Schwing America Inc.

Lightweight concrete was pumped up to 760 feet to construct the 800-foot-high mixed occupancy building at 900 N. Michigan Ave., Chicago. On some buildings, lightweight concrete has been pumped more than 1,000 vertical feet. Protruding rebar is a serious safety concern; see page 589 for more information on reinforcing steel safety.

Structural Lightweight Aggregate Concrete

Using structural lightweight concrete should pose few problems for knowledgeable contractors

By Moira A. Harding

With a typical unit weight of 90 to 120 pounds per cubic foot (pcf) and a compressive strength from 2500 psi to more than 8000 psi (Ref. 1), structural lightweight concrete is a versatile building material. Since it is generally 20% to 40% lighter than normalweight concrete (Ref. 2), a structure's dead load can be reduced, its foundation costs lowered, and its concrete and rebar needs lessened. Structural lightweight concrete also resists fire better than normalweight concrete because of its lower thermal conductivity and its lower coefficient of thermal expansion (Ref. 3). In many structures, these benefits justify the use of lightweight aggregate concrete, which generally costs more than normalweight concrete. Contractors who successfully use structural lightweight concrete share the following characteristics:

- An understanding of the product, particularly the unique qualities of lightweight aggregates
- An ability to establish good communication, especially with the lightweight aggregate supplier
- A knowledge of the field tests and adjustments needed to evaluate and maintain the quality of the concrete

- An appreciation for the proper handling of lightweight concrete

Lightweight Aggregate Characteristics

Although lightweight aggregates are discussed generally here, it is very important for concrete contractors to contact the lightweight aggregate suppliers to discuss the specific characteristics of their aggregate. Since the availability and properties of aggregates vary, lightweight aggregate suppliers provide recommendations on handling procedures. Problems that occur on a lightweight concrete project are probably due to lack of communication between the contractor and the lightweight aggregate supplier.

By definition, structural lightweight concrete contains aggregates that are either all-lightweight or a combination of lightweight and normalweight aggregate (Ref. 3). Generally, an all-lightweight concrete mix weighs between 90 and 100 pcf; a three-way mix of coarse lightweight aggregate, fine lightweight aggregate, and natural sand weighs between 100 and 110 pcf; and a concrete mix of coarse lightweight aggregate and natural sand weighs from 110 to 120 pcf (Ref. 2).

Aggregate types. Lightweight aggregates suitable for structural concrete may be natural materials such as pumice or scoria, or they may be processed aggregates such as expanded shales, clays, slates, and slags. Expanded slag is blast-furnace slag that is treated with water while in a molten state, and expanded shales, clays, and slates have been heated—either in a rotary kiln or on a sintering grate—until they reach a plastic state. In this plastic state, gases are released within the particle, expanding it and forming an internal cellular structure that remains even after the particle is cooled and hardened.

Absorption. More porous than normalweight particles, lightweight aggregates that are not presaturated will absorb the water in the concrete mix. To control slump, the lightweight aggregates should be prewetted before being used in a mix. This absorbed water is not part of the mix water in the lightweight mix, and it does not directly affect slump, water-cement ratio, or quality of the paste. Since the aggregates' water absorption varies, to maintain a high-quality mix, the local supplier should be contacted.

Prewetting Processes

There are three ways to prewet lightweight aggregate particles: thorough sprinkling, thermal quenching, and vacuum saturation (Ref. 3). What's important is both the amount of water that is absorbed and the uniformity with which it is absorbed.

Sprinkling. This process occurs either at the ready mix plant or the aggregate supplier's facility. If the particles are treated at the ready mix plant, they are sprinkled with water for a period of time that can range from hours to weeks, depending on the type and properties of the aggregate. Most aggregates, however, can be saturated in fewer than three days. The particles can also be treated by the aggregate supplier; before shipping and storing, the lightweight aggregate is sprayed with water as the particles travel on a belt.

Thermal quenching. This process occurs at the lightweight aggregate supplier's facility. Thermal saturation requires immersing heated aggregates in water. Particles subjected to thermal quenching absorb significantly more moisture than particles sprinkled for only 24 hours (Ref. 4).

