Chapter 8
Concrete and Masonry

Topics

1.0.0 Concrete
2.0.0 Masonry

To hear audio, click on the box.

Overview
As an Engineering Aid, your contributions to a project will span across the various trade disciplines. You may be creating the drawings, estimating materials for a segment of the project, doing material takeoffs, or any of a number of other tasks that make a project move forward successfully. As you advance in experience and rank, you may work closely with the Quality Control division to provide project oversight. To be a success, you need to be familiar with the terms and language of those different aspects of construction. This segment will introduce you to one of the most commonly used and permanent elements: concrete and masonry.

Objectives
When you have completed this chapter, you will be able to do the following:

1. Describe the different types and requirements of concrete.
2. Describe the different types and requirements of masonry.

Prerequisites
None
This course map shows all of the chapters in Engineering Aid Basic. The suggested training order begins at the bottom and proceeds up. Skill levels increase as you advance on the course map.

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1.0.0 CONCRETE

To quote the Portland Cement Association, an industry organization, “In its simplest form, concrete is a mixture of paste and aggregates. The paste, composed of portland cement and water, coats the surface of the fine and coarse aggregates. Through a chemical reaction called hydration, the paste hardens and gains strength to form the rock-like mass known as concrete.”

![Aqueduct built with Roman Cement](image)

The known use of cement goes back as far as the Roman period where “Roman Cement” helped build some of the great architecture and public systems, many of which are still in place. Roman cement used the local natural resources found around the volcanic activity in Italy. (Figure 8-1)

**Figure 8-1** – Aqueduct built with Roman Cement.

Portland cement is the most common cement used in today’s concrete mixtures, and its composition is very similar to that of Roman cement. Portland cement was the creation of Joseph Aspdin, a bricklayer from Leeds, England. Receiving a patent in 1824, he named this first effort for its resemblance to Portland stone, a highly valued building stone quarried on the Isle of Portland in southern England and used in many public buildings. His first effort was useful mainly for mortar and stucco, but his son William improved both the chemical ingredients and the manufacturing process to arrive at the precursor to modern portland cement.

![Composition of concrete](image)

**Figure 8-2** – Composition of concrete.
Concrete, as shown in Figure 8-2, is a mixture in proper proportions of cement (usually portland), fine aggregate (usually sand), coarse aggregate (usually gravel or crushed stone), and water; the product is not concrete unless it contains all four of these ingredients.

A mixture of cement, sand, lime, and water, without coarse aggregate, is not concrete. It is mortar or grout.

- Mortar---used mainly for bonding masonry units together
- Grout---a water/cement mixture (called neat-cement grout) or water-sand-cement mixture (called sand-cement grout) used to plug holes or cracks in concrete, to seal joints, and for similar plugging or sealing purposes

In concrete, the fine and coarse aggregates are inert, that is, they have no chemical properties and do not react with other chemicals. The cement and water are the active ingredients. To make concrete, you mix the aggregates (inert) and the cement (active) thoroughly together first, then add the water. As soon as you add the water, you have started a chemical reaction between the water and the cement. This chemical reaction, called hydration, causes the concrete to harden.

Always remember: Hydration (the chemical reaction between the cement and water) causes the hardening process! Hardening is not a matter of drying out the mix. Instead, you must keep the concrete as moist as possible during the initial hydration process. Drying out causes a drop in water content below the amount required for satisfactory hydration. The fact that concrete will harden just as well under water as it will in the air demonstrates that drying out is not the hardening factor.

You can cast concrete into bricks, blocks, and other relatively small building units (composed of various but specific ingredients) for assembly with mortar. This is concrete masonry construction.

The proportion of concrete to other materials used in building construction has increased in recent years to the point that designers and builders construct large, multistory modern buildings entirely of reinforced concrete cast in place, or precast.

1.1.0 Requirements for Good Concrete

A good concrete mix must have:

- a supply of good cement (a type suitable for the work at hand)
- a supply of fine aggregate (satisfactory sand)
- a supply of coarse aggregate
- water

Workers must weigh and measure the proportions carefully to meet the mix designed for the current concrete pour. Everything else being equal, the mix with the best graded, best shaped, strongest, and cleanest aggregate will make the strongest and most durable concrete.

However, the best designed, best graded, highest quality mix in the world will NOT make a good concrete pour if it is not workable enough to flow and thoroughly fill the spaces of a form. The concrete must be fluid (plastic) enough to flow into the forms and reach any corners without creating voids (rock pockets). On the other hand, too much water will decrease the concrete’s strength. Modern concrete mixes often use additives called plasticizers to increase the fluidity of the concrete pour without adding more
In addition, improper handling during the whole concrete making process (from the initial aggregate handling, to the mixing, to the final placement of the mix) can cause segregation of aggregate particles by size, resulting in non-uniform, poor concrete.

Finally, if not properly cured, the best designed, best graded, highest quality, and best-placed mix in the world will not produce good concrete. During the early stages of this chemical process, called hydration, concrete needs protection against loss of moisture. Concrete placers or finishers achieve this with a variety of methods from spray mists, to burlap bags, to plastic sheets, to leaving the forms in place for a given period.

Strength, durability, and watertightness are the important properties of good concrete, and the water-cement ratio controls these factors. Generally, using less water produces a higher quality concrete provided the concrete is properly placed, consolidated, and cured.

1.1.1 Strength

Concrete’s **compressive strength** is very high, but its **tensile strength** is relatively low. Concrete that must only resist compression may not require reinforcement.

![Diagram of stress types](image)

However, concrete that must resist stretching, bending, or twisting, (tensile forces) such as concrete in beams, girders, walls, columns, and the like, must be reinforced with steel commonly referred to as rebar. *(Figure 8-3)*

![Figure 8-3 – Examples of stress nomenclature.](image)

1.1.2 Durability

Along with strength, *(Figure 8-4)* shows other properties of good concrete.

Concrete’s durability is the extent to which it is capable of resisting deterioration caused by exposure to its intended service conditions.

Ordinary structural concrete intended for exposure to the elements must be watertight and weather resistant. Concrete subject to wear, such as floor slabs and pavements, must be capable of resisting abrasion.

The major factor controlling durability is strength—in other words, the stronger the concrete, the more durable it will be.

As mentioned previously, the chief factor controlling strength is the water-cement ratio,
but the character, size, and grading of the aggregate also has important effects on both strength and durability.

Even with a water-cement ratio that produces maximum strength consistent with workability requirements, the concrete will not attain that maximum strength and durability unless the fine (sand) and coarse aggregates are well-graded, clean, hard, and durable particles, free from undesirable substances.

![Diagram showing the properties of good concrete](image)

**Figure 8-4 – Properties of good concrete.**

1.1.3 **Watertightness**

The ideal concrete mix would be one made with just the right amount of water required for complete hydration of the cement; however, this would be too dry a mix that is, too stiff to pour in the forms.

A concrete mix fluid (plastic) enough to pour into forms always contains a certain amount of water over and above the amount needed for complete hydration, and this extra water will eventually evaporate, leaving voids or pores in the concrete. The concrete would be watertight if these voids were not interconnected.

They are, however, interconnected by the slight sinking of solid particles in the mix during the hardening period. The mix starts after all, as a fluid mix that flows; and as the aggregate particles sink before complete hardening, they leave water-filled channels, which become voids when the water evaporates. The larger and more numerous the voids, the more compromised the watertightness of the concrete.

Since the size and number of the voids vary directly with the amount of water used in excess of the amount required to hydrate the cement, it follows that to keep the
concrete as watertight as possible, you must not use more water than the minimum amount required to attain the necessary degree of workability.

1.2.0 Plain Concrete
Plain concrete has no reinforcement and is most often used where strength is not essential and stresses are minimal, such as in sidewalks or driveways and floors without any anticipated heavy loading. There are exceptions though, such as the concrete block section pours so famous on the construction of Boulder Dam, now Hoover Dam. These segments were unreinforced, but the dam’s design capitalized on concrete’s compressive strength while tensile strength was not a factor for those particular elements of the dam.

1.3.0 Reinforced Concrete
Reinforced concrete is concrete containing steel (bars, rods, strands, wire-mesh) as reinforcement and designed to absorb tensile and shearing stresses. Concrete structural members, such as footings, columns, beams, floor slabs, and walls, must contain reinforcement to attain the necessary strength in tension.

1.3.1 Reinforced Concrete Structural Members
A reinforced concrete structure includes many types of reinforced structural members to attain the needed tension and shear strengths. These members are examined below. The builder may cast (pour) the members in place, precast them, or use a combination of both.

1.3.1.1 Footing and Footing Reinforcement
Footings support the entire structure and distribute the structure’s load to the ground. The size and shape of a footing depends on the design of the structure and the load the footing must distribute across the ground.

For small individual footings (spread footings), the rebar installers can preassemble (prefab) “steel mats” and place them after excavation or after the forms are set. (Figure 8-5)

Figure 8-5 – Typical spread footing.
For large, continuous footings or grade beams, such as those found under bearing walls, installers will need to assemble the rebar in place. (Figure 8-6)

**1.3.1.2 Column and Column Reinforcement**

A column is a slender, vertical member that carries a superimposed load. Concrete columns, especially those subjected to bending stresses, must always have steel reinforcement. Vertical reinforcement is the principal reinforcement, but a column under loaded stress tends to shorten vertically and expand laterally. Lateral ties serve to counteract those forces and restrain the expansion.

Columns reinforced in this manner are tied columns. If the restraining reinforcement is a continuous winding spiral that encircles the core and longitudinal steel, the column is a spiral column. A spiral column placed below ground level as part of the foundation is a caisson. (Figure 8-7)
Like a column, a pier or pedestal (Figure 8-8) is also a member under compression stress but it is short (usually the height is less than three times the shortest lateral dimension) in relation to its cross-sectional area and carries no shear or torsion stress. Consequently, it may or may not need reinforcement.

