By Joe Nasvik

Designing Pervious

USING PERVIOUS CONCRETE, A SHOREVIEW, MINN.-BASED PROJECT PAVES ITS RESIDENDIAL STREETS.

For the past couple of years, several concrete associations have marketed pervious concrete as a sustainable product with many benefits. Although it has existed in the southeastern part of the country since the 1980s, it is considered a new innovation in most other parts of the U.S. But as is the case with products tried by contractors for the first time, there have been problems and job failures.

Pervious concrete is very different than other types of concrete because of its mix design, placement procedures, and curing requirements. Slab replacements can result when best practices aren't followed.

In 2009 a pervious concrete residential street project for the city of Shoreview, Minn.—a suburban area north of St. Paul, received national attention because it was the largest public street project in the country. But this project also deserves a closer look because of the thoughtful and innovative forensic research conducted by the parties involved before the job even began.

Getting the owner committed

This is the second pervious concrete project for the city of Shoreview, the first being an alley installed in 2007. Tom Wesolowski, the city's assistant engineer, says there were a few problems with the work, such as minor spalling and cracking, but it helped the city's engineering staff to have realistic expectations.

When it became clear the asphalt streets, lacking both curbs and storm sewers, in an older residential part of town needed replacing, the engineering department considered several options. The project area, adjacent to Lake Owasso, is considered an environmentally sensitive area. Options that would increase the level of contaminants and

The large, white square stretch of pervious concrete pavement alongside Lake Owasso in Shoreview, Minn., was installed in 2009. At 79,800 sq. ft. and 7 in. thick, it's the largest pervious public street in the U.S. PHOTO: WILLIAM RANDLE

Two ready-mix trucks backed up side by side in front of the roller screed to place concrete in the 21-ft.-wide street. Concrete flowed freely down the chutes and new trucks arrived every 25 minutes. PHOTO: JOE NASVIK

silt in the lake couldn't be considered. The region's sandy soil, which afforded good drainage, was ideal for pervious pavement, and a factor that led to the city's decision to specify pervious for the project.

Although the pervious concrete option would be more expensive than options that included storm drainage, Wesolowski says the cost wasn't considered significant when compared to the total value of the project. Ready-mix producer Cemstone, Mendota Heights, Minn., was contacted to discuss mix designs for the concrete.

Building a solid specification

Some pervious pavements fail as the result of insufficient subsoil drainage, especially in freeze/thaw climates. Saturating pervious concrete must be avoided or frost-wedging can result, breaking the cement bonds holding the aggregate together. The Shoreview application required 1 to 3 feet of soil excavation, depending on land elevations. Parts of the project were sloped so low, areas would collect more water and needed deeper stone containments to prevent water from ponding in the pervious concrete.

Wesolowski says the selection of aggregate in the subbase is important; it must be open graded and able to support the weight of ready-mix trucks without rutting during concrete placement. As a result, crushed angular 1½-inch top-sized rock was placed on top of soil-separation fabric.

Recognizing the importance of good curing, the city also specified a seven-day wet-curing period using wet curing blankets.

Designing the mix

After gathering information about job failures from around the country, Kevin MacDonald, vice president of engineering services for Cemstone, designed the pervious concrete mix. By understanding the nature of pervious concrete job failures, he was able to avoid others mistakes.

Sawed control joints were installed after the curing operation concluded. PHOTO: JOE NASVIK

Some failures were the direct result of poor curing, or no curing at all. "Curing is important. You have to remember that the surface area of pervious is huge—everywhere inside the slab as well as on the top," MacDonald says. "In addition, cement paste layers are very thin so they are very susceptible to moisture loss."

TO ACHIEVE QUALITY PERVIOUS CONCRETE, POINT-TO-POINT CONTACT BETWEEN AGGREGATES IS VERY IMPORTANT, WHICH OCCURS WITH GOOD COMPACTION.

Pervious projects have failed because shale aggregates, present in the concrete, absorbed water and broke under freeze/thaw conditions, even below the surface. Cement paste and sand in the fresh concrete of another project sank to the bottom of the placement and filled the void spaces. Other pervious slabs failed because mixes included a blend of coarse aggregate sizes, reducing void spacing.

