Sturdy Support for Demanding Sites

Retaining walls all tend to have one thing in common these days: precision engineering.

BY JANET AIRD

Segmental retaining walls have come a long way since humans first fit rocks together to hold back slopes. And although site owners have many additional retaining wall types to choose from—including reinforced earth, poured concrete, soldier pile, and soil nail—segmental walls, also known as dry-stacked and mortarless walls, are still the most popular.

Modern blocks vary in size, shape, and appearance. What they have in common is their precision-engineered design. Their batter is built in. They fit together snugly. They lock together either through the structure of the block itself, such tongue-and-groove, or with clips, pins, or dowels.

Gravity walls are one kind of segmental wall and are ideal when ground space is limited because they need no reinforced footings. Instead, they depend on their weight, the batter, and the friction between the blocks to resist the loading behind them. These blocks can weigh thousands of pounds each and require backhoes to place them, or they can weigh less than a hundred pounds. Some larger blocks have decorative facings.

The amount of loading depends on the slope, the soil conditions, and the weight of the surcharges (such as structures) behind the wall. When the load is greater than the wall can withstand, engineers use additional strategies. They may give the wall more stability
by using a geofabric for geosynthetic reinforcement, or “tieback,” or they may design additional walls with terraces between them.

The following three projects were built in tight spaces, limited by the slope on one side and either a roadway or a stream on the other. They all used gravity walls to solve the challenge in very creative ways. One, the Lower Afton Trail Extension in Minnesota, used blocks that contained 20% recycled material.

**West Lake Sammamish Parkway**

Around noon one Sunday in late January 2012, drivers in the 500 block of West Lake Sammamish Parkway in Bellevue, WA, were shocked to see part of their road slide down the hillside toward the lake.

“It’s a pretty steep embankment,” says Mick Caplis, estimator for Westwater Construction Inc. in Auburn. The parkway cuts into the hillside, which is made up of sandy, silty soil that was disturbed by logging activities in the past. Water from a stream above the parkway flows through a pipe under the road, out through a culvert, and into Lake Sammamish.

No one is certain of the cause of the slide, but the prevailing theory is that after weeks of rain followed by a hard downpour, debris blocked the culvert and stormwater flowed over the parkway into the embankment below. The embankment collapsed, removing the compaction from the pipe.

“The water main blew,” Caplis says, “and a few thousand gallons of water per minute blew the hillside into people’s yards.” Mud damaged some of the homes on the lake and covered half of the road for some 40 feet. Traffic backed up so badly that Caplis couldn’t make it to the site until the next day.

The city of Bellevue had already used gravity walls from Redi-Rock International in other locations, he says. It chose them for this site because the walls, which rely on the massive size of the blocks to stabilize slopes and require no reinforcement, can be built quickly. In addition, they’re aesthetically pleasing for the homeowners who live between the road and the lake.

The local manufacturer, Puget Sound Precast in Tacoma, manufactured the Ledgestone blocks and stained the faces to blend in with the rock tones in the area.

Westwater Construction installed two walls. A small road winds down from the parkway to the homes on the lake. Westwater built an upper wall 12 feet high on this road to stabilize the 30-foot embankment below the parkway and built a lower wall 12 feet high to stabilize the other side of the road.

Top: Beginning of the lower wall construction showing the pipe

Bottom: The upper wall being rebuilt
Engineers designing the walls represented four separate entities: the city of Bellevue Transportation Department, TetraTech, GeoEngineers Inc., and Development Engineering PLLC. In addition, Caplis says, “The city was trying to deal with the homeowners.”

To make matters more difficult, there was a time factor involved because the busy road had to remain closed until the repairs were finished. The Westwater crew is very experienced, Caplis says, and has built just about every kind of wall there is. Their biggest challenge was the small working space. “The radiuses were pretty tight,” he says, “just a few steps.”

They staged the blocks on the parkway until they needed them, using 1,365 square feet of the blocks in total. The upper, 12-foot-high wall took six or seven days to build. Crews excavated approximately 8 feet by 25 feet, and leveled and compacted approximately 6 inches of aggregate. They placed a non-woven geofabric on the soil and began building the wall.

“The blocks are pretty heavy,” Caplis says, and getting them rigged up can be a challenge. Having large enough equipment made the job easier.

Redi-Rock blocks have a knob-and-groove design, which makes them easy to fit together, and the batter is built in. All the blocks are 18 inches high. They’re 46 inches across the front, and wider at the front than at the back. “There’s more surface area when you’re installing them, they take up more wall space, and they provide the weight they need to for hillside stability,” he says.

For the bottom six rows, Westwater used blocks that measured 60 inches from front to back. The first two of these rows are underground. Crews used one row of blocks measuring 41 inches from front to back in the middle and one row of blocks measuring 28 inches on top. “It’s the idea of a pyramid,” Caplis says. “The bottom takes a lot more weight from the soil.”

They placed approximately 6 inches of aggregate between the wall and the geofabric.

The lower wall took four or five days to build. A culvert runs through the base on the west side. Westwater leveled the ground for this wall and stacked the 41-inch blocks on the bottom rows and the 28-inch blocks in the middle. Again, crews placed geofabric behind the wall between the soil and approximately 6 inches of aggregate.

