110401545

Building Construction

1. Earth Materials & Excavation

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Earth Materials

Classifying Earth Materials

- Rock: continuous mass of solid mineral material
  - Generally, the strongest, most stable of earth materials on which a building can be founded.
  - Strength varies with mineral content and physical structure
- Soil: any earth material that is particulate
  - Characteristics and suitability for foundation support vary with particle size and shape, mineral content, and sensitivity to moisture content

Soils Classified by Size

- ***Boulder:*** Individual particle of soil is too big to lift with one hand or requires two hands to lift
- ***Cobble:*** Can be lifted in one hand (takes the whole hand to lift a particle)
- *Coarse-grained soils*
  - ***Gravel***: Individual particles can be lifted between thumb and forefinger
  - ***Sand***: particles individual soil particles can be seen but are too small to be picked up individually
- *Fine-grained soils:* individual particles are too small to see with naked eye
  - ***Silt***: roughly spherical in shape
  - ***Clay***: very small, plate-shaped particles and smaller than silt particles

Organic Soils

- Peat, topsoil and other soils with organic content
  - Generally weak, unstable, and not suited for supported building foundations

Soil Properties I

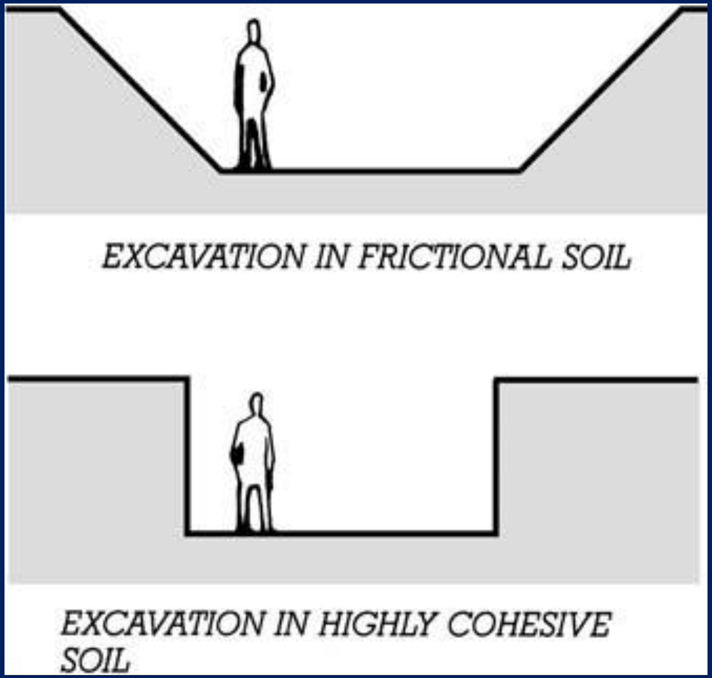
- Coarse-grained Soils (gravel, sand)
  - Don’t stick together when wet; *cohesionlessf* (Frictional)
  - When unconfined, have little strength
  - Structural properties little affected by moisture content
  - Free-draining; best at draining water away from foundations and substructures

Soil Properties II

- Fine-grained soils (silt, clay)
  - Smaller particle size, less free draining
  - When wet, may be subject to liquefaction during seismic events
  - Drainage characteristics vary
  - Varying degrees of cohesiveness (tendency to stick together)

Soil Properties III

- Clays
  - Particles so small that electrostatic forces cause particles to stick together; *cohesive* soil
  - Structural properties vary greatly with moisture content and mineral composition
  - Some are highly expansive when wetted
  - Some are virtually impervious to water



Soil Particle Grading

- *Well graded* soil: Coarsegrained soils consisting of particles of all sizes (*poorly sorted)*
- *Well sorted* soil: limited range of particle sizes; most void space, most free draining (*poorly graded*)

Soil for Building Foundations

- Generally, coarse-grained soils are more desirable for supporting building foundations than fine-grained soils
  - Tend to have greater loadbearing capacity
  - Tend to be more stable, and to react less to changes in moisture content.
  - Rock is generally the best material on which to found a building.

Presumptive Soil Loadbearing Capacity

- Generally, the larger the particle size, the greater the bearing capacity of the soil.

TABLE 1804.2
ALLOWABLE FOUNDATION AND LATERAL PRESSURE

CLASS OF MATERIALS	ALLOWABLE FOUNDATION PRESSURE (psf)[d]	LATERAL BEARING (psf/f below natural grade)[d]	LATERAL SLIDING	
			Coefficient of friction[a]	Resistance (psf)[b]
1. Crystalline bedrock	12,000	1,200	0.70	—
2. Sedimentary and foliated rock	4,000	400	0.35	—
3. Sandy gravel and/or gravel (GW and GP)	3,000	200	0.35	—
4. Sand, silty sand, clayey sand, silty gravel and clayey gravel (SW, SP, SM, SC, GM and GC)	2,000	150	0.25	—
5. Clay, sandy clay, silty clay, clayey silt, silt and sandy silt (CL, ML, MH and CH)	1,500[c]	100	—	130

For SI: 1 pound per square foot = 0.0479 kPa, 1 pound per square foot per foot = 0.157 kPa/m.

a. Coefficient to be multiplied by the dead load.

b. Lateral sliding resistance value to be multiplied by the contact area, as limited by Section 1804.3.

c. Where the building official determines that in-place soils with an allowable bearing capacity of less than 1,500 psf are likely to be present at the site, the allowable bearing capacity shall be determined by a soils investigation.

d. An increase of one-third is permitted when using the alternate load combinations in Section 1605.3.2 that include wind or earthquake loads.

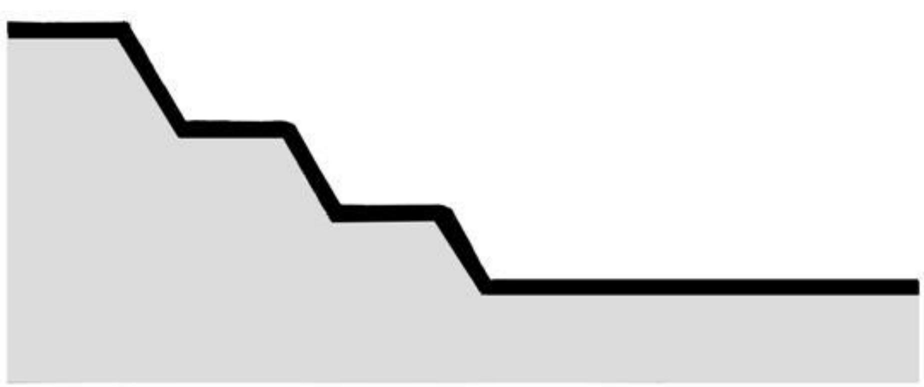
Excavation

Excavation

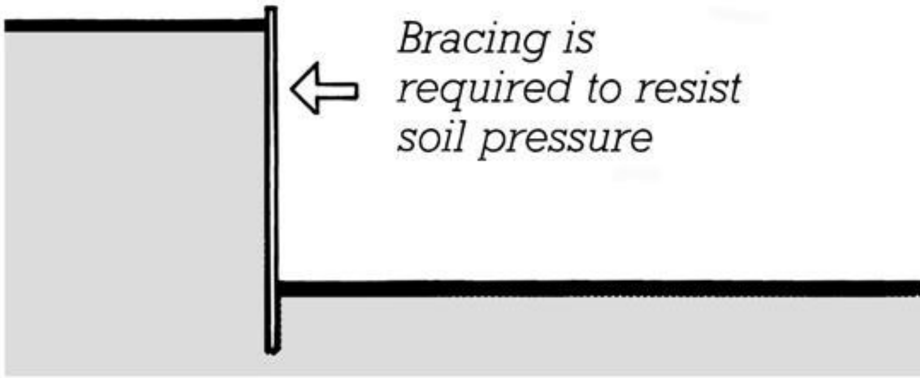
- At least some *excavation is required* for every building:
  - To remove organic topsoil because it is unsuitable for supporting buildings
  - To place the footings at a depth where soil of the appropriate bearing capacity is available.
  - To add one or more levels of basement space to a building (for additional habitable rooms, for parking, or for mechanical equipment and storage)
  - To place the footings out of reach of water and wind erosion, and to place the footings below the level to which the ground freezes in winter (frost line) in colder climates

Excavation Support

- Sloped or benched excavation is less expensive than sheeted excavation, but requires a site without nearby property lines, adjacent structures, or other limits on excavation.



SECTION THROUGH BENCHED EXCAVATION



SECTION THROUGH SHEETED EXCAVATION

Excavation Support II

- Excavation support can take many forms, depending on the qualities of the soil, depth of excavation, equipment and preferences of the contractor, proximity of surrounding buildings, and level of the water table
  - **Shoring**
    - Soldier beams and lagging
    - Sheet piling.
    - Shotcrete

Excavation Support III

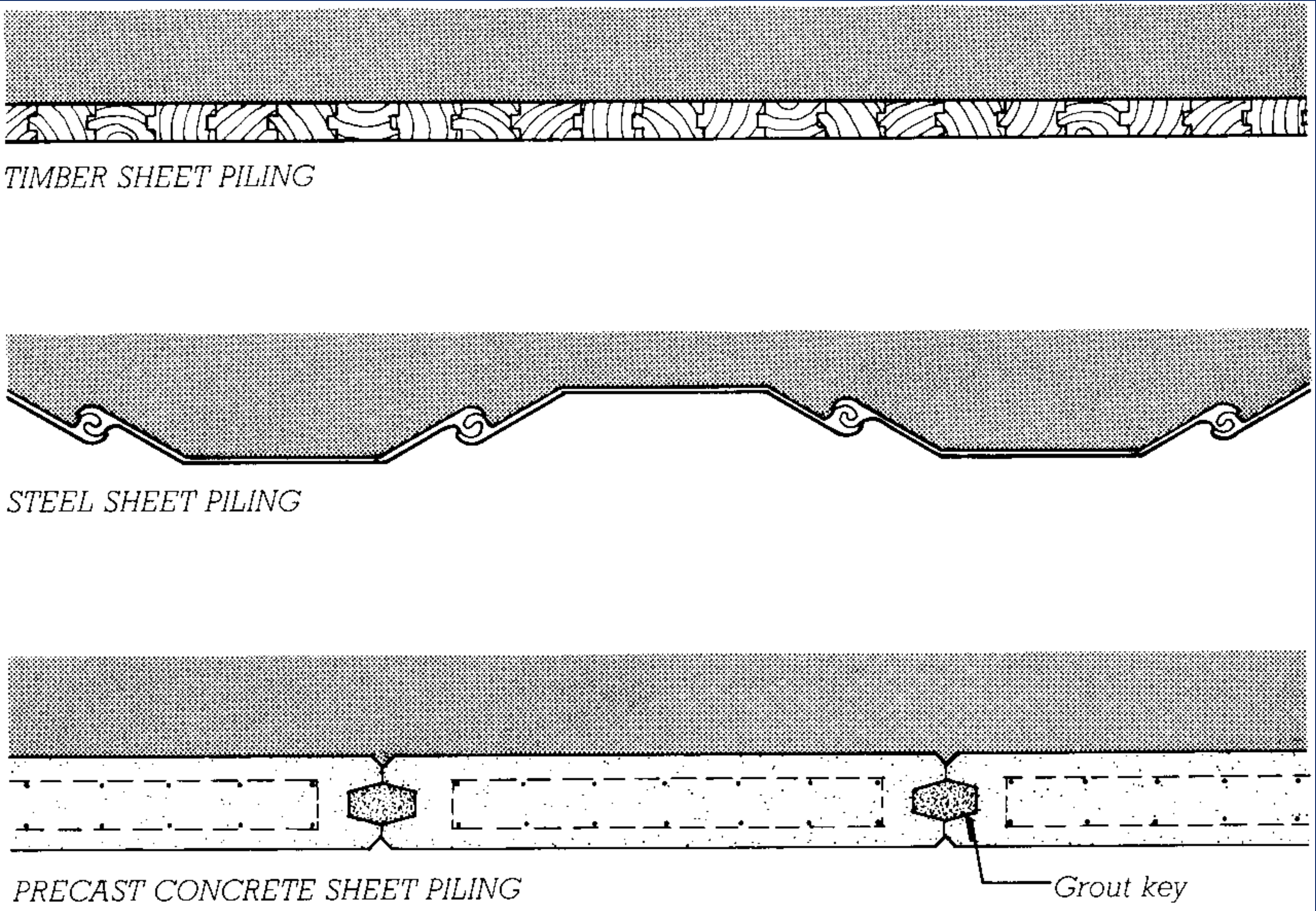
Solider beams and lagging

Excavation Support IV

Sheet piles

Excavation Support V

Sheet piles



Excavation Support VI

- Pneumatically applied concrete (shotcrete): excavation proceeds first and then the sloped sides are reinforced with a relatively stiff concrete mixture sprayed directly from a hose onto the soil.