1.3.1.3 Beam and Beam Reinforcement

Beams are the principal load-carrying horizontal members. They take the loading stresses directly from the floor above and distribute them to the columns supporting the beams. As an engineering principle, the greatest reinforcement is always placed on the opposite (or far side) of the loading/lifting forces (Figure 8-9).

To place the rebar opposite the forces, engineers may design both straight and truss bars to resist the bending tension in the bottom at the central portion of the span between the supports for the beam. Since fewer bars are necessary on the bottom near the ends of the span where the bending moment is small, some bars may be truss bars to serve as additional bars for the bottom central span and serve as additional bars for the top ends of the span as well.

1.3.1.4 Slab and Slab Reinforcement

Concrete slabs come in a variety of forms depending on their location. Ground slabs (also called slabs on grade) take the load directly to the ground or to beams called grade beams placed below ground level. Plain slabs (similar in shape to ground slabs but on a formed surface) take the load directly from the floor and transmit it to beams. In other cases, joists, poured as part of plain slabs, carry the loads to the beams. Joists, similar to but lighter and smaller than beams, strengthen the middle portion of the slab.
Truss slabs using bars with a shape similar to that of truss bars used for beams are of particular interest since the truss bars must serve as lower reinforcement in the central part of the span and as upper reinforcement where supported from below.

Note in Figure 8-10 the placing sequence required for placing reinforcing steel in a floor truss slab. Rebar installers need to follow a placing sequence to avoid additional labor and possible project delay.

![Figure 8-10 – Typical truss slab assembly.](image1)

Installers can use a variety of devices to achieve proper concrete coverage around the rebar from the ground or form. They can support the rebar with individual plastic or heavy gauge wire supports called chairs or continuous strips called bolsters. They often use concrete blocks called dobies (sand-cement mortar) on the ground or with formed pours when use of those dobies does not affect the final appearance of the structure.

![Figure 8-11 – Typical rebar supports for clearance.](image2)

The required concrete coverage determines the height of the chair, bolster, or dobie in Figure 8-11. Project specifications usually provide the minimum clearances necessary for the regional codes and project conditions i.e., Is the project near salt water? If not,
the American Concrete Institute provides standards in \textit{ACI 318 "Building Code Requirements for Reinforced Concrete."} Typically, concrete surfaces in contact with the ground require 3 in. clearance and exposure to weathering requires 1/12- 2 in. If no rebar supports are available, wire ties and/or wood blocks may hold the rebar in position on a temporary basis (\textit{Figure 8-12}) and be removed before the concrete sets. You should not use wood block without removal unless the structure is temporary.

\textbf{Figure 8-12 – Beam reinforcement with and without support.}

\textbf{1.3.1.5 Wall Reinforcement}

Rebar placement for load-bearing walls is the same as columns except that installers usually do it “in-place,” that is not preassembled. Vertical and horizontal members need a minimum of three ties in any length. If installers use wood blocks as temporary spacers (\textit{Figure 8-13}), they must ensure the blocks do not fall into the wall during the pour and must remove them as the concrete nears the top of the pour height.

\textbf{Figure 8-13 – Wall reinforcement with temporary spacers.}

\textbf{1.3.2 Reinforcing Steel}

Steel is the best material for reinforcing concrete; their coefficients of expansion are almost the same, i.e., at a normal temperature, steel and concrete will expand and
contract at a nearly equal rate. Under extraordinary circumstances at very high temperatures, the steel will expand more rapidly than the concrete, and the two materials will separate.

Steel is also the best because it makes a good bond with the concrete. This bond strength is in direct proportion to the amount of steel-concrete contact. In other words, the greater the surface of steel exposed to the adherence of the concrete, the stronger the bond.

Concrete adherence depends on the roughness of the steel surface: the rougher the steel, the better the adherence. Thus, steel with a light, firm layer of rust is superior to clean steel, but steel with loose or scaly rust is inferior. Installers can remove loose or scaly rust by rubbing the bars with burlap or using a wire brush.

Reinforcing steel must be strong in tension and, at the same time, ductile enough for shaping or cold bending.

Reinforcing steel includes:

- Plain round bars
- Deformed bars
- Expanded metal
- Welded wire fabric (wire mesh)

Each type is useful for a different purpose, and engineers design structures with these purposes in mind.

Plain reinforcing bars are usually round in cross section. They are the least used of the rod type of reinforcement because they offer only smooth, even surfaces for the adherence of concrete. Deformed reinforcing bars are better than plain round bars. In fact, when using plain bars of a given diameter instead of deformed bars, you must increase the quantity by approximately 40 percent. The United States uses deformed bars almost exclusively, while Europe uses both deformed and plain bars.

Deformed bars are like plain bars except that they have indentations, or ridges, or both in a regular pattern. Earlier versions of deformed rebar were available as square or with a spiral twist and workers may still encounter them during demolition or on remodeling projects of older structures. Current rebar suppliers deform the bars at the mill with patterns and markings (Figure 8-14) unique to their mill and to the tensile strength of the material.
Figure 8-14 – Sample mill patterns and tensile strength markings.

There are 11 standard sizes of reinforcing bars (Figure 8-15). Bars No. 3 through No. 18 inclusive, are deformed bars. Bar numbers correspond to bar sizes to the nearest 1/8 in. (3.175 mm) measured at the nominal diameter but not including any deformations.

Note: At 13.6 pounds per foot, a #18 bar of any functional length quickly becomes too heavy for personnel handling and requires mechanical lifting equipment.

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Figure 8-15 – Reinforcing steel sizes and their tensile strength markings.
1.3.2.1 Bends

Often, reinforcing bars need bending (fabrication) into various shapes to accommodate the stresses in the project’s design. Remember the reason for using reinforcing steel in concrete—to increase the tensile strength of concrete.

Compare the hidden action within a beam to breaking a stick over your knee. As you apply force (compression) and your knee pushes toward the middle on one side of the stick, the splinters on the opposite side pull away (tension) from the middle. This is similar to what happens inside the beam.

For instance, take a simple beam (a beam resting freely on two supports near its ends as in (Figure 8-16). The dead load (weight of the beam itself) causes the beam to bend or sag.

![Compression Diagram]

Any additional nonpermanent load (live load) increases the loading stress (compression) at the top of the beam. Now, from the center of the beam to the bottom of the beam, the forces tend to stretch or lengthen laterally. This part is in tension, and that is where the beam needs the greatest reinforcement.

**Figure 8-16 – Compression and tension forces.**

With the combination of concrete and steel, the tensile strength in the beam resists the force of the loads and keeps the beam from breaking apart. At the exact center of the beam’s depth, between the compressive stress and the tensile stress, there is no stress at all—it is neutral.

In the case of a continuous beam, it is a little different. The top of the beam may be in compression (between columns) along part of its length and in tension along another part (at columns). This is because a continuous beam rests on more than two supports. Thus, the bending of the beam is NOT all in one direction but reversed as it goes over intermediate supports.

To help the concrete resist these stresses, engineers design the bends of reinforcing steel so installers will maximize the placement of additional rebar where the tensile stresses take place. That is why some rebar bends are in an almost zigzag (truss) pattern. Figure 8-17 shows some typical rebar bends you will encounter.
Figure 8-17 – Typical rebar bends.

When bending reinforcing bars, benders in the field or fabricators in the shop must exercise caution to ensure the bends are not too sharp. Rebar may crack or weaken if bent too sharply. The American Concrete Institute (ACI 318 Building Code Requirements for Structural Concrete) has established minimum bend diameters for the different bar sizes and for the various types of hooks.

There are many different types of bends, depending on where the rods are destined to be used. For example, there are hooks for the ends of heavy beams and girders, offset bends for vertical column splices at or near floor levels, beam stirrups, column ties, slab reinforcement, and spiral for round columns or foundation caissons. These bending details are shown in Figure 8-18.
1.3.2.2 Splices

A **lap splice** of proper length can transmit tension stress through the concrete into the adjoining spliced bar. When engineers do not dimension rebar splices on the drawings, installers should lap bars 30 times their diameter, or not less than 12 in. The number of bar diameters expresses “lap.” For example, the 30-diameter lap for a #8 (1-in.) bar would be 30 in., and for a #4 (1/2 in.) bar it would be 15 in. If using a #3 bar, make the lap at least 12 in.

1.3.2.3 Expanded Metal and Welded Wire Fabric

Builders also use expanded metal to reinforce concrete where there is only a minimal need for tensile strength. Manufacturers make expanded metal by partially shearing a sheet of steel in parallel lines, as shown in Figure 8-19, and then pulling it out and expanding it. Expanded metal comes in a variety of gauges and shapes, and plastering operations frequently use it to build the base (scratch) coat.

Welded wire fabric (WWF or wire mesh) is available in rolls of lighter gauge wire for light building construction and in sheets of heavier gauge wire for highways and buildings when roll gauge sizes will not give sufficient reinforcement (Figure 8-20). WWF is available in square and rectangular patterns in a wide variety of wire gauges welded at each intersection.
Figure 8-20 – Welded wire fabric (mesh).

When ordering welded wire fabric in either the old or the new designations, the wire spacing (in each direction) comes first followed by the wire gauge (in each direction). The old designation used number (in inches) for spacing and number (in wire gauge) for the size of the WWF. The new designation uses number (in inches) for spacing but a letter and a number (in wire cross-section) for size.

