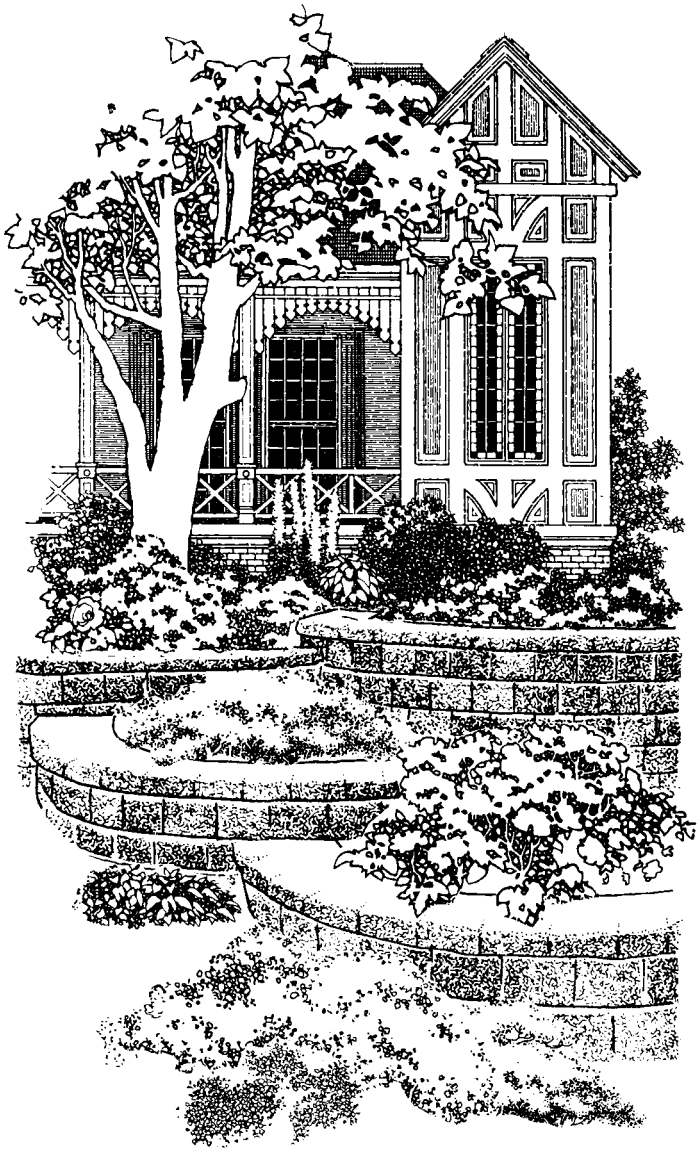
A Contractor's Guide to Installing Segmental Retaining Wall Systems



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Ideal Concrete Block Company, Inc.

INTRODUCTION

Ideal is pleased to offer you this guide to installing segmental retaining walls. The information was compiled from a number of sources. They include Risi Stone Systems, WestbIock Products, National Concrete Masonry Association (NCMA) Pavetech Inc., Vibromax Equipment, and various trade articles, as well as our own experience of working with hundreds of architects, engineers and contractors in the field for over 20 years.

We recognize that many contractors may have developed their own skills and unique techniques in building retaining walls and that many products have proprietary procedures. What we have attempted to do with this guide is to give you some of the best practices in the construction of segmental retaining walls. We hope that it will help improve your productivity and cost efficiencies, while achieving the best quality job that is possible.

This guide is intended to give you practical information, time saving tips and 'rules of thumb'. While it covers many aspects of segmental retaining wall construction, please contact your ***Pavers by Ideal*** *sales representative for comprehensive information on wall construction.*

We value our relationship with our customers, and we seek to bring you innovative ideas and products that create income opportunities. We pride ourselves on our level of experience and the technical support we provide. Our active participation in industry organizations allows us to bring you the latest information and technology. We strive to offer the quality of service that covers your needs. We support you with the help you need...including design consultation, specification assistance, sales promotion, job site training and quality review...to help make your project a success.

We welcome your comments and guidance to help us better serve your needs and support your growth.

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A Contractor's Guide to Installing Segmental Retaining Walls

HISTORY AND OVERVIEW

Retaining walls have been used for thousands of years as a means of utilizing marginal land. In the past decade, the cost of land has spiraled as building and development continues to consume prime real estate. As a result, landscape retaining walls have grown in popularity as a primary method of maximizing existing land space.

Until the development of segmental wall systems, the construction and landscape industries often used traditional materials and construction techniques to build retaining walls. Poured in-place concrete, conventional mortared masonry walls, or timber walls made of pressure treated wood or recycled railroad ties were the popular materials of choice. In the mid 1980's, a new technology emerged and segmental retaining wall systems were created to answer the need for a simplified, easy to install retaining wall. Their appeal continues to grow as property owners look to enhance the value of their property through beautification.

Most segmental retaining wall (SRW) systems are suitable for straight or curved walls, corners, and stairs, and they provide the ideal way to accommodate grade changes in any landscape or garden project. Uses include landscaping walls, terrace walls, tree rings, flowerbeds, planters, and more. SRWs are especially functional for developers because they save space and allow the property to be utilized to its maximum capacity. In heavy-duty structural applications, SRWs can accomplish grade changes, provide erosion control, serve as bridge abutments, and support parking areas. They also offer effective retainment for ponds, creeks, lakes, and stream channelization.

SRW ATTRIBUTES

Segmental retaining walls offer distinct advantages over other types of retaining wall products.

Aesthetics - SRWs are available in a wide choice of colors, shapes, styles, and configurations. Typically, segmental retaining wall units have a split face which offers a sculptured texture that subtly captures the changing hues of the day's light. Some faces have a beveled shape for a curved contour, while others are split straight across on a more uniform plane. Tumbling adds a new dimension by imparting an authentic appearance of natural stone. The units are produced in natural earthtone colors that blend beautifully with their surroundings.

Easy To Use - To borrow a term from another industry, segmental retaining walls are "user-friendly". They have been designed for fast and easy construction and do not require the skills of experienced stone masons. Years of training are not essential to build beautiful and professional looking landscape walls.

Performance - Because they are flexible structures, SRWs can tolerate movement and settlement without cracking and can be used in a variety of applications and wall heights. As a result, it is not necessary for SRW walls to sit below the frost line.

Durability - In order to withstand New England's harsh winter climate, segmental retaining wall units should be made from concrete with compressive strengths of at least 5000 psi (pounds per square inch). Segmental retaining wall units are environmentally safe and they won't rot or decay. You can be assured of lasting durability, structural integrity, and years of lasting beauty with little or no maintenance.

Design Flexibility - Most SRW systems can create curves - both concave (inside) and convex (outside). Some can create a circle as small as 6' in diameter. Tiered or terraced walls, stairs, corners, step-downs, and complex architectural layouts are also possible with many SRW systems.

Affordability - The method of construction allows better productivity and offers comparative or lower costs than most other types of walls including those constructed of wood ties.

Feature	Benefit
• Flexible structure	• Able to accommodate slight shifts
• High strength concrete	• Greater durability
• Factory-manufactured	• Consistent dimensions and strength
• Variety of colors and faces	• High aesthetic appeal
• Modular system	• Flexible design
• Simplified construction	• Minimal training/experience
• Dry stack	• Easy to install

HOW SEGMENTAL WALLS WORK

There are a number of types of segmental retaining wall systems available on the market. Many are proprietary and they vary with respect to size, shape, and appearance. One feature shared by all of the systems is they fit snugly together and step back when stacked. They are sometimes referred to as "dry-stack" or mortarless systems because they do not require mortar to hold them together. The means of interlock also varies with the particular segmental retaining wall system and most are proprietary. Some have a tongue and groove or rear lip molded into the units as the interlock mechanism, while others use clips or pins to connect the units.

Segmental retaining walls under 4' high work by the principle of gravity where the combined weight of the wall units resists the weight of the earth being retained. This type of system is commonly referred to a gravity wall structure. Walls that exceed this height require additional construction techniques such as terracing or the use of geogrid reinforcement and are known as reinforced or engineered wall structures. They are also referred to as MSE or mechanically stabilized earth walls.

Regardless of the type, all segmental retaining wall systems work by the same principles!

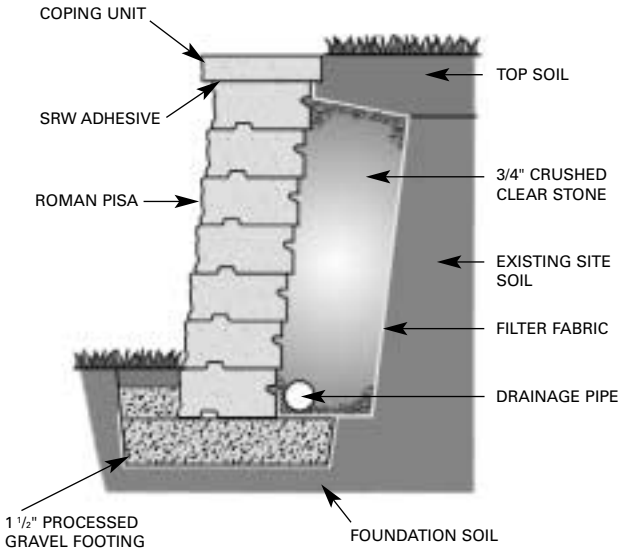
Conventional Segmental Retaining Walls

Conventional segmental retaining walls are gravity structures that resist the pressures of the earth they are intended to retain by **weight**, **batter** (setback), and the **friction** between the concrete units. Conventional segmental retaining wall are generally effective as gravity structures for most *non-critical* wall applications under 4' high.

Engineered/Mechanically Stabilized Earth Segmental Retaining Walls

Mechanically stabilized earth (MSE) segmental retaining walls are engineered walls that are composite systems consisting of SRW units used in combination with geosynthetic reinforcement which serves to increase the mass of the structure. This mechanically stabilized wall system offers the resistance required to support external forces associated with taller walls, surcharged structures, or poor soil conditions. Typically, you will find qualified designers, such as soil engineers, involved with these “engineered” walls which can be built as high as 40'.

Typical Gravity Retaining Wall Cross Section



COMPONENTS IN SRW SYSTEMS CONSTRUCTION

The basic elements of each segmental retaining wall system are: the foundation soil, gravel base or footing, segmental wall units, retained soil, drainage fill, and for soil-reinforced SRWs, the geogrid reinforcement.

Foundation soil - The subgrade soil supporting the gravel base, SRW units, and the reinforced soil zone of a MSE wall.

Base/ footing - The base (footing) distributes the weight of the SRW units over the foundation soil and provides a working surface for construction. Typically, the base consists of granular material, such as 1½" processed gravel or ¾" crusher run, although non-reinforced concrete or flowable fill can be used.

Segmental wall units - The concrete masonry units used to create the mass necessary for structural stability, and to provide stability, durability, and visual enhancement at the face of the wall.

Drainage Stone - Typically ¾" crushed stone which is placed behind the wall to facilitate the removal of groundwater and minimize buildup of hydrostatic pressure on the wall. It is also used to fill the cores of open-cell units in order to increase the weight and shear capacity. Geotextile fabric is typically installed between the drainage stone and the infill soil to prevent fines from clogging the stone.

Infill Soil - The backfill material that is placed and compacted in the area immediately behind the drainage zone.

Reinforced Soil - The compacted backfill material containing the horizontal layers of geogrid placed behind the drainage zone.

Retained soil - The undisturbed soil for “cut” walls or the backfill soil compacted behind the infill or reinforced soils zone.

DESIGN PRINCIPLES

Segmental design concepts are based on proven engineering principals of standard soil mechanics. Proper wall design should always begin with a thorough review of the site, and in many cases, should employ the services of a qualified civil or geotechnical engineer.

Although many of the SRW systems on the market are proprietary in nature and have their own design methods and recommendations, many users assume that walls under 4' high never require the services of a qualified soils engineer. *Not true!* This height is simply a “rule of thumb” and assumes the best case scenario.

Sound judgement must be exercised in analyzing existing soil and groundwater conditions, global stability, external and internal stability, surcharge loads and seismic requirements. The topography of the site also plays a role in deciding wall height, embedment depth, and the profile of the wall. If the calculations show that conditions exceed factors of safety in the design, *use of geogrids may be necessary regardless of wall height.* In other circumstances, the strength of the geogrid may need to be increased or longer lengths and/or additional layers may be required. Water applications such as lakefronts, seawalls and storm water runoff channels require additional specialized engineering considerations.

GOOD SOIL IS THE FOUNDATION TO A SUCCESSFUL WALL!

The performance and construction of most retaining walls is highly dependent on the type and condition of the on-site soils and the contractor’s placement and compaction of these soils behind and under the walls.

"Quick Soil-Typing Guide" from Vibromax Equipment

What to look for	Granular soils, fine sands, silts	Plastic (cohesive) soils, clay
Visual appearance and feel.	Coarse grains can be seen; feels gritty when rubbed between fingers.	Grains cannot be seen by naked eye; feels smooth & greasy when rubbed between fingers.
Movement of water in the spaces.	When a small quantity is shaken in the palm of the hand, water will appear on the surface of the sample. When shaking is stopped, water gradually disappears.	When a small quantity is shaken in the palm of the hand, it shows no sign of water moving out of the voids.
Plasticity when moist.	Very little or no plasticity.	Plastic & sticky; can be rolled.
Cohesion in dry state.	Little or no cohesive strength in dry state; will crumble readily.	Has a high dried strength; crumbles with difficulty & disintegrates slowly in water.

Unless you are working with a soil borings/report and a set of plans that have been developed by a qualified engineer, you may be faced with making a judgement as to the suitability of the site to support a retaining wall. Therefore, it is important to know the properties of various types of soil and understand how they might effect your estimate. To get a better understanding about soils, we have included this section to discuss soil types and properties.

