and exposure to sunlight. More rapid growing results in less dense wood.

S=soft; M=medium; H=hard; VH=very hard; n/a=not normally used
Finishes: Painted and Transparent

CHESTNUT *Castanea dentate*			
Hardness		M	
Principal Finish Uses		Trim, paneling	
Color		Grayish brown	
Paint	n/a	Transp.	Excellent



MAHOGANY Hond. *Sweitenia macrophylla*			
Hardness		M	
Principal Finish Uses		Trim, frames, panel-ing, cabinetry	
Color		Rich golden brown	
Paint	n/a	Transp.	Excellent



MAPLE *Acer saccharum*			
Hardness		VH	
Principal Finish Uses		Trim, paneling, cabinetry	
Color		White to reddish brown	
Paint	Excellent	Transp.	Good

OAK English brown *Quercus robur*			
Hardness		H	
Principal Finish Uses		Veneered paneling, cabinetry	
Color		Leathery brown	
Paint	n/a	Transp.	Excellent



S=soft; M=medium; H=hard; VH=very hard; n/a=not normally used
Finishes: Painted and Transparent

ROSEWOOD *Dalbergia nigra*			
Hardness		VH	
Principal Finish Uses		Veneered paneling, cabinetry	
Color		Mixed red/brown/ black	
Paint	n/a	Transp.	Excellent



TEAK *Tectona grandis*			
Hardness		H	
Principal Finish Uses		Trim, paneling, cabinetry	
Color		Tawny yellow to dark brown	
Paint	n/a	Transp.	Excellent



WALNUT *Juglans species*			
Hardness		H	
Principal Finish Uses		Trim, paneling, cabinetry	
Color		Chocolate brown	
Paint	n/a	Transp.	Excellent



ZEBRAWOOD *Brachystegea fleuryana*			
Hardness		H	
Principal Finish Uses		Trim, paneling, cabinetry	
Color		Gold streaks on dark brown	
Paint	n/a	Transp.	Excellent



Mortar

Mortar adheres masonry units together, cushions them while mediating their surface irregularities, and provides a watertight seal. Composed of portland cement, hydrated lime, an inert aggregate (generally sand), and water, there are four basic types of mortar:

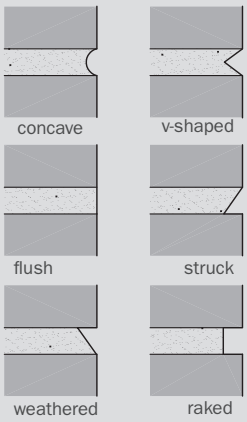
M: High strength (masonry below grade, or subjected to severe frost or to high lateral or compressive loads)

S: Medium-high strength (masonry subjected to normal compressive loads, but requiring high flexural bond strength)

N: Medium strength (masonry above grade, for general use)

O: Medium-low strength (masonry in non-load-bearing interior walls and partitions)

Mortar Joints



Colors

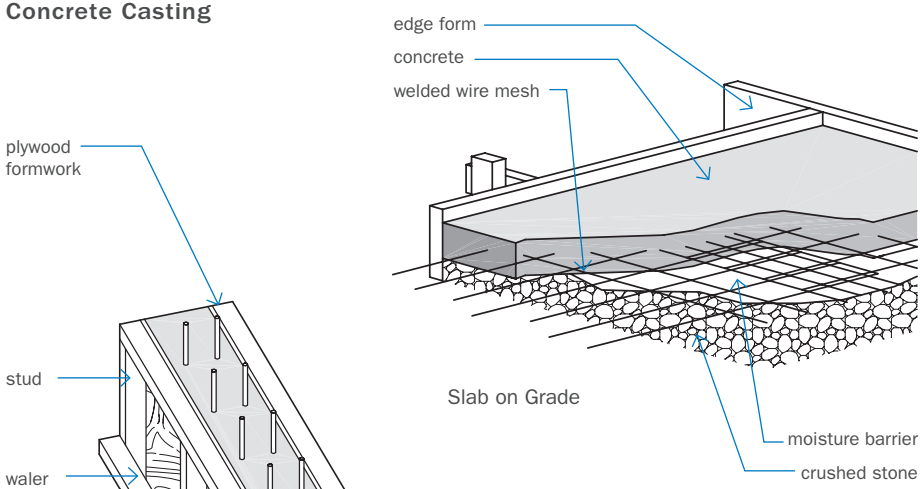
Bricks come in numerous textures and patterns, and both bricks and mortar are available in almost endless varieties of color (especially if either is custom produced). Coordination of brick and mortar colors can be an effective way to achieve different qualities within one brick type and color. Matching mortar to brick color, for example, produces a more monolithic look for the wall. Similarly, darker mortars can make a wall feel darker overall, and lighter mortars can make it feel lighter. Full-scale mockups are helpful for testing color combinations.



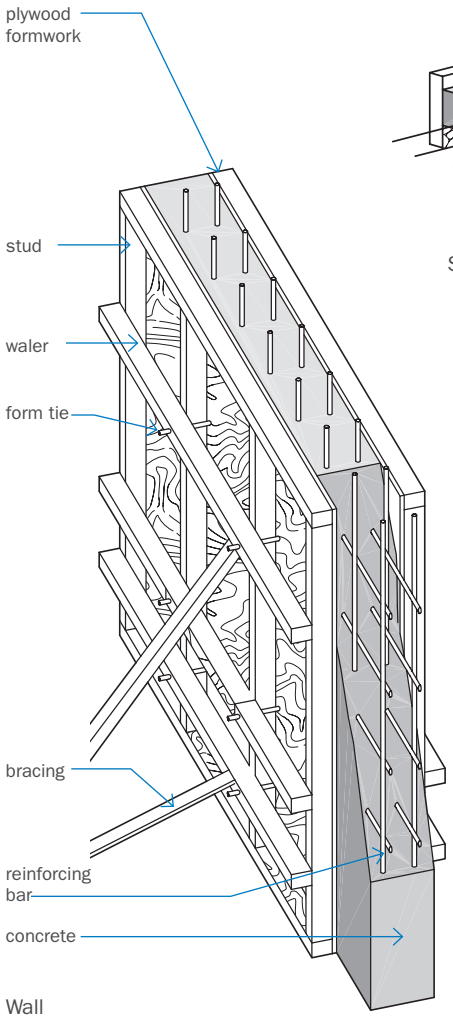
SITECAST CONCRETE FRAMING

Sitecast concrete is concrete that is cast into forms on the building site. It can be cast into any shape for which a form can be made; however, the work and time involved in building formwork, reinforcing and pouring the concrete, waiting for the concrete to cure, and dismantling the formwork makes sitecast concrete slower to erect than precast concrete or structural steel.

Concrete Casting



Slab on Grade



Wall

Cast concrete uses welded wire mesh or reinforcing steel bars (rebar) to prevent cracking or uneven settling and to supply rigidity.

Casting floor slabs, slabs on grade, plates, walls, columns, beams, and girders all involve the use of formwork, which is often plywood but can also be metal or fiberboard. Standardization within a project helps to mitigate the cost of the formwork, which can be reused.

To hold formwork together during pour and curing, form ties are inserted through holes in the formwork and secured in place with fasteners; the protruding ends are snapped off after formwork comes down.

Poured concrete must have regular control joints designed into walls and slabs, either as part of the form or tooled onto the surface before the concrete has cured. A control joint is a line of discontinuity acting as a plane of weakness where movement or cracking can occur in response to forces, relieving potential cracking elsewhere.

PLACING AND CURING

As concrete is poured and placed, care must be taken to ensure that it is not subjected to excessive vibration or sudden vertical drops, which could cause segregation of the materials (course aggregate to the bottom, water and cement to the top). For this reason, vertical transportation should be done with drop chutes. If the concrete must travel excessive distances from the mixer to the formwork, it should be pumped through hoses, not transported in the formwork.

Concrete cures by hydration, as a binding chemical combination of the cement and water; it must be kept moist during this period, generally twenty-eight days, before it is adequately cured. Surfaces may be kept moist by spraying them with water or a curing compound or by covering them with moisture-resistant sheets.

Admixtures

Other ingredients may be added to concrete for various desired effects.

Accelerating admixtures: Promote faster curing (may be used in cold weather, when curing is slowed down).

Air-entraining admixtures: Increase workability of wet concrete, aid in reducing freeze-thaw damage, and may produce lightweight, thermal-insulated concrete.

Blast furnace slag: Similar to fly ash in effect.

Coloring agents: Dyes and pigments.

Corrosion inhibitors: Reduce corrosion of reinforcing steel.

Fibrous admixtures: Short glass, steel, or polypropylene fibers that act as reinforcing.

Fly ash: Improves workability of wet concrete while also increasing strength and sulfate resistance, and decreases permeability, temperature rises, and needed water.

Pozzolans: Improve workability, reduce internal temperatures while curing, and reduce reactivity caused by sulfates.

Retarding admixtures: Promote slower curing and allow more time for working with wet concrete.

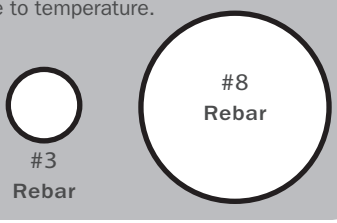
Silica fume: Produces extremely high strength concrete with very low permeability.

