SonomaStone®

segmental retaining wall

Installation Guide

RisiStone®
retaining wall systems

SonomaStone® Installation Guide

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Risi Stone Systems has attempted to ensure that all information contained in this guide is correct. However, there is the possibility that this guide may contain errors. Review all designs with your local sales representative prior to construction. Final determination of the suitability of any information or material is the sole responsibility of the user.

RisiStone
retaining wall systems

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Introduction

the SonomaStone system

The SonomaStone system is a solid, modular concrete retaining wall system that is used to stabilize and contain earth embankments, large or small. Today, the SonomaStone system and several other retaining wall systems licensed by Risi Stone Systems are manufactured and installed across North America and internationally.

In the SonomaStone system, the majority of the facing is constructed from a single mass-produced modular unit. Because the units are solid, they can easily be modified by scoring and splitting. Specialized units like coping units and corner unitsare available to help speed the installation of wall features. The SonomaStone system can be constructed in three basic configurations: a SonomaStone Conventional SRW (single- or multi-depth) or a SonomaStone Geogrid Reinforced SRW.

There are many applications for SonomaStone retaining walls. Most examples can be divided into the three aforementioned configurations which, more or less, follow two basic uses: landscape applications and structural applications.

In landscape applications, the primary purpose of retaining walls is aesthetic in nature. Some examples of SonomaStone landscape uses are steps and terraced applications. Most landscape applications call for walls under 1.2 m (4 ft) in height, with minimal loads being applied to the wall. Consequently, most landscape walls are built as conventional SRWs.

In structural applications, the primary function of retaining walls is to provide structure and strength to steep slopes or cuts. Some common structural uses for SonomaStone retaining walls are high walls, some in excess of 7.5 m (25 ft); walls required to support parking, roads, or highways; and erosion protection along streams or lakes. In most of these cases, geosynthetic reinforcement is used or multi-depth conventional construction is required. Multi-depth conventional SRWs utilize deeper base course units to increase the maximum allowable wall height. This configuration is particularly useful for construction in tight spaces (e.g. close to a property line).

The SonomaStone system is supported by Unilock and Risi Stone Systems. Unilock will make every attempt to answer general questions and they will gladly provide customers with answers for site-specific applications. Each Unilock location has access to prepared information on the SonomaStone system and has plenty of experience installing it. The RisiWall design software also helps to provide solutions for specific site designs. Unique applications often necessitate the assistance of a professional engineer. Risi Stone Systems can provide these solutions through its Engineering Design Assistance program.

features • advantages • benefits

The SonomaStone system has a number of features that make the system unique. Each of these features has been developed to give a SonomaStone retaining wall the advantages of increased beauty, simplified installation, and greater strength. These features benefit the owner by lowering the entire cost of the retaining wall, both during installation and well into the future.

Modular Retaining Wall System
Wall is flexible, yet retains its structural characteristics.
- The wall can absorb minor movements due to frost or settlement.
- Requires minimal embedment below grade.

A compacted granular base is all that is required.
- Reduces the cost by not requiring an expensive structural footing.

Solid Unit Manufactured From 35 MPa (5000 PSI) Concrete
Provides wall with greater durability.
- Ensures the maximum weight of each unit because there are no voids or cores to be filled.
- Less susceptible to freeze-thaw deterioration.
- Less likely to be broken by handling or in transit.

Solid units are easy to split and modify.
- Can easily create site-specific features using the modular units.

No hollows to be filled with gravel and compacted.
- Ensures maximum resistance to overturning forces.
- Saves time and money.

Tongue and Groove Interlock

Interlocking mechanism molded into the units so there are no separate pins or clips.

- No need to incorporate multiple components; installation rates increase.
- Ensures maximum shear connection between units.

Units are dry-stacked.

- Lower costs because no mortar is used in the construction.
- Minimal training is required to achieve excellent installation results.

Units are self-aligning and self-battering.

- Once the first course is laid flat and levelled, subsequent courses will automatically align horizontally and vertically.

Creates a continuous interlock throughout the wall.

- Makes a stronger, more damage-resistant wall.

Size and Weight

The SonomaStone standard units weigh approximately 175 kg (385 lbs). Some locations may manufacture a shorter 1000 mm long unit with a weight of 146 kg (320 lbs). As a result, these units must be machine-placed. (Refer to *Installation – SonomaStone System Clamp* for instructions on use of the mechanical placement clamp.)

SonomaStone with Geogrid Reinforcement

Ability to construct higher walls.

- Can utilize site soil to infill the geogrids, consequently lowering disposal and extra material charges.
- Can use the same facia throughout a site on lower conventional SRWs and higher geogrid reinforced SRWs.

Choice of Configurations

- Walls on one site with different structural requirements can have the same appearance.

90º Corner Units

Manufactured to speed construction.

- Offers a finished appearance to the wall.
- Initiates the correct running bond pattern.
- Increases the strength of corners.
- Saves time during installation.

Complementing Accessories

All the standard features for retaining walls can be supplied by the manufacturer.

- Saves time during installation.
- Creates a uniform, finished look for the wall.

Technical Support and Engineering Design Assistance

Technical expertise developed over thirty years through experience and testing is available to customers.

- Ensures that retaining walls are correctly designed and constructed.
- Advanced software is available to help designers generate designs for stable retaining wall structures.

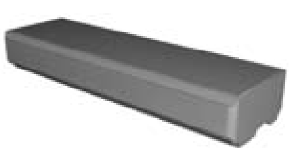
Due to local conditions and preferences, the licensed manufacturer may produce the SonomaStone system with one or more minor variances. These differences in no way affect the performance of the wall.

one metre width unit

Due to the limitations of the manufacturing machinery, manufacturers may opt to produce the slightly shorter, one-metre version of SonomaStone.

colours

Each manufacturer has selected a set of standard colours that they make and keep in stock These colours will vary between manufacturers, and variation of a particular colour by the same manufacturer is also normal. Some have the ability to mix the base colours and create marbled colour blends. The possibility of custom colours may exist for larger orders.

SonomaStone® System Units	Face Width	Back Width	Height	Depth	Weight
 **Standard Unit**	1200 mm (1000 mm)*	1200 mm (1000 mm)*	185 mm	375 mm	175 kg (145.5 kg)*
	47.25 in (39 in)*	47.25 in (39 in)*	7.25 in	14.75 in	385 lbs (320 lbs)*
 **Tapered Unit**	590 mm (490 mm)*	542 mm (442 mm)*	185 mm	375 mm	82 kg (67 kg)*
	23.25 in (19.25 in)*	21.5 in (17.5 in)*	7.25 in	14.75 in	180 lbs (150 lbs)*
 **750 Unit**	1200 mm (1000 mm)*	1200 mm (1000 mm)*	185 mm	750 mm	350 kg (291 kg)*
	47.25 in (39 in)*	47.25 in (39 in)*	7.25 in	29.5 in	770 lbs (642 lbs)*
 **90° Corner Unit**	975 mm (875 mm)*	975 mm (875 mm)*	185 mm	375 mm	140 kg (125.5 kg)*
	38.5 in (34.5 in)*	38.5 in (34.5 in)*	7.25 in	14.75 in	309 lbs (277 lbs)*
 **Coping Unit**	1200 mm (1000 mm)*	1200 mm (1000 mm)*	185 mm	375 mm	170 kg (210 kg)*
	47.25 in (39 in)*	47.25 in (39 in)*	7.25 in	14.75 in	375 lbs (312.5 lbs)*
 **Tapered Coping Unit***	590 mm (490 mm)*	542 mm (442 mm)*	185 mm	375 mm	82 kg (67 kg)*
	23.25 in (19.25 in)*	21.5 in (17.5 in)*	7.25 in	14.75 in	180 lbs (150 lbs)*

** Available only in selected locations.*

overview of a successful project

The following procedure is recommended for the construction of SonomaStone segmental retaining walls over 1.0m (3.0 ft) in height, or as required by local building codes.

Clear Plan

- Aboveground Site Assessment – existing grades, structures, utilities, property lines, visible water features, etc., established.
- Proposed site modifications defined by designer (landscape architect, engineer, architect) based on owner's requirements and site limitations. Includes proposed grades, retaining wall geometry, slopes, proposed use of land (parking areas, water detention, landscape), relocation of existing structures/utilities, new structures/utilities, location of trees, etc.
- Project drawings generated and submitted to appropriate agencies for approval.

Assessment of Subsurface Conditions

- Geotechnical Investigation conducted to evaluate subsurface conditions of site, including soil types, characteristic properties, in-situ state, groundwater conditions, overall slope stability, bearing capacity.
- Recommended design parameters, construction/excavation techniques, effects of proposed and existing structures, ground improvements, erosion protection, drainage considerations, anticipated settlement, etc., should be identified.

Site-Specific Retaining Wall Design

- Information provided in Plan and Geotechnical Investigation provided to SRW designer.
- The design may be provided by Risi Stone Systems through the Design Assistance Program (contact local manufacturer for details), or a third-party engineer qualified in this field. The design must synthesize all available information and include cross-section and/or elevation-view drawings, specifications, calculations, quantities, and related construction details. (See *Following the Design*)

Qualified Professional Engineer Hired for Inspection/Certification

We recommend that inspection and certification of the proposed SonomaStone SRW should be conducted by a qualified third-party engineer. Inspection should not be limited to soil and compaction testing, but include all aspects of the installation.

The scope of the General Review Engineer's responsibilities include, but are not limited to:

- Inspection of all materials used in construction (SRW units, backfill, drainage materials, reinforcement, other structures);
- Verification that the design is compatible with the site in all respects;
- Identification of discrepancies between plan and/or SRW design and actual site conditions and subsequent notification of designer;
- Continuous evaluation of site conditions, compaction testing, foundation bearing capacity, excavation procedures, construction practices for safety and compliance with design;
- Ensuring the wall is constructed according to the design; and
- Providing a letter to the owner certifying the construction of the wall upon completion.

Pre-Construction Meeting

- It is recommended that all involved parties (designers, owner's representative, general contractor, installer, inspecting engineer, supplier, etc.) attend a pre-construction meeting to define schedule and clearly state responsibilities.
- Parties not directly involved with the design and construction of the wall, but who may be doing future work that could influence the wall (e.g. paving, installing a wood fence, etc.) should be included in the meeting to understand the limitations of the wall and address precautions that should be undertaken.
- Experience has shown that this simple step prevents a multitude of potential problems!

Proper Installation

- Adherence to design, specifications, details, guides, and good construction practice is necessary.
- Conducted under supervision of General Review Engineer.

Final Grading

- Final grading should be conducted as soon as possible following construction to divert water away from the wall and create the optimum condition for great performance.

understanding the design

Depending on the stage in the design process, there are generally three potential types of design:

Typical Design

Non-site–specific design(s) selected from Risi Stone Systems' library of pre-engineered cross-section drawings (all available at risistone.com). Selected based on preliminary information regarding proposed maximum wall height, use of structure, grading, etc. Suitable for preliminary cost estimates, feasibility studies, and conceptual approvals.
Not for Construction.

Preliminary Design

A site-specific design produced for preliminary purposes. Conducted when some component of the required design information is not yet available. The design includes all elements necessary to construct the wall, but is not considered ready for construction as it remains contingent on verification of some site-specific detail(s). Includes site-specific cross-section drawing(s), elevation view(s), specifications, quantity calculations, details, statement of limitations, etc. This type of design is usually not sealed by the designer.

Final Design

Identical to the preliminary design with the exception that all necessary information has been established and the design has been deemed ready for construction. This type of design is normally sealed by the designer.

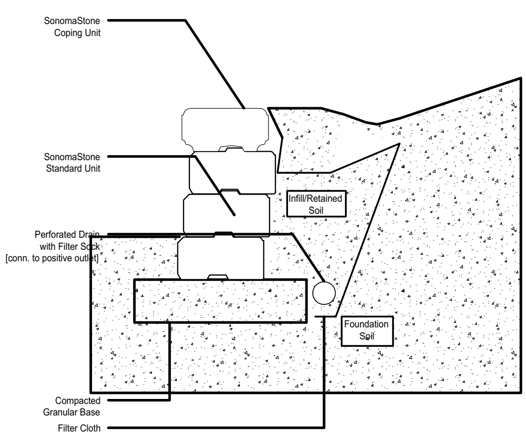
components of the design

The design should clearly provide all information necessary to construct the proposed SRW structure. The basic components are as follows:

Design Notes / Limitations

The design should include information regarding the design standard used, limitations of design, status of design (preliminary or final), design assumptions, purpose of the wall, and potential construction issues.

Typical Cross-Section Drawing



Design Specific Geometric Information

Retaining Wall System	SonomaStone	Geogrid Type and Manufacturer	N/A
Maximum Height mm (in)	740 (29)	Minimum Geogrid LTDS kN/m (lb/ft)	N/A
Maximum Slope Above Wall	1V:3H	Maximum Slope Below Wall	None
Max. Surcharge Above Wall kPa (lb/sq.ft)	None	Depth of Embedment mm (in)	186 (7)
Batter of Wall	7.12•	Compacted Base Dimension mm (in)	746 x 186 (29 x 7)

Design Specific Soil Information

	Soil Region				
	Infill / Retained		Foundation	Base	Drainage
Description (by USCS)	GW Well graded, free draining Granular		CL Inorganic Clays Low Plasticity	GW Well graded, free draining Granular	see infill
Effective Internal Friction Angle	35°		28°	39°	NR
Moist Unit Weight kN/cu.m (lb/cu.ft)	22 (140)		20 (127)	22 (140)	NR
Effective Cohesion kPa (lb/sq.ft)	NR		13 (270)	NR	NR
Soil Notes	Placed in 150mm (6in) lifts and compacted to 95% SPD.	Granular Fill placed at 1H:1V wedge	The allowable bearing capacity must exceed 50kPa (1050lb/sq.ft).	Well graded, crushed, non frost susceptible granular soil compacted to 98% SPD.	Granular infill must be well graded, free draining w/ max 5-8% fines

NR - Not Required

Notes:

1. This design meets or exceeds the minimum factors of safety required by Risi Stone Systems based on the design parameters listed above. The analysis was conducted in accordance with the National Concrete Masonry Association Design Manual for Segmental Retaining Walls, Second Edition.
2. This is a preliminary, non site-specific design. If used for construction, a qualified Engineer must be retained to review/approve the design, confirm site conditions, and inspect construction.
3. No analysis of global stability, total or differential settlement, or seismic effects has been performed.
4. This design is only provided to illustrate the general arrangement of the SRW structure. This drawing must be used in conjunction with the related Detail Drawings and Specifications for proper design and construction.
5. Structures such as handrails, guardrails, fences, terraces, and site conditions such as water applications, drainage and soil conditions, additional live and dead loads, etc., have significant effects on the wall design and must be reviewed/ approved by a qualified Engineer before being used in conjunction with this design.

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SonomaStone®
Retaining Wall
Gravity Section
740mm (2.43ft)
Site: 3H:1V Slope - Clays
Infill: Granular

SM1GBSAI074

Cross-Section Drawing(s)
The cross-section drawing is usually provided to illustrate the general arrangement of the wall, soil zones, assumed parameters, structural elements such as fences and handrails, water levels, etc. A cross-section drawing is normally provided for the maximum height section through the wall and/or the most critical section. Additional cross-sections may be provided to indicate variable conditions or wall orientation (terraces/ location of structures) throughout the structure.

Elevation-View Drawing(s)
The elevation view or "face" view of the wall depicts the wall as a whole, essentially laying the wall out flat on the page. This drawing details the overall geometry of the proposed wall, steps at the top and bottom of wall, required geogrid length and placement (where applicable), location of other structures, etc.

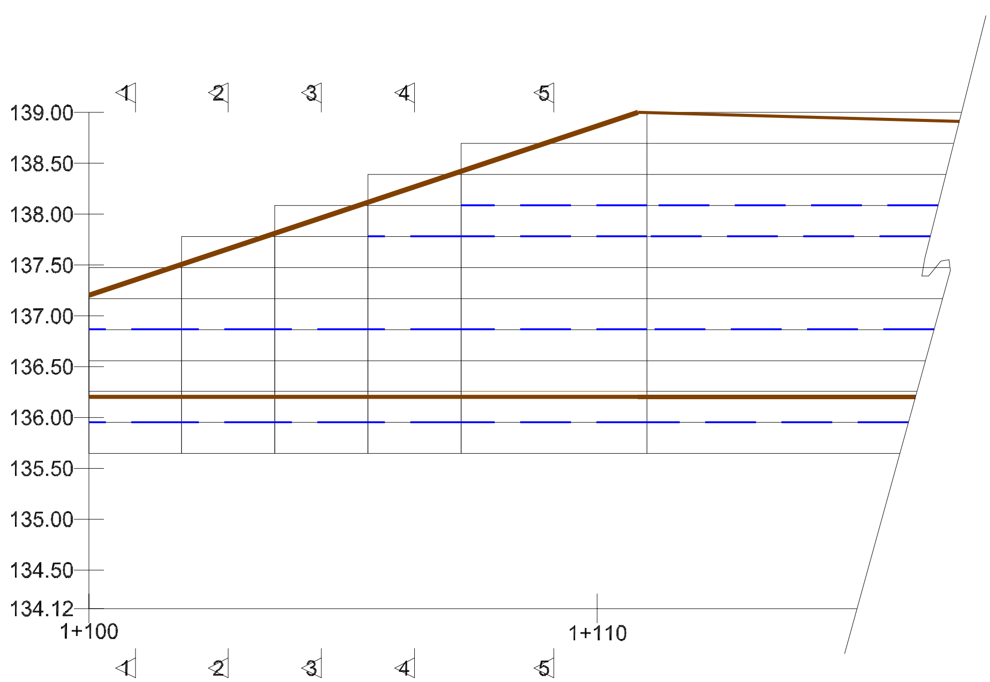
This drawing provides the contractor with an exact model upon which to establish grades and construct the wall.

Calculations and Quantity Estimates
Risi Stone Systems conducts analysis using the RisiWall design software (available at risiwall.com), a state-of-the-art SRW design program with over a decade of research and development built into it. Risi Stone Systems' design reports feature the RisiWall design output. This output is customizable and depending on the application, may include the design calculations, all design parameters, quantity calculations, etc. The quantity calculations exactly represent the wall layout provided in the elevation view and Calculated Panel Geometry section of the RisiWall output. The contractor is responsible for verifying the quantities provided by checking the most recent grading information, and/or site grading, against the elevation view provided.

Details
The cross-section and elevation-view drawings are to be used in conjunction with the related detail drawings. These may include handrail treatments, corner details, curves, stepping foundation, steps, swales, etc. Adherence to these details is vital for optimum wall performance.

Specifications
The Design should include standard specifications that outline specific requirements of the Design, Construction, Materials, Certification, and Finishing.

Typical elevation-view drawing



Installation

SonomaStone system clamp

Two clamps will be available for the SonomaStone system. Both of the clamps are mechanical scissor clamps; they use the self weight of the unit to apply the necessary gripping pressure on the block. It requires no power other than that provided by the lifting machinery (e.g. backhoe, bobcat, etc.).

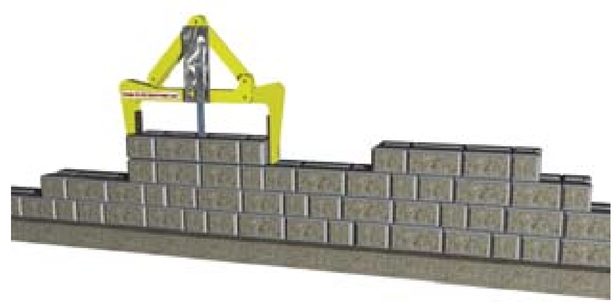
The standard units contain vertical grooves on the ends of the units. These grooves allow the arms of the clamp to fit inside the unit. The unit can then be picked up directly from the pallet and placed on the wall, flush with the adjacent unit.

SonomaStone single clamp

The SonomaStone Single Clamp is able to place all of the system components, one at a time. The clamp can pick up a single standard unit, end to end, when fully extended. For all other components – tapered, coping, and corner units – the clamp is adjusted to grab the units from the front and back, due to the fact that these units do not have vertical grooves on the ends.

SonomaStone triple clamp

This clamp allows for three standard units to be picked up directly from the pallet and placed on the wall. The SonomaStone Triple Clamp is designed to only place standard units (end-to-end). This clamp is meant for larger projects where an additional SonomaStone Single Clamp will be necessary to move all other components. The SonomaStone Triple Clamp is designed to pick up and place a maximum of three units at once. With the incorporation of a mechanical indexing system (patent pending), the clamp automatically cycles through the stack of three units as each is placed individually.



notes and precautions

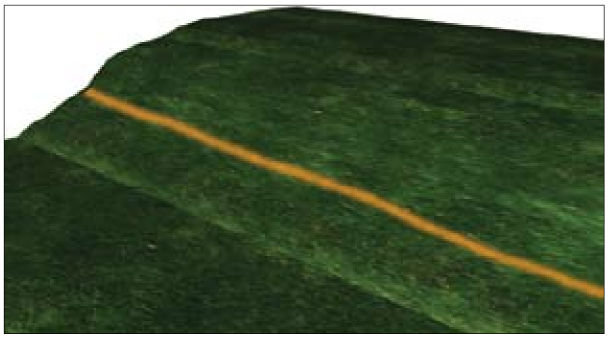
As with any clamp, proper care should be taken to reduce the potential for injury.

