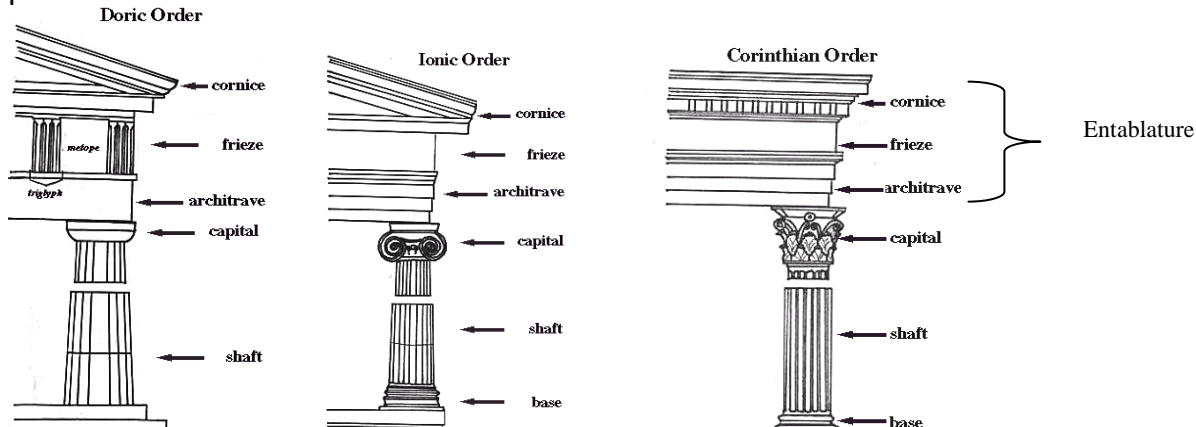


## History:

Identify various parts of classical entablature (Cornice, Frieze, Architrave), Shaft, base, column, pedestal.



**Doric:** simple, direct, perfect relation of parts, and most widely used.

**Ionic:** slender, having a volute or scroll capital, and an individual base.

**Corinthian:** acanthus leaves on capital, used sparingly, and later the favorite of the Romans.

Note: Columns are measured in a ratio. The ratio is the diameter of the shaft at its base compared to the height of the column. As a result, a column can be described as seven diameters high. Sometimes this is given as seven lower diameters high, in order to make sure which part of the shaft has been measured.

Sullivan: architect who believed that form follows function. Influenced Sullivan's use of plain forms. HH Richardson

**HH Richardson:** Richardson developed a powerful personal style, related to the Romanesque of southern France, producing most of his larger buildings with strong, clear, simple rusticated masonry forms. [http://www.greatbuildings.com/architects/Henry\\_Hobson\\_Richardson.html](http://www.greatbuildings.com/architects/Henry_Hobson_Richardson.html) Trinity Church, competition winner, Boston, French Romanesque. Also designed Marshal Fields.

**Luigi Nervi:** Materials he uses. Concrete

**Construction materials of ancient Egypt:** Stone, sun dried bricks. Known for the post-and-beam. The monuments used..... Greek: marble and timber, Roman: marbles, terra cotta, volcanic stone, Pozzolana cement.

**Bernard Maybeck** studied architecture at the Ecole des Beaux Arts. During his studies he embraced the theories of Viollet-le-duc with their combined emphasis on medievalism and technological advancement. He joined the firm of A. Page Brown. He was an important mentor to a number of young architects, including Julia Morgan. Maybeck developed an eclectic vocabulary of forms that borrowed from the regional forms and construction of California. Although his designs show a relationship between decoration and structure, Maybeck accepted and used a variety of styles. He resolved each design with the belief that every architectural problem required an original solution

**Robert Maillort** - Developed a structural reinforced concrete slab. Used reinforced Concrete in bridges & industrial bldgs. "Cement Hall"

**Joseph Aspdin**: developed Portland cement: the first to manufactured hydraulic cement. (sets in water)

**John Smeaton** - found quicklime containing clay, would harden under water. \* used primitive form of this mortar for a lighthouse.

**Frank L. Wright**: experimented w/ concrete in Fallingwater, Johnson Wax Company, the Guggenheim museum, California block houses and Unity Temple.

**Eero Saarinen: Deere Bldg**: what materials? weathering steel and glass facade



designed 9 days, standardization, cast iron members & glass panels, built in 3 months; p5-9



Example of the Doric order - A Greek Temple

**Crystal Palace** - Paxton (London)

**Parthenon, Athens**: Ictinus & Callicrates



The only natural light enters through an unglazed oculus at the center of the dome and through the bronze doors to the portico. The portico consists of three rows of eight columns, of Egyptian granite with Corinthian capitals. They support an entablature facing the square, which bears the famous inscription in Latin, attributing the construction to Agrippa, although the extant temple was rebuilt later by Hadrian.

\*\* **Pantheon, Rome**-



brick and glass. The main office work space is articulated by dendriform columns capable of supporting six times the weight imposed upon them  
The glass is not in panes, but in tubing, and several layers of different sizes are used to admit light but no view



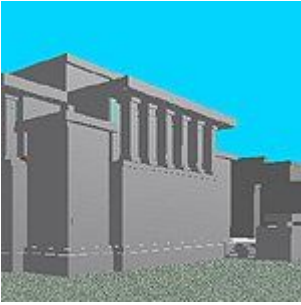
Reinforced concrete. simplicity that comes from the repetition of a vaultlike form, given a dull sheen from its lead-covered exterior, and a beautifully articulated concrete structural frame with infill paneled walls of travertine. The building consists of Sixteen vaulted units. These are cast-in-place, post-tensioned, reinforced concrete.

**Johnson Wax Bldg, FLW, Wisconsin** - Modern

**Kimball Museum, Louis Kahn, Texas 1972**

[http://www.kimbellart.org/building/Architecture\\_facts.cfm?id=3](http://www.kimbellart.org/building/Architecture_facts.cfm?id=3)

Note: " Kahn's modular units are not really barrel-vaulted, as the summit of each intrados is a void into which a baffled skylight has been inserted. The structural system is actually repetitive double-cantilevered butterfly canopies."



Unity Temple - FLW

**Site - Cast Concrete** -its servicing systems were among the most advanced in the world, with hot-air heating integrated in the structure.



Marshall Fields Store, Chicago: Richardson

Rested on a 2-story base of red granite. Its upper walls were built of red sandstone and its interior was framed w/ heavy timber.

**Le Corbusier** worked with Auguste Perret: the French architect who had pioneered the use of Reinforced Concrete.

**Gothic architecture characteristic:** Arch in gothic period as a tri-dimensional spatial solution 3-15 ALS Known for the pointed arch, rib & Panels, and Flying buttresses. Its great works are cathedrals, characterized by the gradual reduction of the walls to a system of richly decorated fenestration. Lasted until the 16<sup>th</sup> century when it was succeeded by the classical forms of the Renaissance.

**Fay Jones** is known for his use of Wood.

**Root of modern architecture:** ALS H 5-1 Extend back to the 15<sup>th</sup> century - Renaissance had design concepts that had significance beyond immediate application.

**Neolithic:** New Stone Age. First learned to live in permanent village as part of a tribe.

### Site Work:

**Differences between piles and caissons.** ALS 1-14

Piles transfer their load by skin friction while Caissons transmit its load by end bearing. (most cases)

**Pile:** Made of wood, steel, concrete, or a composite of two materials.

**Caisson:** shaft drilled into ground and then filled w/ concrete.

A pile is driven into the earth - caisson is drilled and poured.

**End bearing piles** work exactly the same as caissons, but can be used where noncohesive soils or subsurface water conditions preclude the installation of caissons. The pile has penetrated the bearing layer and is firmly embedded in it.

**Friction piles:** used when no firm bearing stratum exists at a reasonable depth or when a high water table would make footings or caissons expensive. Used in silty, clayey and sandy soils. Go to certain depth opposed to refusal.

**When a pile has been "driven to refusal", it means that:** Pile has been driven to a point where additional blows result in no further significant penetration.

**Mandrel:** a member inserted into a hollow pile to reinforce the pile shell while it is driven into the ground. AGS 146

**Sheet piles:** are used as a water dam. ALS 1-16 For bridge piers or construction located in water, the entire area is surrounded w/ watertight sheet piling, the water is pumped out, and the foundations are then constructed. Such an installation is known as a **cofferdam**.

**Identify a needle beam and know what it's used for.** ALS 1-17 **Needle Beam:** a way of underpinning is to use hydraulic jacks holding up a needle beam. The needle beam goes under the structure. FOBC p54 **Underpinning:** a method to temporarily support existing foundations while they are being repaired, strengthened, or when they are being extended to a lower level.

**Used to retain the sides of an excavation:**

**Soldier beams:** wide-flange steel sections driven vertically into the earth at 5 to 10 foot intervals to a depth lower than that of the proposed excavation.

**Wood boards:** (lagging), are placed horizontally between the soldier beams as the earth is removed.

**Sheet piling:** consists of vertical planks, which fit tightly together and are driven into the earth to form a barrier before starting excavation: **NOT wellpoints: this is used to dewater an excavation, not to retain its sides.** **Well Point:** to depress water table. A well point is used to dewater a site or lower the groundwater table. Basically, you drill a number of wells on a site and suck the water out with a vacuum. Point wells are typically pounded or "jetted" into the ground. Typically point wells are used where soil is fine to medium sand and the water table is high and relatively stable year round. The presence of larger stones will typically prevent the installation of a point well casing into the soil. **Sheet pile is not used....** FOBC p38

**Deadman** is a timber, stone, or concrete mass buried in the ground, and used as an anchor for the ends of horizontal tiebacks.

**Retaining walls:** the deadman in the horizontal timber wall are timbers embedded in the soil behind the wall and connected to it with timbers inserted into the wall at right angles. The timbers are held together with very large spikes with steel reinforcing bars driven into drilled holes. FOBC 55

## Soil types, characteristics and testing

### Types:

Hardpan - gravel, clay & sand, unbroken mixture of clay (good foundations)

Gravel -  $\frac{1}{4}$ " to  $3\frac{1}{2}$ " (excellent foundations, low in plasticity; good drainage)

Sand - .002" to  $\frac{1}{4}$ " (same as gravel)

Silt - .002" < (w/ H<sub>2</sub>O = mud)

Organics - make poor bases for foundation

Shale and slate: soft rocks w/ fine texture

Boulders: rocks broken from bedrock

Bedrock: solid rock that forms earth's crust; highest bearing capacity of all soils.

### Properties:

Specific Gravity: determine void ratio

Grain size: to estimate permeability, frost action, compaction, and shear strength

Grain shape: est. shear strength

Liquid & plastic limits: (cohesive soils) to obtain compressibility and compaction values

Water content: (cohesive soils) to obtain compressibility & compaction values

Void Ratio: determine compressibility

Unconfined compression (cohesive soils) est shear

### Tests:

Auger Borings: used in sand/ clay; Not past 50'

Wash Borings: finding bedrock, where too compact for Auger Borings.

Boring Log: shows material, depth at which it was encountered, its previous bore tests at the particular site.

Standard Penetration Test: measures density of a granular soils and consistency of some clays. 2" diameter sampler is driven into bottom of borehole by 140 lbs hammer falling 30 inches. The number of blows that it takes to drive the cylinder 12 in is recorded. Most common bore hole test is SPT.

Dry sample borings: a pipe w/ split sample borings is driven in 5" increment depths and samples are taken at each depth.

Core: most \$\$, most reliable. Taken after the concrete is cured.

Test Pits: trench dug on the job site to visually inspect and collect soil. The practical depth is 10'.

Soil Load tests: build a platform and placing incremental loads on it, observing the amount of settlement that occurs during given time periods until settlement becomes regular after repeated loading. The design load is  $\frac{1}{2}$  of test load.

**Soiling Borings indicate that a site is underlain by loose fill averaging 5 feet in thickness. In this regard, what should take place?** If the fill is removed and re-compacted, it may be used to support bldg footings.

**Sheep foot roller**: A self propelled or towed drum-like roller w/ projecting studs that penetrate the surface of the ground; used to obtain deep compaction of fill material; esp. effective for compaction of clay soils. **Disadvantages:**

ALS 1-11

**Water table**: The level below which all soil is saturated w/ ground water is known as the water table. Follows the ground surface, its level may fluctuate because of seasonal variations, precipitation, or developmental changes on the ground surface, such as paving a large parking area. Foundations below water table are subject to hydrostatic pressure.

**Proctor test**: tests moisture content in relationship to the fill's density for standard compaction.

**Foundation drain functioning:** Drainage tiles have min diameter of 6" and laid on gravel, 6" below the lowest floor slab. **Invert Elevation** for storm drain (illustration): The bottom of the inside of a pipe. **Foundation** drains are usually used in conjunction w/ water proofing. These drains are placed in a bed of compacted fill material around the exterior perimeter of the bldg foundation. They are placed far enough below the floor slab to properly drain and with its lowest **invert elevation** (bottom) at least 4" above the bottom of the footing to prevent possible wash out of the soil beneath the footing.

**Gravel fill:** slabs on grade, not subjected to hydrostatic pressure are often placed over a gravel fill several inches thick. ALS 1-10 Fast draining soil such as sand is preferred for backfilling FOBC p65

## Concrete:

**Differences between pre and post tension.** Pre-tensioning is produced in casting plant. Post-tensioning is made on site.

**Pre-tensioning:** produced in casting plant. Wire is draped in forms according to the required stress pattern, and a tensile force is applied. The concrete is then poured, and allowed to cure. Once the concrete cures, the cables are cut and the resulting compressive force is transferred to the concrete through the bond between cable and concrete. Stressed before curing.

**Post-tensioning:** hollow sleeves or conduits are placed in the forms on site and concrete is poured around them. Within the sleeves are high-strength steel tendons, which are stressed with hydraulic jacks after the concrete has cured. When the desired stress has been applied, the ends of the cables are secured to the concrete and the jacks are removed. To bond construction, the sleeves are removed and grout is forced into the space between the tendons and the concrete. If not bonded, leave alone. Stressed after curing.