Excavation Support VII

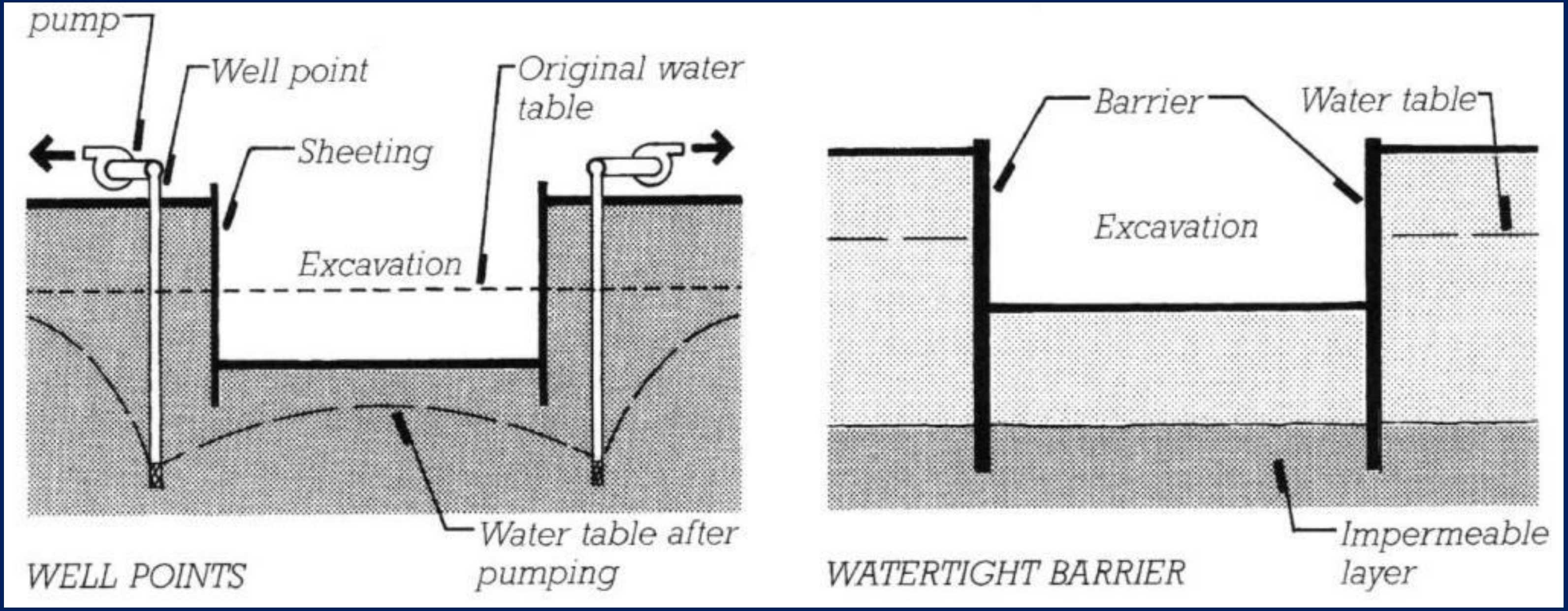
Slope support consisting of soldier beams and shotcrete braced by rakers, followed by waterproofing and cast in place concrete foundation wall

Excavation Support VIII

Soil mixed slope support, with soldier beams, walers, and tie backs

Dewatering I

- Simple: pump water from pits (*sumps)* in the excavation
- Higher volumes of water: use *well points* or *barrier wall*



Dewatering II

- Well points, header pipe, and dewatering pump

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Building Construction

2. Foundations

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Foundations

- The function of a foundation is to transfer the structural loads reliably from a building into the ground.
- A building foundation must support different kinds of loads:
  - Dead load
  - Live loads
  - Rain and snow loads
  - Wind loads
  - Seismic loads
  - Loads caused by soil and hydrostatic pressure

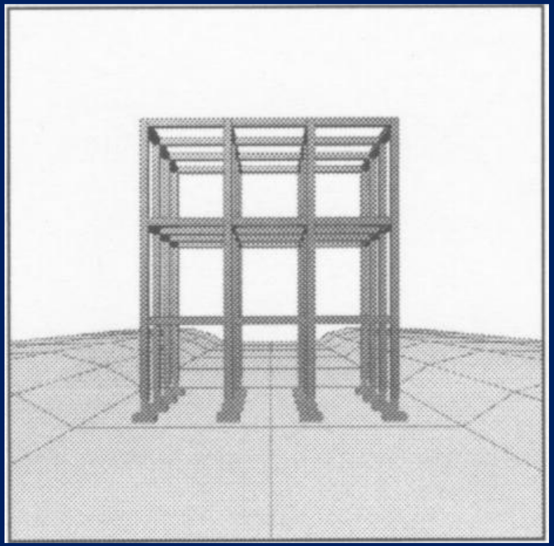
Foundation Requirements

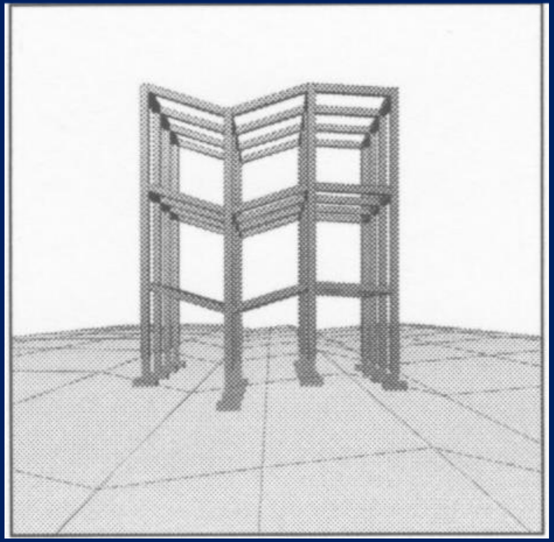
- Must transmit building loads to the rock or soil on which it rests
- Must not fail, resulting in building collapse
- Must not settle so much as to damage structure or impair function
- Must be economically and technically feasible, and without adverse affects on surrounding structures

July 2004 SAI building collapse, Manila, due to faulty foundation

Foundation Settlement

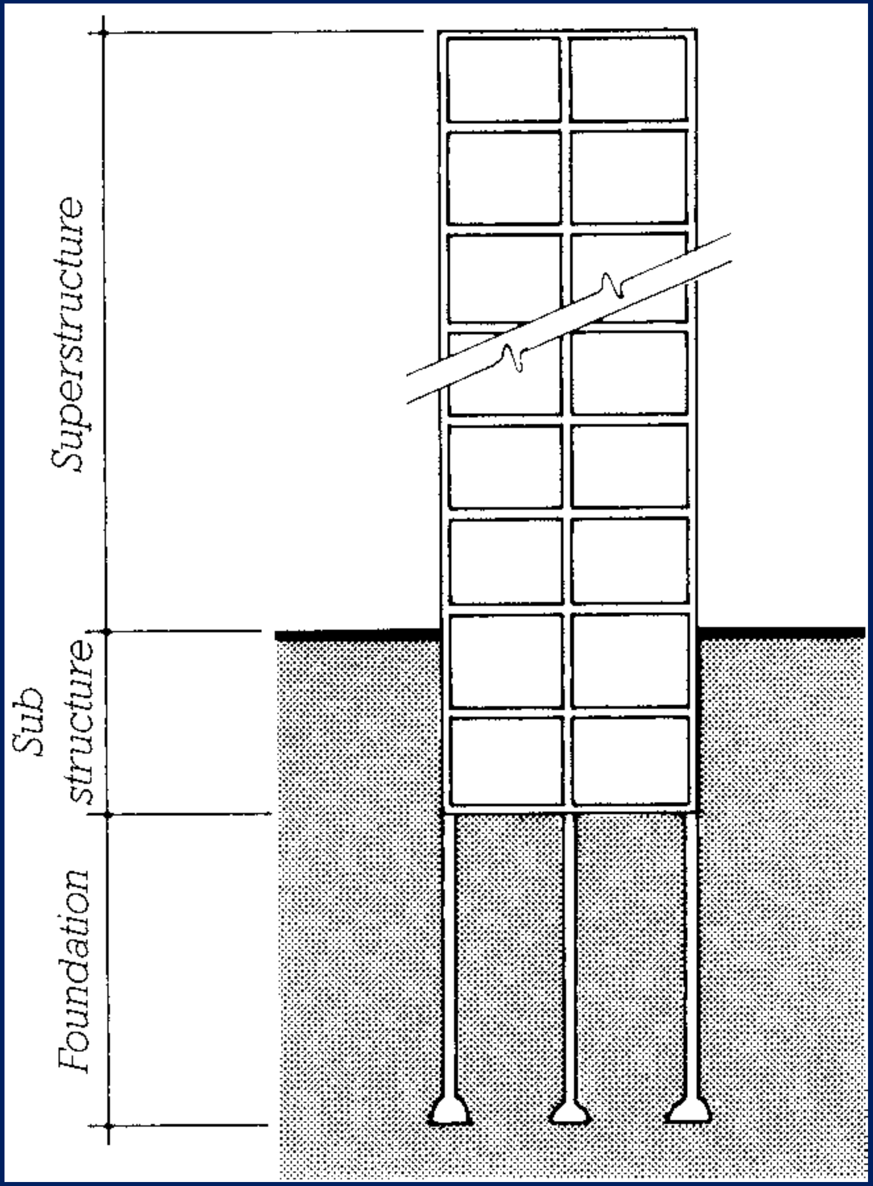
- All foundations settle to some extent as the earth materials around and beneath them adjust to the loads of the building
- Uniform settlement: May disrupt building services where they enter building, or damage elements, such as stairs and walks, at the building/site interface
- Differential settlement: May cause damage to finishes, cladding, and other components where building becomes distorted.





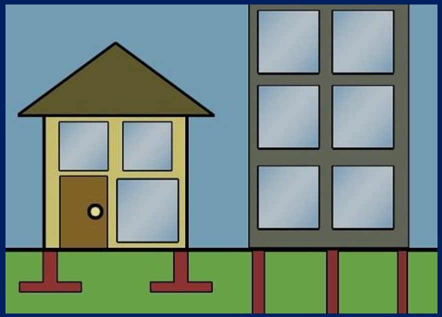
Building Components

- Buildings consist of three major parts:
  - Superstructure: The aboveground portion of the building
  - The substructure, which is the habitable below-ground portion;
  - Foundations: The components of the building that transfer its loads into the soil



Types of Foundations I

- Two basic types of foundations:
  - Shallow foundations: Transfer the load to the earth at the base of the column or wall of the substructure.
  - Deep foundations (either piles or caissons): penetrate through upper layers of incompetent soil in order to transfer the load to competent bearing soil or rock deeper within the earth.

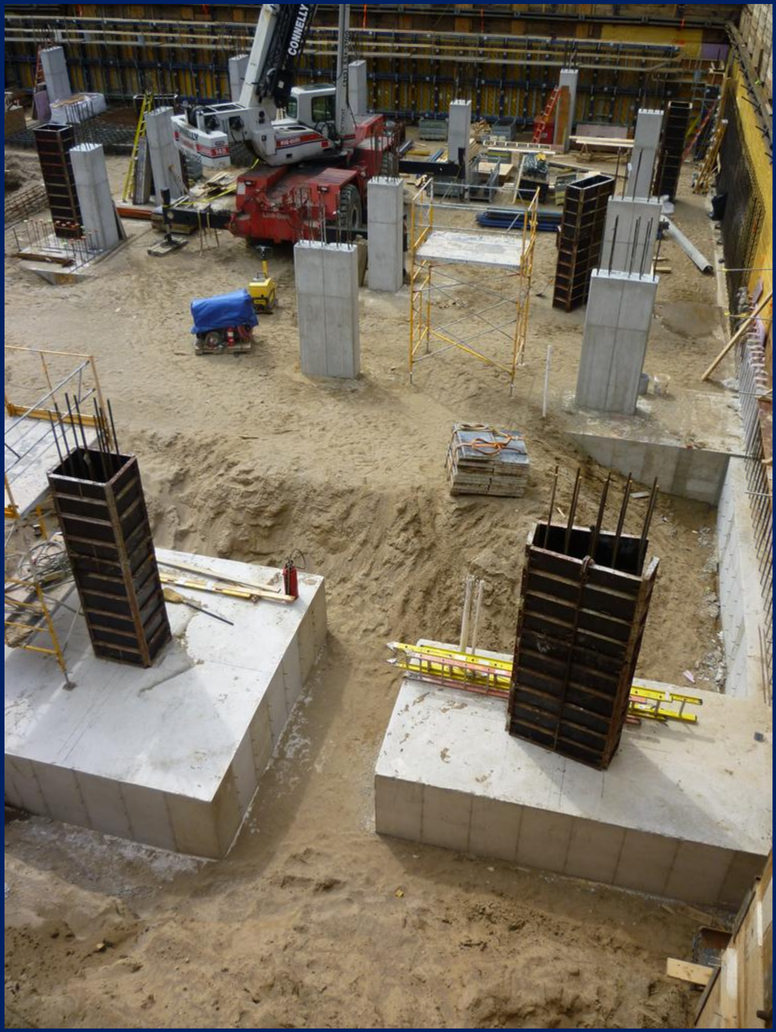


Types of Foundations II

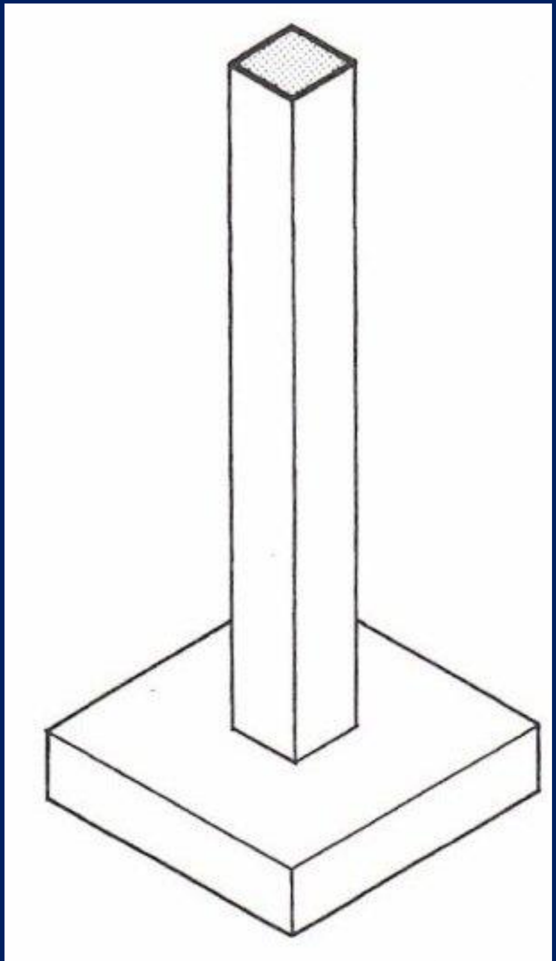
- The primary factors that affect the choice of a foundation type for a building:
  - Subsurface soil and groundwater conditions
  - Structural requirements, including foundation loads, building configurations, and depth
- Secondary factors:
  - Construction methods
  - Environmental factors
  - Building codes and regulations
  - Proximity of adjacent property and potential impacts on that property
  - Time available for construction
  - Construction risks