- The maximum recommended load should not be exceeded
- At no time should anyone stand under the load
- Prior to each use the pads should be inspected to ensure that they are in good condition
- Ensure that proper overall maintenance of the clamp is kept up

plan

With your final design in hand, begin to establish the wall location and proposed grades. Locate all utilities and contact local utility companies before digging. Mark a line where the front of the wall will be placed, keeping in mind the 25mm (1 in) setback per course.

Refer to *Overview of a Successful Project* before beginning. This will help to ensure the project goes smoothly.

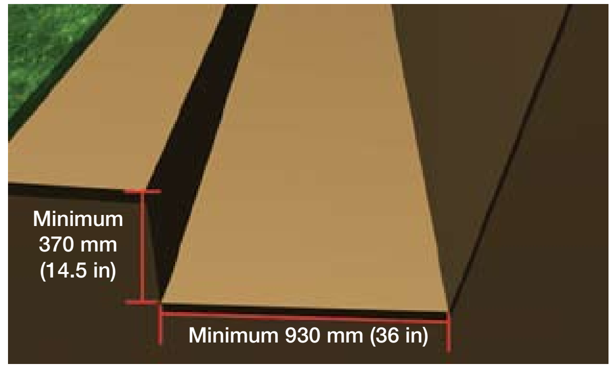


excavate

Excavate a trench down to the foundation grades specified in the design. The front of the trench should be 185mm (7.25 in) from the planned face of the wall. The trench should be a minimum of 930mm (36 in) wide (front to back) and 370mm (14.5 in) deep. This depth assumes one unit is buried (unit height of 185mm [7.25 in]) plus the compacted granular base minimum depth of 185mm (7.25 in). As the wall height increases, depth of embedment also increases, normally about 10% of the wall height. Greater embedment depths may be required to account for slopes more than 3H:1V in front of the wall, scour protection in water applications, global stability, or as specified in the design. The rear 185mm (7.25 in) of the trench is excavated to account for the drainage layer. Excavations should be conducted in accordance with local codes under direction of the CE.

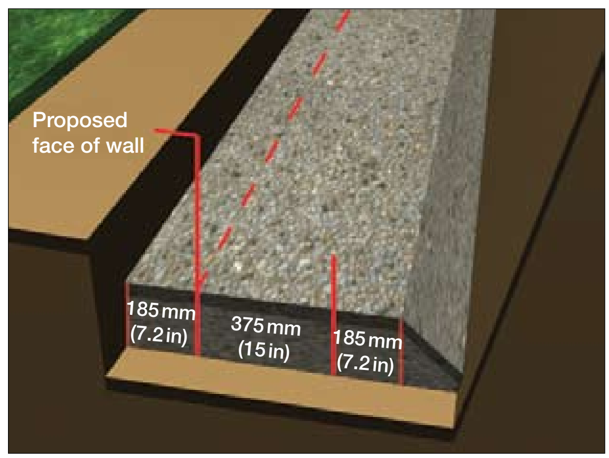
verify foundation subgrade

Once the foundation trench has been excavated to the specified elevations, the native foundation soil must be checked by the CE. The foundation soil must have the required allowable bearing capacity specified in the design.



prepare the granular base

Start the base at the lowest elevation of the wall. The base should be composed of well-graded, free-draining (less than 8% fines), angular granular material, and compacted to a minimum of 98% SPD. The minimum base thickness is 185mm (7.25 in) or as required by the CE to reach competent founding soil. A layer of unreinforced concrete (50mm [2 in] thick) may be placed on top of the granular material to provide a durable levelling surface for the base course. At the direction of the CE, geotextile might be required under the granular base. The minimum base dimensions at the top are 745mm (29 in) wide (front to back) and 185mm (7.25 in) deep. The additional 185mm (7.25 in) trench width allows for the placement of the drain (total 930 mm [36 in]).



step the base

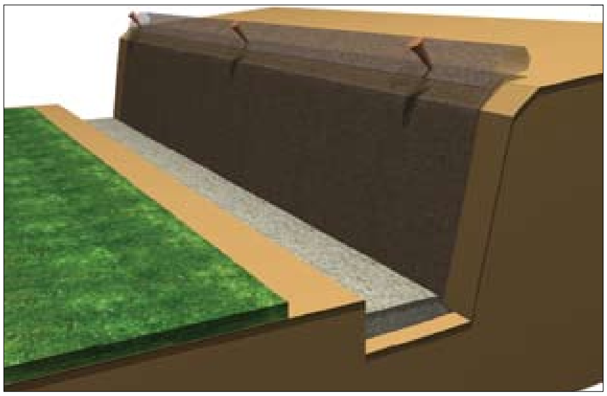
When the grade in front of the wall slopes up or down, the base must be stepped to compensate. The foundation stepping must be set to ensure the minimum embedment is achieved. The height of

installation

each step is 185mm (7.25 in) – the height of one course. The 25mm (1 in) offset must be accounted for at each step. Refer to "Stack Units" for an illustration of stepping the base.

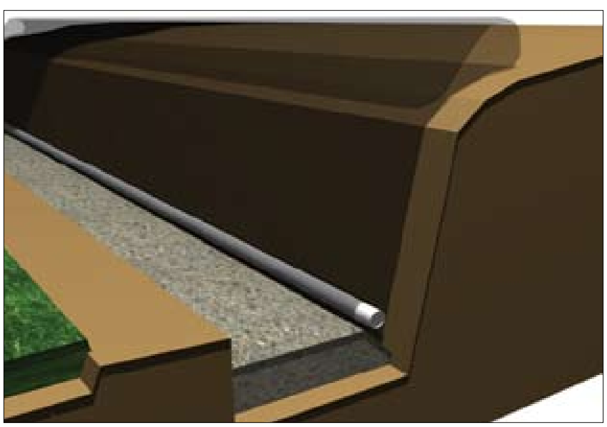
place filter cloth

Lay the approved filter fabric (geotextile) along the bottom of the rear of the trench and extend up the exposed excavation to the proposed wall height. Leave adequate material at the top to fold back towards the wall (completely containing the drainage material). Stake the filter cloth against the slope during construction.



place the drain

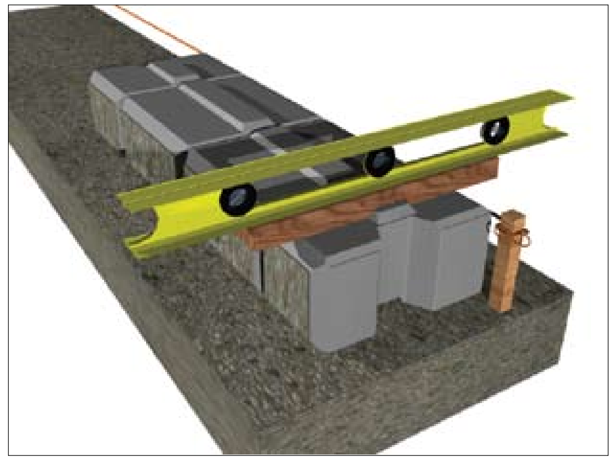
The drain size and type must be in accordance with the project specifications. Generally, a perforated drain with filter sock (100mm [4in] diameter) is used.

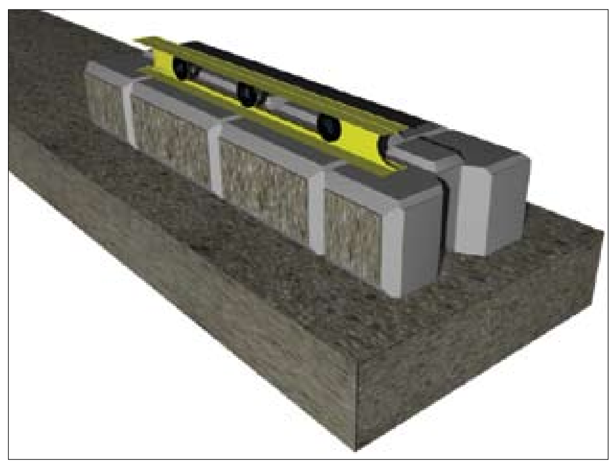


Various options for drain placement may exist, depending on how the pipe is to be outlet (refer to *Details – Drainage*). The drain may be outlet through the wall face or connected to a positive outlet (storm drain). The drainage system is extremely important and outlets must be planned prior to construction. In the case of connecting to a positive outlet, the drain should be placed at the lowest possible elevation and sloped at a minimum of 2%. At the rear of the base, allow the granular material to slope down on the sides towards the drain trench. In the 185mm (7.25 in) area behind the base, place the approved drain tile (perforated drain with filter sock) on top of the filter cloth and minimal granular coverage.

place the first course

Position a level string to mark the location of the back of the first course (should be 375mm [15 in] from the proposed wall face). Place the first course of SonomaStone units side-by-side (touching) on the granular base.

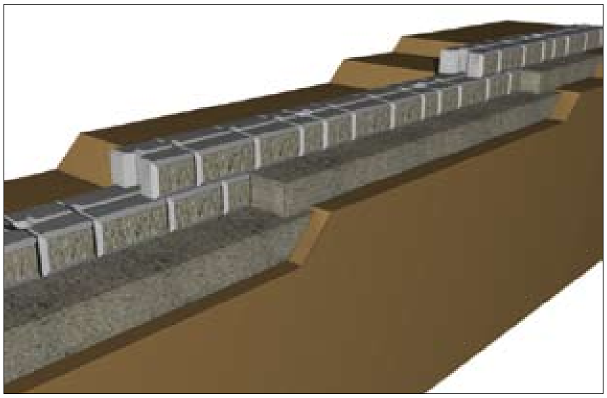




Ensure units are level front to back and left to right. Extra care should be taken at this stage as it is critical for accurate alignment.

stack units

Sweep the top of the underlying course and stack the next course in a running bond pattern so that middle of the unit is above the joint between adjacent units below (600 mm [24 in] offset; 500 mm [20 in] for the one-metre unts).

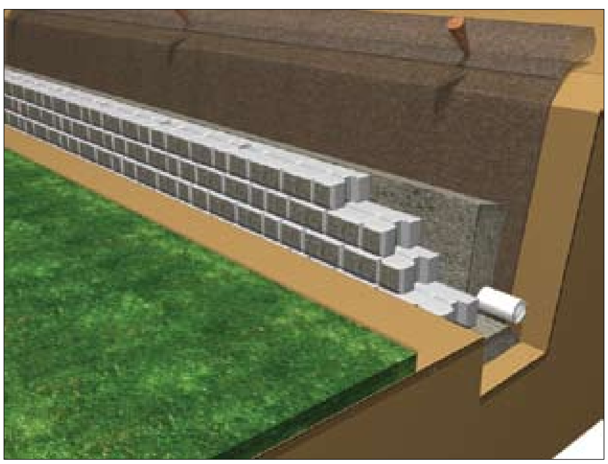


NOTE: When certain details – such as corners and curves – are incorporated into the wall, the running bond pattern may shift slightly. A small deviation of up to +/- 250 mm from the perfect running bond pattern is allowable. However, this deviation should be corrected as soon as the wall layout allows.

Continue stacking courses to a maximum of four courses (740mm [29in]) before backfilling.

backfill drainage material

A free-draining, 19mm (¾ in) clear stone drainage material is placed immediately behind the wall facing and compacted with a light manual tamper. The drainage layer must be a minimum of 300mm (12in) thick and protected from the native material by the filter cloth.

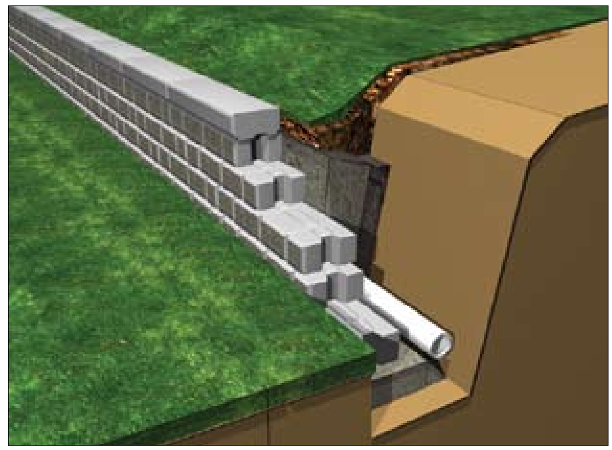


continue stacking and backfilling

Continue stacking units and backfilling as described in the previous two steps until the desired height is reached, based on the design.

encapsulate the drainage layer and finish grading

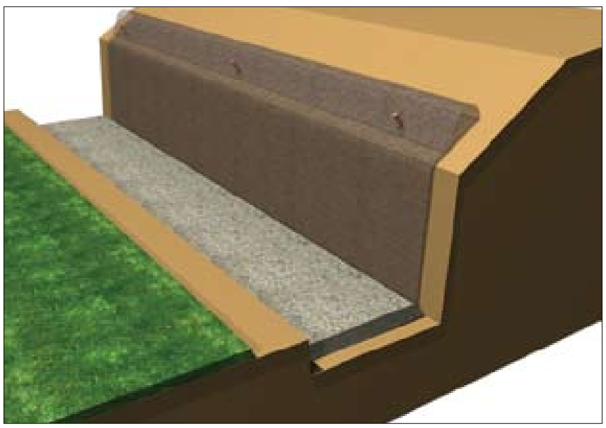
Fold the excess filter fabric over the top of the drainage layer and extend up the back face of the coping unit. Ideally, place an impervious layer of soil on top of the filter fabric and compact manually, providing for the required grading and/or swales. For other treatments such as pavers, concrete, or asphalt, care must be taken to ensure that heavy compaction/paving equipment remains a minimum of 1.0m (3.0 ft) from the back of the coping unit. Slope the surface above and below the wall to ensure water will flow away from and not accumulate near the wall units. See the *SonomaStone – Details* section for ideas on tapering down and ending the wall.



Utilizing the 750 units to create a multi-depth conventional wall allows greater heights to be achieved without the necessity of geogrid reinforcement. This method can be valuable when the proposed wall is in close proximity to a property line or obstruction, and the space for geogrid placement is limited. The procedure for a multi-depth conventional wall is the same as for the single-depth wall described previously, however, a larger base is required.

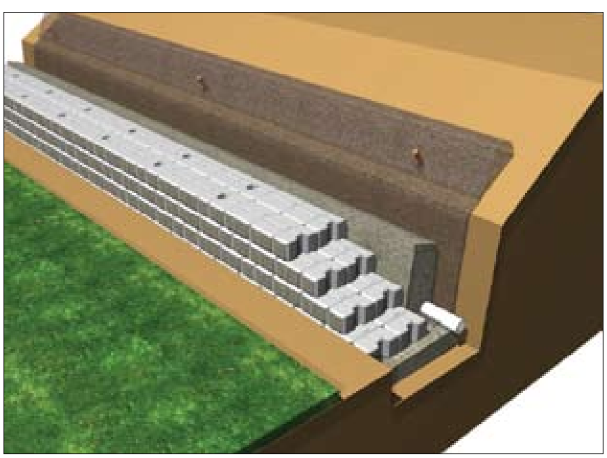
excavate

The width (front to back) of the trench must be increased to 1305 mm (51 in) to allow for the larger 750 unit.



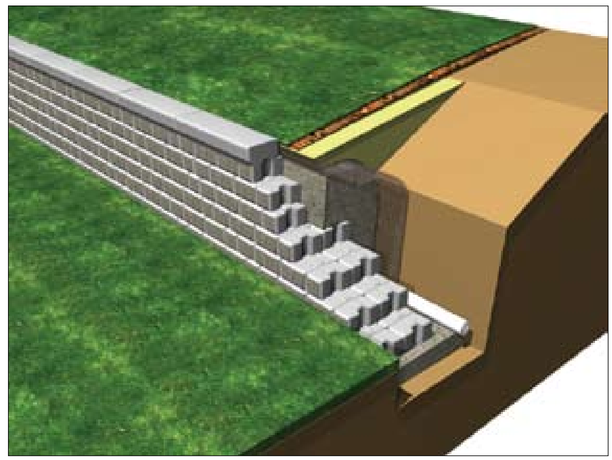
prepare the compacted granular base

The minimum dimensions of the 750 unit granular base are 1120mm (44 in) wide (front to back) and 185mm (7.25 in) deep.



stack units

The 750 units are to be stacked in a running bond pattern as described in the previous section. Once a specified number of 750 courses have been stacked (dependent on site conditions such as loading, soil, etc.), the standard 375 units can be placed on the top. Utilizing the 375 units for the top courses will reduce the cost of materials and reduces the overall cost of the project.



plan

Before beginning construction, be sure to have a final design and arrangements made for a Certifying Engineer (CE) to be present. Begin to establish the wall location and proposed grades. Locate all utilities and contact local utility companies before digging. Mark a line where the front of the wall will be placed, keeping in mind the 25mm (1 in) setback per course.

Refer to *Overview of a Successful Project* before beginning. This will help to ensure the project goes smoothly.

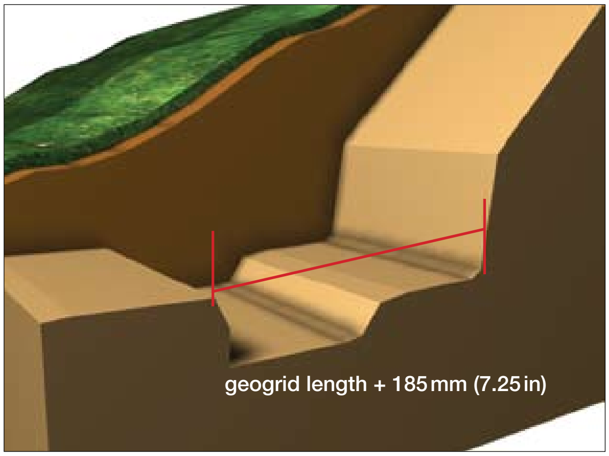
excavate reinforced zone

The excavation must be carefully planned and consider several elements. Based on the type of soil being excavated, the CE must determine the maximum allowable "cut" angle the excavation can sustain. This angle ensures the stability of the excavation during construction.The required geogrid length (as shown in the design) plus 185mm (7.25 in) defines the minimum width at the base of the excavation. Measuring from 185mm (7.25 in) in front of the wall face, extend a line back a distance equal to the base width determined above. Before excavating, consider structures and trees that may be impacted by the excavated slope.

Excavation continues until the slope is cleared and a flat area at the base is exposed extending 185mm (7.25 in) past the proposed face of the wall.

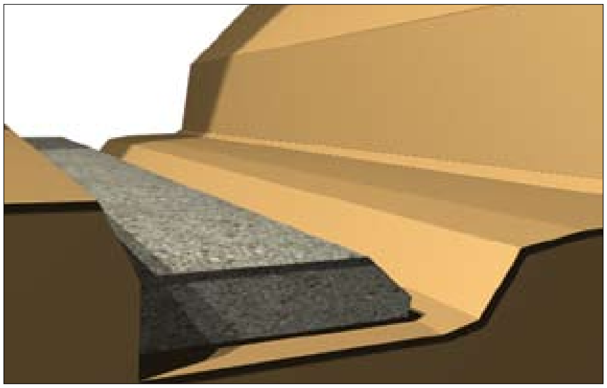
excavate granular base

Excavate a trench for the granular base. The front of the trench should be 185mm (7.25 in) from the planned face of the wall.The trench should be a minimum of 930 mm (36 in) wide (front to back) and 370mm (14.5 in) deep. This depth assumes one unit is buried (unit height of 185mm [7.25 in]) plus the compacted granular base minimum depth of 185mm (7.25 in). As wall height increases, depth of embedment also increases, normally about 10% of the wall height. Greater embedment depths may be required to account for slopes more than 3H:1V in front of the wall, scour protection in water applications, global stability, or as specified in the design. The rear 185mm (7.25 in) of the trench is excavated to account for the drain.



verify foundation subgrade

Once the wall has been excavated, the native foundation soil must be checked by the CE. The foundation soil in a geogrid-reinforced SRW is considered to be the material underneath both the facing and reinforced zone – that is, the entire wall footprint. This verification should not just be limited to the soil underneath the granular footing. The foundation soil must have the required allowable bearing capacity specified in the design.



prepare the granular base

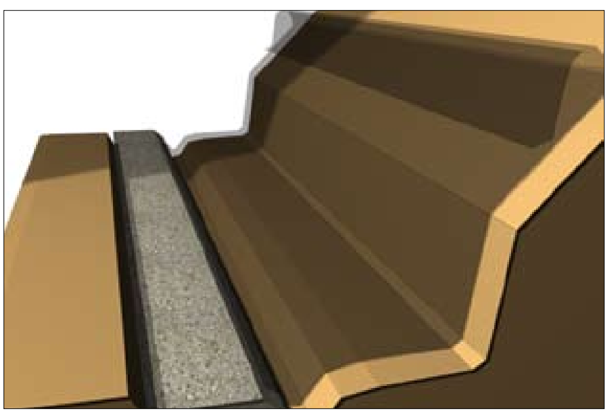
The base should be started at the lowest elevation of the wall. The base should be composed of well-graded, free-draining (less than 8% fines), angular granular material, and be compacted to a minimum of 98% SPD. The minimum base thickness is 185mm (7.25 in) or as required by the CE. A layer of unreinforced concrete (50mm [2 in] thickness) may be placed on top of the granular material to provide a durable level surface for the base course. The minimum base dimensions are 745mm (29 in) wide (front to back) and 185mm (7.25 in) deep. The additional 185mm (7.25 in) trench width allows for the placement of the drain.

step the base

When the grade in front of the wall slopes up or down, the base must be stepped to compensate. As the foundation steps up, ensure the minimum embedment is maintained. The height of each step is 185mm (7.25 in) – the height of one course. The 25mm (1 in) offset must be accounted for at each step. Refer to “Stack Units” for an illustration of stepping the base.

place filter cloth

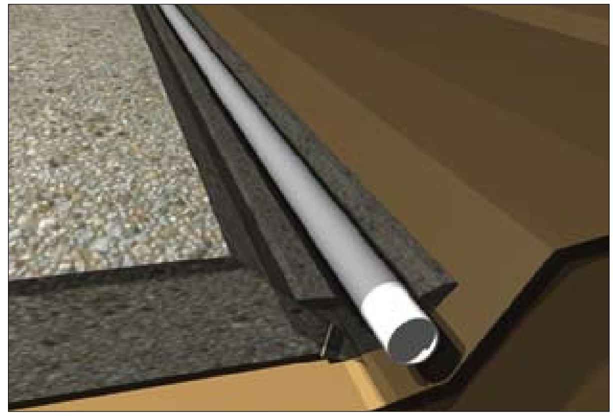
Lay the approved filter fabric (geotextile) along the bottom of the rear 185mm [7.25 in]) of the excavation and extend up the exposed cut face to the proposed wall height. Leave adequate material at the top to fold back towards the wall (completely containing the infill material). Stake the filter cloth against the slope during construction.



place the drain

The drain size and type must be in accordance with the project specifications. Generally, a perforated drain with filter sock (100mm [4in] diameter) is used.

