Concrete Masonry DESIGNS

NOVEMBER 2007

HARDSCAPE ISSUE
Segmental Retaining Walls

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A PUBLICATION OF THE
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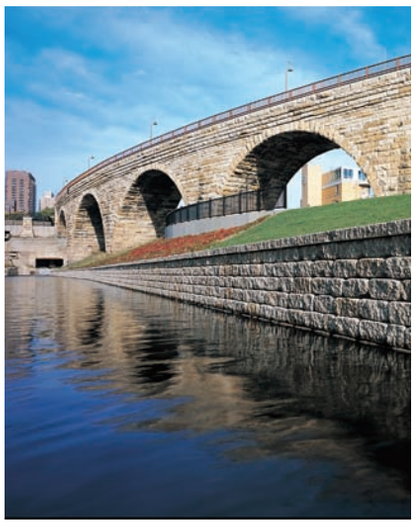

ON THE COVER:

The Stone Arch Bridge is made of native granite and limestone and measures 2,100 feet long by 28 feet wide (640 meters by 8.5 meters). The historic, one-of-a-kind bridge spans the Mississippi River by way of 23 arches. The rugged texture of the segmental retaining wall (SRW) units fit in perfectly in this historic riverfront area.

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The owners of a cemetery in Houston, Texas, used an innovative plan to create more space within the property's existing acreage. SRW units that blend in with the pre-existing structures were used to build two peninsulas.

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When contractors from Franklin Outdoor Services were called upon to bid on a backyard project for a high-end, waterfront home in Lakeville, Minnesota, they soon realized the job would become an uphill battle. They solved the problem by terracing the yard with segmental retaining walls to create a multi-tiered patio with amazing lakeside views.

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Concrete Masonry Designs magazine showcases the qualities and aesthetics of design and construction using concrete masonry.

Concrete Masonry Designs is devoted to design techniques using standard and architectural concrete masonry units, concrete brick, unit concrete pavers, segmental retaining walls, and other concrete masonry products around the world. We welcome your editorial comments, ideas, and submissions.

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Recreating A Historic Riverfront

A Minneapolis monument is restored with a retaining wall reminiscent of an 18th century English countryside

In the early 1900s, power for the Mill Ruins flour mills was generated by water diverted from the Mississippi River. The new Mill Ruins Park has restored the tailrace pool to simulate the original operation for residents and tourists. The water flows through a 500 foot (152 meters) canal where it originally would have been diverted to supply a mill turbine with power.

CONCRETE HARDSCAPE PRODUCTS NOW HAVE A PLACE IN HISTORY IN THE FORM OF A SEGMENTAL RETAINING WALL (SRW) AS PART OF A RESTORED RIVERFRONT PARK IN MINNEAPOLIS, MINNESOTA. THE AREA THAT IS NOW MILL RUINS PARK, LOCATED ON THE BANKS OF THE MISSISSIPPI RIVER, PLAYED A SIGNIFICANT ROLE IN THE HISTORY OF MINNEAPOLIS. THIS SITE CONTAINED THE RUINS OF CANALS, TAILRACES AND SHAFTS THAT ONCE POWERED THE MINNEAPOLIS FLOUR MILL INDUSTRY—THE LARGEST GROUP OF DIRECT-DRIVE WATER-POWERED FACILITIES IN THE WORLD AT THE TIME (DURING THE LATE 18TH AND EARLY 19TH CENTURY). IN FACT, THE ENTIRE RIVERFRONT AREA, INCLUDING ST. ANTHONY FALLS (THE ONLY WATERFALL ALONG THE MISSISSIPPI RIVER), IS ON THE NATIONAL REGISTER OF HISTORIC PLACES.

CONTINUING EDUCATION AIA

PROJECT:
Mill Ruins Park,
Minneapolis, Minnesota

PROJECT OWNER:
The city of Minneapolis Park and Recreation Board

GENERAL CONTRACTOR:
Martin Lake Contracting Inc. of Stacy, Minnesota

CIVIL ENGINEERING AND LANDSCAPE ARCHITECTURE:
URS Corporation,
Headquartered in
San Francisco, California

Showcasing Water-Generated Power

From the late 1800s to the early 20th Century, a series of canals diverted water from the Mississippi where it fell through shafts to supply turbines with water-generated power. These turbines generated electricity, or, in earlier days (before electricity was invented), powered an elaborate system of belts and pulleys to run all the mill machinery. It was a very clever system where nature does the work. That's why it became very profitable for a company to set a mill up in Minneapolis. The Mississippi River is so large and consistent, it would supply power year round. Since the 1960's, the ruins of the original canals, shafts and tailraces have remained buried underneath 15 to 40 feet (4.6 to 12.2 meters) of sand and rock. In the mid 1980s, the Minneapolis Park and Recreation Board acquired the mill ruins intending to redevelop the riverfront area to showcase the city's history in the milling industry.

"This is the true birthplace of the city of Minneapolis," says Greg Brown, senior C.E. for URS Corporation and project manager on the Mill Ruins Park project. "[The site] has huge historical significance because it catapulted the growth of this city."

This two foot (.6 meter) deep pool is where water from the restored mill tunnel is recycled back into the Mississippi River. Notice the old limestone retaining wall that was found at the site. The new wall uses SRW units with a weathered finish and at least three color palettes blended together to match the existing limestone and granite wall.

