Aggregate

Aggregates are inert granular materials such as sand, gravel, or crushed stone that, along with water and portland cement, are an essential ingredient in concrete. For a good concrete mix, aggregates need to be clean, hard, strong particles free of absorbed chemicals or coatings of clay and other fine materials that could cause the deterioration of concrete. Aggregates, which account for 60 to 75 percent of the total volume of concrete, are divided into two distinct categories-fine and coarse. Fine aggregates generally consist of natural sand or crushed stone with most particles passing through a 3/8-inch (9.5-mm) sieve. Coarse aggregates are any particles greater than 0.19 inch (4.75 mm), but generally range between 3/8 and 1.5 inches (9.5 mm to 37.5 mm) in diameter. Gravels constitute the majority of coarse aggregate used in concrete with crushed stone making up most of the remainder.

Natural gravel and sand are usually dug or dredged from a pit, river, lake, or seabed. Crushed aggregate is produced by crushing quarry rock, boulders, cobbles, or large-size gravel. Recycled concrete is a viable source of aggregate and has been satisfactorily used in granular subbases, soil-cement, and in new concrete. Aggregate processing consists of crushing, screening, and washing the aggregate to obtain proper cleanliness and gradation. If necessary, a benefaction process such as jigging or heavy media separation can be used to upgrade the quality.

Once processed, the aggregates are handled and stored in a way that minimizes segregation and degradation and prevents contamination. Aggregates strongly influence concrete's freshly mixed and hardened properties, mixture proportions, and economy. Consequently, selection of aggregates is an important process. Although some variation in aggregate properties is expected, characteristics that are considered when selecting aggregate include:

- grading
- durability
- particle shape and surface texture
- abrasion and skid resistance
- unit weights and voids
- absorption and surface moisture

Grading refers to the determination of the particle-size distribution for aggregate. Grading limits and maximum aggregate size are specified because grading and size affect the amount of aggregate used as well as cement and water requirements, workability, pumpability, and durability of concrete. In general, if the water-cement ratio is chosen correctly, a wide range in grading can be used without a major effect on strength. When gap-graded aggregate are specified, certain particle sizes of aggregate are omitted from the size continuum. Gap-graded aggregate are used to obtain uniform textures in exposed aggregate concrete. Close control of mix proportions is necessary to avoid segregation.

Shape and Size Matter

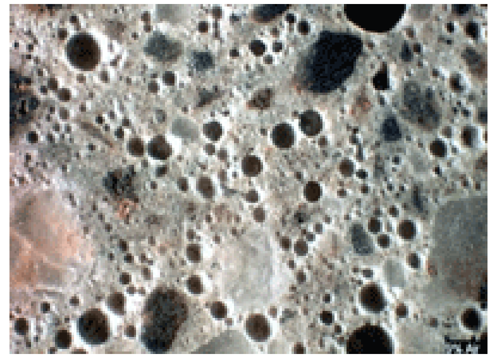
Particle shape and surface texture influence the properties of freshly mixed concrete more than the properties of hardened concrete. Rough-textured, angular, and elongated particles require more water to produce workable concrete than smooth, rounded compact aggregate. Consequently, the cement content must also be increased to maintain the water-cement ratio. Generally, flat and elongated particles are avoided or are limited to about 15 percent by weight of the total aggregate. Unit-weight measures the volume that graded aggregate and the voids between them will occupy in concrete. The void content between particles affects the amount of cement paste required for the mix. Angular aggregate increase the void content. Larger sizes of well-graded aggregate and improved grading decrease the void content. Absorption and surface moisture of aggregate are measured when selecting aggregate because the internal structure of aggregate is made up of solid material and voids that may or may not contain water. The amount of water in the concrete mixture must be adjusted to include the moisture conditions of the aggregate. Abrasion and skid resistance of an aggregate are essential when the aggregate is to be used in concrete constantly subject to abrasion as in heavy-duty floors or pavements. Different minerals in the aggregate wear and polish at different rates. Harder aggregate can be selected in highly abrasive conditions to minimize wear.

Related Topics:

How Cement is Made
Chemical Admixtures
Supplementary Cementing Materials
Air Entrained Concrete
Placing & Finishing Concrete
Curing Concrete

Air-Entrained Concrete

Concrete Basics Home > Air-Entrained Concrete



One of the greatest advances in concrete technology was the development of air-entrained concrete in the late 1930s. Today, air entrainment is recommended for nearly all concretes, principally to improve resistance to freezing when exposed to water and deicing chemicals. However, there are other important benefits of entrained air in both freshly mixed and hardened concrete. Air-entrained concrete contains billions of microscopic air cells. These relieve internal pressure on the concrete by providing tiny chambers for the expansion of water when it freezes.

Air-entrained concrete is produced through the use of air-entraining portland cement, or by introducing air-entraining admixtures under careful engineering supervision as the concrete is mixed on the job. The amount of entrained air is usually between 5 percent and 8 percent of the volume of the concrete, but may be varied as required by special conditions. The use of air-entraining agents results in concrete that is highly resistant to severe frost action and cycles of wetting and drying or freezing and thawing and has a high degree of workability and durability.