Super-plasticizers: High-range water-reducing admixtures that turn stiff concrete into flowing liquid for placing in difficult sites.

Water-reducing admixtures: Allow for more workability with less water in the mix.

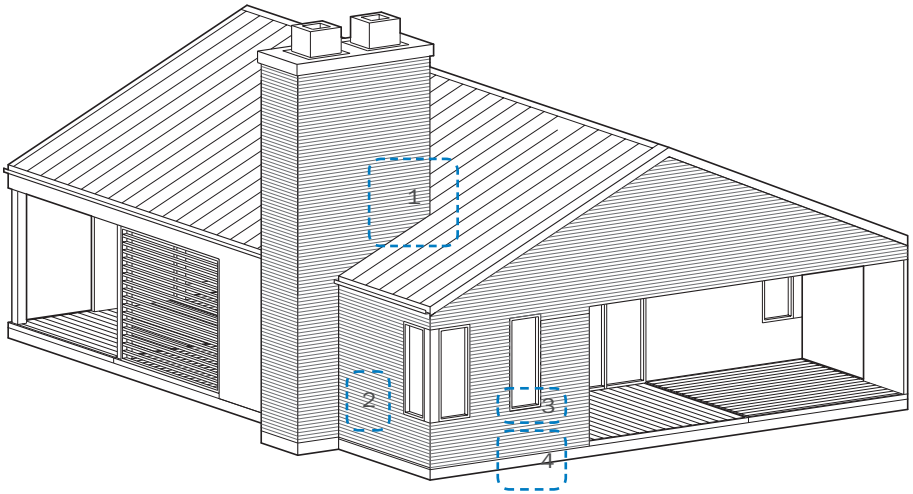
Reinforcing Steel

Without reinforcing, concrete would have few or no structural uses. Fortunately, steel and concrete are chemically compatible and have a similar rate of dimensional change due to temperature.

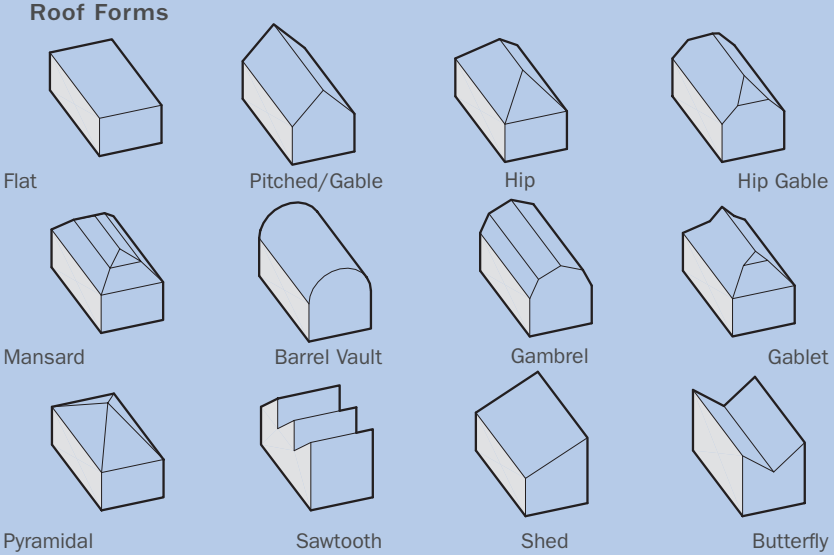


Chapter 4: Building Enclosures

A building's enclosure systems serve many functions. Not only must they separate and protect interior from exterior, they must still allow the inside and outside to have a relationship that contributes to the most effective means of moisture, thermal, and ventilation control, all while presenting the building's public face.



Roof Forms

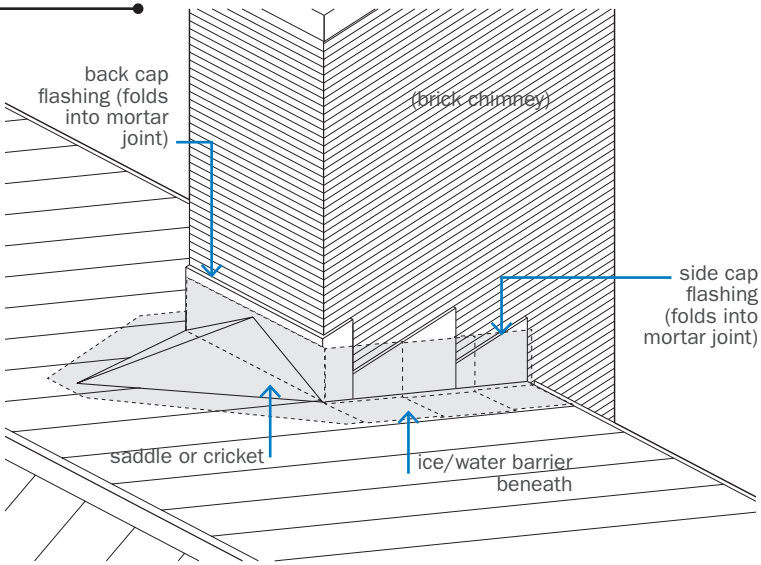


FLASHING

Flashing is used in several locations of a building's exterior to move water away and into the drainage system quickly and efficiently. Flashing is commonly thin sheet metal (copper, aluminum, stainless steel, or painted galvanized steel) or other impervious material such as rubber. Material choices often depend on whether the flashing will be exposed (metals are preferred) or concealed, and with which other materials it is likely to come into contact.

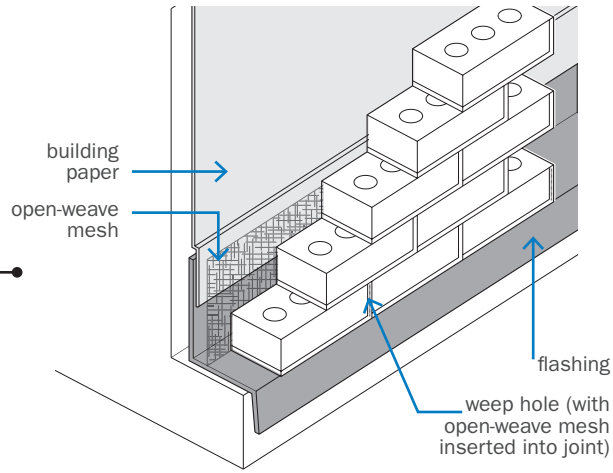
1. Roof
Flashing is wrapped around protruding objects such as chimneys and vents to keep water from settling into joints and seams.