For example, in the old designation, 6x6 — 4x4 mesh would be 6-in. squares with 4-gauge wire in each direction whereas, 4x4 — 6x6 mesh would be 4-in. squares with 6-gauge wire in each direction. In the new designation, these would be 6x6 — W4xW4, and 4x4 — W2.9xW2.9 respectively. Figure 8-21 provides some typical WWF designations used for structural concrete.

Figure 8-21 – Designations for welded wire fabric.

When using WWF, specifications and designs usually indicate the minimum lap. As a practical matter, although a minimum lap of 2 in. may be sufficient for nonstructural concrete, for placement purposes a 1-square lap, regardless of the mesh spacing, is common to facilitate the installer's ability to tie the laps together at intersections.
Installers use a number of different ties to join rebar together and hold it in the proper spacing and in place as the concrete pours. (Figure 8-22) The tie wire may come in large rolls (shoulder coils) where installers cut smaller sections off and roll it around the neck and shoulders as they use the wire. However, in today’s civilian industry where Ironworkers place the rebar, tie wire reels affixed to belts are the common method of distributing the wire. On small projects when only snap ties are necessary, another alternative is looped end tie wires.

**Figure 8-22 – Types of tie wire available.**

Figure 8-23 shows typical types of wire ties used by Ironworkers in the commercial industry. They use the ties with the "round turn" periodically for wall installation because as a horizontal bar tends to sag from its own weight or from personnel climbing, the tie tightens up with the round turn around the vertical bar.

**Figure 8-23 – Typical reinforcement placing ties.**

**1.4.0 Precast Concrete**

Known as cast-in-place, most concrete structural members are poured in their final position. Precasting is the fabrication of a structural member at a place other than its final position of use. It is best adapted to a factory or yard but jobsite precasting is not uncommon for large projects that require a large number of exact or similar pieces. Precast concrete can produce several different shapes and sizes, including piles, girders, and roof members.
Prestressed concrete is especially well adapted to precasting techniques. Fabricators make prestressed units by casting concrete around already tensioned tendons or bars. Prestressed concrete pours require stout anchoring points between which the heavy wire tendons (or bars) stretch under tension, usually in a straight line. The cured concrete adheres and bonds to the tendons (or bars). When the fabricators release the tension, it transfers to the concrete as compression by static friction. Generally, concrete structural members such as standard highway girders, poles, electric poles, masts, and some building members are precast by factory methods unless transportation difficulty makes jobsite casting more desirable.

1.4.1 Precast Concrete Floors, Roof Slabs, Walls, and Partitions

Channel and double-T type precast slabs (Figure. 8-24, views A and B.) are the most commonly used panels for floor and roof decks.

Channel slabs can vary in size from 9 to 12 in. deep, 2 to 5 ft. wide, 1 to 2 in. thick and to 50 ft. in length. If desired or needed, the concrete casters may extend the legs of the channels across the ends and, if used in combination with top slabs, can stiffen the channel with occasional cross ribs. Wire mesh may be the reinforcement in a top slab.

Double-T slabs can vary in size from 9 to 16 ft deep, and 4 to 6 ft wide, and as long as 50 ft. When a top slab size ranges from 1 1/2 to 2 in. in thickness, it should be reinforced with wire mesh.

Tongue-and-groove panels (Figure. 8-24 view C) can vary extensively in size, according to the design requirement. They sit in position much like tongue-and-groove lumber; that is, the tongue of one panel fits inside the groove of an adjacent panel. Large pier construction projects often use them as decking panels.

Figure 8-24 – Typical precast panels.

Welders ordinarily connect the floor and roof panels to supporting members with the matching plates built into the precast units.

Builders can also precast vertical panels in a horizontal position in a casting yard or on the floor of the building. Cranes then set the precast units in their final position. (Figure 8-25)
Figure 8-25 – Crane with spreader bars erecting precast wall panel.

Usually, these panels are solid, reinforced slabs, 5 to 8 in. thick, with the width varying according to the distances between columns or other supporting members. As it is with wood frame construction, when there are windows and door openings, extra reinforcements is required around the openings.

A concrete floor slab with a smooth, regular surface can be the “casting surface.” When used for casting, builders should cover this smooth surface with a liquid or sheet material that prevents bonding between the slab surface and the vertical panel. The upper surface of the panel may be finished in the same way as regular concrete: by trowel, float, or broom.

Sandwich panels are panels that consist of two thin, dense, reinforced concrete-face slabs separated by a core of insulating material, such as lightweight concrete, cellular glass, plastic foam, or some rigid insulating material.

Designers sometimes specify these panels for exterior walls to provide additional heat insulation. The thickness of the sandwich panels varies from 5 to 8 in. and the faces are tied together with wire, small rods, or in some other manner. Matching plates also connect the wall panels to the building frame top and bottom by either welds or bolts. Caulking on the outside and grouting on the inside should make the points between the wall panels watertight.

1.4.2 Precast Concrete Joists, Beams, Girders, and Columns

Joists are small, closely spaced beams used in floor construction. Small, closely spaced beams used in roof construction are purlins. Their shape in cross section is like a T or
an I. The ones with the inverted T-sections are usually used in composite construction where they support cast-in-place floor or roof slabs.

The terms beam and girder usually apply to the same type of member but the one with the longer span is the girder. Beams and girders may be conventional precast design or prestressed. Most beams will be I-shaped unless the ends are rectangular but T-shaped ones are also usable.

Precast concrete columns may be solid or hollow. If the designer specifies the hollow type, heavy cardboard tubing forms part of the column’s core. A looped rod previously cast in the column footing and projecting upward into the hollow core helps hold the column upright. An opening left in the side of the column allows the core to be filled with grout, which causes the embedded looped rod to become an anchor. The final step is **dry packing** the opening.

### 1.4.3 Advantages of Precast Concrete

Precasting concrete has its greatest advantage when a project requires many identical members because the same forms are reusable several times.

Some other advantages are:

- Control of concrete quality
- Smoother surfaces
- Less storage space required
- Weather conditions may not affect casting
- Better protection for curing
- Weather conditions do not affect erection
- Faster erection time

### 1.5.0 Prestressed Concrete

A prestressed concrete unit is one in which engineered stresses have been placed by either pre-tensioning or post-tensioning before it has been subjected to a load.

Pre-tensioning involves high-tensile strength steel strands as reinforcement (as well as other reinforcement) stretched in a straight line through a form between two end abutments or anchors. The steel strands receive a predetermined amount of stress and the concrete pour encases the reinforcement. As the concrete sets, it bonds to the pre-tensioned steel. When the concrete reaches a specified strength, the tension on the reinforcement is released. This pre-stresses the concrete, putting it under compression, thus creating a built-in tensile strength.

Post-tensioning also involves high-tensile strength steel strands as well as other reinforcement, but in this method, workers place the strands under stress with hydraulic equipment after the concrete reaches a predetermined strength.

One method involves hollow tubing placed within the concrete pour through which the workers later add the strands. Another method involves individual strands encased in grease-filled plastic casings. In both methods, unlike pre-tensioning’s straight pull, post-tension cables must follow an engineered profile of highs and lows that provides tension at specific locations.

Post-tensioning individual units at a precast location is an option, but common practice
has most post-tensioning operations done at the job-site on the cast-in-place concrete pour.

In general, post-tensioning is used if the unit is over 45 ft long or over 7 tons in weight. Members that are relatively small or can be readily precast are normally pre-tensioned. These include precast roof slabs, T-slabs, floor slabs, and roof joists. However, some types of pre-tensioned roof slabs may be considerably longer and heavier than this.

When a beam is prestressed, (Figure 8-26) by either pre-tensioning or post-tensioning, the tensioned steel produces a high compression in the lower part of the beam. This compression creates an upward bow, or camber, in the beam. When a load is placed on the beam, the camber is forced out, creating a level beam with no deflection.

![Figure 8-26 – Results of prestressing concrete beams.](image)

1.6.0 Special Types of Concrete

Special types of concrete are those with unique physical properties or those produced with unusual techniques and/or reproduction processes. Portland cement is the binding medium for many special types of concrete but some special cements use other binders.

1.6.1 Lightweight Concrete

Lightweight concrete is usually classified according to its weight per cubic foot. Conventional concrete weighs approximately 150 lb per cubic foot. Lightweight concrete ranges from 20 to 130 lb per cubic foot, depending on its intended use. Concrete mix designers can use gas-generating chemicals or lightweight aggregates, such as expanded shale, clay, or slag, to make lightweight concrete.

Insulating lightweight concrete has a unit weight ranging from 20 to 70 lb per cubic foot, and its compressive strength seldom exceeds 1,000 psi. This type of concrete is generally used for insulating applications, such as fireproofing. Concrete using perlite or vermiculite as aggregate is very light and used primarily as insulating material. Both perlite, (a volcanic glass) and vermiculite (a natural mineral) expand when exposed to the heat from the hydration process of cement and water.
Structural lightweight concrete has a unit weight of 90 to 115 lb per cubic foot and a 28-day compressive strength in excess of 2,000 psi. This type is used primarily to reduce the dead-load weight in concrete structural members, such as floors, walls, and the roof section in high-rise structures, thus reducing the foundation support requirements as well.

Semi-lightweight concrete has a unit weight of 115 to 130 lb per cubic foot and an ultimate compressive strength comparable to normal concrete. In this mix, normal weight sand of is substituted partially or completely for the lightweight fine aggregate.

### 1.6.2 Heavyweight Concrete

Heavyweight concrete uses special heavy aggregates and has a density of up to 400 lb per cubic foot. This type is principally for radiation shielding, counterweights, and other applications where higher density is desired. Except for density, the physical properties of heavyweight concrete are similar to those of normal- or conventional-weight concrete.