Rule of Thumb: Poor soils may require the use of geogrid in walls under 4' high and affects the length, number of layers, and strength of the geogrids!

Soil Types - Soils are divided into three groups:

- **Granular** - sands and gravel consisting of grains down to .002"
  - Best for strength and support
- **Clay** - very fine particles, > 50% passing #200 sieve
  - May cause settlement
- **Organic** - loam, peat that is made up of moss, leaves and vegetable matter, and top soil
  - Should be removed

Dig A Hole: If test borings are not available, one of the simplest ways to determine the type of soil you will encounter during excavation is to dig a few holes with a hand shovel. The chart shown above will help to identify soil types.

From a design and construction standpoint, the soils can be classified as follows (Unified Soil Classification Designation):

Excellent: Sand & Gravel (GW, GP, SW, SP)	36° (ϕ)
Good: Sand & Gravel mixed with Clay & Silt (GM, GC, SM, SC)	33° (ϕ)
Moderate: Fine Sands & Silty Sand (SP, SP-SM, SP-SC)	30° (ϕ)
Poor: Low Plastic Silts & Clay (ML, CL)	27° (ϕ)
Bad: High Plastic Silts & Clay, (CH, MH)	23° (ϕ)
Bad: Peat & Organic Soils (OL,OH, PT)	n/a

Bear in mind that excessive wall movement or settlement can occur due to poor soil conditions under or behind the wall structure regardless of the geogrid design.

Rule of Thumb: Contact a qualified engineer when the site has plastic soils such as clay and peat.

GRAVITY SRW STRUCTURES

Design Assumptions

The design methodology for conventional gravity walls is based upon the following assumptions and conditions.

1. There is no slope behind the wall.
2. Surcharge loads applied at the top of the wall are limited to foot traffic where the applied forces will be between 0-50 psf.
3. There is good surface and subsurface drainage to prevent hydrostatic pressures at the back of the wall fascia and the reinforced soil zone.
4. The site soil has adequate strength to support the wall and good draining soils will be used behind the wall. In addition the ground water table is assumed to be well below the reinforced zone.
5. The cubic foot weight of the soil is the moist unit weight that includes the weight of water occurring naturally in the soil.
6. Seismic loading is not considered.
7. The site can support the weight of the wall.
8. The foundation soil will not settle or deform to cause failure.

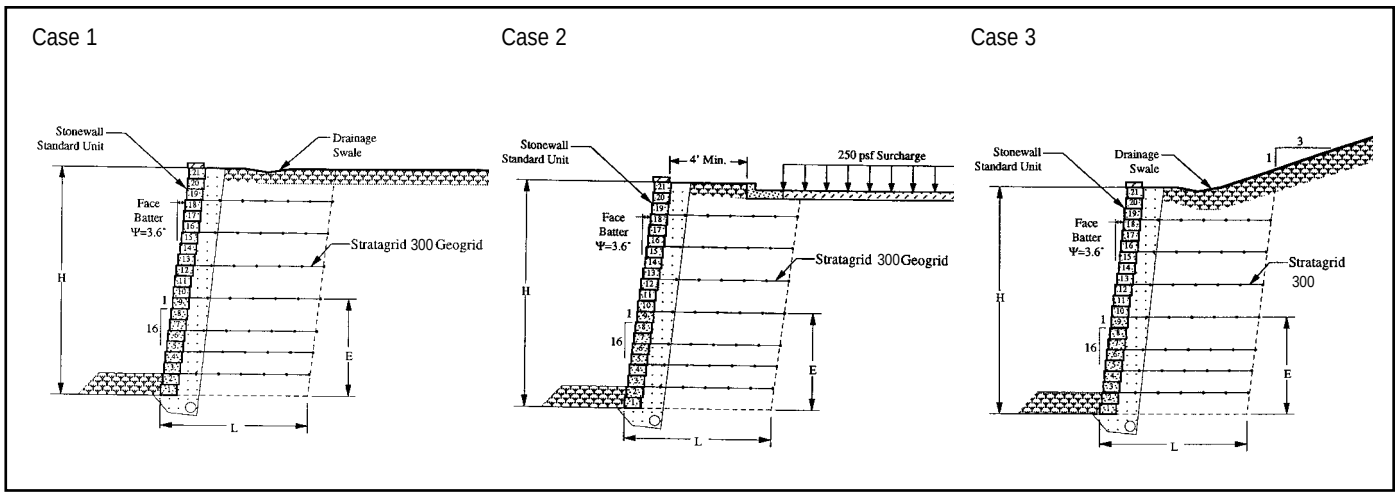
Rule of Thumb:
If the conditions differ from those listed, use better infill or foundation soil, decrease the height of the wall, and/or incorporate geogrid.

OTHER SITE CONDITIONS

When faced with the responsibility of designing and constructing a SRW wall, it is important to know the topography in front of and behind the wall, as well as the type of loads that might be imposed on the wall.

Slopes

A slope above the wall will create an additional load that must be considered in the design. The loads imposed by sloping embankments vary depending upon the angle of the slope. A slope is the ratio of the height of the rise to the length of the run and is the angle between the slope surface and the horizontal plane.



For example, a 2:1 slope means that for every 2' it goes back, the slope rises 1'. In the case of gravity wall structures, the use of geogrid may be needed, or in engineered walls that include geogrid, additional embedment may be required.

Another slope condition occurs when there is a slope at the toe in front of a wall. This can cause the wall structure to overturn or experience global instability. For gravity walls, geogrid may be required or longer lengths of grid may be needed for reinforced walls.

Surcharges

It is important to know what other types of loads might be expected to occur. Typically, there are two types of surcharges.
Live loads: These are typically construction traffic, parking, vehicle traffic, or pedestrians. These loads are transient and can not be considered to contribute any stabilizing forces to the retaining walls structure.

Dead loads: Other retaining walls, back slopes, or buildings on top of the retaining wall are examples of this type of load. Structures and dwellings in close proximity also impose loads on walls. Since they may be present for the entire life of the retaining wall, it is allowable to consider the load as a stabilizing force in certain cases.

Backslope	Liveload
2H:1V 26°	Pedestrian - 50 psf
3H:1V 18°	Cars & Light truck traffic - 100 psf
4H:1V 14°	Truck Traffic – 250 psf
	Construction Equipment – 500 psf

Water

Water can add excessive weight to the soil behind a wall that can ultimately cause the wall to fail even at low heights. In fact, if allowed to totally saturate the soil, water can increase the density by almost 60 lb/cu ft! When water cannot be directed over or around the wall by drainage swales, water must be directed through the wall. In addition to the ¾" crushed stone drainage zone immediately behind the wall units, the wall infill zone may require a blanket drain (below) and/or chimney drain (behind) to collect and remove the water from the wall structure. It is also important to identify sites where the water table is near the base of the wall.

Seepage

Certain soil conditions, such as stratified layers of clay and sand, can act as natural conduits for water. The amount of water these layers may carry can be very significant. If you discover these during excavation, additional drainage materials should be incorporated into the retaining wall. Typically a chimney drain will be installed along the vertical cut face to intercept, collect, and direct the water into a drain which will take the water away from the wall.

Water Applications

Segmental retaining walls can be built at sites such as ponds where the bottom of the wall is submerged. Construction techniques include:

- Burying the footing as much as possible
- Using Turfstone to contain the footing material
- Place geotextile fabric over infill material in front of wall and cover with riprap
- Gapping the units ¾" apart at the low water level
- Back-filling an area approximately equal to the height of the wall with free draining ¾" stone

Contact your ***Ideal*** sales representative for more information.

SOME COMMON SENSE

When it comes to the design and construction of segmental retaining walls, it is always better to take a conservative approach. ***Remember, when <u>any</u> of the SRW manufacturers say that walls can be built to 4' high without grid, it is predicated on the basis that the wall will be built under the <u>best</u> conditions.***

Rule of Thumb: If you have any concern as to whether the site offers the best conditions, you should consider using the services of a qualified soils engineer.

AN ENGINEER'S ROLE

An engineer serves an important role in SRW design. First, they must meet their client's needs to minimize costs and fulfill the functional requirements of a project, and second, they are obligated to protect the public by ensuring project safety and compliance with regulations.

An engineer provides important assistance to an owner and contractor by:

1. Examining the site - inspecting the soil and groundwater conditions and providing input parameters.

2. Developing a specific design to meet to the conditions of the site and ensuring that it complies with state and local building codes.

3. Specifying and inspecting the materials used in the retaining wall structure to ensure they are appropriate.

4. If retained, an engineer can observe, test, and examine the installation to ensure compliance with project specifications and wall drawings.

Tip: *In some cases, state and local building codes may require a stamped drawing by a registered design professional.*

By using a qualified engineer, the owner and contractor can be assured that the wall will perform as intended and they can expect a reduction in the total cost of the project. In addition, the engineer will significantly reduce the owner and contractor's liability.

Rule of Thumb: If the engineer designs, inspects, and approves the structure, the engineer will be responsible and liable for the retaining wall.

IDEAL CONCRETE BLOCK COMPANY SRW PRODUCTS

Most of the information presented to this point has been generic in nature and applies to all types of SRW systems, regardless of the manufacturer. While the performance characteristics are similar, the design methods and recommendations of the various systems are proprietary in nature and should not be transferred from one to another. Some manufacturers may choose to use conservative standards and calculate designs using a higher factor of safety, while others may choose to use the best case conditions in their assumptions. For this reason, the following section will deal with the specifics of the SRW products ***Ideal*** manufactures.

Ideal Concrete Block Co. manufactures a variety of SRW products to suit a wide range of applications. All of our systems fit securely together without mortar and automatically step back when stacked. **Stonewall**™ utilizes pins to align the units, while our **Pisa II**® and **Roman Pisa**® incorporate a tongue and groove connection. **GravityStone**® is a crib wall system that can be built as a multiple-depth structure, eliminating the need for geogrid. **Stonewall**™, **Pisa II**® and **Roman Pisa**® may be used for conventional gravity walls up to 4' high or for MSE segmental retaining walls in excess of 20' high. **GravityStone**® can be built as high as 15' without geogrid. Our smaller units are limited to wall applications less than 2 1/2' high and are generally used for simple garden type applications.

PHYSICAL CHARACTERISTICS

All of our concrete segmental wall units are manufactured at our Westford facility using a special concrete mixture formulated to withstand New England's harsh winter climate and freeze-thaw environment.

Ideal's wall units are dimensionally accurate and have a textured split-face appearance reminiscent of natural stone. Our units meet or exceed North American standards, including the new ASTM C 1327 Standard Specification for Segmental Retaining Wall Units. The typical characteristics offer:

- *Minimum Compressive Strength . . . . . 5000 psi*
- *Maximum Water Absorption 13%*
- *Freeze Thaw (150 cycles ASTM C 1262) . . . . . No effect*

PRODUCT INFORMATION

SEGMENTAL RETAINING WALL UNITS

Pisa II®
8"w x 6"h x 12"d • 45 lb/pc • 3 pcs/sf
Batter 1:8 (1 1/2" per ft)

Pisa II offers a textured face that is elegant in its simplicity. **Pisa II** is uniformly split and molded with subtle chamfers to create a wall with distinct horizontal lines. A continuous offset tongue and groove automatically steps **Pisa II** back and securely locks the units together.

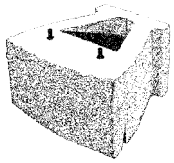
Roman Pisa®
8"w x 6"h x 12"d • 45 lb/pc • 3 pcs/sf
Batter 1:8 (1 1/2" per ft)

Roman Pisa is an upscale segmental wall unit that offers the natural appearance and texture of weathered stone. Our unique factory process rounds the corners and softens the edges, while preserving the structural integrity of its tongue and groove connection. **Roman Pisa** has the practicality and functionality of **Pisa II** and can be used as a gravity system in walls under 4' high or as a MSE segmental system for walls well over 4' high!

Roman Pisa® Jumbo Unit
12"w x 6"h x 8"d • 51 lb/pc • 2 pcs/sf

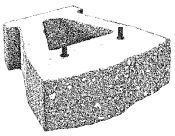
The **Roman Pisa** *Jumbo Unit* is a larger size block that can be used vertically to create a variety of appealing Ashlar patterns.

Stonewall™
12"w x 8"h x 12"d • 50 lb/pc • 1.5pcs/sf
Batter 1:16 (3/4" per ft)



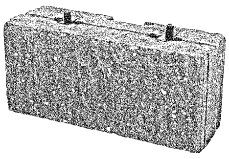
Stonewall has a rock face which is curved to give the rugged appearance of natural quarried stone. Nylon pins align the units as they stack for consistent and accurate construction. *Also available with a straight face.*

Stonewall II™
12"w x 4"h x 12"d • 24 lb/pc • 3.33 pcs/sf



Stonewall II is a smaller version of **Stonewall** and is ideal for lower-height walls.

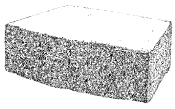
GravityStone®
18"w x 8"h x 6"d • 62 lb/pc • 1 pc/sf
Please see the GravityStone section for complete information on all the components comprising this system.



GravityStone combines the simplicity of easy-to-handle dry stack units with the superior earth retention capabilities of crib wall structures. It also can be used to build free-standing, double-sided walls up to 6' high and pillars! *Available with split face texture or tumbled.*

DECORATIVE GARDEN WALL UNITS

ScapeStone™
12"w x 4"h x 8"d • 30 lb/pc • 3.1 pcs/sf



ScapeStone offers a beveled face that provides a beautiful wall with an attractive natural appearance. Just a few dabs of ***SRW Adhesive*** will hold the system securely in place. Perfect for walls up to 2' high.

