

A wall system that sandwiches polystyrene between two layers of shotcrete eliminates the need for heating and air conditioning units.



A Concrete Building That Requires No Heating

by Mark A. Wallace

Though built near Chicago, where temperatures plummet below 0° F (-18° C) in the winter and exceed 100° F (38° C) in the summer, the 430,000-square-foot (39,948 m²) warehouse of Roman Inc. has no heating or air conditioning units. Only the dock areas, windowed offices, and lunchroom have heating and air conditioning units, and even they have only one-fourth the units that a conventional building would need. Despite this, the temperature in the warehouse stays about 70° F (21° C) year round. How is this possible?

To eliminate warehouse heating and cooling costs, what was required was a special concrete and polystyrene wall system called Solarcrete™, a heavily insulated roof, air lock entries, insulated and carefully weather-stripped doors, and three high-efficiency air exchangers. But the key was the Solarcrete wall system.

All exterior walls of the Roman Inc. warehouse are 12 inches (305 mm) thick, with 7 1/4 inches (184 mm) of expanded polystyrene insulation on the inside and 2 3/8 (10 mm) inches of shotcrete on both the interior and exterior. The walls are buried 3 1/2 feet (1 m) into the ground,

below the frost line, so they extend full height from the footings to the roof, without any joints or breaks that could let air enter. The only elements that penetrate the insulation are galvanized steel web ties, but these ties are thin and any thermal transfer across them is negligible.

The metal deck roof is covered with two layers of polyisocyanate (polyurethane) insulation, each 2 1/2 inches (64 mm) thick, with joints staggered to create a thermal break. Over the insulation a rubber membrane and ballast are applied. Thanks to this large amount of insulation, both walls and roof each have an R value of 35. "Essentially, we've constructed a one-piece ice cooler that's settled into the ground below the frost line," says Tony Jedlinski, executive vice president of Roman Inc. "The 50° (10° C) temperature in the ground is the only connection this building has to the outside world; therefore, in the winter I only need to provide an additional 20° F (7° C) of heat to bring it up to 70° F (21° C) and my light fixtures alone will take care of that. In short, we've created a cave above ground.

In addition to the specially designed walls and heavily insulated roof, the

builder took extra care to minimize air infiltration. All exterior doors and frames are insulated, and weather-stripped. "The building is also designed a little like a giant spaceship," says Peter Konopka, a principal owner of Solarcrete. "All general entrances have air locks to prevent cold air from getting in in the winter or getting out in the summer."

In such a tightly sealed building, ventilation is essential to keep the air from becoming stale. It is also required by building code. But with ventilation, the energy savings achieved from the insulation could easily go up the flue pipes with the exhausted air. To prevent this, the builder installed three high-efficiency air exchangers that capture 85% of the energy in the air before it is expelled.

Walls Assemble Quickly and Easily

The walls have three components: polystyrene, reinforcement, and concrete. The polystyrene and reinforcement are pre-assembled into panels and trucked to the jobsite where they are erected and shotcreted inside and outside with concrete.

For the Roman Inc. building, panels were made 10 feet wide (3 m) and 40 feet

(12 m) tall (the height from footing to roofline). At the jobsite, workers set the panels into place with a small crane, anchored them to the footing with powder fasteners, and wire-tied them to the building's steel frame. A crew of five or six workers erected 30 wall panels (or 300 feet [92 m] of wall) in one day.

After the panels were erected, workers wire-tied vertical plastic strip control joints to the panels' transverse reinforcing bars every 6 feet (2 m) horizontally to serve as depth gauges for shotcreting, as screed rails, and as expansion joints. To make the concrete "nice and flat," says Konopka, it was straightgedged after shotcreting, then floated with a soft sponge. Because the control joints do not pass through the entire wall, they did not have to be caulked.

Once the control joints were attached, the panels were ready for shotcreting. A crew of five to six trained workers shotcreted and finished 30,000 square feet (2800 m²) of wall a day, 1000 square feet (93 m²) for each cubic yard of concrete. The inner and outer layers of concrete were each applied in two courses, the first one 1 1/2 inches (38 mm) thick and the second one, applied a day later, 7/8 inch (22 mm) thick. Thinner layers are easier to finish, says Konopka. On the Roman Inc. building, one crew shotcreted the inside while another crew shotcreted the outside. Panel erection and shotcreting for the entire job took 2 1/2 to 3 months.

The 7000 to 8000 psi (48 to 55 MPa), 7 1/2-bag shotcrete mix is made with polypropylene fibers, a superplasticizer, water-reducing admixture, and fly ash. To ease pumping, the 2 inch (51 mm) slump mix contains up to 500 pounds (227 kg) of 3/8-inch (10 mm) pea gravel, but otherwise has no rock, only torpedo sand.