**Parts of formed in place concrete - names of wires and their accessories (stirrup, ties, etc).** Various shapes. ALS 2-9

**Form ties:** metal wires or rods used to hold opposite sides of the form together and also to prevent their collapse. Some ties are threaded rods that can be unscrewed and reused. Tie holes are made w/ cone-shaped heads placed against the concrete form. When removed, a deep, round hole is left that allows the tie to be cut off below the surface of concrete.

**Stirrups:** Same as hanger. A bent rod, usually U-shaped or W-shaped; used in reinforced brick or concrete construction. A reinforcing device to resist shear and diagonal tension stresses in a beam. A metal seat, attached to a wall beam or post or hung from a girder, to receive and support a beam or joist. Identify....

**Spalling:** the breaking off. Freeze- thaw of masonry causes spalling.

**Ferroconcrete:** the first reinforced concrete. ALS 2-4

**Portland cement:** lime, silica, iron oxide, and alumina. Used in concrete matrix. Cement paste is chemically active ingredient in concrete and referred to as the matrix. ALS 2-4

**Crazing:** fine cracks in precast or cured concrete plaster.

**Reinforcing steel chairs for concrete:** Holds the reinforcing steel in its location. And can assist in controlling torsion. ALS 2-11

**Concrete cover for reinforcement:**

<u>Location</u>		<u>Distance</u>
	Slabs and walls	$\frac{3}{4}$ "
	Beams and columns	$1 \frac{1}{2}$ "
	Retaining walls	2"
Surface exposed to weather or w/ ground	No 5 bars and smaller	$1 \frac{1}{2}$ "
	Larger than no. 5 bars	2"
Concrete poured on ground		3"

Max aggregate size should be no greater 1/3 the thickness of concrete slabs, or  $\frac{3}{4}$  min space between reinforcing bars. ALS 2-5

**Reinforcing bars:**

- On bar, info states mill, size, type & grade.
- 1/8 increments. A #6 bar would be 6/8"
- grades: 40 & 50, or 60 (has line through it)
- The grade is the Yield strength  
40= 40,000 lbs per square inch.

Most common ASTM A615 (billet) Grade 60 ALS 2-10

**Concrete Paving:**

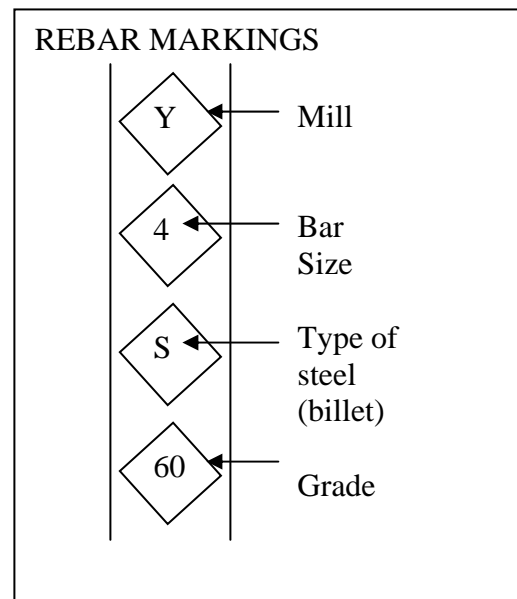
- Provide 5" thick
- Expansion joint every 20'

**Walks:**

- Control joints every 5'
- Expansion joint every 20'
- Provide 4" thick

**Asphalt:**

- Provide 2"-3" thick



**4 types of control joints: control, construction, expansion, and isolation. B15-9 (picture)**

**1. Control joints** in concrete -are tooled, sawed, or pre-molded joints to allow for shrinkage of large concrete areas. Control joints create a weakened section that induces cracking to occur along the joint, rather than in a random fashion. Identify

**2. Construction:** occur wherever two successive pours occur. Plane of weakness, should be located at points of minimum shear. These joints are also where water leakage can occur. Can be keyed or w/ a waterstop. Water-tight control joint uses a waterstop. (picture- identify)

**3. Expansion joints:** Often sized to resemble a mortar joint, usually 3/8" to 1/2". The max size of the expansion joint may depend on the sealant capabilities.

**4. Isolation:** allow two adjacent sections to move independently of one another, not as complex as expansion joints. Usually just separated with pre-molded joint material.

**Types of cement: ALS 2-5**

PORTLAND CEMENT	TYPE OF CONCRETE	PRIMARY USE - STRUCTURAL ELEMENTS
Type I	Standard	For general all-purpose use
Type II	Modified	For slow setting and less heat
Type III	High early strength	For quick setting and early strength - <b>cold climate</b> . In pre-casting of concrete. Construction schedule is accelerated.
Type IV	Low Heat	For very slow setting (little heat) - massive structures
Type V	Sulfate Resisting	For alkaline water and soils - contact w/ H2O

**What type of Portland cement would be used in slip form concrete construction?** Type III

Note: Concrete should be laid between 50-70 degrees.

**Concrete lift-slab construction:** the slabs are pre-stressed by post-tensioning in both directions & minimizes the need for concrete formwork.

**Admixtures:**

**Air entraining agents:** Resists freezing action. Add tiny bubbles to increase workability and durability and improve its resistance to freezing and thawing cycles. Helps reduce segregation. Used for pavings and exposed arch. Used in cold climates. Freeze-thaw

**Accelerators:** speed up the process of hydration to receive strength faster. Used in cold weather

Type: Admixture-Calcium Chloride

**Plasticizers:** reduce amount of water needed while maintaining consistency of correct placement and compaction.

**Retarders:** slow down the setting time to reduce the heat of hydration.

**Water proofing agents:** decrease permeability.

**Insulating Light weight concrete:** used for thermal insulation in roof construction. Weighs 15-90 lb cf and low in compressive strength.

**Structural Light weight concrete:** weigh 90 to 115 lb cf. Uses expanded shale or clay. Max size of coarse aggregate is 3/4 ", air entrainment is always used, handling and placing are easier, the modulus of elasticity is lower, shrinkage is greater, thermal insulation is better, cost is greater. Concrete weighs 150 lbs per cubic foot.

Laitance: from excess water. A chalky surface deposit of low strength. Must be removed before any new concrete is poured in order for the new concrete to bond to the old.

**\*Concrete mixture strength determining factor:** P15-7 Concrete hardens and gains strength by curing through chemical reaction. Depends on moisture & temp. Concrete gains 70% of its strength during the first week of curing. Cylinder test measures compressive strength along w/ impact hammer and Kelly ball test. **Water controls strength. Add Lime for workability.**

**The order of removing form work:**

- (1) wall and beam sides (after about 1 day; since they support no load).
- (2) columns (after about 4 days; these forms also support no load; the weight of the concrete is supported in direct compression).
- (3) supported slabs (after about 7 days; slab forms support the weight of the slab and should not be removed until the concrete has acquired sufficient strength to support its own weight).
- (4) beams (after about 14 days; more critical because beams are primary framing members).

**Tests:**

Slump: measures consistency & workability acceptable slump = 2"-6" Starts at 12" cone.  
 Cylinder test: measures compressive strength tested at 7 & 28 days in crushing machine

**What would be most appropriate for water repellent coating for a pre-cast concrete wall with a moderately rough integral color surface such as a heavy sand blast texture? Siloxane or silane penetration sealer.**

**PreCast spans: BCI: 4.35**

Type of concrete unit	Thickness in depth	Span range
Solid flat slab	4"	12'-16'
	6"	14'-24'
	8"	18'-30'
Hollow Core Slab	6"	14'-22'
	8"	20'-32'
	10"	24'-40'
	12"	30'-44'
	12"	28'-40'
Double Tee	18"	36'-50'
	24"	45'-70'
	32"	54'-80'
	36"	62'-90'
	48"	80'-110'
	Beams	20"
28"		22'-40'
36"		26'-50'
44"		30'-56'
52"		34'-70'
60"		42'-80'

## **Masonry:**

Standard brick dimensions: **Modular** (3 5/8" x 7 5/8") and **Utility** (3 5/8" x 11 5/8") w/ 3/8" joint 2 1/4" high

**Composite wall:** identify A masonry wall having at least one wythe dissimilar to the other wythe or wythes with respect to type or grade of masonry unit or mortar. VdoA 156

**Categories:** graded according to resistance to exposure and the ability to resist freeze-thaw cycle

**SW** - severe weathering

**MW** - moderate weathering

**NW**- negligible weathering

**Facing brick** available in SW and MW and further classified into:

1. **FBX**- high degree of mechanical perfection, minimal color range and minimal size difference is desired
2. **FBS** - wide range of color and size is acceptable
3. **FBA**- non uniform in color size and texture

**Hollow brick:** SW & MW and HBS, HBX, HBA - same category def as facing brick.

**Masonry over steel framing, what is most likely the reason for deterioration of a wall system?** Infiltration of water if the bricks are not laid right. The water can rust out the screws which are the key to keeping the system together. Or failure of the ties.

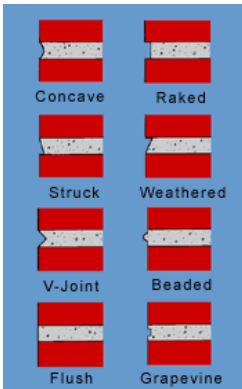
**When are ties not required in a Masonry wall?** In Load bearing walls.

**Min & max space in cavity wall:** 2"- 3" of airspace. Rigid foam insulation applied to the inside wythe, occupies 1/2 of space. ALS 3-7.

Gypsum block is used for interior non-load bearing partitions & because of its chemical properties for light-weight fireproofing protection. As far as fireproofing goes a 2" of gypsum block = 4" of concrete block.

**Which Architect used Terra cotta tiles?** Sullivan

**Identify Mortar joints:** match up right properties to name of mortar



**Types of mortar:**  
 M } exposed to weather (less lime)  
 S }  
 N } less compressive strength required  
 O } (more lime)

Recommended for exterior use: Concave, Flush, and vee

During construction of a masonry wall, the construction supervisor notices that a few joints lack sufficient mortar. He advises the masonry foreman to repair these joints by adding fresh mortar where necessary while the surrounding mortar is still green. This process is called: Pointing

Location	Building Component	Mortar Type
Exterior, above grade	Load-bearing wall	
	Non-load-bearing wall	
	Parapet wall	
Exterior, at or below grade	Foundation walls, retaining walls, pavements, walks, manholes	
Interior	Load-bearing walls	N
	Non-load-bearing walls	O

\* Only when masonry is unlikely to be frozen when wet or exposed to high winds

**M**= high strength mortar for masonry walls **below grade**, and walls subject to high lateral or compressive loads or to severe frost action.

**S**= A medium-high-strength mortar for walls where bond and flexural strength are more important than high compressive strength.

**N**= A medium-strength mortar for general use **above grade**

**O**= A low-strength for interior nonbearing partitions.

Identify type of mortar used in repointing a historical building.

**Many questions on mortar (low temp install question):** Heat water and providing temperature enclosures. ALS 3-16. Admixtures not recommended where high bond strength is desired.

**Jointing:** Original tooling of a mortar joint, and its purpose is to compress and smooth the mortar surface, thus inhibiting dirt and water from lodging in the joint.

**Tuck pointing:** refers to repairs made to old work. (also called repointing)

**Parging:** process of applying mortar to the back surface of a masonry retaining wall in order to improve its water resistance. Below grade with 2 coats of type M mortar to a thickness of  $\frac{1}{2}$ " to seal cracks and pores. FOBC 361

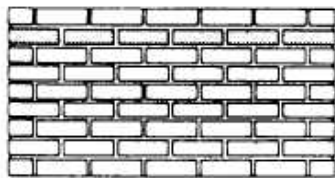
**Corbels and Racking** A corbel is defined as a shelf or ledge formed by projecting successive courses of masonry *out* from the face of the wall. Racking is defined as masonry in which successive courses are stepped *back* from the face of the wall. (given pic, identify it)

**Belt Course:** A sill course. A horizontal board across or around a building, usually a flat wood member with a molding. Identify

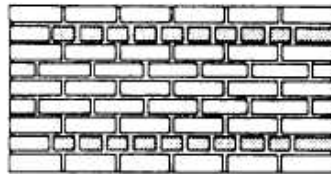
**Which soft stone decolorize over time?** limestone. (verify) If washed with mutric acid.

**Identify brick courses and bond patterns:** the method of laying several courses of brick  
The method of laying several courses in a wall is called bonding pattern:

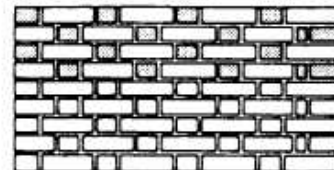
Different patterns are:



RUNNING



COMMON OR AMERICAN



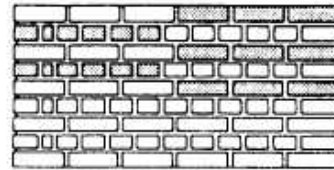
FLEMISH



ENGLISH



STACK



ENGLISH CROSS OR DUTCH

Stretchers align

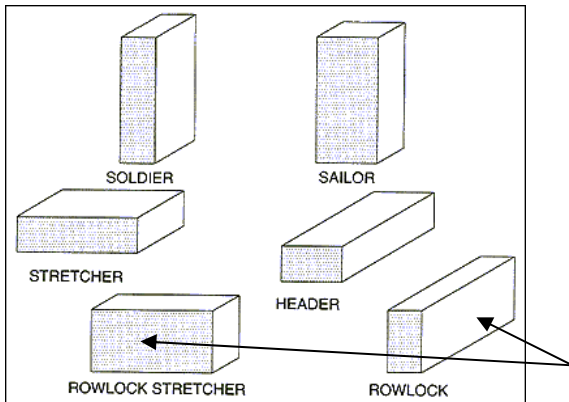
Stretchers do not align

**Cross Bond:** has stretchers on one row, headers on the another row. (not shown)

**Course:** one continuous horizontal layer of masonry.

**Wythe:** a continuous vertical section of a wall one masonry unit in thickness.

**Brick Courses:**



Also called Bull header and Bull Stretcher

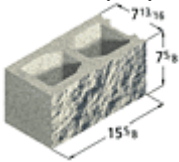
- Brick should be laid when temps are between 40-90 degrees

- Bricks should be wetted prior to setting in order to min absorption of water from the mortar. Loss of water will cause mortar to set too soon & bond between brick & mortar will be weak.
- Wetting will also wash dust from the brick surface absorption rate shall not exceed 7 ounces of water per min.