2. Wall
Flashing may prevent water from entering a wall, or may divert water that has entered a wall cavity.

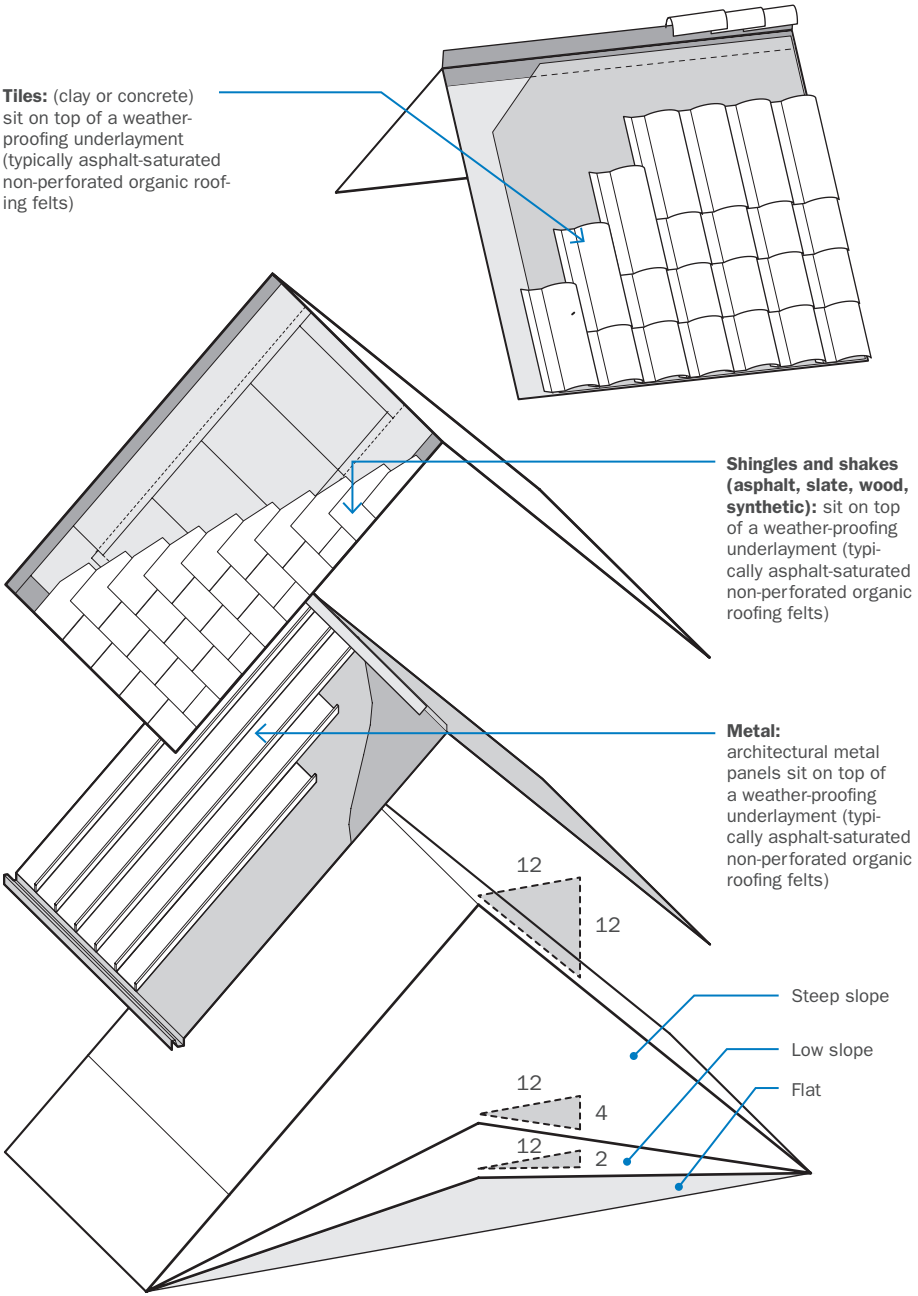


3. Sill
Interruptions in a wall, such as doors and windows, are vulnerable to water penetration.

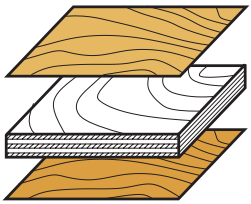
4. Base
Gravity helps water escape walls down the sloped surfaces of the flashing, and out through weep holes.



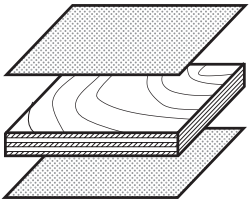
ROOF SYSTEM TYPES: STEEP SLOPES



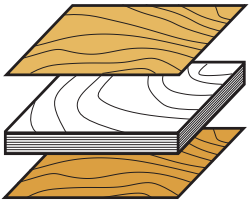
Wood-based Board Types



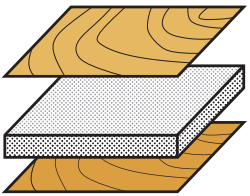
Veneer core hardwood plywood: VC is common plywood (typically, fir) with a finished wood grain surface veneer; it is relatively lightweight and easy to handle.



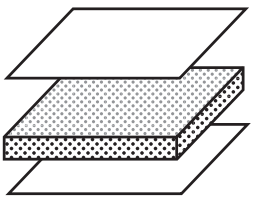
Medium- and high-density overlay plywood: MDO and HDO are generally common plywood with an MDF surface, resulting in panels that weigh less than full MDF but have smoother and more stable surfaces than VC.



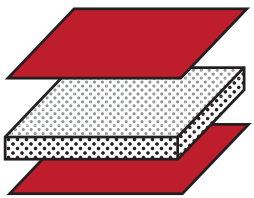
High-density plywood: HDP has more plies and fewer voids than common plywood. Its strength and stability make it useful for cabinetry, and it typically comes in birch (Baltic) or maple (Appleby).



Medium-density fiber core hardwood plywood: MDF is produced by heat-pressing a mixture of fine wood dust and a binder into panels. Paint-grade blank sheets can be used as they are or with a veneer skin, while dyed MDF has a consistent color from face to core. Though ideal for use in cabinetry and shelving, full MDF is very heavy.



Particle board core plywood: PBC produced by heat-pressing a coarse wood dust and a binder into panels, which are lower in weight than full MDF, due to the coarser dust. As the surface is rougher and less consistent, it is an ideal substrate for many other products.



Melamine: Melamine consists of a particle board core with a thermally fused, resin-saturated paper finish. Though the name refers to the resin in the paper liner, and not the paper or board, the entire product is commonly referred to as melamine. Melamine is ideal for use in cabinetry and comes in a wide variety of colors. MDF can also be used as the substrate.

Chapter 6: Structural Systems

Structural elements of a building—its walls, frame, and foundation—hold it up (or keep it down) by resisting gravity (vertical forces) and lateral (horizontal) loads such as winds and earthquakes. The primary components of a building's structural system are its foundation system and framing system. The type selected for either is contingent on many factors, including the building's use, desired height, soil conditions of the site, local building codes, and available materials. Elements of a building's structure cannot be removed without compromising its strength and stability.

Loads

All stresses acting on a building's structure, no matter how complex, can be reduced to either tension or compression. In basic terms, a building's structure must press up with the same force that the weight of the building is pressing down, which includes all fixed dead loads and varying live loads.

Tension is a pulling and stretching force.

Compression is a pressing, pushing, or squeezing force.

Dead loads: Fixed, static loads made up of the building's own structure, skin, equipment, and other fixed elements.

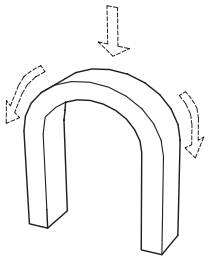
Live loads: Moving or transient loads such as occupants, furnishings, snow, ice, and rain.

Wind loads: Pressure from wind that affects lateral loads as well as possible uplift forces on roofs or downward pressure.

Other loads: Impact loads, shock waves, vibrations, and seismic loads.

STRUCTURAL TERMINOLOGY

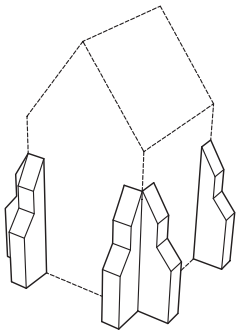
Arch: Structural device that supports vertical loads by translating them into axial forces.



Axial force: System of internal forces whose outcome is a force acting along the longitudinal axis of a structural member or assembly.

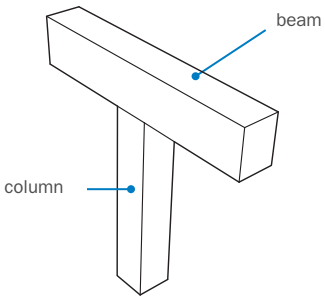
Beam: Horizontal linear element that spans an opening and is supported at both ends by walls or columns.

Buttress: Vertical mass built against a wall to strengthen it and to resist the outward pressure of a vault.



Cantilever: Horizontal beam or slab that extends beyond its last point of support.

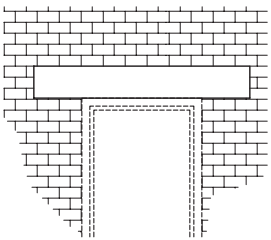
Column: Upright structural member acting in compression.



Dome: Arch rotated in plan to produce an inverted bowl-shaped form.

Girder: Horizontal beam, which is usually very large, that supports other beams.

Lintel: Beam used to span the opening in a wall left for a window or a doorway. The lintel supports and distributes the load of the wall above the opening.



Prestressing: Applying a compressive stress to a concrete structural member, either by pre-tensioning (pouring concrete around stretched steel strands, then releasing the external tensioning force on the strands once the concrete has cured) or post-tensioning (tensioning high-strength steel tendons against a concrete structural member after the concrete has cured).

Retaining wall: Wall used to mediate abrupt changes in ground elevation and to resist lateral soil pressures.

Shear: System of internal forces whose outcome is a force acting perpendicular to the longitudinal axis of a structural member or assembly.

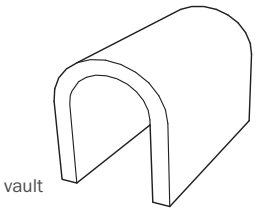
Shoring: Temporary vertical or sloping supports.

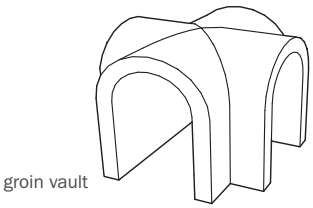
Slump test: Test in which wet concrete or plaster is placed in a metal cone-shaped mold of specific dimensions and allowed to slump under its own weight after the cone is removed. The index of the material's working consistency is determined by the distance between the height of the mold and the height of the slumped mixture.

Strain: Intensity of deformation at a point in an object.

Stress: Intensity of internal force acting at a point in an object.

Vault: Extruded arch.



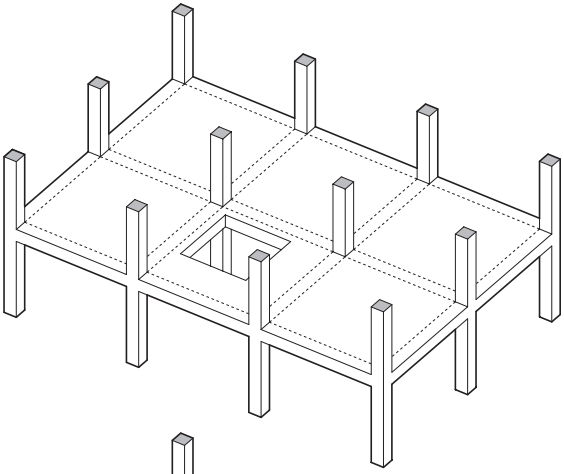


Materials

Structural framing elements may be made of wood, heavy timbers, concrete, masonry, steel, or a combination of these.