This lower wall has 3 feet of free-standing blocks on top, which acts as a guardrail to prevent cars from going over the edge of the road, he says. “It’s also aesthetic. It creates a little bit of a

“The water main blew, and a few thousand gallons of water per minute blew the hillside into people’s yards.”
bridge effect.”

The culvert, a 24-inch pipe, allows the stream to flow under the highway. Westwater wrapped cork sheets around the pipe to make a tight seal and to allow slight movement in the wall, and then poured a concrete strip around it for strength.

As finishing touches, Puget Sound Precast manufactured custom Ledges-tone faces to fit around the pipe. These were attached to the concrete at the end of the job. Westwater planted trees, ground cover, and shrubs above the wall.

The whole project took less than two weeks.

“It went pretty well for us and for the homeowners, too, from what we’ve heard,” Caplis says. “We even got a nice letter. They were pretty happy with our performance and the wall.”

**The Shady Oak Highway Project**

Sometimes even the best of plans go awry. This was the case in Minnetonka, MN, at the beginning of the Shady Oak Highway Reconstruction Project, where approximately 1.75 miles of the heavily traveled county highway was being widened from two lanes to four.

One stretch required a retaining wall just below a residence and two mature oak trees. The customer, Hennepin County, had specified a sheet pile wall with a cast-in-place facade. The prime contractor, C.S. McCrossan Construction Inc. of Maple Grove, had made the cut into the hillside and excavated. Then crews began to drive the sheet piles into the ground in preparation for the wall.

“When we started driving, we encountered boulders,” says McCrossan project manager Kent Messenbrink. “Soil borings never showed them. We had to come up with an alternative—that’s how we got into big block walls.”

The county decided not to excavate to remove the bedrock, and there was no room for geogrid tiebacks because of the limited space between the new lane and the property above. Instead, McCrossan contacted ReCon Wall Systems in St. Louis Park, which manufactures wet-cast air-entrained concrete wall blocks for gravity walls.

Gravity walls depend on the weight and mass of the blocks to stabilize the slope. They’re ideal when the side of an existing slope has been cut. They don’t require any soil reinforcement, and they maximize the amount of space at the bottom of the wall. ReCon blocks are

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The Lower Afton Trail extension runs between wooded slopes and a stream.
manufactured with the batter built in.

In addition, the county wanted a wall made of air-entrained concrete blocks, because they contain the amount of air needed to prevent freeze-thaw cycles from cracking the blocks, and they withstand road salts.

Aesthetics were a consideration as well. “This wall was one of 16 we did,” Messenbrink says. “Another reason we chose big block was that it most closely resembled the others in style.”

ReCon called Ron Vickery of Vickery Engineering and Consulting LLC in Eden Prairie, MN, for the design.

“These block walls go under the heading of segmental retaining walls,” Vickery says. “There’s no mortar between them, and when you get to a site, you just stack them to the appropriate height.”

The Minnesota Department of Transportation (MN/Dot) has a maximum height restriction of 8 feet for segmental retaining walls, so Vickery designed an 8-foot wall. C.S. McCrosan pulled out the pilings and gave them back to the county, and TMS Construction Inc. of Prior Lake started building the wall. The blocks were shipped to the site in the order they would be used.

Then the homeowner became concerned about erosion on his lot and asked for a 12-foot-high wall.

“That took additional e-mails,” Vickery says. “We had to work with MN/Dot to get them comfortable with extending the wall 4 feet. They understood it had to be done, but they needed a little extra information. I did a parametric study and submitted my calculations to them.”

Vickery did a redesign. He used deeper blocks (from front to back) at the bottom of the wall and extended the wall.
length. The final design was a 12-foot-high, nine-row wall approximately 200 feet long. MN/Dot approved.

All the blocks are 16 inches tall and 4 feet across the front. The blocks on the bottom row are 60 inches deep and weigh 3,000 pounds each. The blocks in the four middle rows are 39 inches and weigh 2,200 pounds, and the blocks on the top four rows are 24 inches deep and weigh 1,400 pounds.

The overall project took two years to complete, while the construction of this particular wall from initial construction through redesign to final construction took from April 2009 to April 2010. The wall itself took a month to build.

TMS Construction deconstructed the partially built wall to incorporate the modifications. The blocks are fairly easy to stack and restack, Vickery says. They have eyes for a cable and can be set with a backhoe. “Once they’re hanging and level, they’re remarkably easy to move into place.”

The blocks fit together with notches, which is enough because of their massive weight, according to Messenbrink.

After additional soil was excavated and leveled to accommodate the larger blocks, TMS lay drain tile behind and below the designed location of the first row of blocks. Crews placed, leveled, and compacted 6 inches of aggregate as a soil stabilizer, then backfilled with a layer of sand as a cushion under the blocks and for additional drainage.

“As it rains, both sides of the wall drain down through the sand to the perforated pipe,” Messenbrink says.

The most challenging parts of building the wall were related to the concrete coping that runs along the top.

