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Cellular concrete can be pumped over long distances at rates exceeding 100 cubic yards per hour. The highly fluid material also is self-leveling.

Cellular concrete to the rescue

Produced onsite with basic equipment, cellular concrete is an economical way to solve a variety of construction problems

BY STEVE LAVALLEE

Cellular concrete is a lightweight material that solves many heavy-duty construction problems. Used beneath roadways, bridge ramps, buildings and other structures, it reduces soil loading while adding compressive and shear strength. Contractors and engineers also use cellular lightweight concrete as backfill for tunnels, waterlines and

sewers, to provide shock absorption in earthquake zones, to fill voids in silos and abandoned mines, to reduce hydrostatic pressure on walls, and for a myriad of other uses.

Easily formed onsite

Composed of cement, water and small, discrete air cells, cellular concrete offers a unique range of benefits (see box on page 41). Contrac-

tors can produce it quickly and easily onsite by mixing a preformed foam into a portland-cement slurry.

The first step is to make the preformed foam by diluting a foam concentrate with water. This mixture is then pumped through special equipment that adds fixed volumes of air at fixed pressures to create a material having the consistency of shaving cream. Next, the material is

mixed with cement and water in a conventional rotary mixer to distribute the air voids uniformly and form a highly stable cellular structure.

Because production of preformed foam involves no gas-releasing chemical reactions, the foam doesn't expand once it enters the cement, and the density remains constant. The cement paste attains initial set in about 90 minutes. Though the foam in the concrete matrix is stabilized after initial set, six to 10 hours must pass before a placement of cellular concrete can be topped by a subsequent lift.

The design of a cellular-concrete mix must balance the need for load reduction with compressive-strength requirements. Because the material has a high air content, it generally has lower strengths than conventional concrete (see table). Applications that need significant strength, such as foundations, may call for

Benefits of cellular concrete

- Generally lower in cost than alternative load-reduction methods
- Easily placed by pump or gravity for rapid installation
- Lightweight
- Durable and noncorrosive
- Permanent and stable
- High slump (virtually self-leveling)
- Provides 100% compaction to fill spaces entirely without shrinkage
- Can have a broad range of densities and compressive strengths
- Absorbs shock waves
- High freeze-thaw resistance
- Insulating (can contain up to 80% air)
- Low water absorption and permeability

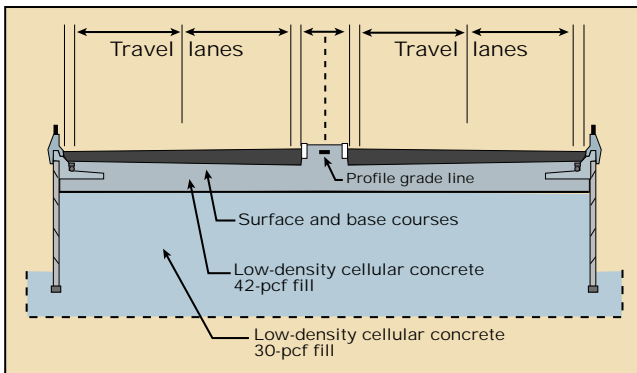
higher densities to achieve greater compressive strengths. For many applications, however, such as flowable fill in trench lines or behind retaining walls, the com-

pressive strength can be well below 100 psi. Because cellular-concrete flowable fill relies on large amounts of air rather than water for its fluid, self-leveling qualities, the material bleeds less than conventional flowable-fill concrete and shrinkage is al-

most negligible. The typical water-cement ratio of cellular concrete ranges from 0.48 to 0.52.

Success stories

Contractors have successfully used cellular concrete in thousands of projects. One such success story was the \$1 billion Cypress Replacement Project in San Francisco, which involved renovating 3½ miles of freeway destroyed in the 1989 Loma Prieta earthquake. Due to unstable soil conditions on this project, engineers specified the use of cellular concrete beneath the roadway for load support. Contractor Anning-Johnson Co., Melrose Park, Ill., poured more than 90% of the 110,000 cubic yards



Typical road section with cellular concrete used as load support.

Cellular concrete density and strength*			
Cast density** (lbs/cu ft)	Dry density** (lbs/cu ft)	Compressive strength (lbs/sq in.)	Bearing capacity (tons/sq ft)
25	21	60	4.3
30	25	120	8.6
35	31	200	14.4
40	34	300	21.6
45	38	420	30.2

*Actual properties depend on the cement used, water-cement ratio, curing conditions and other variables. Data are based on 28 days of curing. Mixes containing fly ash need at least 56 days to attain the strengths noted.