More on air-entraining admixtures.

Chemical Admixtures

Concrete Basics Home > Chemical Admixtures

Chemical admixtures are the ingredients in concrete other than portland cement, water, and aggregate that are added to the mix immediately before or during mixing. Producers use admixtures primarily to reduce the cost of concrete construction; to modify the properties of hardened concrete; to ensure the quality of concrete during mixing, transporting, placing, and curing; and to overcome certain emergencies during concrete operations.

Successful use of admixtures depends on the use of appropriate methods of batching and concreting. Most admixtures are supplied in ready-to-use liquid form and are added to the concrete at the plant or at the jobsite. Certain admixtures, such as pigments, expansive agents, and pumping aids are used only in extremely small amounts and are usually batched by hand from premeasured containers.

The effectiveness of an admixture depends on several factors including: type and amount of cement, water content, mixing time, slump, and temperatures of the concrete and air. Sometimes, effects similar to those achieved through the addition of admixtures can be achieved by altering the concrete mixture-reducing the water-cement ratio, adding additional cement, using a different type of cement, or changing the aggregate and aggregate gradation.

Five Functions

Admixtures are classed according to function. There are five distinct classes of chemical admixtures: air-entraining, water-reducing, retarding, accelerating, and plasticizers (superplasticizers). All other varieties of admixtures fall into the specialty category whose functions include corrosion inhibition, shrinkage reduction, alkali-silica reactivity reduction, workability enhancement, bonding, damp proofing, and coloring. Air-entraining admixtures, which are used to purposely place microscopic air bubbles into the concrete, are discussed more fully in "Air-Entrained Concrete."

Water-reducing admixtures usually reduce the required water content for a concrete mixture by about 5 to 10 percent. Consequently, concrete containing a water-reducing admixture needs less water to reach a required slump than untreated concrete. The treated concrete can have a lower water-cement ratio. This usually indicates that a higher strength concrete can be produced without increasing the amount of cement.

Recent advancements in admixture technology have led to the development of mid-range water reducers. These admixtures reduce water content by at least 8 percent and tend to be more stable over a wider range of temperatures. Mid-range water reducers provide more consistent setting times than standard water reducers.

Retarding admixtures, which slow the setting rate of concrete, are used to counteract the accelerating effect of hot weather on concrete setting. High temperatures often cause an increased rate of hardening which makes placing and finishing difficult. Retarders keep concrete workable during placement and delay the initial set of concrete. Most retarders also function as water reducers and may entrain some air in concrete.

Accelerating admixtures increase the rate of early strength development, reduce the time required for proper curing and protection, and speed up the start of finishing operations. Accelerating admixtures are especially useful for modifying the properties of concrete in cold weather.

Superplasticizers, also known as plasticizers or high-range water reducers (HRWR), reduce water content by 12 to 30 percent and can be added to concrete with a low-to-normal slump and water-cement ratio to make high-slump flowing concrete. Flowing concrete is a highly fluid but workable concrete that can be placed with little or no vibration or compaction. The effect of superplasticizers lasts only 30 to 60 minutes, depending on the brand and dosage rate, and is followed by a rapid loss in workability. As a result of the slump loss, superplasticizers are usually added to concrete at the jobsite.

Corrosion-inhibiting admixtures fall into the specialty admixture category and are used to slow corrosion of reinforcing steel in concrete. Corrosion inhibitors can be used as a defensive strategy for concrete structures, such as marine facilities, highway bridges, and parking garages, that will be exposed to high concentrations of chloride. Other specialty admixtures include shrinkage-reducing admixtures and alkali-silica reactivity inhibitors. The shrinkage reducers are used to control drying shrinkage and minimize cracking, while ASR inhibitors control durability problems associated with alkali-silica reactivity.

More on chemical admixtures.

Controlled Low-Strength Material

Concrete Basics Home > Controlled Low-Strength Material

In 1964, the U.S. Bureau of Reclamation documented the first known use of controlled low-strength material (CLSM). Plastic soil-cement, as the Bureau called it, was used as pipe bedding on over 320 miles (515 km) of the Canadian River Aqueduct Project in northwestern Texas. Since 1964, CLSM has become a popular material for projects such as structural fill, foundation support, pavement base, and conduit bedding.

CLSM is a self-compacted, cementitious material used primarily as a backfill in lieu of compacted backfill. Several terms are currently used to describe this material, including flowable fill, controlled density fill, flowable mortar, plastic soil-cement, soil-cement slurry, K-Krete, and other names. CLSM is defined as a material that results in a compressive strength of 1200 psi (8 MPa) or less. Most current CLSM applications require unconfined compressive strengths of 200 psi (1.4 MPa) or less. This lower strength requirement is necessary to allow for future excavation of CLSM.

