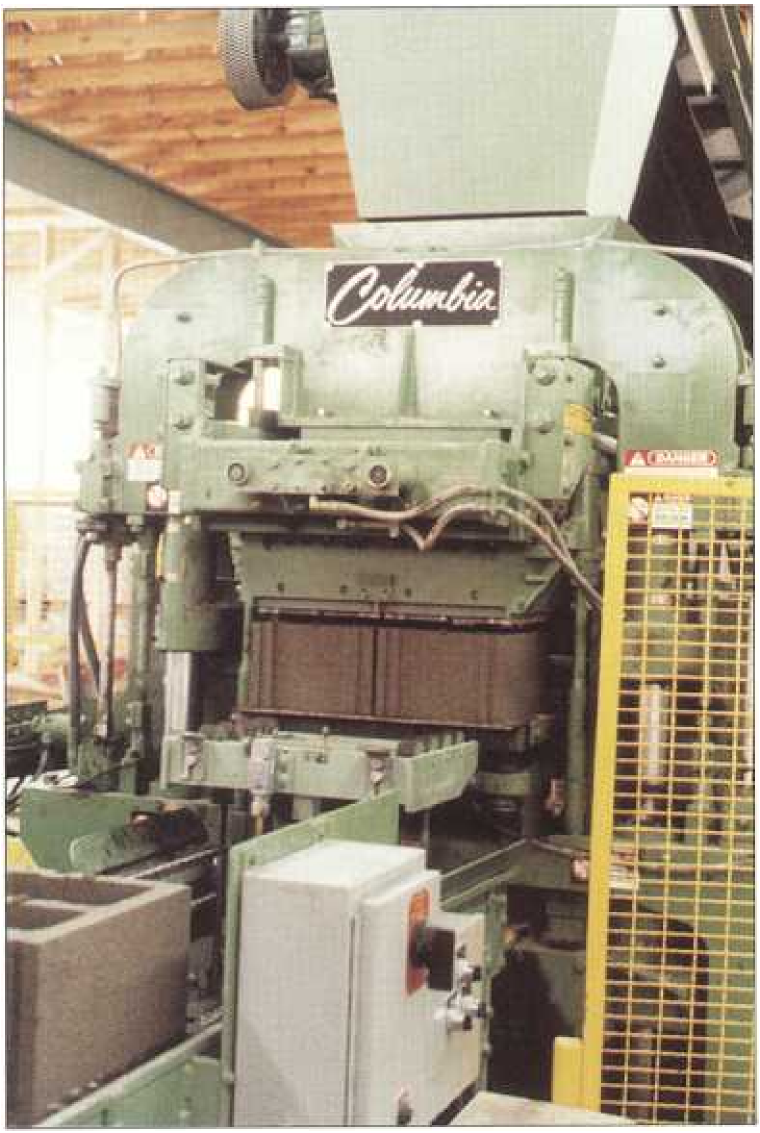


The same equipment is used to produce both lightweight and normalweight block.

Producing structural lightweight concrete block

Because of the greater porosity of lightweight aggregates, follow these procedures to ensure production of top-quality concrete masonry units

By Carolyn Schierhorn

The demand for lightweight block for loadbearing walls is increasing. Coping with a labor shortage in some geographic areas, the masonry industry is trying to boost the productivity of existing masons and laborers, as well as attract new workers, including women, into the field. Increasing productivity also reduces construction time and overhead costs, thus making masonry a more competitive building system.

Like normalweight concrete masonry, structural lightweight block must meet the requirements of ASTM C 90 (Standard Specification for Loadbearing Concrete Masonry Units). ASTM C 90 classifies loadbearing lightweight concrete masonry (under strength and absorption requirements) as having an oven-dry weight of less than 105 pounds per cubic foot. Mediumweight block weighs from 105 pounds to less than 125 pounds per cubic foot; normalweight block weighs at least 125 pounds per cubic foot (see Table 1).