Garden WallStone™
8"w x 4"h x 9"d • 21 lb/pc • 4.5 pcs/sf

Garden WallStone's split face and small profile make it ideal for low level walls including tree rings, planters, and retaining walls under 2 1/2' high. A rear lip provides an automatic step back and permits easy wall construction.

COPING UNITS

Universal Coping Stone™
24"w x 3 1/4"h x 13"d • 79 lb/pc • 2 lf/pc

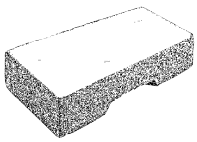
Universal Coping Stone is an attractive cap unit that provides a beautiful finish for **Stonewall, Pisa II**, and **GravityStone** walls. One edge is split, while the opposite edge is smooth, giving you two styles from which to choose. Simply install the units with the desired edge positioned outward. *Universal Coping Stone* can also be used for stair treads and corner units. A right-handed or left-handed corner is easily made by splitting a 6" piece off one of the ends. Grooves molded into the bottom make splitting easy and accurate.

Tip: *Use our Universal Coping Stone whenever your wall includes 90° corners.*

Pisa II® & Roman Pisa® Full Caps
8"w x 6"h x 12"d • 45 lb/pc • 3 pcs/sf
1 1/2 pcs/lf

Full Caps are the same size as the standard **Pisa** units but do not have a tongue, so their top is flat. In the **Roman Pisa** style, *Full Caps* are available in both a straight and tapered configuration. **Pisa II** *Full Caps* are not tapered, so they work best with straight walls. While *Full Caps* may be used as a finished coping for either **Pisa** style, they must be used for the last course when finishing the wall with our *Universal Coping* or **Roman Pisa** *Coping* units.

Pisa Revers-A-Cap®



Revers-a-Caps are 3"h x 14"d and are tapered front to back. One face is 8" wide and the opposite is 7" wide. For straight walls, reverse every other unit, while for curves, reverse them as needed to eliminate gaps between the units. For walls with a radius less than 7 1/2', it may be necessary to cut a few. *Revers-a-Caps* come with a smooth face, or edge. If you prefer to match the face of **Pisa II**, simply split the faces off along the groove we've molded into the bottom. Use a brick set chisel, or if you have a lot of units to split, consider using a guillotine splitter. See your ***Ideal*** dealer or a local equipment rental store.

Stonewall™ Caps
12"w x 4"h x 8"d • 30 lb/pc • 1 pcs/lf

Stonewall *Caps* are available in straight or tapered units. Use them whenever you want to match the face of the regular size **Stonewall** units or **Stonewall II**.

Roman Pisa® Coping Stone
12"w x 4"h x 13"d • 40 lb/pc
1 pc/lf

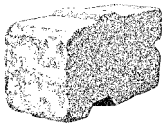
The **Roman Pisa** *Coping* units match the tumbled appearance of **Roman Pisa**. A tumbled straight or split-face is available. **Roman Pisa** can also be used for stair treads.

CORNER/HALF UNITS

Pisa II® and Roman Pisa® Corners
8"w x 6"h x 12"l • 43 lb/pc • 2 pcs/sf
1 per course per corner

Both the **Pisa II** and **Roman Pisa** *Corners* provide a split-face finish along an 8" width and 12" length to match the appearance of the *Stretcher* units in the wall. **Pisa II** is available in *Left & Right Hand* units, which are alternated in every course to maintain the running bond with minimal cutting. **Roman Pisa** *Corners* are reversible

Pisa II® and Roman Pisa® Half Units
4"w x 6"h x 12"d • 22 1/2 lb/pc • 6 pcs/sf



Use **Pisa II** and **Roman Pisa** *Half Units* for creating combination running bond, as well as ashlar patterns.

Stonewall™ Corners/Halves
6"w x 8"h x 12"l • 32 lb/pc

This single unit can be used for all corners and wherever a half piece is required in **Stonewall** wall applications.

SPECIALTY UNITS

Pisa Lite™ and **Pisa Sounds™**
Pisa Lite and Pisa Sounds are innovative illumination and sound systems that have been designed to match the look and color of **Pisa II** units. As you build the wall, simply replace a regular **Pisa II** wall unit with one of these specially made units wherever you want a light or a speaker!

COLORS

Granite Grey: *Pearl grey accented with brilliant white chips*
Rustic Brown: *A strong brown with a black tint*
Rosewood Blend: *Variegated tones of reddish browns and black*
Vineyard Blend: *A blend of weathered grays and buffs*
Quarry Blend: *A variegated blend of subtle grays and blacks*

CONSTRUCTION

1. General Conditions

The success of any segmental retaining wall installation depends on complete and accurate field information, careful planning and scheduling, the use of quality materials, and proper construction procedures.

It is good practice to have the retaining wall location verified by the owner. If working with an architect or engineer, confirm the existing and proposed finished grades to ensure the heights are in agreement with the project-grading plan. Check the contract document to see what type of submittals may be required. Often, you will be asked to submit product information. If site preparation is part of the contract, be prepared to conduct tests for compaction and density.

There are several ways to measure compaction. The most common is the Proctor method, which is conducted by a testing company. The procedure requires a technician to take a soil sample from the site and test its optimum density in the lab. He will then return and test the density of the soil at the site to compare it to the laboratory value. If within a certain percent, it is considered passing. Another method is the nuclear density test where a lab technician uses a nuclear instrument that emits radioactive waves to determine the density of the soil at the site. Although both tests bear an added cost to the project, they can help you avoid costly expenses at a later date if excessive settlement and movement occur.

If you are providing design assistance to your customer, first determine the height, length and configuration of the wall they want you to build. Make a drawing showing any adjoining structures, fences, stairs, and paved areas. Be sure to include an accurate sketch of the area you want the wall to retain, noting the slope and drainage patterns. Once the plan is complete, check with your local building department to determine if a permit is necessary. In some cases, a stamped drawing may be required, which means you need the services of a professional engineer. The authorized ***Ideal*** dealer in your area may be able to help you obtain this type of service. Otherwise, they can help determine the quantity of SRW units, gravel, crushed stone, and other materials you will need to complete your project. You can also refer to the handy charts included in the **Estimating Section**.

Usually, it is the contractor's responsibility to coordinate the delivery and storage of materials at the site to ensure unobstructed access to the work area and materials. Remember that delivery trucks are heavy, so select a location where the material can be placed. The SRW units will arrive on pallets, while the gravel and crushed stone will be delivered by separate trucks. Be sure to inspect the shipment as soon as the material arrives to make sure it matches your order for shape, color, size and quantity. Every cube comes with tags that provide important information about the product. Be sure to read them carefully. If there is a problem, contact your supplier immediately. Do not install the units in the wall, as use will constitute acceptance.

2. Planning

Before beginning any excavation, contact your local utility companies such as *Dig Safe* or *Call Before You Dig* and request that they mark underground cables or pipes. These services are usually free, but may require 72 hours notice.

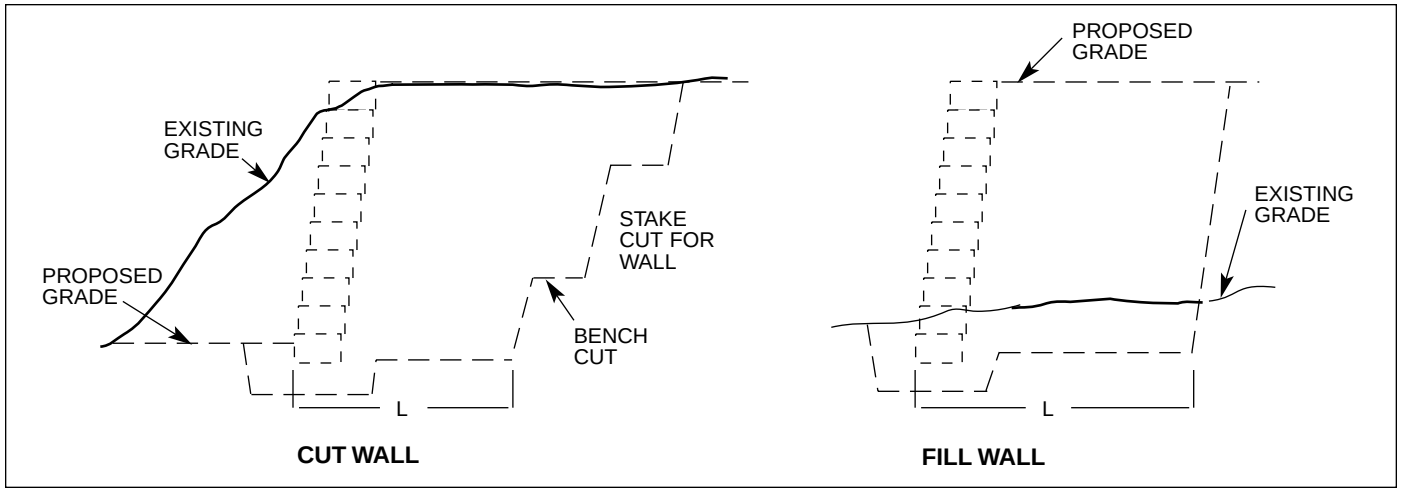
NOTE!!!! The following instructions are suitable for walls under 4' high when measured from the first course of units placed on the base. Sites with poor drainage, excessive groundwater, sloping embankments, or walls 4' and higher are conditions that require additional preparation or construction techniques such as terracing or the inclusion of geogrid. These are considered **"engineered walls"** and a section discussing some of the parameters involved in their construction has been included. ***We recommend that you contact a qualified soil engineer if any of these conditions exist.***

It is a good idea to develop a method to handle surface stormwater runoff before, during, and immediately after completion of a wall. When ground cover is disturbed by excavation, the soil is susceptible to becoming saturated during heavy rain events. Stormwater run-off should be diverted around the excavation and wall installation area to prevent erosion, potential wall collapse, and a delay in the work schedule. These diversions should funnel the stormwater into a temporary erosion control system and remain intact until the wall is deemed completed by the owner.

3. Excavating

The structural integrity of any retaining wall starts from the ground up and the key to good construction is preparing a firm foundation for support. Segmental retaining wall units are considered flexible structures, so the footing does not need to be placed below the frost line.

There are two basic topographical conditions under which SRWs may be constructed: "cut" and "fill". A "cut" wall is a site where the banking already exists and at least a portion of which must be removed. A "fill" wall is erected on fairly level ground and



requires back filling to bring the embankment to grade. If your project is a "cut" wall, excavate the area to the lines and grades shown on the approved plans. Take precautions not to over-excavate and always maintain safe slope parameters per OSHA requirements. Also, carefully consider the effects that the construction will have on structures and parking areas nearby. Make sure not to undermine or encroach upon the soils supporting these structures in any way.

Until now, the construction information we have provided is applicable to any wall system. The next section will provide the complete information you will need to construct a conventional **SRW** wall using either **Stonewall** or **Pisa II/Roman Pisa**. Please note that **Pisa II** and **Roman Pisa** are identical in size and configuration. Except where noted, the construction methods and techniques for them are interchangeable. The steps involved in the construction of a **GravityStone** wall will be shown separately.

Staking out the wall - Start by staking out the location of your wall, allowing for the automatic step back of 1/2" with every course of **Stonewall** and 3/4" with **Pisa II** and **Roman Pisa**. If building your wall in front of an existing embankment, allow enough room to maintain 12" of space behind the wall. This is called the drainage zone, which will be filled with 3/4" stone as you build the wall. The wall location is especially important on outside (convex) curves where the step-back of the units will decrease the radius of the curve as the wall goes higher. See the section on **Curved Walls** for more information.

Trench - Once you have staked out the location of your wall, excavate a trench at least 14" deep by 24" wide for **Stonewall** and 12" deep by 24" wide for **Pisa II/Roman Pisa**. You will need to dig deep enough to allow for a 6" thick gravel base and the first row of units that will be embedded below finished grade. If the wall is to step-up into a slope at different levels, start at the lowest point and excavate each rise in elevation in 8" increments for **Stonewall** and 6" increments for **Pisa II/Roman Pisa**. If the wall has multiple step-ups, be sure to allow for the 1/2" step-back per each 8" increase in height for Stonewall and 3/4" step-back per each 6" increase in height for **Pisa II** and **Roman Pisa**.

Stonewall Note: If the height of your wall above finished grade is 2' or less, the gravel base can be reduced to 4" thick and the first course of units can be buried just 4" below finished grade. If your wall is greater than 4' high, you will need to bury your first course an additional 1" for every course of wall units over 4' high, so it will be necessary to excavate deeper. For example, for a 6' high wall, you will need to dig the trench at least 17" deep in order to bury the entire first course, plus 3" of the second course of units.

Pisa II and Roman Pisa Note: If the height of your wall above finished grade is 2' or less, make the gravel base only 4" thick and bury the first course of units just 3". If your wall is greater than 4' high, you will need to bury your first course an additional 1" for every course of units over 4' high, so additional excavation is needed. For example, a 6' high wall will require a trench at least 16" deep in order to bury the entire first course and 4" of the second course.

Rule of Thumb:
If the wall is greater than 4' high, you will need to bury your first course of wall units an additional 1" for every course over 4' high.

The soil at the bottom of the trench must be firm and stable. Remove all loam, grass, roots and large rocks. If necessary, continue to excavate until you reach a granular soil such as GP, GW, SP, or SW soil types (see page 3) for support and drainage. Compact with the plate compactor or hand tamper until the bottom of the trench is level and firmly packed. Next, place filter fabric over the bottom and sides of the trench. To prevent soil from washing into the drainage soil, extend the fabric up the slope to completely cover the embankment. Overlap sections of the fabric by at least 12".