Planning the Riverfront Redevelopment

In 1984, the URS Corporation became involved in planning the four phases of the riverfront redevelopment, including building a new Mill Ruins Park. Phases one and two called for building new pedestrian trails and rebuilding the old tailrace pool. Durable SRWs that coordinate with the old limestone and granite walls that remained from the original structure were an integral part of the plan.

The final design called for a 700 foot long by 7 foot high (213 meters by 2 meters) SRW to border the pool on one side. On the other side of the pool, a 300 foot by 7 foot high (91 meters by 2.1 meters) retaining wall begins where the existing limestone wall had deteriorated. "The retaining walls were built to border the restored tailrace pool, which was recreated with a two-to-three foot depth for visual effect—we didn't want it to be any deeper or it would become a safety issue for park patrons," notes Mr. Brown.

Construction Cost and Goals

Phases one and two were implemented concurrently in 1999 and completed in 2001 at a construction cost of approximately $3.4 million. Phase three involved recreating the original canal plank road, which is basically a wooden covering that tops the 60 foot (18 meters) wide canal that previously powered all the west side mills. Phase four added a pedestrian walking trail and pedestrian bridge around the tailrace pool area. The total construction cost for phase three and four was $2.1 million.

The goal of the riverfront redevelopment was to recreate one of the 19th century water inflow canals that powered the mills, so that residents and tourists could learn more about this important part of Minnesota history. The project needed to stay within the city's $5.5 million budget for all four phases.

A Cost-effective Solution

"We chose a weathered SRW unit and blended at least three different colors—charcoal, brown and white—together to mimic the color and texture of the existing limestone walls that we uncovered [bordering] the old tailrace pool," comments Mr. Brown. "The SRW was built using units 6 inches high by 16 inches wide by 12 inches deep (152 mm by 406 mm by 305 mm)."

"The new retaining wall could have been built of poured-in-place concrete, if we could have afforded the higher construction cost. We chose the tumbled, weathered look of this [SRW] product because it mimics the past—and it just looks so much better than concrete."

Restoring the Mill Tunnel

"About 400 feet (122 meters) from the portal of this tunnel we constructed a 3 foot (.9 meter) diameter pipe (similar to a water main pipe) from the upper pool of the river down through the ceiling of the tunnel. River water flowing through this pipe floods the 500 foot (152 meters) tunnel which eventually spills out into the tailrace pool. "This is essentially how things would have worked back in the original days of mill operation," says Mr. Brown, "except they would have had the pipe feed water to a turbine before being discharged out of the tunnel."

Building the Retaining Wall

Before construction could start on the new retaining wall that borders the tailrace pool, contractors had to excavate sand and rock in order to expose the old tailrace tunnel portals, which they found approximately 15 feet (4.6 meters) below ground level. In the late 1800s this was a working tailrace, but when the canals were abandoned in favor of modern electricity, the area had become a gravel pit of sand and rock "dumped there by industrial uses and by the Corps of Engineers when they built the lock and dam," says Mr. Brown.

None of the mill tunnels were operating when this construction project began. The contractor expected to have to excavate all 500 feet (152 meters) of the tunnel chosen to be restored. During excavation, however, contractors found that the tunnel opening had been sealed for construction purposes when the area was backfilled with gravel. This meant that the tunnel was still intact which greatly reduced the excavation required to ready the tunnel for water flow.

"During excavation, we found part of the existing [tailrace pool] retaining wall. We restored and stabilized some of these old limestone walls. Part of our challenge was to create the new retaining wall in a way that fit in with the existing walls. The new SRW borders two sides of the restored tailrace pool. The original wall was made of native Minnesota limestone," states Mr. Brown. "We worked hard to make sure the new wall fits in perfectly."

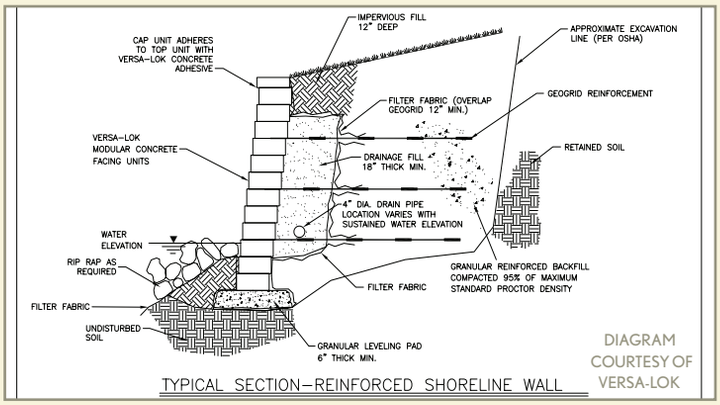


DIAGRAM COURTESY OF VERSA-LOK

> We CHOSE THE TUMBLED, WEATHERED LOOK OF THIS PRODUCT BECAUSE IT MIMICS THE PAST—AND IT JUST LOOKS SO MUCH BETTER THAN CONCRETE.
>
> — GREG BROWN, SENIOR C.E. FOR URS CORPORATION AND PROJECT MANAGER ON THE MILL RUINS PARK CONSTRUCTION

A geosynthetic filter fabric was installed to ensure that the backfill would not wash out. This also provided a good base for the first course of SRWs. Subsequent courses were interlocked with nylon/fiberglass pins, which make it easier to keep the wall straight and stable.