“Once the height of the wall was extended, the coping became a challenge because it was at a slope and extended over
the face of the wall,” Vickery says. “The manufacturer of the blocks, Amcon Block in St. Cloud, did a great job.”

The coping extends beyond the face of the wall because it had to match the coping on all the other walls McCrossan built, 7,000 linear feet of wall altogether, Messenbrink says. Amcon cast the top edge of some of the blocks at an angle so they would fit under the coping in some spaces. McCrossan used forms supported by 2-by-4s and 2-by-8s and then poured the cap in place. They used some rebar in the concrete.

“It worked out beautifully,” Vickery says. “I drive by the wall every once in a while and it looks really nice.”

Lower Afton Trail Extension
A 3,000-mile trail runs along the Mississippi River, from its headwaters in Itasca, MN, to the Gulf of Mexico. In one spot, both the trail and the river wind between downtown St. Paul and the 846-acre Battle Creek Regional Park, less than 5 miles to the east.

In 2012, a new 1-mile-long trail south of the park and north of Lower Afton Road gave residents an additional point of access from the park to the river trail. The trail, along a hillside covered with trees and underbrush, was the last link in connecting the regional trail system to the communities southeast of the city.

“There’s a trail that runs on the north of the road and one that runs on the south, but there was no good way for residents to connect from one trail to the other,” explains Luke Kowarsch, project manager for Peterson Companies Inc. in Chisago City. “Residents were forced to use the road to get between the two trails.” The newly constructed trail that runs adjacent to Lower Afton Road connects the two trails; it starts at Point Douglas Road to the west and ends at McKnight Road to the east.

Peterson Companies, a site work contractor that does earthwork, utilities, erosion control, and seeding, built the trail. Some of the trail runs very close to the road and some runs hundreds of feet from it, and the farther from the road, the higher the slope. The trail approaches vertical in some areas. Because of the steepness, the project required a retaining wall, and in some places, a two-tiered wall.

Ramsey County specified that 20% of the block in the walls be recycled material. The company chose one that was recently developed by Versa-Lok Retaining Wall Systems in Oakdale and is manufactured by Willow Creek Concrete Products in Fairburn, GA. According to Ken Jopp of Versa-Lok, the Afton Trail project was the first time these blocks have been installed.

“Willow Creek just started making them in 2012,” he says. “They’ve been tested, and their performance is just like the regular blocks.”

The contents are proprietary, but the blocks are guaranteed to contain at least 20% recycled material. They meet all county and federal performance and strength testing requirements. They’re available in grey and tan and can be stained to order. Willow Creek will make the blocks as they’re requested, but Versa-Lok can’t guarantee they’ll be available in other parts of the country.

“I suspect as time goes on and as the green movement spreads, their availability will spread,” Jopp says.

“Once the height of the wall was extended, the coping became a challenge because it was at a slope and extended over the face of the wall.”

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The planning stage for the trail began in August 2009 and took 18 months. The wall and the trail were completed in June 2012.

The design of the wall was based on the slopes of the hillside as well as the slope of the trail itself. To comply with Americans with Disabilities Act regulations, it has a maximum running grade of 5%.

“The site conditions were tough,” says Kowarsch. Crews cut through the wooded areas from their limited access points, which consisted only of a few roads that intersected with the proposed trail, and cleared the land with backhoes and dozers to provide access for the equipment and the material. Workspace was tight, though, because above the trail they limited the amount of disturbance to the trees as much as possible, and below is the road in one place and a concrete-encased stream in another.

Peterson excavated for the walls and banked the trail, and then Blackstone Contractors LLC of Corcoran, which does specialty contracting, began building the wall.

“We do a lot of retaining walls,” says Bruce Karvonen, operations manager with Blackstone. “The unique part of this job was the way the block was manufactured. It’s an eco-block.”

Ultimately Blackstone built seven walls. The main, lower wall extends the length of the project and is just a few feet from the trail. The upper walls are much shorter and of varying lengths depending on the steepness of the slopes. The height of the walls varies between approximately 6 and 8 feet. The lower and upper ones are separated by approximately 5 feet of grass.

Blackstone crews leveled and compacted 6 inches of class 5 aggregate in the trench excavated by Peterson. They then installed one continuous drain tile behind the wall, with an outlet every 50 feet, so water can drain. They used geosynthetic reinforcement behind the wall and, for additional drainage, placed 3/4-inch aggregate between the wall and the native soil.

They stacked a minimum of two courses of blocks 8 inches high below grade.

“These walls are dry-stacked,” Karvonen says. “And they use a top-pin-ning system to create a mechanical connection between the courses. They’re pretty easy to build.” Each block weighs about 80 pounds.

Once the walls were completed, Peterson went back in, graded the trail, and paved it with asphalt. Crews planted grass seed that was specified by the county, many of them native grasses, and covered the seed with straw erosion control blankets. In the spring, they’ll remove the straw that hasn’t been chewed up by the lawnmower, he says.

“It was a challenge to complete the work on time and on budget, which was accomplished,” Kowarsch says. “It turned out very nice.”

Janet Aird specializes in agricultural and landscaping topics.