The term CLSM can be used to describe a family of mixtures for a variety of applications. For example, the upper limit of 1200 psi (8 MPa) allows use of this material for applications where future excavation is unlikely, such as structural fill under buildings. Low density CLSM describes a material with distinctive properties and mixing procedures. Future CLSM mixtures may be developed as anticorrosion fills, thermal fills, and durable pavement bases.

CLSM is composed of water, portland cement, aggregate, and fly ash. It is a fluid material with typical slumps of 10 inches (254 mm) or more. It has the consistency of a milk shake.

Fast Discharge

Like most concrete, CLSM may be mixed in central-mix concrete plants, ready-mixed concrete trucks or pugmills. Once CLSM is transported to the jobsite, the mixture may be placed using chutes, conveyors, buckets, or pumps depending upon the application and its accessibility. A truck often can be discharged in less than 5 minutes. A constant supply of CLSM will keep the material flowing and will make it flow horizontal distances of 300 feet (91 m) or more. Although CLSM may be placed continuously in most applications, care must be taken when backfilling around pipes. For pipe bedding and backfilling, CLSM is placed in lifts to prevent the pipes from floating. Internal vibration or compaction is not needed to consolidate CLSM mixtures. Its fluidity is sufficient to consolidate under its own weight.

The fluidity/flowability and self-compacting properties of CLSM mixtures make CLSM an economical alternative to compacted granular material due to savings of labor and time during placing. CLSM is also an all-weather construction material—it will displace any standing water left in a trench—making it a ideal material for many projects.

The primary application of CLSM is as structural fill or backfill in place of compacted soil. The flowable characteristics of CLSM mean that it can readily be placed into a trench and into tight or restricted-access areas where placing and compacting fill is difficult. CLSM also makes an excellent bedding material for pipe, electrical, telephone, and other types of conduits because the mixture easily fills voids beneath the conduit and provides uniform support.

CLSM will not settle or rut under loads, making the material an ideal pavement base. Additionally, CLSM can be placed quickly and support traffic load within hours of placement-minimizing repair time and allowing a rapid return to traffic. CLSM may be equal to or less than the cost of using standard compacted backfill.

Since 1979, the Iowa Department of Transportation has used CLSM to structurally modify more than 40 substandard bridges by converting them into culverts. CLSM is also used to fill large voids such as old tunnels and sewers. In a Milwaukee project, 830 cubic yards (635 cubic meters) of CLSM were used to fill an abandoned tunnel.

A ready-mixed concrete producer can aid in developing a mix design for CLSM. However, when ordering CLSM, consider the following:

- Strength: Applications that require removal of CLSM at a later date usually limit the maximum compressive strength to less than 200 psi (1.4 MPa).

- Setting and Early Strength: Hardening time can be as short as one hour, but can take up to 8 hours depending on mix design and trench conditions.

- Density in Place: Density of normal CLSM in place typically ranges from 90 to 125 pounds per cubic foot (1440 to 2000 kg/cubic meters).

- Flowability: Flowability can be enhanced through the use of fly ash or air entrainment.

- Durability: CLSM materials are not designed to resist freezing and thawing, abrasive or erosive actions, or aggressive chemicals.

More information can be found at the National Ready Mix Association Web site.

After concrete is placed, a satisfactory moisture content and temperature (between 50°F and 75°F) must be maintained, a process called curing. Adequate curing is vital to quality concrete.

Curing has a strong influence on the properties of hardened concrete such as durability, strength, watertightness, abrasion resistance, volume stability, and resistance to freezing and thawing and deicer salts. Exposed slab surfaces are especially sensitive to curing. Surface strength development can be reduced significantly when curing is defective.

Curing the concrete aids the chemical reaction called hydration. Most freshly mixed concrete contains considerably more water than is required for complete hydration of the cement; however, any appreciable loss of water by evaporation or otherwise will delay or prevent hydration. If temperatures are favorable, hydration is relatively rapid the first few days after concrete is placed; retaining water during this period is important. Good curing means evaporation should be prevented or reduced.

Curing methods:

Liquid membrane-forming compounds sprayed onto the surface are effective, economical moisture barriers for moist-curing concrete.

Polyethylene sheets are effective, economical moisture barriers for moist-curing concrete.

Burlap kept saturated with water is an effective medium for
moist-curing concrete.
Straw or hay is still used to insulate fresh concrete in freezing weather.

Related Topics:
How Cement is Made
Aggregrate
Chemical Admixtures
Supplementary Cementing Materials
Air Entrained Concrete
Placing & Finishing Concrete

-
Placing & Finishing Concrete
Concrete Basics Home > Placing & Finishing Concrete

Mixing, transporting, and handling of concrete should be carefully coordinated with placing and finishing operations. Concrete should not be deposited more rapidly than it can be spread, struck off, consolidated, and bullfloated. Concrete should be deposited continuously as near as possible to its final position. In slab construction, placing should be started along the perimeter at one end of the work with each batch placed against previously dispatched concrete. Concrete should not be dumped in separate piles and then leveled and worked together; nor should the concrete be deposited in large piles and moved horizontally into final position.