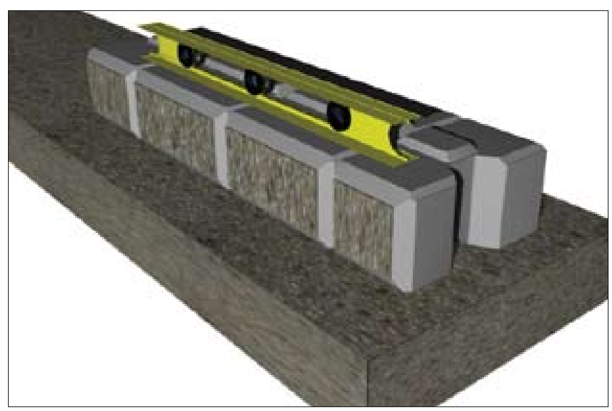
Various options for drain placement may exist, depending on how the pipe is to be outlet (refer to *SonomaStone – Details – Drainage*). The drain may be outlet through the wall face or connected to a positive outlet (storm drain). The drainage system is extremely important and outlets must be planned prior to construction.

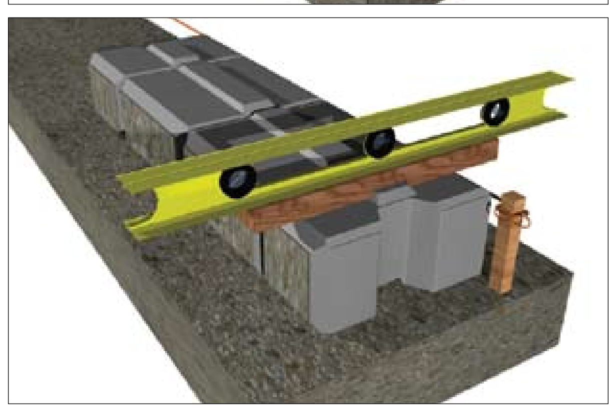


In the case of connecting to a positive outlet, the drain should be placed at the lowest possible elevation and sloped at a minimum of 2%. At the rear of the base, allow the granular material to slope down on the sides towards the drain trench. In the 185mm (7.25 in) area behind the base, place the approved drain tile (perforated drain with filter sock) on top of the filter cloth and minimal granular coverage.

place the first course

Position a level string to mark the location of the first course (should be 375mm [15 in] from the front face

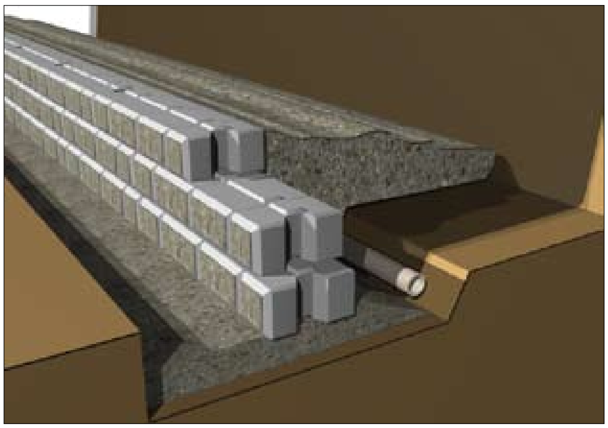




of the wall). Place the first course of SonomaStone units side-by-side (touching) on the granular base. Ensure units are level front to back and left to right. Extra care should be taken at this stage as it is critical for accurate alignment.

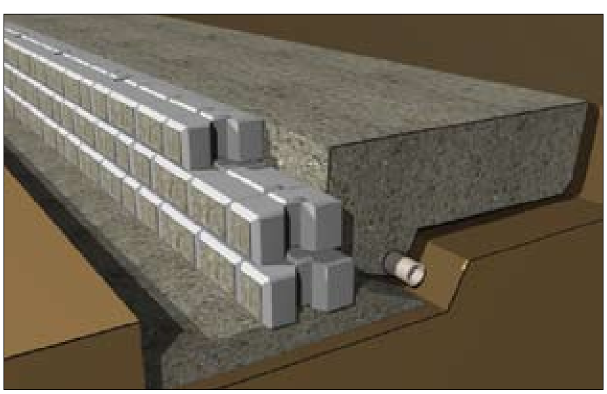
stack units

Sweep the top of the underlying course and stack the next course in a running bond pattern (so that the middle of the unit is above the joint between adjacent units below). Continue stacking courses up to the elevation of the first layer of geogrid or to a maximum of four courses (740mm [29in]) before backfilling.

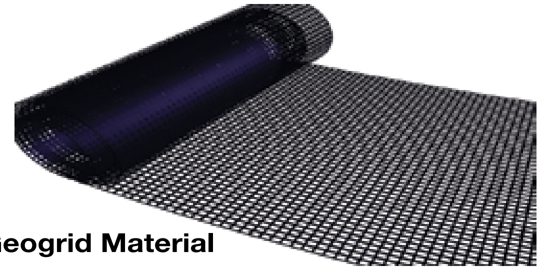


backfill

Begin backfilling the wall with a well-graded, free-draining (less than 8% fines), angular granular material. The infill material is placed in maximum 150mm–200mm (6in–8in) lift thickness and compacted to a minimum of 95% SPD. The compaction must be checked by the CE at regular intervals. Continue backfilling up to the elevation of the first layer of geogrid reinforcement. Caution must be taken to ensure the allowable lift thickness is not exceeded and/or heavy compaction equipment is not operated within 1m of the back of the wall (only hand-operated plate compactor). Overcompaction behind the wall facing will result in an outward rotation of the units and poor vertical alignment.



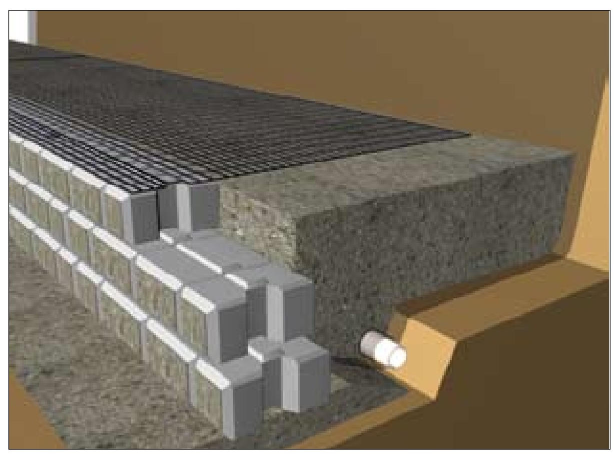
Note: Other backfill materials may be used if approved by the designer and CE. (See *Alternate Backfill Materials*)



Geogrid Material

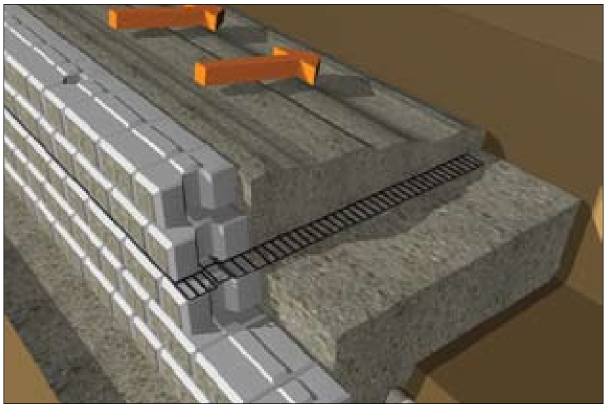
install geogrid reinforcement

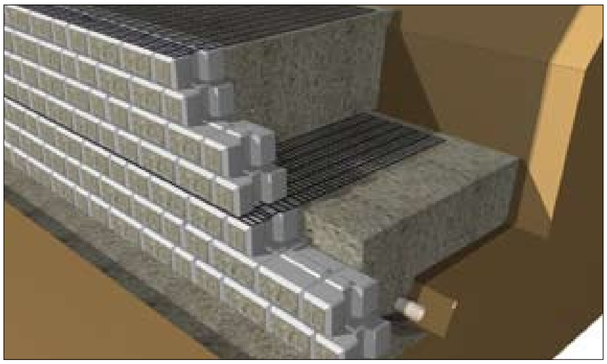
Ensure the geogrid reinforcement specified in the design matches the product on site (no substitutes are acceptable without consent of the design engineer). Cut the geogrid from the roll to the specified length, ensuring the geogrid is being cut perpendicular to the direction of primary strength. Ensuring the SonomaStone units are free of debris, lay the geogrid on top of the units to within 25mm (1 in) of the face. Place the next course of SonomaStone units (as described above) to secure the geogrid in place. Pull the geogrid reinforcement taut across the infill material to its full length and stake in place to maintain tension. The backfill material should be level with the back of the SonomaStone unit, allowing the geogrid to be laid out horizontally.



backfill over geogrid reinforcement

Backfill next lift of granular infill material on top of the geogrid reinforcement, placing the loose material near the front of the wall, and raking it back, away from the face (this method maintains tension in the geogrid during backfilling). Continue stacking units and backfilling until the next layer of geogrid reinforcement is reached.



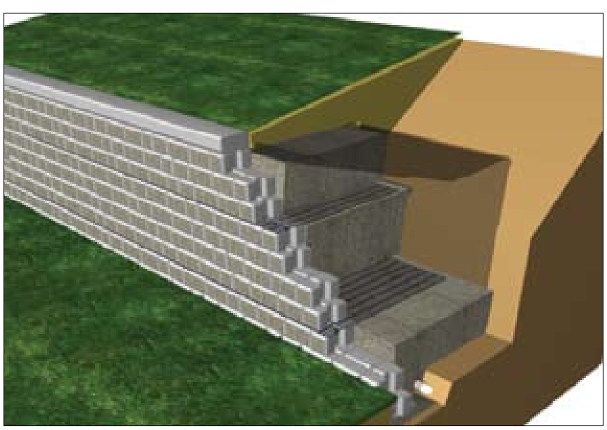


continue stacking and backfilling

Continue placing the SonomaStone units, backfilling, and laying the geogrid reinforcement as described above until the desired wall height is reached.

encapsulate the granular infill and finish grading

Fold the excess filter fabric over the top of the infill zone (reinforced zone) and extend up the back face of the coping unit. Ideally, place an impervious layer of soil on top of the filter fabric and compact manually, providing for the required grading and/or swales. For other treatments such as pavers, concrete, or asphalt, care must be taken to ensure that heavy compaction/ paving equipment remains a minimum of 1.0m from the back of the coping unit. Slope the surface above and below the wall to ensure water will flow away from and not accumulate near the wall units.



In the geogrid installation, we recommend using well-graded, free-draining (max. 8% fines) granular backfill material for the reinforced zone. This type of high quality material has several important benefits:

benefits of imported granular (free-draining) material

- Does not require tedious construction of a drainage layer.
- Requires less monitoring by CE.
- Compaction is less dependent on moisture content.
- Less susceptible to long-term creep of the soil mass.
- Higher shear capacity (greater strength) means less geogrid reinforcement.
- Better drainage and higher performance.

use of other approved materials

Other approved materials may be utilized for backfill, subject to minimum recommended parameters. We recommend that alternative backfill materials be limited to:

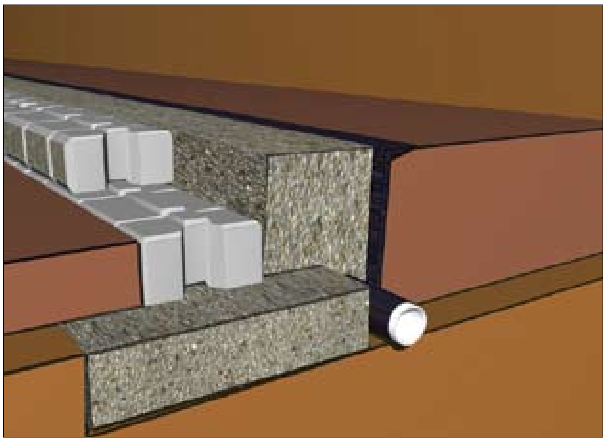
- Fine-grained soils with low plasticity (i.e. SC, ML, CL, with PI ≤ 20)
- Material free of organics, debris, etc. that is approved by the CE as adequate for structural fill

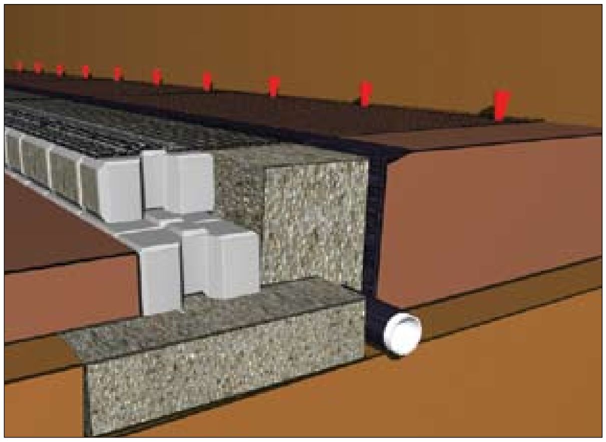
construction of required drainage layer when using non–free-draining materials

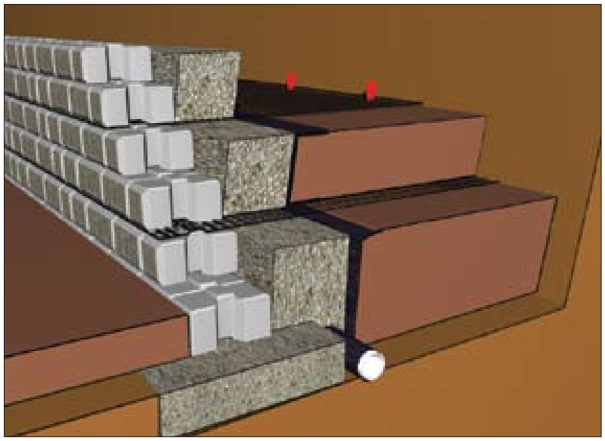
As these materials are not considered to be free-draining, a minimum 300mm (12 in) thick, 19mm (¾ in) clear stone drainage layer must be placed immediately behind the wall with design-specified filter cloth to separate it from the reinforced soil.

At the geogrid layer elevations, the filter cloth must be cut and have minimum 150mm (6 in) overlap as shown.

The reinforced soil must be compacted to 95% SPD or as specified in the design. At subsequent geogrid layers, the drainage layer must be completely encapsulated as described above. As this is a critical component of the wall construction, care must be taken to ensure the drainage material is protected from contamination.







installation

The SonomaStone system can be constructed vertically. However, a number of other issues must be considered. Due to the increased complexity that is associated with vertical walls, their use should be limited to areas in which a battered wall is not possible (i.e. wall returns, step sidewalls, etc.).

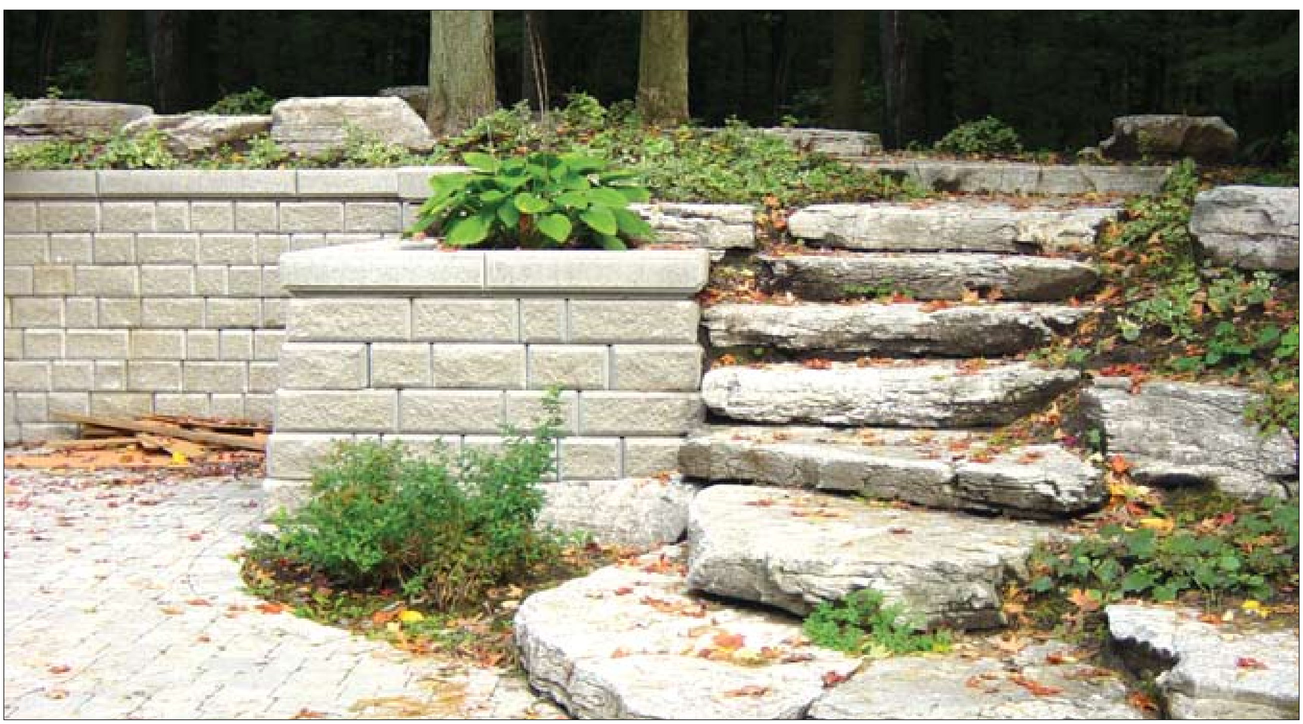
375 Units

There are several key factors to consider when constructing a successful vertical wall.

- The system can be constructed vertical only with the 375 unit.
- In order to construct a vertical wall the units must be placed in a specific order. The middle units in the bundles (split-faced on both sides) must be utilized on every other course (the unit must be placed to the opposite of course below). This will result in an excess amount of units, 1 of 3 will be left over. These units must be set aside and used for battered sections of the walls.
- As SRWs are designed to “relax” forward to develop an Active Earth Pressure, it is very possible that a vertical wall could rotate forward past vertical, either during or after construction. To help accommodate this rotation, it is recommended that the base be constructed with a 2% negative slope from front to back (as shown).
- The foundation material plays a substantial part in vertical walls. Any settlement in these types of walls could result in an over-vertical batter. Extra care must be taken to ensure the foundation bearing capacity is more than adequate, and that any anticipated settlement is taken into account.
- It is important to keep the compaction lifts of the backfill material to a minimum (150 – 200mm). Over-compaction of the material behind the units may result in a rotation forward.
- Heavy equipment (e.g. for compaction or paving) must be kept a minimum of 1m from the back of the wall.

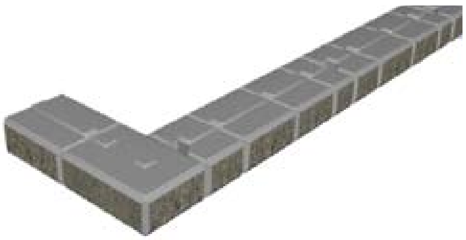
It is generally recommended that battered walls be constructed wherever possible. However, with proper preparation and care, vertical walls can be constructed successfully.

Details

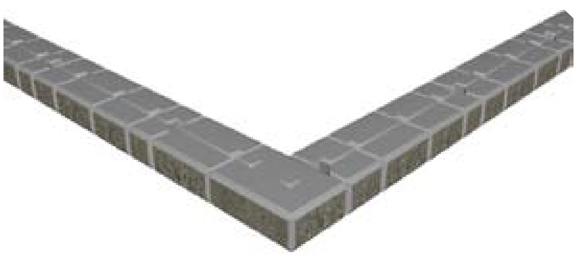


375 unit

90º Outside Corner
Place units on base course leading to the corner. Place corner unit (right corner shown) so both rough faces will be exposed in the final construction.