### 1.7.0 Tilt-Up Construction

Tilt-up concrete construction is a special form of precast concrete building. This method consists of jobsite prefabrication in which the builder casts the wall as a horizontal slab, tilts it to a vertical position, and secures it in place.

Tilt-up construction is best suited for large one-story buildings, but multistory structures can also be “tilt-ups.” Usually, multistory structures use platform construction by setting the walls for the first story, placing the floor above, then repeating the procedure for each succeeding floor. An alternate tilt-up method is to cast two- to four-story panels, similar to the balloon framing of wood structures.

Because tilt-up walls are usually cast on the ground floor slab of the structure, builders must ensure the slab is smooth and level, temporarily plug all openings for pipes and other utilities, and treat the casting area with a good bond-breaking agent to ensure the panel does not adhere to the slab when lifted.

### 1.7.1 Reinforcement of Tilt-Up Panels

The steel in a tilt-up panel is set in the same manner as it is in a floor slab. Placers set mats of rebar on chairs and tie it as needed. If it is a single mat, the reinforcement should be as near the center depth of the panel as possible. The reinforcing bars may run through holes provided in the side forms of the panel for future connection with the vertical supports (usually pilasters). When welded wire fabric or expanded wire mesh is the main reinforcing, reinforcing steel called dowels protrude through the holes to serve that function. Any openings need additional reinforcement. Mechanical lifting devices (usually a crane) pick up and tilt the panel to a vertical position using pickup inserts, specially designed tilt-up hardware. *(Figure 8-27)* Placers tie these inserts to the reinforcement at specific, designated locations to accommodate the maximum stress that occurs during the lifting process. Additional reinforcement may be necessary at these pickup locations. Some engineering manuals provide information on inserts, their locations, and capacities.
1.7.2 Tilt-Up Panel Foundations

An economical and widely used method to support tilt-up panels is a simple pad footing. (Figure 8-28) The floor slab, though constructed first, is NOT poured to the perimeter of the building. This permits later excavation and pouring of the footings as the tilt-up panels are curing. In this method, again like balloon framing, the panel sits on the footing below the slab level. Placers then complete the perimeter section of slab. It may connect directly to the outside wall panel via dowels placed in the panel before pouring, or the design may call for a trench to run mechanical, electrical, or plumbing lines.

Another commonly used method is to set the panels on a perimeter grade beam or foundation wall at floor level. Regardless of the type of footing, the panel should be set into a mortar bed to ensure a good bond between the foundation wall and the panel.

1.7.3 Panel Connections

Designers can use a variety of ways to make tilt-up connections. The strongest method is a cast-in-place pilaster incorporating the doweled out panel rebar. However, this does not allow for expansion and contraction so the designer may prefer to tie only the corner panels into pilasters and allow the remaining panels to move.
Other methods are an option:

- Butted connection---using grout or a gasket if the wall does NOT contribute any structural strength to the structure
- Steel columns---welded to steel angles or plates secured in the wall panel
- Precast columns—steel angles or plates secured in both the columns and plate and welded together to secure the panel

When the design calls for panel-to-panel connections that do not actually hold the panels in place, a typical method is to weld them to the foundation and to the roof by using steel angles or plates.

Regardless of the type of connection, they must all be waterproof. This is usually accomplished with expansion joint material placed between panels not closed by any of the other designed connections.

**1.7.4 Finishes**

Tilt-up panel finish is similar to any other concrete floor or wall. While some unique finish may require an exterior face-up pour, most will require the typical exterior face-down pour. A face-up pour will affect the panel hoisting and the pick up insert locations.

**1.8.0 Concrete Construction Joints and Connections**

Construction joints (Figure 8-29) are divisions between concrete pours done at intervals spaced widely enough to allow partial hardening. Some are at natural stages of construction, others are necessary due to the capability or availability of the concrete itself depending on the size of the pour.

Construction joint locations must be where they will cause the minimum amount of weakness to the structure; for example, where the shearing stresses and bending moments are relatively small or where other structural members will support the joints.

For horizontal work, such as floor slabs, construction joints should be in a vertical plane, whereas for vertical work, such as columns, the joints should lie in a horizontal plane.

![Figure 8-29 – Typical location of construction joints.](image)

Foundation walls bond to footings with vertical dowels which extend from the footings.
high enough beyond the construction joint to achieve the required lap for the next wall pour (Figure 8-30). A wedge-shaped through, called a keyway, is built into the footing to strengthen the bond between footings and walls. In areas where water seepage at construction joints may be a concern, a variety of water stop products is available.

![Image of construction joint with keyway, water stop, and dowels]

**Figure 8-30 – Typical construction joint with keyway, water stop, and dowels.**

### 1.8.1 Contraction Joints

Contraction joints control cracking caused by temperature changes incident to concrete shrinkage. Cutting to a depth of one-fourth to one-third the thickness of the section typical serves as a dummy contraction joint. Some contraction joints are made with a filler and a thin coat of paraffin, asphalt, and/or other materials to break the bond. Local temperatures may require contraction joints in reinforced concrete slabs at 15-to 25-ft intervals in each direction (Figure 8-31).

![Diagram of sawed contraction joint]

**Figure 8-31 – Typical contraction joint.**

<table>
<thead>
<tr>
<th>Application Type</th>
<th>Head of Water FT</th>
<th>Catalog Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
<td>Main FT</td>
<td>4 ft. 14&quot; LFT.</td>
</tr>
<tr>
<td>Ribbed Water Stop</td>
<td>75</td>
<td>3/16&quot;</td>
</tr>
<tr>
<td>Keyway</td>
<td>55</td>
<td>3/16&quot;</td>
</tr>
<tr>
<td>Dowels</td>
<td>100</td>
<td>3/16&quot;</td>
</tr>
<tr>
<td>Induced</td>
<td>73</td>
<td>3/16&quot;</td>
</tr>
<tr>
<td>Plastic or Hardboard</td>
<td>82</td>
<td>3/16&quot;</td>
</tr>
<tr>
<td>Preformed Strip</td>
<td>125</td>
<td>3/16&quot;</td>
</tr>
<tr>
<td>128</td>
<td>3/16&quot;</td>
<td></td>
</tr>
</tbody>
</table>
1.8.2 Expansion Joints

Expansion joints (also called isolation joints) are necessary wherever expansion might cause concrete to buckle because of temperature change. An expansion joint may be a pre-molded cork or mastic filler to separate sections from each other, thus allowing room for expansion if local conditions anticipate elongation or closing of the joint. Figures 8-32 shows expansion joints for a variety of locations.

![Diagram of expansion joints]

Figure 8-32 – Typical expansion joints.

1.9.0 Concrete Forms

Builders place (cast) most structural concrete by pouring plastic (flowing) concrete into spaces enclosed by previously constructed forms. Once the concrete hardens into the shape outlined by the forms and reaches any required strength, workers remove (strip) the forms. Forms for concrete structures must be tight, rigid, and strong. If the forms are NOT tight, loss of water and paste may cause sand streaking, rock pockets, and weakness to the concrete. The forms must be strong enough to resist the high pressure exerted by the concrete during its plastic state.

1.9.1 Form Materials

Builders often use undisturbed soil or clay, if sufficiently rigid and excavated to proper dimensions, as earth forms for foundation elements. However, design, specifications, and construction methods dictate what form materials are necessary for specific structures above grade. Commonly used form materials are wood, plywood of various grades, steel, and fiberglass. Forms for concrete pavement and curves should be metal. Surfaces exposed to view in the finished structure and those requiring special finishes need additional attention to detail.

1.9.2 Foundation Forms

Foundation forms (Figure 8-33) may include forms or parts of forms for column footings, pier footings, grade beams, and wall footings. Whenever possible, builders excavate the soil to the proper dimensional depth and use the earth to form the base and sometimes the sides of the foundation pour. In most cases, footings are cast directly upon the earth with appropriate rebar clearances, and only the sides are molded in forms when necessary.
Figure 8-33 – Typical footing form for piers and columns.
1.9.3 Wall Forms

Builders often prefabricate wall forms but they can build them in place as well, depending on the shape and the desirability for reuse.

Wall forms have five basic parts: (Figure 8-34)

- Sheathing---shapes and retains the concrete until it sets
- Studs---form a framework and support the sheathing
- Wales---keep the form aligned and support the studs
- Braces---hold the forms erect under lateral pressure
- Ties and spreaders or tie-spreader units---hold the sides of the forms at the correct spacing

Figure 8-34 – Typical wall form.
Wall forms must maintain their dimensional measurement during the pour. To achieve this on simple walls, builders often use a combination of wood blocks cut to the wall depth as spreaders and wire passed around the studs and wales for compression. *(Figure 8-35)* This requires periodic holes in the forms through which to pass the wire, which is cut off after the forms are removed. When using this method, workers must be sure to remove the spreaders as the concrete approaches and not let them fall into the pour.

*Figure 8-35 – Wire ties and wood spreaders for wall form.*

For larger walls and projects with sufficient wall pours to justify the material purchase, two alternative methods (metal snap ties and tie rods) have replaced the wire and block spreader. *(Figure 8-36)* Both systems perform the spreading and compression function simultaneously. An inner section holds the wall forms apart with washers or cones while an outer section on both sides holds the forms together. The ties come in a variety of standard inner dimensions to accommodate a structure’s design. Both systems may require grouting to fill the small holes created, depending on the desired finish.
Figure 8-36 – Typical snap tie wall form.

The use of prefabricated (prefab) panels for formwork is on the increase. The panels are reusable many times, thus reducing the time and labor required for erecting forms piecemeal on the site. A potential downside in using prefabbed panels is the cumulative weight of the panel. Careful consideration needs to go into the prefab planning for handling the panels and if necessary make provisions for mechanical handling.