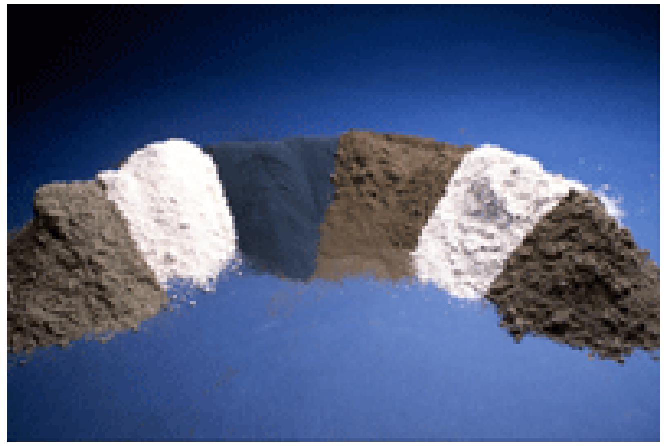
Consolidation

In some types of construction, the concrete is placed in forms, then consolidated. Consolidation compacts fresh concrete to mold it within the forms and around embedded items and reinforcement and to eliminate stone pockets, honeycomb, and entrapped air. It should not remove significant amounts of intentionally entrained air. Vibration, either internal or external, is the most widely used method for consolidating concrete. When concrete is vibrated, the internal friction between the aggregate particles is temporarily destroyed and the concrete behaves like a liquid; it settles in the forms under the action of gravity and the large entrapped air voids rise more easily to the surface. Internal friction is reestablished as soon as vibration stops.

Finishing

Concrete that will be visible, such as slabs like driveways, highways, or patios, often needs finishing. Concrete slabs can be finished in many ways, depending on the intended service use. Options include various colors and textures, such as exposed aggregate or a patterned-stamped surface. Some surfaces may require only strikeoff and screeding to proper contour and elevation, while for other surfaces a broomed, floated, or troweled finish may be specified. In slab construction, screeding or strikeoff is the process of cutting off excess concrete to bring the top surface of the slab to proper grade. A straight edge is moved across the concrete with a sawing motion and advanced forward a short distance with each movement.

Bullfloating eliminates high and low spots and embeds large aggregate particles immediately after strikeoff. This looks like a long-handled straight edge pulled across the concrete. Jointing is required to eliminate unsightly random cracks. Contraction joints are made with a hand groover or by inserting strips of plastic, wood, metal, or preformed joint material into the unhardened concrete. Sawcut joints can be made after the concrete is sufficiently hard or strong enough to prevent raveling. After the concrete has been jointed, it should be floated with a wood or metal hand float or with a finishing machine using float blades. This embeds aggregate particles just beneath the surface; removes slight imperfections, humps, and voids; and compacts the mortar at the surface in preparation for additional finishing operations. Where a smooth, hard, dense surface is desired, floating should be followed by steel troweling. Troweling should not be done on a surface that has not been floated; troweling after only bullfloating is not an adequate finish procedure. A slip-resistant surface can be produced by brooming before the concrete has thoroughly hardened, but it should be sufficiently hard to retain the scoring impression.



Supplementary cementing materials, also called mineral admixtures, contribute to the properties of hardened concrete through hydraulic or pozzolanic activity. Typical examples are natural pozzolans, fly ash, ground granulated blast-furnace slag, and silica fume, which can be used individually with portland or blended cement or in different combinations. These materials react chemically with calcium hydroxide released from the hydration of portland cement to form cement compounds. These materials are often added to concrete to make concrete mixtures more economical, reduce permeability, increase strength, or influence other concrete properties.

Fly ash, the most commonly used pozzolan in concrete, is a finely divided residue that results from the combustion of pulverized coal and is carried from the combustion chamber of the furnace by exhaust gases. Commercially available fly ash is a by-product of thermal power generating stations.

Blast-furnace slag, or iron blast-furnace slag, is a nonmetallic product consisting essentially of silicates, aluminosilicates of calcium, and other compounds that are developed in a molten condition simultaneously with the iron in the blast-furnace.

Silica fume, also called condensed silica fume and microsilica, is a finely divided residue resulting from the production of elemental silicon or ferro-silicon alloys that is carried from the furnace by the exhaust gases. Silica fume, with or without fly ash or slag, is often used to make high-strength concrete.