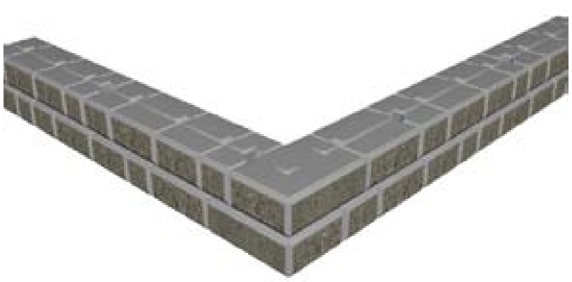


Continue placing base course units on adjacent wall, abutting the back side of the corner unit.



Commence second course by placing alternate corner unit (left corner shown) to interlock corner.

Place standard units to complete the course.



Repeat until desired wall height is achieved.

For reinforced applications, the geogrid from the two side walls will overlap and should be separated by a minimum of 75mm (3 in) of compacted soil. Alternatively, the geogrid reinforcement could be placed in the perpendicular principle direction in the cross-over area on the next course.

Place coping units to complete wall. Cut coping as required to produce a mitred corner.

90° Inside Corner
Place units on base course leading to the corner. Place corner unit so that the smaller rough face will be hidden in the final construction. It may be necessary to remove bumps and bulges from the larger rough face to achieve a tighter fit.

Continue placing base course units on adjacent wall.

Commence second course by placing alternate corner unit to interlock corner.

Place standard units to complete the course.

Repeat until desired wall height is achieved.

For reinforced applications, the geogrid should be placed within 25mm (1 in) of the face of the wall. As it is only necessary to have geogrid extending directly away from the wall, a gap will result in the geogrid layer as shown.

Place coping units to complete wall. Cut coping as required to produce a mitred corner.

details

Odd-Angled Outside Corner

Place base course leading to the corner. Cut corner unit as required for the desired angle (*see chart on following page*). It will be necessary to remove some of the shear key to allow for the next course.

Note: It is possible to modify a 90º unit or a standard unit depending on the angle to be achieved.

Continue placing base course on adjacent wall.

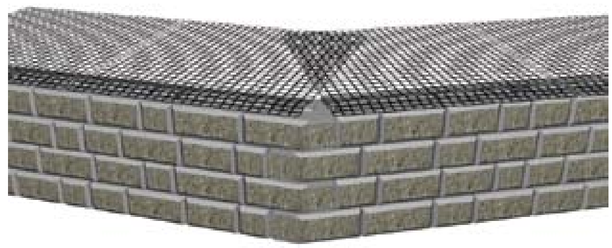
Place the modified corner unit on the next course to achieve an interlocked corner.

Place standard units to complete course.

Repeat until desired height is achieved.

Place coping units to complete wall. Cut coping as required to produce a mitred corner.

The geogrid from the two side walls will overlap and should be separated by a minimum of 75mm (3in) of compacted soil. Alternatively, the geogrid reinforcement could be placed in the perpendicular principle direction in the crossover area on the succeeding course.



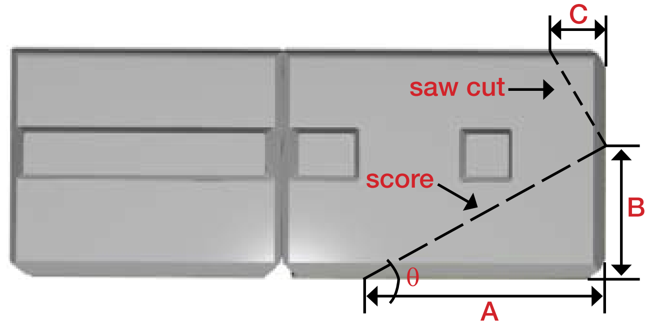
Cutting an Odd-Angled Corner

A left/right odd-angled outside corner unit begins with a left/right 90° outside corner unit.

Sawcut the smooth side of the corner unit as indicated in the chart below. The cut will begin at distance **C** from the rear of the unit.

Score the top and bottom of the opposite side of the unit to a depth of approximately 12 mm (0.5 in), beginning at distance **A** from end of unit.

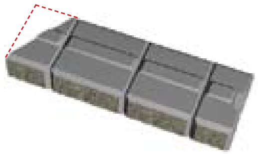
Using a hammer and chisel, break off the corner of the unit to reveal a rock-faced odd-angled outside unit. Remove knob as required.



Required Corner Angle (θ)	Distance A (mm)	Distance A (in)	Distance B (mm)	Distance B (in)	Distance C (mm)	Distance C (in)
5	187.14	7.37	16.37	0.64	31.38	1.24
10	186.06	7.33	32.81	1.29	60.34	2.38
15	184.25	7.25	49.37	1.94	87.25	3.44
20	181.67	7.15	66.12	2.60	112.42	4.43
25	178.28	7.02	83.14	3.27	136.10	5.36
30	174.04	6.85	100.48	3.96	158.49	6.24
35	168.86	6.65	118.24	4.66	179.79	7.08
40	162.66	6.40	136.49	5.37	200.13	7.88
45	155.33	6.12	155.33	6.12	219.67	8.65
50	146.73	5.78	174.87	6.88	238.51	9.39
55	136.69	5.38	195.21	7.69	256.76	10.11
60	125.00	4.92	216.51	8.52	274.52	10.81
65	111.40	4.39	238.90	9.41	291.86	11.49
70	95.57	3.76	262.58	10.34	308.88	12.16
75	77.10	3.04	287.75	11.33	325.63	12.82
80	55.48	2.18	314.66	12.39	342.19	13.47
85	30.06	1.18	343.62	13.53	358.63	14.12
90	0.00	0.00	375.00	14.76	0.00	0.00

Odd-Angled Inside Corner

Place base course leading to the corner. Cut corner unit as required for the desired angle.



Continue placing base course on adjacent wall. It will be necessary to remove some of the shear key to allow for the next course. The abutting unit is placed halfway along the side of the modified unit to maintain the running bond pattern.

Place the modified corner unit on the next course to achieve an interlocked corner.

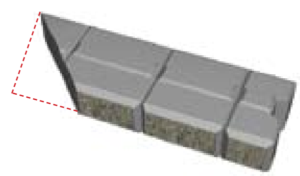
Place standard units to complete course. It may be necessary to run one of the standard units (halfway through the block as discussed above) into the infill material to maintain the running bond pattern.

Repeat until desired height is achieved.

Place coping units to complete wall. Cut coping as required to produce a mitred corner.

For reinforced applications, the geogrid should be placed 25mm (1 in) from the front face of the wall. A gap in the geogrid layer will result as shown.

For angles greater than 135º, it is recommended that the corner be constructed as above; however, cutting the block as shown in the following diagrams.



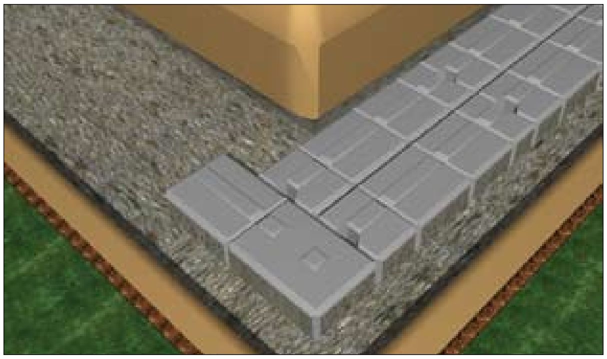
details

750 unit

Note: Once the recommended number of 925 units are placed (refer to site-specific design), the remaining courses can be installed with the standard 375 units. Refer to *Corners – 375 Unit – 90º Outside Corner* for construction.

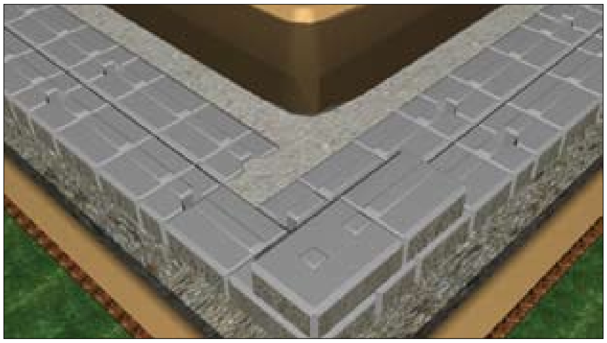
90º Outside Corner

Place units on base course leading to the corner. Place standard 375 corner unit (left corner shown) so both rough faces will be exposed in the final construction.



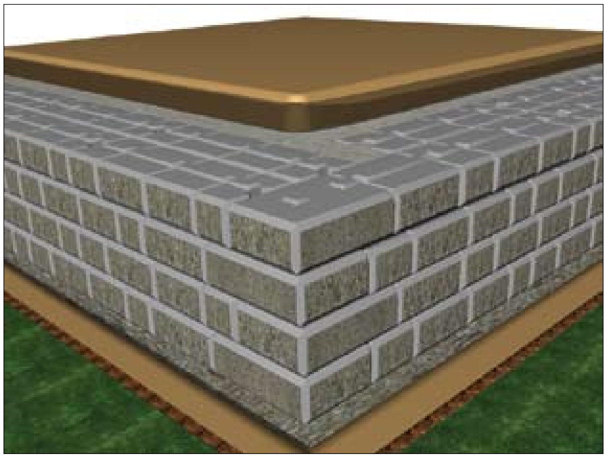
Continue placing base course units on adjacent wall. Ensure drainage layer material fills existing void between 750 units.

Commence second course by placing alternate standard 750 corner unit (right corner shown) to interlock corner. Remove tongue on back of lower 750 unit to allow next course.



Place standard units to complete the course, again ensuring that drainage material fills the void between the 750 units.

Repeat until desired wall height is achieved.



90º Inside Corner

Place units on base course leading to the corner. It will be necessary to remove the shear key to allow for the next course. It may be necessary to remove bumps and bulges from the larger rough face to achieve a tighter fit.

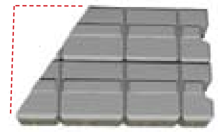
Continue placing base course units on adjacent wall. A half-unit overlap will be required as shown to maintain the running bond pattern.

Overlap 750 unit into adjacent wall by half a unit to maintain running bond pattern. The shear key will need to be removed.

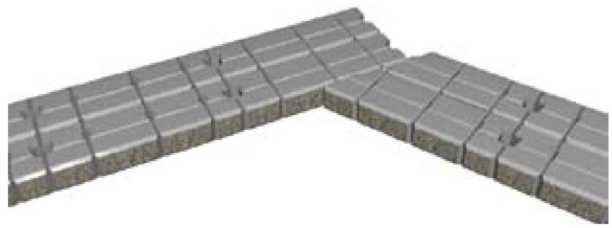
Continue placing 750 units to complete course.

Odd-Angled Inside Corner

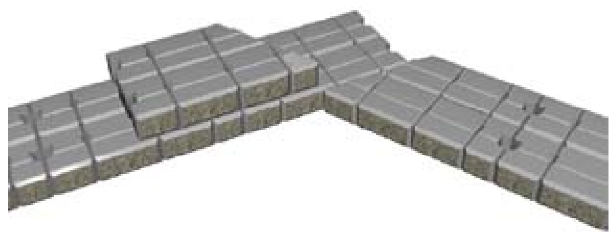
Place base course leading to the corner. Cut corner unit as required for the desired angle.



In order to maintain the running bond pattern, position adjacent unit so that it is placed halfway along the side of the modified unit. It will also be necessary to remove a portion of the shear key in order to lay the next course.

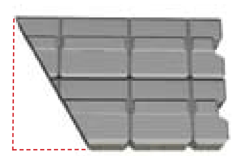


Commence second course by placing alternate modified unit to achieve an interlocked corner.



Place standard units to complete the course. Repeat until desired wall height is achieved.

For angles greater than 135º, it is recommended that the corner be constructed as above; however, you must cut the corner unit as shown in the following diagram.



details

Odd-Angled Outside Corner
Place units on base course leading to the corner. Place cut 375 corner unit so that both rough faces will be exposed in the final construction. (See *Corners–375 Odd-Angled Outside Corners* for directions on how to prepare a cut 375 corner unit.) Continue placing the base course units on the adjacent wall.

Commence second course by placing alternate cut 375 corner unit to interlock corner.

Place standard units to complete the course.

Repeat until desired wall height is achieved.

details

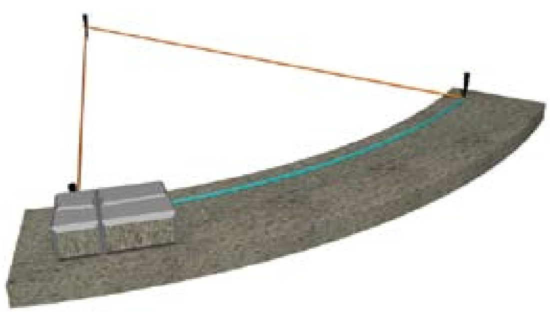
convex curves

The SonomaStone system is able to create a minimum 4.27 m (14 ft) radius (3.8 m [12.5 ft] with one-metre unit) with tapered units on a convex curve, and a 73 m (240 ft) radius with standard units by separating the adjacent units at the front face based on the radius required.

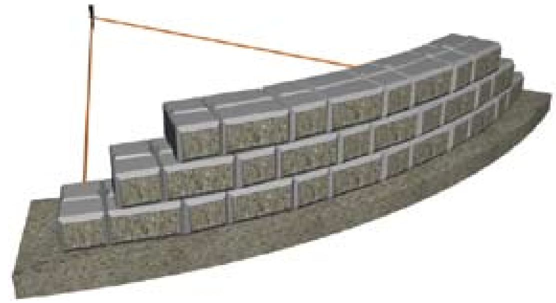
In preparation for the bottom course, remember that the radius will decrease by 25 mm (1 in) every course. Therefore, the smallest curve will result on the uppermost course. Also, the vertical joints will start to line up on successive courses, making it necessary to place half units at random locations.

NOTE: The steps below outline the use of SonomaStone tapered units, but can also be utilized with SonomaStone standard units.

Once the radius to be used is decided upon and the necessary curve for the base course is calculated, the base can be roughly outlined with spray paint. Upon completion of the base, the starting and ending points of the curve can be staked. The curve should be marked with paint to ensure the proper radius is established. If the base course is installed with too tight a radius, the upper courses may have to be cut to fit.



Place additional courses, remembering that the radius decreases by 25 mm (1 in) every course until the desired height is achieved.



Geogrid layers should be placed within 25 mm (1 in) of the front face of the block. The geogrid should be placed on the SonomaStone units so that the geogrid does not overlap until it enters the soil zone.

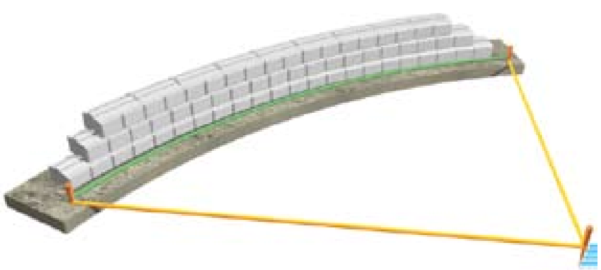
Cut standard coping units to meet the desired radius. Secure with concrete adhesive (tapered coping unit available only in selected locations).

concave curve

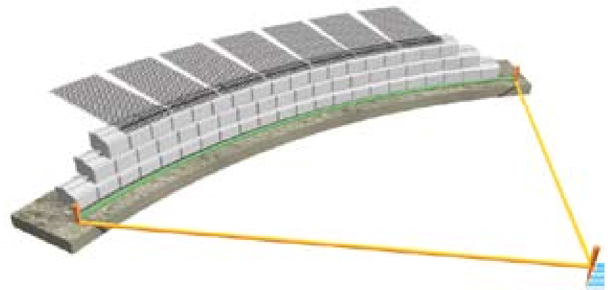
For concave curves, the SonomaStone tapered units are able to create a minimum 4.27 m (14 ft) radius (3.8 m [12.5 ft] with one-metre unit) radius, while the standard units create a 73 m (240 ft) radius by separating the units at the back face. The smallest radius will occur on the bottom course. Each additional course will result in a 25 mm (1 in) increase in radius. Also, the vertical joints will start to line up on successive courses, making it necessary to place half units at random locations.

Once the radius to be used is decided upon and the necessary curve for the base course is calculated, the base can be roughly outlined with spray paint. Upon completion of the base, the starting and ending points of the curve can be staked. The curve should be marked with paint to ensure the proper radius is established.

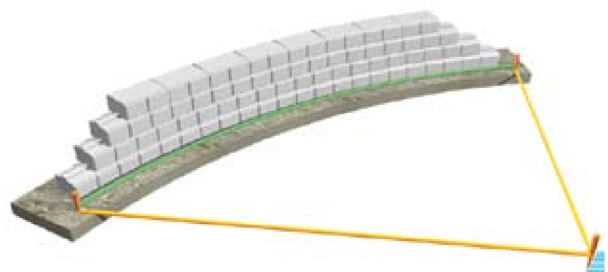
Place additional courses, remembering that the radius decreases by 25 mm (1 in) every course until the desired height is achieved.



Geogrid layers should be placed within 25 mm (1 in) of the front face on the block. It will be necessary to have gaps between adjacent sections of geogrid. At alternating geogrid elevations the geogrid sections should be positioned so they overlap the gaps in the geogrid on the layers below.



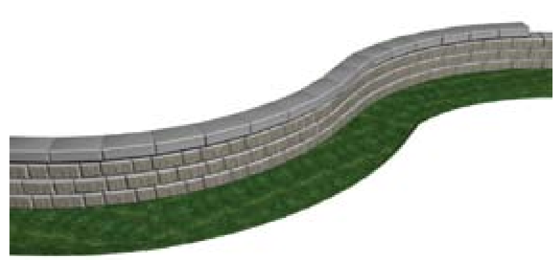
Cut standard coping units to meet the desired radius. Secure with concrete adhesive (tapered coping unit available only in selected locations).



serpentine curves

The SonomaStone system is able to achieve serpentine curves by incorporating convex curves into concave curves, and vice versa.

This can make for a visually pleasing structure.



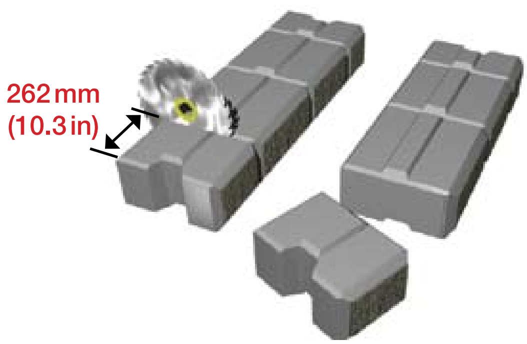
details

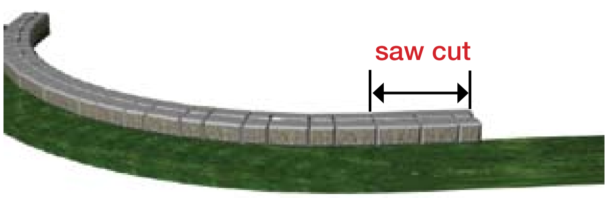
transition between a curved and straight segment

NOTE: The following procedure applies for both convex and concave curves into a straight segment.

Follow the appropriate techniques, found in the previous pages, to construct the base and initial course of a curve, whether it is convex or concave. Once complete, continue with the following steps.

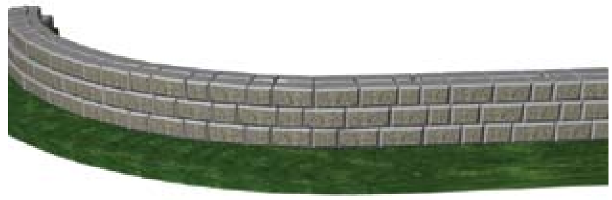
In order to maintain a running bond pattern, the first standard unit laid on each course once the curve is complete must be saw-cut. This can be done by removing the 262mm portion of the SonomaStone unit.





Place standard units to complete base course.

Repeat until desired wall height is achieved. (If geogrid is required, the technique of laying geogrid along a curve can again be found in the previous pages.)



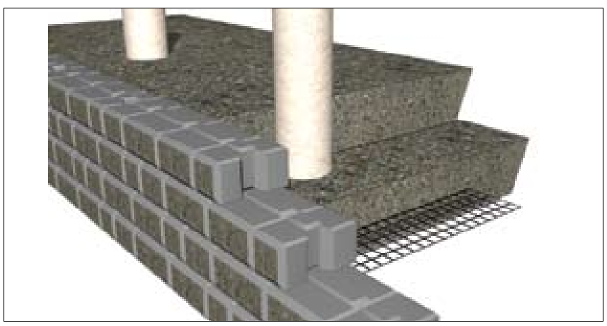
To finish the wall, some locations stock tapered coping units. Otherwise, standard coping units can be cut to fit.

details

wood fences

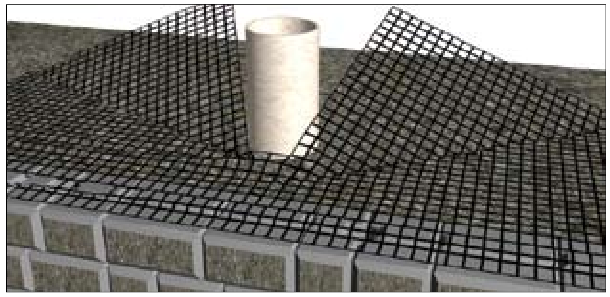
Wood fences/acoustical fences may be constructed behind a SonomaStone wall. These types of fences can pick up significant wind loads. The retaining wall must be designed to account for this additional loading and the fence typically can not be secured to the SonomaStone retaining wall. Concrete sonotubes, placed behind the wall, should be utilized to found the handrail/fence into the reinforced soil zone.