When MacDonald designed this project's pervious mix, his priorities included: finding the right coarse aggregate, providing the correct amount of cementitious paste, and preventing the paste from moving after concrete placement. In terms of hardened characteristics, MacDonald says the internal void ratio should be in the 40% range and he considers flexural strength to be more important than compressive strength. The Shoreview mix included:

- 100% crushed bedrock aggregate to ⅜-inch clear size—100% retained by the ⅜-inch sieve and 100% passed by the ½-inch sieve; as well as minimum deleterious aggregate content
- Cement content in the 550-pound range; 100 pounds consisting of fly ash
- A hydration-stabilizing admixture to help the concrete remain plastic during placement and slow the reaction to stabilize water afterward (Early stiffening causes flow problems and temps workers to add water onsite.)
- A 0.30 water-cement ratio
- An air-entraining admixture to help disperse cement
- A viscosity-modifying admixture to reduce the rundown of paste to the bottom after placement.

The void spacing in pervious concrete is very important, notes MacDonald, and the large aggregate gradation is the most important factor. Technology to keep cement paste evenly dispersed is the next consideration. If it slumps down to the bottom of a placement, void spacing is diminished and the pavement is at risk.

To achieve quality pervious concrete, point-to-point contact between aggregates is very important, which occurs with good compaction immediately following placement. This is probably achieved best with vibratory screeds or surface compaction provided with heavy weights. Void spaces are provided by

The contractor fabricated an efficient moving platform to place a wet-curing membrane over the freshly placed pavement. PHOTOS: JOE NASVIK

the mix design so overcompaction isn't a risk. "You can't reduce void spaces beyond what large aggregate sizes permit," says MacDonald.

Innovating practices on the jobsite

Cliff Swenson, project manager and estimator for North Country Concrete, Ramsey, Minn., says his company has five years of pervious concrete installation experience. In terms of placement, they think problems mostly relate to how well the fresh concrete is compacted and how fast curing operations proceed. To address this, North Country Concrete purchased a ride-on roller screed that spanned the entire 21-foot-wide street, rolling on the curb and gutters that were constructed several days earlier. Two rollers guided the machine and screeded the concrete, while the third roller in the machine's rear could be adjusted up or down to compact the concrete a ½ inch as the machine passed by—enough to provide the inter-aggregate connections needed.

To solve the curing problem, North Country Concrete fabricated a moving platform with a water dip-tank to follow immediately behind the screed to perform the wet-curing operation. Workers pulled the curing membrane off a role, passed it through the dip-tank full of water, and placed the wet material on the pavement. Swenson says when the curing membrane was removed, the pavement was still wet after seven days.

Working with a 12-person crew, North Country placed as much as 200 cubic yards of concrete per day. Two ready-mix trucks arrived every 20 to 25 minutes, backing into position side by side to place concrete along the 22-foot width of the street. The crews found the material flowed down the shoots without assistance. Despite the additional admixtures and enhanced

design, Swanson thinks the price of the concrete was in line with other pervious mixes North Country has worked with in the past.

Closing thoughts

It's a little unusual for all parties in a contract to adopt a leading-edge philosophy and work together to solve problems. The city of Shoreview had realistic expectations for the project but also wanted a state-of-the-art result. This was ensured by involving all of the players in early problem-solving discussions.

Shoreview also recognized that the pavement would only be as good as its maintenance system so they periodically employ a truck-mounted vacuum to remove debris and dirt from the pores of the concrete throughout the nonwinter season. During the winter months, the city avoids using sand or salts to remove snow and ice.

Every good project studies the outcomes, so the city will monitor the water in Lake Owasso and the wells in the area. At some locations, they can tell how much water is residing in the open-graded stone layer below the pavement. Due to unusual weather conditions this past winter, a layer of snow and ice resides on the surface of the pavement, making any damage unclear. But with spring weather near, the project participants plan to walk the street to determine how it survived its first winter. Shoreview's engineering department is confident the improved technology provided better pavement compared to its first pervious project a couple of years ago.

Shoreview will evaluate this project for the next few years to ensure it meets performance expectations. **CC**

To illustrate the ability of the pavement to absorb water, Cemstone emptied a ready-mix truck full of water as fast as it could be dispatched. PHOTO: JOE NASVIK

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