Shallow Foundations

- Column Footing
- Wall Footing (Strip Footing)
- Combined footing and cantilevered footing
- Mat or Raft foundation
- Floating Foundation

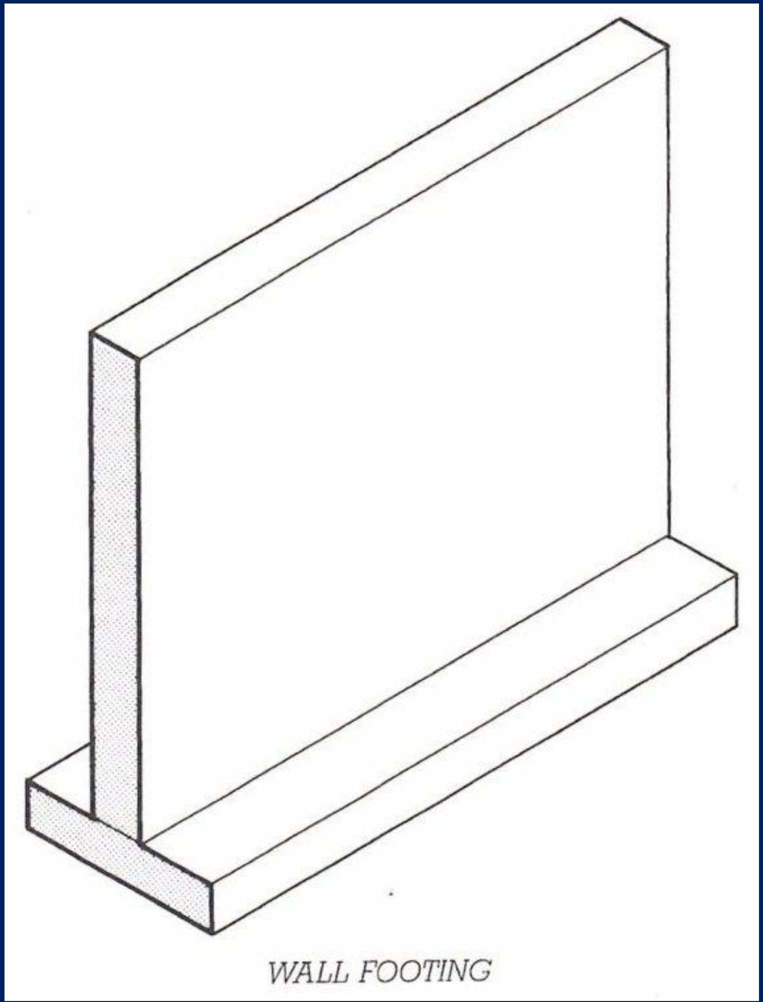


Column Footing



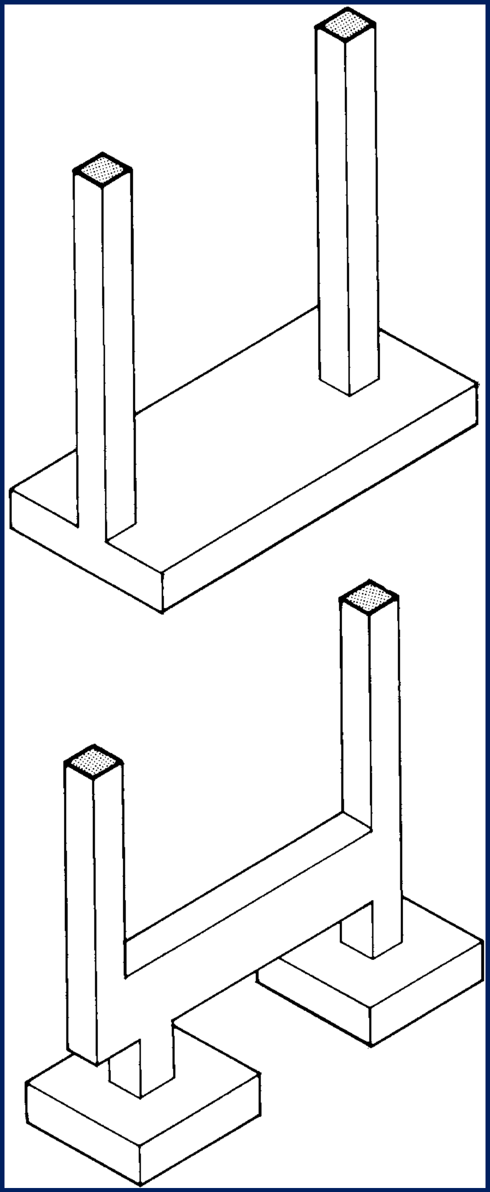
COLUMN FOOTING

Wall Footing (Strip Footing)



Combined and Cantilevered Footing

- Used when columns are on the border of a property line.
- By combining the foundation for the column against the property line, at the left, with the foundation for the next interior column to the right in a single structural unit, a balanced footing design can be achieved.

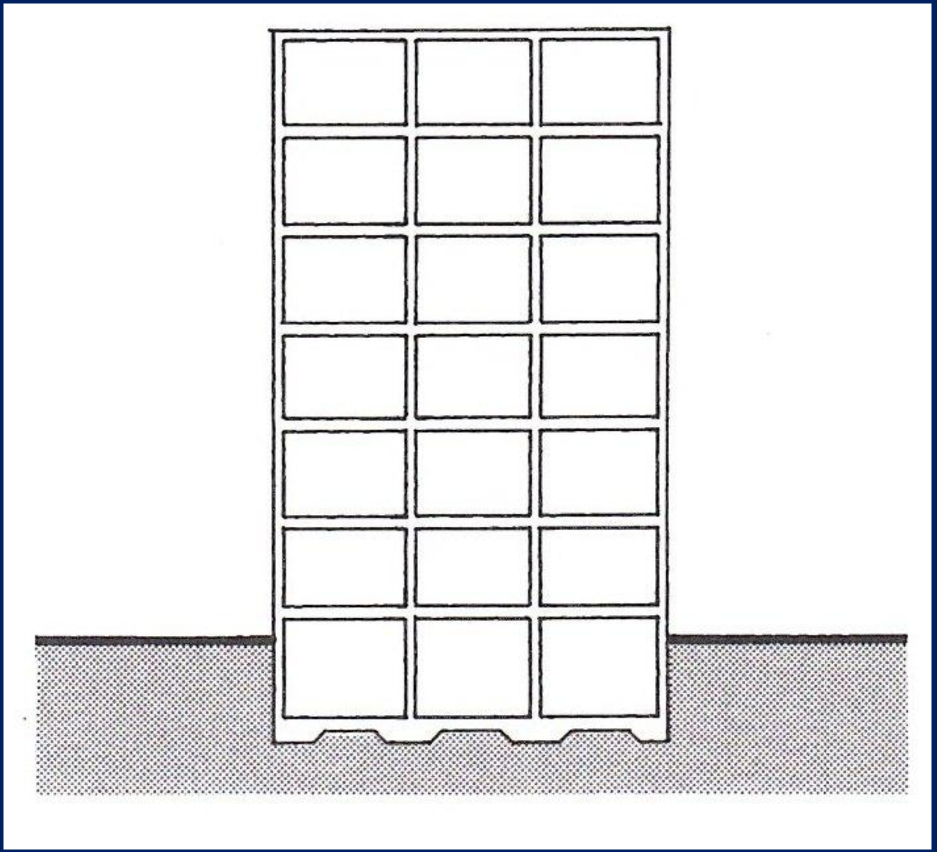


Mat or Raft Foundation

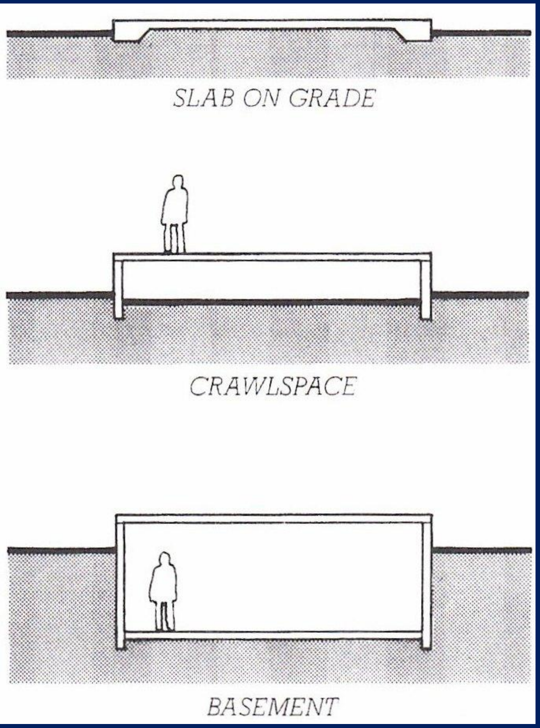
- Used when the allowable bearing capacity of the soil is low in relation to the weight of the building
- Mats for very tall buildings may be 6 feet (1.8 m) thick or more and are heavily reinforced

Floating Foundation

- Balances the weight of soil removed with the weight of building to be constructed
- The load on the remaining soil is little changed.

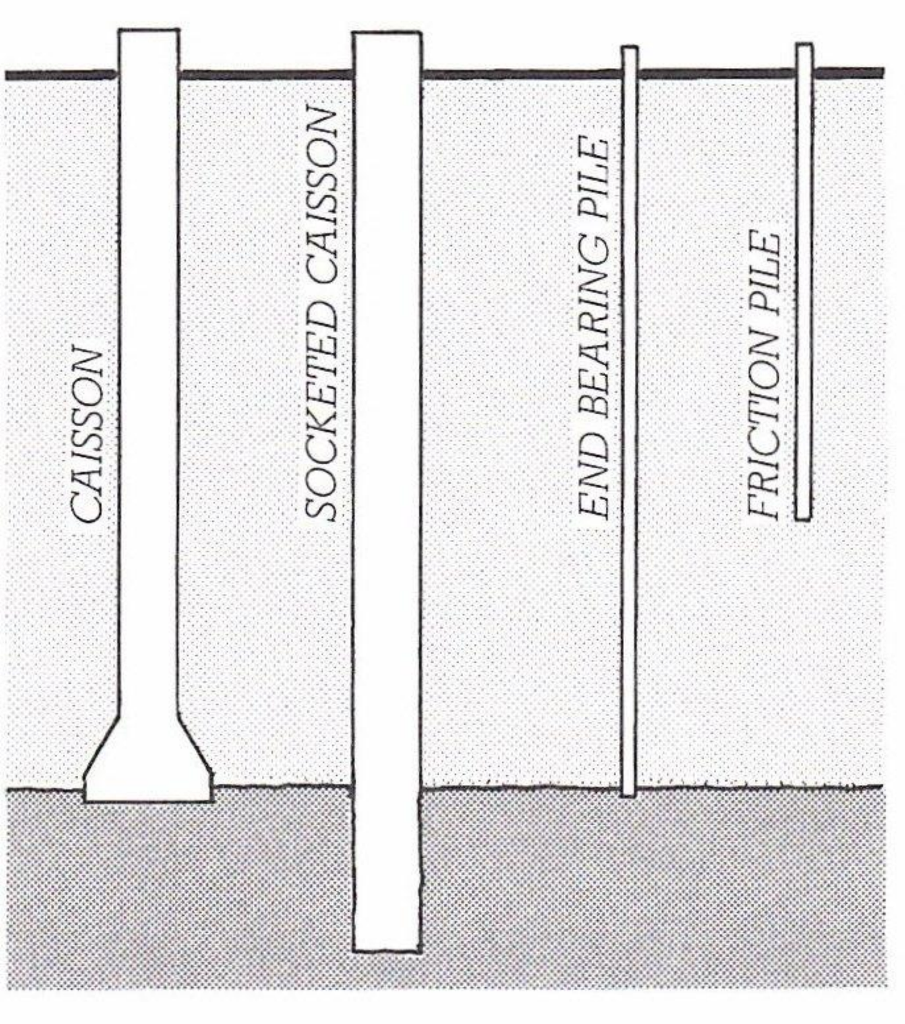


Slab on Grade, Crawlspace, and Basement



Deep Foundations

- Where the soils directly below the building substructure are weak or unstable, deep foundations transmit building loads to deeper, more competent, soils.
  - Caissons: Concrete cylinders poured into drilled holes
  - Piles: driven into the earth.