A Perfect Fit

Using appropriate, high-quality products helped this project stay on track, while also meeting the strict aesthetic requirements of the historic site. "We were able to meet our budget for all four phases at a total construction cost of $5.5 million. This wall is six years old now, and we haven't had any failures and we don't expect any," Mr. Brown says. CMD

Perfect Peninsulas

The Forest Park Cemetery in Houston, Texas, is 254 acres (103 hectares) of serene, wooded land owned by Service Corporation International (SCI), the largest cemetery conglomerate in the world. Surrounded by mature trees and perfect turf, the cemetery plots in Forest Park are in high demand but the cemetery was low on space. In order to maximize use of the existing acreage, SCI adopted an innovative plan to create usable space by building out into Lake of the Woods, a small scenic lake on the site. The construction plan for the 75+ year-old property called for two 53 foot (16.2 meters) curving peninsulas that stretch out into the lake. In addition to the walls, a seven foot (2.1 meters) diameter outfall pipe was installed in the system to aid in flood control "These peninsulas are supported by segmental retaining walls (SRWs) built approximately 19.5 feet (5 meters) in height with about five to seven feet (1.5 to 2.1 meters) of the wall exposed above the water level," asserts Anchor Wall Systems Engineer Dean Sandri, P.E. of Laguna Niguel, California.

Before choosing the peninsula design, other creative options for rehabilitating Lake of the Woods were explored, and the idea of adding a mausoleum on an island was suggested. The island idea was eventually abandoned because bridge construction costs were too high. So instead of an island, the dual peninsula concept was developed using distressed-finish SRWs in a white to light tan color that is relatively consistent with the limestone used to build the original perimeter lake walls. The aged, stone-cut appearance of the SRW units also blended with a stone chapel near the lake.

The peninsula plan was an ingenious solution because it addressed two site issues at once. The lake had become shallow and murky, and the borders —made of granite—were failing. By building the peninsulas, SCI was able to freshen the lake by dredging it and repairing the failing lake walls. The plan also created additional high-value space on the peninsulas for mausoleums.

Using Retaining Walls to Create Lakeside Property at Forest Park Cemetery

PROJECT:
Forest Park Cemetery,
Houston, Texas

PROJECT OWNER:
Service Corporation
International,
Houston, Texas

GENERAL CONTRACTOR/ SEGMENTAL RETAINING WALL CONTRACTOR:
Lecon, Houston, Texas

DESIGN ENGINEER:
Mike Pervis,
Houston, Texas

To begin the project, the lake was dredged and construction began "in the dry," says Sandri. Of course, soil reinforcement is one of the keys to the success of any large segmental retaining wall, especially walls built in a water application. To address this issue, a high-tensile polyester reinforcement was connected to the wall facing and extended horizontally approximately 14 feet (4.3 meters) behind the wall, forming a massive cohesive retaining wall assembly 14 feet wide by 19.5 feet high (4.3 by 5.9 meters).

"There is always some concern with SRWs used in water applications that the rising and lowering of the water table will carry some of the fine sand out of the wall backfill and cause degradation of the backfill," says Mr. Sandri. To address this concern, uniformly graded, clean, crushed rock was used as backfill. The clean rock backfill allows water to move freely in and out of the wall backfill without any soil being carried through the wall face as the lake elevation fluctuates.

Installation Challenges

The primary challenge was to build the retaining walls without disrupting the serenity of the larger cemetery. Because SRWs don't require much heavy equipment or skilled manpower for installation, construction of the retaining walls was quiet, relatively simple and confined to the immediate area of the walls. For obvious reasons, it was especially important that the construction process did not damage or inhibit access to the rest of the cemetery.

The particular SRW selected for this project uses units with three different face sizes, to more closely resemble natural stone. "These peninsula walls were designed to curve or meander, just as a lake or pond would, which looks much more natural than using geometric shapes," says Sandri. When installed, the stone-cut appearance of this multi-sized SRW system looks very much like a stone or rock wall, which helped these two new peninsulas fit in with the original granite shore walls that remained in place.

"The construction of these walls was relatively straightforward," comments Mr. Sandri. "We performed some brief on-site training to help the contractor through the learning process since this was the installing contractor's first experience with a multiple-piece wall system. Even the meandering curve of the retaining walls was not an installation challenge. You can build curves, radii and corners [with SRWs] as easily as you can build a straight line. Using a multi-piece [SRW] system—even in a curved wall application—is fairly easy. Compared to large block systems, the low block weights made the product easy for contractors to handle."

"[Building a wall with] mortar and rock—it's a very expensive propos
Wall). With SRWs, you don't need any special equipment and you c

Using the Right Product for the Job

The cemetery owners (SCI) chose to use an SRW system on the peninsula retaining walls primarily because they wanted the wall to look natural and blend in with the existing bulkheads. "The owners wanted the wall to look like distressed stone, just like the granite bulkheads. That look can't really be achieved with poured concrete," asserts Mr. Sandri.

According to Mr. Sandri, another consideration is the meandering nature of the wall. Although poured-in-place concrete can be used to create geometric shapes, this type of curving wall is very difficult to build with poured-in-place concrete. "You've got to form the curves with plywood forms, and once you are done, you need to put a facing on it. Then you would have to attach the mortar and rock—it's a very expensive proposition, more than twice the cost of an SRW system. With SRWs, you don't need any special equipment and you don't need highly skilled labor. That keeps costs low," states Sandri.