The Expanded Shale, Clay & Slate Institute defines lightweight masonry as being less than 94 pounds per cubic foot (or a 25-pound, 8x8x16-inch CMU). Many blocks are called "lightweight" when, in reality, they are semi-lightweight or mediumweight block. Commercially available lightweight concrete block range from 85 pounds per cubic foot (a 22-pound, 8x8x16-inch CMU) to 105 pounds per cubic foot (a 28-pound, 8x8x16-inch CMU); they are made with varying amounts and types of lightweight aggregates.

All three weight classifications must meet the same requirement for net compressive strength—at least 1900 psi. Regarding maximum water absorption, however, the requirements differ. Lightweight concrete masonry may absorb up to 18 pounds of water per cubic foot, compared to 15 pounds per cubic foot for mediumweight and 13 pounds per cubic foot for normalweight block (Ref. 1).

Although the same equipment is used to produce both lightweight and normalweight units, you must modify certain procedures to make up for the greater porosity of lightweight aggregates.

Selecting aggregates

With a specific gravity ranging from 1.1 to 2.0 (considerably below that of sand and gravel) lightweight aggregates for loadbearing concrete masonry include: aggregates manufactured by expanding shale, clay, or slate; natural volcanic materials, such as pumice and scoria; and by-products, such as blast-furnace slag and coal cinders.

The weight of the aggregate depends on the amount of air trapped in each individual particle. The more air that is trapped, the lighter the weight and the better the insulation value, but the lower the strength (Ref. 2). Lightweight concrete block strong enough for structural applications are 20% to more than 30% lighter than conventional block.

Lightweight aggregates often are blended together and with conventional aggregates, such as sand, to satisfy various weight and performance criteria. Exactly which lightweight aggregates to use, however, is largely determined by cost and availability. As with normalweight block, high freight costs keep lightweight concrete masonry production a regional enterprise.

On the West Coast of the United States and in the Rocky Mountain region, where pumice and scoria are available naturally, these materials are frequently used in block production. In addition, imported pumice from the Mediterranean is competitively priced on the East Coast. But in general, block producers favor expanded shale, clay, and slate, which are more uniform than pumice and scoria and require less cement in the manufacturing process.

Tom Hammer of Westblock Products Inc., a Portland, Ore.-based block producer, manufactures a 28-pound, nominal 8x8x16-inch block with an aggregate blend that is 50% pumice and 50% sand and gravel by volume. "With the pumice alone, you can achieve only about 75% of the required 1900-psi strength, so we add sand and gravel."

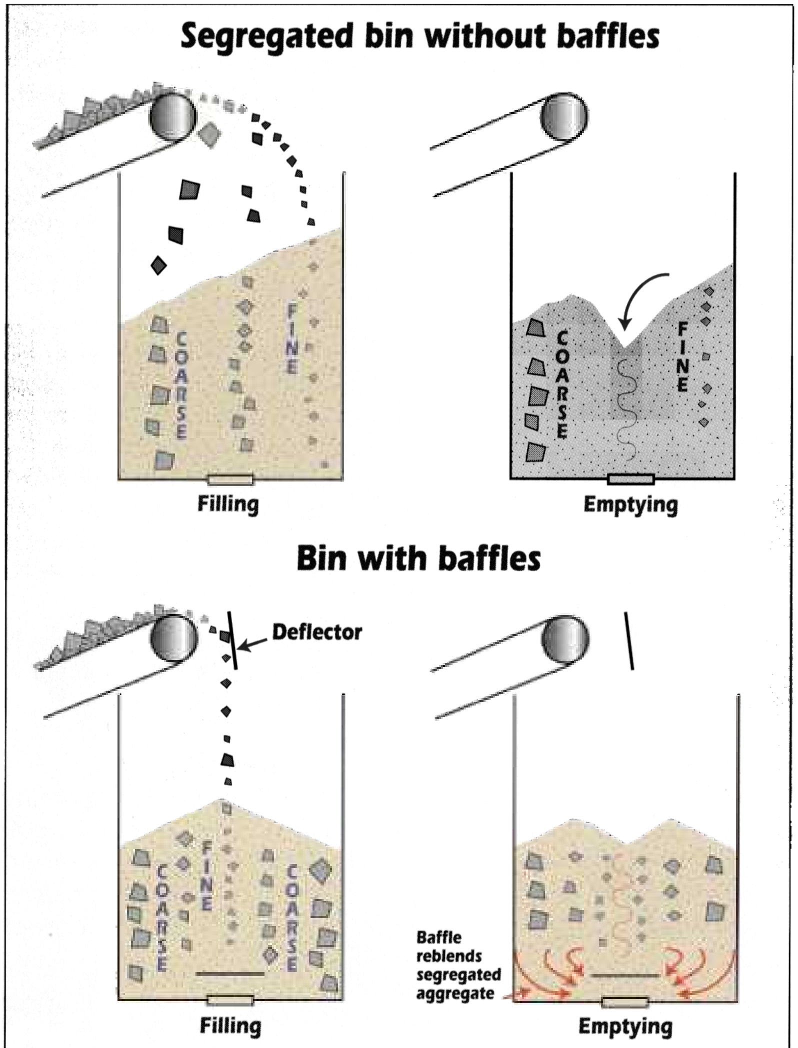
Hammer uses pumice because it is available and affordable in his area. "We charge only a dime extra per unit for lightweight block," he says.