There are many types of prefabricated forms to select. Contractors sometimes build their own panels from wood framing covered with plywood sheathing.

Metal frame with plywood sheathing panels are also in common use and available in a variety of sizes. Special sections provide form for inside corners, pilasters, and so forth. Patented panel clamps hold panels together and flat bar ties lock into place between panels, eliminating the need for spreaders.

Forms are aligned by the use of one or more doubled rows of 2 by 4’s secured to the forms by a special device attached to the bar ties.

Panels made completely of steel are also available. Inside and outside corner sections are standard, and insert angles allow the contractor to make up odd-sized panels.
Large placement projects requiring mass concrete often use giant panels or ganged panels. Crews assemble these large forms on the ground, and cranes are necessary to hoist and place them, so equipment availability is the only limit to their size. (*Figure 8-37*)

**Figure 8-37** – Typical ganged wall form system.

With all wall forms, whether built in place or prefabbed, builders must give special attention to corners. (*Figure 8-38*) These are weak points because the continuity of sheathing and wales is broken, particularly at the inside corner. Forms must pull together tightly at these points to prevent leakage of concrete.

**Figure 8-38** – Typical wall form at corners.

### 1.9.4 Column Forms

In *Figure 8-39*, yokes brace a typical concrete column form to hold the sheathing together against the plastic concrete’s bursting pressure, which is created by the height of the pour. The pressure is greater at the bottom than the top, so yokes are closer...
together at the bottom.

Notice that yokes on two sides of the panel extend beyond the panel and have bolts running through drilled holes. These hold the sheathing to size in one direction. In the other direction, the yokes fit between the first yokes with wedges driven between the yokes and bolts to tighten the form.

**Figure 8-39 – Typical column form.**

### 1.9.5 Beam and Girder Forms

The type of construction a builder will use for girder and beam forms will depend on the pour schedule and the concrete curing time. The schedule may allow removal in one piece, but the more common method is to leave the bottom (soffit) of the girder/beam in place and shored to allow additional curing as the project progresses. Usually, if the schedule requires the bottom form of the beam for another area of the project, the builder must resshore the beam immediately after stripping and maintain the reshoring until the concrete achieves its strength.

*Figure 8-40* shows a typical girder and beam form designed for stripping while leaving their soffits in place for longer shoring. In these examples, the slab will pour *monolithically* with the girders/beams. Notice how the sides come down to the bottom of the soffit rather than sitting on the soffit. This allows workers easier access to remove the sides without removing the soffit.
**Figure 8-40 – Typical girder and beam forms.**

Beam forms are not usually subject to bursting pressure, but builders must shore them up at frequent intervals to prevent sagging under the weight of the fresh concrete. *Figure 8-41* shows the elevated view of a monolithic slab/beam pour (notice the absence of a construction joint in the beams at the bottom of the slab). This drawing indicates that the beam sides are 3/4-in. plywood, the beam soffit is a solid piece of 2-in. dimensioned lumber, with the whole form supported on the bottom by 4x4-in. T-head shores. It is a typical interior beam form with the slab forms supported by the blocking and ledgers on the beam sides. They are transmitting the slab loads down to the supporting shores.

**Figure 8-41 – Typical components of beam formwork with slab framing.**
Test your Knowledge (Select the Correct Response)
1. The important properties of good concrete are_______________________.
   A. grade, mix, and water
   B. shape, flow, and cement
   C. wear, aggregate, and hardness
   D. strength, durability, and watertightness

2.0.0 MASONRY

Masonry is the building of structures from individual units laid in and bound together by mortar. The common materials of masonry construction include brick, concrete block, stone, limestone, glass block, and tile. They are all available in a variety of styles although some come in standard manufactured sizes.

2.1.0 Concrete Masonry

Concrete masonry has become increasingly important as a construction material following manufacturers' rapid increase in technological developments. Properly designed and constructed concrete masonry walls satisfy various building requirements including fire, safety, durability, economy, appearance, utility, comfort, and good acoustics.

Concrete Block is the most common concrete masonry unit (CMU) and there are three classifications: heavyweight, middleweight and lightweight. The differences are much like the differences in conventional concrete and lightweight concrete, they are in the aggregate.

The heavyweight block is cement, water, and an aggregate such as sand, gravel, and/or crushed limestone. The lightweight block is cement, water, and a lightweight aggregate such as cinders, pumice, expanded shale, or vermiculite. Middleweight block, of course, is a combination of heavy and light aggregate. Lightweight units weigh about 30 percent less than heavyweight.

In the United States, loadbearing concrete masonry units of any weight must meet American Society for Testing and Materials (ASTM) C 90 standards to be acceptable. Among those are:

- Compressive strength---provides a measure of the blocks’ ability to carry loads and withstand structural stresses
- Absorption---provides a measure of the density of the concrete
- Moisture content---indicates if the unit is sufficiently dry for use in wall construction.
2.1.1 Block Sizes and Shapes

Manufacturers offer concrete block units in sizes and shapes to fit different construction needs. *(Figure 8-42)* Units are available in full- and half-length sizes, as well as specialty units such as headers, jambs, and pilasters.

*Figure 8-42 – Typical sizes and shapes of concrete masonry units.*

Like lumber, you refer to concrete units by their nominal dimensions. A unit measuring 7 5/8 in. wide, 7 5/8 in. high, and 15 5/8 in. long is referred to as an 8- by 8- by 16-in. unit (8x8x16). When laid in a wall with 3/8-in. mortar joints, the unit will occupy a space 8 in. deep, 8 in. high, and 16 in. long. Besides the basic 8x8x16 concrete masonry units, there are smaller partition units and units that masons use similar to brick in brick masonry. Besides the shapes shown in *Figure 8-42*, a number of smaller shapes for various special purposes are available.

Units may be cut (Figure 8-43) to the desired shapes with a bolster (a wide brick chisel available in various sizes) or, more conveniently and accurately, with a power-driven masonry saw with a saw tooth configuration specifically designed for masonry.

*Figure 8-43 – Typical bolsters and masonry saw blade.*
The standard 8x8x16 CMU has specific names for the various parts of its structure: (Figure 8-44)

- Face Shell---the long sides
- End shell---the recessed ends
- Web---the material that forms the partitions between the cores
- Cores---the holes between the webs
- Edges---the vertical ends of the face shell on either side of the end shell

![Figure 8-44](image.png)

**Figure 8-44 – Concrete block terms.**

### 2.1.2 Wall Patterns

The large number of shapes and sizes of concrete blocks lend themselves to a great many uses. Figure 8-45 shows only a few of the wall patterns possible using various **pattern bonds** and block sizes.

![Wall patterns](image.png)

**Figure 8-45 – Wall patterns with concrete masonry units.**
In addition, the recent technological developments have created multiple opportunities for architectural relief patterns on the face of the blocks. *(Figure 8-46)* Commercial publications from the Portland Cement Association show many more.

**Figure 8-46 – Samples of architectural block.**

*Figure 8-47* shows some of the styles of screen blocks (blocks with patterned holes) masons use to make a decorative wall called a pierced or screen wall. Other architectural effects are achievable by laying some block in relief, that is, by having some block faces more prominent, or by varying the type of mortar joint.

**Figure 8-47– Screen block designs.**

### 2.1.3 Modular Planning

Experienced masons lay out concrete masonry walls to make maximum use of full- and half-length units, thus minimizing cutting and fitting on the job.
Figure 8-48 – Modular dimensions in concrete masonry wall openings.

Assuming that the project’s window and doorframes are of modular dimensions that will fit, all layouts should be in increments of 8 inches (Figure 8-48). This allows the best use of full-size and half-size units, aligns the cells for both, and expedites job progress. Layout should consider:

- Length and height of walls
- Width and height of openings
- Wall areas between doors, windows, and corners
- Horizontal dimensions should be in multiples of full-length masonry units, 2 x 8 = 16 inches. or half-length units of 8 inches.
- Vertical dimensions should be in multiples of full-height masonry units, 8 inches.

When units 8 inches by 4 inches by 16 inches are used, the horizontal dimension should still be planned in multiples of 8 inches (half-length units), but the vertical dimensions, should be in multiples of 4 inches, the height of the block. Keep in mind how blocks interlace at corners when changing direction, if the thickness of the wall is greater or less than the length of a half unit (8 inches), a special length unit is required at each corner in each course, again creating additional cutting.

2.2.0 Structural Clay Tile Masonry

Another masonry product available is a hollow masonry unit made of burned clay or shale. It has various names: structural tiles, hollow tiles, structural clay tiles, structural clay hollow tiles, structural clay hollow building tiles, but the most common term is building tile.

Manufacturers create building tile by pushing plastic clay through a die in a predetermined shape and cutting it off into units. The units are sent to a kiln and burned in much the same manner as bricks.

The structure of building tile is referred to much the same as concrete block:

- Cell—-the apertures in a building tile
- Shell—-the solid sides of a tile
- Web---the perforated material enclosed by the shell

A tile laid on one of its shell faces is a side-construction tile; one laid on one of its web faces is an end-construction tile. Figure 8-49 shows sizes and shapes of basic side- and end-construction building units. Special shapes are also available for use at corners, at openings, and as closures.

![Figure 8-49 - Standard shapes of structural clay tile.](image)

### 2.2.1 Physical Characteristics

The qualities by which to judge good structural clay tile are the same as characteristics for good concrete, compressive and tensile strengths, and durability (abrasion resistance).

The compressive strength of the individual tile depends upon the thickness of the shell and web, the materials used, and the method of manufacture. A minimum compressive strength of 300 lb per square inch may be expected.

The tensile strength of structural clay tile masonry is small. In most cases, it is less than 10 percent of the compressive strength.