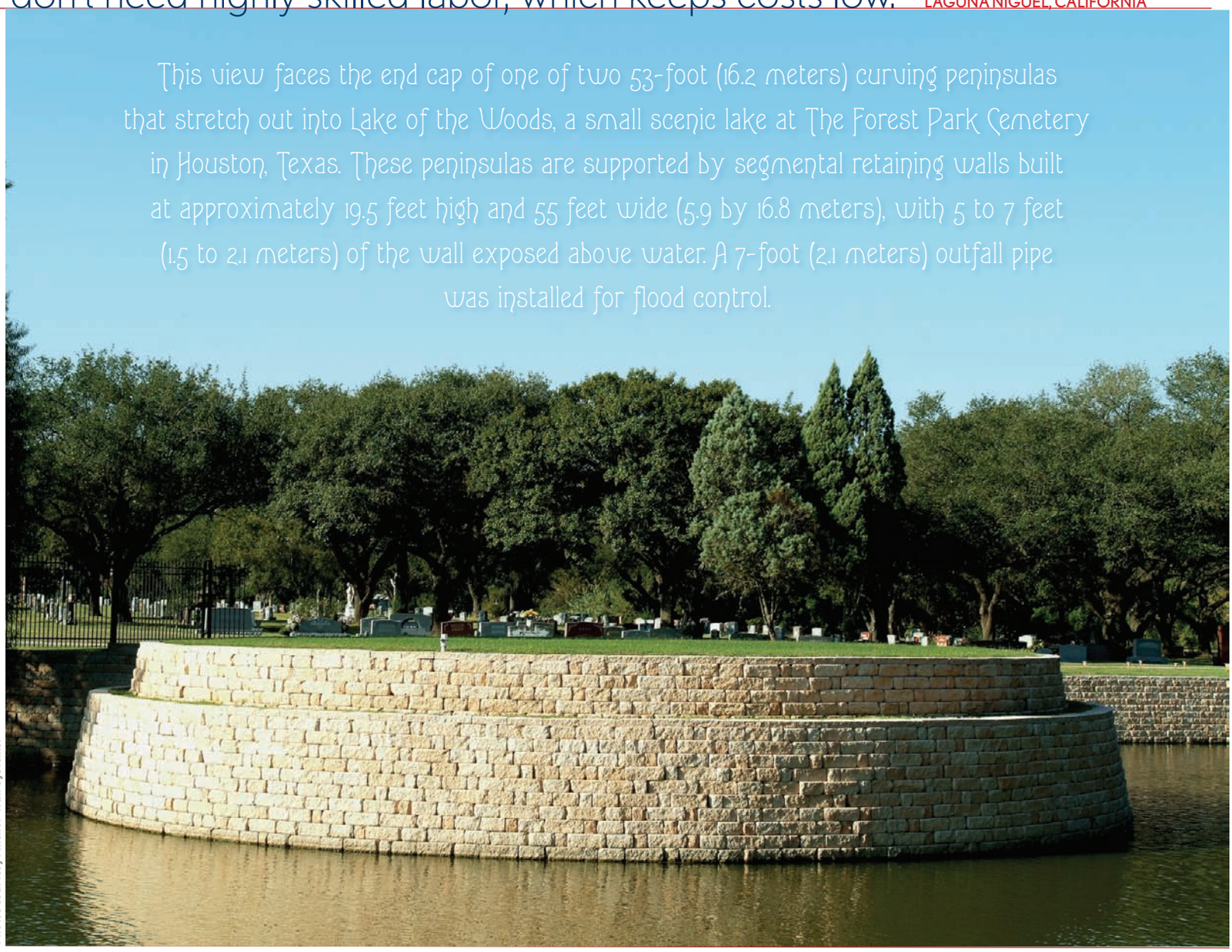
"The owner (SCI) is very pleased with the project," says Sandri. The bottom line—the multi-sized, stone-cut look of the SRW worked well, stayed within the budget, achieved design goals, and allowed construction to proceed with minimal interruption at the site. Forest Park is now the only Houston cemetery to offer premium, surrounding lakeside-view plots. CMD

Photos courtesy Anchor Wall Systems.

osition, more than twice the cost of a SRW (Segmental Retaining

u don't need highly skilled labor, which keeps costs low."

—DEAN SANDRI, P.E.
ANCHOR WALL SYSTEMS,
LAGUNA NIGUEL, CALIFORNIA



This view faces the end cap of one of two 53-foot (16.2 meters) curving peninsulas that stretch out into Lake of the Woods, a small scenic lake at The Forest Park Cemetery in Houston, Texas. These peninsulas are supported by segmental retaining walls built at approximately 19.5 feet high and 55 feet wide (5.9 by 16.8 meters), with 5 to 7 feet (1.5 to 2.1 meters) of the wall exposed above water. A 7-foot (2.1 meters) outfall pipe was installed for flood control.

Photos courtesy Anchor Wall Systems.