Wall type	Fire Resistance (hrs)	STC
4" brick	1	45
8" brick	4	52
10" brick	4	59
4" concrete block	$\frac{1}{2}$ to 1	44
8" concrete block	1 to 2	55

} Painted or plastered

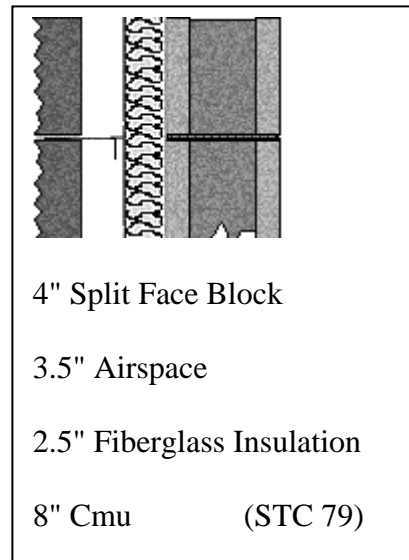
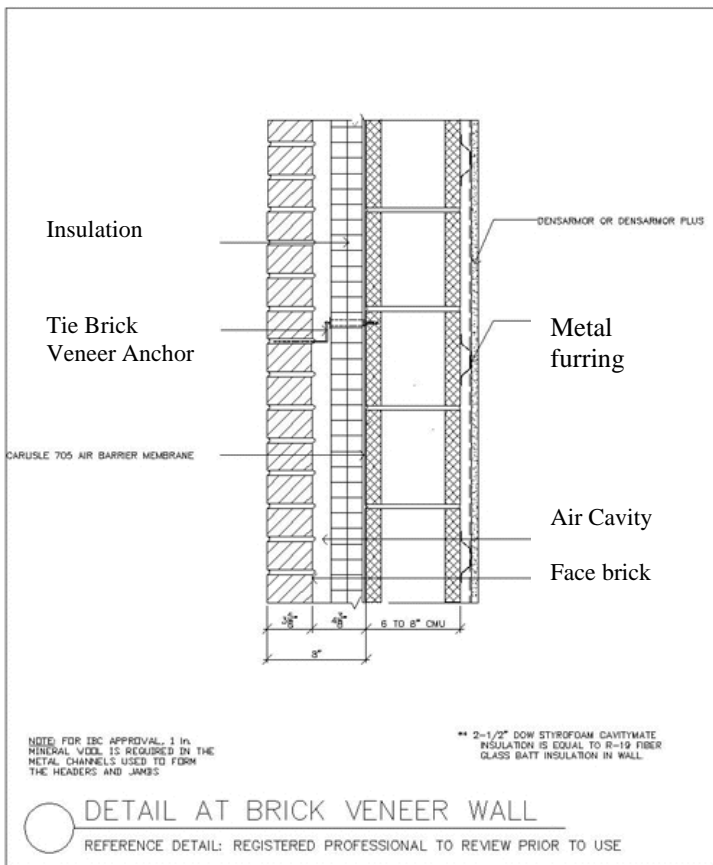
**Identify split face CMU (in detail)**



Split-face concrete blocks or concrete masonry units (CMUs) are a special class of decorative or architectural block that has a rough, stone-like texture created by splitting a block during production. This look is reminiscent of the rock-faced masonry in Richardsonian Romanesque houses popular in the mid-1880s, the continued use of fieldstone for exterior foundations, and the brief revival of medieval stone houses after the First World War. Plus, split-faced CMUs require less work than other decorative finishes, which may involve applying a ceramic-type glaze, polishing the exposed surface aggregate, machining raised patterns, fluting, scoring, or ribs. Like other architectural CMUs, split-faced block does not require any further application of a decorative finish on the exterior surface, such as paint or stucco. However, the current use of split-face block is almost entirely confined to commercial and institutional buildings and not yet widespread in residential buildings.

**CMU back up wall detail**

**Split Face CMU detail**



Efflorescence - a white, crystalline deposit of water-soluble salts on the surface of brick masonry. Caused when water seeps into the masonry and dissolves soluble salts present in the masonry, backup wall, mortar, or anything in contact with the wall. The dissolved salts are brought to the surface of the brick and appear when the water evaporates. This can be minimized by using materials w/ little or no soluble salts, by forming tight joints, and by detailing the wall to avoid water penetrations. It can be removed by dry brushing, light sandblasting, washing w/ high pressure wash, or by washing w/ a 5% solution of muriatic acid. B 16-9

**Calc. cost of a brick wall with certain SF.:**

Random course ashler - cut, squared off bldg stone unit of various sizes. Use chrome nickel stainless steel ties. AGS 248 Rubble stone: Irregular stone w/ at least 1 good face used for ashlar veneers, copings, sills, curb etc. ALS 3-13.

Ashler masonry: stones are shaped & smoothed (dressed) into rectangular blocks. ALS 3-13

**At the conclusion of a workday, an exterior masonry wall remains unfinished. Since the weather report calls for heavy rain that evening, you should advise the contractor to: Cover the exposed top of the wall w/ a plastic cover extending two feet down both sides of the wall.**

**When the outside temp drops below 40 degrees, no further masonry work should be performed unless precautions are taken against freezing.**

**Bond beam:** Horizontal reinforcement consists of either thin welded grids laid in bed joints or reinforcing bars placed in blocks with channeled webs. ALS 3-10

**Metals:**

**What material are manhole covers made from?** cast iron

Zinc coating that protects members: ASTM A924

Light gauge members: ASTM A563

Terne Plate: Most common type of steel for structural use A36. B 17-7, 9 Alloy of 75% lead and 25% tin is used to plate steel for roofing.

Light gage joists and rafters span 40' B17-12 Most use K series, 2' deep, 40' span.

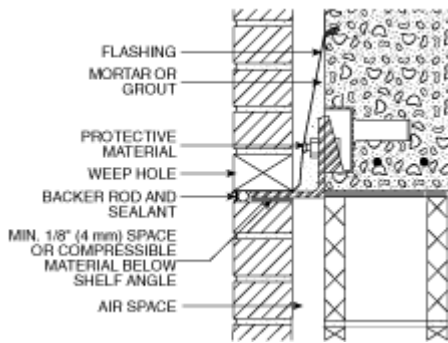
**Open Web Steel Joists: FOBC 377**

Series	Type (up to)	Depth
K series	60'	8" to 30"
LH Series (long span)	96'	18" to 48"
DLH Series (deep long span)	144'	52" to 72"

**Galvanizing:** protecting iron and steel against corrosion. A coating of zinc is applied.

**Galvanic action series:** which metals should not be together: Metals far apart on the list should not be placed in contact w/ ea other.

1. Aluminum
2. Zinc
3. Iron and Steel
4. Stainless Steel
5. Tin
6. Lead
7. Brass
8. Copper
9. Bronze
10. Gold



**Shelf Angle:** are used to support brick masonry, transfer the weight of brickwork to the structural frame and create **horizontal expansion joints**. Flashing should be installed over all shelf angles, extended beyond the edge of the angle when possible. Flashing may be self adhered to the shelf angle or have sealant at the edge to prevent wind driven rain from penetrating underneath the flashing. The flashing material should extend back to the inside wythe and turn up a minimum of 8 in. (200 mm). **All shelf angles should have a horizontal expansion joint underneath.**

Know what shelf angle etc. is and how it works and why joints are required with a compressive sealant. AGS- 215 - Brick Industry Association A compressive sealant is used to address the different expansion values of the materials.

**Steel beam with hinge and rod hooked to hinge. Purpose of the hinge?**

Shapes of structural members, which shapes go with which metals. ("I", round, square etc - some metals can be all shapes). B 17-9 Structural members are either steel or aluminum. FOBC 376

Steel: beams, columns & plates

Light gage framing: steel studs, floor and roof decking, prefabricated truss joists and fasteners.

**Types of structural steel shapes**

Wide flange: H-shaped sections for both beams & columns

American Standard I beam

Structural tee

American standard channel

Angle, unequal legs

Angle, equal legs

Tube and square

Bars & plates

**Wide flange** = W18x85. 18 is nominal depth in inches. Weighing 85 lbs per linear foot.

**Steel angle**= length of the angles, followed by thickness of legs. Used in pairs for members for steel trusses or singly as lintels used for bracing.

**Brass & Bronze shapes**

Square tubing, round tubing, angles, channels, bar and rods.

**LH, K series (open web steel joist) ALS 5-12**

Open web steel joist: standardized, shop-fabricated trusses w/ webs composed of linear members and chords of back to back steel angles.

**Designation:** depth, series designation, particular type of chord used. Example: 36LH13 = joist= 36" deep, LH series, number 13 chord type B17-11

**Hot rolled:** eliminates flaws in the metal: wide-flange beams & channel sections.

**Cold rolled:** thin steel shapes that increase strength and decrease ductility. All metals except iron.

**Which type of steel isn't used in construction? pig**

**Pig iron, rail steel, axle steel & billet steel, what are they used for and what are they NOT!!! used for?** When iron ore is initially smelted, pig iron is the crudely refined product. Steel has no more than 2% carbon in it. Pig iron has around 4% or more, depending on the ore source. Axle, billet, and rail are types of steel used for rebar. Pig iron is not used for rebar.

**What makes steel more weldable?**

**Which material is more brittle but strong?**

**Wrought iron:** ALS 5-6 Almost pure iron w/ low carbon content, soft but strong, extremely ductile, easily worked, & resistant to corrosion. Can be forged, bent, rolled. CAN NOT be cast, tempered, or easily welded.

**Monel Metal** (trade name): copper and nickel. Highly resistant to corrosion and easily worked. Used for roofing. B17-9

**Terne Metal:** 80% lead and 20% tin

**Identify extrusions vs. hammered:** Wrought Iron - iron that has been purified by beating it repeatedly with a hammer. FOBC 368

**Metal extrusion:** B 17-3 The process of producing metal shapes of a constant cross section by forcing the hot metal through an orifice in a die by means of a pressure ram.

**Annealing:** a process in which the metal is reheated and slowly cooled to obtain a more ductile metal, which will improve its machinability and cold-forming characteristics. B17-3

**Some metals cannot be rolled and some cannot be formed, some are best extruded etc.**

<b>Metal</b>	<b>Method Formed</b>
Steel	
Wrought Iron	hammering
Cast iron 2% carbon	Can NOT be hammered, rolled, or drawn
Grey cast iron	
Aluminum	Welded, brazed, soldered, formed, drawn, stamped, casting, or spun. Most often <b>extruded</b> .
Copper	Spinning, casting, rolling, bending, brake forming, extrusion.
Zinc	Die casting

Brass	Extruded or cast
-------	------------------

**Castellated beam:** A steel beam that can be altered for a longer span without increasing its weight. Allows for a deeper beam with little effect on weight. The steel section is flame cut along a zigzag and then the two elements are welded back together in a way which creates a deeper section, thus increasing spanning potential. **What is its function?**

**Which types of metal make up stainless steel?** Is a steel alloy containing a minimum of 11% chromium. Nickel is often added to increase the corrosion resistance and improve cold workability. Additional trace elements such as manganese, molybdenum, and aluminum are added to impart certain characteristics. Is highly corrosion resistance because of the formation of chromium oxide film on the surface. Ballast 17-6

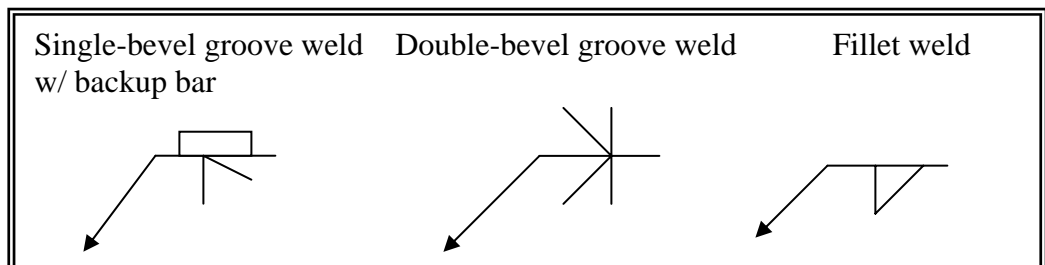
**% of carbon in structural steel** From 0.20% to 0.50% B17-6

Metal	Qualities	Uses in construction
Steel	High strength, low corrosion,	Metal decking, columns, beams, concrete reinforcement, fasteners, curtain walls panels, interior finish panels, trim, pipes, flashing, electrical conduit
Wrought Iron	Soft, corrosion resistant, machinable	Ornamental iron work such as gates, grilles, and fences
Cast iron 2% carbon	Corrosion resistant	Columns and beams
Grey cast iron	Brittle,	Plumbing valves, pipes, hardware, manhole covers, and fireplugs
Aluminum	Corrosion resistance, good forming,	Structure, wall panels, curtain walls, window and door frames, metal decking
Copper	Low strength, good conductance, corrosion resistant, easy forming	Electrical wiring, hardware, curtain walls, piping, gutters, roofing, window & door frames, wall panels, railings
Zinc	Brittle, low strength, corrosion-resistant	Sheet roofing & flashing, fasteners, nails, plumbing hardware, structural parts
Lead	Corrosion resistant, easily worked	Cover complex roofing shapes, acoustical insulation, vibration control, radiation shielding
Brass	Workability, poor machinability, ductile	Door window frames, railings, trim, hardware, and plumbing fixtures.