Vacuum saturation. Another process that occurs at the aggregate supplier's facility, vacuum treatment consists of placing the aggregates in a tank and saturating them under a vacuum. In 30 to 45 minutes, vacuum-treated aggregates may achieve almost 100% saturation (Ref. 4).

It is critical for either the aggregate supplier or the ready mix producer to perform the prewetting process correctly. If the aggregate particles in lightweight concrete are properly prewetted, then the concrete should behave much like normalweight concrete.

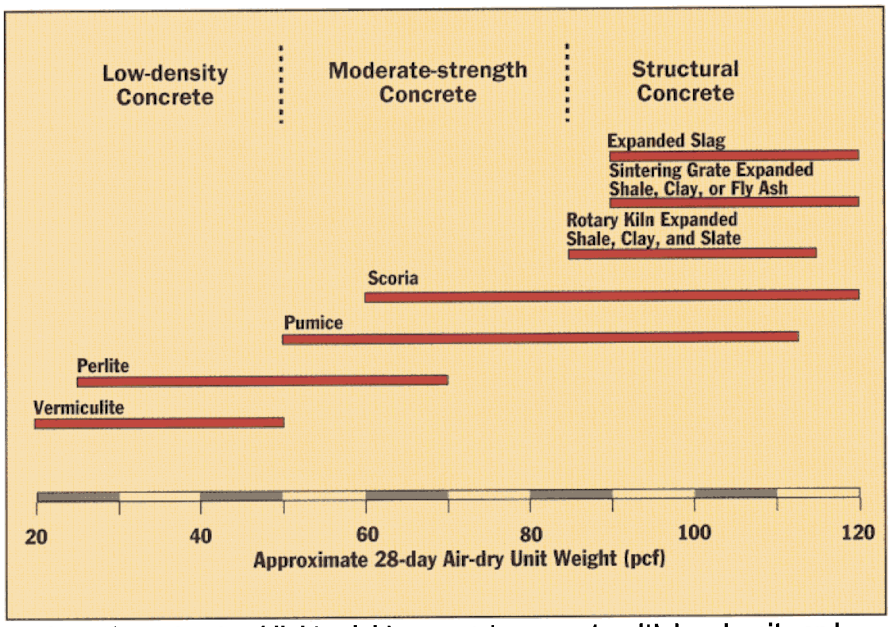
Establish Communication

Making good use of structural lightweight concrete calls for excellent communication throughout the project. Especially critical is the relationship between the contractor, ready mix producer, and lightweight aggregate supplier. To design the best mix, the aggregate supplier and ready mix producer should know, for example, the methods the contractor will use to convey, place, consolidate, finish, and cure the concrete. The ready mix producer and lightweight aggregate supplier typically work together to provide a good mix, with the aggregate supplier recommending the best ways to handle its product.

One established method of communication is the prejob conference between the concrete contractor, ready mix supplier, lightweight aggregate field service representative, testing agency representative, and owner. Participants need to thoroughly discuss the project's specifications, coordinate the ordering of the concrete, and establish procedures for sampling, testing, and handling the concrete. To facilitate the process, the contractor may want to review the mix and work with the ready mix and aggregate suppliers to ensure desirable fresh concrete properties, such as workability and finishability.

Field Tests and Adjustments

The American Concrete Institute recommends sampling the lightweight concrete to verify its in-place strength as well as testing its unit weight, air content, and slump to monitor the quality of the mix (Ref. 5). The results of the last three tests can help the



Don't confuse structural lightweight aggregate concrete with low-density and moderate-strength lightweight concretes.

contractor and ready mix producer make minor mix adjustments in the field or at the plant. For a thorough discussion of recommended tests and testing procedures, consult ACI and ASTM.

Compressive strength. The concrete samples needed for strength tests should be taken from the point of discharge and the point of final placement to detect if any existing conditions or placement methods could have altered the original mix (Ref. 6).

Unit weight. Monitoring the concrete's unit weight at the jobsite is one of the best ways to control the properties of the mix design. The unit weight of the fresh concrete must generally fall within ± 2 pcf of the weight of the original mix design. If the field weight is too heavy, then there is probably an underyield; if it is too light, an overyield. Since these variations can be caused by changes in the amount of batched aggregates, changes in air content, or changes in water content, the ready mix producer may need to adjust the mix.