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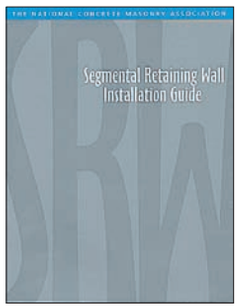
Retaining Walls —A Building Guide and Design Gallery

The essential resource to constructing segmental retaining walls with detailed, easy-to-follow, complete diagrams/charts for do-it-yourself homeowners and landscape contractors.
Order number TR212.
Professional price $24.95

Segmental Retaining Wall Installation Guide

Educates contractors and owners in the proper techniques to install segmental retaining wall systems. This resource addresses the specific installation steps for engineered and non-engineered systems, and includes technical information regarding excavation, geosynthetic grids, and more.



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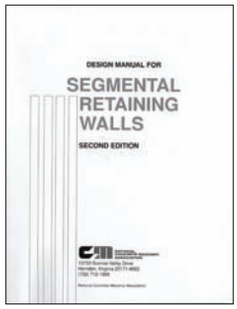
e-TEK and e-Details

NCMA's TEK series and Details provide architects, engineers, and specifiers up-to-date information on concrete masonry. TEKs include more than 130 technical bulletins on various topics related to the industry. A new TEK is published monthly, while others are revised to reflect code or building design changes, as necessary.

Electronic versions—called e-TEKs and e-Details—are free through select NCMA member websites. Find a member sponsoring e-TEKs and e-Details at ncma.org. All drawings in e-Details are downloadable electronically in DWG for AutoCAD and DXF, among other formats. Obtain hard copies of e-TEKs or e-Details at ncma.org or call the Publications Department at 703-713-1900.

Design Manual and Software for Segmental Retaining Walls

This manual provides a standardized, generic engineering approach for analysis and design of segmental retaining wall units. A segmental retaining wall is constructed of dry, stacked units (without mortar) that are usually connected through concrete shear keys or mechanical connectors. NCMA members provide a variety of proprietary units. Included in the manual is the latest design methodology for gravity and soil-reinforced earth walls, as well as design criteria, design tables, illustrations, installation procedures, and sample specifications. 289 pages; second edition, third printing (2002).



Order number TR127A.
Professional price $66.00

Design Software for Segmental Retaining Walls

SRWall version 3.22 covers design of both conventional gravity and soil reinforced walls, in accordance with NCMA's second edition Design Manual for Segmental Retaining Walls (TR127A) and Segmental Retaining Walls: Seismic Design Manual (TR-160) for walls subjected to earthquake loading. Users are highly encouraged to read the manuals for the respective procedures before using the program. Windows 95 or newer (2001).

Order number CMS11711.
Professional price $182.00

Buy the manual and software together and save $15.
Order CMS11711 and TR127A.
Professional price $233.00

Inspection Guide for Segmental Retaining Walls

This publication provides an easy-to-understand resource for field use by installers, designers, and inspection personnel. The guide outlines parameters for design and construction requirements of segmental retaining walls, including basic engineering requirements, a design checklist, and a construction observation checklist—all based on NCMA's design methodology for segmental retaining wall systems.
6 pages (1998).
Order number TR159.
Professional price $3.50 **CMD**

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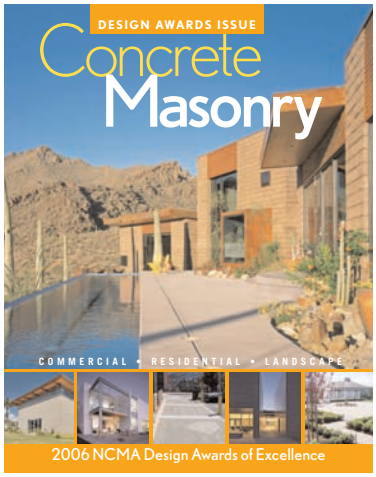