Low carbon - soft, ductile, resistant to corrosion

Increase carbon - increases strength & hardness, reduces ductility & weldability

**Welding symbols:**



### Weights of metals for bldgs

Material	Density	Material	Density
Magnesium	110	Steel	490
Aluminum	173	Brass	529
Zinc	446	Copper and bronze	556
Cast Iron	450	Lead	708
Wrought Iron	480		

### Structural and Rough Carpentry:

**Determine cost of lumber based on board foot price:** Board foot = 1" x12" x1' in length  
If given a 2" x 10" , that is 12" oc, how much would it cost?

**Platform framing:** (western) the studs are one story in height and the floor joists bear on the top plates of the wall below. Sub floor extends to outer edge of wall frame and serves as a work platform. Bldg Construction Illustrated 5.4,5

**Balloon framing:** the wall studs are continuous for the full height of the bldg, usually 2 stories, from the foundation to the top plates under the roof rafters. Not used too much because of fire protection issues. The first floor joists bear on a foundation wall plate while second floor joists lap the studs and rest on a continuous ribbon let into the studs. ALS 4-18 question shows a foundation/wood frame detail, 1 story, asking what type it is.

**Modulus of Elasticity** of different woods AGS- 352 (in millions of psi) Ponderosa Pine = 1,150,000 psi; Ponderosa Pine Face = 1,200,000 psi; Inland Red Cedar Face = 1,250,000 psi.; Douglas Fir= 1,800,000 psi In machines stress ratings, lumber is subjected to bending, and the values of modulus of elasticity and allowable fiber stress are computed and automatically stamped on ea piece. ALS 4-8 Chart in FOBC

**Structural wood panels:** specified by span rating. 32/16 would be used as roof sheathing over rafters spaced 32" apart or as subflooring over joists spaced 16" apart.

**Framing anchors:** used to strengthen wood joints, at relatively low cost, while eliminating the need for toenailing. May be used to attach joists to a beam, but strictly speaking, they are not joist hangers. ALS 4-18

FOBC p108 has pictures of anchors and hangers. Identify.

**Seasoning:** moisture content is 19% for framing lumber.

## Finish Carpentry and Arch woodwork:

**How wood flooring is attached at end of wall.** Wood floors are attached by blind nailing. The last piece is nailed in by face nailing, but room is left for expansion and covered by the base board.

### **Nailing techniques:**

**Blind nailing:** Nailing in such a way that the nailheads are not visible on the face of the work.

**Toe nailing:** Nailing obliquely to the surfaces being joined; alternate nails may be driven at opposite angles to provide increased holding power.

**Face Nailing:** Strongest - hooks 2 pieces of wood perpendicular to grain

### **Identify various nail types (common, finish, cut & roof)**

**Common:** used for most structural connections. A cut or wire low-carbon steel nail, having a slender plain shank and a medium diamond point; used in work where finish is unimportant, as in framing

**Box:** thinner than common & have less holding power, has a long shank which may be smooth or barbed.

**Finish:** thin nails w/ small heads used to attach finish wood elements.

**Casing:** a slender nail w/ a small, slightly flared head used for finishing work.

**Spike:** larger than 60d

### **Nails and uses AGS 318 (chart w/ pics and descriptions)**

<b>Rough Construction</b>	<b>Roofing</b>	<b>Finish Work</b>	<b>Miscellaneous</b>
Common	Siding & Shingle	Wallboard	Cement
Annular	Roofing (barbered)	Fine Nail	Offset (lath)
Helical	Roofing	Lath	Hooked (lath)
Common Cut Strike	Nonleaking Roofing	Casing or Brad	Staple
Double-Headed	Shingle Nail	Finishing	
Square	Cut slating (nonferrous)		
Round Wire	Gutter Spike (round)		
	Gutter Spike (annular)		

### **Veneer Finishes**

**Book matching:** most common - every other piece is turned over so that the adjacent leaves form a symmetrical grain patten.

**Slip matching:** consecutive pieces are placed side by side w/ the same face sides being exposed.

**Random:** no particular sequence and can be from different flitches. ALS 4-12

**Running match:** alternates bookmatched veneer pieces regardless of their width or how many must be used to complete a panel.

**Balance match:** utilizes veneer pieces trimmed to equal widths in ea panel

**Center Match:** has an even number of veneer leaves of uniform width so that there is a veneer joint in the center of the panel.

**Wood joints (dovetails) Spline joint:** ALS 4-19 AGS 380 Identify finger joint.

**Plywood characteristics and grades:** Know the stamps

AGS 355 Grade designations: Structural panel grades are generally identified in terms of the veneer grade used on the face and back of the panel. (e.g., A-B, B-C, etc?) or rated by a name suggesting the panel's intended use (e.g. APA-rate Sheathing, ApA- rated Sturd-I-Floor, etc)

**N** = Smooth surface: Natural finish

**A** = Smooth, paintable.

**B** = Solid Surface. Shims

**C** = Plugged - Improved C-grade veneer w/ splits limited to 1/8"

**C** = Tight knots to 1 1/2 "

**D** = Knots and knotholes to 2 1/2" width

Plywood is a manufactured wood panel consisting of several thin wood veneer sheets that are permanently bonded together w/ adhesive under high pressure, w/ the grain of ea ply perpendicular to the grain of the adjacent plies. Produced by rotary cutting - quarter & plain being better. 4'x8' - 5/16" to 1 1/8" thick.

**APA:** American Plywood Association.

**Softwoods: Grading**

A = best

D = poorest

For exterior, inner pieces must be C or better. Interior may have D grade.

**Species: by group number:**

1 = the strongest & stiffest

5 = the weakest

**Unsanded panels for structural purposes:** Not marked w/ grade & species but span rating w 2 numbers. 1<sup>st</sup> number is the max recommended for roof span in inches and 2<sup>nd</sup> being the max recommended span for subflooring.

**A cabinet which is required to have only 1 good finish side would be labeled? A-B (verify)**

**Moisture Protection and Thermal Insulation:**

Insulation values of wood, glass, concrete, masonry (and their conductive properties) Conductive values of the above. Insulation values of materials (ceiling, plaster, etc)

**Which wall type is better insulated? R= 1/C**

Higher the R, the lower the C = better

Material	type	R value (resistance)	C value (conductance)	Better insulator
Concrete:	req/ lt wt	.11 / .59		Light weight
Masonry:	Mortar	.2		
	Brick Common	.2		
	8" CMU reg wt/ lt wt	1.11/2		8" CMU reg wt
	Stone	.8		
Metals:	Aluminum	.0007		
	Steel	.0032		
	Copper	.0004		

Wood:	Plywood	1.25		Plywood or softwood
	Hardwood	.91		
	Softwood	1.25		
Glass:	Single-glazed clear	.9		
	SG Low E, Clear	1.4		
	Double glazed, clear	2		
	DB Low E Clear	3.12		
	DB Poly Film Clear	4.5		DB Poly Film Clear
Insulations:	Min. wool batt	+3.2		
	Fill	3.7		
	Perlite	2.78		
	Board Polystyrene	4		
	Board fiber	2.94		
	Board glass fiber	4.17		Board glass fiber
	Board urethane	8.5		
Air:	Between nonrefl.	1.34		
	One side refl	4.64		One side reflector
	Inside film	.77		
	Outside: winter	.17		
	Outside: summer	.25		
Plaster		.2		
Gypsum		.6		
Resilient flooring		.05		
Carpet w/ pad		2.08		

**Certain insulation materials were better than others under ground or for certain applications** and also what materials were not supposed to be installed at certain temperatures. (rigid insulation - under ground)

**What materials are used to insulate basements?** Inside the wall: mineral batt or plastic foam inside furring stripes. Outside: polystyrene foam or glass fiber. FOBC p 64

**Different types of insulation (what is each best suited for?)** ALS 6-13 (chart)

**Loose Insulation:** (also called fill insulation) rock wool, perlite, and vermiculite are all non combustible and have good thermal resistance. Used to fill cells of CMU and other hard to reach places. Used in retrofit applications. Polystyrene used as fill.

Rock wool: fibrous material formed by blowing molten rock under pressure

Perlite: volcanic rock expanded by heating

Vermiculite: mica expanded by heating.

Cellulose: shredded wastepaper or wood fibers. Chemicals added to make fire resistant and inhibit growth of fungus and repel rodents.

**Batt Insulation:** consists of fibrous material placed on or within a kraft paper carrier. Mineral fiber or glass fiber.

**Rigid Insulation:** Boards and sprayed on. Organic board insulation is made from wood or cane fiber. Rigid boards can be made w/ perlite or cork. Organic boards has given way to inorganic plastics

have much higher insulating values. Fiberglass and perlite rigid board are available as wall or roof insulation. Inorganic boards are: polyurethane, polystyrene, or polyisocyanurate.

Water Proofing	Damp proofing (above grade)	Vapor Barrier	Rigid Insulation (under ground)	Loose Insulation	Batt Insulation
Asphalt felts	Silicone	Polyethylene film	Polystyrene	Rockwool	Mineral fiber
Butyle	Polyurethane		Polyurethane	Perlite	Glass fiber
Polyvinyl chloride			Polyisocyanurate	Vermiculite	
Betonite panels				Cellulose	
				Polystyrene	

Betonite panels: clay in kraft paper.

**Slabs on grade waterproofing and drainage:** The tops of slabs should be located at least 8" above the exterior finish grade. Vapor retarders should be placed under a slab so as to resist moisture from entering the bldg. Usually they are made of a **single layer polyethylene sheet** or multiple layer glass fiber reinforced paper w/ polyethylene film coating on both sides. Usually these membranes are 4-6 mils in thickness. There should also be a 2"-3" layer of sand placed over or under the vapor retarder.

**Parging:** consists of type M mortar or plaster applied to the exterior face of a below grade wall.

**Damp proofing:** a coating applied to resist moisture penetration resulting from capillary action. Usually the coating is bituminous materials or silicones. Silicone and polyurethane are used above ground.

**Waterproofing:** used where hydrostatic pressures may develop in the surrounding soil. Made of plastic, asphaltic, or synthetic rubber sheets; of asphaltic mastics or coatings; special cementitious plasters, or bentonite clay. A coat of Portland cement mortar, a layer of asphalt fiberboard or masonry units will protect the membrane. Bentonite clay panels swell when wetted and become impervious to the passage of water. Also flexible to adjust to movements in the wall it protects.

Know your \*thylene's, \*styrene's, \*amides', \*yrate's, \*rethane's. at what temperature, and how much they weigh. (insulation materials)

The order of their listed materials from least to most dense....

**Material Properties of common bldg insulation.**

Bldg Insulation	Density	R	Bldg Insulation	Density	R
Glass fiber (batts & blankets, rigid boards)	1.5-4.0 4.0-9.0	3.14 3.8-4.8	Rock or slab wool	1.5-2.5	2.9-3.7
Cellulose (loose blown)	2-3	2.8-3.7	Molded polystyrene (rigid)	.9-1.8	3.6-4.4

			boards)		
Extruded polystyrene (rigid boards)	1.6-3	4-6	Polyurethane (rigid boards)	1.7-4	5.8-6.2
Polyisocyanurate (rigid brd)	1.7-4	5.8-7.8	Vermiculite (loose fill)	4-10	2.4-3
Phenolic (foamed in place or rigid boards)	2.5-4	4.4-8.2	Perlite (loose fill)	5-8	2.63

General statements: **LEAST resistance:** Rock or slag wool, loose blown; batts and blankets; **MOST** rigid boards. **LEAST Density:** Rigid board, batts and blankets, **MOST:** loose fill. Vapor barriers are placed on the **WARM** side of the insulation to prevent water from reaching the dew point temp. Some vapor barriers are integral with the insulation; others, such as polyethylene films, are applied as separate sheets.

**Which Insulation holds its value longer when it is ?**

**Minimum size of flashing required on a roof to parapet flashing detail? AGS 441**

Base flashing should extend 8 to 12 in. above highest anticipated waterline. Metal counter flashing should lap base flashing by at least 4".

**Know how flashing works:** In masonry construction is necessary to collect moisture that enters the wall system and to channel it to the exterior through weep holes. 2 types: Exposed and embedded flashing (limited to drainage-type walls). Embedded flashing is typically used in drainage walls at the base, above all openings, at sills and shelf angles, and under copings.

**What metal should not be used for flashing?** Polyethylene should NOT be used as flashing unless it has been chemically stabilized so it will not deteriorate when exposed to sunlight. Asphalt-impregnated building paper (bldg felt) is NOT an acceptable flashing material. Made of sheet metal (copper, lead, stainless steel, galvanized steel, or aluminum), plastic, or composite materials (usually paper-backed, coated, metallic sheet, or fibrous glass mesh). When selecting flashing materials, be careful to avoid choosing a material that would have cathodic reactions with mortar, other metals, or other construction materials.

flashing details: AGS Flashing

**Cap flashing, cant strip** ALS 6-14, 15

Cap flashing: A strip of sheet metal, often built into masonry and turned down over other flashing; used to prevent water from entering the joints and the exposed upturned edges of base flashing on a roof.

Cant strip: A beveled strip of wood or other material used esp. under built-up roofing where the roofing turns up, providing a gradual transition; used to prevent the cracking of roofing applied over it. 45 degree max bend. Continuous triangular cant strips are placed in the intersection to provide positive drainage away from joint and to give smooth transition surface for the installation of the flashing at these points.