Rule of Thumb:
Foundation soil shall be compacted to at least 95% Standard Proctor Density.

4. Installing and Compacting the Base

The material for the base, or footing as it is sometimes called, should be a well-draining gravel consisting of coarse granular material. We recommend either **1½" processed gravel** or **crusher run**.

Fill the trench with about 3" of gravel then level and compact it thoroughly with the plate compactor. When the gravel has been thoroughly compacted, add the next layer. Add and compact enough gravel until the base is 6" thick and the top 8" below grade for **Stonewall** and 6" thick and the top 6" below grade for **Pisa II** and **Roman Pisa**. As noted earlier, the elevation of the base will be deeper for walls over 4' high.

Tip: *To facilitate the compaction process, wet but do not saturate the gravel with water.*

Rule of Thumb:
The base shall be compacted to at least 95% Standard Proctor Density.

Tip: *For long walls with minimal elevation changes, you might consider using Flowable Fill to construct the base instead of compacted gravel.*

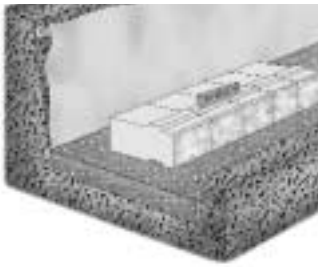
Rule of Thumb:
Foundation soils with a low bearing capacity, areas with the water table close to the foundation, or submersed foundations require different designs and stabilization techniques. Contact an Ideal representative.

5. Installing the First Course

The first course of wall units is the most important and takes the longest time to install. Once you have positioned and leveled the units in this row, you will be able to place subsequent courses quickly and easily.

Tip: *To make leveling easier, spread and compact up to ½" of coarse concrete sand on top of the compacted base material.*

Start by placing the units directly on the base in the center of the trench. For **Stonewall**, the slot should be on the bottom with holes facing up. If using **Pisa II** or **Roman Pisa** *Stretcher* units, place the units with the groove side down. If your wall steps up, begin at the lowest level of the excavation. Use a carpenter's level to align and level each block side to side and a torpedo level front to back.

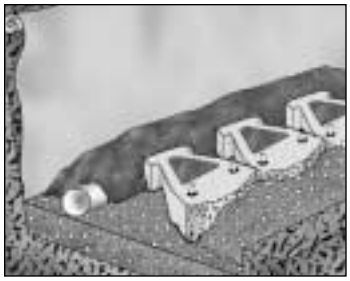


Lay the units side by side along the length of the footing, taking care to follow the desired alignment of the wall. Adjust the spacing between units for curved sections as needed. If your wall has 90° corners, it is best to start from a corner. See the **Details Section** for more information on building corners. You can also start next to a fixed structure such a house foundation.

Tip: *When building straight walls, you may want to begin by setting the first units at each end of your trench. Level each unit and pull a string line between them along the back of the units. Use this line to align the rest of the units in the row, carefully leveling each unit as it is placed. If needed, use some gravel or coarse concrete sand to shim the units.* ***Never tilt the unit forward.***

Drainage Pipe - After the first course has been installed, place perforated pipe behind the wall to help collect water and drain it away. Position the pipe, with the holes facing **down**, on the base behind the wall units along the entire length of the wall and several feet beyond. Some brands are sold already covered with a geotextile sock; otherwise wrap the pipe in filter fabric. The pipe should be sloped at each end to allow gravity to flow water beyond the wall.

Drainage Stone - If using **Stonewall**, fill the cores and the space between the units with ¾" crushed stone, which should be uniform in size and should not contain fines. Next, backfill the trench behind the **Stonewall** or **Pisa II**/**Roman Pisa** units with ¾" crushed stone. Tamp the stone level to the top of the units being careful not to move the units in any way. Now, fill and compact the trench on the front side of the units by using the same 1½" processed gravel used for the base. Sweep the top of the units clean, and if using **Stonewall**, insert the nylon pins into the holes in the top of the units. Use a hammer to tap open the holes and seat the pins with the smooth portion of the stem pointing up. Two pins are required for each unit.



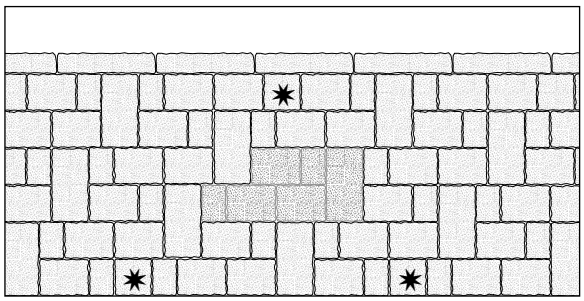
6. Laying the Wall

Place the second course of SRW units onto the first course, taking care to engage the connection mechanism. For **Stonewall**, fit the slot in the bottom of the units over the pins protruding from the units in the first row. For **Pisa** and **Roman Pisa** units, place the second course of wall units by fitting the

groove onto the tongues of the units below. Position the units in a "running bond" pattern, staggering them so the joints occur over the middle of the unit below. Align the units to achieve a uniform appearance - the design of both the slot and tongue and groove allows some play for adjustment. As you lay successive courses, you may need to use *Half* units to maintain the bond and it may be necessary to cut some units. While a perfect "running bond" is not necessary, always maintain some stagger to the joints. Trim the face of the units as needed using a 3 lb hammer and mason's chisel or brick-set. **ALWAYS EXERCISE CAUTION AND WEAR SAFETY GLASSES AND A NIOSH APPROVED RESPIRATOR!**

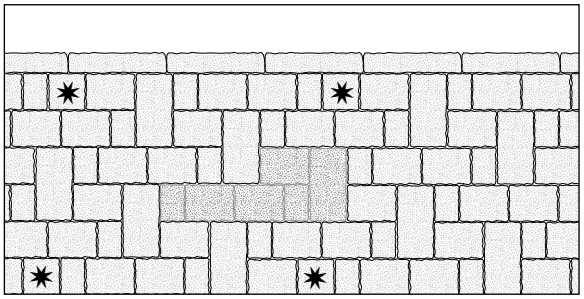
Tip: *Occasionally, it may be necessary to shim block to maintain level coursing. Small pieces of plastic, asphalt shingles, or galvanized wall ties work well for this purpose.*

Roman Pisa Ashlar Patterns - So far, we have described the steps involved in the construction of a **Stonewall**, **Pisa II**, or **Roman Pisa** wall installed a running bond pattern using regular *Stretcher* units. If building a **Roman Pisa** wall in an ashlar pattern, you will be combining *Half* and 12" *Jumbo* units with regular *Stretchers*. Although they may look complicated, ashlar patterns are easy to assemble by simply repeating the basic pattern throughout the wall. Follow the layouts shown for the configuration of the pattern you have chosen. You can even create your own custom pattern by interchanging *Stretcher* and *Half* units with *Jumbo* units. Grooves molded into the 12" length and 8" side of the *Jumbo* unit allow it to be placed either horizontally or vertically in the wall. Always place several 3/8" beads of ***SRW Adhesive*** on the top surface of the *Jumbo* and *Half* units immediately prior to placing the next course. One 10 oz tube will be required for approximately every 10 sf of wall area for ashlar patterns.



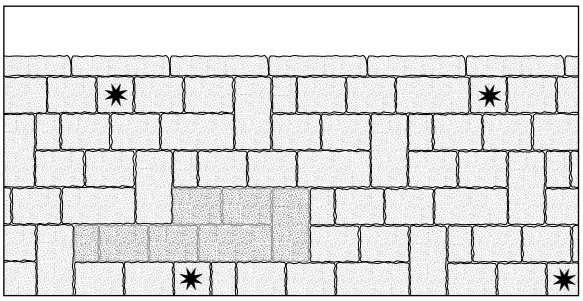
ASHLAR PATTERN 1

164 Stretcher, 110 Half and 56 Jumbo units per 100 sf*



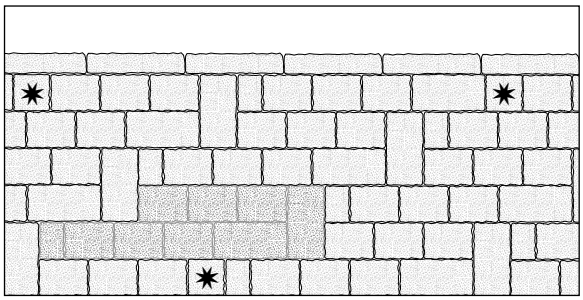
ASHLAR PATTERN 2

164 Stretcher, 110 Half and 56 Jumbo units per 100 sf*



ASHLAR PATTERN 3

160 Stretcher, 42 Half and 80 Jumbo units per 100 sf*



ASHLAR PATTERN 4

168 Stretcher, 30 Half and 60 Jumbo units per 100 sf*

**Includes 8 Full Cap units for every 10' of closure row.*

✷ *Denotes 12" Jumbo units cut in half to 6" x 6" squares for the starting and closure courses.*

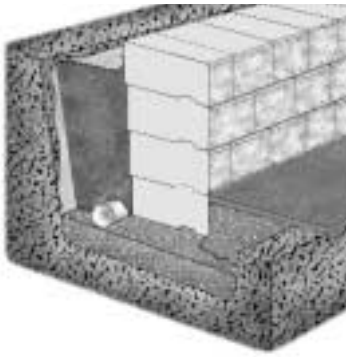
Successive courses - After you have installed the second course, fill the cores (if using **Stonewall**) and backfill at least 12" of space behind the units with 3/4" crushed stone as described earlier. Then you will need to backfill the bank behind the crushed stone drainage zone. Pull the filter fabric over the front of the wall and place a 3"-4" layer of 1 1/2" processed gravel (or native soil excavated from the site) and compact thoroughly. Add enough gravel or soil until it is even with the top of the units. If necessary, add more 3/4" drainage stone and tamp level. The key is to consolidate the stone and backfill material as much as possible to avoid future settlement.

Tip: *Place a piece of plywood between the crushed stone and the banking to keep the 3/4" stone and backfill material as separated as possible. Slide the plywood up as you backfill.*

Tip: *Always select block from several pallets as you are installing to distribute the color uniformly.*

Rule of Thumb:
The infill soil should be placed in 3"-4" lifts behind the crushed stone and compacted to a minimum 95% of Standard Proctor Density.

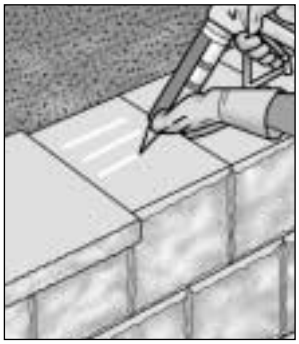
Repeat this procedure for the remaining courses until you have reached the desired height of your wall. Be sure to backfill after every course, taking care not to move the units out of alignment. Do not backfill the last course at this point.



Rules of Thumb:
• Use only hand operated compaction equipment within 3' from the back of the wall.
• The completed wall shall be within +/- 1.25" when measured over a 10' distance, in either a horizontal or vertical direction, compared to the design line and grade control.

7. Capping the Wall

Finish the wall by using one of the five styles of cap units for the last row. Whichever type you select, secure them to the wall with our ***SRW Adhesive*** which is a construction grade sealant that's been formulated for use with concrete. Simply apply several 3/8" beads to the top surface of the units in the last row. It's best to do only 3 or 4 units at a time to prevent the sealant from skinning over. When setting the coping units, apply firm pressure to secure them in place. Allow 24 hours or so for complete curing.



8. Finishing the Wall

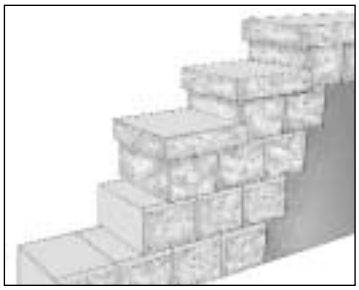
To complete the project, fold the filter fabric over the 3/4" stone drainage zone at the mid-level of the next to last row and add a layer of low-permeability soil to minimize water infiltration. Finish the grading so that water does not pond behind the wall. If needed, construct a small drainage swale to collect and channel the water away, or grade the surface to direct water over the top and down the face of the wall. If landscaping is included in your contract, complete the project by placing topsoil, sod, or plants.

Congratulations! You have built a beautiful segmental retaining wall that will provide years of enjoyment and virtually maintenance free service for your customer.

DETAILS

Step-ups

When building along the direction of a slope, the wall must be stepped in increments. With **Stonewall**, step each course in 8" increments, while **Pisa II\Roman Pisa** are stepped in 6" increments. Do not attempt to slant the wall to the angle of the slope.



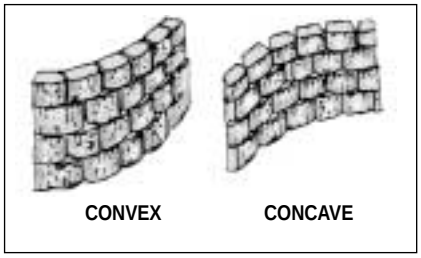
Ending the Wall

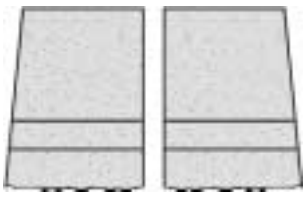
There are several ways to end a wall along a slope. One is to turn the units into the grade, burying at least one complete unit along the incline.