Below is a summary of the specifications and classes of supplementary cementing materials:

- Ground granulated iron blast-furnace slag-ASTM C989
- Grade 80-Slags with a low activity index
- Grade 100-Slags with a moderate activity index
- Grade 120-Slags with a high activity index
- Fly ash and natural pozzolans — ASTM C618

Working Safely with Concrete
Concrete Basics Home > Working Safely

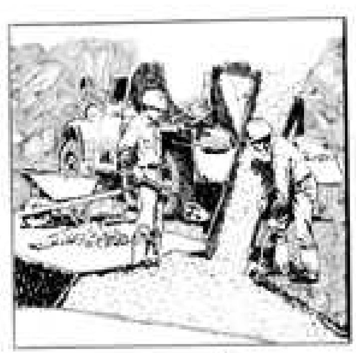
Concrete is easy to work with, versatile, durable, and economical. By observing a few basic precautions, it is also safe-one of the safest building materials known. Over the years, relatively few people involved in mixing, handling, and finishing concrete have experienced injury. Outlined below are some simple suggestions-protection, prevention, common sense precautions-useful to anyone working with portland cement and concrete.

The jobsite should be adequately marked to warn the public of construction activities. Fences, barricades, and warning signs can be used to restrict public access. And the work area should be kept clean and uncluttered to minimize hazards to workers. Remember: safety is the job of everyone onsite.

Protect Your Head and Eyes

Construction equipment and tools represent constant potential hazards to busy construction personnel. That's why hard hats are required on construction projects. It is therefore recommended that some sort of head protection, such as a hard hat or safety hat, be worn when working any construction job, large or small.

Proper eye protection is essential when working with cement or concrete. Eyes are particularly vulnerable to blowing dust, splattering concrete, and other foreign objects. On some jobs it may be advisable to wear full-cover goggles or safety glasses with side shields. Remember that sight is precious. Protect the head and eyes by using proper safety equipment and remaining alert.



Protect Your Back

All materials used to make concrete-portland cement, coarse aggregate, sand, and water-can be quite heavy even in small quantities. When lifting heavy materials, your back should be straight, legs bent, and the weight between your legs as close to the body as possible. Do not twist at the waist while lifting or carrying these items. Rather than straining your back with a heavy load, get help. Remember to use your head, not your back.

Let mechanical equipment work to your advantage by placing concrete as close as possible to its final position. After the concrete is deposited in the desired area by chute, pump, or wheelbarrow, it should be pushed-not lifted-into final position with a shovel. A short-handled, square-end shovel is an effective tool for spreading concrete, but special concrete rakes or come-alongs also can be used. Excessive horizontal movement of the concrete not only requires extra effort, but may also lead to segregation of the concrete ingredients.

Avoid actions that cause dust to become airborne. Local or general ventilation can control exposures below applicable exposure limits; respirators may be used in poorly ventilated areas, where exposure limits are exceeded, or when dust causes discomfort or irritation. Avoid prolonged exposure to dust.

Protect Your Skin

When working with fresh concrete, care should be taken to avoid skin irritation or chemical burns. Prolonged contact between fresh concrete and skin surfaces, eyes, and clothing may result in burns that are quite severe, including third-degree burns. If irritation persists consult a physician. For deep burns or large affected skin areas, seek medical attention immediately.

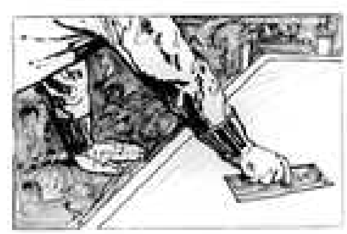
The A-B-Cs of fresh concrete's effect on skin are:
Abrasive Sand contained in fresh concrete is abrasive to bare skin.
Basic & Portland cement is alkaline in nature, so wet
Caustic concrete and other cement mixtures are strongly basic (pH of 12 to 13). Strong bases-like strong acids-are harmful, or caustic to skin.
Drying Portland cement is hygroscopic-it absorbs water. In fact, portland cement needs water to harden. It will draw water away from any material it contacts-including skin.

Clothing worn as protection from fresh concrete should not be allowed to become saturated with moisture from fresh concrete because saturated clothing can transmit alkaline or hygroscopic effects to the skin.

Waterproof gloves, a long-sleeved shirt, and long pants should be worn. If you must stand in fresh concrete while it is being placed, screeded, or floated, wear rubber boots high enough to prevent concrete from getting into them.

The best way to avoid skin irritation is to wash frequently with pH neutral soap and clean water.

Placing and Finishing



Waterproof pads should be used between fresh concrete surfaces and knees, elbows, hands, etc., to protect the body during finishing operations. Eyes and skin that come in contact with fresh concrete should be flushed thoroughly with clean water. Clothing that becomes saturated from contact with fresh concrete should be rinsed out promptly with clear water to prevent continued contact with skin surfaces. For persistent or severe discomfort, consult a physician.

When working with fresh concrete, begin each day by wearing clean clothing and conclude the day with a bath or shower.

Additional Information

For a complete listing of publications, videotapes, and further information on concrete safety for contractors, contact the American Society for Concrete Construction (ASCC) at 800-877-2753, or 38800 Country Club Drive, Farmington Hills, MI 48331-3411. Two useful publications are the *ASCC Safety Manual*, an extensive safety guide for concrete contractors, and the *ASCC Employee Safety Handbook*. For more information on cement, consult the manufacturer's material safety data sheet.