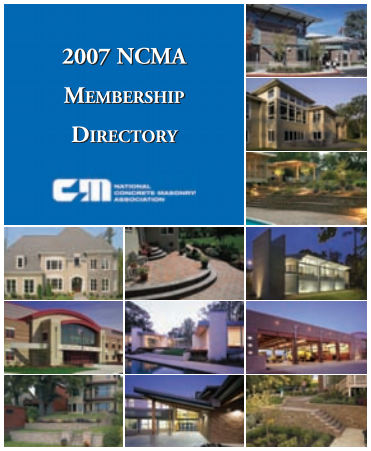

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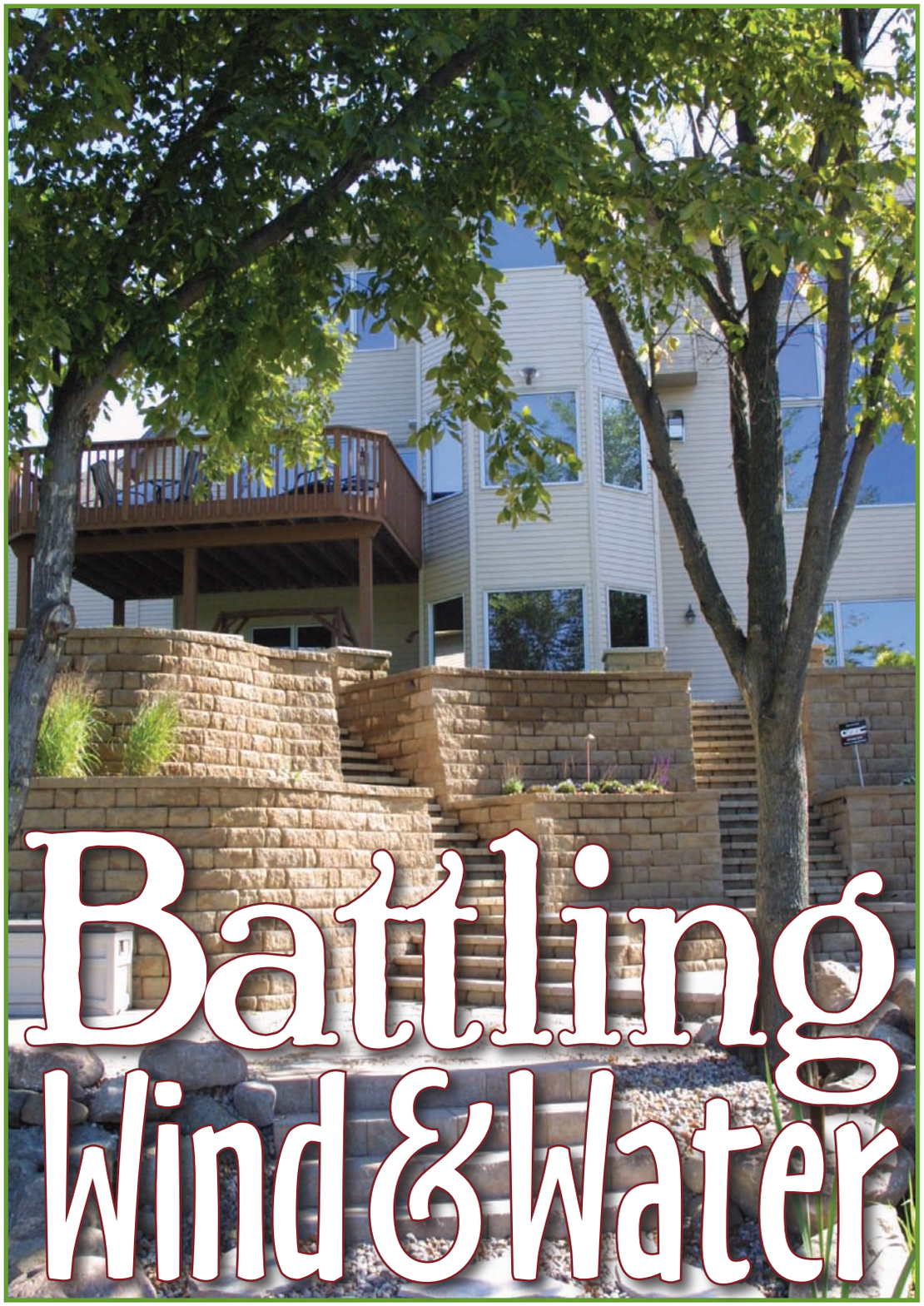
Sustainable Concrete Products for Structures and Hardscapes



This patio area was previously unused because the area was a steep embankment leading down to a muddy lakeside bog. The new patio deck and a double tier of six-foot (1.8-meter) high retaining walls used a tumbled, brown segmental retaining wall system that looks like aged stone. The new patio blends perfectly with the lake environment and allows the homeowner to enjoy an up-close view of the lake with a stone path leading to the water's edge.

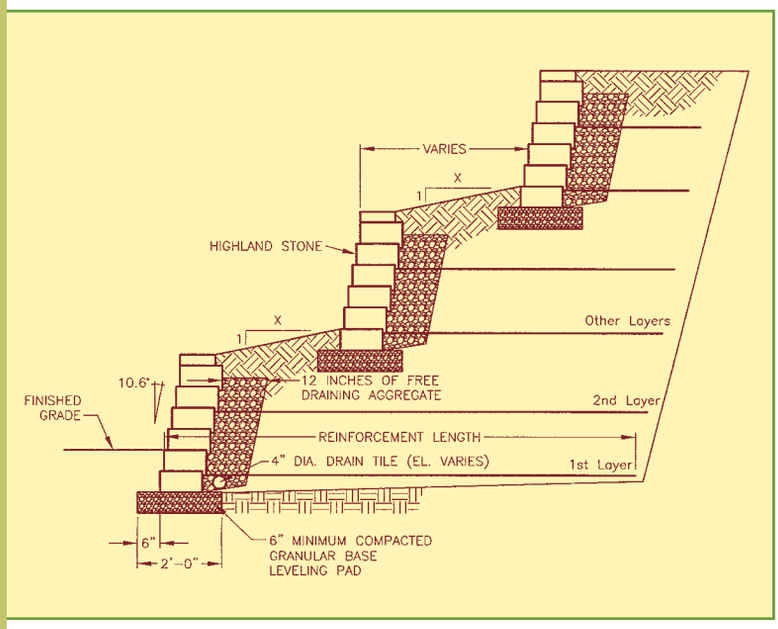
Hardscape and soil stabilization products transform a useless bog into a tiered patio with amazing lakeside views.

LANDSCAPE architects and contractors are often called to transform challenging terrain into practical, beautiful outdoor spaces. Site challenges can frequently include steep slopes, poor base material, poor drainage, flooding from nearby water sources, wind erosion of existing soils, and trees and buildings.

When Jim Hartwell, owner of Franklin Outdoor Services (FOS), a Burnsville, Minnesota landscape contractor, prepared to bid on a high-end residential landscape project in Lakeville, Minnesota, he quickly realized he'd be battling many of the site challenges above. The beautiful home is showcased by a formal entry accented by small raised planting areas and shaded by stately river birches. The back yard, however, was beautiful but unusable.