Another choice is to place a *Corner* unit at the end of every course that steps down to expose the split face at the end of the wall. With **Pisa II\Roman Pisa** walls, it will be necessary to remove the tongue from the units on which the Corner units will sit, or simply replace those units with *Full Caps*. Use a *Universal Coping Stone* to finish the wall by splitting it into the appropriate corner piece and positioning it onto the units to attain a 1" overhang. For **Roman Pisa**, use the **Roman Pisa** *Coping Stone*. Be sure to secure them with ***SRW Adhesive*** as shown under **Section 7** - **Capping the Wall.**

Curved Walls

Stonewall creates graceful serpentine walls with concave and convex curves. The minimum radius is 3' to the face of the unit. You can build tree rings and planters as small as 6' in diameter from face to face. When erecting walls over 4' high, the radius should be equal to or less than the height of the wall. For example, a 6' high wall will require a radius of 6'. When building walls with a radius, the first course must be wider to allow for the automatic step-back in subsequent courses. To minimize this, pull the unit forward against the pins in every course in order to lay the wall as vertical as possible. Otherwise, it will be necessary to cut some units in the upper courses to fit.





Pisa II and **Roman Pisa** *Stretcher* units are tapered 1" in width from front to back, so building curved walls is easy. They lay out to a minimum radius of 7 1/2' for convex curves. You'll note that the units are only tapered on either the right or left side. Typically, the shipment includes about half of each type. When laying convex curves, only use units with the same taper in a row. It does not matter whether they are "rights" or "lefts" - just don't mix them together. Alternate them every course as you build the wall to get a 7 1/2' radius. Concave curves can be built with a radius as tight as 6' by laying the faces tight and opening the backs as much as possible. If building a convex wall in a **Roman Pisa** ashlar pattern, plan on laying out a radius of 15' to minimize cutting. Fill the space between the units with 3/4" crushed stone as you backfill.

Corners

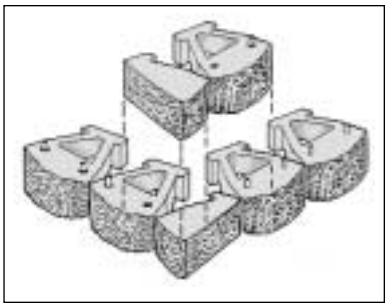
As you lay out the location of the wall, mark the position of the corners with a stake and use string lines to indicate the line of the intersecting walls. When digging the trench, allow additional space at the corner location.

Once the gravel base has been placed and compacted to the desired elevation, mark the exact location of the corner. Use a builder's square to insure an accurate 90° angle, or lay it out using the 3-4-5 triangle method. It is best to start the wall in the corner and build outward.

Tip: *Snap a chalk line directly on the gravel footing as a guide to align the wall.*

Outside Corners using Stonewall

When it comes to building outside corners, **Stonewall** gives you two choices and both are easy to do. The corners can be a simple *convex* curve based on a radius discussed previously, or they can be built at a 90° angle. When incorporating 90° corners, you will need to order **Stonewall** *Corner* units. Follow these simple steps to construct 90° corners.

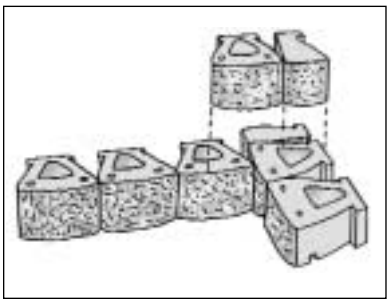


1. Position a **Stonewall** *Corner* unit on the base exactly where the intersecting lines meet in the corner. Then place regular **Stonewall** units on each side of it. Using a level, align and plumb the units. Continue the wall on each side using regular units following the directions shown in **Section 5** -**Installing the First Course**, however, do not put a pin in the closest hole of the unit sitting adjacent to the shortest face of the corner.

2. For the second course, position a **Stonewall** *Corner* unit in the alternate direction onto the *Corner* and regular unit below. Place regular **Stonewall** units on each side, following the directions shown in **Section 6** - **Laying the Wall.** Once again, leave out a pin in the hole closest to the short face of the corner.

3. Continue this procedure for each course, alternating the corner units 90° every course to maintain the running bond pattern. Use a *Universal Coping Stone* as a cap to finish the corner.

Inside Corners using Stonewall

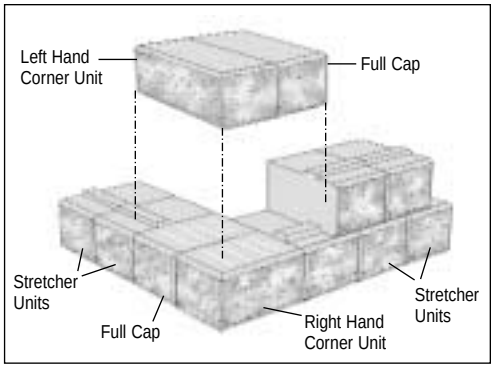


If your wall has inside corners, **Stonewall** gives you several choices here as well. You can build them as a *concave* curved wall or at 90°.

When building them at 90°, one method is to abut one of the walls against the other using *Half* units in every other course to keep it flush to the adjoining wall. Another way ties the walls into each other by overlapping units from one wall into the other in alternating courses. Be sure to apply ***SRW Adhesive*** to the units in the corner in every course.

Outside Corners using Pisa II/Roman Pisa

Building outside corners with **Pisa II** and **Roman Pisa** is also easy. They are constructed using *Full Caps* and *Right* and *Left Hand Corner* units. When ordering, be sure to specify the height in order to get the right amount of each type. Follow these simple steps to construct 90° corners.



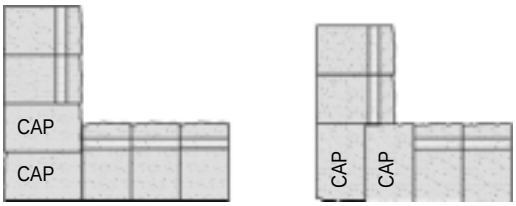
1. Carefully position a *Right Hand Corner* unit first. Place a *Full Cap* unit beside it to the left. Using a level, align and plumb the units. Continue the wall on each side using **Pisa II** or **Roman Pisa** *Stretchers* as described in **Section 5** - **Installing the First Course**.

2. For the second course, select a *Left Hand Corner* unit and position it onto the *Right Hand Corner* and *Full Cap* below. Next place a *Full Cap* beside it to the right and continue the second course using *Stretcher* units.

3. Continue this procedure for each course, alternating the *Right* and *Left Hand Corner* units every course to maintain the running bond pattern. When the wall reaches the height you desire, use a *Universal Coping Stone* or **Roman Pisa** *Coping* as a cap to finish the corner.

Inside Corners using Pisa II/Roman Pisa:

Inside corners are also easy to build. Use 2 *Full Caps* for every course at the intersecting corners, alternating each course as you build. Apply ***SRW Adhesive*** for added strength.



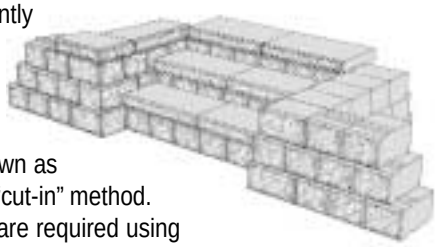
Alternating Courses

Note: Regardless of the type of system used, you must apply several 3/8" beads of ***SRW Adhesive*** to the top of each corner unit immediately prior to placing the successive corner block. If your wall has 90° corners on each end, it will be necessary to cut units within the wall to accommodate the wall batter and to maintain the running bond pattern.

Stairs

A stairway built into a segmental retaining wall adds a functional and beautiful dimension to any landscape design. Building stairs is relatively simple...SRW units are used for the side walls and risers and *Universal Coping Stones, Revers-a-Caps, Full Caps,* or *Roman Pisa Coping Stones* are used for treads.

While stairs can be created in a number of configurations, the basic construction techniques are the same. Most stairs are 48" wide; otherwise lay them out in multiples of 12" for **Stonewall** and 8" for **Pisa II** and **Roman Pisa**. You will also need to build a corner on each side of the stairs where you wish to incorporate them into the main wall. It is best to construct the corners and side walls independently of the risers.



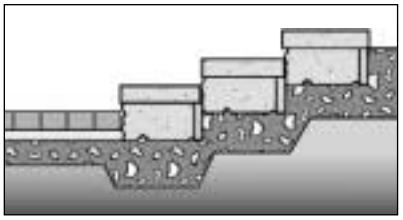
There are two methods for building stairs. They are known as the "fill" method and "cut-in" method. Although more units are required using the "fill" method, it may prove faster and easier, especially if there are a small number of steps. Simply excavate the entire stairway area straight back, then place and compact a 6" thick gravel base as a level foundation. Multiple courses of SRW units are then used to build up the risers for the number of steps you want. The rise with **Stonewall** will be 8", while with **Pisa II/Roman Pisa** the rise will be 6".

With either method, first determine the location of the stairway. Allow enough space behind the wall, as each stair will step-back 12". Usually, the corners and side walls are constructed independently of the risers.

The "Cut" Method

With the "cut" method, a gravel base is used under each stair. An advantage to this procedure is that it allows you to adjust the height of the rise. Generally, 6" to 8" is acceptable, although local building codes may specify the required height. The depth of the excavation will depend on the height required for the risers and the coping style used. The height of the first riser should measure from the top of the tread to the finished grade.

Stonewall - Start with the corners and build them as you normally would in the style you want, either curved or 90°. To avoid the automatic step-back as you construct the side walls, do not use the pins to connect the full size **Stonewall** units. Instead, lay each course **vertically, with no setback** and bond the units together using our ***SRW Adhesive.*** Otherwise, you will need to cut the riser and coping units to fit the space created by the step-back developed in the side walls.



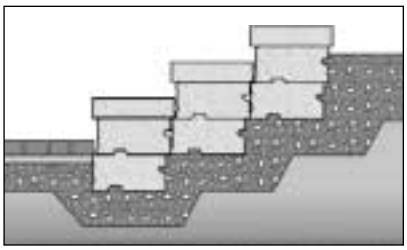
Once the side walls have been erected, you can start the stairs at the front or set them in from the corners. At least one full size **Stonewall** is used under each stair tread to provide stability. The depth of the excavation will depend on the height required for the risers and coping style used. Install and compact a 6" gravel base as the footing. Place a row of **Stonewall** units onto the base across the width of the stair opening and level them front to back and side to side. Fill the open cores of the units and the spaces between them with 1½" processed gravel and sweep the units clean. If you have decided to use two courses of **Stonewall** units for each stair, insert the pins and position the second row.

Construct the next riser assembly by placing and compacting another 6" thick gravel footing behind the first course of units. Now place a row of **Stonewall** units onto the base and position them directly behind the units in front. Finish as noted above. Install successive risers in the same manner for the number of stairs needed.

Pisa II/Roman Pisa - Risers are constructed using a **Pisa II** or **Roman Pisa** *Stretcher*, a *Full Cap* and a coping unit for the tread, although you can choose to use *Full Caps* as the tread if desired. Depending on the style you use, you must then determine the height of the rise.

Start by building corners, as described in the **Corner Section**, on each side of the stairs. To construct the side walls, we recommend using *Full Caps* to avoid the automatic step-back created by the tongue and groove molded into the *Stretcher* units. Lay all the courses in the side walls **vertically, with no set-back.** Be sure to bond the units together with ***SRW Adhesive.*** Backfill with ¾" stone as you go up, and don't forget to use filter fabric to keep the soil from infiltrating the stone.

Once the side walls have been erected, you can start the stairs at the front or set them in from the corners. The depth of the excavation will depend on the height required for the risers and the coping style used. The height of the first riser should measure from the top of the tread (or *Full Cap* if a coping unit is not used) to the finished grade. Install and compact a 6" gravel base as the footing. Place a row of *Stretchers* onto the base and carefully level them front to back and side to side. Next, place the second course using *Full Caps*.



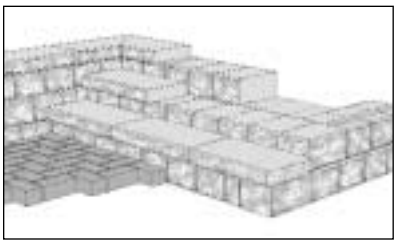
Construct the next riser assembly by placing and compacting another 6" thick gravel footing behind the first course of units. Now position a row of *Stretchers* onto the base and position them directly behind the *Full Caps* in front. Complete the riser by placing *Full Caps* for the second course. Install successive risers in the same manner for the number of stairs needed.

Treads

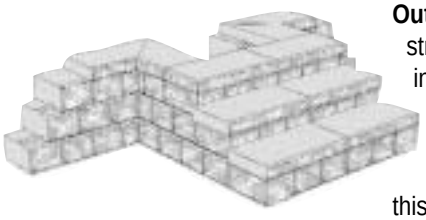
Once the stair risers have been constructed, you will need to set the treads. Adhere the style coping unit you have selected with ***SRW Adhesive*** as instructed in **Section 7 - Capping the Wall**. Position the treads to provide a 1" overhang. Allow the adhesive to cure at least 24 hours before opening the stairs to traffic.

Tip: *Consider using our Bullnose Coping paver units for treads.*

Other Step Options with Pisa II and Roman Pisa



Perpendicular – This structure is simply a wall with an inside and an outside corner, and the courses of the wall between the two corners step back at 12" per course. Install the units for the riser courses as previously explained, then finish by placing our *Universal Coping Stones* for the treads.



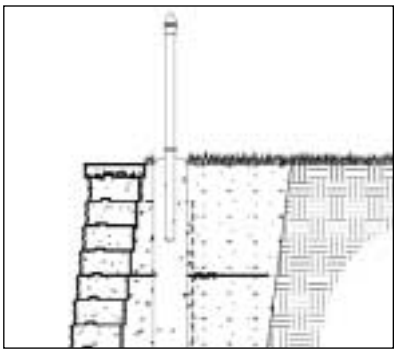
Outset steps – This structure is constructed in the same manner as the perpendicular steps, one course at a time. However, with this arrangement, it is necessary to construct two inside corners, and two outside corners. To avoid a step-back, use only *Full Cap* units for the side walls, making sure to adhere them with ***SRW Adhesive***. Otherwise, the side walls will batter toward each other by $^{3}/_{4}$" inch per course and each riser will be $1^{1}/_{2}$" narrower than the course below.