**Perm (moisture protection) Choose which wall type is better permeability.**

The permeance rating indicates the amount of moisture that can travel through a given surface area of a material over a certain time. The lower the permeance or perm rating, the better the material's resistance to water vapor transmission. AGS 405 (chart)

**What material has the lowest permeability:** kraft paper

**Reglets** (what metal?) Flashing is secured in reglets w/ lead wedges at max. 12" o.c., fill reglet w/ nonhardening water-resistant compound. AGS 438 A fillet or small flat-faced projection, as used in a fret molding or to cover a joint between two boards. Dic

thermal moisture of materials

**What kinds of materials are used for water proofing basements (outside)?** Water proofing: control of moisture and water that is subject to hydrostatic pressure. These may be built up layers of bituminous saturated felts, or singly-ply membranes of synthetic materials such as butyl, polyvinyl chloride, or other proprietary products. (outside basement walls would be Portland cement and a coat or two of a bituminous material, or rubberized asphalt, polymer modified asphalt, butyl rubber, polyurethane rubber, thermoplastic sheets (6 mil) minimum, polyvinyl chloride, elastomeric material, and bentonite clay panels that expand and block the water.) With these systems you need a drainage system to remove the water from building up.

Damp proofing: Control of moisture that is not under hydrostatic pressure. **Types:** Admixtures (added to concrete), Bituminous coatings (asphalt or coal-tar pitch), Cementitious coatings (Portland cement mortar), Plastics (silicone and polyurethane [usually used for above-grade dampproofing])

Bentonite panels: flat packages of bentonite clay inside kraft paper packages. They are placed under slabs and against walls. After backfilling, the kraft paper deteriorates and the clay expands in the presence of moisture to form a waterproof barrier. B20-2

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## **Roofing**

**Know what installation technique for metal roofs is best used to prevent "oil-canning"** Oil canning: the perceived waviness in the flat areas of roofing and siding panels. Part of a light gauge cold formed metal products, particularly those w/ broad flat areas. Prevention: ordering tension leveled and re-squared material; the addition of stiffening beads; selection of lower gloss coatings and lighter colors will minimize the visual effect; more stringent specs regarding the alignment of the supporting structure.

**How do you lie the plywood on a roofing project? Vertical or horizontal? Would the seams line up or are off set?**

**Identify the seam at the edge of a standing seam roof :** rake: A board or molding along the sloping edge of a gable. Covers the edges of siding. As far as the edge of the roof ... if it is a gable it's called a rake. A rib is a 'ridge' along the metal roof panels to make it stronger. Continuous cleats are often used at the eaves.

different seam types: ALS  
<http://threadgillsheetmetal.com/profiles.htm>

**Terne Plate:** steel coated w/ lead and tin. Metal roofing material.

Concrete roofing tile: is manufactured by extruding a mixture of Portland cement, sand, and water on individual molds under high pressure. Color comes from synthetic oxides.

**Which of the following would you use on a through-roof penetration...** gravel stop, scupper, reglet, or pitch pocket? Reglet: is the general term for a series of bends in layers of metal to form an interlocking seam, which is a major component of flashing. pitch pocket: "A container, usually formed of sheet metal, around supporting connections with roof-mounted machinery. Filling the container with pitch, or better yet, plastic roof cement, helps seal out water even when vibration is present." Scupper: An opening in a wall or parapet that allows water to drain from a roof. A device placed in such an opening to prevent clogging of the drain. Gravel Stop: A flange, usually of metal strip, used to prevent gravel or loose surfacing from washing off a roof; may also provide a finished edge for a built-up roofing.

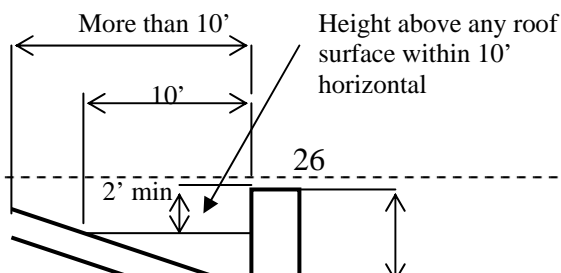
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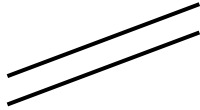
**How EPDM is used:** EPDM is Ethylene Propylene-diene monomer. It's used on flat roofs. AGS 426 Is elastomeric roofing is synthesized from ethylene, propylene, and a small amount of diene monomer. Manufactured sheets range in thickness from 30 to 60 mils. **Advantages:** exhibits a high degree of resistance to ozone, ultraviolet, extreme temp and other elements, and degradation from abrasion. It is resilient, strong, elastic, and less prone to cracking and tearing when compared to other forms of membrane roofing. **Disadvantages:** application methods, formulas and configurations for adhesives, fasteners, and coatings are unique w/ ea system manufactured. Materials, design, and appropriate use vary widely. Close supervision and regular inspection by manufacturer are required. Labor cost and time allotted for installation vary.

3 Generic Installation methods: Fully adhered, loose laid, and mechanically fastened. Loose laid puts weight over in form of gravel or pre-cast roof paver system.

**Area of Ventilation under a sloped rafter:** Provide 2" under rafter for ventilation. Use blocking to prevent installation from covering area.

**Height of chimney above roof:** 2'-0" above top ridge up to 10 feet away from ridge horizontally.





Chimney 3'  
min Gas Vent  
or Type L  
vent 2' min

Height of flue above cap.

**Temperature in which to work on roof, concrete:** 100 degrees ambient air temp or 90 degrees ambient with wind of 8 mph.

**Procedure/advantages:**

**Metal roofs:** are installed over asphalt roofing felt laid on top of wood or nailable concrete decking

**Terne** or tin roofs require rosin-sized paper because reacts with asphalt

Min slope is 3 in 12.

**Built up roofs:** can be installed over nailable or non-nailable decks. **Nailable decks:** a base sheet of unsaturated felt is nailed to the deck and covered with a coating of roofing cement. **Non-nailable decks:** the base sheet is omitted and a base coat is applied. Then 3,4, or 5 layers of saturated roofing felts are laid on top of each other, each layer bedded in roofing cement. A final coating of bituminous material is placed over the entire roof and covered with gravel or crushed slag. Purpose of gravel is to protect the roofing from sunlight and other effects of weathering.

Weight of roofing material

**Doors, Windows and Glazing:**

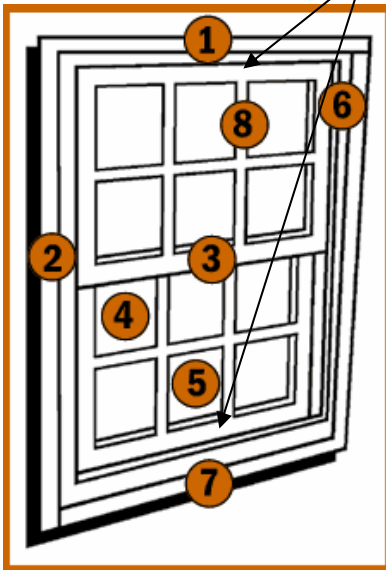
Proper and improper door alignments when looking at the clearances at the stricker jamb. B21-5

**STC rating for a door**

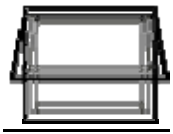
<b>Description Doors</b>	<b>STC</b>
Louvered door	15
1 1/2" hollow core	17
1 3/4" solid wood door	30
2 solid core doors w/ sound lock	45
Lead lining and full sealing	45-65

**Parts of a window:**

Rail



1. **Head**  
The main horizontal member forming the top of the window or door frame.
2. **Jamb**  
The main vertical members forming the sides of a window or door frame.
3. **Frame**  
The enclosure in which window sash or door panels are mounted.
4. **Glazing**  
Glass in a window or door; the act or process of fitting with glass.
5. **Pane**  
A framed sheet of glass within a window.
6. **Sash**  
A single assembly of stiles and rails made into a frame for holding glass
7. **Sill**  
The main horizontal member forming the bottom of the frame of a window or door.
8. **Muntin Bar**  
Any small bar that divides a windows glass. Also called a grille or windowpane divider.
9. **Mullion (not shown)** The wood inbetween two windows (if another window was on the right.)
10. **Top rail and bottom rail**



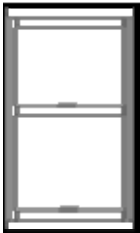
**Awning**

Awning windows are hinged at the top and open outward. Hinged windows such as awnings generally have lower air leakage rates than sliding windows from the same manufacturer because the sash closes by pressing against the frame. Screens are placed on the interior of the window unit.



**Casement**

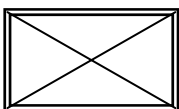
Casement windows are hinged at the sides. Hinged windows such as casements generally have lower air leakage rates than sliding windows from the same manufacturer because the sash closes by pressing against the frame. Casement windows project outward, providing significantly better ventilation than sliders of equal size. Because the sash protrudes from the plane of the wall, it can be controlled to catch passing breezes, but screens must be placed on the interior side.



**Single-Hung/Double Hung**

In double-hung units, both sashes slide vertically. Only the bottom sash slides upward in a single-hung window. Ventilation area can vary from a small crack to an opening of one-half the total glass area. Screens can be placed on the exterior or interior of the window unit.

**Pivot window:** Remember, the arrow points to the hinges



## What glass item does not need to be made of safety glass? jouliesie windows

**Aluminum replacement windows** were introduced into the marketplace prior to vinyl replacement windows. They were really the first material that replacement windows were made of. Though ideal for customized replacement window design, aluminum replacement window frames cause conductive heat loss (i.e., they have low R-values) and produce some amounts of condensation around the window frames. However, thermal breaks made of insulating plastic strips placed between the inside and outside of the frame and sash greatly improve the thermal resistance of aluminum replacement window frames. Aluminum windows can be painted, unlike their vinyl window counterparts. However, the paint job will not be as good as one from a window frame made from wood.

**Rule of thumb for daylighting penetration:** 1.5 times the height of a standard window

Inverted V louvers: (given picture and say what is used for)

Compression Zipper: (given picture):

### *Layers of Glass and Air Spaces*

**Single-pane.** This has very little insulating value with (approximately  $r-1$ ). It provides only a thin barrier to the outside and can account for considerable heat loss and gain.

**Double-pane.** To improve a window's energy efficiency the number of glass panes in the unit is doubled, because multiple layers of glass increase the window's ability to resist heat flow.

### *Types of Glass B21-19 Glass type-Heat treated glass*

There are various types of glass manufacturers use in constructing windows.

**Clear glass** has been the primary material available for window panes in homes. However, in recent years, the market for glazing--or cutting and fitting window panes into frames--has changed significantly. Now several types of special glazing's are available that can help control heat loss and condensation.

**Low\_ emissivity (low-e) glass.** This has a special surface coating to reduce heat transfer back through the window. These coatings reflect from 40% to 70% of the heat that is normally transmitted through clear glass, while allowing the full amount of light to pass through.

**Heat-absorbing glass.** This contains special tints that allow it to absorb as much as 45% of the incoming solar energy, reducing heat gain. Some of the absorbed heat, however, passes through the window by conduction and re-radiation.

**Reflective glass.** This has been coated with a reflective film and is useful in controlling solar heat gain during the summer. It also reduces the passage of light all year long, and, like heat-absorbing glass, it reduces solar transmittance.

**Float glass:** also called **annealed glass.** Mostly made in US. Made by pouring molten glass on a bed of molten tin and allowing it to slowly cool, forming a smooth, flat surface.

**Heat-strengthened glass:** heating glass to 1100 degrees and slowly cooling. Has twice strength of annealed glass of same thickness. Used where the surface is subject to solar-induced thermal stresses and cyclic wind loading.

**Tempered glass:** subjecting annealed glass to a special heat treatment in which it is heated to 1150 degrees and quickly cooled. The process sets up compressive stresses on the outer surfaces and tensile stresses inside the glass. 4x's stronger than annealed glass. Considered safety glass.

**Laminated glass:** 2 or more pieces bonded together by a resin. Can be bullet resistant. Used where sound control is required.

**Wire glass:** has mesh of wire embedded in the middle of the sheet. Used in fire-rated assemblies where it is required by bldg codes. 50% stronger than annealed. Can not be tempered and does not qualify as safety glazing.

**Spandrel glass:** Used as the opaque strip of glass that conceals the floor and ceiling structure in curtain wall construction. Made by fusing a ceramic frit color to back of heat-strengthened or tempered glass.

- If a window's resistance to heat flow, or R-value, is high, it will lose less heat than one with a lower R-value.
- In a typical house, over 40% of the annual energy budget is consumed by heating and cooling

**Air between window panes of curtain wall:** dry-air

**Latchsets and locksets:** B21-10

**Latchset:** only holds the door closed. It has a beveled latch extending from the face of the door edge and automatically engages the strike mounted in the frame when the door is closed.

**Mortise:** installed in a rectangular area cut out of the door. More secure than bored lock. Allows the use of a dead bolt and a latch bolt.

**Bored:** also called cylindrical: installed by boring holes through the face of the door and from the edge of the door to the other bored opening. Less expensive. Used in residential and small commercial projects.

**Pre-assembled:** Also called unit. Come as complete unit. They are slid into a notch made in the edge of the door. Found in older bldgs.

**Interconnected:** have cylindrical lock and dead bolt. Two locks are interconnected so that a single action of turning a knob or lever handle on the inside releases both bolts.

**Types of Hinges:** B21-10

**Full mortise:** both leaves fully mortised into the frame and edge of door

**Half surface:** one leaf mounted on the face of the door and the other leaf mortised into the frame. (How it is on the door.)

**Half-mortise:** surface applied to the frame and mortised into the edge of the door.

**Full-surface:** applied to the face of both the door and frame.

**Off set pivot:** allow door to swing 180 degrees

**Center hung pivot:** allow door to swing in both direction and can be completely concealed, but only allow a 90 degree swing.

## **Finish Materials:**

**What is the cheapest way to install bathroom partitions?** Bathroom Partitions are not wall hung. Plastic partitions are the cheapest.