Piers (caissons): Drilled into earth

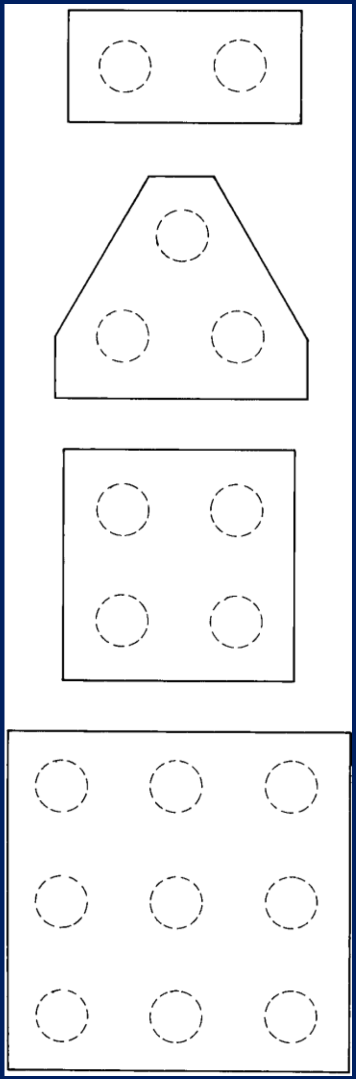
- Steel reinforcing is being lowered into the drilled hole. Once the reinforcing is positioned, concrete will be poured.

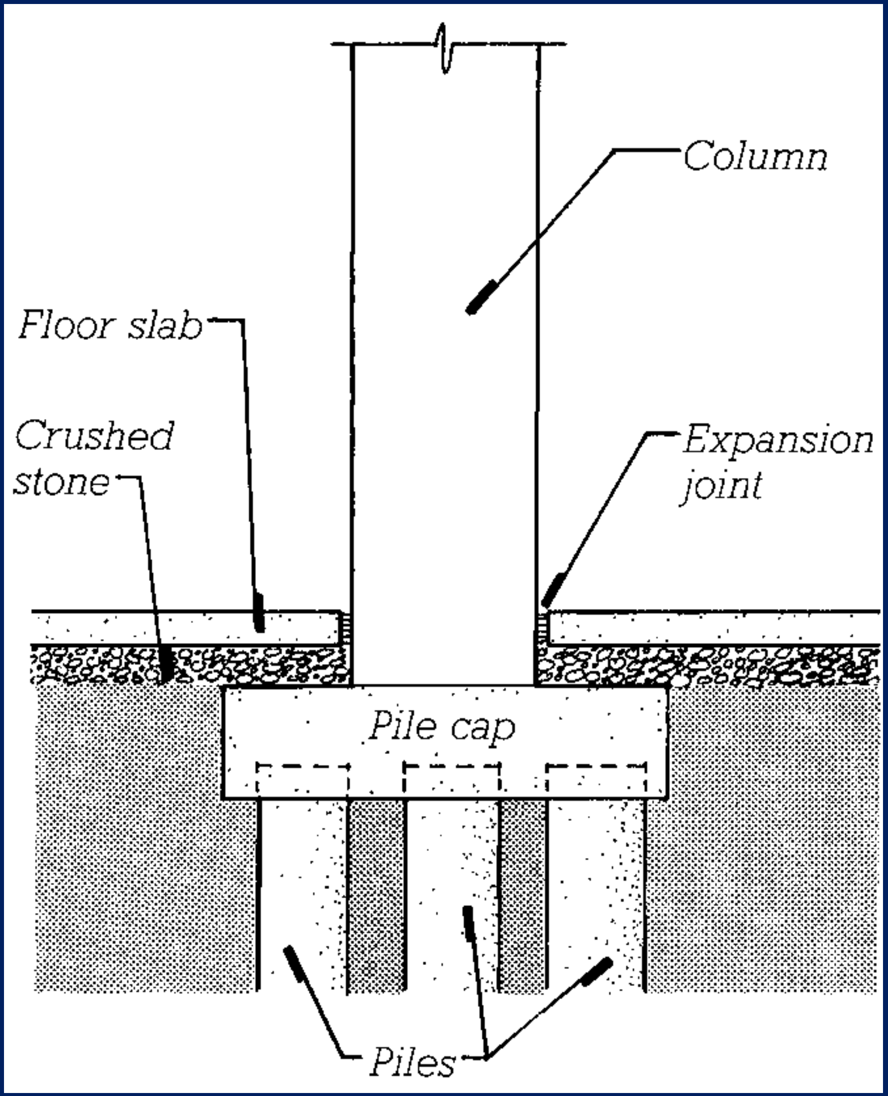
Piles: Driven into Earth

- A *pile is distinguished* from a caisson by being forcibly driven into the earth rather than drilled and poured
- May be made of steel, wood, or precast concrete (pictured here)

Piles

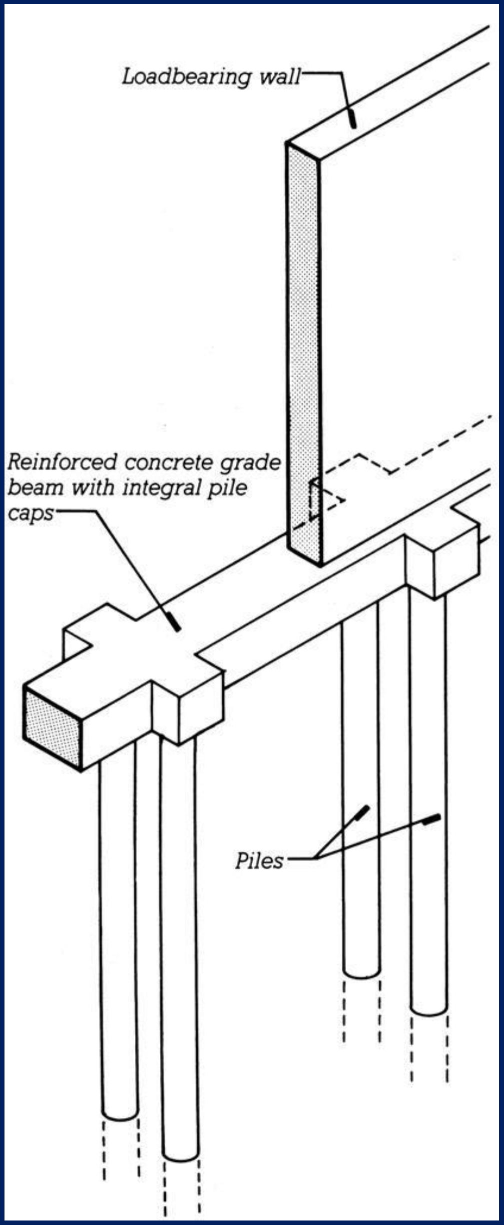
- Right: An elevation view of a pile cap, column, and floor slab.
- Left: Clusters of two, three, four, and nine piles with their concrete caps, viewed from above.





Piles and Grade Beam

- *Pile caps* share loads among clustered piles.
- A *grade beam* spans between the piles to provide continuous support for the wall above.



Drilled Piers and Grade Beams

- Reinforcing bars project from the tops of completed drilled piers. Gravel is being deposited between the piers, to form a base for concrete grade beams which will span between the piers.

Waterproofing & Drainage

- To ensure a substructure’s resistance to water entry, two approaches are used:
  - **Drainage**: draws groundwater away from a foundation, reducing the volume and pressure of water acting on the foundation’s walls and slabs.
  - **Waterproofing**. Acts as a barrier, stopping water that reaches the foundation from passing though to the interior.

Dampproofing & Waterproofing I

- Dampproofing : The spray of asphaltic layer on the foundation or basement wall.
  - Less expensive and less resistant to water passage than true waterproofing, and used where groundwater conditions are mild or waterproofing requirements are not critical

Dampproofing & Waterproofing II

- Waterproofing: Materials are resistant to hydrostatic pressure.
  - Includes a sprayed sealer that is covered with a membrane that waterproofs the wall.
  - It can prevent the passage of water even under conditions of hydrostatic pressure
  - Waterproof membranes are most commonly formulated from plastics, asphalt compounds, or synthetic rubbers

Drainage I

- Drainage mat and free-draining backfill material allow ground water to flow away from the substructure.
- The machine in the foreground is used to compact the fill material as it is placed in *lifts* roughly 6 inches deep at a time.

Drainage II

- Perforated piping conducts water away from the substructure.
- Filter fabric “socks” cover the piping to prevent soil particles from accumulating in and eventually clogging the pipes.
- The upturned elbow will be connected to a *cleanout* fitting at grade that permits future snaking of the piping to remove blockages if needed.

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Building ConstructionI

4. Making and Placing Concrete

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Content

- Concrete Quality
- Concrete Strength
- Water-Cement Ratio
- Mixing Concrete
- Testing Concrete
- Placing Concrete
- Consolidating Concrete
- Curing Concrete
- Formwork

Concrete Quality I

- Workability*:* Ease of placing, consolidating, and finishing wet concrete
- Structural properties when hardened: Strength, stiffness, durability
- Many other important properties:
  - Rate of early strength gain
  - Degree of shrinkage during curing
  - Flatness, for slabs and paving
  - Surface hardness, for industrial slabs
  - Porosity
  - Density
  - Surface appearance, for architectural concrete

Concrete Quality II

- Resistance to freeze/thaw and weather, for exterior concrete
- Watertightness, for dams, tanks, exterior walls

Concrete Quality III

- The rules for making high-quality concrete:
  - Use clean, sound ingredients
  - Mix ingredients in the correct proportions;
  - Handle the wet concrete properly to avoid segregating its ingredients
  - Cure the concrete carefully under controlled conditions

Concrete Strength I

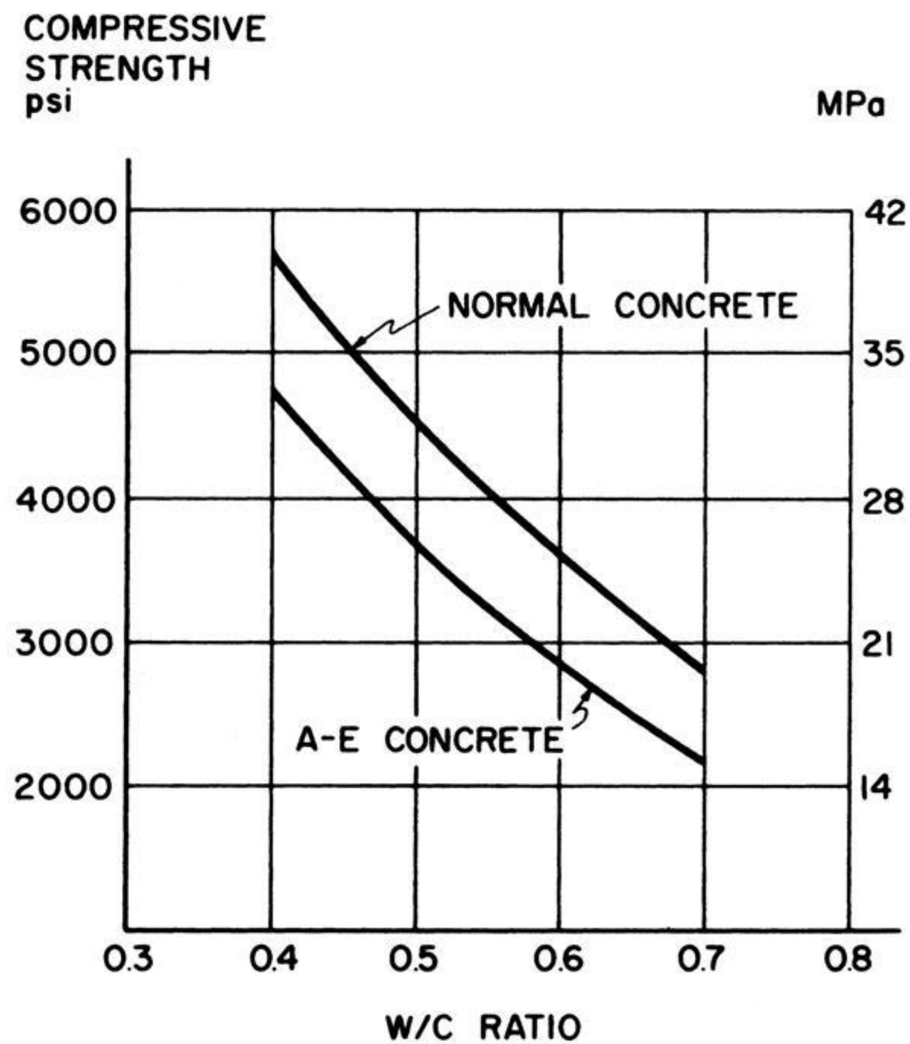
- Concrete strength varies with design of the concrete mix.
- Normal strength concrete
  - Up to 6000 psi (421.8 kg/cm^2) compressive strength
  - Made with conventional ingredients
- High-strength concrete
  - Greater than 6000 psi to roughly 20,000 psi (421.8-1406 kg/cm^2)
  - Supplementary cementitious materials are required to reach higher strengths
  - Lower water content is required for higher strength
    - Water reducing admixtures or high-range water reducing admixtures (superplasticizers) are used to improve workability.