Terraced Walls

Terraced or tiered walls are often used for aesthetic reasons to suit a particular landscape design scheme. In some cases, they have been used as a means of avoiding building a wall over 4' by breaking it into two walls. While it may seem logical to do so, it may contradict sound engineering principles used in calculating factors of safety for conventional gravity wall designs. If the upper wall is within a horizontal distance of less than twice the height of the lower wall, a surcharge load will be applied to the lower wall and geogrid reinforcing may be required. In this case, the two walls model the structure of a single taller wall and engineering analysis for the wall should be sought.

Rule of Thumb:
A terraced wall should be set back a distance equal to, but not less than, twice the height of the lower wall in front. For example, if the lower wall in front is $3^{1}/_{2}$' high, the tiered wall behind it should be built at least 7' back.

Fences/Parking Areas



Generally, building codes will determine the height at which a fence is required along the top of a wall, although you may want to install fencing at lower heights. Fencing should not be anchored to the top of the wall regardless of height. As you erect the wall, place a cardboard construction tube behind the wall and compact the soil around it. If the wall is reinforced with geogrid, cut holes in the layers of grid that surround the tube. Once the wall has been brought to its finished elevation, position the fence post in the tube and set it using standard procedures by filling the tube with concrete.

Rule of Thumb:
Place posts and guard rails a minimum distance of 3' behind the back of the wall units.

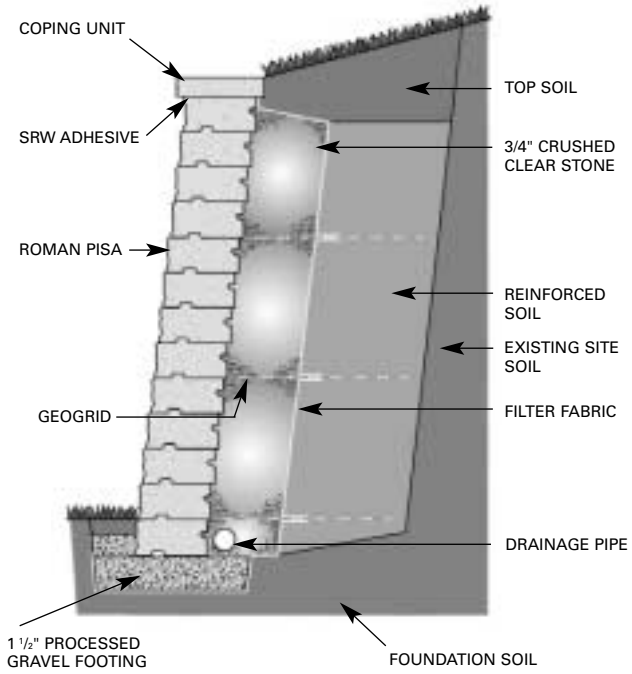
If the wall is going to support a parking area, it will be necessary to install guard rails along the top. Guard rails are installed in a similar manner to fence posts. Follow the customary procedures recommended for the particular type being used.

GEOGRID-REINFORCED MSE STRUCTURES

A MSE retaining wall system combines the beauty and strength of a segmental retaining wall system with geosynthetic soil reinforcement techniques to create taller, more cost efficient walls as compared to traditional retaining wall structures.

Geogrids are used to stabilize a retaining wall structure by reinforcing the soil behind the wall, thereby increasing the mass of the entire structure. The mechanically stabilized wall resists loads, surcharges, and poor soil conditions. A geogrid-reinforced segmental retaining wall is an alternative to conventional poured in-place gravity or cantilevered retaining walls used in many civil engineering structures. This reduces the load carrying requirements of the facing elements, thus decreasing the cost of the wall's construction. The result is a savings in costs, material, and time.

Typical MSE Retaining Wall Cross Section



Geogrid Placement Procedures

Generally speaking, the grid is placed on the wall units, extended back onto the compacted gravel, back-filled, and compacted. As courses of units are added and back-filled, additional layers of grid are placed at appropriate heights. The number of layers and length of geogrid depend on several conditions, including the type of soil being retained. Poor draining soils, such as clay, require more geogrid than granular soils, which drain well.

1. Build the wall to the required height for the first layer of geogrid following the directions shown in the **Construction Section**. Be sure that the drainage and infill zone behind the units have been properly back-filled with ¾" stone and soil, respectively. The fill should be compacted with soil in 3"- 4" lifts to obtain a minimum 95% standard Proctor density and leveled with the top of the wall. Sweep the top of the units clean.

2. The grid shall be rolled out, cut to specified length, placed onto the wall units, and then extended back onto the compacted soil. Overlap the adjacent sections of grid by 4".

Rules of Thumb: Grid
- The grid should be unrolled in a direction perpendicular to the wall!
- Maximum spacing of grid should not exceed 2'.
- Length of geogrid is equal to 0.6 - 0.7 of the wall height for level walls with no surcharge.

3. Place the next course of SRW units, taking care that the grid sits flat and is securely between the units.

4. Pull the geogrid away from the back of the wall until it is taut and free of wrinkles.

Tip: *Use pins, staples or sand bags to ensure there is no slackness prior to placement of the nest layer of infill soil. Remove when covered with soil.*

5. Place the next layer of infill soil on top of the geogrid by beginning near the wall fascia and spreading it back across the grid. Backfill in 3"- 4" lifts, using only vibratory plate compactors within a 3' area from the back of the wall.

Rules of Thumb: Equipment
- Do not use heavy compaction equipment within 3' of the back of the wall.
- No tracked construction equipment shall be allowed to operate directly on top of the geogrid until at least 6" 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.

6. Place soil in the rest of the infill area in maximum lifts of 6" and compact to obtain a 95% standard Proctor density

7. Continue to place additional courses backfilling with stone and gravel as every course is laid.

Tip: *To place the geotextile fabric, that is used to separate the drainage stone from the infill soil, between layers of grid "pillow" it back into the infill soil.*

Corners

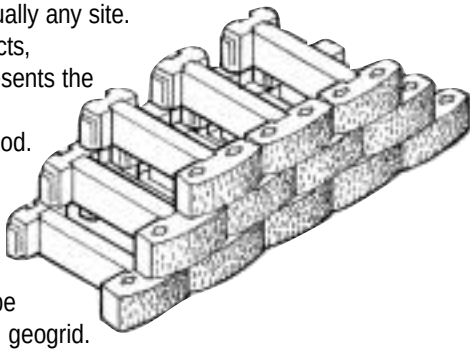
When placing grid in corner locations, never overlap layers of grid directly on top of each other. Provide at least 3" of soil between layers for proper anchorage if both layers are placed in the same SRW elevation.

For additional information, see the design charts on page 29.

GRAVITYSTONE®

GravityStone is the next generation of segmental retaining wall systems. It combines the simplicity of easy-to-handle dry stack units with the superior earth retention capabilities of crib wall structures. Its unique and patented components interconnect to form a structural wall system that enables construction of single-cell, multiple-depth gravity structures, or MSE walls.

With the capability of modular cell or geogrid reinforced design, **GravityStone** offers designers and builders a choice of wall systems to fit virtually any site. In "cut" wall projects, **GravityStone** presents the most economical construction method. Excavation is minimized, less equipment is required, and higher walls can be built without using geogrid.



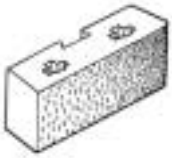
Compared to typical crib wall systems, **GravityStone** components are significantly lighter in weight which results in a labor savings as much as 20%! In "fill" wall applications, where circumstances are more suitable for earth stabilization, **GravityStone** also offers advantages over conventional segmental wall systems by reducing the amount of geogrid by as much as 50%! And unlike conventional segmental wall systems, **GravityStone** can be used to construct substantial, free-standing, double-sided walls!

GETTING STARTED

Installation of **GravityStone** is quick and easy. Adequate planning is essential to executing a fast, smooth, and efficient installation. Familiarity with the **GravityStone** products offers the installer many options for optimizing efficiencies and costs of constructing retaining walls. This section provides a working explanation of the fundamental construction procedures that will help to ensure the dependable performance and economic value of **GravityStone** retaining walls. While specialized installation details are shown in the **Details Section** on page 20, please consult the **GravityStone Contractor's Manual** for complete information when using **GravityStone** under the most demanding loading conditions.

COMPONENTS

The **GravityStone** system is comprised of three basic units: *Face*, *Trunk* and *Anchor/Junction*. The patented system is light in weight, easy to handle, and forms a strong wall with the use of "GridLock" interlocking couplings.



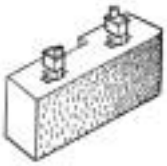
Face: The standard unit for all cell configurations. It is available in a straight split-face and a tumbled surface finish.
18"w x 8"h x 6"d • 62 lb/pc • 1 sf/pc

Trunk: Connects the *Face* and *Anchor/Junction* to complete the structural assembly for each cell.
23 5/8"l x 8"h x 3 5/8"w • 53 lb/pc

Anchor/Junction: Connects to the *Trunk* and creates passive resistance to prevent the cell from moving outward. It also provides the connection for additional cells in multi-cell structures. The *Anchor/Junctions* can be used to connect to *Face* units as a **Mini-Cell** or **Double-Sided Mini-Cell** assembly. 11 5/8"l x 8"h x 4 5/8"w • 29 lb/pc

The following components complete the **GravityStone** system:

Corner Unit: This unit is used to construct outside corners.
15"l x 8"h x 6"d • 52 lb/pc

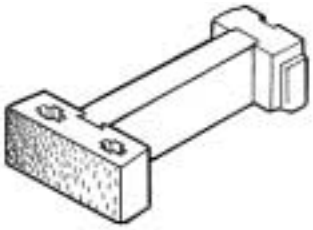


Plugs: Connects the *Face* units in one course to the *Face* units in the next course. The patented design allows them to be reversed to achieve a vertical or battered wall with a 5/8" setback per course or 1" per foot of wall height (4.5 degree batter).

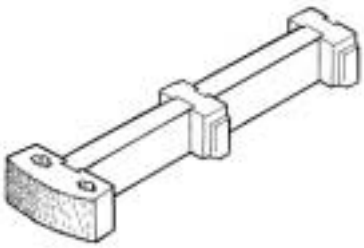
GRAVITYSTONE CELLULAR ASSEMBLY

The units comprising the **GravityStone** system assemble into various cellular configurations to create a large, stable wall mass. The assembly is created by interlocking the "GridLock" couplings molded into each unit.
The three primary assemblies are:

Single-Cell: Consists of a *Face* unit, a *Trunk* unit, and a *Anchor/Junction* unit.
The effective overall dimensions are:
18"w x 8"h x 32"d
Effective depth = 32"



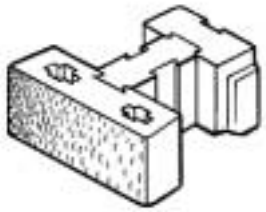
Multi-Cell: Consists of a *Face* unit, multiple (2 or more) *Trunk* units, and multiple *Anchor/Junction* units. The effective overall dimensions are:
18"w x 8"h x varying depths shown below:



2 cell effective depth = 58"
3 cell effective depth = 84"
4 cell effective depth = 110" ***For each additional cell add 26"***

Note: Although some illustrations show a curved face unit, only the straight face units are available.

Mini-Cell: Consists of a *Face* unit, and two *Anchor/Junction* units. The effective overall dimensions are: 18" w x 8" h x 21" d



CHOICE OF SYSTEMS

GravityStone can be classified into two types of wall systems:

- **Modular:** Where only **GravityStone's** concrete elements are used. May be comprised of single and/or multi-cell assemblies.
- **MSE:** Where the use of geogrid is incorporated.

DESIGN SELECTION -
"The Product Fit to the Site"

Both **GravityStone** systems are suitable for any retaining wall application and can even be combined on the same wall or project. To determine the best solution and most cost-effective system for a project, a thorough analysis should be conducted by a qualified engineer.

The following is a comparison of their basic advantages:

Modular - If the site has a "cut" embankment, Modular construction generally is the most cost efficient. With well-draining type soils, walls as high as 8' can be built using the **Single-Cell** assembly, or up to 15' with **Multi-Cell** construction. Modular construction also gives you the option of building the wall vertically, with a batter, or using an inclined base with a vertical plug alignment to create a straight wall column. This feature is helpful for sites that require a high wall within limited space constraints.

MSE - If the site is a "fill" embankment where a considerable quantity of additional backfill is necessary, MSE walls are generally the most cost effective because lower quality soils are permissible. Because **GravityStone** structures are larger than conventional segmental retaining walls, the amount of geogrid required may be reduced by as much as 50%! Walls, with little or no surcharge, can be built as high as 15' by using geogrid in conjunction with a **Mini-Cell** construction assembly (*Face-Anchor/Junction-Anchor/Junction).* For taller walls, or those subject to surcharge and back slopes, the **Single-Cell** assembly (*Face-Trunk-Anchor/Junction),* combined with geogrid, is best.

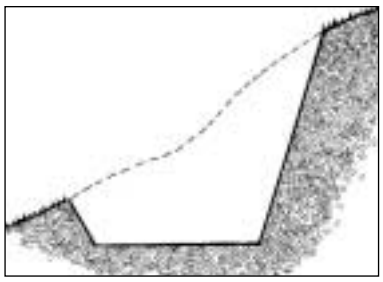
CONSTRUCTION

Please review the **General Conditions** and **Planning** sections on page 7 for an overview on project design guidelines and preparation for segmental retaining walls.