**Paint types, how they behave, what are they used for, etc.**

Latex: water based, w/ vinyl chloride or acrylic resins as binders. Indoor/outdoor

Epoxy: more durable. Used as binder for resistance to corrosion and chemicals. Resist abrasion and adhere to concrete, metal and wood. Considered high performance and requires skilled applicators.

Urethane: high performance. Used for resistance to abrasion, grease, alcohol, water and fuels.

Interior applications include clear coverings for wood floors. Exterior: clear or pigmented paint for anti-graffiti coatings. Polyurethane paint is used for its aesthetic qualities because of high-gloss finish.

**Gypsum board characteristics:** B22-2 Is made of gypsum plaster core sandwiched between sheets of paper or other materials. Lengths: 4' wide and 8,10,12, & 14 feet long. Thicknesses:  $\frac{1}{4}$ ",  $\frac{3}{8}$ ",  $\frac{1}{2}$ ", and 5'8". **\*\* There is a  $\frac{3}{4}$ " thick that carries a 2-hour fire rating. Commonly used:  $\frac{5}{8}$ ".  $\frac{1}{2}$ " for residential, commercial w/ furred walls. Edges: Tapered, square, and tongue-and-groove. Tapered being the most common. Types: X - fire rated; foil-backed - vapor barriers; water-resistant-behind tile.**

**Whether you want a low perm or high perm interior paint in hot/humid area.** High permeable to allow moisture to escape. If it didn't, moisture would get trapped and cause mold.

**Plaster:** made up of gypsum, lime, sand, vermiculite and water

Vermiculite: light weight, fire resistance

Keene's cement: a plaster high resistance to abrasion and H<sub>2</sub>O penetration. Used in wet areas or on walls subject to scratching or other abuse.

**What is fiber mesh used for?** ALS 8-4 Used to adhere plaster to wall system.

The fiber mesh is used primarily as part of an EIFS system. A fiber mesh is put on top of the Styrofoam then the EIFS concrete mix. Then paint it.

**EIFS** is a system of Styrofoam board applied to the exterior or interior walls. Similar to stucco. It has Styrofoam board, a mesh applied to that, then several coats of a stucco like product to create an exterior finish. It stands for Exterior insulation finish system. Used as a way to insulate from exterior of masonry walls. FOBC 347 Types:

- Polymer Based (PB): use expanded polystyrene insulation w/ the base coat applied directly to the insulation w/ an embedded fiber mesh.
- Polymer modified (PM): base coats are thicker and include higher % of Portland cement than does PB system. Control joints are needed in PM systems to limit cracking. Should be located from 10 to 12 feet. More resistant to impact. Higher thermal resistance. More resistant to water penetration.
- Mineral based (MB): uses Portland cement stucco in traditional manner.

**What's the "Brown Coat" refer to?** Portland cement plaster is used as brown coat under Keene's cement. First coat is called the **scratch coat**. In standard plastering, the scratch coat is followed by the **brown coat**, and then the final **finish coat**. Scratch and brown coats are 1/8" thick. 2-coat work combines the scratch and brown coats. Used w/ metal lath.

**Stucco:** Term reserved for exterior applications of plaster made w/ Portland cement, lime, sand and water. Used when a hard, non-water absorbent plaster is needed. Requires expansion joints at a min of 10' or where likely to crack, such as at the corners of door & window openings.

## **Vertical Transportation:**

**Elevators:** Must have reopening device that will stop and reopen the car and hoistway door if the door is obstructed. Tactile designations at ea jamb of hoistway doors should be 2" high, centered at 60" above the floor. Call buttons should be raised or flush, 35-48" above the floor. Audible hall signals should sound once for cars traveling in the up direction and twice for cars traveling down. AGS 666

**What type of glass is required for a window in an elevator?** Wired glass. Laminated if wire isn't a choice.

## **ADA:** B8-5

**Accessible bathroom dimensions:** 5' turning radius.

**Grab bars in toilet stalls:** (behind toilet: 36" bar, 6" from wall) (side of toilet: 12" max from wall, 42" long) Mounted 33" to 36" from floor. If stall is not used, grab bars must be on side and on wall behind toilet. If a toilet room is being built or substantially altered and the room has six or more toilet stalls, one stall must be a 36" wide "**ambulatory**" stall. People who walk with crutches, a cane, a walker or who have limited balance usually find it safer to use a stall that has parallel grab bars. A toilet room with six stalls should have one wheelchair accessible stall, one ambulatory and four regular stalls. See ADAAG 4.22.4.

**TP dispenser:** must be installed within reach of the center of the dispenser a min of 19" above the floor.

**Accessible door, exiting requirements:** see code notes 18" - 24" clear space on pull side of door.

**HC ramp max height between landings:** 30"

**Slope of flare side of a curb:** 1:10 max AGS 961 > 1:20 is considered a ramp and no handrails are required.

**Railings required where?** (ADA) Ramps w/ rises greater than 6" or lengths greater than 6'. They must extend 12" beyond the top and bottom of the ramp and have a diameter or width of gripping surface from 1  $\frac{1}{4}$ " to 1  $\frac{1}{2}$ ". Handrails are not required for ramps adjacent to seating in assembly areas.

**Railings for stairs:** must extend beyond the top and bottom of riser. Top of gripping surface must be between 34" and 38" above stair nosings. Must be clear space between the handrail and the wall of 1 ½". Note: When an exit stairway is part of an accessible route in an unsprinklered bldg, there must be a clear width of 48" between handrails.

<p><b>ADA</b> p8-3 Ballast          3' min corridor          5' min width corridor (2 wheelchairs)          32" door opening          T shaped= 36" x 36"          5' turning radius          4' min between 2 doors          4" extruding out if &gt; 27" high          Ramp: 1:12 w/ 36" width (30" max rise)                1:10 if max rise does not exceed 6"                1:8 if max rise does not exceed 3"</p>
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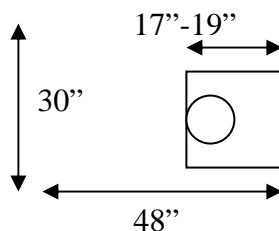
**Carpet for ADA requirements: 4.5.3\* Carpet.** If carpet or carpet tile is used on a ground or floor surface, then it shall be securely attached; have a firm cushion, pad, or backing, or no cushion or pad; and have a **level loop, textured loop, level cut pile, or level cut/uncut pile texture**. The maximum pile thickness shall be 1/2 in (13 mm) (see Fig. 8(f)). Exposed edges of carpet shall be fastened to floor surfaces and have trim along the entire length of the exposed edge. Carpet edge trim shall comply with 4.5.2. <http://www.access-board.gov/adaag/html/adaag.htm>

**Textured surfaces** on door handles are required if they lead to a dangerous area such as loading platforms, boiler rooms, and stages. B8-11

**Elevators:** min width of door = 3'6" (4' is better). Doors can be center opening or side opening, and single speed, or two speed. Single speed, center opening doors are common and allow faster passenger loading and unloading. Any car configuration that provides a 36" door and either a 60" diameter or T-shaped wheelchair turning space within the car, w/ the door in the closed position is permitted. AGS 964

**Elevator control panels:** 35" min and 48" max above floor. Buttons must be at least ¾". Buttons for floor designations should be located in ascending order. Visual characters, tactile, and Braille are required to identify buttons. And located to the left of ea button. AGS 963

**Drinking fountains:** Max height is **36"** to spout from floor. 27" min to bottom of fountain. 9" min to under pipes for feet room. Fountain can protrude out 17" -19". With a clear floor space of 48" from wall and 30" (width of fountain)



**Fire Protection:**  
**Building occupancies**

**Types of Occupancy:**

A: Assembly, B: Business, E: Educational, F: Factory and industrial, H: Hazardous, I: Institutional, M: Mercantile, R: Residential, S: Storage, U: Utility. Each of these are divided into divisions to distinguish subgroups that define the relative hazard of the occupancy.

**Fire stops in wood structure. Firestops-** barriers installed in concealed spaces of combustible construction to prevent spread of fire caused by drafts. Ex. 2" thick wood members, gypsum board or mineral wool. Building code specifies when and where firestops should be used. Generally used in concealed space between floors, attic space, under stairs and in vertical openings around vents, chimneys and between floors. This is an example of compartmentation.

**Flame -spread groups**

- I 0-25
- II 26-75
- III 76-200 (wood)

**For a door to be considered a "fire rated" door, it must have?** Exit doors must have self-closing devices, all hardware must be labeled or listed. Use steel hinges, ball bearing type. Glass must be wire or fiberglass and set in a steel frame w/ the glass stop made of steel. B21-15 Per NFPA 101 and 80, hinges must be steel and ball bearing type, pivot type meeting ANSI 156.1. Typically hinges are supplied with the door and frame as a listed assembly. There are restrictions on light size, typically 100 sq.in. for 1 1/2-hour rating, 1296 sq.in. for doors up to 3/4-hour rating. No glass for a 3-hour rating. Doors must be self closing (auto closer or spring hinge) and positive latching. Exit devices (panic bar) are typically required in means of egress of areas with an occupancy of 100 or more people. Panic hardware is provided on non-fire rated doors, fire exit hardware is provided on fire rated doors (semantics).

**Fire ratings:**

Material	Width	Rating
Solid Reinforced concrete	6 1/2"	4 hour
	6"	3 hour
	5"	2 hour
	3 1/2"	1 hour
Solid Brick Masonry	8"	4 hour
	6"	2 hour
	4"	1 hour
CMU	8"	2-4 hour
	6"	1 1/2 hour
	4"	1 hour

Most to least for fire rating: Solid reinforced concrete, then solid brick, brick cavity wall, and CMU.

Note: All stone is affected by rapid temp change and should NOT be used where fire resistance is important. ALS 3-13

**Fire-resistant assemblies: Bldg Construction Illustrated pA12-13**

Fire Rating	Floor and Roof Materials	Walls and Partition Materials
1 hour	Double wood floor, wood joists @ 16" o.c., 1/2" Type X gypsum board or 5/8" gypsum plaster on metal lath	2x4 studs @ 16" o.c., 5/8" gyp. Plaster on metal lath, or 2 layers 1/2" regular gyp. Or 5/8" Type x gyp. on ea side.
		2" solid gyp plaster on 3/4" channels and 3/8" gyp lath
		2 1/2" steel studs @ 16" o.c., 5/8" gyp plaster on metal lath, or 5/8" Type X gyp on ea side
2 hour	Fire-resistant roofing over wood fiber insulation board & 1 1/2" steel roof deck, steel joists, 3/4" gypsum plaster on metal lath	2x4 studs @ 16" o.c., 7/8" neat wood fibered gyp plaster on metal lath, or 2 layers 5/8" Type X gyp on ea side
	2" reinf. Conc slab on steel form units, steel joists, 5/8" Type X gyp or perlite plaster on 3/8" perforated gyp lath attached to 3/4" cold-rolled channels	2" solid gyp plaster, 1/2" Type X gyp on ea side of 1" gyp coreboard.
		Steel studs @ 16" or 24" o.c., 3/4" perlite gyp plaster on 3/8" perforated gyp lath, or 2 layers 1/2" type X gyp on ea side.
4 Hour	2 1/2" reinf. Conc slab on steel form units, Steel joists, 5/8" Type X gypsum, 3/4" vermiculite gyp plaster on metal lath	
	1 1/2" sand-gravel concrete topping, 8" precast conc slabs 1/ all joints grouted	
	3" slab, reinf. Conc joists, 1" vermiculite gyp plaster on metal lath a attached to 3/4" cold-rolled channels @ 12" o.c,	
	6 1/2" regular or 5" exp shale concrete slab	

**Know which is the most and least fire-resistive in 4 given details of a CMU wall. Remember thickness equivalency. Mass is what makes the CMU more or less fire proof.**

(2" of gypsum block = 4" of cmu [fire proofing])

8" - 2 to 4 hour rating

6" - 1 1/2 hour rating

4" - 1 hour rating.

Note: rating of all masonry walls may be increased with a coating of Portland cement or gypsum plaster.

**Safing insulation:** Fire stop product for curtain and head-of-wall construction joints

**Thermafiber** safing insulation is a mineral wool forming material used in fire stop applications such as floor and wall penetrations and head of wall construction joints. Also used at the slab edge of multi-story buildings in combination with Firespan or curtain wall insulation as part of perimeter fire containment systems.

**Flammability ratings for various occupancies:** When we speak of "flammability", I usually think of the flammability of interior finishes (measured by flame spread, smoke developed, fuel contributed, carpet pill test, etc). This is primarily a construction issue.

When classifying occupancies, you have varying degrees of "hazard". The model building codes typically assign a hazard classification (light, ordinary, high) for most common occupancies (i.e.: a

warehouse storing steel structural shapes would be light; one storing grocery products, ordinary; one storing flammable liquids or toilet paper would be high; fireworks manufacturing, extra hazardous.) The hazard rating looks more at the contents and use of a facility versus the construction. It takes into account both the combustibility and likely of an ignition/explosion of an occupancy.

The other codes then base structural fire ratings, necessity and degree of fixed fire protection, egress requirements (travel distances, number of exits, etc) on hazard classification. In the IBC (chapter 3), hazard ratings are integral to the occupancy classifications, which in turn drive structural fire resistance, protection, and separation requirements.

**What characteristics would allow you to open up opportunities for more choices in materials?**

**What governs the testing standards of materials for fire protection?**

**Flame spread rating:**

Wall/Door Rating Combinations B7-12

Type & Hourly Rating of Wall	Door Assembly Rating
2-hr exit stair	1 ½ hr, B label
1-hr occupancy separation	1 hr, B label
1-hr exit passageway	¾ hr, C label
1-hr corridor	20 minutes

**Intumescent paints:** a type of fire-resistant paint. When subjected to flame or intense heat, these paints liquefy, allowing escaping gases to form an insulating layer of char, which forms a protective layer around the substrate.