Regardless of origin, all lightweight aggregates for concrete masonry must satisfy the requirements of ASTM C 331 (Standard Specification for Lightweight Aggregates for Concrete Masonry Units).

Fine aggregate must have a dry loose weight of no more than 70 pounds per cubic foot; coarse aggregate, a dry loose weight of no more than 55 pounds per cubic foot. The maximum dry loose weight of combined fine and coarse aggregate is 65 pounds per cubic foot (see Table 2). Lightweight aggregates must meet the grading requirements shown in Table 3 (Ref. 3).

Since as much as 65% to 75% of the absolute volume of a lightweight block consists of aggregate, it must be top-quality. When purchasing lightweight aggregate:

- Check every available source of material that may be economically feasible for use in your block plant.
- Consider the size and reputation of the aggregate supplier, hauling distance, and road load limits.
- Make sure the source can consistently



Source: Buildex Inc.

Table 1. Strength and Absorption Requirements of Loadbearing Concrete Masonry

Weight classification	Oven-dry weight of concrete (lb/ft³)	Minimum compressive strength (psi) (average of 3 units)	Maximum water absorption (lb/ft³)
Lightweight	Less than 105	1900	18
Mediumweight	105 to less	1900	15
Normalweight	125 or more	1900	13

Source: ASTM C 90 (Ref. 1)

furnish well-graded and sufficient amounts of material to ensure uninterrupted production.

- Perform periodic sieve tests at your plant to check on the aggregate supplier's quality control, since broken screens and worn conveyors, chutes, and hoppers can yield aggregate that fails to meet your original gradation specifications (Ref. 4).

Variations in mix design

Because so many variables must be considered, it's difficult to make useful generalizations about mix designs for loadbearing lightweight block. Lightweight concrete masonry often requires more cement for a given amount of aggregate than normalweight block.

However, cement-to-aggregate ratios for concrete masonry made of a particular lightweight aggregate can vary as widely as they do among block made of different aggregates (see Table 4). As is true of normalweight aggregate, lightweight aggregate of the same name varies from one locale to another. Moreover, block today are custom-formulated to meet a wide range of job specifications.

"I estimate that most block mixes containing our expanded shale—designed to produce an 8-inch stretcher weighing 23 to 26 pounds—have cement-to-aggregate ratios ranging from 1:8 to 1:12 by volume, to meet ASTM C 90 strength requirements," observes an aggregate manufacturer. High-strength mixes, designed to produce 3000- to 5000-psi net area strengths, require more cement—a ratio of approximately 1:6.

According to this manufacturer, some of the factors that determine cement content include blockmaking machine speed; smoothness of the equipment handling green and cured block; type and amount of curing; and time in the yard to age the block before testing.