1. Excavating

Staking out the wall - Start by staking out the location of your wall. Excavate the area to the lines and grades shown on the approved plans. The wall location is especially important on outside (convex) curves where the step-back of the units will decrease the radius of the curve as the wall goes higher. See the section on **Curved Walls** for more information. If your project is a "cut" wall, allow approximately 12" of working space behind the wall. Take precautions not to over-excavate and always maintain safe slopes parameters per OSHA requirements. Also, carefully consider the effect construction will have on nearby structures and parking areas. Make sure not to undermine or encroach upon the foundation supporting these structures in any way.

Trench - Once you have staked out the location of your wall, excavate a trench at least 14" deep. Dig deep enough for a 6" thick gravel base and to embed the first row of units below finished grade. The width (front to back) of the base depends on the assembly chosen. Dig wide enough to accommodate the number of cells required, plus an additional 6" in front and 6" in back. For **Single-Cell** walls, the width for excavation is 44"; each additional cell requires an additional 26".



Note: If the height of your wall above finished grade is less than 4', use a 4" thick gravel base and bury the first course only 4" below finished grade. If your wall is greater than 8' high, you will need to bury your first course an additional 1" for every course of units over 8' high so it will necessary to excavate deeper. For example, a 10' high wall will require a 17" deep trench to accommodate a 6" base and 11" of units below grade. It will also be necessary to embed the first course deeper when the area in front of the wall slopes down.

If the wall is to step-up into a slope at different levels, start at the lowest point and excavate each rise in elevation in 8" increments. If the wall has multiple step-ups, be sure to allow for the $^{5}/_{8}$" step-back that occurs in every course for each 8" increase in height.

The soil at the bottom of the trench must be firm and stable. Remove all loam, grass, roots and large rocks. If necessary, continue to excavate until you reach granular type soil such as GP, GW, SP, or SW soil types for optimum stress distribution and drainage. Using a plate compactor, tamp the bottom of the trench until it is level and firmly packed. Next place filter fabric over the bottom and sides of the trench. Extend enough fabric up the back side to completely cover the embankment in order to prevent soil from washing into the crushed stone. Overlap sections of fabric by at least 12".

Rule of Thumb:
Foundation soil shall be compacted to at least 95% Standard Proctor density.

2. Installing and Compacting the Base

The material for the base, or footing as it is sometimes called, should be well-draining gravel consisting of coarse granular

material. We recommend **1 1/2" processed gravel** or **crusher run**. ***Note:*** *In some cases, the engineer may specify the use of 3/4" stone as a blanket drain.*

Fill the trench with about 3" of gravel, then level and compact it thoroughly with the plate compactor. When the gravel has been thoroughly compacted, add the next layer. Add and compact enough gravel until the base is 6" thick and the top 8" below finished grade. As noted earlier, the thickness and elevation of the base will be deeper for walls over 6' high.

Note: In some instances, it may be advantageous to construct an inclined base to develop additional batter. See the **GravityStone Manual** for complete information.

Tip: *To facilitate the compaction process, wet but do not saturate the material with water.*

Rule of Thumb:
The base shall be compacted to at least 95% Standard Proctor Density.

Tip: *For long walls with minimal elevation changes, you might consider using Flowable Fill to construct the base instead of compacted gravel.*

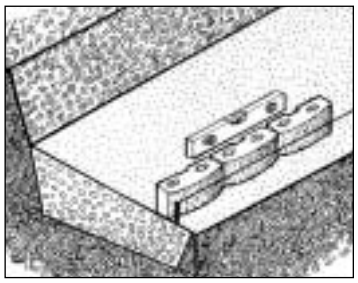
Rule of Thumb:
Foundation soils with a low bearing capacity, areas with the water table close to the foundation, or submersed foundations require different designs and stabilization techniques with products such as Turfstone.

3. Installing the First Course

The first course of units is the most important and takes the longest time to install. Once you have positioned and leveled the units in this row, you will be able to place subsequent courses quickly and easily.

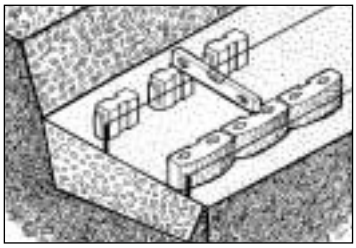
Tip: *To make leveling easier, spread and compact up to 1/2" of coarse concrete sand on top of the compacted base material.*

Face Units - Snap a chalk line on the base or drive stakes and pull a string line to mark the location of the front of the wall. Start by placing the *Face* units directly on the base along the chalk or string line. Use a carpenter's level to align and level each unit from side to side and a torpedo level from front to back. Lay the units side by side along the length of the footing, carefully following the desired alignment of the wall. Adjust the spacing between units for curved sections as needed. If your wall steps up, begin at the lowest level of the excavation.

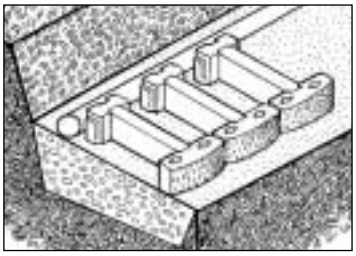


If your wall has 90° corners, it is best to start from a corner. See the **Details Section** for more information on building corners. You can also start next to a fixed structure such as the foundation of a house.

Anchors - Use a three-foot level with an offset mark to position the anchors at the appropriate distance behind the faces. For Single-Cell assemblies, the distance is about 22" behind the *Faces*. A string line may also be used to assist in the proper placement. Verify that the *Anchor/Junction* units are level from side to side and from front to back as you proceed.



Trunks - Now slide a *Trunk* unit into a *Face* and *Anchor/Junction* by engaging the "GridLock" couplings. You now have a **Single-Cell** assembly of **GravityStone**. Continue this procedure for the entire course. Verify that the cells are level and positioned properly.



Tip: *Once the Trunk unit is started into the Face and Anchor/Junctions, slightly lift and adjust the Anchor/Junctions to ease the placement of the Trunk.*

Inserting Alignment Plugs

The alignment *Plugs* are reversible. When placed in the forward position, the wall will lay up vertical. When the lugs are set to the back, the wall will batter back 5/8" for each course.

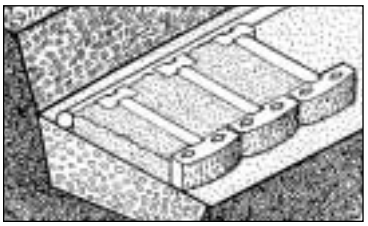
Tip: *Walls are stronger when a batter is used although curved walls are easier to build in a vertical alignment.*

Insert the alignment *Plugs* into the holes in the desired position. Two *Plugs* are required for each unit. Ensure that the flange on the alignment plug seats into the recessed void on top of the *Face* unit.

Drainage Pipe & Drainage Stone - After the first course has been installed, place perforated pipe, with the holes facing **down**, on the base behind the units along the entire length of the wall and several feet beyond. The pipe should be sloped at each end to allow gravity to flow any collected water beyond the wall. Some brands are sold already covered with a geotextile sock; otherwise wrap the pipe in filter fabric.

Filling the Cells

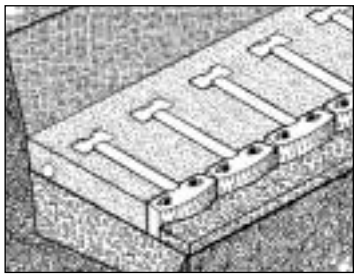
Unless otherwise instructed by an engineer, fill the cells with a #57 or #67 graded stone. Use a tamping rod to consolidate the stone in the cells. Tamp the stone level to the top of the units,



being careful not to move the units in any way. Be sure to verify the cells are level and positioned properly.

Rule of Thumb:
Never stack more than two layers of **Single-Cells** before placing and compacting the fill.

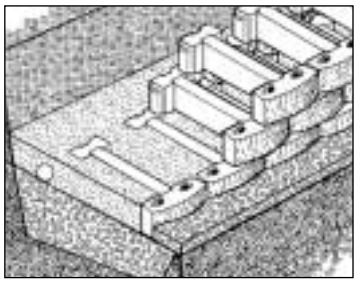
Next, fill and compact the trench on the front side of the units by using the same 1 ½" processed gravel you used for the base and then back-fill behind the cells with #57 or #67 graded stone. Sweep the tops of the *Face, Trunk* and *Anchor/Junctions* clean. off excess gravel.



Note: *If your wall requires a* ***Multi-Cell*** *assembly or geogrid reinforcement, review the instructions under the appropriate section that follows at this time.*

4. Laying the Wall

Second Course - Place the second course of *Face* units onto the first course taking care to engage the alignment *Plugs*. Position the units in a "running bond" pattern by staggering them so the joints occur over the middle of the unit below. Align the units to achieve a uniform appearance. Then place the *Anchor/Junctions* on top of the *Anchor/ Junctions* in the course below, straddling them for the length of the wall. Slide the *Trunk* unit into the *Face* and the *Anchor/Junctions*. Remember to slightly lift and adjust the *Anchor/Junction* units to help the *Trunk* slide in smoothly.



Tip: *Occasionally, it may be necessary to shim some units to maintain level coursing. Small pieces of plastic, asphalt shingles or galvanized wall ties work well for this purpose.*

Successive Courses - As you lay successive courses, you will need to cut some units in half to maintain the bond. If the wall is constructed with a batter, it will be necessary to cut some units in sections of wall between two corners. To maintain the integrity of the *Plug* holes, remove pieces of equal size from each end of the *Face* units. While a perfect "running bond" is not necessary, always maintain some stagger to the joints. Trim the face of the units as needed using a 3 lb hammer and mason's chisel or brick-set. **ALWAYS EXERCISE CAUTION AND WEAR SAFETY GLASSES AND A NIOSH APPROVED RESPIRATOR!**

Insert the alignment *Plugs* into the *Face* units in the proper position. Proceed with filling the cell assemblies with stone as previously noted. Backfill with #57 or #67graded stone, and if necessary, place and compact soil behind the wall.

Tip: *Double check for alignment (Plug position and orientation) and level, from front-to-back and from side to side, prior to filling.*

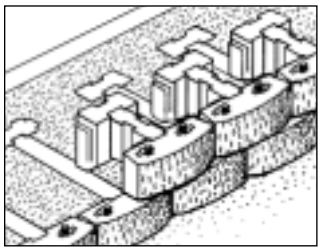
Subsequent Courses - Repeat this procedure for the remaining courses until you have reached the desired height of your wall.

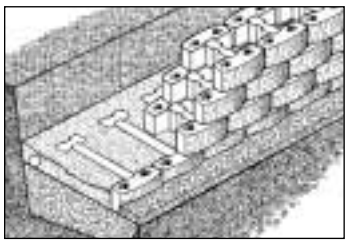
Tip: *Always select block from several pallets as you are installing to distribute the color uniformly.*

Rule of Thumb:
Use only hand-operated compaction equipment within 3' from the back of the wall.

Rule of Thumb:
The completed wall shall be within +/- 1.25", measured over a 10' distance, in either a horizontal or vertical direction compared to the design line and grade control.

Mini-Cell: In some instances, the last three courses can be constructed by using a **Mini-Cell** arrangement instead of the standard **Single-Cell** assembly. Unless otherwise designed by a qualified engineer, this applies only to walls without a slope or surcharge.

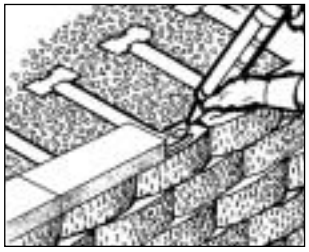




Double-Sided Mini-Cell: For projects where the back of the wall is exposed above grade, build a **Double-Sided Mini-Cell** configuration for an attractive finish on both sides of the wall by placing 2 **Face Units** back-to-back connected with an **Anchor Junction**.

5. Capping the Wall

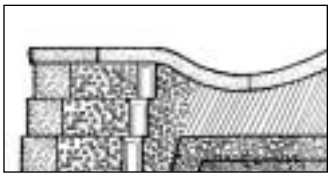
Finish the wall with our *Universal Coping Stone* unit. Position them flush to the front, or with a slight overhang. Secure them to the wall with our ***SRW Adhesive*** by applying several ⅜" beads to the top surface of the *Face* and *Trunk* units. It's best to do only 3 or 4



units at a time to prevent the sealant from skinning over. When setting the coping units, apply firm pressure to secure them in place. Allow 24 hours or so for complete curing.

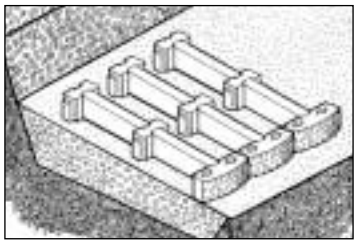
6. Finish Grading

To complete the project, fold the filter fabric over the drainage zone of 3/4" stone at the mid level of the next to last row and add a layer of low permeability soil to minimize water infiltration. Finish the grading so that water does not pond behind the wall. If necessary, construct a small drainage swale to collect and channel the water away, or grade the surface to direct water over the top and down the face of the wall. If landscaping is included in your contract, complete the project by placing topsoil for sod or plants.