Concrete Strength II

- Specially formulated, ultra-high performance concretes: have compressive strengths as high as 30,000 psi. (2109 kg/cm^2)
- Why use higher-strength concrete:
  - Reduce column dimensions in tall buildings
  - Achieve higher earlier strength, allowing construction to proceed more quickly
  - Satisfy more strict structural requirements
- The *water-cement ratio* (*w/c ratio*) is the most important determinant of concrete strength.

Water-Cement Ratio

- Lowering the proportion of water to cement:
  - Increases concrete strength and durability
  - Decreases workability
  - Increases cost
- W/C ratio is measured by weight, not volume.
- When supplementary cementitious materials are added to the mix, the ratio is measured as the *water-cementitious materials ratio.*



Mixing Concrete

- Most concrete is prepared at batch plants and delivered to the construction site in *transit-mix (ready mix) trucks*.
- The concrete ingredients are mixed in the rotating drum of the truck so that the concrete is ready to pour on arrival at the construction site.
- Smaller batches of concrete may be prepared on site by hand or with the aid of portable power mixers.

Testing Concrete I

- **Slump Test:**
  - The slump test provides a rough measure of the workability of concrete while wet.
  - Concrete is placed into a conical cylinder; the cylinder is removed, and the loss in height of the concrete mass is measured.
    - Concrete with too low slump may be difficult to place.
    - Concrete with too high slump may have had too much water added.
  - Slump tests are performed on batches of concrete as they arrive on the concrete site.

Testing Concrete II

- **Slump Test:**
  - Specified maximum slump is usually in the range of 3 to 5 inches.

Testing Concrete III

- **Strength Test Cylinders**
  - Test cylinders may be cast from each batch of concrete delivered to the construction site.
    - The most common cylinder size is 6 in. diameter x 12 in. high.
    - Concrete is placed in a cylindrical mold and consolidated to eliminate voids.
  - Cylinders are returned to the laboratory, cured under controlled conditions, and then strength-tested at appropriate times. Test results for laboratory-cured cylinders verify the quality of the concrete as delivered to the site.

Testing Concrete IV

- **Strength Test Cylinders**
  - Cylinders can also be cured on site in conditions similar to that for the cast concrete. Results from these tests can be used to determine when it is safe to remove formwork or subject cast concrete to construction loads.

Placing Concrete I

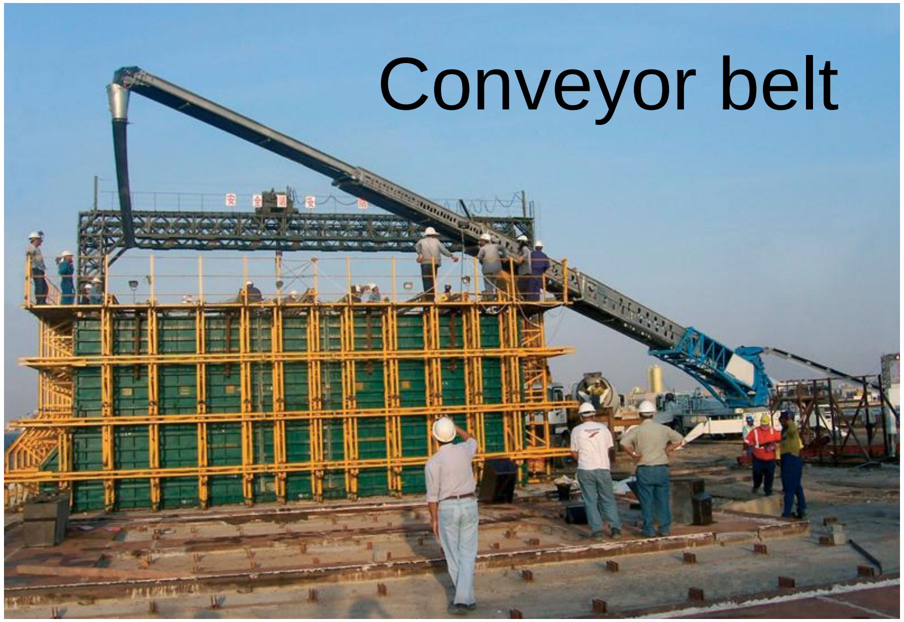
- Avoid delays, during which concrete can stiffen and become difficult to place.
  - Depending on conditions, concrete can be placed up to 90 minutes after mixing commences.
- Concrete that does stiffen can have water added prior to placing, provided that:
  - Maximum w/c ratio is not exceeded
  - Maximum slump is not exceeded
  - Agitation limits are not exceeded

Placing Concrete II

- Concrete may be placed on site :
  - Directly from the discharge chute of a transit-mix truck,
  - Wheelbarrows,
  - Power buggies,
  - Crane-lifted buckets *(right)*,
  - Conveyor belts,
  - Concrete pumps

Placing Concrete III

Concrete pump


Conveyor belt

Placing Concrete IV

- *Segregation,* separation of large aggregate from the finer portions of the mix, must be avoided.
  - Place concrete as close to final position as possible.
  - Do not push concrete over large horizontal distances.
  - Avoid dropping concrete from high heights or discharging against obstacles (use *drop chutes* if needed).
  - Avoid excessive vibration

Consolidating Concrete I

- Consolidation (Compaction): The elimination of voids and air pockets within the concrete pour.
  - Consolidation is especially critical with stiff concrete mixes or when concrete is placed around densely packed reinforcing arrays
  - Over-consolidation must be avoided, as it can lead to segregation of aggregate
- Consolidation methods:
  - Hand *rodding* or *tamping*
  - *Screeding*
  - Internal vibration
  - External vibration

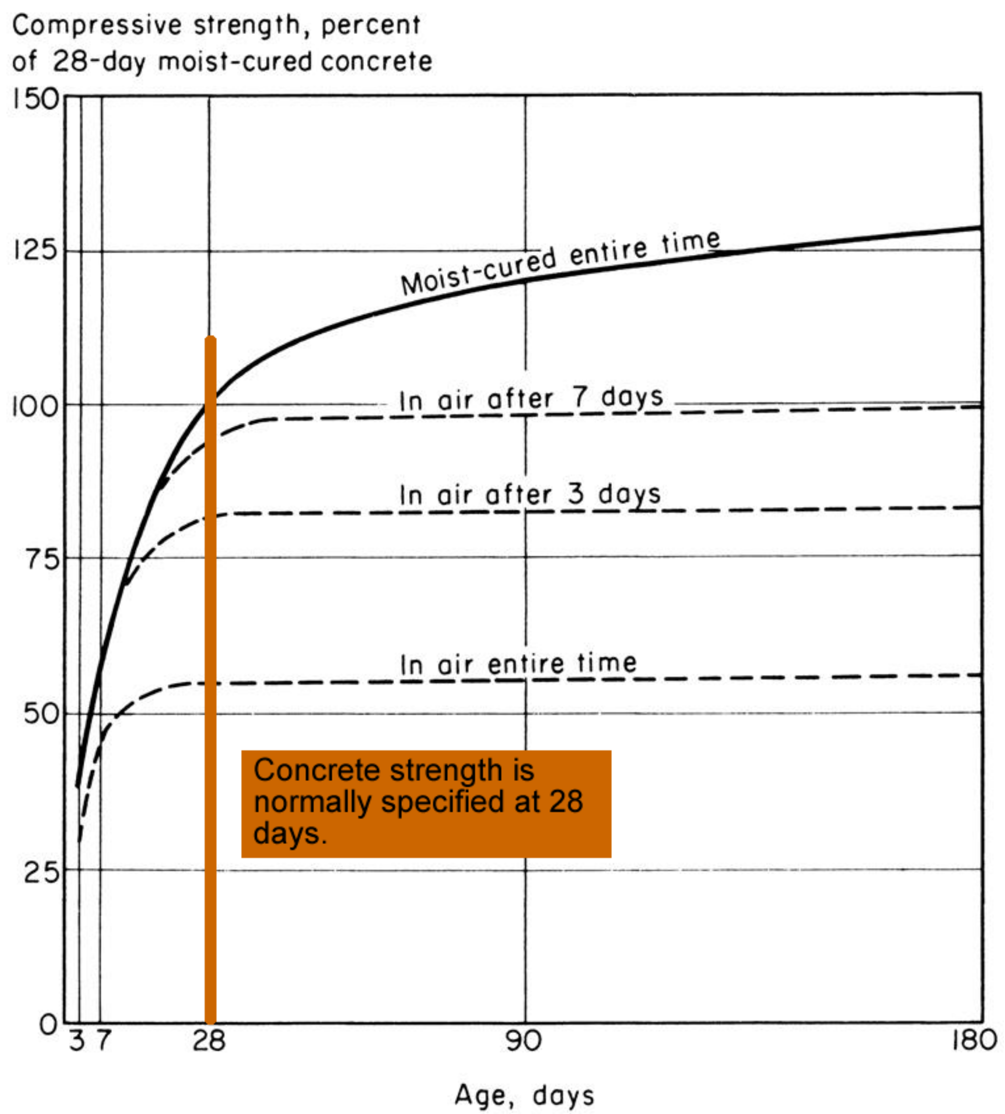
Consolidating Concrete II

Curing Concrete I

- Concrete hardens by *hydration (* the chemical bonding of water and cement
  - If concrete dries out prematurely, the hydration process stops and maximum strength is not achieved
  - Hydration, along with increasing strength and durability, can continue for a very long time, even years. Concrete strength is normally specified at 28 days
- In very hot or cold weather, steps may be taken to moderate the temperature of the concrete, such as pre-heating of ingredients, adding water as ice, or the use of retarders or accelerators to adjust cure rate.

Curing Concrete II

- Exposed surfaces of newly poured concrete must be protected from evaporation and drying.
  - Concrete may be regularly misted,
  - Covered with moisture-retaining materials, or
  - Treated with a chemical surface sealer (curing compound)



Formwork I

- *Formwork:* usually temporary, to hold freshly poured concrete in the desired shape until the concrete achieves sufficient strength to support itself.
- Formwork also frequently helps to protect newly poured concrete from drying too quickly.

Formwork II

- Formwork must be strong and stiff enough to support the weight and fluid pressure of the concrete.
- In conventional concrete construction, formwork can account for half or more of total concrete construction costs.
- Formwork is usually made of braced panels of wood, metal, or plastic.
- Form release compounds: Oils, waxes, or plastic coatings applied to formwork surfaces to prevent adhesion of the formwork to the concrete and ease formwork removal.

Sitecasting vs. Precasting

- Precasting:
  - A process in which concrete is cast into reusable forms at an industrial plant.
  - Rigid, fully cured structural units from the plant are then transported to the job site
- Sitecasting,
  - Also called cast-in-place construction,
  - A process in which concrete is poured into forms that are erected on the job site.