"We build lots of retaining walls with segmental retaining wall (SRW) units. We haven't had any of our walls fail, and we've been using our system of geogrid and SRWs for years."

–DALE WOLF, CONSTRUCTION SUPERVISOR AT FRANKLIN OUTDOOR SERVICES, BURNSVILLE, MINNESOTA



PROJECT:
Private Residence,
Lakeville, Minnesota

ARCHITECT:
None required

GENERAL CONTRACTOR:
Franklin Outdoor Services
Burnsville, Minnesota

STRUCTURAL ENGINEER:
None required

Site Challenges

Behind the home, a steep slope dropped down to a private lake. The house had beautiful views of the lake, but the owners could not use the back yard because the slope leading down to the lake was too steep to walk, and the soil was soft and marshy. The homeowners wanted to create an accessible lakeside patio, but were worried about water erosion.

The Solution

In order to create a design that would address the site challenges, Hartwell chose a high-performance, extremely durable product, which would also enhance the beauty of the lakeside site—segmental retaining walls (SRWs). Because the homeowner wanted the patio to blend in with the natural lake environment, Hartwell chose SRWs with the texture, color and shape of natural stone. Hartwell's plan for the project included installation of two six foot (1.8 meter) high retaining walls, along with steps leading down to a lakeside patio below.

One of the features that sold Hartwell on this particular SRW system for this project was the unique facing available. The SRW units are manufactured in three different face sizes, which are used together to create the appearance of a hand-hewn stone wall. Like all SRWs, this system is manufactured with a "no slump" concrete mix, which is required to meet rigid requirements for properties such as compressive strength, dimensional tolerances and freeze-thaw durability, where applicable.

Because of the weak, marshy soil at the site, a geosynthetic soil reinforcement, or geogrid, was used to stabilize the soil under the patio deck. The same geogrid was also used in conjunction with the SRW units, to create an integrated system able to provide stability in the marshy environment. In general, soil reinforcement is used for tall SRWs, or for those with sloping backfills, subjected to live loads and/or those with poor foundations. "Without sufficient reinforcement, native soils like these found in a marshy areas will not hold up any type of patio deck or retaining wall, and both would certainly fail at considerable expense to the homeowner and embarrassment to us, the contractor," says Mr. Hartwell.

In addition, the construction process itself can be hampered by wet soils. "We knew the bog would pose a big compaction problem; you couldn't even walk on it without your feet sinking in." says Dale Wolf, construction supervisor at FOS.

"Installing a stable segmental retaining wall or patio is fairly simple—even in areas prone to water," says Mr. Hartwell. "No special tools, equipment or manpower is needed. The most important part of a project like this is planning to use high quality products made to suit the site conditions, such as SRW units and an appropriate geosynthetic."

Preparing the Site

To transform the bog into a stable patio, Mr. Wolf prepped the site by clearing brush, leveling and smoothing out the subgrade, and removing sharp objects, such as tree branches or large rocks

that could puncture the geogrid fabric. Next, the geogrid was pulled taut over the entire area to be compacted and secured with fabric staples. Class-five soil was brought in as additional base material and compacted in two inch (51 mm) lifts until the site was up to grade.

Building the Walls

To build the retaining walls, the SRW units were placed, starting with the corners and working out. "Once the SRW units are in place, you must leave a void just behind the block for crushed rock," says Mr. Wolf, who placed drainage aggregate in a 6 to 12 inch (152 to 305 mm) thick layer between the SRW unit and compacted backfill soil. Wolf compacted the soil backfill to 95 percent standard Proctor moisture/density relationship after each course of the backfill structure. The geogrid was placed between each layer of SRW units. To avoid damage during construction, all heavy machinery must be kept at least three feet (0.9 meter) away from the back of the wall. Within this zone, manually-operated compaction devices, such as vibrating plate compactors, should be used. A corrugated drainage channel surrounded by drainage aggregate ensures proper water drainage at the base of the wall.

For added security against water erosion, the SRW units were glued with polyurethane construction adhesive. Native plants were planted at the base of each retaining wall to provide additional erosion control. Copper landscape lighting was added to showcase the planting beds.

over ten feet (3 meters) high, it's best to use single-direction geogrid with the strongest direction of the geogrid perpendicular to the wall facing.

Natural stone could have been used to build the patio deck and retaining walls, but it is "much more time-consuming and requires a much higher level of skilled labor, which is expensive," says Mr. Wolf. "We don't do any [poured-in-place] concrete work or brick and mortar retaining walls. As far as drainage is concerned, an SRW works really well and lets the wall weep—allows water to move freely through the wall—so the fill behind the wall doesn't absorb the water and then expand and contract with water and temperature changes. The bottom line is that we build lots of retaining walls with SRW units. We haven't had any of our walls fail, and we've been using our system of geogrid and SRW for years."

Exceeding Homeowner Expectations

"The finished product was even better than the homeowner expected," says Mr. Hartwell. "Where there was previously a boggy area, now there is a perfectly level patio with a small stone fire pit that offers the perfect space for outdoor leisure."

"Customers want the best value for their money, and SRWs are economical and reliable while achieving a natural, stone-like finish," asserts Mr. Hartwell. "Our customers don't want us to have to come back and fix problems later. They want it done right the first time, and they are willing to give us the project if we spend time educating them on the value of quality design and products."