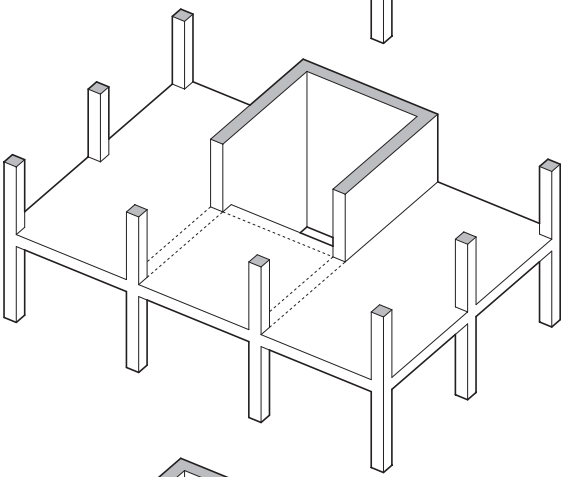
Moment Frame

Rigid framework resists lateral forces



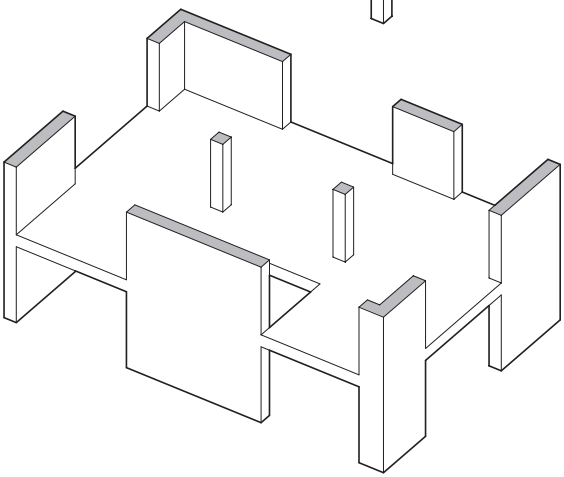
Braced Frame

Internal structure braces light frame



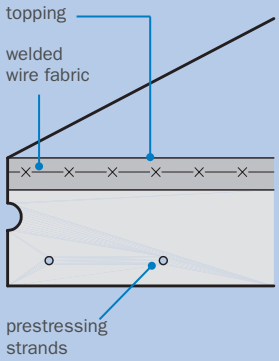
Tube

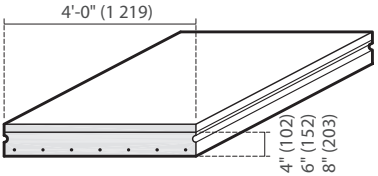
Exterior walls contribute to structural stability



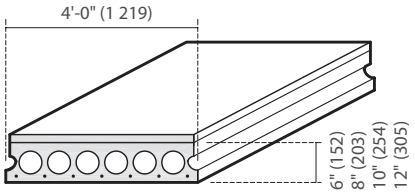
PRECAST CONCRETE FRAMING

Slab Detail



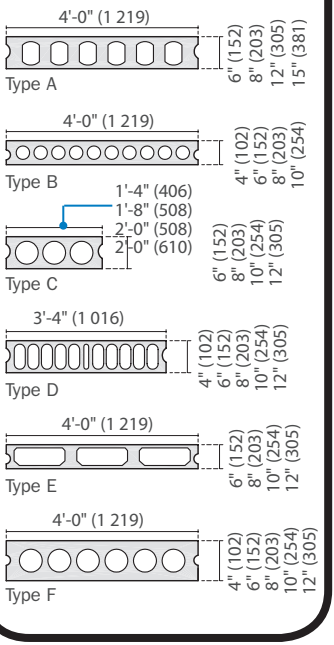


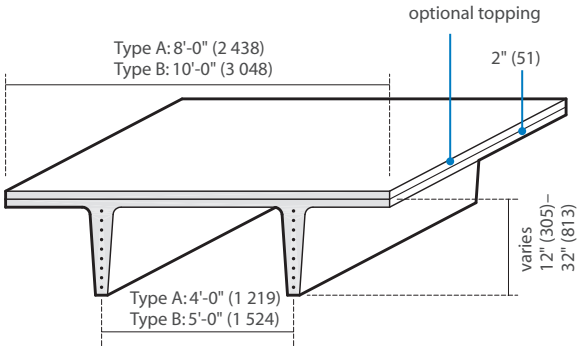
Solid Flat Slab



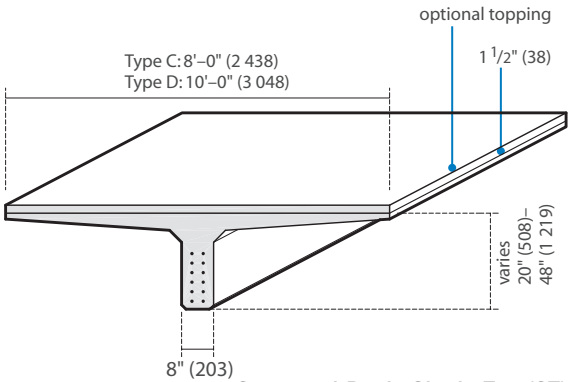
Hollow Core Slab

Hollow Core Slab Types



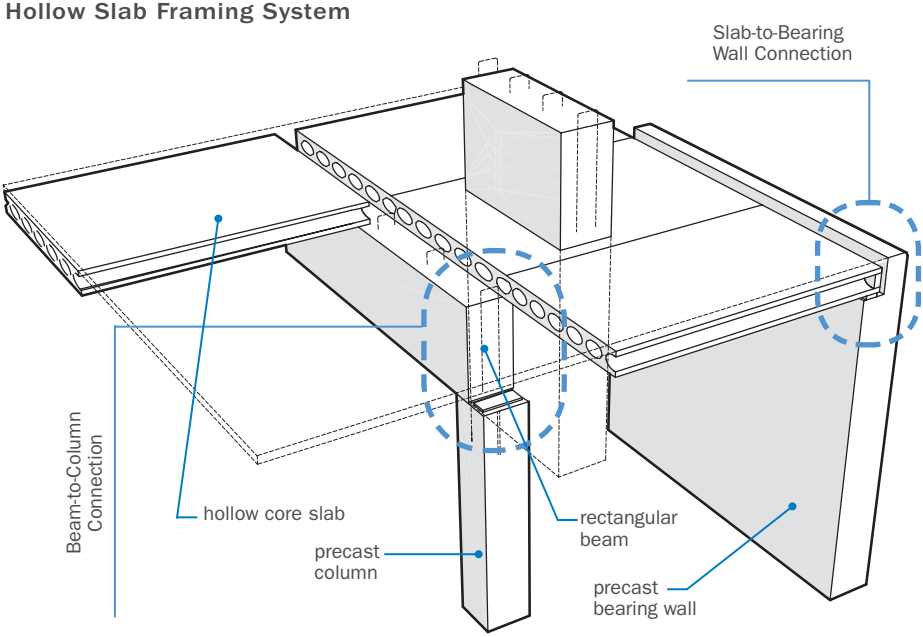


Stemmed Deck, Double Tee (DT)

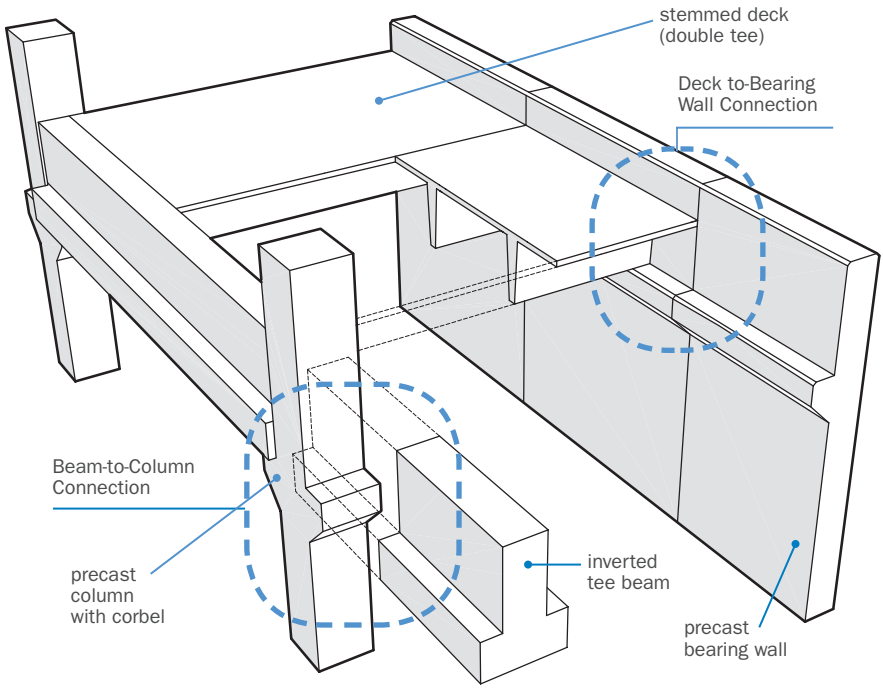


Stemmed Deck, Single Tee (ST)