Loads created by pedestrians and/or wind on the fences must be incorporated into the geogrid design. As the sonotube depth increases, the additional lateral force generated in each geogrid is reduced. Wood/vinyl fences (solid) that take a wind load produce extremely high loads. Generally, foundations for these types of structures should extend more than the height of the fence into the reinforced soil, and the geogrid layout designed accordingly.

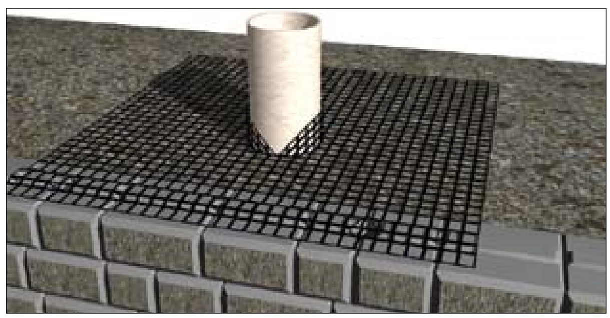


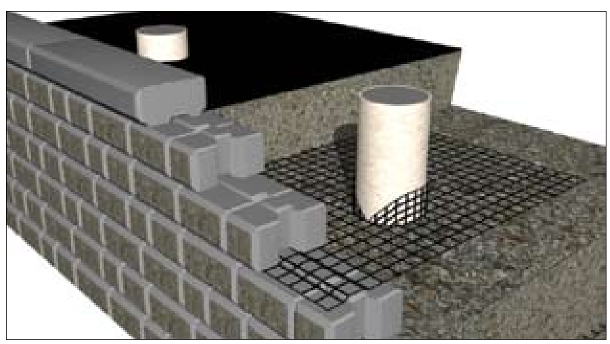
Construct the geogrid reinforced SonomaStone SRW up to the elevation corresponding to the underside of the fence foundation (concrete sonotube). Identify the proposed location of the solid fence foundations (sonotubes). Take into account the batter (setback) of the wall (25mm [1 in] per course) and the required offset at the top (It is preferable to leave a 300mm [12 in] buffer zone between the outside of the sonotube and the back of the wall. If this is not possible, expansion joint material must be placed between the back of the coping unit and concrete sonotube). Place the sonotube and backfill around it to hold it in place. Continue stacking units, backfilling and compacting to 95% SPD until the next geogrid layer is reached.

Cut the geogrid perpendicular to the wall along the centerline of the sonotube, creating two geogrid panels – one on each side of the sonotube. Lay the geogrid flat in front of the sonotube. Secure the geogrid in place at the wall with the next course of units. At the intersection with the sonotube, fold the geogrid flat against vertical side of the sonotube and then around the back, maintaining the edge of the geogrid along the centerline of the sonotube. Lay the geogrid flat behind the sonotube and pull taut. Secure the geogrid at the rear (with stakes) and continue backfilling.



Repeat the previous step for each layer of geogrid encountered by the sonotube.

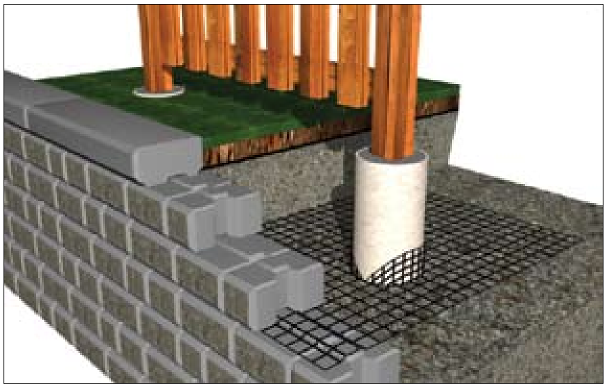




Secure the coping unit and fold filter cloth back over drainage material. Cut filter cloth at centerline of sonotube to allow the sonotube through (similarly to method used to allow sonotube to penetrate geogrid layer), ensuring complete coverage of reinforced

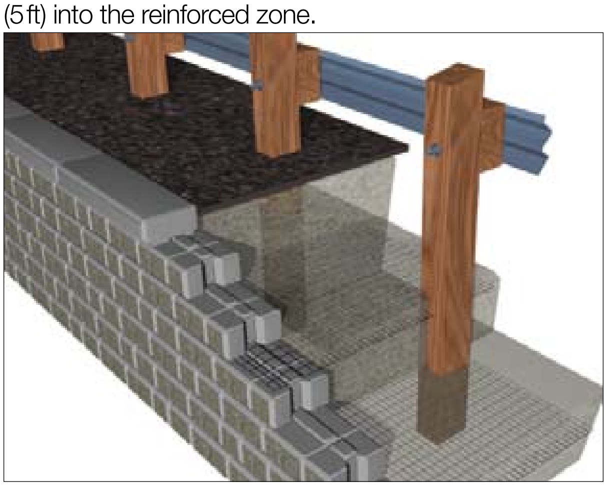
details

material. Cover sonotubes prior to concrete pour to prevent debris from entering. Pour concrete in foundations in accordance with fence design (reinforcing steel and/or dowels may be required).



guardrails

For areas adjacent to roadways and parking lots, flexible steel beam guiderails may be placed behind a geogrid reinforced SonomaStone SRW in accordance with the applicable governing standards. Additional "crash" loads must be accounted for in the design of the wall. Accepted procedures usually require the guiderail posts to be offset a minimum of 1m (3ft) from the back of the wall, extending a minimum of 1.5m (5ft) into the reinforced zone.



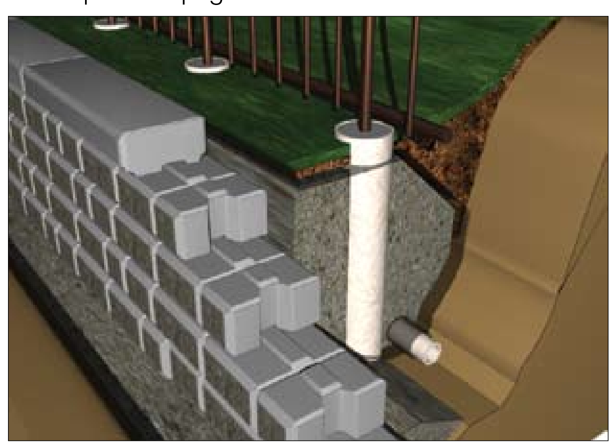
It is recommended that the posts be placed as the wall is constructed (refer to handrail construction) and compaction surrounding the posts be carefully monitored to ensure optimum confinement.

pedestrian handrail/chainlink fence

Chainlink fences and pedestrian handrails (not wind bearing) may be attached directly to the SonomaStone wall. In order to resist the required loads, the post (maximum diameter 100mm [4in]) must be core-drilled a minimum of 650mm (25in), and be secured with **non-expansive grout**. (Non-shrink grout: follow manufacturer's recommended installation procedures. Use of expansive grout will cause failure of the units.) A 1m (3ft) layer of geogrid is to be incorporated on the second course down from the top of the wall. The holes are to be drilled a minimum of 200mm (8in) from the front face of the wall with a maximum post separation of 2430mm (96in).

An alternate to installing pedestrian handrails/chainlink fences is to found the posts in concrete sonotubes behind the wall into undisturbed native ground. Sonotubes must extend a minimum of 1.2m (4ft) either below the bottom of the wall for gravity structures, or 1.2m (4ft) below finished grade for the geogrid reinforced walls. Sonotubes must extend the required depth into a firm "socket" of soil as to independently resist the lateral handrail loads.

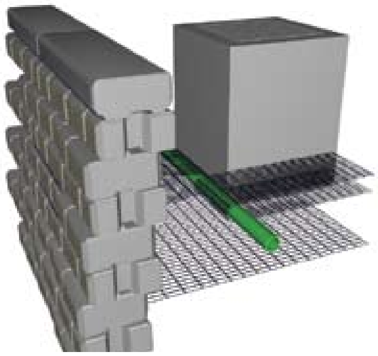
In order to identify the proposed location of the handrail foundations (sonotubes), it is essential to account for the setback of the wall (19mm [¾in] per course) and the required offset at the top of the wall. It is preferable to leave a 305mm (12in) buffer zone between the outside of the sonotubes and the back of the wall. If this is not possible, expansion joint material must be placed between the back of the coping unit and the sonotubes. Steps for incorporating sonotubes with a geogrid reinforced wall can be found in *Wood Fences* on the previous page.



obstructions

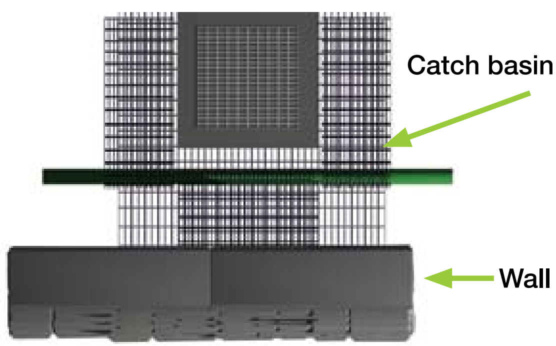
catch basin

Take the following steps when a catch basin is interfering with the placement of geogrid reinforcement as specified by the site design. Select an appropriately sized steel pipe with a length of at least twice the width of the catch basin. This pipe will be used to tie back the section of wall adjacent to the catch basin. Construct the wall up to the elevation of the first layer of geogrid.



Area Adjacent to Catch Basin:

1. Cut a layer of geogrid to a length equal to twice the depth from the front face of the wall to the catch basin plus 200mm (8 in).
2. Lay the geogrid on the specified course and secure it by placing the next course.
3. Pull the geogrid back towards the catch basin. Lay the steel pipe on top of the geogrid and pull the remaining length of geogrid up away from the pipe.
4. Backfill to the top of this course and pull the remaining geogrid back over the infill zone towards the wall. Lay the geogrid flat on top of the most recently placed course and secure in place with next course.



Area on Either Side of Catch Basin:

Instead of tying the facing to the pipe (as in previous section), tie the pipe back into the infill zone as described above, ensuring a minimum of 150mm (6 in) of compacted infill material between the top and bottom layer of geogrid.

structures

Retaining walls constructed near structures must be placed outside the zone of influence of the footing as required by the Geotechnical Engineer (typically a 7V:10H influence line). If there is a space limitation, it may be necessary to underpin the foundation of the structure. In some cases closer proximities are possible.

trees

When planting trees or shrubs behind SonomaStone walls, a few steps must be taken to ensure the stability of the wall. The root ball should only impact the top two layers of geogrid reinforcement. The geogrid should be cut perpendicular to the wall along the centerline of the root ball, placed flat and at the intersection with the root ball folded up the sides around to the back, maintaining the edge of the geogrid along the centerline of the root ball. Small trees (max. 0.915m [3 ft]) may be placed a minimum of a 1.5m [5 ft] from the face of the wall. Larger trees (max. 1.8m [6 ft]) are to be placed a minimum of 3m (10 ft) from the face of the wall. These distances are required to avoid root growth into the SonomaStone units and to reduce the wind loading effects caused by the trees. If multiple trees are to be planted, contact an engineer to assess the impact of the geogrid cuts. A root barrier may also be required to avoid root growth towards the wall and drainage layer structures.

Proper drainage of a segmental retaining wall is one of the most critical aspects of design and construction. Unless otherwise stated, the design assumes that no hydrostatic pressures exist behind the wall. To ensure this condition is met, water flow from all directions and sources must be accounted for in the design through proper grading and drainage measures, diverting water away from the wall whenever possible.

internal drainage

We have created this two-page chart to explain and illustrate the four different internal drainage possibilities.

Non-Free–Draining Reinforced Zone

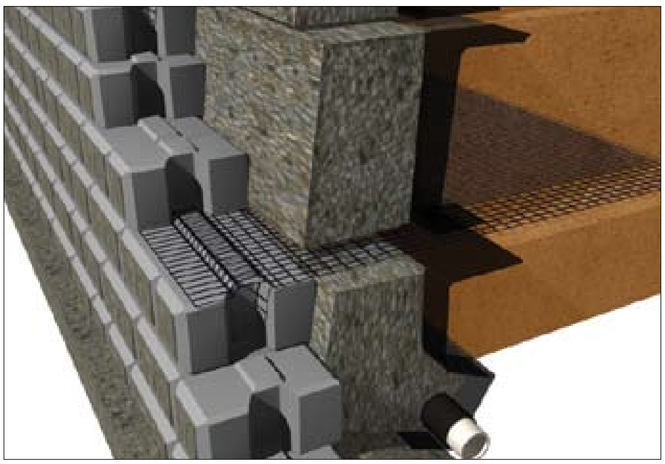
If the infill material being used to construct the reinforced zone is not considered to be free draining (>8% fines), a drainage layer is required immediately behind the face of the wall. The drainage material must be a minimum of 300mm (12 in) thick, composed of a gap-graded, free-draining, angular clear stone (19mm [¾ in]). An approved filter cloth must be placed between the drainage layer and the infill material to prevent the migration of fines and contamination of the drainage material. At each geogrid layer, the filter cloth must be pulled back into the reinforced zone a minimum of 150mm (6 in) and cut. The drainage layer must be fully encapsulated with a 150mm (6 in) overlap at each geogrid elevation as shown.

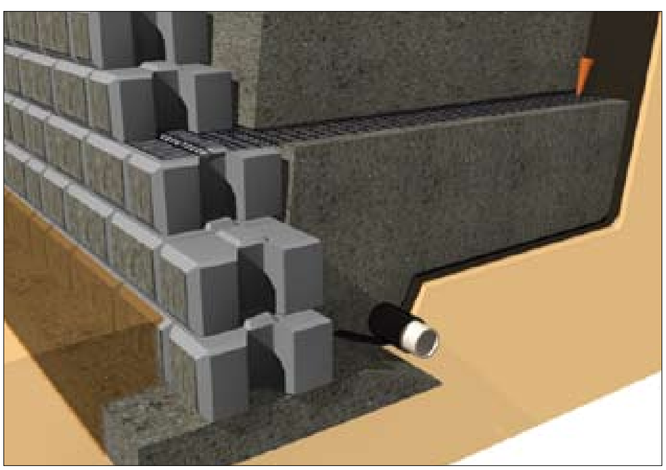
Free-Draining Reinforced Zone

As the construction of a separate drainage layer immediately behind the facing units can be cumbersome and reduce efficiency, a popular option is to use a free-draining, granular material for the reinforced zone. It is recommended that this material be well-graded, with less than 8% fines. An approved filter cloth should be placed between the reinforced zone and retained and foundation soil to prevent the migration of fines. The use of an imported granular material in the reinforced zone has many other advantages besides its good drainage properties (see *Specifications – Soils*).

Outlet to Catch Basin / Drain

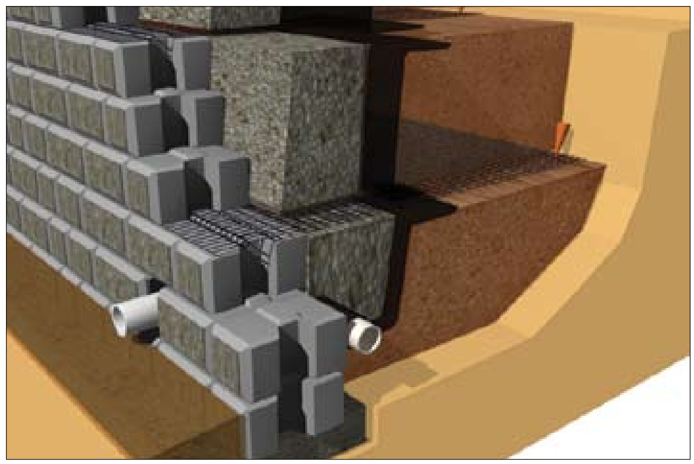
If the drain is being connected to a catch basin or other positive outlet, it should be located at the lowest elevation possible. Placing the drain at the founding elevation ensures better drainage of the base and subsoils. A minimum 2% slope is recommended.

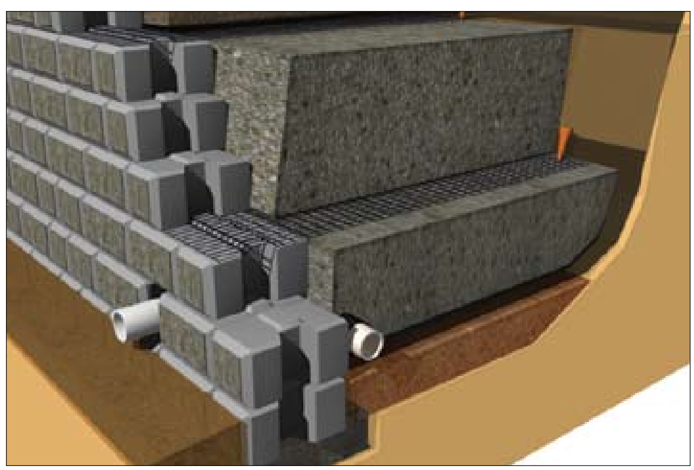




Outlet Through Face

If the drain is being outlet through the face of the wall, it is recommended that an approved, less pervious engineered fill material be compacted under the drain up to the grade in front of the wall. This measure collects water percolating through the reinforced zone and directs it to the drain, rather than allowing the base to become saturated. The outlet pipe should be a non-perforated PVC (connected through a T-joint) placed a minimum of 15.0m (45 ft) on centre (or as required by the design). The SonomaStone unit may be cut and shifted over as required to allow the pipe to be outlet. It is recommended that the area around the pipe be grouted to prevent the washout of fine soil particles. A concrete splash pad at the outlet pipe locations is recommended if large water flows are anticipated.



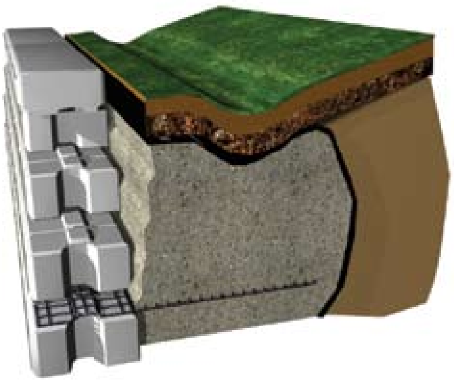


external drainage

Swales

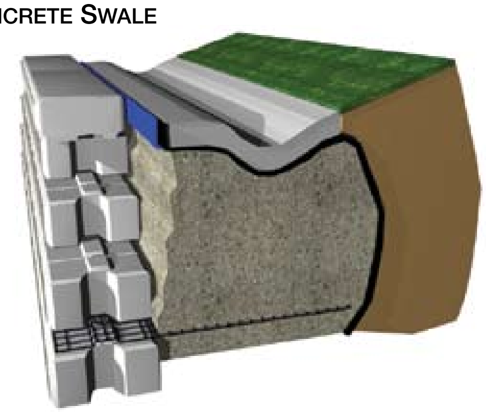
Surface water run-off should be diverted away from the retaining wall to help prevent the build up of hydrostatic pressures behind the wall. This can be achieved by providing a swale with a minimum gradient along the length of the wall of 2%.

CLAY SWALE



A 100mm (4 in) top soil layer may be underlined with a 100mm (4 in) low permeability clay soil to divert the surface run-off. The top soil layer is to support the growth of vegetation that provides erosion protection for both the top soil and clay layers. The slope directly away from the wall helps to ensure that water is not given a direct route into the drainage material if settlement occurs. A filter fabric should be placed between the clay layer and infill material to prevent the migration of fines.

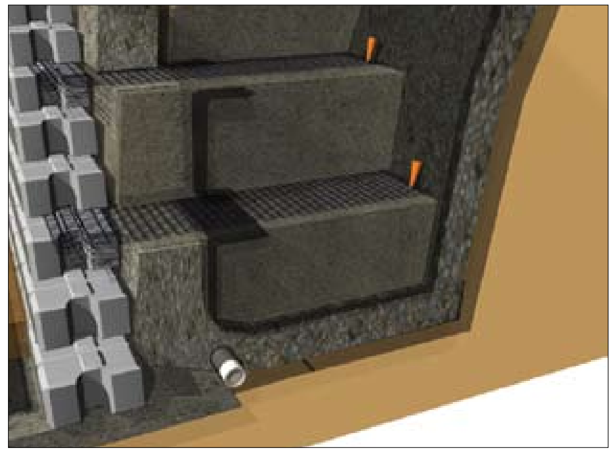
CONCRETE SWALE



A 100mm (4 in) concrete or asphalt swale may be used to divert surface runoff. A 25mm (1 in) expansion joint should be placed between the concrete and the back of the retaining wall. Heavy paving equipment should be kept a minimum of 1 m away from the wall to prevent movement of the top courses.

Blanket / Chimney Drains

Where high groundwater flows are anticipated, the use of blanket drains (drainage layer extended horizontally along the base of the wall) or chimney drains (drainage layer extended up the back of the infill zone to intercept groundwater flows) prevent infiltration in the SonomaStone structure. A drainage composite material can be very effective when used to construct a chimney drain.