Air content. To improve the workability and durability of lightweight concrete, an air-entraining admixture is always added to the mix, and admixtures such as water reducers are generally added. The air-content test can help contractors and ready mix suppliers ascertain that the dosage is correct. ACI Committee 213 recommends that the total air content of lightweight concrete range between 4% and 9%, depending on the maximum size of the aggregate (Ref. 3).

Slump. Because of the porous nature of lightweight aggregate, mix water may be absorbed as the concrete is transported from the ready mix plant to the jobsite. Therefore, the slump of lightweight concrete at the ready mix plant may be higher than it will be on-site, and the ready mix supplier's delivery ticket should specify the amount of water that may be added to the mix on-site without exceeding the design water-cementitious materials ratio.

Slump samples should be taken from the discharge point of the ready mix truck, and if jobsite conditions (such as use of pumps) warrant it, from the point of final placement. Changes in slump may indicate a change in air content or in aggregate moisture content, gradation, or density. Contractors should also remember that the lower the slump, the better the mix is able to maintain cohesiveness—helping contractors minimize slump loss and segregation and avoid finishing delays.

Handling Lightweight Concrete

There are few exceptions to recommended practice (Ref. 3). If the lightweight aggregate is prewetted properly by the aggregate supplier and ready mix producer, the contractor should be able to treat lightweight concrete in much the same way as normalweight concrete. In fact, placing and finishing lightweight concrete may be easier because of the presence of the air-entraining agent. (At any given slump, air-entrained concrete is more workable than non-air-entrained concrete at the same slump.) Full-scale field trials, however, should still be conducted before proceeding with the project.

Placement. The method of placing lightweight concrete depends on jobsite conditions. As with normalweight concrete, lightweight concrete can be placed using conventional methods such as pumps, chutes, or crane and buckets (Ref. 6). And like normalweight concrete, most structural mixes are pumped. If the mix is pumped, however, the contractor needs to provide the ready mix producer with detailed information about the pumping operation.

It is crucial in a pumping mix that the lightweight aggregate be prewetted in accordance with the lightweight aggregate supplier's recommendation (Ref. 7). The pressure of the pump forces mix water into the cells of the lightweight aggregate and stiffens the mix. If the mix is too stiff, it will be very difficult to pump and finish. Years ago, many in the industry were unaware of the importance of prewetting the aggregate. But if the aggregate is properly prewetted and the mix well-designed, the contractor should encounter no unusual problems.

Consolidation. Just like normalweight concrete, it is important not to overvibrate lightweight concrete. In contrast to normalweight concrete, if lightweight concrete is overvibrated, the aggregate may gravitate to the top because it is lighter than the paste. The heavier mor-

tar, which is needed at the surface for finishing, sinks.

Finishing. Metal tools are recommended throughout the finishing process because they are less likely to tear the surface of the concrete. After strikeoff operations, ACI allows finishers to use a grid tamper, or jitterbug, to keep the lightweight aggregate particles from floating to the surface (Ref. 3). To help finish normalweight concrete, a jitterbug can only be used on concrete with a slump that is less than 3 inches.

During floating operations, it is still important not to overwork the concrete. Too much darbying or bull floating can bring the lightweight aggregate to the surface and drive down the mortar needed for finishing. Lightweight concrete takes the same amount of time to set as normalweight concrete with a similar cementitious content.

Curing. Begin curing the concrete as soon as possible after the final finishing. The curing of lightweight concrete tends to differ slightly from that of normalweight concrete, since lightweight aggregates produce an internal curing effect as they slowly release their stored moisture. The presence of this internal moisture, however, does not replace recommended curing practices. As in any curing process, it is important to keep the concrete continuously moist, so that it can develop the requisite tensile strength to keep the concrete from cracking.

For many years, ready mix producers have been able to supply lightweight concrete that behaves in much the same way as normalweight concrete. Before this knowledge was widely known, perhaps contractors had cause to avoid using structural lightweight concrete. But knowledgeable contractors are able to use lightweight concrete to produce strong, durable structures. For the contractor who still hesitates, many lightweight aggregate suppliers provide service engineers to make the contractor's first experience with lightweight concrete as productive as possible.

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