Warning

Contact with wet (unhardened) concrete, mortar, cement, or cement mixtures can cause SKIN IRRITATION, SEVERE CHEMICAL BURNS (THIRD-DEGREE), or SERIOUS EYE DAMAGE. Frequent exposure may be associated with irritant and/or allergic contact dermatitis. Wear waterproof gloves, a long-sleeved shirt, full-length trousers, and proper eye protection when working with these materials. If you have to stand in wet concrete, use waterproof boots that are high enough to keep concrete from flowing into them. Wash wet concrete, mortar, cement, or cement mixtures from your skin immediately. Flush eyes with clean water immediately after contact. Indirect contact through clothing can be as serious as direct contact, so promptly rinse out wet concrete, mortar, cement, or cement mixtures from clothing. Seek immediate medical attention if you have persistent or severe discomfort.

Concrete Basics

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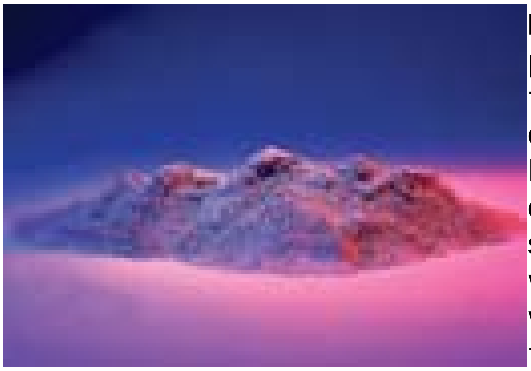
In its simplest form, concrete is a mixture of paste and aggregates. The paste, composed of portland cement and water, coats the surface of the fine and coarse aggregates. Through a chemical reaction called hydration, the paste hardens and gains strength to form the rock-like mass known as concrete.

Within this process lies the key to a remarkable trait of concrete: it's plastic and malleable when newly mixed, strong and durable when hardened. These qualities explain why one material, concrete, can build skyscrapers, bridges, sidewalks and superhighways, houses and dams.

Proportioning

The key to achieving a strong, durable concrete rests in the careful proportioning and mixing of the ingredients. A concrete mixture that does not have enough paste to fill all the voids between the aggregates will be difficult to place and will produce rough, honeycombed surfaces and porous concrete. A mixture with an excess of cement paste will be easy to place and will produce a smooth surface; however, the resulting concrete is likely to shrink more and be uneconomical.

A properly designed concrete mixture will possess the desired workability for the fresh concrete and the required durability and strength for the hardened concrete. Typically, a mix is about 10 to 15 percent cement, 60 to 75 percent aggregate and 15 to 20 percent water. Entrained air in many concrete mixes may also take up another 5 to 8 percent.



Portland cement's chemistry comes to life in the presence of water. Cement and water form a paste that coats each particle of stone and sand. Through a chemical reaction called hydration, the cement paste hardens and gains strength. The character of the concrete is determined by quality of the paste. The strength of the paste, in turn, depends on the ratio of water to cement. The water-cement ratio is the weight of the mixing water divided by the weight of the cement. High-quality concrete is produced by lowering the water-cement ratio as much as possible without sacrificing the workability of fresh concrete. Generally, using less water produces a higher quality concrete provided the concrete is properly placed, consolidated, and cured.

Other Ingredients

Although most drinking water is suitable for use in concrete, aggregates are chosen carefully. Aggregates comprise 60 to 75 percent of the total volume of concrete. The type and size of the aggregate mixture depends on the thickness and purpose of the final concrete product. Almost any natural water that is drinkable and has no pronounced taste or odor may be used as mixing water for concrete. However, some waters that are not fit for drinking may be suitable for concrete.

Excessive impurities in mixing water not only may affect setting time and concrete strength, but also may cause efflorescence, staining, corrosion of reinforcement, volume instability, and reduced durability. Specifications usually set limits on chlorides, sulfates, alkalis, and solids in mixing water unless tests can be performed to determine the effect the impurity has on various properties. Relatively thin building sections call for small coarse aggregate, though aggregates up to six inches (150 mm) in diameter have been used in large dams. A continuous gradation of particle sizes is desirable for efficient use of the paste. In addition, aggregates should be clean and free from any matter that might affect the quality of the concrete.

More on concrete design and production.

Hydration Begins

Soon after the aggregates, water, and the cement are combined, the mixture starts to harden. All portland cements are hydraulic cements that set and harden through a chemical reaction with water. During this reaction, called hydration, a node forms on the surface of each cement particle. The node grows and expands until it links up with nodes from other cement particles or adheres to adjacent aggregates.

The building up process results in progressive stiffening, hardening, and strength development. Once the concrete is thoroughly mixed and workable it should be placed in forms before the mixture becomes too stiff.