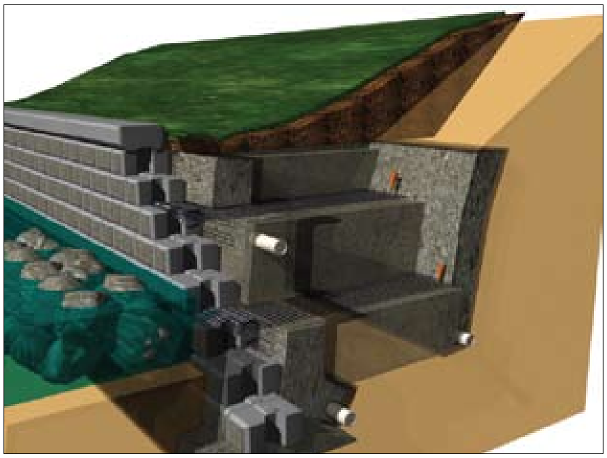
water applications

SonomaStone geogrid reinforced segmental retaining walls may be used in water applications such as lake/river shorelines, detention ponds, etc. A number of additional issues must be considered when designing and constructing in this type of application, such as erosion of the base/foundation, wave effects, perched water conditions, and ice effects.

The SonomaStone wall analysis must incorporate the effects of buoyant unit weights, rapid draw-down conditions, etc, when determining geogrid length, type, and placement. The required wall embedment normally increases as the potential for erosion becomes a factor. A minimum 600mm (2.0 ft) embedment is standard practice. As well, rip-rap or other forms of erosion protection may be required.

The footing may be concrete or standard granular wrapped in filter cloth to prevent washout. If the potential for rapid draw-down (water level falling quicker in front of the wall than the backfill material will allow) exists, the infill material must be chosen to reduce the effects. It is recommended that a clear-stone drainage layer be used in conjunction with a well-graded, free-draining, granular reinforced zone. The filter cloth used between the drainage layer and reinforced zone should be selected taking into account the two types of granular materials.
The placement of drains is based on the anticipated normal and high water levels. An outlet through

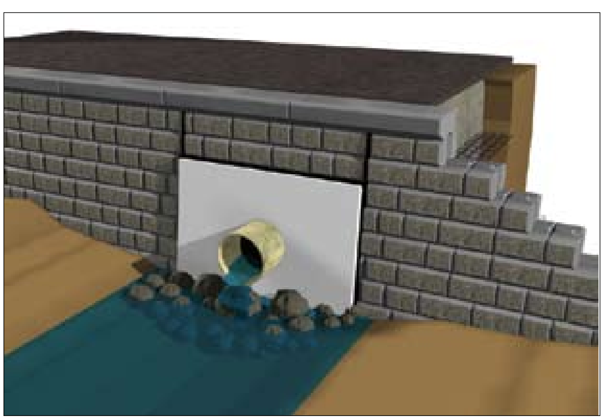
the wall face should be placed above the normal and high water levels at minimum 15m (45 ft) on centre. If the groundwater level is expected to fall below the foundation elevation, an additional drain should be added at this level. As well, a chimney or blanket drain may also be required depending on conditions.



If ice or wave effects are anticipated, rip-rap protection must be designed accordingly.

box culverts and headwalls

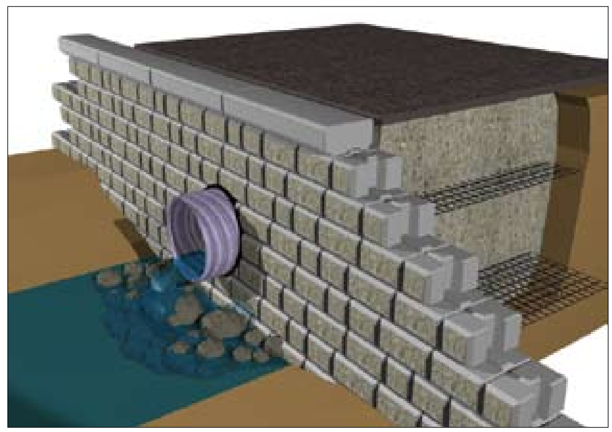
The key point in building this type of wall is to structurally separate the SonomaStone wall from the concrete headwall. Essentially, the SonomaStone wall must be constructed as three separate structures, allowing any potential differential settlement to occur without distress in the face. The walls must be abutted tightly with a 25mm (1 in) expansion joint separating them and the headwall. The picture shows the bottom of SonomaStone units resting on top of the headwall. However, this may not actually happen on site. A layer of mortar may have to be used to raise the elevation of the headwall to ensure that the courses line up on the adjacent sections of wall.



As the diameter of the culvert increases it may be easier to construct a head wall at the end of the culvert and assemble the wall using the box culvert details.

round culvert through wall

A culvert may be outlet through the face of the wall, providing the pipe has been designed to withstand the load of the wall above it and no excessive settlement is anticipated which may alter the alignment of the pipe. Once these issues have been addressed, the SonomaStone units can be cut to fit on site. A 25mm (1in) asphalt-impregnated fibreboard expansion joint should be placed around the pipe to ensure a tight fit and prevent the infill material from washing out. Rip-Rap is also required to protect the base from washout.

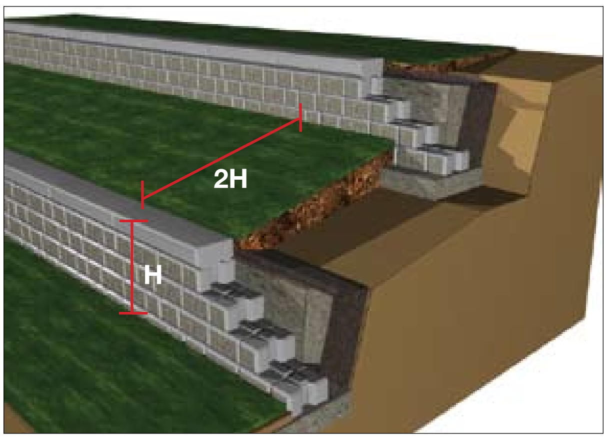


conventional SRWs

If done correctly, terracing can be an effective way to reduce loading and gain greater overall height, while still maintaining an aesthetic appearance.

Generally, a good rule of thumb is to set the distance from the back of the lower wall to the face of the upper wall to be greater than the height of the lower wall. If there is a slope between the two walls, this separation will need to be increased.

It is recommended that a qualified engineer review the terraced SRW design and site soil conditions, specifically checking the global stability of the proposed structure.

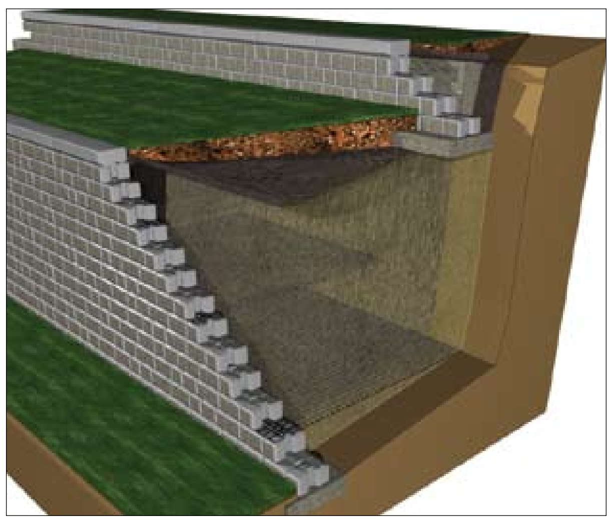


reinforced SRWs

Reinforced SRW walls can be designed to support upper terraces that are in close proximity to the back of the wall. Generally, the further the upper wall(s) are offset from the top of the lower wall, the less expensive the design will be. Once a minimum offset distance is established in the design, this must be adhered to throughout the structure.

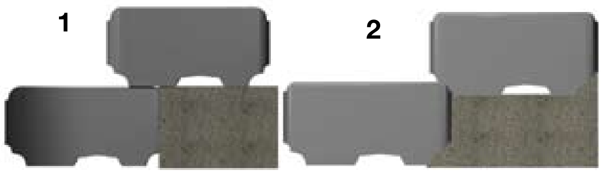
The loads produced by terraced walls can be great. As an example, a small 0.6m (2.0ft) high wall produces a load equivalent to a heavy traffic surcharge on the lower wall. These loads may be reduced by increasing the separation between the walls or increasing the foundation depth of the upper wall. Wherever possible, the lower wall should be higher than the upper wall.

It is recommended that a qualified engineer review the terraced SRW design and site soil conditions, specifically checking the global stability of the proposed structure.



steps

The SonomaStone coping unit may be used as a step. Check your local building code to ensure the front bullnose is in compliance. The coping unit can be placed in two possible orientations:



inset

Start with two 90° outside corner sidewalls. The walls can be built vertically as shown in the drawing or in a battered arrangement, as specified in the design. (Note: For vertical walls, a portion of the tongue on the corner units may have to be removed.) If the side walls are battered, the step width must be adjusted to meet wider distances between the side walls as each course steps back. The side walls can be constructed on a level foundation elevation as shown in the drawing or stepped up to follow the grade change created by the steps. No matter which, make sure a minimum of one course of side wall units is embedded. If handrails are core-drilled on top of the wall, a layer of geogrid may be needed.

Using SonomaStone coping units as the steps, place the first course on the same foundation as side walls. Backfill behind the first step to create the foundation pad for the next step.

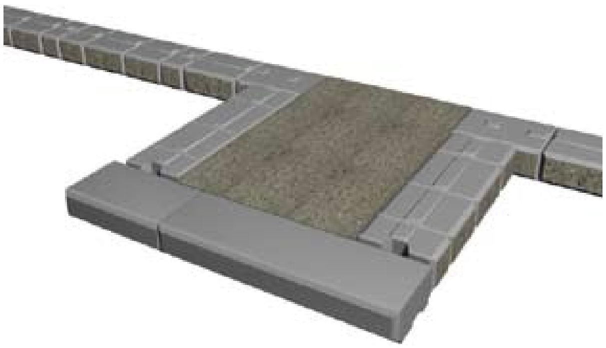
For the second riser, place coping unit on top of the first riser unit either as Detail 1 or as Detail 2. If the width of the step is larger than one full coping unit, the coping units may need to be cut and placed in a running bond pattern (cut dimension based on the distance between the side walls).

Repeat the previous stage to finish the steps as shown in the drawing. Refer to the coping detail for 90° outside corners.

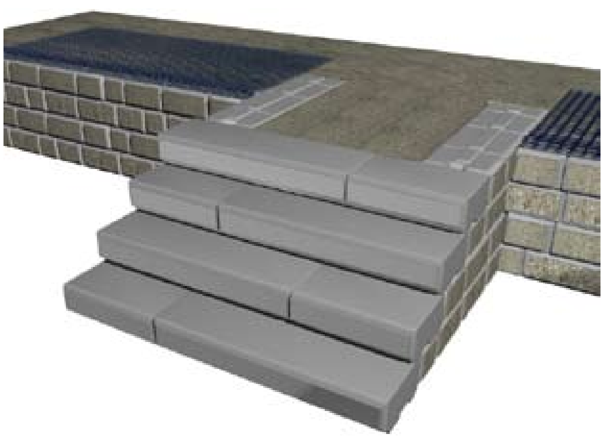
Core drill handrails as specified in the design.

protruding

Start the wall with coping units and standard units as shown in the drawing. The total length of coping units is the width of the step. The distance from the coping units to the inside corner of the wall shall be the total horizontal distance of the steps from the bottom to the top. The side walls must be constructed vertically to ensure the same width of steps at each course. For inside corner units and the standard units adjacent to the coping units, part of the tongue will have to be removed before installing the next course. For additional stability and settlement control, a layer of geogrid may be placed as shown.

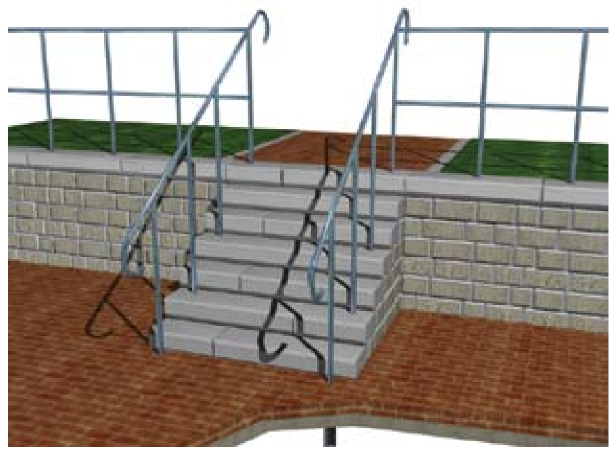


Repeat the previous stage for the second course. The step coping units need to be placed as in Detail 1 to make sure the step rise is comparable to the wall rise. Place the coping units in a running bond pattern. In order to place the coping unit on top of the sidewall, part of the tongue of the sidewall unit will have to be removed. Alternatively, 90° corner units may be used for the step sidewalls. If handrails are core-drilled on top of the wall, a layer of geogrid may be needed as shown in the drawing.



Repeat the previous stages to finish the steps as shown in the drawing.

Core drill handrails as specified in the design.

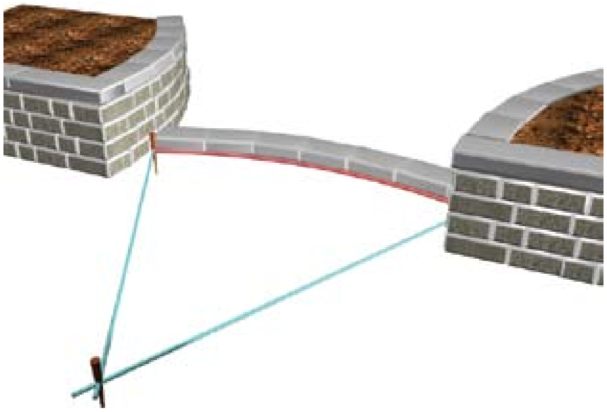


details

concave

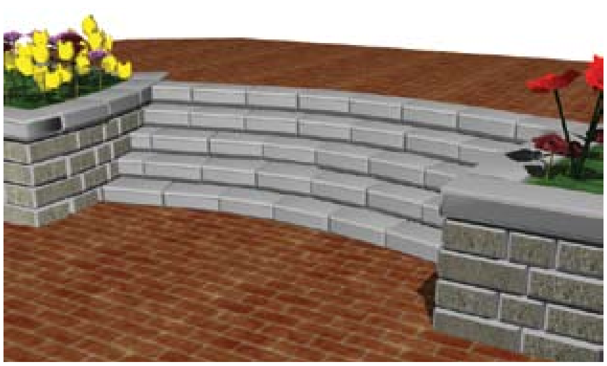
For concave steps, the SonomaStone coping units must be cut to create the required radius (tapered coping units are available in selected locations).

Locate the centre of the curve and lay out the curve onsite. Place the first riser units along the marked line.



Backfill the first course with granular base materials and compact to 98% SPD. The top elevation of the base should be flush with the top elevation of the lower coping units. The coping units shall be placed as in Detail 1 (see previous page). Make sure the new curve is parallel to the curve of lower riser and place the coping units in a running bond pattern. Cuts will likely be required.

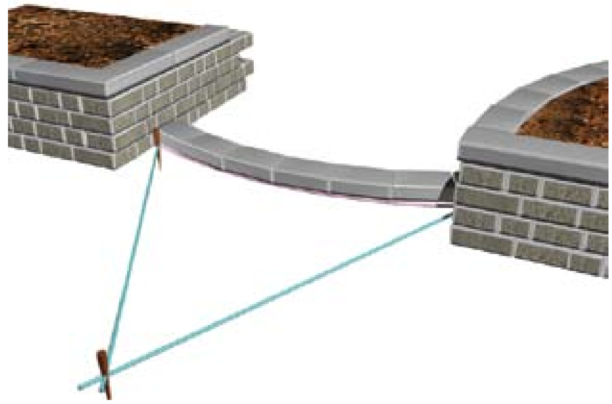
Repeat the previous stage to finish the steps.



convex

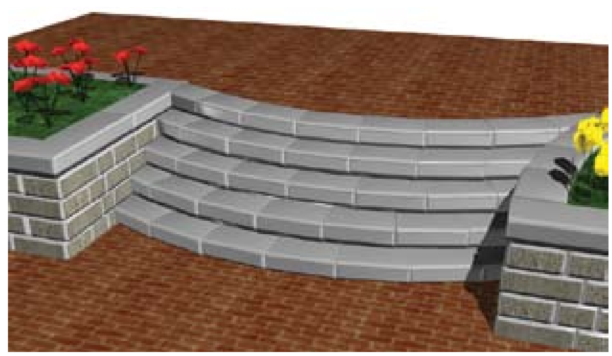
For convex steps, the smallest radius will occur on the uppermost course. Like the concave steps, the tapered coping units will require cuts to create a continuous step surface.

Locate the center of the curve and mark the curve on site. Place the first riser with SonomaStone tapered coping units along the marked line. Cuts will be required to create a continuous surface.



Backfill the first course with granular base materials and compact to 98% SPD. The top elevation of the base should be flush with the top elevation of the lower coping units. The coping units shall be placed as in Detail 1 (see previous page). Make sure the new curve is parallel to the curve of lower riser and place the coping units in a running bond pattern. Cuts will likely be required.

Repeat the previous stage to finish the steps.



It is generally recommended that retaining walls are not ended abruptly but rather gradually. This allows the infill material to be contained and helps prevent any free standing heights that may eventually start to lean or fail. There are several ways to end walls gradually and here are a few examples.

90º return end

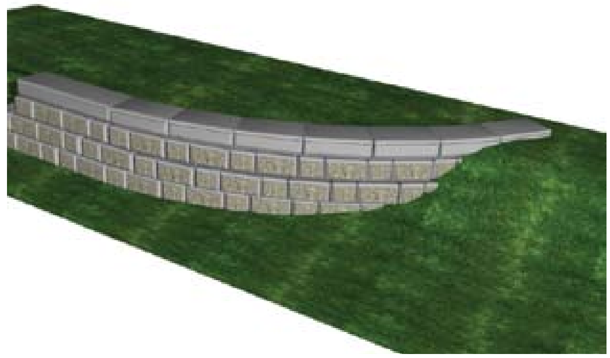
A corner (90º shown) could be constructed to run the wall into the slope that is being retained, thereby containing the granular material behind the wall.

stepped down end

The wall could be extended and stepped down to a reasonable height to allow the ground to be graded around the wall end.

curve into bank

A curve could be constructed to run the wall into the slope that is being retained, thereby containing the granular material behind the wall.



abut existing structure

The wall could be abutted to an existing structure. This would involve cutting the retaining wall blocks in order to maintain the running-bond pattern. An expansion joint (25mm asphalt-impregnated fibreboard) should be placed between the retaining wall and the structure. This will allow the wall to move slightly while still containing the granular material. Note that if the existing structure's footing extends under the retaining wall for a short distance, this could lead to differential settlement and in turn, cracking of the SRW units or separation between the blocks.

Specifications

Part 1 General

1.01 Description

A. The work covered by this section includes the furnishing of all labor, materials, equipment and incidentals for the design, inspection and construction of a modular concrete retaining wall including drainage system and reinforcement as shown on the Construction Drawings and as described by the Contract Specifications. The work included in this section consists of, but is not limited, to the following:

a) Design, Geotechnical Review of Design and Inspection, and General Review by a registered Professional Engineer. The Wall Design Engineer may be a different individual or firm from the Inspecting Engineer(s).
b) Excavation and foundation soil preparation.
c) Furnishing and placement of the leveling base.
d) Furnishing and placement of the drainage system.
e) Furnishing and placement of geotextiles.
f) Furnishing and placement of segmental retaining wall facing units.
g) Furnishing and placement of geosynthetic reinforcement.
h) Furnishing and compaction of infill, drainage and retained soils.
i) Furnishing of final grading to ensure water is directed away from the wall.

1.02 Related Work

A. Section 02100 – Site Preparation
B. Section 02200 – Earthwork

1.03 Reference Standards

A. Engineering Design
a) NCMA Design Manual for Segmental Retaining Walls, Second Edition.
b) NCMA TEK 2-4 – Specifications for Segmental Retaining Wall Units.
c) NCMA SRWU-1 – Determination of Connection Strength between Geosynthetics and Segmental Concrete Units.
d) NCMA SRWU-2 – Determination of Shear Strength between Segmental Concrete Units.

B. Segmental Retaining Wall Units
a) ASTM C 140 – Sampling and Testing Concrete Masonry Units
b) ASTM C 1262 – Evaluating the Freeze-Thaw Durability of Manufactured Concrete Masonry Units and Related Concrete Units.
c) ASTM C 33 – Specification for Concrete Aggregates
d) ASTM C 90 – Standard Specification for Load-Bearing Concrete Masonry Units
e) ASTM C 150 – Specification for Portland Cement
f) ASTM C 595 – Specification for Blended Hydraulic Cements

C. Geotextile Filter
a) ASTM D 4751 – Standard Test Method for Apparent Opening Size

D. Geosynthetic Reinforcement (Applicable for structures designed with geogrid reinforcement)
a) ASTM D 4595 – Test Method for Tensile Properties of Geotextiles by the Wide-Width Strip Method.
b) ASTM D 5262 – Test Method for Evaluating the Unconfined Creep Behavior of Geosynthetics.
c) GRI GG-1: Single Rib Geogrid Tensile Strength
d) GRI GG-5: Geogrid Pullout
e) GRI GT-6: Geotextile Pullout

E. Soils
a) ASTM D 698 – Moisture Density Relationship for Soils, Standard Method
b) ASTM D 422 – Gradation of Soils
c) ASTM D 424 – Atterberg Limits of Soils
d) ASTM D G51 – Soil pH

F. Drainage Pipe
a) ASTM D 3034 – Specification for Polyvinyl Chloride (PVC) Plastic Pipe
b) ASTM D 1248 – Specification for Corrugated Plastic Pipe

G. Where specifications and reference documents conflict, the Owner or Owner's Representative shall make the final determination of applicable document.