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Building Construction

9 – Stone Masonry

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Stone Masonry

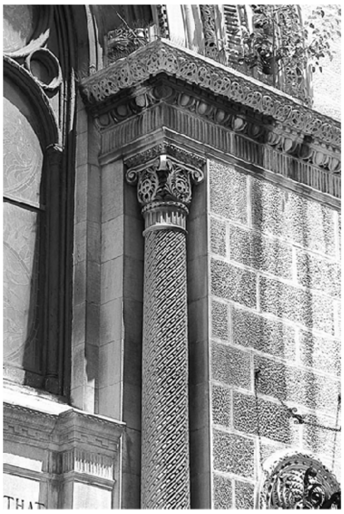
- Rock
  - The portion of the earth's crust having no definite shape and structure
- Stone:
  - Natural, hard substance formed from minerals and earth material which are present in rocks
- Stone Masonry
  - Building stones obtained by quarrying from the rocky strata of earth and reducing it to the required shapes and sizes for construction

Stone as a Construction Material I

- To qualify as a construction material, stone should have the following qualities:
  - Strength:
    - Most types of stone have more than adequate compressive strength.
  - Hardness:
    - Important when stone is used for flooring, paving, and stair treads.
  - Durability: Resistance to the weathering effects of rain, wind, heat, and frost action
    - Necessary for exterior stonework

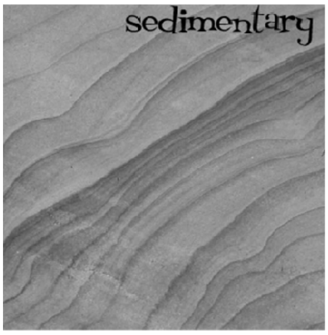
Stone as a Construction Material II

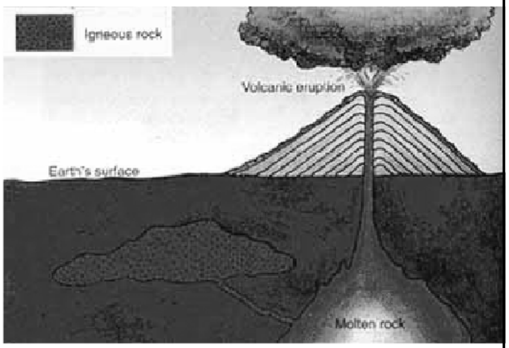
- Workability:
  - A stone’s hardness and grain texture must allow it to be quarried, cut and shaped
- Density:
  - A stone’s porosity affects its ability to withstand frost action and staining
- Appearance:
  - Appearance factors include color, grain, and texture



Geologic Stone Types I

- Igneous rock: Formed by the crystallization of molten magma. (e.g. granite)
- Sedimentary rock: Formed by the deposition of sediment by wind and water. (e.g. limestone, sandstone, and shale)





Geologic Stone Types II

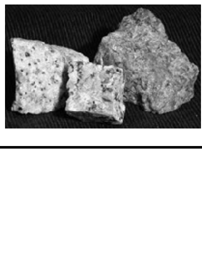
- Metamorphic rocks has undergone a change in structure, texture, or composition due to the natural agencies, as heat and pressure, especially when the rock becomes harder and more crystalline, as marble and slate
  - Formerly igneous or sedimentary rock transformed by heat and pressure

Building Stone Classification

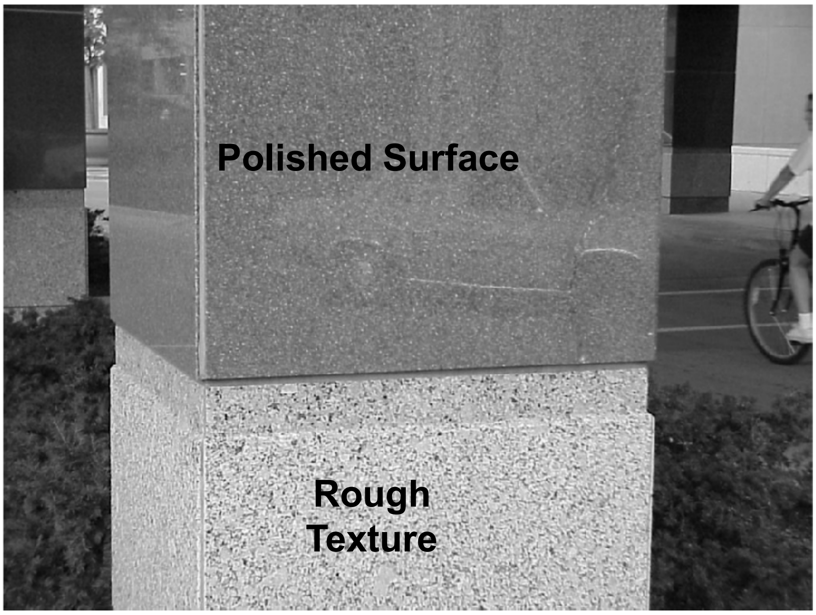
- Granite
- Limestone
- Marble
- Sandstone
- Slate
- Travertine
- Basalt
- Serpentine

Granite I

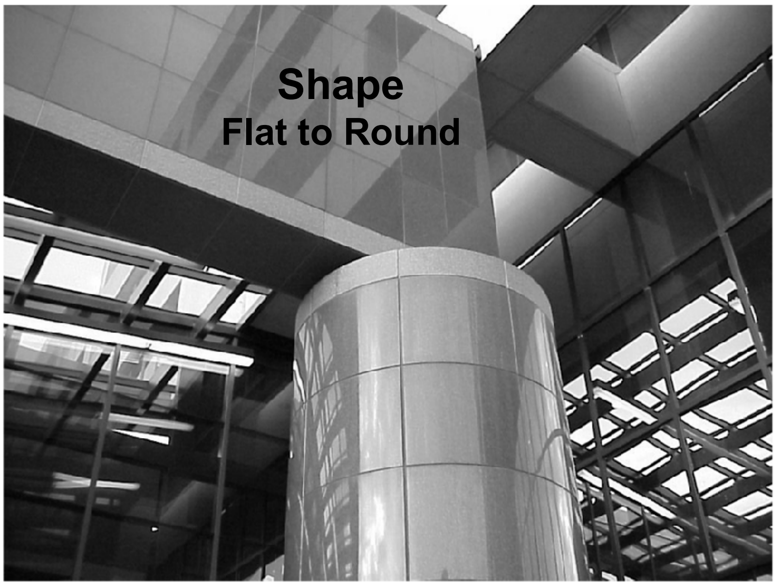
- Igneous rock
- Mixture of mineral crystals; principally feldspar, quartz
- Nonporous, strong, durable
- Suitable for exposure to severe weathering, ground contact
- Many colors (Red, pink, yellow, green, blue, white and brown)
- Can accept many finishes, including polished
- Used for:
  – Flooring, wall paneling, column facing, stair threads



Granite II



Granite III



Limestone I

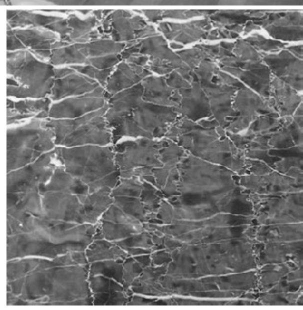
- Sedimentary rock
- Calcium carbonates (oolitic limestone) and magnesium carbonates (dolomitic limestone)
- Strength and porosity vary with density (Generally High compressive & tensile strength)
- Smooth, uniform in structure & composition (no cleavage lines)
- Colors from white, to gray, to red
- Normally has a textured finish; only a few types can be polished
- Used for wall & floor surfaces

Limestone II

Limestone III

Marble I

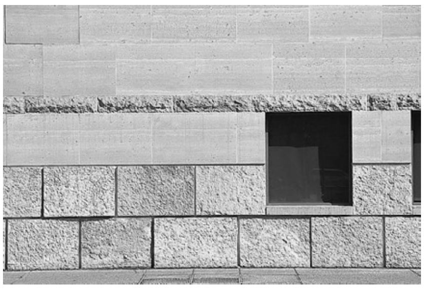
- Metamorphic rock
- Recrystallized limestone
- Varies greatly in its physical properties and appearance
- Many colors, frequently with extensive veining
- Easily polished
- This group also includes other stone types that can take a high polish but are not true geologic marbles: limestone marble, onyx marble, serpentine marble, etc.
- Used for: flooring, wall & column facing



Marble II

Sandstone

- Sedimentary rock
- class of rock of cemented silica
- Sandstone: from quartz deposits
- Grains with texture ranging from very fine to very coarse
- Varies in density and porosity (Generally Porous)
- Cannot be polished
- Color is often light, but may vary significantly with types of materials that bind the quartz particles



Slate I

- Metamorphosis of clays and shale's (mineral clays) deposited in layers
- Dense, hard, nonabsorbent
- Closely spaced planes of cleavage (May be separated into thin, tough sheets called *slates*)
- Variety of colors (black, green red, grey, or purple)
- Used for:
  – Flooring
  – window sills
  – Stair treads & facing

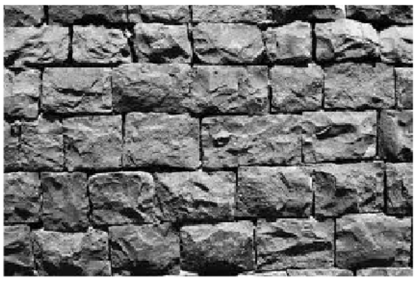
Slate II

Travertine

- Sedimentary rock
- Partially-crystallized, patterned calcite
- Chemically similar to limestone
- pleasing texture with small natural pockets on a cut surface
- Similar to marble in its physical properties
- Used for interior decorative stone

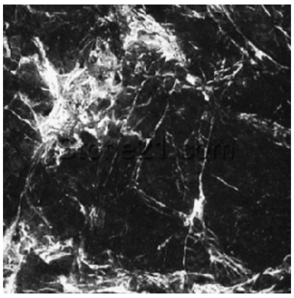
Basalt

- Igneous rock
- Color ranges from gray to black
- used mainly for paving stones and retaining walls



Serpentine

- Metamorphic rock rock
- Main ingredient is serpentine;
- color ranges from olive green to greenish black, is fine grained and dense
- Serpentine stone takes a high polish but can crack easily
- Serpentine often contains some asbestos. Exposure to asbestos fibers has potential human-health consequences.



Quarrying I

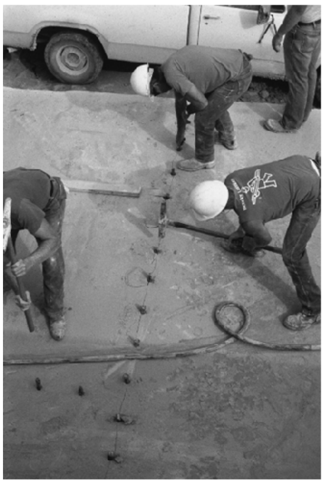
Quarrying (limestone)

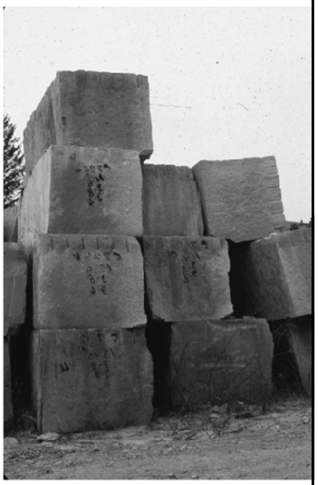
- A long-bladed diamond saw, traveling on rails, makes deep, long cuts into the solid rock.
- Closely-spaced horizontal holes are drilled into the vertical face of the rock to create a plane of weakness near the bottom of the saw cuts (not shown).
- Rubber bladders are inserted into the saw kerfs and inflated, causing the large slabs to fall away from the solid rock.

Quarrying II

Quarrying (cont.)

- Steel wedges are driven into the separated slab, to cause it to split into smaller blocks.
- Blocks are labeled and stacked, ready for transporting to the mill.





Milling Operations I

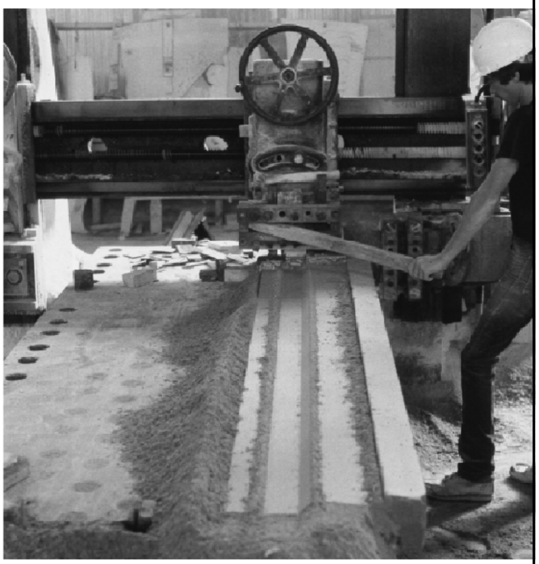
- Bandsawing
- Circular sawing

Milling Operations II

- Hand carving

Milling Operations III

- Planing
- And a variety of other shaping and surface finishing operations



Ways to Select Stone

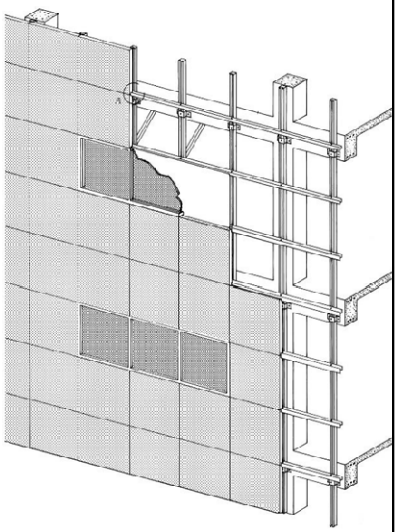
- Past history can be a good predictor of future performance in similar applications and environments.
- *Petrographic* analysis: Microscopic analysis of mineral content and structure
- Laboratory Testing: Water absorption, density, compressive strength, dimensional stability, freeze-thaw resistance, chemical resistance, flexural strength, etc.