The abrasion resistance of clay tile depends primarily upon its compressive strength; the stronger the tile, the greater the resistance to wear. The abrasion resistance decreases as the amount of water absorbed increases.

Structural clay facing-tile has excellent resistance to weathering. Freezing and thawing action produces almost no deterioration. Tile that absorbs no more than 16 percent of its weight of water has always given satisfactory performance in resisting the effect of freezing and thawing. Masons should only use portland cement-lime mortar or mortar prepared from masonry cement if the tile is exposed to the weather.

Walls containing structural clay tile have better heat-insulating qualities than walls composed of solid concrete masonry units because of the dead air space that exists in clay tile walls. The resistance to sound penetration compares favorably with solid masonry walls, but is somewhat less.

The fire resistance of tile walls is considerably less than the fire resistance of solid masonry walls but can improve with the application of a coat of plaster. Structural clay tile partition walls 6 inches thick will resist a fire for 1 hour provided the fire produces a temperature of not more than 1700°F.

The solid material in structural clay tile weighs about 125 pounds per cubic foot. Since
the tile contains hollow cells of various sizes, the weight of the tile varies depending upon the manufacturer and type. A 6-inch tile wall weighs approximately 30 pounds per square foot, while a 12-inch tile weighs approximately 45 pounds per square foot.

2.2.2 Uses for Structural Clay Tile

One of the more obvious differences between a concrete masonry unit (CMU) and a structural clay tile is the direction of the cells upon installation. CMU cells orient vertically and are often filled with concrete and reinforcing iron to provide a solid wall. Structural clay tile installation orients the cells horizontally, and the tiles are never filled, providing a dead air space of insulation.

Structural clay tile is appropriate for use as exterior walls of either the loadbearing or non-loadbearing type. It is suitable for both below-grade and above-grade construction. Structural loadbearing tile is made in thicknesses from 4-inches to 12-inches with various face dimensions, but building codes and specifications restrict the use of these tiles, so consult the project specification before using them.

Non-loadbearing partition walls, with the 4-inch to 12-inch thicknesses, are frequently made of structural clay tile. These walls are easy to build, light in weight, and have good heat and sound insulating properties.

*Figure 8-50 shows the use of structural clay tile as a back unit for a brick wall and a structural tile wall using 8-inch, by 5-inch, by 12-inch. tile. The open-end exposure of the horizontal celled tile is closed by applying a thin tile called a soap at the corner.*

![Figure 8-50 – Structural tile as a backing for bricks and as an eight-in. wall.](image)

2.3.0 Stone Masonry

Stone masonry is masonry in which the units consist of natural stone. In rubble stone masonry, the stones remain in their natural state without any kind of shaping. In ashlar masonry, the mason squares the face of the stones so the surface of the finished structure will be more or less on a continuous plane. Both rubble and ashlar may be random or coursed (*Figure 8-51*). Random rubble is the crudest or most natural looking, of all types of stonework. It appears as though little attention was paid to laying the stones, but experienced masons will offer that the "natural" look may be the most difficult to create. Coursed rubble consists of roughly squared stones assembled in such a manner as to produce approximately continuous horizontal bed joints.
Each layer of a masonry wall must contain bonding stones that extend through the wall, as shown in Figure 8-52. This produces a wall that is tied together to the depth of the wall. The bed joints should be horizontal for stability, but the “builds” or head joints may run in any direction.

Figure 8-51 – Examples of rubble and ashlar stone masonry.

Figure 8-52 – Bond stones in random stone masonry.

The stone for stone masonry should be strong, durable, and cheap. Durability and strength depend upon the chemical composition and physical structure of the stone. Some of the more commonly found suitable stones are limestone, sandstone, granite, and slate. To minimize costs and reduce transportation, masons may use unsquared stones obtained from nearby ledges, quarries, or even fieldstones. The size of the stone should be such that two people can easily handle it. A variety of sizes is
necessary to avoid using large quantities of mortar.

Stone masonry mortar may consist of portland cement and sand in proportions of one part cement to three parts sand by volume. However, such mortar shrinks excessively and does not trowel well. A better mortar for this application is a portland cement-lime mortar mix. Lime does not usually stain the stone. Also, ordinary portland cement mortar will stain most types of stone. If staining is an issue, masons should use non-staining white portland cement for the mortar mix.

2.4.0 Brick Masonry

In brick masonry, masons lay units of baked clay or shale of uniform size in courses with mortar joints to form walls of virtually unlimited length and height. The units may form the wall itself or be the facade to an existing structural wall. These units are small enough for placing with one hand. The chemical and physical characteristics of the ingredients vary considerably. In some regions, excavators open pits that yield raw material that, when ground and moistened, forms and bakes into durable brick. In other regions, manufacturers must mix clays or shales from several pits to produce bricks. Those varying ingredients, along with kiln temperatures, combine to produce brick in a variety of colors and harnesses.

The nominal dimensions of a U.S. standard building brick are 2 1/4 by 3 3/4 by 8. The actual dimensions may vary a little because of shrinkage during burning.

2.4.1 Brick Nomenclature

Frequently, the mason must cut the brick into various shapes. The most common shapes are shown in Figure 8-53. They are: half or bat, three-quarter closure, quarter closure, king closure, queen closure, and split. They are used to fill in spaces at corners and other places where a full brick will not fit. The six surfaces of a brick are: cull, end, beds, side, and face.

2.4.2 Brick Classification

There are three general classifications of brick: common, face, and backup.

Unless the brick is a façade against a structural wall, a finished brick structure contains face brick (placed on the exposed face of the structure) and backup brick (placed behind the face brick). The face brick is usually of higher quality than the backup brick. However, the mason may use common brick to build the entire wall. Common brick is
made from pit-run clay, that is, with no attempt at color control and no special surface treatment like glazing or enameling. Most common brick is red.

Although any surface brick is a face brick by virtue of its placement, the term face brick also distinguishes high-quality brick from brick that is of common-brick quality or less. Applying this criterion, the color of face brick is uniformly more even than that of common brick, and locally may be obtainable in a variety of colors as well.

Face brick surface finish has a better appearance than common brick. It may also be more durable, due to the use of select clays and other materials, or from special manufacturing methods.

Backup brick may consist of brick that is inferior in quality even to common brick. Brick that was underburned, overburned, made with inferior clay, or made by inferior methods is often incorporated into the structure as backup brick and may be used as a cost saving measure.

Still another type of classification divides brick into grades according to its probable exposure to climatic conditions.

These are as follows:

- GRADE SW---brick designed to withstand exposure to below-freezing temperatures in a moist climate like that of the northern regions of the United States.
- GRADE MW---brick designed to withstand exposure to below-freezing temperatures in a drier climate than Grade SW.
- GRADE NW---brick primarily intended for interior or backup brick; may be used exposed in a region where no frost action occurs or in a region where frost action occurs but the annual rainfall is less than 15 in.

### 2.4.3 Types of Bricks

There are many types of brick. Some are different in formation and composition while others vary according to their use.

Some commonly used types of brick are:

- COMMON brick---made of ordinary clays or shales
  - burned in the usual manner in the kilns
  - no special scorings or markings
  - no special color or surface texture
  - known as hard- and kiln-run brick
  - generally used for backing courses in solid or cavity brick walls
- FACE brick---used in the exposed face of a wall
  - higher quality units than backup brick
  - better durability and appearance
  - most common colors are various shades of brown, red, gray, yellow, and white
- CLINKER brick—have been overburned in the kilns
  - usually hard and durable
  - may be irregular in shape
  - describable as rough-hard
- PRESS brick—made by the dry press process
  - regular smooth faces, sharp edges, and perfectly square corners
  - usually used as face brick
- GLAZED brick—one surface of each brick glazed in white or other color
  - ceramic glazing consists of mineral ingredients that fuse together in a glass-like coating during burning
  - particularly suited for walls or partitions in hospitals, dairies, laboratories, or other buildings where cleanliness and ease of cleaning are necessary
- FIREBRICK—special type of fire clay
  - will withstand the high temperatures of fireplaces, boilers, and similar usages without cracking or decomposing
  - larger than regular structural brick and often hand molded
- CORED brick—holes extending through the beds to reduce weight
  - no significant difference between the strength of cored brick walls compared to solid brick walls
  - resistance to moisture penetration about the same for both types of walls
  - most easily available brick meeting requirements, cored or solid, can be used
- SAND-LIME brick—made from a lean mixture of slaked lime and fine siliceous sand
  - under steam pressure molded under mechanical pressure
  - hardened

2.4.4 Masonry Terms

Specific terms identify various positions of masonry units, bricks, or groups of bricks and mortar joints in a wall. *(Figure 8-54)*

These are as follows:
- Course—continuous horizontal layer (or row) of masonry that, bonded together, form the masonry structure
- Stretcher—masonry unit laid flat with its longest dimension parallel to the face of the wall
- Header—masonry unit laid flat with its longest dimension perpendicular to the face of the wall; generally used to tie two wythes of masonry together
- Wythe—continuous single vertical wall of brick
- Rowlock—brick laid on its edge (face).
- Bull-Stretcher—rowlock brick laid with its longest dimension parallel to the face of
the wall
- Bull-Header---rowlock brick laid with its longest dimension perpendicular to the face of the wall
- Soldier---brick laid on its end with its longest dimension parallel to the vertical axis face of the wall

![Diagram of masonry positions](image)

**Figure 8-54 – Terms for positions of bricks.**

### 2.4.5 Types of Bonds

In masonry, the word *bond* has three different references and one (pattern) can have a large number of additional meanings.