1.04 Approved Products

A. Sonoma Stone Segmental Retaining Wall System as supplied by the Risi Stone Systems Authorized Manufacturer.
B. Color and finish shall be as directed by the Owner or as shown in the Drawings

1.05 The Contractor

A. The term Contractor shall refer to the individual or firm who will be installing the retaining wall.

B. The Contractor must have the necessary experience for the project and have successfully completed projects of similar scope and size.

1.06 Delivery, Material Handling and Storage

A. The installing Contractor shall check all materials delivered to the site to ensure that the correct materials have been received and are in good condition and meet the required dimensional tolerances.

B. The Contractor shall store and handle all materials in accordance with manufacturer's recommendations and in a manner to prevent deterioration or damage due to moisture, temperature changes, contaminants, breaking, chipping or other causes.

1.07 Design

A. The term Wall Design Engineer refers to the Individual or Firm that has been retained to provide the Retaining Wall Design in accordance with Section 3 of this specification.

B. The term Inspecting Geotechnical Engineer refers to the individual Geotechnical Engineer or Geotechnical Engineering firm that has been retained to provide Geotechnical review of Design and Geotechnical Inspection and Materials testing services for the construction of the Wall.

C. The term General Review Engineer refers to the individual or firm retained to provide a General Review of construction to ensure general conformity of construction with the design and specifications. It is preferable that this is the same individual or firm that would be providing the Geotechnical Inspection described above (1.07 B.), provided they have a comprehensive understanding of Segmental Retaining Wall construction.

1.08 Submittals

A. The Contractor shall submit the following information for approval within the time frame set out in the contract, prior to the construction of the segmental retaining wall:

a) Design Submittal – Provide stamped construction drawings and specifications completed and sealed by the Wall Design Engineer in accordance with the design requirements outlined in Part 3 of this specification.

b) Materials Submittal – Manufacturer's certifications, stating that the SRW units, the geosynthetic reinforcement if applicable and imported aggregates and soils meet the requirements of this specification and the Engineer's design.

c) Installer Qualifications – The Contractor must be able to demonstrate that their field construction supervisor has the necessary experience for the project by providing documentation showing that they have successfully completed projects of similar scope and size.

1.09 Measurement for Payment

A. Payment for earthworks and retaining wall system will be in accordance with the contract documents or this specification, if it has been included in the contract documents by the Project Administrator.

B. Payment for earthworks to prepare the site for the retaining wall construction will be based on the contract unit price per cubic meter (or cubic yard) for site cut and fill earthwork as detailed in the Site Plan. Additional earthwork as directed and approved in writing by the Owner, or Owner's representative, shall be paid for under a separate pay item.

C. Payment for the retaining wall system will be based on the contract price per square meter (or square foot) of vertical wall face area as shown on the construction drawings. The vertical wall face area shall be measured from the top of the base or footing to the top of the coping course multiplied by the length of the wall. The contract unit price shall include the cost of all engineering (design and inspection), labor, materials, and equipment used to install the leveling base or spread footing, wall modules, drainage materials, infill soil, geosynthetic reinforcement, retained soil and site clean up. Additional vertical wall face area as directed and approved in writing by the Owner, or Owner's representative, shall be paid for under a separate pay item.

Part 2 Materials

2.01 Definitions

A. Modular concrete retaining wall units are dry-cast solid concrete units that form the external facia of a modular unit retaining wall system.

B. Coping units are the last course of concrete units used to finish the top of the wall.

C. Infill soil is specified material that is placed directly behind the drainage soil and within the reinforced zone, if applicable.

D. Retained soil is an in-situ soil or a specified soil that is placed behind the wall infill soil (beyond the geogrid reinforced zone).

E. Foundation soil is the in-situ soil beneath the wall structure

F. Drainage aggregate is a free draining soil with natural soil filtering capabilities, or a free draining soil encapsulated in a suitable geotextile, or a combination of free draining soil and perforated pipe all wrapped in a geotextile, placed directly behind the modular concrete units. If the design specifies that the entire infill zone (geogrid zone) is to be well graded, gravel material with a maximum of 8% fines, a separate drainage layer may not be required (refer to design drawings).

G. Drainage pipe is a perforated polyethylene pipe used to carry water, collected at the base of a soil retaining wall, to outlets in order to prevent pore water pressures from building up behind the wall facing modules.

H. Non-woven geotextiles are permeable synthetic fabrics formed from a random arrangement of fibers in a planar structure. They allow the passage of water from one soil medium to another while preventing the migration of fine particles that might clog a drainage medium.

I. Geogrid reinforcement is a polymer grid structure having tensile strength and durability properties that are suitable for soil reinforcement applications.

J. All values stated in metric units shall be considered as accurate. Values in parenthesis stated in imperial units are the nominal equivalents.

2.02 Products

A. Concrete Segmental Retaining Wall Units will be the following as specified in the design:

a) Sonoma Stone 375 units 185 x 1200 x 375 mm (7.25 x48 x 15 inches) with a maximum tolerance of plus or minus 3 mm (1/8 in.) for each dimension.

b) Sonoma Stone 750 units (if specified in the construction drawing) 185 x 1200 x 750 mm (7.25 x 48 x 30inches) with a maximum tolerance of plus or minus 3 mm (1/8 in.) for each dimension.

c) Sonoma Stone Tapered units for curves (if specified in the construction drawing) 185 x 600 x 375mm (7.25 x 24 x 15 inches) with a maximum tolerance of plus or minus 3 mm (1/8 in.) for each dimension.

d) SienaStone 500 units (if specified in the construction drawing as the base course) 185 x 1200 x 333 mm (7.25 x 48 x 13 inches) with a maximum tolerance of plus or minus 3 mm (1/8 in.) for each dimension.

e) The retaining wall modules shall be solid units and have a minimum weight of 175kg (385 lbs.) for Sonoma Stone 375 unit, 350kg (770lbs) for Sonoma Stone 750 unit, and 87kg (190lbs) for Sonoma Stone Tapered Unit.

f) The concrete wall modules shall have a integral shear key connection that shall be offset to permit a minimum wall batter of 1H : 8V. A vertical alignment is possible if specified in the design. Vertical alignment is achieved by rotating every second course 180 degrees. A slight negative batter (as specified in the design) must be constructed into the gravel base when aligning the blocks vertically to account for minor forward movement of the wall during and following construction.

g) The concrete wall modules shall have a minimum 28-day compressive strength of 35 MPa (5000 psi) as tested in accordance with ASTM C 140. The concrete shall have a maximum moisture absorption rate of 5 percent to ensure adequate freeze-thaw protection.

2.03 Infill Soil

A. The infill soil shall consist of free draining sands or gravels with less than 8% passing the #200 sieve size or as specified in the Construction Drawings.

B. In the case where the design has allowed the use of approved native material or material other than the free draining gravel described above, the following minimum criteria must be met:

a) The fine content (passing the No.200 sieve) of the infill soil cannot exceed 35%.

b) A liquid limit <40 and a plasticity index <10 per ASTM D 4318.

c) PH in the range of 3 to 9 per ASTM G 51.

d) A drainage layer consisting of washed, gap graded crushed gravel (3/4" clear stone or equivalent) that is free draining with no fines must be placed immediately behind the facing to a depth not less than 300mm (12"). The drainage layer must be separated from the backfill with an approved filter fabric. The filter fabric must be folded back at the vertical intersection with the geogrid reinforcement if applicable a minimum of 150mm (6") to ensure the drainage layer is not contaminated.

e) During construction, the infill zone must be protected from water and freezing conditions at all times.

f) A strict program of continual monitoring by the IGE of material type, moisture content, compaction, etc, must be followed to ensure quality of the backfill materials throughout the entire wall.

C. Following construction, final grading must be established immediately to ensure the backfill zone is protected from water infiltration.

D. The Inspecting Geotechnical Engineer shall review the proposed material and determine the suitability of the wall infill soil at the time of construction. The material must be checked on a regular basis for suitability during construction.

2.04 Retained Soil

A. The retained soil shall be on site soils unless specified otherwise in the Construction Specifications or as directed by the Owner or Owner's Representative. If imported fill is required, it shall be examined and approved by the Engineer.

2.05 Foundation Soil

A. The foundation soil shall be the native undisturbed on site soils with an allowable bearing capacity as specified on the construction drawing. The foundation soil shall be examined and approval by the Inspecting Geotechnical Engineer (IGE) prior to the placement of the base material. The Foundation zone encompasses the area beneath the wall facia and the geogrid reinforced zone (entire footprint of wall). In the case where unsuitable founding soil exists, removal and replacement of the foundation soil must be conducted under the direction of the IGE. The foundation zone extends out in front and behind the wall footprint at a 1H:1V line to the required depth, or as determined by the IGE.

2.06 Levelling Base Material

A. The footing material shall be non-frost susceptible, well graded compacted crushed stone (GW-Unified Soil Classification System), or a concrete leveling base, or as shown on the Construction Drawings.

2.07 Drainage Soil

A. The drainage soil shall be a free draining angular granular material of uniform particle size smaller than 25 mm (1 inch) separated from the infill soil or retained soil by a geotextile filter. The drainage soil shall be installed directly behind the SRW units if the infill soil is unable to provide adequate drainage capacity (i.e. infill soil has fine content exceeding 8%).

2.08 Drainage Pipe

A. The drainage pipe shall be perforated corrugated HDPE or PVC pipe, with a minimum diameter of 100 mm (4 inches), protected by a geotextile filter to prevent the migration of soil particles into the pipe, or as specified on the construction drawings.

2.09 Geotextile Filter

A. The non-woven geotextile shall be installed as specified on the construction drawings. Although selection of the appropriate geotextile specifications is site soil specific, a commonly used geotextile for filtration will have an Apparent Opening Size ranging between 0.149 and 0.212 mm (U.S. Sieve Sizes 100 to 70) and a minimum unit weight of 135 grams per square meter (5.0 oz /square yard). The coefficient of permeability will typically range between 0.1 and 0.3 cm/second.

2.10 Geogrid Reinforcement (Applicable for structures designed with geogrid reinforcement)

A. The Wall Design Engineer shall determine the type, strength and placement location of the reinforcing geosynthetic. The design properties of the reinforcement shall be determined according to the procedures outlined in this specification. If required, detailed test data shall be submitted with the design calculations and shall include tensile strength (ASTM D 4595 or GGI GG-1), creep potential (ASTM D 5262), site damage and durability (GRI GG-4) and pullout resistance (GRI GG-5 or GRI-GT-6) and connection strength (NCMA SRWU-The geosynthetic must be a polyester geogrid approved by Risi Stone Systems for use with the intended product. The Contractor must not substitute the geogrid specified in the design with another without the consent of the Wall Design Engineer.

2.11 Concrete Adhesive

A. The adhesive is used to permanently secure the coping stone to the top course of the wall. The adhesive must provide sufficient strength and remain flexible.

Part 3 Wall Design

3.01 Design Standard

A. The Wall Design Engineer is responsible for providing a design that shall consider the external stability, internal stability, and local stability of the SRW System. It is the responsibility of the Inspecting Geotechnical Engineer (IGE) to review the Wall Design to determine if further design considerations must be implemented to ensure adequate global/overall slope stability, and/or, if the foundation soils will require special treatment to control total and differential settlement. The design life of the structure shall be 75 years unless otherwise specified in the construction drawings.

B. The segmental retaining wall shall be designed in accordance with recommendations of the NCMA Design Manual for Segmental Retaining Walls, Second Edition. The following is a summary of the minimum factors of safety for the various modes of failure evaluated in the proposed design.

External Stability		**Internal Stability**		**Local Stability**	
Base Sliding	1.5	Tensile Overstress	1.0	Facing Shear	1.5
Overturning	2.0	Pullout	1.5	Connection	1.5
Bearing Capacity	2.0	Internal Sliding	1.5		
Global Stability	1.3				

3.02 Soil

A. Design parameters: The soil parameters assumed in the design shall be stated on the design drawings. If sufficient site soil information is unavailable at time of design, and typical, assumed soil design parameters are used for design purposes, the assumed parameters must be verified by the Inspecting Geotechnical Engineer upon further exploration or excavation of the site. If the design parameters are required to be modified, site specific design parameters shall be provided to the Wall Design Engineer by the IGE in a letter.

3.03 Design Geometry

A. The length, height, and overall elevations of the retaining wall must comply with the requirements of the proposed elevation detail, station information and site grading plan.

B. The structures' design height, H, shall be measured from the top of the leveling pad to the top of the wall where ground surface intercepts the wall facing.

C. Slopes above and below all sections of the segmental retaining wall are detailed in the site grading plan.

D. The minimum wall embedment shall be the greater of 1) the height of a SRW unit or 2) the minimum embedment required because of the slope below the wall. Increased embedment may be required due to erosion potential or global stability requirements.

Slope Below Wall	**Minimum Embedment**
Level	H/10
3 : 1 (18.4 deg)	H/10
2 : 1 (26.5 deg)	H/7

E. The following surcharges shall be applied to the top of each design cross section based on the following proposed uses above the wall.

specifications

Use Above Wall	Minimum Surcharge
No Traffic	0 kPa (0 lb/sq. ft)
Light Traffic	4.8 kPa (100 lb/sq. ft)
Heavy Traffic	12.0 kPa (250 lb/sq. ft)

3.04 State of Stress

A. The lateral earth pressure to be resisted by the reinforcements at each reinforcement layer shall be calculated using the Coulomb coefficient of earth pressure, Ka, times the vertical stress at each reinforcement layer.

B. The vertical soil stress at each reinforcement layer shall be taken equal to the unit weight of the soil times the depth to the reinforcement layer below the finished grade behind the facing units. A coefficient of active earth pressure, Ka, shall be used from the top to the bottom of the wall. The coefficient of active earth pressure, Ka, shall be assumed independent of all external loads except sloping fills. For sloping fills, the coefficient of active earth pressure, Ka, appropriate for the sloping condition, using Coulomb earth pressure shall be used in the analysis.

3.05 Inclination of Failure Surface

A. A Coulomb failure surface passing through the base of the wall at the back of the reinforced zone up to the ground surface at or above the top of wall shall be assumed in design of walls.

3.06 Geosynthetic Reinforcement(Applicable for structures designed with geogrid reinforcement)

A. The allowable reinforcement tension, Ta, shall be determined in accordance with the method outlined in the NCMA Design Manual for Segmental Retaining Walls, Second Edition. This method calculates the Long Term Design Strength (LTDS) of the geosynthetic reinforcement by considering the time-temperature creep characteristics of the reinforcement, environmental degradation, construction induced damage and an overall factor of safety.

3.07 Geogrid Length (as required on the construction drawing)

A. The minimum soil reinforcement length shall be as required to achieve a minimum width of structure, B, measured from the front face of the wall to the end of the soil reinforcements. B must be greater than or equal to 60 percent of the total height, H. The length of the reinforcements at the top of the wall may be increased beyond the minimum length required to increase pullout resistance.

3.08 Settlement Control

A. It is the responsibility of the Inspecting Geotechnical Engineer to determine if the foundation soils will require special treatment to control total and differential settlement.

3.09 Further Design Assumptions

A. Design assumptions listed below must be verified during the review process by Civil Engineer and during construction by the Inspecting Geotechnical Engineer and General Review Engineer, where applicable, as noted in Section 4.0.

B. The Wall Design assumes that surrounding structures will not exert any additional loading onto proposed wall (ie. An adjacent structural foundation is at or below proposed wall base or outside of a theoretical zone of influence as determined by the IGE). The Design also assumes that structures will remain structurally independent from proposed wall unless otherwise noted in the design.

C. The Wall Design assumes that the maximum anticipated groundwater elevation is a minimum of 2/3 x H (height) below the base of the wall. The Inspecting Geotechnical Engineer (IGE) must confirm this prior to construction. If the maximum anticipated groundwater elevation exceeds this, additional blanket and/or chimney drains will be required. The IGE must contact the Wall Design Engineer in writing, detailing the anticipated conditions, in order that a redesign may be performed.

D. The Wall Design assumes no hydrostatic pressure within or behind the wall. Therefore site water management is of extreme concern and is required both during construction of the wall and after completion of construction. it includes:

a) Verification of the grading plan has been developed to route water away from the retaining wall location by the Civil Engineer.
b) Drain pipes are properly installed and vented to daylight at all times during construction.
c) Surface water is directed away from the wall. The Civil Engineer must be notified of the requirement for a swale by the Contractor. The design of the swale system behind the wall must be performed by the site Civil Engineer as part of the overall site drainage/grading plan based on anticipated surface water flows. This may require re-grading to accommodate the dimensions of the swale. Modifications to the grades may result in increased wall height(s).
d) Constant monitoring of the site for other sources of seepage at the excavation (i.e. irrigation pipes, fluctuations in groundwater, etc.).
e) The design has assumed that no utilities such as gas/water mains, storm sewers, hydro/communications cables, etc, are placed within the reinforced zone of the wall(s). The contractor must notify the Civil Engineer and the Wall Design Engineer if conflicts exist to discuss moving these elements or designing to accommodate them.

3.10 Global Stability Analysis

A) A qualified Geotechnical Engineer (IGE) must be retained to review the Wall Design and site conditions for overall global stability prior to construction based on the actual site geometric, soil, and groundwater conditions known at the time. Further exploration of the geotechnical conditions may be required at the discretion of the IGE. This analysis, and the subsequent impact on the design (i.e, the results of the global stability analysis may require increased geogrid length, strength, and/or quantity, and/or increased wall embedment from that originally assumed in the wall design) must be relayed back to the Wall Design Engineer in order that the design revisions can be implemented.

B) The Wall Design Engineer must be provided with a copy of the global stability analysis for review prior to construction

3.11 Required Design Review by Other Parties

A. The following highlights the minimum review process that is required prior to construction. Other parties such as municipalities (required), architects, landscape architects, developers, owners, other designers, etc, and all other stakeholders should review the design prior to acceptance to ensure specific requirements are met.

B. Civil Engineer – The Project Civil Engineer must be provided with a copy of the plans and specifications for the proposed wall(s) in order that they may review the wall design for general compatibility with the site, including the following specific elements.

a) Surface drainage. The design requires that surface water be directed away from the retaining wall(s). If slopes behind the wall exist, a swale system will be required which must be included as part of the overall site drainage plan. If the inclusion of a swale was not considered in the original grading plan, the Civil Engineer must provide for this, including required dimensions based on the anticipated volume of water to be collected as well as any grading changes required to accommodate the swale (i.e. potential minor increases in wall height).

b) Drainage of other structures. The design requires that other structures such as pavements adjacent to the wall have independent drainage systems (perimeter drain) to ensure the wall drainage system is relied on to perform an outletting function for these other structures. Further to this, down spouts from buildings must be outletted away from the wall into other specified positive drains.

c) Outletting/connection of internal drainage system pipes. The Civil Engineer must provide direction as to the connection points or outletting of the wall(s) internal and external drainage system as part of the overall site drainage plan. This must be provided to the contractor in writing prior to construction.

d) Utilities beneath and adjacent to the retaining wall. The design does not allow utilities, unless otherwise specified, within the reinforced zone of the retaining wall. Furthermore, it is advisable to locate all utilities (catch basins, water lines, hydro, communications, etc) outside of the general wall area (assume a 1H:1V cut from the back of the reinforced zone) to allow future access to the utilities. Also, utilities existing or proposed to be located beneath or through (as in the case of a culvert pipe) the wall must be verified as capable of supporting the applied loads. The applied wall load is listed on the cross section drawing as the minimum allowable bearing capacity required to support the wall.

e) Property lines. The wall must not encroach on property lines unless consent is given by all stakeholders. Temporary access may be required during excavation and must be confirmed prior to start of construction. The proposed excavation and final structure location (including depth of geogrid reinforcement, wall batter and stepping of wall, actual block thickness) must be reviewed and approved by the civil engineer for the site. Temporary shoring may be required to ensure compliance with property line restrictions and OHSA.

f) Other structures. Unless specifically provided for in the design, other structures such as buildings, light standards, fences, parking lots and roadways, signage, curbs and barriers, etc, that are within the area of the retaining wall must be highlighted to the Wall Design Engineer, as these must be taken into account in the design of the wall or provisions provided for in the design of the other structures to prevent additional loading on the proposed retaining wall (i.e. offsetting the structures or extending the depth of the foundations below the bottom of the wall).

f) Use of area above/around wall. The wall was designed for the loading specified in this drawing. This loading was chosen based on the site grading plan and assumed use. The design requires that the Civil Engineer verify that the assumed use is acceptable for the site. Also, it must be determined if the area above the wall will ever be used as a depot for the storage of other materials or equipment during or after construction or for snow plowing in the winter. The wall has not been designed to bear the unknown weight of a snow storage area, nor has the drainage system been designed to accommodate the subsequent snow melt.