Moreover, normalweight aggregates, such as ASTM C 33 concrete sand or crushed limestone, often are added to the mix at 10% to 30% by volume. The angularity of the crushed limestone can help improve green strength; and the fine fraction (passing the No. 100 sieve) acts like added cement paste in the green block. Using the proper amount and gradation of limestone allows producers to make units with less cement than they would otherwise need (Ref. 5).

Preventing segregation

Lightweight aggregates are more susceptible to segregation than normalweight aggregates, and coarse aggregates more than fine aggregates. Prewetting the material is one way to prevent segregation and should take place at the lightweight aggregate manufacturing plant or, if necessary, at the point of unloading when the aggregate is received. Apply a fine-water spray or mist to the aggregate just as it is discharged from the rail car or truck (Ref. 6).

Another way to control segregation is to use deflectors and suspend a plate over the discharge opening of the silo, to force the material to remix as the silo empties (see illustration). The plate should be several times larger than the opening and placed far enough above it to allow material to flow out of the silo. In addition, avoid running the silo completely empty.

Prewetting the aggregate also serves another purpose. Lightweight aggregates are more porous than other aggregates and, consequently, have a high affinity for water. For uniform production, this absorption should be satisfied before adding cement.

Furthermore, if the moisture isn't adjusted properly, either manually or via an automatic moisture meter, the mix will run too dry. A dry mix will undergo less compaction in the block machine and, therefore, will

Table 2. Unit Weight Requirements of Lightweight Aggregates for Concrete Masonry

Size designation	Maximum dry loose weight (lb/ft³)
Fine aggregate	70
Coarse aggregate	55
Combined fine and coarse aggregate	65

Source: ASTM C 331 (Ref. 3)

Table 3. Grading Requirements for Lightweight Aggregates for Concrete Masonry Units

	Percentage (by weight) passing sieves having square openings							
Size designation	**¾ in.**	**½ in.**	**⅜ in.**	**No. 4**	**No. 8**	**No. 16**	**No. 50**	**No. 100**
Fine aggregate: No. 4 to 0	...	...	100	85-100	...	40-80	10-35	5-25
Coarse aggregate: ½ in. to No. 4	100	90-100	40-80	0-20	0-10	...	...	
⅜ in. to No. 8	...	100	80-100	5-40	0-20	0-10	...	...
Combined fine and coarse aggregate: ½ in. to 0	100	95-100	...	50-80	...	...	5-20	2-15
⅜ in. to 0	...	100	90-100	65-90	35-65	...	10-25	5-15

Source: ASTM C 331 (Ref. 3)

yield masonry units that are more porous and have less strength.

Minimizing batch variation

Any lightweight aggregate blend can have variations in loose density, which can affect the batch consistency. In most plants, automated weigh batchers proportion materials by weight. With the use of lightweight aggregate, small variations in weight equate to big variations in volume due to the low unit weight of the material. This is significant because increases in volume weaken the mix; the cement, remaining at a constant weight and volume, then coats a greater volume of aggregate.

As a safeguard, producers should set up a volume-gauging system when making lightweight block. In plants that have a skip hoist, an experienced machine operator who sees the mix as it moves from the mixer to the block machine can adjust the batch weights if the size of the mix varies. Bin indicators, mirrors for sight adjustment, and slots cut in the batch hopper can also help detect aggregate volume changes.

Many block plants periodically run unit weight tests of their blended aggregate in the loose-pour condition, which simulates the condition in which the material enters the mixer. By this means, any variation in unit weight can be determined and adjustments made on the weigh batcher (Ref. 6).

One block machine manufacturer recommends volumetric batchers, which are standard in Europe and beginning to gain ground in the United States, to improve batch consistency.

Mixing lightweight concrete

In the production of normal-weight block, the materials are dry-mixed in the mixer for several minutes before water is added. When making lightweight block, however, the aggregates should be mixed with water before adding the cementitious materials.