**Accurate to ±3 pcf.

of cellular concrete required.

The underlying soil on this job was extremely poor; it had little strength, compressed easily and was susceptible to liquefaction in earthquakes. Thus, the existing road and about 2½ feet of the soil beneath it had to be removed. Anning-Johnson crews then compacted the roadbed and covered it with 2½ feet of cellular concrete made with the Mearl-Crete foaming agent manufactured by Engelhard Corp., Iselin, N.J. With a density of 30 pounds per cubic foot and an average compressive strength of 150 psi, the concrete reduced surface loading by about 225 pounds per square foot. The same cellular-concrete mixture also was used to bank sections of the roadway. These pours were as thick as 6 feet.

To mix and place the lightweight concrete, crews set up a mixing sta-

tion onsite and pumped the material as far as 2,800 feet to reach the point of placement. For large placements, up to 100 cubic yards an hour of cellular concrete was pumped through a 3-inch-diameter hose at a pressure of 60 psi. Most of the job involved lifts of 8 to 14 inches.

Other highway projects that have benefited from the use of cellular concrete have involved pours as thick as 30 feet. Many of these jobs used a 30-pcf cellular concrete topped by a relatively thin cap of 42-pcf cellular concrete (see figure on page 41). This structure provides excellent load reduction and strength.

Cellular concrete also provides many benefits as an annular grout in tunnels. Two recently built, 15,000-foot transit tunnels in Portland, Ore., are good examples. Use of a low-density cellular grout saved \$600,000 on this \$186 million tunnel project, part of a

new 18-mile rail extension. The cellular grout also helped stabilize portions of the tunnel by filling voids as large as 60 cubic yards that opened during boring.

"The ground fractured badly when we mined the tunnel," says Shane Yanagisawa, chief project engineer for the project's general contractor, a joint venture of Frontier Kemper Constructors and Traylor Brothers Inc., both of Evansville, Ind. "In looking for alternative grout mixtures to fill cracks, crevasses and voids around the tunnel, we also wanted to keep water from seeping into the tunnel through cracks in the con-

crete. We evaluated about 20 different possibilities and chose a novel combination of cement, fly ash and foaming agent."

Using the cement and fly ash

Considerations when using cellular concrete

Although standard concrete (containing rock aggregate) and cellular concrete are similar in many ways, contractors must adapt their operations in the following ways when working with cellular concrete:

- Foam must be generated and mixed into the cement-water slurry onsite.
- Forms, when used at all, can be much less complex than those used with standard concrete, saving time and money during prepour preparation.
- Cellular concrete must be pumped from the mixing station to the point of placement. Pumping can extend for great distances at rates exceeding 100 cubic yards per hour.
- Cellular concrete's high slump makes it virtually self-leveling, which can eliminate or minimize spreading, raking, floating and other construction operations.
- The density and compressive strength of cellular concrete are controlled onsite by varying the amount of foam injected. Density can be varied from 20 to 120 pounds per cubic foot and compressive strength, from 20 to 3000 psi.
- The insulation afforded by air trapped in the cellular structure retains the heat of hydration, which eases cold-weather placement and makes curing more complete.
- When pouring the material underwater, make sure the mix is designed for negative buoyancy and low washout.



Containing large volumes of air, preformed foam has the consistency of shaving cream. Contractors can control the density and compressive strength of cellular concrete onsite by varying the amount of foam injected into it.

combination reduced material costs while meeting key performance specifications. In addition, the grout lacked the shrinkage often seen with typical contact-grout mixtures.


Workers mixed the cement and fly ash in batch plants outside the tunnel portals then trucked the material to 6-cubic-yard surge tanks in the tunnels. Foam was added to the grout right before it was pumped through holes drilled in the 12-inch-thick reinforced-concrete tunnel lining. Grouting crews placed about 12,000 cubic yards of the material over a 140-day period, completing

an average of 100 feet of tunnel per shift.

Recent advances

Though cellular concrete has been used in construction for more than 40 years, recent advances in the material's mix design have made it a viable option for a broader range of applications. The combination of cement and fly ash used in the Portland rail tunnel project is one example. Another advance is the use of Engelhard's high-reactivity meta-kaolin (HRM) to improve the underwater integrity and cohesiveness of

cellular concrete.

HRM—a high-performance mineral admixture refined from purified kaolinite clay—forms a gel-like matrix in cellular concrete to limit cement washout as the concrete passes through water. Underwater uses for HRM cellular concrete include renovating and stabilizing piers, providing load relief, protecting wood, and displacing water in abandoned pipelines. 

Steve LaVallee is a sales and project manager for Anning-Johnson Co.

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