Hollow Slab Framing System



Stemmed Deck DT Framing System

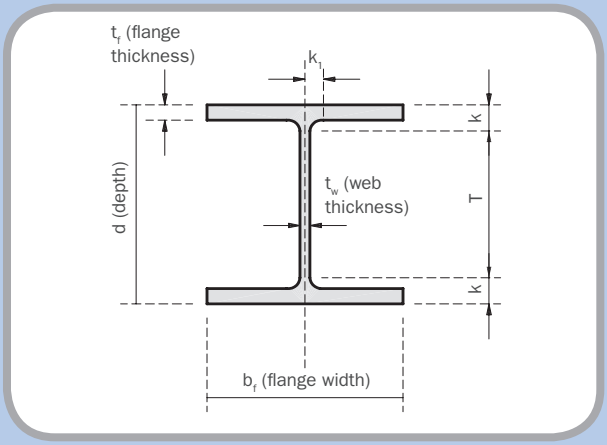


Structural Steel Shape Designations

	Shape	Description
W	Wide-flange	hot-rolled, doubly symmetric wide-flange shapes used as beams and columns
HP	Wide-flange	hot-rolled, wide-flange shapes whose flanges and webs are of the same nominal thickness and whose depth and width are essentially the same; often used as bearing piles
S	American Standard beam	hot-rolled, doubly symmetric shapes produced in accordance with AASM* dimensional standards; generally being superseded by wide-flange beams, which are more structurally efficient
M	Miscellaneous	doubly symmetrical shapes that cannot be classified as W or HP shapes
L	Angle	equal leg and unequal leg angles
C	American Standard channel	hot-rolled channels produced in accordance with AASM dimensional standards
MC	Channel	hot-rolled channels from miscellaneous shape
WT	Structural tee	hot-rolled tees cut or split from W shapes
ST	Structural tee	hot-rolled tees cut or split from S shapes
MT	Structural tee	hot-rolled tees cut or split from M shapes
TU	Tube	hollow structural steel members shaped like a square or rectangle; used as beams or columns, or in bracing

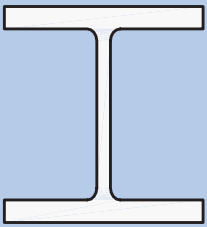
*AASM: Association of American Steel Manufacturers

Steel Shape Examples



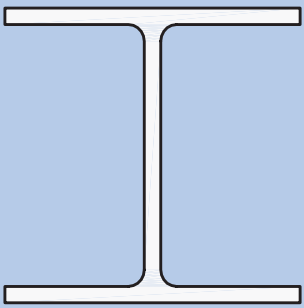
Wide-flange
W8×67

8 = nominal depth (in.);
67 = weight per foot of length (lb.)



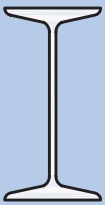
Wide-flange
HP12×84

12 = nominal depth (in.);
84 = weight per foot of length (lb.)



American Standard
S8×18.4

8 = nominal depth (in.);
18.4 = weight per foot of length (lb.)



Miscellaneous
M10×8

10 = nominal depth (in.);
8 = weight per foot of length (lb.)



Structural Tees
WT25×95



ST15×3.75



Tube
TU2×2×1/8



Angle
L6×4×7/8

6 and 4 = nominal depths of legs (in.); 7/8 = nominal thickness of legs (in.)



Channel
MC7×22.7

7 = nominal depth (in.);
22.7 = weight per foot of length (lb.)

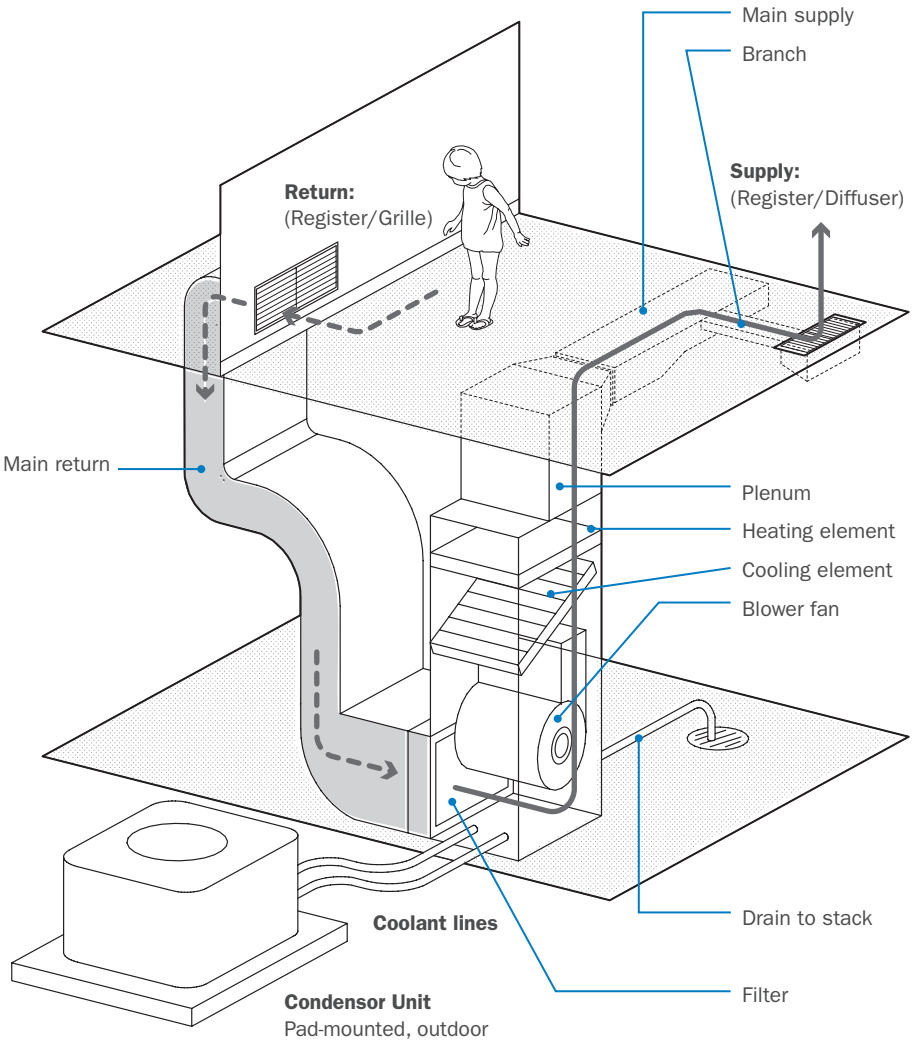


FORCED AIR DUCT SYSTEM

A duct system distributes heated, cooled, and fresh air throughout the building, while also filtering and dehumidifying the air.

HYDRONIC SYSTEMS

Hydronic systems provide heating, but typically not cooling. Hot water is circulated through tubing, from the central heat source to radiators throughout the space to be heated. The radiators may be wall-mounted or floor-mounted. Tubes may also be designed into floor systems, providing consistent radiant heat. Heat sources may include boilers, water heaters, and solar power.



FORCED AIR FURNACE — Typical residential heating and cooling system

Calculating Slope Degrees:

$$\text{Slope} = \frac{\text{Vertical Rise Distance (V)}}{\text{Horizontal Distance (H)}} = \text{tangent m}$$

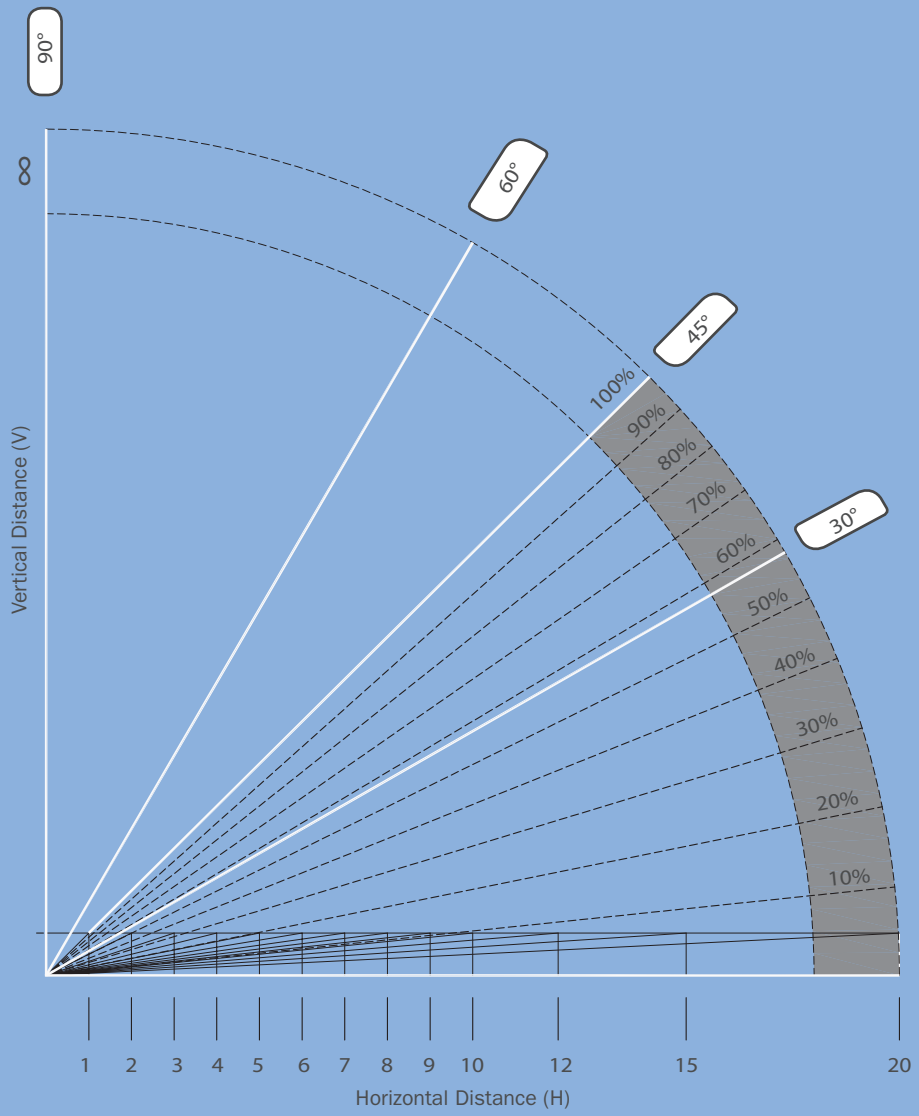
Slope Angle = tangent m

Calculating Gradient:

$$= 1 \text{ unit in } \frac{\text{Horizontal Distance (H)}}{\text{Vertical Distance (V)}}$$

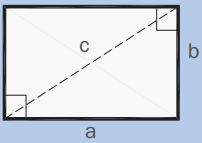
Calculating % Grade:

= 100 × Tangent (Slope) or 100 × V/H



PLANE FIGURE FORMULAS

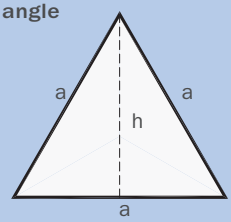
Rectangle



area = ab
perimeter = 2(a+b)
$a^2 + b^2 = c^2$

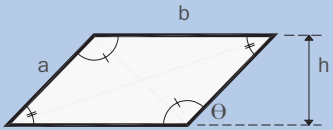
Equilateral Triangle

(all sides equal)



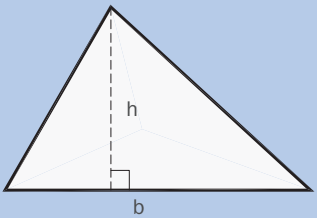
area = $a^2\frac{\sqrt{3}}{4} = 0.433\ a^2$
perimeter = 3a
$h = \frac{a}{2}\sqrt{3} = 0.866a$

Parallelogram



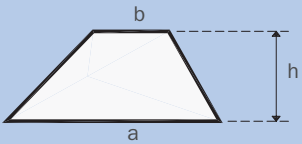
area = ah = ab sinΘ
perimeter = 2(a+b)

Triangle



area = $\frac{bh}{2}$
perimeter = sum of length of all sides

Trapezoid

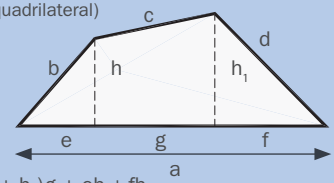


area = $\frac{(a+b)}{2}h$

perimeter = sum of length of sides

Trapezium

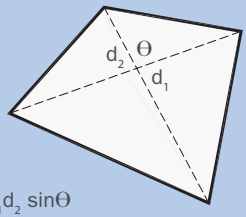
(irregular quadrilateral)



area = $\frac{(h + h_1)g + eh + fh_1}{2}$

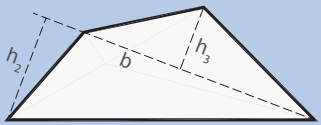
perimeter = sum of length of all sides

Quadrilateral



area = $\frac{d_1 d_2 \sin\Theta}{2}$

or



area = $\frac{bh_2}{2} + \frac{bh_3}{2}$

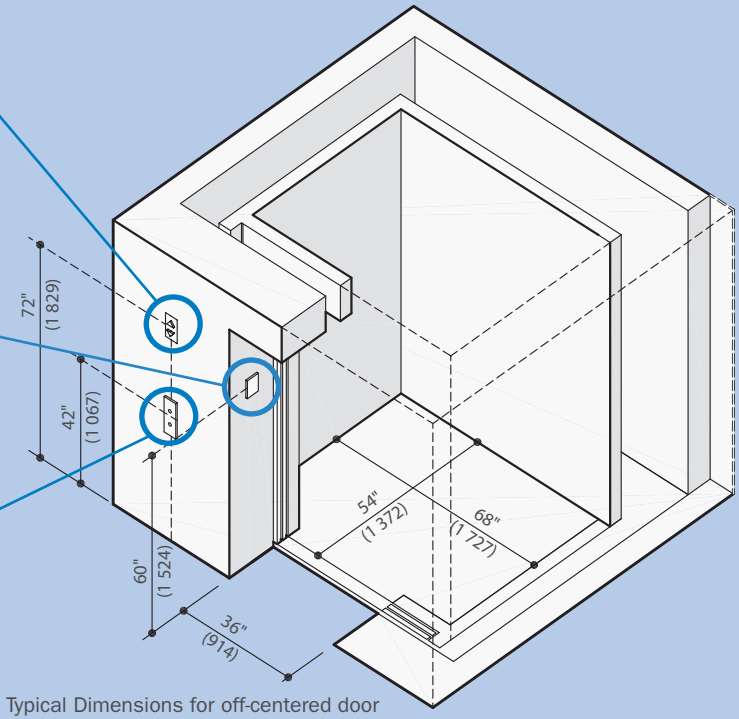
(Divide figure into two triangles and add their areas together.)

ELEVATORS

Hall lantern fixtures at each hoistway entrance must indicate visibly and audibly which car is answering a call.

Door jambs should have raised and Braille floor designation markings.

Call buttons must be a minimum 3/4" (19) in the smallest direction.



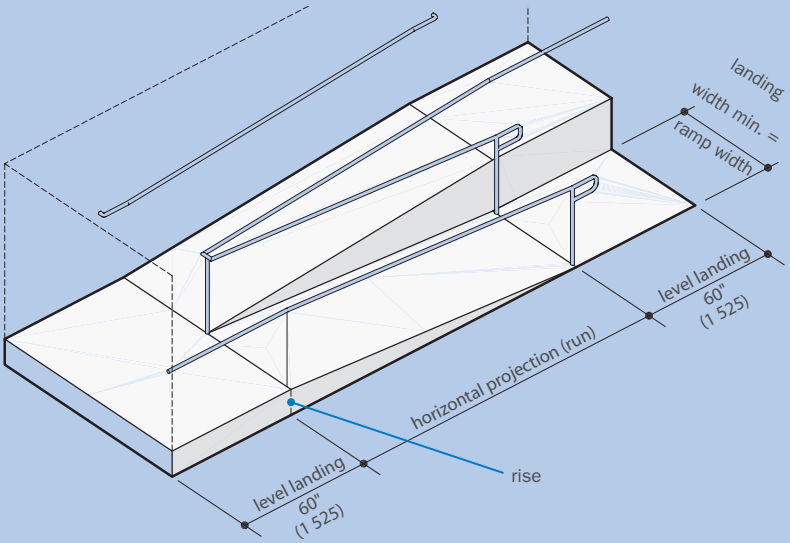
Typical Dimensions for off-centered door

RAMPS

The rise for any ramp run before landing shall be 30" (762) max.

The minimum clear width of a ramp should be 36" (914), inside handrails. If a ramp has a rise greater than 6" (150) then it should have handrails on both sides.

Maximum slope is 1:12.



STAIRS

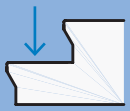
Nosings

Risers should be sloped, or the underside of nosings should have an angle not less than 60° from the horizontal.