FAST FACT: UNLIKE RIGID RETAINING WALLS, THE FLEXIBLE NATURE OF SEGMENTAL RETAINING WALLS ALLOWS THE UNITS TO ACCOMMODATE SLIGHT MOVEMENT RELATIVE TO EACH OTHER, WITHOUT DISPLAYING CRACKS .

Ensuring Wall Stability in Water Applications

"To build this type of retaining wall, especially one prone to changing water levels, a geogrid can help stabilize the wall by allowing interaction between the soil above and below the geogrid," says SRW engineer Mike Orton. "The soil locks together and helps to develop strong pull-out resistance, increasing the stability of the wall." And when working with SRWs

According to Hartwell, most homeowners are willing to make the investment in a high-quality retaining wall because it's their home, it's personal to them, and they want it to endure. "Standing firm on quality installation and materials is what separates good contractors from the bad ones," says Hartwell. CMD

Concrete Masonry's AIA Continuing Education Learning Program

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Return this form to the National Concrete Masonry Association. Only original forms are accepted for learning unit credit.

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Send completed Report Form to: AIA CES, National Concrete Masonry Association, 13750 Sunrise Valley Drive, Herndon, VA 20171-4662. If you have questions, please contact NCMA at 703-713-1900.

November 2007

A I A Q U E S T I O N S (Check the correct answer)

1. Filter fabric can be used to:
A. Prevent water flow.
B. Minimize the migration of fine soil particles.
C. Remove staining from SRW units.
D. Answers A and C.

2. When building an SRW for a water application, it is recommended to use
A. Clay as the reinforced backfill soil.
B. No geogrid or filter fabric.
C. Clean, open-graded aggregate as the reinforced backfill soil.
D. None of the above

3. During construction, heavy equipment must be kept at least _____ behind the back of the wall.
A. 6 feet
B. 4 feet
C. 3 feet
D. 12 inches

4. When placing geogrids, the design strength direction should be perpendicular to the wall face
A. True.
B. False.

5. Geosynthetic Soil Reinforcement (geogrid) can be used to :
A. Reinforce soil behind and in conjunction with SRW units.
B. Prevent water flow.
C. Reinforce base soils underlying SRWs and pavements.
D. Answers A and C.
E. None of the above.

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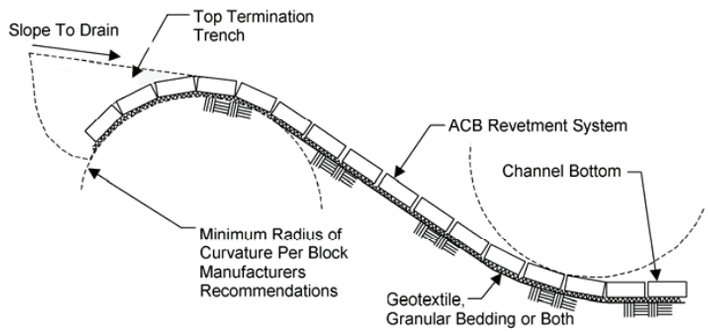
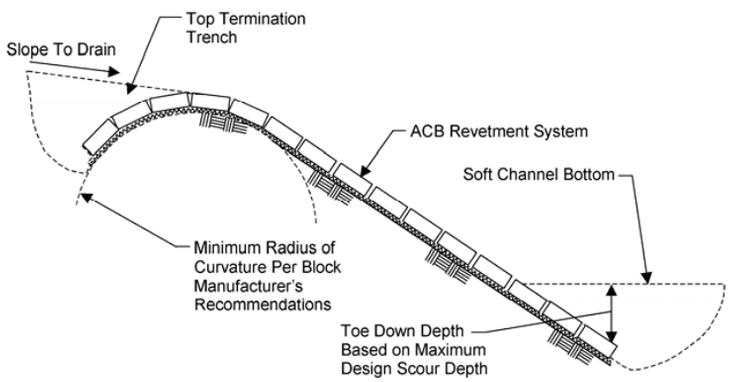
☐ Check here to request a catalog of concrete masonry technical literature.

ACB Concept of Minimum Radius-Of-Curvature for Bed and Bank Protection and Toe Termination.

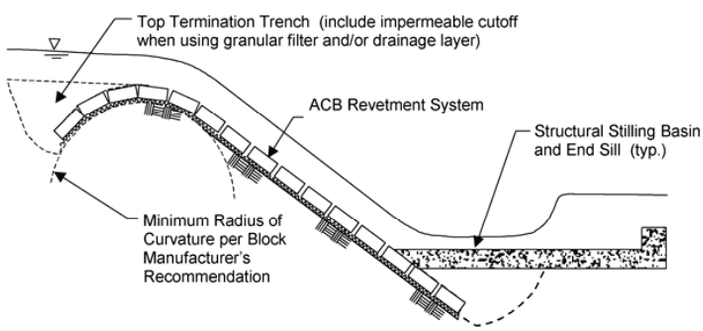
These details show the conceptual associations between minimum radius-of-curvature and various bed and bank applications with Articulating Concrete Block. Installation should be completed in accordance with manufacturer's recommendations.



Conceptual detail of minimum radius-of-curvature for bed and bank protection.



Conceptual detail of minimum radius-of-curvature for bank protection.



Conceptual detail of toe termination for spillways or embankment overtopping flow. CMD

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