	Water Absorption by Weight, Maximum	Density, Minimum	Compressive Strength, Minimum	Modulus of Rupture, Minimum	Flexural Strength, Minimum
Granite ASTM C615	0.40%	160 lb/ft^3 *2560 kg/m^3*	19,000 psi *131 MPa*	1500 psi *10.34 MPa*	1200 psi *8.27 MPa*
Limestone ASTM C568	3–12%	110–160 lb/ft^3 *1760–2560 kg/m^3*	1800–8000 psi *12–55 MPa*	400–1000 psi *2.9–6.9 MPa*	
Sandstone ASTM C616	1–8%	125–160 lb/ft^3 *2003–2560 kg/m^3*	4000–20,000 psi *27.6–137.9 MPA*	350–2000 psi *2.4–13.9 MPa*	
Marble ASTM C503	0.20%	144–162 lb/ft^3 *2305–2595 kg/m^3*	7500 psi *52 MPa*	1000 psi *7 MPa*	1000 psi *7 MPa*

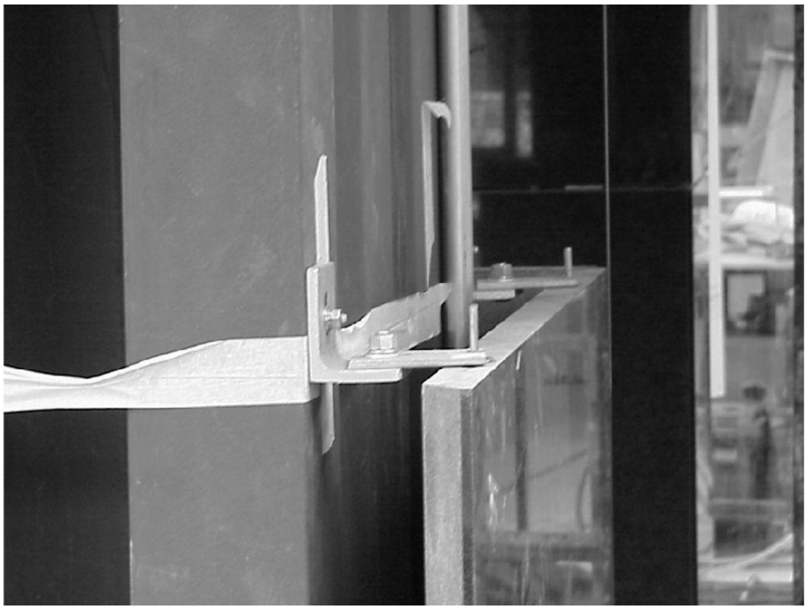
Stone Construction Methods I

Stone Cladding, Stone Curtain Wall

- Stone panels mechanically attached to building frame
- Attachment system carries the weight of the panels
- Thin slabs of stone cut to dimension and thickness to cover back up walls and provide finished exterior



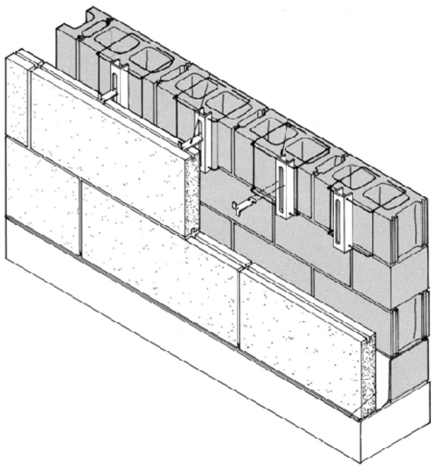
Stone Construction Methods II



Stone Construction Methods III

Stone Masonry

- Stones carry their own weight.
- Most commonly set in mortar, like brick or CMU
- May also be *dry set*, stacked without mortar (below), or set on shims with sealant-filled joints
- Right: Stone blocks carry gravity loads. CMU wall with anchors provides lateral support.

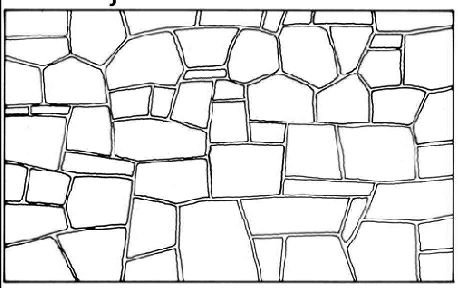


Stone Masonry Patterns

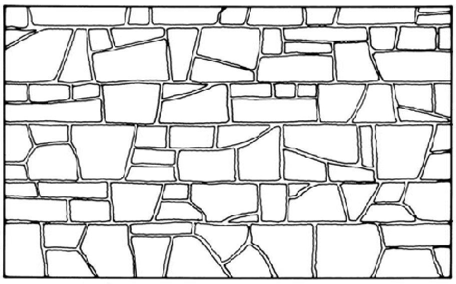
- Rubble (Unsquare pieces)
- Ashlar (Square Pieces)
- Dimension Stone:

Rubble Stone I

- *Rubble*: Unsquared stone blocks
  - *Random:* Laid without continuous horizontal joints
  - *Coursed:* Laid with continuous horizontal joints



Random Rubble



Coursed Rubble

Rubble Stone II

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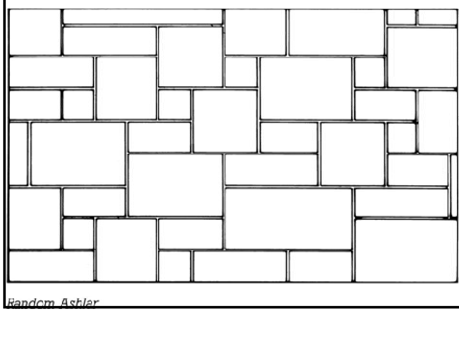
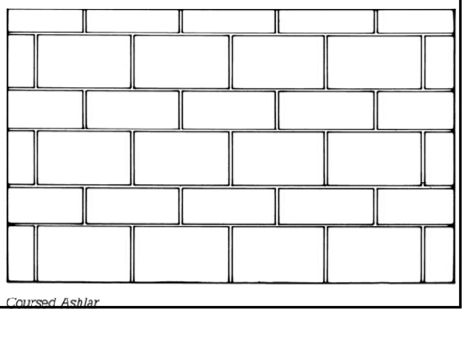
Ashlars I

- *Ashlar:* Squared blocks
  - *Random:* Laid without continuous horizontal joints
  - *Coursed:* Laid with continuous horizontal joints

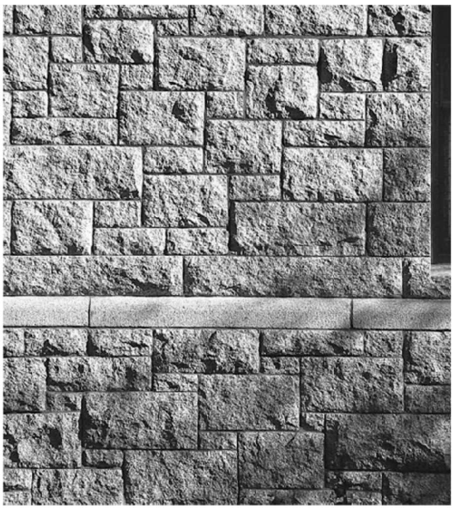


Random Ashlar



Coursed Ashlar

Ashlars II



Dimension Stone I

- Dimension Stone: is squared stone cut to specific width and/or length and of specified thickness, used commonly for wall panels, lintels and flooring.

Dimension Stone II

Stone Finish I

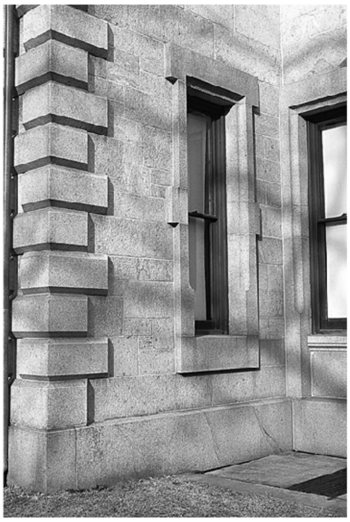
- **Rusticated - A term describing stone masonry with a recessed cut margin, so a channel is formed when the blocks are aligned**

Stone Finish II

- **Sand Finish - A stone finish that is granular and moderately smooth, varying with the characteristics of the specific stone**

Stone Finish III

- **Sawn Face - A term describing stone exhibiting the marks left by the saw used to cut it**

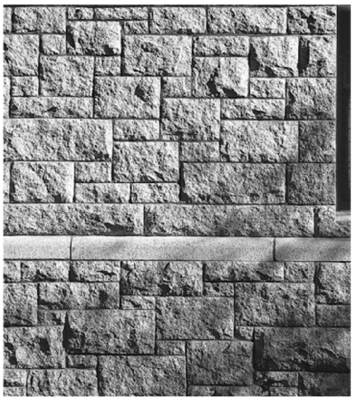


Stone Finish IV

- **Rock Face - A stone finish with emphasized face-plane shifts and rough corners, exaggerating the natural look of the stone**

Stone Finish V

- **Split Face - A stone finish exhibiting the natural quarry texture resulting from splitting the stone**



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Building Construction

11 – Concrete Masonry

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Concrete Masonry Units (CMUs)

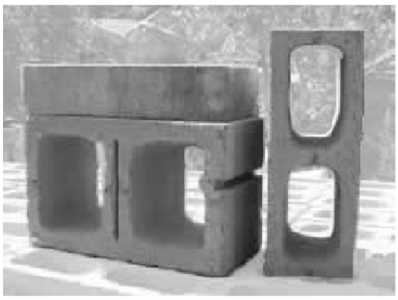
- Precast Concrete Masonry Blocks: Manufactured by vibrating a stiff concrete mixture into metal molds, immediately turning it out wet onto a rack (so that the mold can be reused immediately) at a rate of 1000 or more units per hour –
- Racks are cured at an accelerated rate by subjecting them to steam, either at the atmospheric pressure or for faster curing at higher pressure. After the units are steam cured, the units are dried to a specific moisture content, and bundled in wooded crates for shipping to the construction site

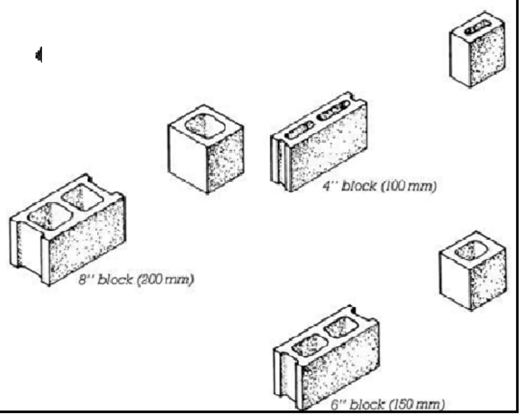
Concrete Masonry Units (CMUs)

- Steam curing in autoclaves accelerates curing

Concrete Masonry Units (CMUs) III

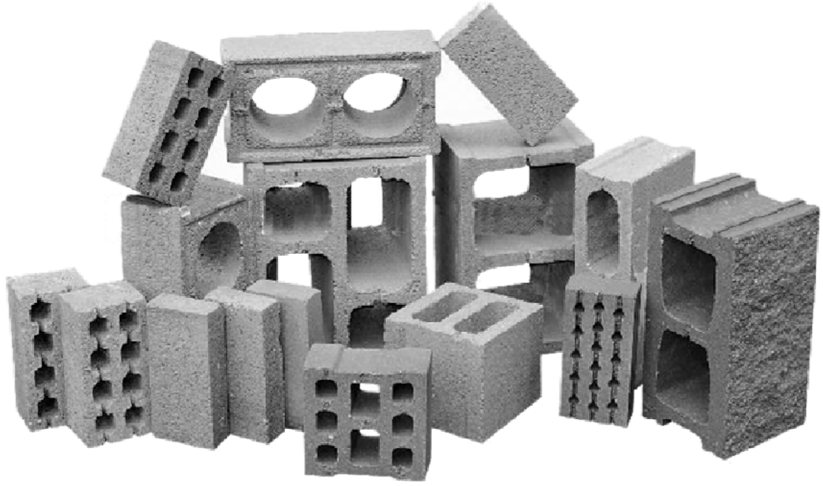
- Made in varying sizes and shapes:
  - Standard hollow blocks Standard nominal size: 8" x 8" x 16"
  - Actual size is 3/8-inch less in each dimension.





Concrete Masonry Units (CMUs) IV

- Can be manufactured in a great variety of shapes and sizes



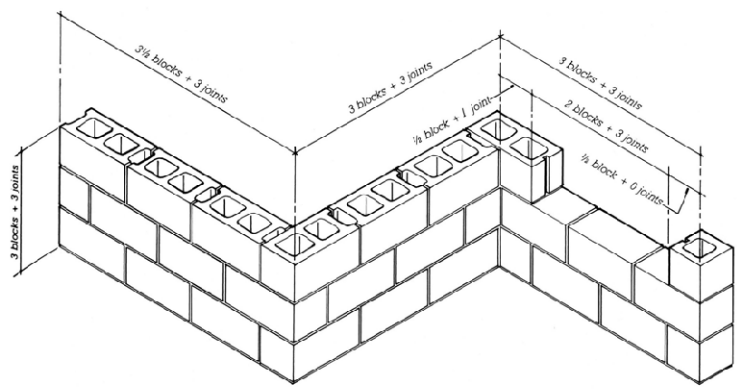
CMU Weight Classifications

- Lighter weight blocks
  - Less expensive to transport and lay
  - Lower thermal conductivity: higher fire-resistance rating and potentially better building envelope thermal performance
- Heavier weight blocks
  - More durable
  - Higher compressive strength
  - Better acoustical isolation between adjacent spaces

ASTM C90 Weight Classification	Density of Concrete (dry)	Typical Weights of Individual Units
Normal weight (sometimes also referred to as "Heavyweight")	At least 125 pcf (2000 kg/m^3)	33–39 lb (15–18 kg)
Medium weight	From 105 pcf to less than 125 pcf (1680–2000 kg/m^3)	28–32 lb (13–15 kg)
Lightweight	Less than 105 pcf (1680 kg/m^3)	20–27 lb (9–12 kg)

Concrete Masonry

- Concrete Masonry Dimensions
  - Like brick masonry walls, concrete block wall dimensions should conform to the dimensional module of the block, in this case 8 inches. This minimizes the need to cut block or work with small pieces.