To hide any hairline cracks and provide a uniform architectural look, the exterior shotcrete was sprayed with an acrylic finish coat and the walls inside the warehouse were painted with an elastic paint. Inside the offices, drywall was glued directly to the walls.

Revolutionary But Not New

Hundreds of buildings have been built using the Solarcrete system since it was first introduced in 1974, in places as far afield as Alaska, Florida, Israel, Poland, and Russia. It has been used to construct warehouses, manufacturing plants, townhomes and single-family dwellings. The system has been approved by the three model

building codes in the U.S., and is suitable for constructing load-bearing walls or steel-framed curtain walls. It exceeds seismic requirements in earthquake-prone areas, and tests have shown that it has a two-hour fire rating. Together the insulation and concrete provide an estimated sound transmission class (STC) of 55. Last but not least, the system can broaden an architect's design options. The insulation can be cut and shotcreted to create arches and battered, curved, and serpentine walls.

A Solarcrete building does not cost more to build than masonry, tilt-up concrete, or metal panel buildings do. The entire Roman Inc. building, 430,000 square feet (39,948 m²) of warehouse and 95,000 square feet (8,825 m²) of offices, cost \$11.8 million.

Moreover, Solarcrete buildings save in energy costs over the life of the building. A 160,000-square-foot (14,865 m²) Solarcrete building built 10 years ago by Roman Inc. cost only \$11,000 (or less than 7¢ per square foot) a year to heat and cool. Two-

bedroom, 1150 square-foot (107 m²) townhouses built using this system have cost only \$25 a month to heat and cool.

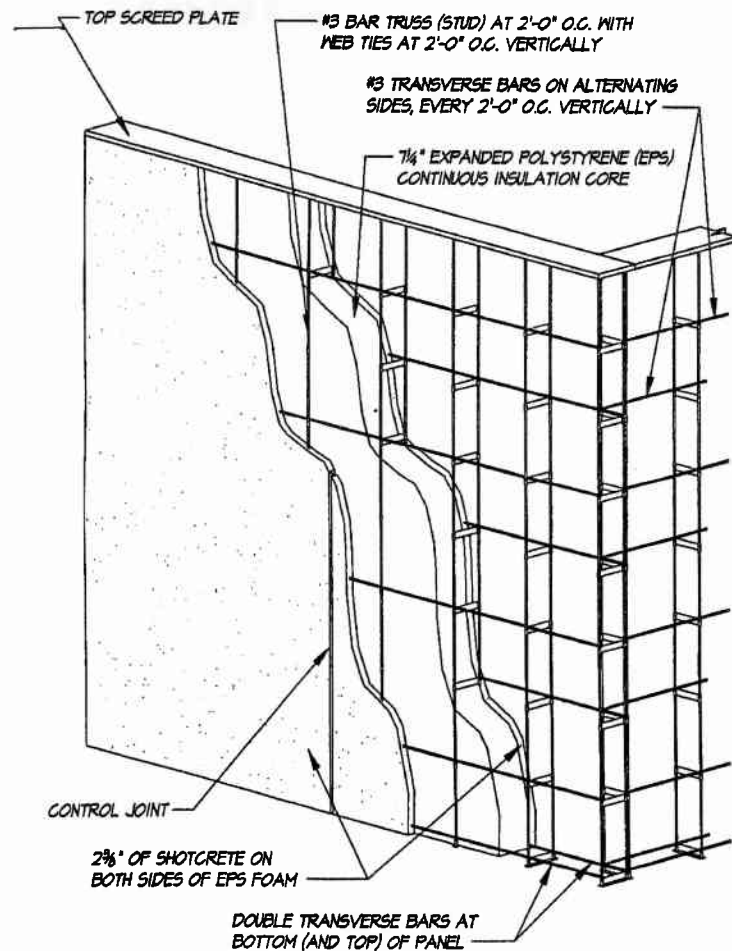
To show how well this system maintains a constant temperature, Solarcrete placed 30 sensors at different heights and locations in the Roman Inc. building and connected them to a computer for easy monitoring. On the day we visited the site, sensor readings ranged from 68.9°F (20.5°C) to 72.1°F (22.3°C) inside, while outside it was 56°F (13°C). It works on its own without refueling, maintenance, or monitoring.

"When you put insulation in the wall and cover it with concrete it's there for a hundred years," says Jedlinski. "You never have to do a thing to it. It makes a lot more sense to me than putting in a whole heating system with lots of controls and parts that have to be repaired all of the time." ■

*For more information regarding Solarcrete

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