**What determines the number of exists? occupancy load**

**Smoke proof enclosures are required by: height of bldg**

**Fire rated doors: B21-15 (chart)**

Rating	Opening Class	Use of wall	Rating of wall
3	A	Fire walls, occupancy separations	3 or 4
1 ½	B	Exit stairways, vertical shafts, fire separations	2
1	B	Exit stairways, vertical shafts, fire separations	1
¾	C	Corridors, fire-resistive walls, hazardous area	1
1/3	-	Corridors, smoke barriers	1 or less
1 ½	D	Severe exterior	2 or more
¾	E	Moderate to light, exterior exposure	1 or less
1/3	-	Moderate to light, interior exposure	1 or less

**Classes of fire: various types of fire extinguishers**

- Class A: ordinary fires which can be distinguished w/ water
- Class B: flammable gasses & liquids

- Class C: electrical equipment - to extinguish by non-conductive. When disconnected electrically, class A & B extinguishers work.
  - Class D: combustibles metals (sodium, potassium)
- \*\* Halon is used to put out class B & C fires. Audible and visible alarm required.

**What type of fire extinguishers is most suitable for a video recording studio?** Halon  
**Halon** quickly extinguishes a fire w/ no damage to contents and minimal risk to people, making it ideal for spaces such as computer rooms, libraries, recording studios etc.

**Dry Chemical:** effective for use in airplane hangars and similar locations

**Carbon Dioxide:** effective for flammable liquid and electrical fires, but pose significant hazards to people, thus limiting their use to very confined spaces without people.

**What type of sprinkler/ fire distinguisher is used in a commercial kitchen?** Wet chemical system is located below the hood and a compatible, portable system.

**Detectors:** required by code to be near fire doors, in exit corridors, in individual hotel rooms, in bedrooms, and in places of public assembly. Often required in main supply ducts and return air ducts.

**Ionization detector:** responds to chemical products of combustion. Problem, detect smoke from cig or kitchen. Known as early warning detectors.

**Photoelectric detector:** reacts to visible smoke/ blocks beam of light.

**Flashover:** when fire reaches combustion at the same time.

**Heat Actuated Sensors:** piece of wax separates the contacts of an alarm circuit. When it melts, the alarm goes off. Can activate too late

**Dry standpipe** If it extends more than 75' above grade, the pipe connections must be provided in every required stairway as well. No water in system. Must be attached to a source

**Wet standpipe** required in bldgs of 4+ stories, theaters and other places of assembly, hazardous occupancies, all group I,B,S and M occupancies. Must be located so every point is within 30' of the end of a 100' hose. Hose is stored in case on the wall. Bldgs exceed 150' in height require combination standpipe for every stairway which extends from ground to roof. Pipe must be equipped w/ the 1 1/2 " outlets for fire department and 1 1/2" hose racks as in wet standpipe. Water is in system, waiting for activation.

**Sprinklers required:**

- Basements and cellars (except private houses and garages)

- Backstage areas, dressing rooms, workshops, storage areas of theaters; any concealed spaces above stairways in schools, hospitals, institutions such as prisons, and places of assembly such as theaters and arenas.
- Over all rubbish and linen chutes
- Retail sales area over 12K SF per floor or 24K SF gross
- Assembly over 12K SF in area.

**Preaction system:** requires both the sprinkler head be activated and an independent fire sensing device triggered. This avoids accidental discharge.

**Deluge system:** believes in wetting the entire area.

**Critical Radiant Flux (CRF):** This is the minimum radiant energy a fire needs to sustain flame propagation in the flooring system. In this test, a higher number indicates a more flame-resistant system

**Noncombustible:** If **NO** part of it will ignite and burn when subjected to fire. B7-8

**What should be considered when designing atrium spaces when it comes to smoke?** height, volume, travel distance.

**Fire protection testing is governed by?**

### Codes:

First building code was developed in Babylonia: Today's building codes can be traced back to: **The Babylonian Law of Hammurabi**, 2000 BC (ruler of Babylon).

**How many doors required for 150 Occupancy loads w/ .2 per an occupant load**

$150 \times .2 = 30''$ . 1 door has a clear width of 33" in a 3'0" door. B 7-11

**Means of Egress calculation for the width of a door**

**Exit doors:** min 3' wide and 6'8" high. Max of individual leaf is 4'

**Calculate egress requirement for an assembly space w/o fixed seats.** A chart will be given

**Exits:**

- Ea. Exit stairway must be within 200' of any point (250' for a sprinklered facility)
- No passage exit be < 44". To determine flow take total occupant load to serve stairway X by 0.2 = min exit width
- Elevators may be used if they are not connected to heat responsive call buttons.
- Stair enclosure walls in bldgs 4+ stories, or type I & II construction, require 2-hour construction. 1- hour rated for all other bldgs.
- Bldgs 75+ in height, exit must be pressurized - activated upon fire alarm system.

**How far away can a door be from another exit door?**

**Study egress configurations and rules.**

Occupant load is determined by taking the area in SF assigned to a particular use and dividing by an occupant load factor as given in UBC table 10-A. These load factors range from a low 3 sf per person for waiting areas to a high 500 sf for warehouses. The number of exits from a space or bldg is then determined by the occupant load. 2 exits required on 2<sup>nd</sup> floor, 3 exits when the load is 501 to 1000 persons and 4 required over 1000 people.

**Exit passageway:** an enclosed exit connecting a required exit or exit access w/ a public way. Typically used to connect the ground-floor door of an exit stair w/ the outside of bldg so occupants have protected means of egress once they reach the bottom of the stair. Usually a 1 hour rating. B7-8

**Horizontal exit:** an exit leading from one bldg into another or from one compartment to another in the same bldg, on approximately the same level, through or around a wall constructed as required for a 2-hour occupancy separation. B7-8

**Panic hardware:** hardware that unlatches the door when pressure is applied against it.

**Rules on ramps for exits:**

**Fire escape:** Use as an exit stairway. In some cases, a protected passageway or foyer may connect an exit stairway to the outside.

**Automatic closing:** when door remains open, but closes when temp reaches 165 degrees.

**Self-Closing:** closes after each use. B7-8 Required to be a fire rated door

### **Pre-Design:**

**Albedo:** The fraction of the radiant energy received on a surface that is reflected. 0 = black surface. 1= mirror. Grass and vegetation have low. Snow and pavement have high.

**Conductivity:** the time rate of flow of heat through a material. Natural materials have low; metal, concrete, and masonry have high. **What object has high Conductivity?** Concrete

**Zoning:** what is 'not' a zoning ordinance. occupancy load. Is a building code.

**Appropriate times to do cost analysis for a project.**

**Pre-Design:** budgets based on area

**Pre-programming:** cost per SF or divided into functional areas

**Programming:** arch estimates construction schedule

**Schematic design:** budget on major subsystems, general layout of the project is developed along w/ preliminary alternate studies for materials & bldg systems. When you would select the structural system.

**Design development phase:** pre-specs, more detailed cost, start the parameter method

**Construction documents:** parameter method- expanded itemization of construction quantities & assets, unit costs to these quantities. Ex carpeting, vinyl opposed to floor finishes, final working drwgs & full project manual.

**What preliminary budgets are based upon for a project in the Design Development phase?** Use the parameter method, which involves an expanded itemization of construction quantities and assignment of unit costs to the quantities. EX: instead of floor finishes, it would be broken into carpeting, vinyl, tile, etc...Using an estimated cost per sf, the cost of ea type of flooring can be estimated based on area. B3-13

### **Construction Documents:**

Study construction documents and anything related to cost (construction estimates & costs, life cycle costs, material costs, etc.)

**What is not required to record during the construction meeting?** location

**What is impact cost?**

**Cost estimating -cost per beds for hospital; Cost per student for school:** part of pre-programming (pre-design) budgets when it is solely based on area. **What is overhead? And what does it comprise of?** B 3-14 Part of construction cost. Overhead can be divided into general and project. **General:** is the cost to run a contracting business that involves such things as office rent, secretarial help, heat, and other recurring costs. **Project:** is the money it takes to complete a job that does not include labor, materials or equipment. Temporary offices, project telephones, sanitary facilities, trash removal, insurance, permits, and temp utilities. Can range from 10-20% for total costs for labor, materials, and equipment.

#### **Direct cost:**

A detailed calculation of the amount of each type of material and labor necessary to produce the required construction. Also can be included:

- Demo of existing structures or other improvements
- Site work
- Landscaping
- Furniture, furnishings, and equipment
- Special equipment

#### **Indirect cost:**

- Contractors overhead, including insurance, payroll taxes and benefits, general and administrative expenses such as site office salaries, and equipment rental costs.
- General conditions costs, including project signs, engineering surveys and inspections, tests, drawings and photo's, permits, and repairs and clean-up.

- A contingency amount for cost escalation and unforeseen conditions.
- Contractor's profit calculated as a % of total direct construction costs.
- **Construction cost** does not include: professional fees, land cost, financing costs, or other costs (such as land surveys) that are the responsibility of the owner.

**Outline specification- Master Specs format (CSI)** Masterformat system has 3 parts: part 1- General, part 2- Products, part 3- Execution. P26-5

- |                                           |                                   |
|-------------------------------------------|-----------------------------------|
| Bidding Requirements                      | Division 8- Door and Windows      |
| Contracting Requirements                  | Division 9- Finishes              |
| Division 1- General Requirements          | Division 10- Specialties          |
| Division 2- Site Construction             | Division 11- Equipment            |
| Division 3- Concrete                      | Division 12- Furnishings          |
| Division 4- Masonry                       | Division 13- Special Construction |
| Division 5- Metals                        | Division 14- Conveying Systems    |
| Division 6- Wood and Plastics             | Division 15- Mechanical           |
| Division 7- Thermal & Moisture Protection | Division 16- Electrical           |

Where would you find an iron gate? Division 5 - Metals  
 Flag pool would be found in what section? Specialty: Division 10

Pay attention to some of the **COSTS** of construction and labor: Labor consists of the most costly in a project. The Architect's Portable Handbook. Percentage of cost of structural to the overall project cost: \$16.51 SF - 21.7% of total

**System Cost Budget: B3-13**

Subsystem	\$/sq. ft.	% of total	Subsystem	\$/sq. ft.	% of total
Foundations	3.96	5.2	Ceiling finishes	2.79	3.7
Floors on grade	3.08	4	Conveying systems	6.45	8.5
Superstructure	16.51	21.7	Specialties	.70	.9
Roofing	.18	.2	Fixed Equipment	2.74	3.6
Exterior walls	9.63	12.6	HVAC	9.21	12.1
Partitions	5.19	6.8	Plumbing	3.61	4.6
Wall finishes	3.70	4.8	Electrical	4.68	6.1
Floor finishes	3.78	5			

**Mechanical:**

**Water closet calculation W/ table provided :** (easy- just read chart)

**What is the best way to economize a laboratory fume hood?**

"Laboratories have proven to be especially difficult HVAC control problems due to their fume hood. Conditioned air is provided from the central HVAC system, often by a VAV supply. Whenever a fume hood is exhausting air (frequently in huge quantities, the VAV supply and return systems are affected. Complicating this relationship is the nature of the laboratory work; where the experiment could be damaged by outside contaminants, the lab should be positively pressurized to

minimize infiltration (and the VAV must therefore supply and return slightly more air than the fume hood exhausts). However, where the experiments involve diseased, toxic, or other hazardous substances, the lab must be negatively pressurized (and the VAV must supply and return slightly less air than the fume hood exhaust) DDC's (Digital direct Control) tied to a central system can balance energy conservation, lab worker safety, and safety for the non-lab environment." MEEB 9th Ed. p 482

**What kind of vent system is used in a laboratory?**

**What is the liquid portion of waste called? Sludge or effluent?**

**Laminar:** separate: turbulence: Eddy (terms associated with air/wind movement) Laminar is when you look at flowing water and it is smooth. Turbulent is when you look at it and it is sloshing all around. Reynold's number is basically a measurement of turbulence. Sounds like a weird test. Laminar = Reynold's number is below 2100. Flow is non-turbulent. Turbulent = high Reynold's number (think above 38000) Flow is not laminar or in "transition zone". Deals with wind/air.

**Eddy:** terms associated with air/wind movement. Kinda like a vortex, place where water is in circular motion. A current, as of water or air, moving contrary to the direction of the main current, especially in a circular motion. [www.dictionary.com](http://www.dictionary.com)

**\*\*\* Air Curtain** is: Blows air down from top of door.

[http://www.bondorseals.com//more\\_info/air\\_curtain/air\\_curtain.htm](http://www.bondorseals.com//more_info/air_curtain/air_curtain.htm) It conserves energy and improve comfort by limiting the escape of internal heat, reducing cold drafts and providing a welcoming down-flow curtain of warm air at entrance ways in industrial plants and store buildings. In cold weather they reduce the load on heating systems. By drawing warm air down to floor level where it is needed. Stratified air is mixed and circulated with building heat and heat given off by lights and machinery, etc. The high velocity curtain of air deflects winds and reduces excessive heat loss through open doorways. During warm weather they can direct a stream of air downward to help keep dust, dirt, insects and fumes from entering through open doorways. If air conditioning exists in the building during warm weather, the air curtains can be used to prevent loss of conditioned air as well.

**Trombe wall** (thermal storage wall): passive solar type. Placed directly behind a south facing glass wall and collect solar energy during the day for release at night. Most thermal walls are vented which allows cool air to circulate in the space between the glass and wall, heat and travel by convection up and over the wall back into the space. Vents located at top and bottom to allow thermo-circulation. Can also be constructed of water containers or phase change materials. Water is better then concrete or masonry because it has a higher specific heat and can store more energy. **Where are the vents located on this kind of wall?** Upper and lower part of wall. top vent allows warm air to exit the "trombe space" to the adjacent room. The bottom vent allows cooler air to enter the "trombe space" to be heated, then that heated air goes exits "trombe space" and the cycle continues.

**Where would you put the insulation on a passive system made of concrete masonry?** provide none.

**What would be used to patch a leak at the bottom of a reservoir:** clay (guessing)

**"Sick building syndrome":** when natural or artificial ventilation is inadequate to remove odors & chemicals emitted by building materials.