- **STRUCTURAL BOND**---a method of interlocking or tying individual masonry units together in one of three ways so that the entire assembly acts as a single structural unit
  - overlapping (interlocking) the masonry units
  - metal ties embedded in connecting joints
  - adhesion of grout to adjacent wythes of masonry
- **MORTAR BOND**---the adhesion of the joint mortar to the masonry units or to the reinforcing steel
- **PATTERN BOND**---pattern formed by the masonry units and the mortar joints on the face of a wall; may result from the type of structural bond or be purely decorative

The following five pattern bonds are the most commonly used today, but there are many combinations and variations available. *(Figure 8-55)*

- **RUNNING BOND**---the simplest of the basic pattern bonds
  - consists of all stretchers, no headers; uses metal ties
  - used largely in cavity and veneered walls
  - also used as facing for tile wall
- **COMMON** or **AMERICAN BOND**---a variation of running bond with a course of full length headers at regular intervals
  - headers provide structural bonding as well as pattern
  - header courses usually appear every fifth, sixth, or seventh course, depending on the structural bonding requirements
  - a three-quarter brick must start each header course at the corner
  - may be varied by using a Flemish header course
- **STACK BOND**---purely a pattern bond
  - no overlapping of units, all vertical joints aligned
  - usually bonded to backing with rigid steel ties, may use 8-in. thick stretchers
  - needs steel pencil rod reinforcement in horizontal mortar joints for large area and loadbearing walls
  - requires dimensionally accurate or carefully matched units for alignment
  - pattern variety possible with numerous combinations
- **FLEMISH BOND**---made of alternate stretchers and headers with headers in alternate courses centered over stretchers in intervening courses
  - if headers not used for structural bond, half-bricks (blind-headers) used
  - a three-quarter brick starts each header course at the corner for a Flemish Corner
  - a one-quarter brick starts each header course at the corner for an English Corner
- **ENGLISH BOND**---alternate courses of headers and stretchers
  - headers are centered on the stretchers and joints between stretchers
  - vertical (head) joints between stretchers in all courses line up vertically
  - blind headers used in courses that are not structural bonding
  - headers alternate between RUNNING BOND courses
- **ENGLISH CROSS BOND** is a variation---headers alternate between STACK BOND courses
Figure 8-55 – Samples of brick masonry bonds.

Summary

Concrete and masonry are a common factor in many Seabee projects from reinforcing and pouring slab foundations for aircraft parking aprons to building new schoolhouses with concrete masonry units and mortar. A good understanding of their principles will help you support the project successfully with original drawings, sectional sketches, material testing, quality control, or any other task assigned to you.
Review Questions (Select the Correct Response)

1. What are the ingredients for mixing concrete?
   A. Water and cement only
   B. Water, cement, and fine aggregates only
   C. Water, cement, and coarse aggregates only
   D. Water, cement, fine aggregates, and course aggregates

2. What chemical reaction occurs to harden concrete?
   A. Dehydration
   B. Hydration
   C. Oxidation
   D. Deoxidation

3. Which two ingredients react to harden concrete?
   A. Cement and fine aggregates
   B. Cement and course aggregates
   C. Cement and water
   D. Course aggregates and fine aggregates

4. Concrete is high in ______ strength but relatively weak in ______ strength.
   A. tensile, compressive
   B. compressive, tensile
   C. shear, tensile
   D. tensile, shear

5. ________ is concrete’s resistance to deterioration caused by exposure to service conditions.
   A. Strength
   B. Compressibility
   C. Flexibility
   D. Durability

6. During a concrete pour, ______ settle(s) leaving voids filled by ________.
   A. solid particles, cement
   B. cement, water
   C. solid particles, water
   D. cement, solid particles
7. Which of the following actions should you take to ensure concrete is as watertight as possible?

A. Add more water.
B. Add less water.
C. Use only the amount of water required to attain the necessary workability.
D. Add more sand to fill any voids.

8. Which of the following materials can be placed in concrete to reinforce it?

A. Steel bars
B. Steel rods
C. Steel strands, wire, and welded wire fabric
D. All of the above

9. What reinforced concrete structural member supports and distributes building loads to the ground?

A. Plain slab
B. Footing
C. Beam
D. Column

10. _________ reinforcement is (are) the principle reinforcement(s) in a column.

A. Lateral ties
B. Vertical
C. Spiral
D. Caisson

11. Engineers may design both straight and _____ bars to resist the bending tension in the bottom of a beam.

A. spiral
B. truss
C. lateral
D. caisson

12. Steel is the best material for reinforcing concrete because their coefficients of _____ are almost the same.

A. compression
B. tension
C. shear
D. expansion
13. The bond strength of steel-concrete is in direct proportion to the amount of _____________.

A. cement  
B. contact  
C. fine aggregate  
D. water

14. Reinforcing bars increase in diameter from one size to the next by _____ increments.

A. 1/16 inch  
B. 1/8 inch  
C. 1/4 inch  
D. 3/8 inch

15. What might occur if a reinforcing bar is bent too sharply?

A. The bar could crack or be weakened.  
B. The bar will not adhere to the concrete.  
C. Concrete strength would be reduced.  
D. Hydration would not occur.

16. What is the minimum length of a lap splice for (a) No. 3 bars and (b) No. 6 bars when not dimensioned on the drawings?

A. (a) 11.25 in (b) 22.50 in  
B. (a) 12.00 in (b) 22.50 in  
C. (a) 22.50 in (b) 12.00 in  
D. (a) 22.50 in (b) 11.25 in

17. A concrete structural member fabricated at a location other than its final position of use is known as ________?

A. preconstructed  
B. cast-in-place  
C. prefabricated  
D. precast

18. A concrete structural member cast in its final position of use is known as______.

A. preconstructed  
B. cast-in-place  
C. prefabricated  
D. precast
19. Small, closely spaced beams used in (a) floor and (b) roof construction are known as _____ and _____.

A. (a) joists (b) purlins  
B. (a) joists (b) joists  
C. (a) purlins (b) purlins  
D. (a) purlins (b) joists  

20. What primary difference, if any, exists between precast beams and girders?

A. Beams are wider than girders  
B. Beams are used for different purposes than girders  
C. Beams are made of different material than girders  
D. Beams are shorter than girders  

21. If not rectangular or T shaped, what cross-sectional shape will the ends of most precast beams have?

A. W  
B. D  
C. I  
D. C  

22. Which of the following is considered the most important advantage to precasting?

A. Less required storage space  
B. Faster erection time  
C. Reusable forms  
D. Quality-controlled concrete  

23. Which of the following descriptions most accurately describes pre-tensioning of concrete members?

A. After the concrete has been placed and has reached a specified strength, reinforcement strands are pulled through formed channels, and a predetermined amount of stress is applied.  
B. Reinforcement strands are pulled through tubes and stressed after placement of the concrete.  
C. Reinforcement strands are stressed to a predetermined point before placement of the concrete and are released just before the concrete has set.  
D. Reinforcement strands are placed in the forms and are stressed to a predetermined point before the concrete is placed; the strands are then released after the concrete has reached a specified strength.
24. In what part of a prestressed beam does the tensioned steel produce high compression?

   A. Upper  
   B. Lower  
   C. Exact center  
   D. Approximate center

25. What condition occurs when a load (force) is placed on a prestressed beam?

   A. The camber is forced out, leaving a beam with positive deflection.  
   B. The upward bow is increased.  
   C. The camber is forced out, leaving a level beam with no deflection.  
   D. The upward bow is forced out, creating deflection in the beam.

26. Conventional concrete’s approximate weight is ________.

   A. 175 lb/cu ft  
   B. 150 lb/cu ft  
   C. 130 lb/cu ft  
   D. 115 lb/cu ft

For questions 8-27 to 8-30, select the type of concrete from the following list that best matches the characteristic given.

1. HEAVYWEIGHT CONCRETE  
2. SEMI-LIGHTWEIGHT CONCRETE  
3. INSULATING LIGHTWEIGHT CONCRETE  
4. STRUCTURAL LIGHTWEIGHT CONCRETE

27. Weighs 115 to 130 lb/cu ft and has a compressive strength comparable to conventional concrete.

   A. 1  
   B. 2  
   C. 3  
   D. 4

28. Weighs 20 to 70 lb/cu ft and is used for fireproofing.

   A. 1  
   B. 2  
   C. 3  
   D. 4

29. Weighs up to 400 lb/cu ft and is used for radiation shielding.

   A. 1  
   B. 2  
   C. 3  
   D. 4
30. Weighs up to 115 lb/cu ft and is used to decrease the dead-load weight of structural members.

A. 1  
B. 2  
C. 3  
D. 4  

31. In tilt-up panel construction, where are the wall panels usually cast?

A. On the ground  
B. Precast off site  
C. Cast-in-place  
D. On the ground floor slab  

32. In tilt-up panel construction, where is additional reinforcement generally needed?

A. Around any openings  
B. At the bottom  
C. Around the edges  
D. At the top  

33. In a tilt-up panel construction, in what manner are pickup inserts installed?

A. Independently of the reinforcement  
B. Tied to reinforcement  
C. Welded to reinforcement  
D. Tied to the panel forms  

34. What is the strongest method of connecting tilt-up panels together?

A. A butted connection using grout or gasket  
B. A cast-in-place column with the panel-reinforcing steel tied into the pilaster  
C. Steel columns welded to steel angles or plates secured in the panel  
D. Precast columns tied with the panel  

35. Construction joints must be located where ________________.

A. the builder finds it most convenient  
B. it causes the minimum amount of weakness  
C. the beam meets the column  
D. the slab meets the wall
36. What is the purpose of contraction joints?