Laying CMU I

- Mortar is identical to that used for brick masonry.
- Corner leads are laid first.
- String lines and levels are used to keep walls straight, plumb, and level.
- Joints are tooled and the face of the blocks cleaned as work progresses.

Laying CMU II

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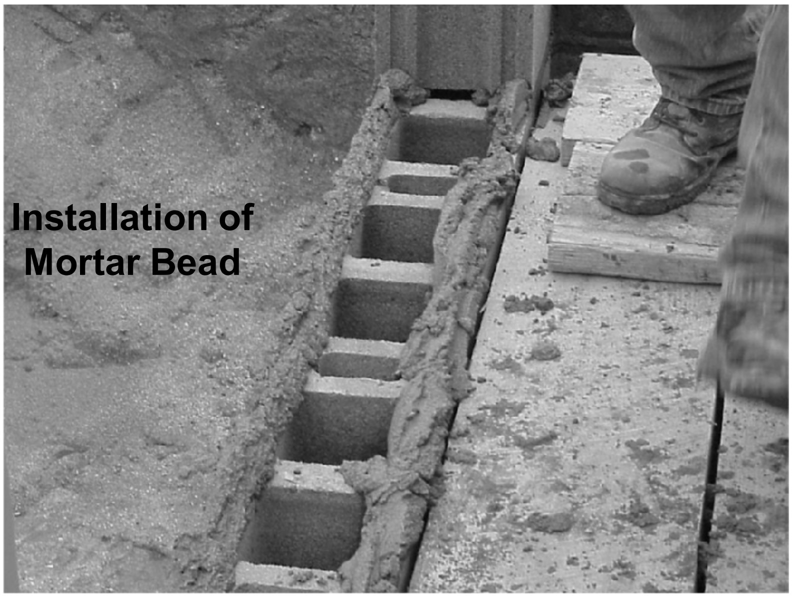
Laying CMU III

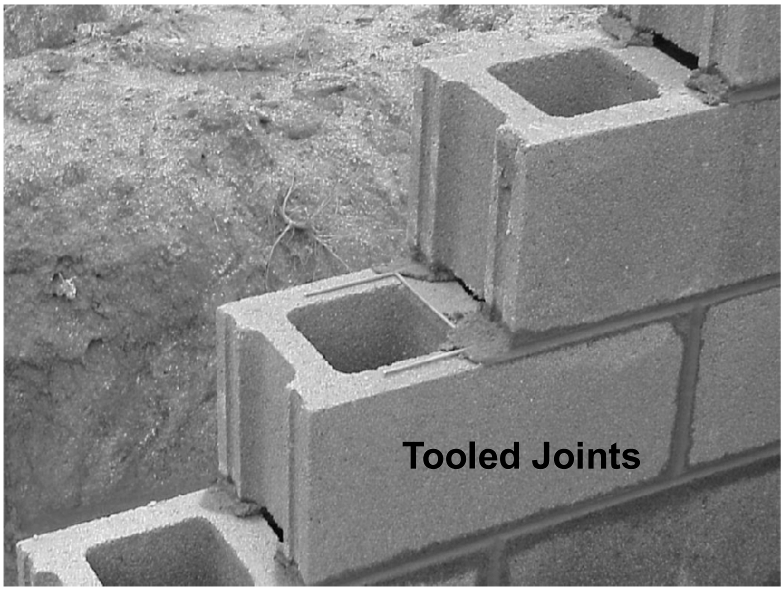
Layout & Lead Blocks

Laying CMU IV



Laying CMU V

Laying CMU VI



Laying CMU VII

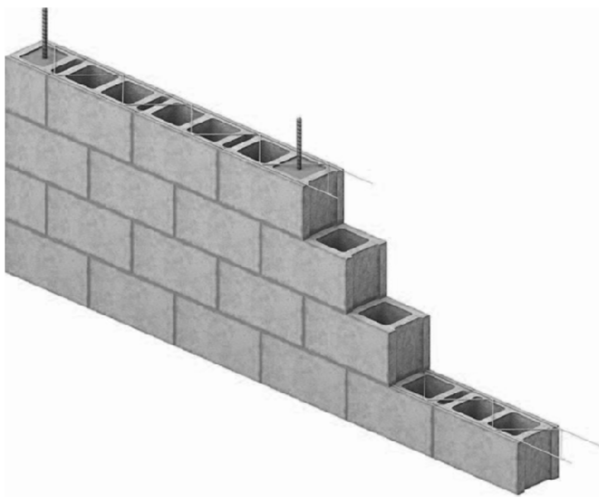
Concrete Masonry Reinforcing I

- Reinforcing increases compressive strength, resistance to cracking, and resist to lateral forces.

Vertical steel reinforcing bars in a fully-grouted concrete block wall

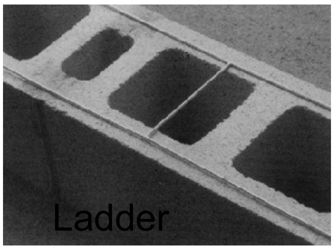
Concrete Masonry Reinforcing II

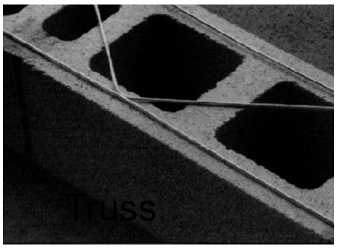
- Horizontal joint reinforcing and vertical steel reinforcing bars
- Joint reinforcing is made from wires that are small enough in diameter to fit within the mortar joint.



Concrete Masonry Reinforcing III

- Joint Reinforcing
  - Ladder
  - Truss
- width should be 2” less than wall





Concrete Masonry Reinforcing IV

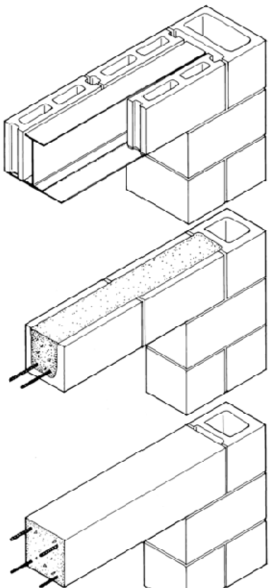
- Horizontal reinforcing bars
- A masonry saw has been used to partially cut out the webs of the blocks, making space for the bars. (The cutoffs can be seen lying on the ground to the left of the wall.)
- The blocks have yet to be grouted.

Concrete Masonry Reinforcing V

- Horizontal and vertical reinforcing bars
- Note the blocks with specially-shaped webs that accommodate the horizontal reinforcing without modification.

Spanning Concrete Block Openings

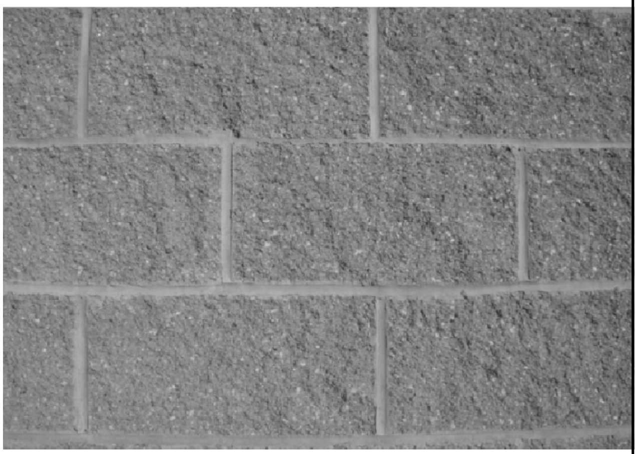
- Top: Structural steel (Steel Lintels)
- Middle: Steel reinforced concrete block lintel
- Bottom: Precast reinforced concrete lintel



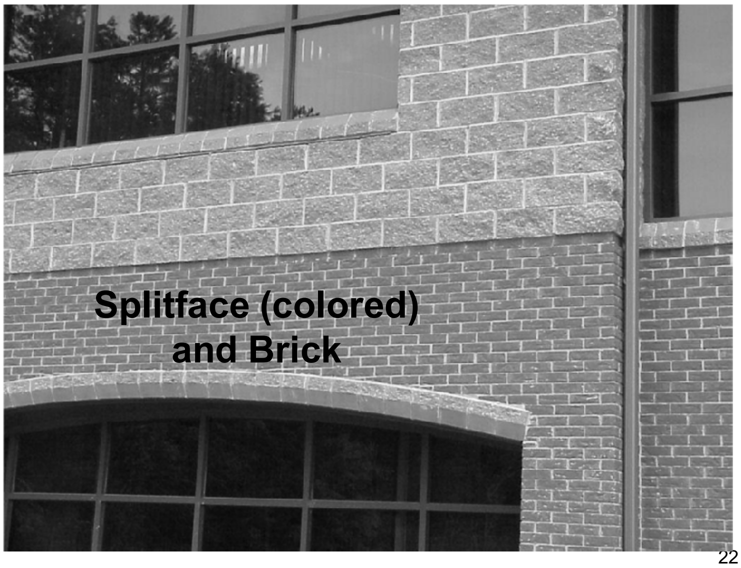
Decorative or Architectural Concrete Masonry Units I

Split-face block

- Two or more blocks are cast as a single unit.
- During the curing process, the blocks are split with knife-like blades.
- Naturally textured surfaces with exposed aggregate are created.



Decorative or Architectural Concrete Masonry Units II



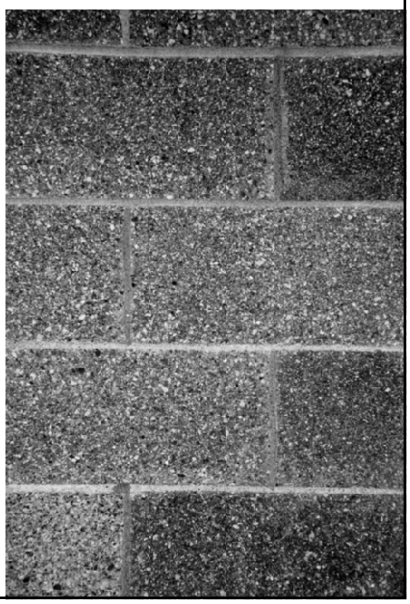
Decorative or Architectural Concrete Masonry Units III

Ribbed split-face block

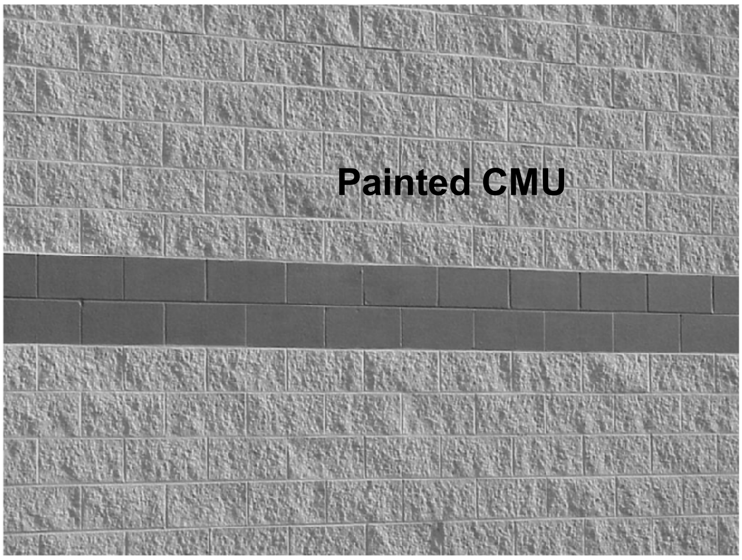
Decorative or Architectural Concrete Masonry Units IV

Ground-face block

- After curing, block surface is ground smooth, creating a polished terrazzo-like surface.
- In any architectural block, the color of aggregates and cement can also be varied.

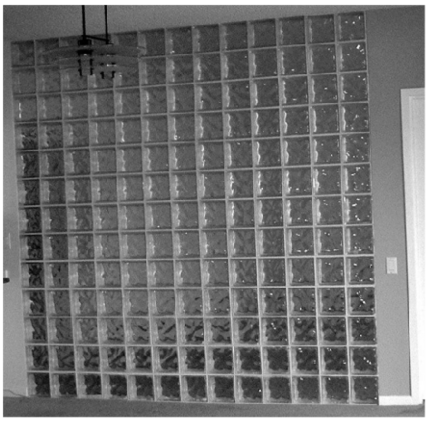


Decorative or Architectural Concrete Masonry Units V



Other Types of Masonry Units

- *Glazed block, structural glazed facing tiles* (left)
- *Glass block* (right)



Masonry Partition Systems

- Concrete masonry partitions:
  - May be plastered or faced with gypsum board or left exposed (either painted or unpainted).
  - Several types of lightweight aggregate may be used to reduce the dead weight of the partition.
  - Decorative concrete masonry units (architectural concrete unit masonry), may also be used.
  - Electrical wiring is relatively difficult to conceal in concrete block partitions; the electrician and the mason must coordinate their work closely, or the wiring must be mounted on the surface of the wall after the mason has finished