flush riser

11" (280) min. tread depth



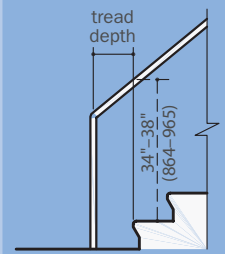
angled nosing

7" (178) max. riser height

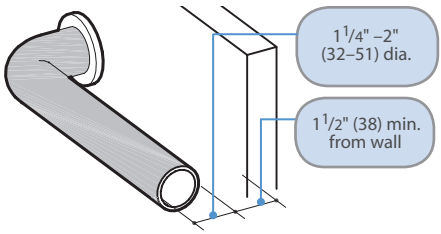


rounded nosing

Handrail Extension (min.)at Bottom of Run



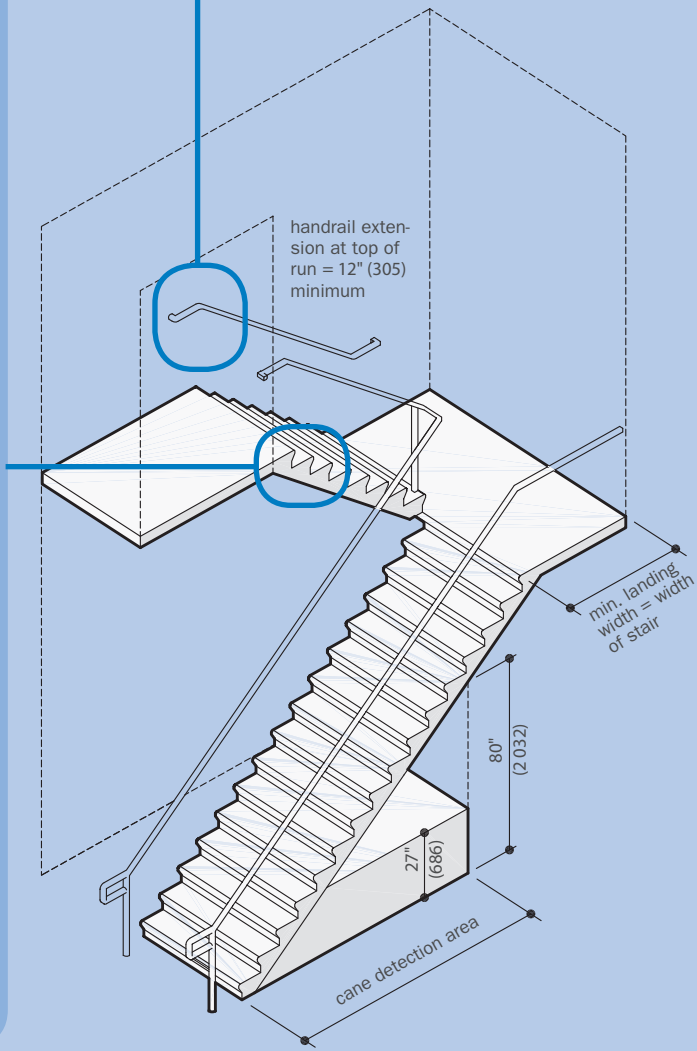
Handrails



at wall: handrail returns to wall

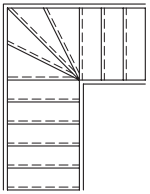
at switchback: handrail is continuous

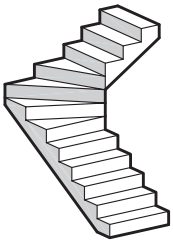
where no wall: handrail returns smoothly to the floor



L-shaped Stair with Winders

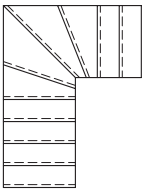
Winders may help to compress the area needed for a stair by adding angled treads where a landing might go in a typical L-shaped stair. Most winders do not comply with local codes.

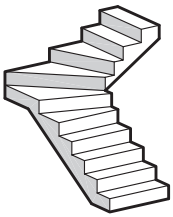




L-shaped Stair with Offset Winders

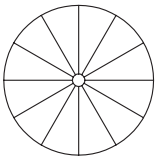
Offset winder treads are more generous in proportion and, therefore, may comply with applicable codes.

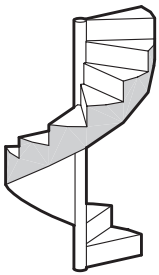




Spiral Stair

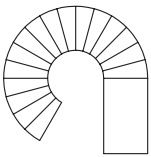
Spiral stairs occupy a minimum amount of plan space and are often used in private residences. Most spiral stairs are not acceptable as egress stairs, except in residences and in spaces of five or fewer occupants in 250 sq. ft. (23 m^2) or less.

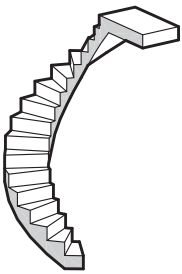


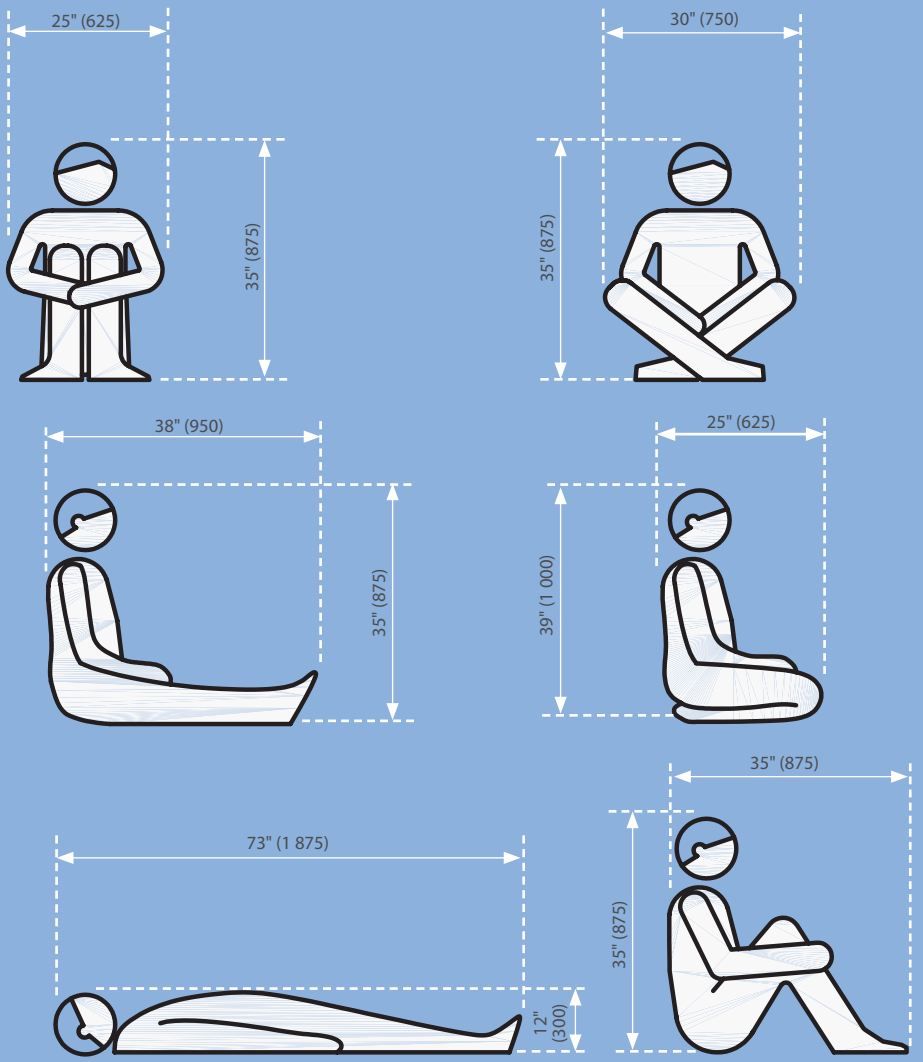


Curved Stair

Curved stairs follow the same layout principles of spiral stairs, though with a sufficient open center diameter, the treads may be dimensioned to legal code standards for egress.







Lounging Position General Space Considerations

1760 1780 1800

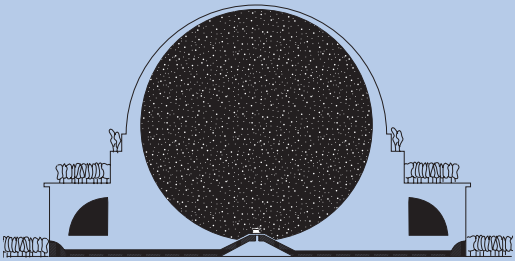




Salt Works (1780)
Chaux, France
Claude-Nicolas Ledoux

Neoclassicism
(1750–1880)