**Bad chemicals found in buildings:** Formaldehyde, benzene, ammonia, resins in plywood, particleboard, foam insulation. Inside of building is contaminated by human respiration, bacteria, molds, and material emissions.

**Sump Pump:** First line of defense against water in the basement is a sump with a pump in it. The sump may be connected to drain tile that drains the footings of the house, under the entire basement, or just the area where the sump is located. The water that drains into the sump must be removed, and this is accomplished with a sump pump.

The two basic sump pump models are the up-right (commonly called a pedestal) and the submersible. The pedestal pump has the motor on top of the pedestal and the pump at the base, which sits on the bottom of the sump. The motor is not meant to get wet. The pump is turned on and off by a ball float. One advantage of this type of pump is that the on/off switch is visible so the action of the ball float can be easily seen. Submersible pumps are designed to be submerged in water and sit on the bottom of the sump. The on/off switch is attached to the pump and can be either a ball float connected to an internal pressure switch or a sealed, adjustable, mercury-activated float switch. Either type of pump should have a check valve on the water outlet pipe so water doesn't flow back in the sump when the pump shuts off.

**What do most refer to when it comes to designing an elevator, escalator, and stairs?** ANSI  
ANSI= American National Standards Institute. Where people turn to for direction in designing elevators, escalators and stairs.

## **Sustainability & Historical:**

**LEED:** Leadership in Energy and Environmental Design.

**Sustainability:** meeting the needs of the present generation without compromising the ability of future generations to meet their needs.

**When is it appropriate to use aluminum windows for replacement windows in an historic bldg?**  
When wood windows is not appropriate. When you can get the same color, style, and size in aluminum. A must read = [http://www.areforum.org/forums/view\\_topic.php?id=40&forum\\_id=5](http://www.areforum.org/forums/view_topic.php?id=40&forum_id=5)

**How to fix brick joints in Historic buildings.** Re-pointing the joints but first by raking to release the loose parts. Never pressure wash. Use water and mild detergent. Masonry should only be cleaned in order to halt deterioration or to remove heavy soiling. **What type of mortar to use?**

**If a historical bldg that had a structurally sound exterior masonry wall, but it showed some wear, what would the architect recommend?** Never sand blast by using wet grit. Do not paint the

exterior, it will change the historical value. Power wash could be the answer, but you should wash in the gentlest method and mild detergents and only to halt deterioration or to remove heavy soiling.  
AGS 846

**Sustainable design: what is it? What materials should be used? What should be done w/ landscaping on the site upon completion of bldg work?** Sustainable design: encourages a new, more environmentally sensitive, approach to arch design and construction. Landscape site conditions: the location of dense, coniferous trees on the elevation against the prevailing wind (usually west or northwest) may decrease heat loss due to infiltration and wind chill factor. Sites w/ deciduous shade trees can reduce summer solar gain if positioned properly on the south and west elevations of the bldgs. P8 2004 supplement

**What are the issues to be concerned with when selecting green material?**

Guiding Principles of Sustainable Design (Excellent Site)

<http://www.nps.gov/dsc/dsgncnstr/gpsd/toc.html>

Sustainable Design Module (Has pdf files to download)

<http://www.umich.edu/~nppcpub/resources/compendia/architecture.html#sdes>

Sustainable design resource guide (Organize in the CSI 16 Div)

<http://www.aiacolorado.org/SDRG/home.htm>

Top ten green buildings article.

[http://www.architectureweek.com/2004/0602/environment\\_1-1.html](http://www.architectureweek.com/2004/0602/environment_1-1.html)

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**Life cycle costs: Purpose:** a method for evaluating all relevant costs over time of alternative bldg designs, systems, components, materials, or practices. The LCC method takes into account first costs, including the costs of planning, design, purchase, and installation; future costs, including costs of fuel, operation, maintenance, repair, and replacement; and any salvage value recovered during or at the end of the time period examined.

- Construction cost represents 15% of long term cost of project
  - Financing costs may be decreased when fast track is used
  - Life cycle costs include the costs of replacement and renovation.
- CSI

**Life Cycle costs and the Process for Approaching Sustainable Design**

**Life Cycle Design:**

"Cradle to grave" - gathering of raw materials to their ultimate disposal, provides a better understanding of the long-term costs of materials.

**In the decision process of picking sustainable products, think in the three phases:**

<p><u>Pre-building phase:</u> -- Manufacturing</p> <ul style="list-style-type: none"><li>• Extraction process</li><li>• Processing</li><li>• Packaging</li><li>• Shipping</li></ul>	<p><u>Building Phase:</u> -- Use</p> <ul style="list-style-type: none"><li>• Construction</li><li>• Installation</li><li>• Operation</li><li>• Maintenance</li></ul>	<p><u>Post Building Phase:</u> -- Disposal</p> <ul style="list-style-type: none"><li>• Recycling</li><li>• Reuse</li></ul>
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**3 aspects of the life of a bldg material are most significant in considering environmental impact: AGS 833.** Is the raw material renewable or nonrenewable; how much total waste or how many toxic by-products are produced in its production and during the life of the product; how much energy is consumed in its life cycle?

The embodied energy of a bldg material comprises all the energy consumed in acquiring and transforming the raw materials into finished products, transporting them to the bldg site, and final disposal.

**Approximate value of embodied energy in bldg materials:**

Low	Medium	High
Sand/gravel (18 BTU/LB)	Gypsum board (1,830 BTU/LB)	Plastic (18,500 BTU/LB)
Wood Sand-lime brickwork	Brickwork	Steel
Light weight concrete (940 BTU/LB)	Lime	Lead
	Cement	Zinc
	Mineral fiber insulation	Copper
	Glass	Aluminum (103,500 BTU/LB)
	Porcelain (11,300 BTU/LB)	

**Life Cycle checklist:** can be used to analyze the environmental impact of bldg materials

1. Raw material acquisition (mining, harvesting, drilling, extraction)
2. Raw material processing and manufacturing
3. Product packaging and final packaging (for shipping)
4. Product distribution
5. Product installation, use, maintenance
6. Disposal, recycling, reuse

**Does CMU have good life cycle cost?**

**Pollution:** <http://www.idontcareaboutair.com/facts/health.shtml>

Materials w/ high rates of VOC: particleboard, some carpets and adhesives and certain paints.

**Volatile Organic Compounds (VOC)** VOCs react in the presence of nitrogen oxides and sunlight to form ground-level ozone, a major component of smog. Ozone irritates the eyes, damages the lungs, and aggravates respiratory problems. It is our most widespread and intractable urban air pollution problem. Ozone also reduces agricultural production and the growth rate of trees. A number of exhaust VOCs are also toxic, with the potential to cause cancer, nerve damage, and other health effects. Benzene, a known human carcinogen, is an example of a toxic VOC found in vehicle exhaust.

When is VOC admitted when it comes to paint? In the plant, when applying, during demo??

**Acoustics:**

Sound absorption coefficients for standard materials. Which wall type is more or less sound proof?

There are 3 families of devices for sound absorption - fibrous materials, panel resonators, and volume resonators. All types absorb sound by changing sound energy into heat energy. Fibrous materials: depends on thickness, density, porosity and resistance to airflow. Provide air gap in between material and rigid surface.

**Coefficients of Absorption: MEEB 1370 (higher number, better absorbs sound)**

Material	Specific Type	125Hz	1000Hz	4000Hz	NRC
Air			.9	7.2	
Brick	Unglazed	.03	.04	.07	.005
	Unglazed, Painted	.01	.02	.03	0
Carpet	On concrete	.02	.37	.65	.29
	On 40- oz hairfelt or foam rubber	.08	.69	.73	.55
Concrete	Coarse	.36	.29	.25	.35
	Block, painted	.10	.07	.08	.05
Fabrics	In contact w/ wall - 10 oz	.03	.17	.35	.15
	18 oz, draped to half area	.14	.72	.65	.60
Floors	Concrete or terrazzo	.01	.02	.02	0
	Linoleum, asphalt, rubber, or cork tile on concrete	.02	.03	.02	.10
	Wood	.15	.07	.07	.10
Glass	Large panes of heavy plate glass	.18	.03	.02	.05
	Ordinary window glass	.35	.12	.04	.15
Gypsum		.10	.03	.03	.05
Marble		.01	.01	.02	0
Plaster	Gypsum or lime, smooth finish on tile or brick	.013	.03	.05	.05
	Gypsum or lime, on lath	.14	.09	.11	.15
Plywood	3/8" thick	.28	.09	.11	.15
<b>Absorp materials</b>	High performance vinyl-faced fiberglass	.82	.96	.77	.90
	Painted nubby glass cloth panels	.81	.87	.96	.85
	Random fissured 5/8" thick panels	.66	.80	.80	.75
	Mineral fiber tiles and panels	.47	.76	.81	.65

Notes: When paint surface, loose absorption qualities. Fabrics (drapes), Carpet, and then Concrete are good materials. (besides the materials mentioned for specific absorption qualities.) Materials act differently with different level sounds.

Which blocks sounds, ground, trees, trees on top of hill etc? Vegetation only masks sound. Only solid things can actually block it. Located a solid structure closer to the object you are trying to block, or closer to what you are trying to block it from.

STC (sound transmission class): a single-number average over several frequency bands of a barrier's ability to reduce sound. The higher the STC rating, the better the barrier's ability to control sound transmission. AGS 67 see sketches of typical high sound isolation construction

**Pick highest STC of different type of walls**

**Does CMU have high STC?**

NRC (noise reduction coefficient): arithmetic average of the absorption coefficients at 250, 500, 1000, and 2000 Hz. It is useful as a single-number criterion for the midband effectiveness of a porous absorber. If high or low end frequencies are of interest, NRC is useless.

**Differences between the two:** STC is TRANSMISSION of sound and NRC is ABSORPTION of sound. STC would be crucial for party walls between two apartment units for example..... the floor between upper and lower levels NRC would be critical in design of an auditorium in attempt to provide optimal acoustics (reverb time, etc.) STC therefore takes on different characteristics that affect the rating.... such as wall/floor mass, air space etc. NRC responds to actual material properties, i.e. absorptive, reflectance of sound.

**Acoustical values of materials:**

<u>Description</u>	<u>STC</u>
Basic partition: single wood stud, 1/2 " gypsum board, air cavity	35
<b>Add to basic partition</b>	
Double gypsum on one side	+2
Single-thickness absorbent material in air cavity	+3
Double thickness insulation	+6
Resilient channel supports for gypsum board	+5
Staggered studs	+9
Double studs	+13
1" light weight hollow block/ 12" dense hollow block	36 - 53
4" brick, 12" brick	41-54
6" solid concrete, 12" solid concrete	47-56

<u>Description Windows</u>	<u>STC</u>
Operable wood sash 1/8" unsealed	25
Operable wood sash, laminated glass, unsealed	30
Operable wood sash, double-glazed, 1/8" panes, 3/8" air space, gasketed	29
Fixed sash, double 1/8" panes, 3" air space, gasketed	44
Fixed sash, double 1/4" panes, 4" air space, gasketed	48

<u>STC of Spaces by bldg type</u>	<u>STC</u>
School: classroom, mechanical room, offices, restrooms	40, 45, 45, 47
Office: offices, restrooms	38, 40
Hotels: rooms, bathrooms, corridors	50,45,42
Residential: bedroom, bathroom, living room,	50, 50, 54
Note: STC is the wall inbetween spaces. Depends on what the space is next to it.	

<u>Type of Space</u>	<u>NC (db)</u>
Normal speech can clearly be heard through barrier	25
Loud speech can be heard and understood fairly well, normal speech can be heard but barely understood	30
Loud speech is not intelligible but can be heard	35
Loud speech can only be faintly heard: normal speech cannot be heard	42-45
Loud speech is not audible; loud sounds other than speech can only be heard faintly, if at all	46-50

\*\* STC 57 is Great

**Acoustical control:**

**Isolated rooms:**

The most effective floor construction is a "floated" concrete pad, which is separated from the base bldg structure by steel springs, neoprene, or glass fiber isolation mounts. This slab can support inner walls. Any necessary structural bracing to the base bldg structure should be w/ a resilient, non-rigid connection. The ceiling of the box can be suspended from resilient hangers, or it can be supported from the walls of the inner box. Eliminate flanking paths.

**Acoustical ceiling tiles:** Absorb sound, do not prevent sound transmission

**Room with placement of baffles, proportions, room size influence?** Reverberation or NRC?

**Loose batts:** reduce sound transmission through or over partitions; installed over suspended ACT or between gypsum wall partitions. STC 40-60

**Structural:**

Detail of Moment connection

Calculate column and beam loads,

Load bearing vs. non-load bearing walls.

**What a pilaster does structurally.** Pilaster: An engaged pier or pillar, often with capital and base. Added to a concrete wall to support additional loads.

If you wish to minimize floor thickness to reduce total building height or spandrel depth on the building façade: The thinnest floor systems are concrete slabs without ribs, preferable prestressed, such as: sitecast concrete, two-way flat plate or flat slab, especially when post-tensioned; precast prestressed hollow core or solid slab; Posttensioned one-way solid slab.

Straw bale construction: long-lasting bldg method. Started in late 19<sup>th</sup> century and still stand today. Stacked in running bond pattern, plastered or stuccoed straw bale walls are 24" thick. Have insulating value R-57 (3x's of typical insulated wood) AGS 841

## Additional Stuff:

Material	Allowable tensile strength	Allowable Compressive Strength	Density	Modulus of Elasticity
Wood	700 psi	1,100 psi	30 pcf	1,200,000 psi
Brick Masonry	0	250 psi	120 pcf	1,200,000 psi
Steel (ASTM A36)	22,000 psi	22,000 psi	490 pcf	29,000,000 psi
Concrete	0	1,350 psi	145 pcf	3,150,000 psi