C. Landscape Architect - the Project Landscape Architect must be provided with a copy of the plans and specifications for the proposed wall(s) in order that they may review the wall design for general compatibility with the site, including the following specific elements.

a) It is assumed that any planting/trees will be mechanically stabilized until a root system sufficient enough to transfer the loads exists. The wall has not been designed to support any additional loading affects. It may be necessary to incorporate a root barrier (as req. by others) to prevent the migration of tree roots into the drainage layer. Only planting requiring nominal depth of topsoil (200mm-300mm) may be placed immediately adjacent to the Wall (within the reinforced zone). Larger plants/trees must be kept outside of the reinforced zone to ensure the wall geogrid is not damaged / disturbed due to excavation of for the root ball and/or the wall is not subject to additional loading.

Part 4 Construction

4.01 Geotechnical Design Review and Site Inspection

A. To be conducted by a qualified Geotechnical Engineer retained by the contractor.

B. The scope of the Inspecting Geotechnical Engineer's (IGE) responsibility includes the following.
Prior to construction the IGE will:

a) Establish a scope of work and schedule of visits with the contractor in accordance with the items listed below. It must be clearly determined whether the scope of work is limited to providing the Geotechnical Review and Inspection or if they are being retained to also provide the General Review, explained below, (and required by the Ontario Building Code for projects within Ontario. The local building code must be checked to understand the requirements with respect to inspection of construction).

b) Review design drawings and specifications to establish an understanding of the design requirements with respect to assumed geotechnical conditions.

c) Review the overall global stability aspects of the proposed wall/slope configuration. the IGE will provide an analysis or assessment of the global stability of the proposed wall/slope configuration and submit this to the Wall Design Engineer.

During construction the IGE will:

a) Provide field inspection and quality control services to ensure the backfill (infill), drainage, retained and foundation soils are in conformance with the design and specifications and meet the minimum requirements for strength, unit weight, type and consistency stated in the design. This is achieved through regular compaction testing, monitoring of backfilling and compaction procedures, inspection and testing of materials (USCS classification, fine content, plasticity), and verification of subgrade bearing capacity. The extent and scope of the testing program must be to the satisfaction of the IGE such that they are confident that the materials testing aspects of the overall construction inspection have been properly conducted. The ultimate goal of the materials testing program will be to reasonably ensure the assumed geotechnical parameters, specified soil types, bearing capacity requirements, compaction requirements, and water/groundwater assumptions included in the design have been met throughout the wall(s). The extent of materials / compaction testing will be a function of the type of soil, weather conditions, consistency of results, IGE judgment, etc. As a recommended minimum guideline, compaction tests should occur at the front of the reinforced zone (within 1.2m (4.0ft) of the face) and near the back of the reinforced zone (for geogrid reinforced zones with depth greater than 1.5m) at least every 10m-15m o/c horizontally along the length of the wall. Vertically, tests should be performed on at least every second lift (300mm – 450mm) as the backfill is placed and compacted. The type of material being used as backfill must be constantly checked against the specification. For imported fill materials, documentation (tickets) from the aggregate supplier must be reviewed and kept by the IGE. When using approved on site soils, depending on the homogeneity of the soils, the physical properties of the soils (type, plasticity, internal angle of friction, unit weight, permeability, etc), must be checked on a regular basis to ensure those parameters assumed in the design are being met or exceeded on site (either through testing, visual inspection or both). The allowable bearing capacity of the subgrade specified in the design must be verified under both the facing of the wall and the reinforced zone (entire wall footprint). The allowable bearing capacity of the subgrade must be verified at intervals not exceeding 3m along the length of the wall.

b) Identify loose or unsuitable founding or retained soils and subsequent removal and replacement of these areas. NOTE: the footprint of the wall includes the geogrid reinforced zone and is not limited to the facing. Therefore, foundation treatments must encompass the entire wall footprint and extend a minimum of 0.6m in front and behind the face and end of the geogrid respectively. The replacement material must extend down at a 1H:1V line to competent native material.

c) Ensure the wall remains outside of the loading influence (generally 10H:7V line of influence) of other adjacent structures unless they have been specifically accounted for in the design (i.e. building footings, hydro poles, light standards, etc).

d) Ensure groundwater conditions and/or other water sources have been identified and compared with the assumptions made in the design (generally design assumes that groundwater is well below base of wall). Additional water sources noted on site such as seepage from the cut embankment must be identified and the Wall Designer notified as these have not been accounted for in the design.

e) Ensure stability of excavations and conformance with OHSA standards.

f) Ensure that surface water and/or other sources of water are being controlled during construction and directed away from the wall to a positive outlet.

g) Ensure that all fill materials are adequately protected from the elements and/or frozen materials or materials that do not meet the moisture content requirements stated in the design are not used in the construction of the wall.

h) The contractor must notify the IGE in advance of critical stages in the construction of the wall(s) in order that the IGE may be present to observe and inspect the work. The IGE must be notified reasonable well ahead of time as agreed upon with the Contractor.

C. The Owner may engage a testing and inspection agency for quality assurance, but this does not replace the official geotechnical inspection function described above. In many cases, owner-sponsored construction quality assurance testing is generally insufficient in scope to address the work itemized above, and also to meet the detailed documentation requirements needed to establish a thorough Geotechnical testing and General Review program.

D. Testing and inspection services shall be performed by trained and experienced technicians currently qualified for the work to be performed.

E. The IGE shall submit written reports of inspections and material testing to the General Review Engineer and Contractor on a weekly basis. Such reports shall include description of the work performed, deficiencies noted in construction, and corrective action taken to resolve such deficiencies. The owner shall be notified directly by the contractor's testing agency of deficiencies noted by the IGE and provided with a summary and schedule for corrective action. Written reports will also include location, type, and results of all tests taken on the project.

4.02 General Review of Design and Construction

A. To be conducted by a Qualified Professional Engineer retained by the Contractor. This may be the same professional (Geotechnical Engineer) noted above provided they are familiar with and qualified in the methods and practices of Segmental Retaining Wall (SRW) construction, or this can be another Professional Engineer.

B. A General Review of construction is required as part of many building codes and/or Professional Engineering Guidelines. It is the responsibility of the contractor to ensure that all code requirements are being met with regards to the General Review of Construction by a qualified Professional.

C. The contractor is therefore responsible to retain the services of a professional qualified to provide a “General Review of Construction” as dictated by the governing codes and legislation. Risi Stone Systems and/or its Licensee (the SRW unit supplier) do not provide this service.

D. The General Review Engineer (GRE) must review the design drawings and specifications to establish an understanding of the requirements of the design with respect to concepts, materials, limitations and all other requirements of the design. The general review engineer must contact the Wall Design Engineer to address any outstanding issues, questions or concerns regarding the design prior to construction.

E. The GRE shall inform the Wall Design Engineer in writing if conditions on site differ in any way or at any time from the design. The Wall Design Engineer is to be consulted with regard to discrepancies between design and construction. The appropriate revisions will be provided by the Wall Design engineer accordingly based on new information submitted by the GRE in writing. Changes in conditions on site include, but are not limited to; seepage from the excavation or higher than assumed groundwater elevations, soil conditions, both insitu and/or engineered soil conditions differ from those assumed in the design, surface drainage issues on the site require greater attention or measures to control than originally assumed, wall geometry differs from the design (maximum heights, etc), other structures exist not shown on the grading plans and interfere with or are influenced by or influence the wall (catch basins, light standards, buildings, fences, etc), loading conditions differ from those shown on the design (i.e. roadways or pathways closer to back of wall than originally assumed), slopes above or below the wall steeper than assumed in the design, etc.

F. The General Review must be carried out in accordance with the guidelines set out by the governing Professional Engineering body. The purpose of the general review is to ensure, through periodic visits on a rational sampling basis, whether the work is in general conformity with the plans and specifications (i.e. geogrid length and placement, block tolerances, drainage provisions, proper construction techniques, wall alignment and heights, embedment depth, installation of base, review of geotechnical testing reports, etc). This would include ensuring that all structural elements noted in the design are being installed per the design and specifications as well as review of the reports generated by the independent geotechnical testing firm noted above to ensure the geotechnical parameters assumed in the design exist or have been achieved on site.

G. The GRE shall provide a letter to the contractor and owner that the completed Wall had been installed in general conformity with the design, specifications, and contract documents.

4.03 Contractor’s Quality Assurance Program

A. The Contractor is ultimately responsibility to ensure the wall is constructed in accordance with the design and specifications. The contractor must be qualified in the construction of segmental retaining walls, proper methods of construction, etc, and have thoroughly reviewed and understood the design documents and specifications. General installation guides illustrating proper methods and techniques for good construction are available at no cost to the contractor from Risi stone systems or the Licensee upon request. It is recommended that the contractor establish a well documented, thorough quality control program. It is recommended that the General Review Engineer be provided with copies of these construction reports on a regular basis as further support. This may be required by the General Review Engineer.

B. The Contractor’s field construction supervisor shall have demonstrated experience and be qualified to direct all work related to the retaining wall construction.

C. The Contractor must notify the IGE and GRE (if they are different individuals) of critical stages in the construction of the wall(s) in order that they may be present to observe and inspect the work. The IGE and GRE must be notified reasonably well in advance of the scheduled date(s) for construction.

4.04 Construction Tolerances

Installation of SRW face location shall be within all the following tolerances:

A. Vertical Control from plan: +/- 1.25 inches over a 10 ft distance

B. Horizontal Control from plan:
   a) Straight lines: +/- 1.25 inches over a 10 ft distance

C. Rotation of the wall face during construction:
   a) Maximum 2.0 degrees from established wall plan batter
   b) Maximum, +/-10.0% from total established horizontal setback.

D. Bulging:
   a) +/- 1.25 inch over a 10 ft distance

4.05 Site Preparation

A. Comply with Federal, State/Provincial, and local requirements for execution of the work, including local building codes and current OHSA excavation regulations. Provide excavation support as required to maintain stability of the area during excavation and wall construction and to protect existing structures, utilities, landscape features, or property or improvements.

B. Prior to grading or excavation of the site, confirm the location of the retaining walls and all underground features, including utility locations within the area of construction. Ensure surrounding structures are protected from effects of wall excavation.

C. Coordinate installation of underground utilities with wall installation.

D. Control surface water drainage and prevent inundation of the retaining wall area during construction.

E. The foundation soil shall be excavated or filled as required to the grades and dimensions shown on the Construction

Drawings or as directed by the Owner or Owner's Representative.

F. The foundation soil shall be proof rolled and examined by the IGE to ensure that it meets the minimum strength requirements according to the design. If unacceptable foundation soil is encountered, the contractor shall excavate the affected areas and replace with suitable quality material under the direction of the Engineer.

G. In cut situations, the native soil shall be excavated to the lines and grades shown on the Construction Drawings and removed from the site or stockpiled for reuse as retained soil if the design has allowed the use of this material.

4.06 Installing Drainage System

A. If specified in the design, the approved geotextile shall be set against the back of the first retaining wall unit, over the prepared foundation, and extend towards the back of the excavation, up the excavation face and back over the top of the infill soil to the retaining wall, or as shown in the Construction Drawings.

B. If specified in the design, the remaining length of geotextile shall be pulled taut and pinned over the face of the retained soil. Geotextile overlaps shall be a minimum of 300 mm (1 ft.) and shall be shingled down the face of the excavation in order to prevent the Infiltration of retained soil into the wall infill.

C. The drainage collection pipe shall be placed under the direction of the Civil Engineer inaccordance with the overall drainage plan for the site. The pipe shall be laid to maintain gravity flow of water from reinforced soil zone. Daylight drainage collection pipe at storm sewer manhole or along slope at an elevation lower than lowest point of pipe within reinforced soil mass, every 40 feet minimum.

D. Main collection drain pipe just behind segmental units shall be minimum 100mm (4 inches) in diameter. Secondary collection drain pipe shall gravity flow independently or tie into main collection drain pipe with laterals at maximum 12m (40 feet) spacing along wall face.

E. If other sources of water are discovered during excavation or anticipated, other drainage measures/systems such as chimney or blanket drains may be required. The IGE should contact Wall Design Engineer for recommendations.

4.07 Levelling Base or Spread Footing Placement

A. The leveling base material shall be crushed stone compacted to 98% Standard Proctor Density, or vibrated concrete along the grades and dimensions shown on the Construction Drawings or as directed by the Engineer. The minimum thickness of the leveling base shall be shown on the Construction Drawings.

4.08 Installation of Modular Concrete Retaining Wall Units

A. The bottom row of retaining wall modules shall be placed on the prepared leveling base as shown on the Construction Drawings. Care shall be taken to ensure that the wall modules are aligned properly, leveled from side to side and front to back and are in complete contact with the base material. The units shall be placed in the middle of the gravel base, with equal distance from the front and back of the base. The minimum base width is specified on the design drawings, generally extending at least 1 block height in front and behind the base course.

B. The wall modules above the bottom course shall be placed such that the tongue and grove arrangement provides the design batter (i.e. setback) of the wall face. Successive courses shall be placed to create a running bond pattern with the edge of all units being approximately aligned with the middle of the unit in the course below it.

C. The wall modules shall be swept clean before placing additional levels to ensure that no dirt, concrete or other foreign materials become lodged between successive lifts of the wall modules.

D. A maximum of 3 courses of wall units can be placed above the level of the infill soil at any time.

E. The contractor shall check the level of wall modules with each lift to ensure that no gaps are formed between successive lifts that may affect the pullout resistance of geogrid reinforcement, if applicable.

F. Care shall be taken to ensure that the wall modules and geosynthetic reinforcement where applicable are not broken or damaged during handling and placement.

4.09 Drainage Soil (As required by Design)

A. The drainage soil will be placed behind the retaining wall modules with a minimum width of 300 mm (1 ft.) and separated from other soils using the approved geotextile.

B. Drainage soil shall be placed behind the wall facing in maximum lifts of 6 inches and compacted to a minimum density of 95% Standard Proctor.

C. No heavy compaction equipment or paving equipment shall be allowed within 1 meter (3 ft.) of the back of the wall facia.

4.10 Infill Soil (As specified on the construction drawing)

A. Wall infill soil shall be placed behind the first course of the wall facing units in maximum lifts of 150 mm (6 inches) and compacted to a minimum density of 95% Standard Proctor Maximum Dry Density(ASTM D 698) at a moisture content from 2% below to 2% above optimum. The fill shall be placed and compacted level with the top of the wall modules at the specified geogrid elevations prior to placing the geogrid reinforcement where applicable.

B. Wall infill soil shall be placed on top of the geogrid reinforcement layers if applicable in maximum lifts of 150 mm (6 inches) and compacted to a minimum of 95% Standard Proctor Density. Care shall be taken to ensure that the geogrid lays flat and taut during placement of the infill soil. This is best achieved by placing fill on top of the geogrid near the wall facia and spreading toward the back of the infill soil zone.

C. No tracked construction equipment shall be allowed to operate directly on top of the geogrid until a minimum thickness of 150 mm (6 inches) of fill has been placed. Rubber tired equipment may drive on top of the geogrid at slow speeds but should exercise care not to stop suddenly or make sharp turns. No heavy equipment shall be allowed within 1 meter (3 ft.) of the back of the wall.

D. At the end of each day's operation, slope the last lift of reinforced backfill away from the wall facing to rapidly direct runoff away from the wall face. Do not allow surface runoff from adjacent areas to enter the wall construction site.

4.11 Geogrid Soil Reinforcement (Applicable for structures designed with geogrid reinforcement)

A. Verify type and orientation (Roll direction) of geosynthetic reinforcement.

B. Geogrid sections, pre-cut to meet the length required in the design drawings, shall be placed horizontally at the specified elevations and with longitudinal axis perpendicular to the wall face (i.e. machine direction), at the elevations shown on the Construction Drawings. The pre-cut sections of geogrid are to be placed immediately adjacent to one another, without overlapping and without gaps between them. Ensure the strong (machine) direction of the geogrid is placed perpendicular with the wall facing. Do not roll geogrid out along the length of the wall (parallel).

C. The geogrid shall be placed over the compacted infill soil and the wall facing units with the outside edge extending over the tongue of the bottom unit and to within 25 mm (1 in.) of the front facing unit. The compacted infill soil must be level with the back of the block to ensure the geogrid is placed horizontally, and that no voids exist under the geogrid as it extends out over the infill zone. Care shall be taken to ensure that the wall modules are swept clean and that the geogrid is in complete contact with the top and bottom faces of the adjacent wall modules. The next course of wall modules shall be carefully placed on top of the lower modules to ensure that no pieces of concrete are chipped off and become lodged between unit layers.

D. With the geogrid secured in place, the geogrid shall be pulled taut away from the back the wall modules during placement of infill soil. Alternatively, suitable anchoring pins or staples can be used to ensure that there are no wrinkles or slackness prior to placement of the infill soil. The geogrid shall lay perfectly flat when pulled back perpendicular to the back of the wall facia.

4.12 Retained Soil

A. Retained soils shall be placed and compacted behind the infill soil or drainage soil if applicable, in maximum lift thickness of 150 mm (6 inches). The retained soils shall be undisturbed native material or engineered fill compacted to a minimum density of 95% Standard Proctor.

B. No heavy compaction equipment shall be allowed within 1 m (3 ft.) of the back of the wall modules.

4.13 Finishing Wall

A. Items 4.06 to 4.10 shall be repeated until the grades indicated on the Construction Drawings are achieved.

B. Coping units shall be secured to the top of the wall with two 10 mm (3/8 inch) beads of the approved flexible concrete adhesive positioned 50mm (2 inches) in front and behind the tongue of the last course of retaining wall units.

C. Finish grading above the wall to direct surface run off water away from the segmental retaining wall. A swale system must be implemented above the wall if the grade slopes toward the back of the wall. The dimensions of the swale are dependent on the anticipated water flow and must be determined by the Civil Engineer responsible for site drainage. Use a soil with a low permeability to restrict the rate of water infiltration into the retaining wall structure. The low permeability material used to cap off the top of the wall shall be between 200mm (8") and 300mm (12") in thickness, unless the designed requires otherwise.

D. Upon completion of the wall(s), additional structures (fences, handrails, vehicular guardrails, buildings, pools/ponds, etc) or changes to grading/loading (increased wall height beyond that shown in the design, slopes, parking areas, changes in proximity to water flow, etc), other than those shown in the construction design, can not be installed/implemented without the review and consent of the Wall Design Engineer.

E. If the Contractor is not responsible to complete final landscaping above or around the wall, they must ensure that whoever is doing it is made away of the requirements with respect to final grading, allowable depth of topsoil, excavation behind the wall for planting, etc. The Contractor must not leave the wall unfinished without making those responsible for landscaping fully aware of the limitations and requirements of the Wall Design. This extends to handrails and fences, signs, or other appurtenances that may impact the wall performance. If paving is required behind the wall, the paving contractor must be notified of the limitations of the wall with respect to heavy compaction/paving equipment within 1.0m (3.0ft) of the back of the wall.

Aggregate
Materials such as sand gravel and crushed stone used with cement to make concrete.

Batter
Apparent inclinations of the retaining wall face due to the units' setback, measured from vertical.

Certifying Engineer (CE)
The Professional Engineer retained to verify site conditions, inspect construction, and ultimately provide a letter to the owner certifying the design is compatible with the site and the wall was constructed according to the design. The CE typically will sub-contract out the soils testing and/or compaction testing to a geotechnical testing firm.

Compaction
The process of reducing the voids in newly placed soils by vibration, kneading, or tamping to ensure the maximum density and strength in the soil.

Coping
Top course of units on a wall. Provides a finished appearance and ties the wall together.

Concave Curve
The surface of the wall is curved like the interior of a sphere or circle.

Conventional Segmental Retaining Wall System
An earth retaining structure that uses its mass to resist the movement of the earth behind the structure.

Convex Curve
The surface of the wall is curved like the exterior of a sphere or circle.

Cut Bank
The excavated enbankment of site soil created before the retaining wall is installed.

Density
Measure of the quantity of mass per unit volume. Dimensions are kg/cu.m or lb/cu.ft.

Drainage Conditions
Varying groundwater/soil conditions require different treatments to ensure proper drainage. The steps in our Installation section illustrate a typical situation where no excessive groundwater flow is anticipated. For other options, refer to Details – Drainage.

Drainage Fill
A poorly graded aggregate material with a high permeability and porosity (e.g. clear stone).

Facia/Facing
The assembled modular concrete units that form the exterior face of the retaining wall.

Filter Cloth
A continuous sheet of flexible, permeable fabric used to separate, filtrate, and reinforce.

Foundation Soil
The site soil upon which the retaining wall is constructed.

Geogrid
A synthetic material that has an open, thin sheet, grid-like structure that is used to reinforce soil.

Infill Soil
Soil material placed and compacted around the geogrids. Ideally free-draining granular material.

Reinforced Segmental Retaining Wall System
An earth retaining structure that incorporates synthetic materials used to reinforce the soil directly behind the structure and resist the movement of the earth embankment.

Retained Soil
Site soil in a cut bank or soil material placed and compacted behind the reinforced soil/wall structure.

Running Bond
Pattern created by stacking units so the vertical joints are offset one half unit from the course below.

Setback
The horizontal distance that units in successive course are offset.

Side Wall
Return wall at the edge of the steps running perpendicular to the risers.

Slope
A surface that inclines up or down (i.e. is not horizontal).

SPD
Standard Proctor Density

SRW
Segmental Retaining Wall

Surcharge
Loads or extra weight placed on the soil above and behind the retaining wall (e.g. traffic).

Wall Embedment
Depth of retaining wall that is buried. Distance from top of base to lower surface grade.

Weight
Measure of gravity force on an object.

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