A. To prevent buckling due to expansion of the reinforcing steel caused by temperature changes
B. To prevent buckling due to expansion of the concrete caused by temperature changes
C. To prevent cracking due to shrinkage of the reinforcing steel caused by temperature changes
D. To prevent cracking due to shrinkage of the concrete caused by temperature changes

37. Expansion joints are also known as _____ joints.

A. Construction
B. Shrinkage
C. Contraction
D. Isolation

38. _____ is placing plastic concrete into spaces enclosed by forms.

A. Casting
B. Reeling
C. Molding
D. Premolding

39. (True or False) Builders must always use forms for molding the sides of footings and only pour against the soil for the bottom of the footings.

A. True
B. False

40. What part of a wall form shapes and retains the concrete until it sets?

A. Brace
B. Wale
C. Stud
D. Sheathing

41. What do builders often use on simple walls to maintain wall depth dimensions during a pour?

A. Sheathing and stakes
B. Wales and battens
C. Ties and wood spreaders
D. Cleats and yokes
42. Which of the following devices combines the functions of wire ties and wooden spreaders?

A. Tie holder  
B. Snap tie  
C. Tie spreader  
D. Bar tie

43. _____ are the column form members that brace against bursting pressure.

A. Yokes  
B. Battens  
C. Walers  
D. Studs

44. Where is the bursting pressure greatest in pouring column forms?

A. Middle  
B. Top  
C. Bottom  
D. Beam side

45. Typically, girder and beam form _____ need to remain in place longer for additional curing.

A. sides  
B. soffits  
C. cleats  
D. chamfers

46. What is the most commonly used unit in concrete masonry?

A. Concrete block  
B. Clay tile  
C. Stone  
D. Brick

47. Which of the following measures a concrete block’s ability to carry loads and withstand structural stresses?

A. Absorption  
B. Moisture content  
C. Density  
D. Compressive strength

48. What is the actual size, in inches, of an 8- by 8- by 16-inch CMU?

A. 7 1/2 by 7 1/2 by 15 1/2  
B. 7 5/8 by 7 5/8 by 15 5/8  
C. 8 by 8 by 16  
D. 8 1/4 by 8 1/4 by 16 1/4
49. A concrete masonry unit’s face shell is the ____________.
   A. partitions between the cores
   B. hole between the webs
   C. long side of the block unit
   D. recessed end of the block

50. Modular planning minimizes cutting and fitting by using ____________.
   A. full-size units only
   B. half-size units only
   C. full-size and quarter-size units
   D. full-size and half-size units

51. In addition to the thickness of the shell and webs, the compressive strength of structural clay tile depends upon the ____________.
   A. materials used and method of manufacture
   B. the opening and cell size
   C. its resistance to abrasion
   D. its resistance to deterioration

52. When structural clay building tiles are used in construction that will be exposed to the weather, masons should prepare mortar from which of the following materials?
   A. Portland cement-lime or waterproofed cement
   B. Portland cement-lime or masonry cement
   C. Masonry cement or waterproofed cement
   D. Masonry cement or straight lime

53. Walls containing structural clay tile have better ______ qualities than solid concrete masonry units.
   A. soundproofing
   B. weather resistant
   C. abrasion
   D. heat insulating

54. Which of the following factors restricts the use of structural clay tile?
   A. Above or below grade level
   B. Weight and sizes of the tiles
   C. Availability of the material
   D. Building codes and specifications
55. Which of the following stone masonry descriptions best describes the term “rubble”?

A. The faces of stone are square and placed in position so the finished surfaces will present a continuous plane surface appearance.
B. The stones used are left in their natural state without any kind of shaping.
C. The stones are laid in courses without consideration of size or weight.
D. The stones are roughly squared and laid in such a manner to produce approximately continuous horizontal bed joints.

56. Which of the following is considered to be the crudest of stone masonry?

A. Coursed ashlar
B. Coursed rubble
C. Random ashlar
D. Random rubble

57. Stone for stone masonry should be strong, durable and ______.

A. absorbent
B. cheap
C. resistant
D. weathered

58. What are the nominal dimensions in inches of a standard U.S building brick?

A. 1 1/4 by 3 3/4 by 8
B. 1 1/2 by 3 3/4 by 8
C. 1 3/4 by 3 3/4 by 8
D. 2 1/4 by 3 3/4 by 8

59. Common brick is best described as ________________.

A. unglazed, uniform in color, and made from select clay
B. unglazed, variable in color, and made from inferior clay
C. unglazed, variable in color, and made from pit-run clay
D. glazed, uniform in color, and made from select clay

60. ______ brick is the classification designed to withstand exposure to below-freezing temperatures in a moist climate.

A. SW
B. MW
C. NW
D. MC
61. Which of the following types of brick is commonly used as the backing course for a cavity wall?

A. Face  
B. Common  
C. Glazed  
D. Fire

62. What type of brick is made of special clay and is designed to withstand high temperatures?

A. Press  
B. Clinker  
C. Glazed  
D. Fire

63. A ________ is a continuous single vertical wall of brick.

A. rowlock  
B. stretcher  
C. soldier  
D. wythe

64. Which of the following statements best describes the term rowlock?

A. A brick laid flat with its longest dimension perpendicular to the wall.  
B. A brick laid on its edge (face).  
C. A brick laid with its longest dimension parallel to the face of the wall.  
D. A brick laid on its end with its longest dimension parallel to the vertical axis face of the wall.

65. Structural bonding of brick walls causes the entire assembly to act as a single unit. Which of the following methods accomplishes this bond?

A. Adhesion of grout to adjacent wythes of masonry  
B. Embedding metal ties in connecting joints  
C. Interlocking of the masonry units  
D. All of the above

66. What is the name of the simplest pattern bond made up entirely of stretchers?

A. Running  
B. American  
C. Flemish  
D. Common
67. Which of the following pattern bonds begins with a three-quarter brick at the corner of each header course?

A. Stack  
B. Flemish  
C. Block  
D. Common

68. An English bond pattern wall is composed of alternate courses of ________.

A. Three-quarter and blind headers  
B. Stretchers and bull-headers  
C. Headers and stretchers  
D. Headers and rigid steel ties
**Trade Terms Introduced In this Chapter**

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bending moment</td>
<td>A moment of force (often just moment); a synonym for torque, an important basic concept in physics, civil engineering, and mechanical engineering.</td>
</tr>
<tr>
<td>Compressive strength</td>
<td>Resistance of a material to fracture under compression.</td>
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<tr>
<td>Dowel</td>
<td>A solid cylindrical rod, usually made of wood, plastic or metal.</td>
</tr>
<tr>
<td>Dry packing</td>
<td>Placing of zero slump, or near zero slump, concrete, mortar, or grout by ramming into a confined space.</td>
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<tr>
<td>Facade</td>
<td>Any side of a building facing a public way or space and finished accordingly.</td>
</tr>
<tr>
<td>Fieldstone</td>
<td>A stone occurring naturally in fields, often used as a building material.</td>
</tr>
<tr>
<td>Hydration</td>
<td>A chemical reaction in which water takes part with the formation of a single product.</td>
</tr>
<tr>
<td>Lap splice</td>
<td>When two pieces of rebar are overlapped to create a continuous line of rebar. The length of the lap varies depend on concrete strength, the rebar grade, size, and spacing.</td>
</tr>
<tr>
<td>Ledges</td>
<td>A level of rock-bearing ore; a vein.</td>
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<tr>
<td>Monolithically</td>
<td>Constituting or acting as a single, often rigid, uniform whole; in this usage, pouring concrete for slab and beam units at the same time.</td>
</tr>
<tr>
<td>Pattern bond</td>
<td>Pattern formed by the masonry units and the mortar joints on the face of a wall. The pattern may result from the type of structural bond used or may be purely a decorative one unrelated to the structural bonding.</td>
</tr>
<tr>
<td>Perlite</td>
<td>A formless volcanic glass that has a relatively high water content; occurs naturally and has the property of greatly expanding when heated sufficiently; useful for its light weight after processing.</td>
</tr>
<tr>
<td>Quarries</td>
<td>An excavation or pit, usually open to the air, from which building stone, slate, or the like, is obtained by cutting, blasting.</td>
</tr>
<tr>
<td>Siliceous</td>
<td>Containing, consisting of, or resembling silica, the major ingredient in sand; used to manufacture a variety of materials, especially glass and concrete.</td>
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<tr>
<td>Term</td>
<td>Definition</td>
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<tr>
<td>Slaked lime</td>
<td>A soft, white, crystalline, very slightly water-soluble powder: used chiefly in mortars, plasters, and cements.</td>
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<tr>
<td>Soffit</td>
<td>The underside of a structural component, such as a beam, arch, staircase, or cornice.</td>
</tr>
<tr>
<td>Load</td>
<td>Any type of force exerted on an object, which may be in the form of a ‘weight’ (gravitational force), a pressure, or anything which affects the object in question; includes dead load (weights of material, equipment, or components that are relatively constant throughout the structure’s life) and live load (all the forces that are variable within the object’s normal operation cycle).</td>
</tr>
<tr>
<td>Tensile strength</td>
<td>Resistance of a material to a force tending to tear it apart.</td>
</tr>
<tr>
<td>Trowel</td>
<td>Any of various tools having a flat blade with a handle, used for depositing and working mortar, plaster, etc.</td>
</tr>
<tr>
<td>Vermiculite</td>
<td>A natural mineral that expands with the application of heat.</td>
</tr>
<tr>
<td>Wythe</td>
<td>A continuous single vertical wall of brick.</td>
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Additional Resources and References

This chapter is intended to present thorough resources for task training. The following reference works are suggested for further study. This is optional material for continued education rather than for task training.

U.S. Army Armament Research and Development Command, Dover, N.J 1978

Portland Cement Association: http://www.cement.org
CSFE Nonresident Training Course – User Update

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