Cenotaph for Isaac Newton (1784)
(unbuilt)
Étienne-Louis Boullée



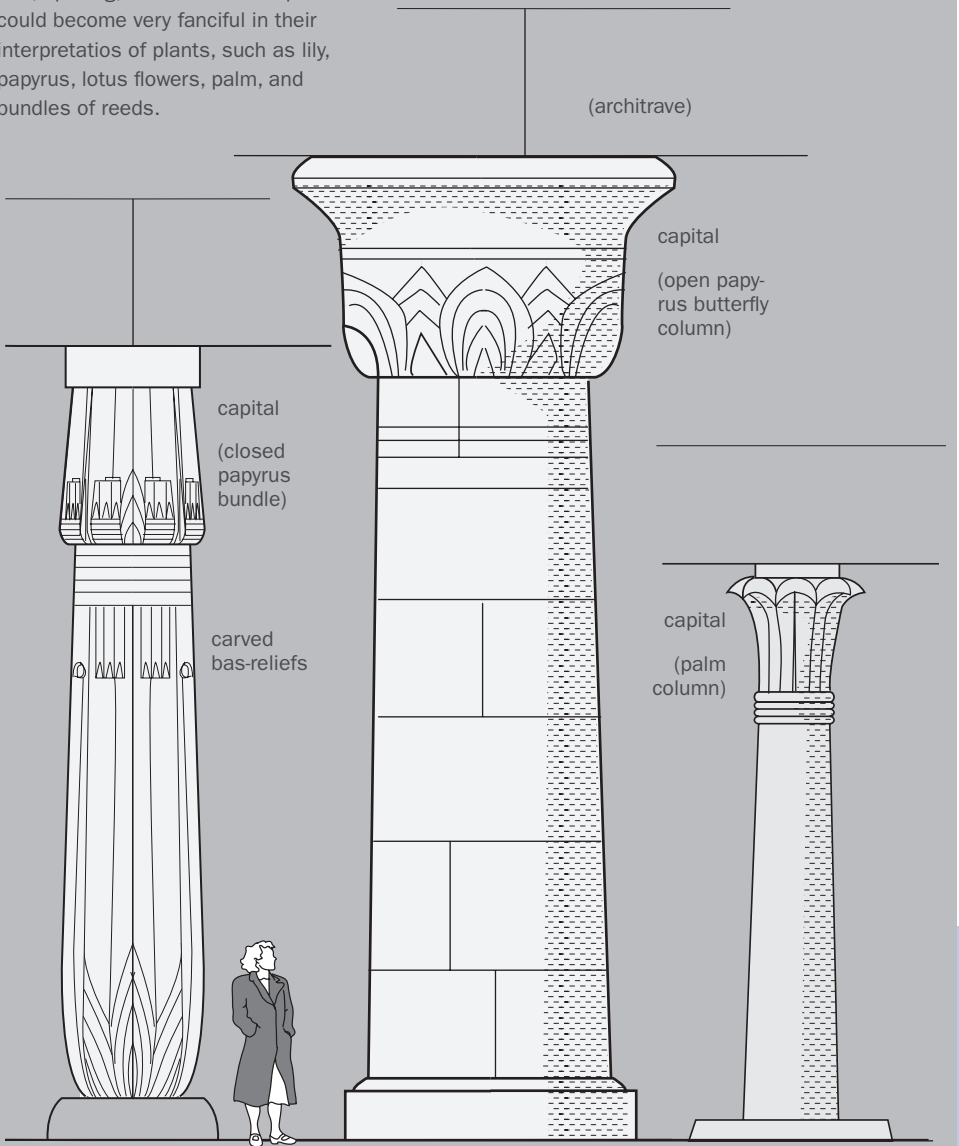
Monticello (1771–1782)
Charlottesville, Va., USA
Thomas Jefferson

Panthéon (1764–1790)
Paris, France
Jacques Germain Soufflot

Bank of England
(1788)
London, England
John Soane

COLUMNS

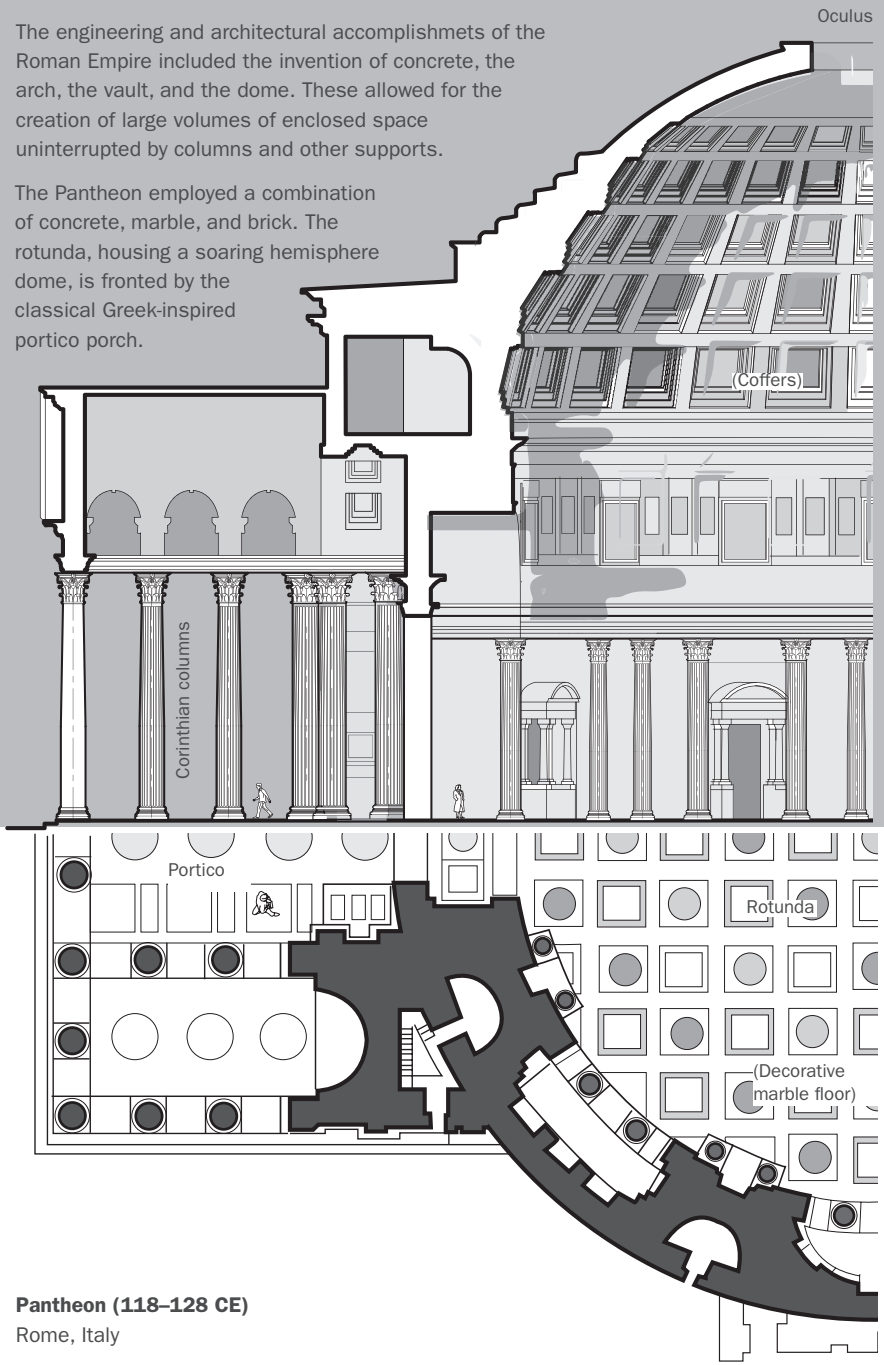
Egyptian column designs were highly varied in height, diameter, ornamentation, spacing, and form. The capitals could become very fanciful in their interpretatios of plants, such as lily, papyrus, lotus flowers, palm, and bundles of reeds.



ANCIENT ROME

The engineering and architectural accomplishmets of the Roman Empire included the invention of concrete, the arch, the vault, and the dome. These allowed for the creation of large volumes of enclosed space uninterrupted by columns and other supports.

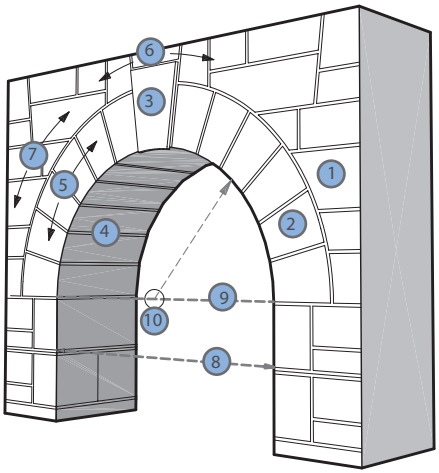
The Pantheon employed a combination of concrete, marble, and brick. The rotunda, housing a soaring hemisphere dome, is fronted by the classical Greek-inspired portico porch.

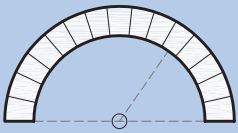


Pantheon (118–128 CE)
Rome, Italy

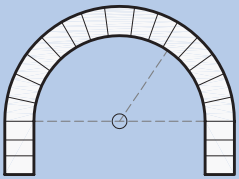
ARCHES

1. abutment
2. voussoirs
3. keystone
4. intrados (soffit)
5. extrados
6. crown
7. haunch
8. span
9. springing line
10. center

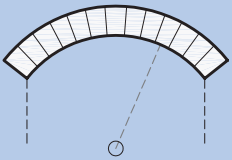




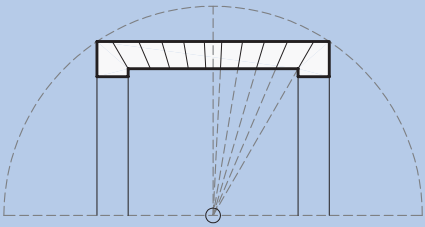
Semicircular



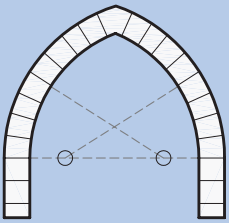
Semicircular Stilted



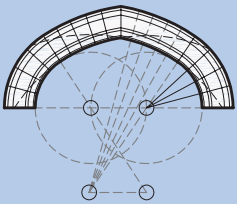
Segmental



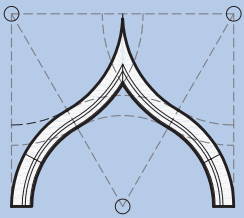
Jack



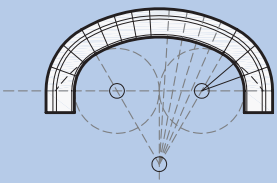
Pointed Saracenic (Gothic)



Tudor (Four-Centered)



Ogee



Three-Centered

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ISBN: 978-1-63159-379-6
$24.99 US | £16.99 UK | $32.99 CAN
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