One block machine manufacturer recommends this mixing procedure (Ref. 4):

1. Charge the mixer with all lightweight aggregate.

2. Add one-half to two-thirds of the total mixing water.

3. Mix for 30 seconds.

4. Add all the cementitious material.

5. Add the balance of the required mixing water.

6. Continue mixing an absolute minimum of two to four minutes.

7. If additional water is required

Table 4. Range of Cement-to-Aggregate Ratios (by weight)

Type of aggregate	Range of mixes
Expanded shale, clay, and slate	1:8 to 1:12
Pumice	1:4 to 1:6
Expanded slag	1:5 to 1:7
Cinders	1:6 to 1:8
Sand and gravel	1:8 to 1:12
Limestone	1:6 to 1:8
Air-cooled slag	1:8 to 1:12

Source: Ref. 4

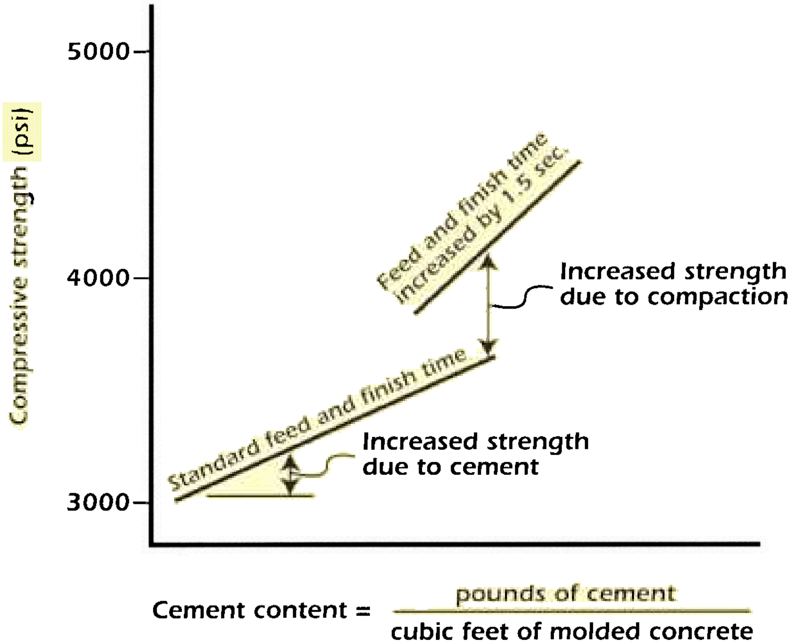
to bring the mix to the right consistency, mix for an additional one minute.

Increase mix compaction

Whether producing conventional or lightweight concrete masonry, the molding process is the same. However, when increasing the strength of lightweight block from 1900 psi to 4000 or 5000 psi, it's important to slow the machine cycle time by about 20% to achieve more compaction. Increasing the compaction time has an even greater impact on compressive strength than increasing the cement content, emphasizes Thomas Holm, vice president of engineering for Richmond, Va.-based Solite Corp., which operates eight block plants (see Table 5).

The machine operator should extend the feed-finish time, in which the feed drawer is positioned over the mold and the vibrating head comes down and consolidates the zero-slump concrete.

Table 5. Impact of Compaction vs. Cement Content on Compressive Strength



Source: Solite Corp. (Ref. 7)

Curing and drying

Like normalweight block, most lightweight block today are cured in low-pressure steam kilns. But lightweight units generally are cured at higher temperatures to facilitate cement hydration.

Since lightweight units are more porous and absorb more water during curing, some producers dry the block out slightly longer than normalweight block to prevent shrinkage problems later on. To evaporate the moisture in the units, many low-pressure steam kilns can be set to circulate dry heat for about four or five hours.

Handling finished units

Lightweight units typically are cubed and stored in the same manner as conventional block. But since lightweight block are more porous, some producers are more likely to cover the cubes with plastic to protect them from rain and snow.

The modifications needed to produce lightweight block, however, are minimal compared with the potential gains from pursuing this burgeoning market. Just remember to handle the aggregate to minimize segregation. Use quality control as needed to adjust for aggregate density variations and to keep block yield constant. And put as much water in the block as practical for compaction, strength, and resulting economy. ❖

Carolyn Schierhorn is senior editor of Aberdeen's Magazine of Masonry Construction.

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