During placement, the concrete is consolidated to compact it within the forms and to eliminate potential flaws, such as honeycombs and air pockets. For slabs, concrete is left to stand until the surface moisture film disappears. After the film disappears from the surface, a wood or metal handfloat is used to smooth off the concrete. Floating produces a relatively even, but slightly rough, texture that has good slip resistance and is frequently used as a final finish for exterior slabs. If a smooth, hard, dense surface is required, floating is followed by steel troweling.

Curing begins after the exposed surfaces of the concrete have hardened sufficiently to resist marring. Curing ensures the continued hydration of the cement and the strength gain of the concrete. Concrete surfaces are cured by sprinkling with water fog, or by using moisture-retaining fabrics such as burlap or cotton mats. Other curing methods prevent evaporation of the water by sealing the surface with plastic or special sprays (curing compounds).

Special techniques are used for curing concrete during extremely cold or hot weather to protect the concrete. The longer the concrete is kept moist, the stronger and more durable it will become. The rate of hardening depends upon the composition and fineness of the cement, the mix proportions, and the moisture and temperature conditions. Most of the hydration and strength gain take place within the first month of concrete's life cycle, but hydration continues at a slower rate for many years. Concrete continues to get stronger as it gets older.

The Forms of Concrete

Concrete is produced in four basic forms, each with unique applications and properties. Ready-mixed concrete, by far the most common form, accounts for nearly three-fourths of all concrete. It's batched at local plants for delivery in the familiar trucks with revolving drums. Precast concrete products are cast in a factory setting. These products benefit from tight quality control achievable at a production plant. Precast products range from concrete bricks and paving stones to bridge girders, structural components, and panels for cladding.

Concrete masonry, another type of manufactured concrete, may be best known for its conventional 8 x 8 x 16-inch block. Today's masonry units can be molded into a wealth of shapes, configurations, colors, and textures to serve an infinite spectrum of building applications and architectural needs. Cement-based materials represent products that defy the label of "concrete," yet share many of its qualities. Conventional materials in this category include mortar, grout, and terrazzo. Soil-cement and roller-compacted concrete—"cousins" of concrete-are used for pavements and dams. Other products in this category include flowable fill and cement-treated bases. A new generation of advanced products incorporates fibers and special aggregate to create roofing tiles, shake shingles, lap siding, and countertops. And an emerging market is the use of cement to treat and stabilize waste.

Concrete Products

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Architectural and Decorative Concrete: This section highlights design possibilities and discusses considerations for selecting color and texture for architectural and decorative concrete.

Autoclaved Cellular Concrete, or ACC was invented in Sweden in the early 1900s. The lightweight, high-strength building material now used on every continent.

Concrete Masonry has undergone significant change within the last decade, becoming a more cost-effective, energy-efficient building product than ever.

Controlled Low-Strength Material is a cement-based product often used as a backfill

High-Strength Concrete: In the last two decades concrete has gotten stronger and better for high-rise construction.

Insulating Concrete Forms: These builder-friendly wall systems have recently made a mark on the housing industry of North America.

Concrete Pavement: This section describes the four types of concrete pavements and details the preparation, placement, and curing of concrete pavements.

Concrete Pipe provides water for people and farmlands or carries away sewage and drains land.

Precast Concrete became more common after World War II.

Prestressed Concrete: Patented in San Francisco in 1886, prestressed concrete made its impact on the United States construction industry almost 75 years later.

Ready-Mixed Concrete accounts for nearly three-fourths of all concrete used annually.

Roller-Compacted Concrete: Initially developed for use by the forestry industry in Canada, roller-compacted concrete is a durable paving and dam material that is placed using asphalt construction equipment.

Shotcrete is a mortar or concrete that is dispensed from a hose onto a surface at a high velocity.

Soil-Cement: Developed in 1935, this product is often used as a paving base, mixing cement with compacted soil.

Tilt-Up Concrete is a construction method where walls are cast in a horizontal position and then tilted into a vertical position and moved into place with a mobile crane.

How Portland Cement is Made

Concrete Basics Home > How Cement is Made

Take a Virtual Tour of a Cement Plant (click here)

Bricklayer Joseph Aspdin of Leeds, England first made **portland cement** early in the 19th century by burning powdered limestone and clay in his kitchen stove. By this crude method he laid the foundation for an industry which annually processes literally mountains of limestone, clay, cement rock, and other materials into a powder so fine it will pass through a sieve capable of holding water. Cement is so fine that **one pound of cement contains 150 billion grains**.

Portland cement, the basic ingredient of concrete, is a closely controlled chemical combination of calcium, silicon, aluminum, iron and small amounts of other ingredients to which gypsum is added in the final grinding process to regulate the setting time of the concrete. **Lime and silica make up about 85% of the mass**. Common among the materials used in its manufacture are limestone, shells, and chalk or marl combined with shale, clay, slate or blast furnace slag, silica sand, and iron ore.

Each step in manufacture of **portland cement** is checked by frequent chemical and physical tests in plant laboratories. The finished product is also analyzed and tested to ensure that it complies with all specifications.

Two Manufacturing Processes

Two different processes, **"dry" and "wet,"** are used in the manufacture of portland cement.

When rock is the principal raw material, the first step after quarrying in both processes is the primary crushing. Mountains of rock are fed through crushers capable of handling pieces as large as an oil drum. The **first crushing** reduces the rock to a maximum size of about **6 inches**. The rock then goes to **secondary crushers or hammer mills** for reduction to about **3 inches** or smaller.

In the wet process, the raw materials, properly proportioned, are then ground with water, thoroughly mixed and fed into the kiln in the form of a **"slurry"** (containing enough water to make it fluid). In the dry process, raw materials are ground, mixed, and fed to the kiln in a dry state. In other respects, the two processes are essentially alike.

The raw material is heated to about **2,700 degrees F** in huge cylindrical steel rotary kilns lined with special firebrick. Kilns are frequently as much as **12 feet in diameter** large enough to accommodate an automobile and longer in many instances than the height of a 40-story building. Kilns are mounted with the axis inclined slightly from the horizontal. The finely ground raw material or the slurry is fed into the higher end. At the lower end is a roaring blast of flame, produced by precisely controlled burning of powdered coal, oil or gas under forced draft.

As the material moves through the kiln, certain elements are driven off in the form of gases. The remaining elements unite to form a new substance with new physical and chemical characteristics. The new substance, called **clinker**, is formed in pieces about the size of marbles.

Clinker is discharged red-hot from the lower end of the kiln and generally is brought down to handling temperature in various types of **coolers**. The heated air from the coolers is returned to the kilns, a process that **saves fuel** and **increases burning efficiency.**

Virtual Tour of Cement Plant

More on Cement Basics.

go to Greenstreak Group links

CSI Div 3 Concrete

The Construction Specification Institute's Master Format™ is the specification writing standard for most commercial building design and construction projects in North America. http://www.csinet.org/s_csi/index.asp

CSI Division 3 contents relate to the work results, requirements, products and activities as it relates to CONCRETE. Greenstreak products discussed within this section are primarily designed and used for concrete structures and infrastructure.

X-Plug®

Link to X-Plug Overview Page

The X-Plug is a "patent pending" mechanical plug specifically designed to SEAL the void formed in a concrete wall by the removal of a taper tie rod or pass through tie sleeve. With the X-Plug's mechanical design, tightening of the stainless steel nut causes an expansion of the EPDM rubber plug, increasing its diameter inside the taper tie void. This action simultaneously compresses the main body plug onto the bolt to create a liquid-tight seal between the plug and the wall of the taper tie void.

Waterstops

Link to Waterstops Overview Page

Concrete structures are only as watertight as the waterstops that join them. Structures such as water treatment plants, reservoirs, locks, dams, and below grade facilities, most likely have a waterstop system in place. Several factors must be considered when selecting a waterstop. They include, but are not limited to, joint type and joint movement, hydrostatic pressure and chemical exposure. Greenstreak offers the industry's most comprehensive line of waterstops available today. Please select from the materials below for additional information to consider when selecting the right waterstop for your project.

G-Seal

Link to G-Seal Product Page

G-Seal is a cost effective alternative to traditional joint sealing products. Designed to fit over a variety of expansion board materials, G-Seal provides a long lasting, maintenance free joint seal. With features similar to that of a waterstop, G-Seal will accommodate joint movement without failure. G-Seal is available in styles for both new construction and retrofit applications.

Architectural Form Liners

Link to Form Liners Product Page

Greenstreak Form Liners attach to most any forming system or casting bed prior to concrete placement. Following normal placement practices and curing times, the forming system and liner are stripped leaving an architectural concrete finish.

Flat Slab Accessories

Flat Slab Accessories Page

Quality flat slabs are crucial components of commercial and industrial facilities. The ability to transport materials and products efficiently can be impeded by poor performing concrete joints, uncontrolled cracks and surface imperfections. Greenstreak's offers products for forming and curing of the slab and to accommodate load transfer throughout the life of the slab.

Tilt-Up Accessories

Tilt-Up Accessories Page

Tilt-Up concrete construction has become a preferred construction method for its efficiency and attractiveness. Greenstreak has been providing Architectural Form Liners to contractors using this method for over 30 years and has expanded this offering with the innovative Reveal Stix™ and Tilt-Up Shims.

Contractors building with this method will also find many of our products for Flat Slabs to be beneficial when building Tilt-Up structures.

Miscellaneous Concrete Accessories

Miscellaneous Concrete Accessories Page

Greenstreak offers a broad range of quality concrete accessory products. Products include joint formers, finish formers, concrete handling products, PVC waterstop splicing equipment and accessories, expansion boards, and epoxy

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- CSI Div 31 Earthwork
  - PEC-MAT

- **CSI Div 3 Concrete**

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http://www.greenstreak.com/Div3/Div3.asp