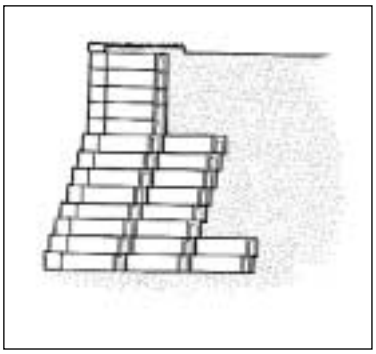


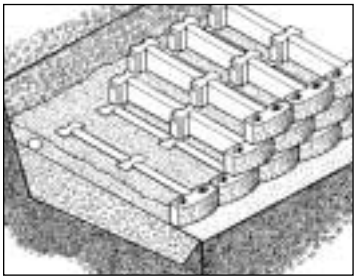
MULTI-CELL ASSEMBLY

For walls that will experience an increased load due to height, surcharge, or backslope, a larger structure consisting of additional cells with *Trunks* and *Anchor/Junctions* may be required. An engineer will determine the amount of cells and number of courses that will be required. This method is especially advantageous when weather conditions affect ability to place and compact the soil for conventional segmental wall systems using geogrid.



A multi-cell structure typically is wider at the bottom courses and narrows as the wall grows in height. For example, a 12' high wall could be constructed using three cells deep for the first 2 courses, two cells deep for the next 5 courses, and one cell deep for the next 9 courses.





To install the additional *Trunk* and *Anchor/Junction units,* simply repeat the steps described above. After the first cell has been assembled, place another row of *Anchor/Junctions* about 22" behind the ones in front. Then slide the *Trunks* in between them to complete the second cell assembly. Remember that all additional cells will need to be filled with gravel and compacted.

DETAILS

Curves

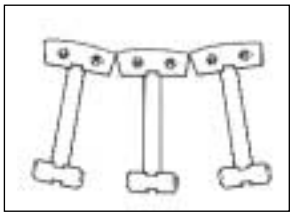
GravityStone is designed so that the *Plugs* that align the units are placed on the "quarter spot". This minimizes the difficulty of maintaining plug alignment when building curving walls. Unit placement for curves should be started at the central tangent and worked towards the free end. Start at the central tangent of smallest radius on walls with multiple curves.

Tip: *Eliminate some Anchor/Junction and/or Trunk units on curves and corners to facilitate placement.*

Layout

To layout a curved wall, an arc muct be struck along the soil to mark the proper location of the base. Start by determining the mid-point of the curve you wish to build, If constructing a concave (inside) wall, you must locate the center of the circle in front of the wall. To do so, pull a string away from the front of the wall. The length of the string should be equal to the length of the radius of the circle you wish to mark. Once the center of the circle has been located, drive a stake at the center point and swing an arc out to the front of the wall to mark the position of the base. If building a convex (outside) wall, locate the circle behind the wall and follow the same steps.

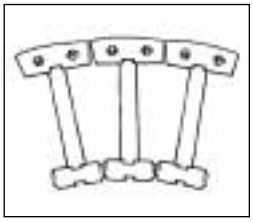
Concave Walls



Stacking the Block - When using a batter, the radius will grow wider the higher the wall is built. To minimize this effect, the height of the wall should be equal to or greater than the radius of the wall. Stacking the units with a zero set-back maintains the radius and helps to eliminate troubles in constructing radius walls. However, if there is batter in the main wall, then it must be continued in the concave wall section.

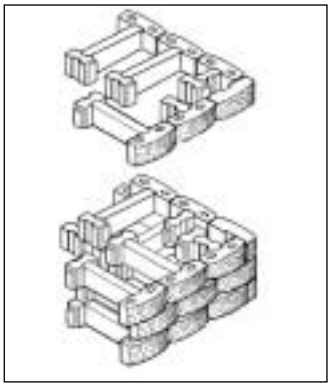
The Anchor - Concave walls cause the *Anchor/Junctions* to spread apart in a fan shape. In some circumstances, this may result a lack of support for the next course of Anchors. If this occurs, simply place other *Anchor/Junctions* at the location where the next course of *Anchor/Junctions* will rest.

Convex Walls



If a batter is being used, the radius will tighten the higher the wall is built. As long as the radius is equal to or greater than the height of the wall, the effects of the batter will be minimized. Making a slight gap between the units on the first course can also ease the effects of tightening of the wall. Additionally, using the plugs in a zero set-back will help eliminate any difficulty in creating a curved wall. However, remember to always maintain the batter that is being used in the main wall sections.

Outside Corners



90° Corner Unit - When incorporating corners, it is best to start the wall in the corner and build out. Follow these simple steps to construct corners with a 90° *Corner* unit.

1. Mark the location of the corner with a stake and use string lines to indicate the line of the intersecting walls. When digging the trench, allow extra space at the corner location.

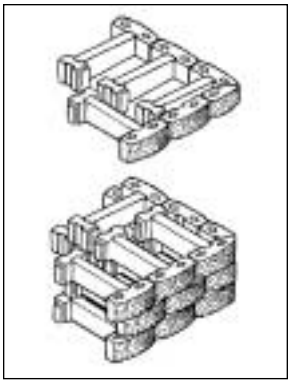
2. Once the gravel base has been placed and compacted to the desired elevation, mark the exact location of the corner. Use a builder's square to ensure an accurate 90° angle, or lay it out using the 3-4-5 triangle method.

Tip: *Snap a chalk line directly on the gravel footing as a guide to align the wall.*

3. Position a *Corner* unit on the base exactly where the intersecting lines meet in the corner. Then place **GravityStone** *Face* units on each side of it. Using a level, align and plumb the units. Install *Anchor/Junctions* to create a crossing pattern. Continue the wall on each side using *Face* units following the directions shown in **GravityStone Section 3** - **Installing the First Course**. However, do not insert a *Plug* in the closest hole of the unit sitting adjacent to the shortest face of the corner.

4. For the second course, position a *Corner* unit, in the alternate direction, onto the *Corner* and *Face* unit in place below. Place *Face* units on each side, following the directions shown in **GravityStone Section 4** - **Laying the Wall**, once again leaving out a *Plug* in the hole closest to the short face of the corner.

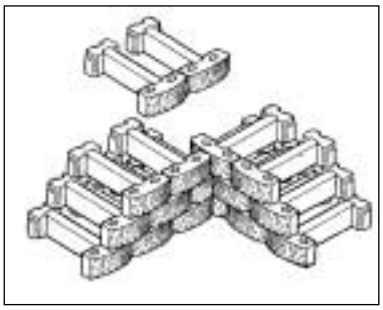
5. Continue this procedure for each course, alternating the *Corner* units 90° every course to maintain the running bond pattern. Use a *Universal Coping Stone* as a cap to finish the corner.



Mitered Corner Unit - A corner unit can also be created by mitering a **GravityStone** *Face* unit at a 45° angle. You will need to miter both half and full-size units. At the end of one wall, use a half-length mitered unit. At the end of the intersecting wall, use a full-length mitered unit. Align the wall ends by abutting the mitered ends. Alternate the half and full length units, from one side to the other, as the corner is built. Apply ***SRW Adhesive*** to the *Face* unit, which has no *Trunk* or *Anchor/Junctions.* Fill the units with drainage stone as the corner section is built.

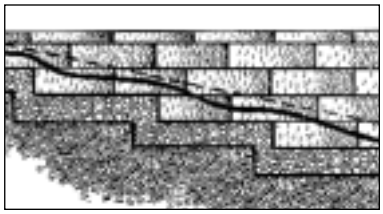
Inside Corners

To stack this properly, you must overlap the ends of the wall sections. The minimum overlap at the top course is 9". When building a vertical wall the overlap will be constant. However, if you are building a wall with a batter, the wall will step-back 1" for each vertical foot of wall. Therefore, the overlap in the 1st course must be increased to maintain the minimum 9" overlap in the top course. For example, a 10' high wall will require an additional overlap of 10" in the first course for a total overlap of 19".



Step-Ups

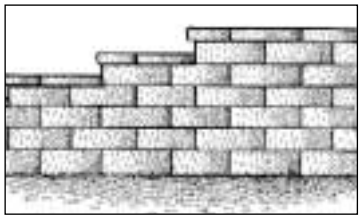
When building along the direction of a slope, the wall must be stepped in increments of 8". Do not attempt to slant the wall to the angle of the slope. When building a long wall with a batter, it will be necessary to gradually adjust the alignment of the base course. Remember that the wall will step-back 1" for every foot in height of grade change.



Ending the Wall

There are several ways to end a wall along a slope. One is to turn the units into the grade, burying at least one complete unit along the incline.

Another choice is to place a *Corner* unit at the end of every course that steps down to expose the split face at the end of the wall. Split a *Universal Coping Stone* into the appropriate corner piece and position it onto the units to attain a 1" overhang. Be sure to secure them with ***SRW Adhesive***.



Stairs

A stairway built into a **GravityStone** wall adds form and function. For efficient installation, we recommend you build the stairs independently of the side walls. You will also need to build a corner on each side of the stairs where you wish to incorporate them into the main wall. When using the *Face* units for risers, you will need to lay out the stair opening in multiples of 18". You can also construct the risers using **Stonewall** units, which would require laying out the stair opening in 12" increments.

Start with the corners and build them as you normally would. To avoid the automatic step-back as you construct the side

walls, set the Plugs forward to create a vertical rise. Otherwise, you will need to cut the riser and coping units to fit the space created by the step-back developed in the side walls.

Once the side walls have been erected, you can start the stairs at the front or set them in from the corners. How high you lift your foot and how much room you have to put it down is known as the "rise over run". The height of the first riser should measure from the top of the tread to the finished grade. For a 12" run, use 2 *Face* units, placed back to back, for the stair riser or use 1 **Stonewall** unit. If using **Stonewall,** follow the installation instructions under **Stair Construction** on page 13. If using the **GravityStone** *Faces,* put a few dabs of ***SRW Adhesive*** on the back of them to form a 12" deep module.

The depth of the excavation will depend on the height of the rise. Install and compact a 6" gravel base as the footing. Place a row of double module *Face* units onto the base across the width of the stair opening, and level them front to back and side to side.

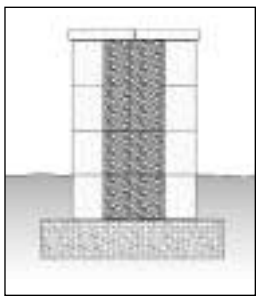
Construct the next riser assembly by placing and compacting another 6" thick gravel footing behind the first course of units. Position another row of *Face* units onto the base directly behind the units in front. Finish as noted above. Install successive risers in the same manner for the number of stairs needed.

Treads

Once the stair risers have been constructed, you will need to set the treads. We recommend our *Universal Coping Stone*, although other coping styles or natural stone treads can also be used. Adhere the style you have selected with ***SRW Adhesive***. Position the treads to provide a 1" overhang. Allow the adhesive to cure at least 24 hours before opening the stairs to traffic.

FREE-STANDING WALLS

Another advantage of the flexibility of the **GravityStone** components is their ability to create a dry stack, free-standing, double-sided wall. For walls under 4' in height, **Gravity-Stone** *Anchor/Junctions* are used to connect the *Faces.* **GravityStone** *Trunks* are used for walls in the 4' to 6' high range. Walls over these heights require the services of an engineer to determine additional requirements.



For **Double-Sided Mini-Cell** (*Face-Anchor/Junctions-Face)* configurations, the gravel base should be 34" wide and have a minimum depth of 8" and deep enough to accommodate one course of units below grade. For **Double-Sided Single-Cell** walls (*Face-Trunk-Face),* the dimensions of the gravel base should be 44" wide by 12" thick and deep enough to embed 12" of wall units below grade. Step the foundation in 8" increments to accommodate grade changes. Do not slant the wall along a slope. The cells are filled with 1 1/2" processed gravel or crusher run as the wall is built to add structural stability and resistance to wind loads. Finish the wall by securing the coping with our ***SRW Adhesive***.

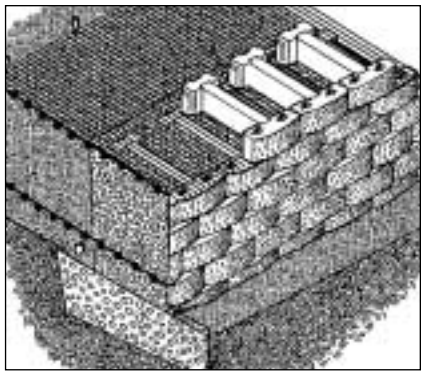
Tip: *For curved sections of the wall, do not connect the opposite Face units. Instead, lock the Trunk or Anchor/ Junctions into only one of the Face units (if necessary, shorten them to fit). The friction and weight of the gravel should hold them securely.*

GRAVITYSTONE WITH GEOGRID REINFORCEMENT

For walls that will experience increased loads due to height, surcharge, or backslope, additional reinforcement techniques may be required. One method is to use geogrid to reinforce the earth behind the wall. The number of layers, their positioning, and length, as well the strength of the geogrid material, are all variables that require evaluation and calculation. When using geogrid, the design must be prepared by a qualified professional engineer.

Installation

Place the geogrid over the top of the **GravityStone** units and position it as close to the front of the unit's face as possible. Cut out the material so that it does not go over the plugs. Extend the grid back onto the compacted gravel. Additional gravel is then placed on top of the grid and is compacted. As courses of units are added and back-filled, additional layers of grid are placed at appropriate heights. ***Geogrid materials can only be oriented one way. Be sure to determine the proper direction it should be placed!***



The number of layers and length of geogrid depend on several conditions, including the type of soil being retained. Poor draining soils such as clay require more geogrid than granular soils which drain well. Typically, grid should be placed every 2 or 3 courses and should extend back a distance about equal to three-quarters the height of the wall. Your engineer will be able to specify to number of layers of grid that will be required and how far back the grid should extend.

Note: Some designs may require a drainage chimney, made of 3/4" crushed stone, that extends vertically immediately behind the reinforced soil and geogrid area to collect and drain water off in order to prevent it from saturating the reinforced infill soil area.

For more information, see the **Geogrid Placement Procedures** section on page 15, the **GravityStone Manual**, or consult the design charts on page 29.

ESTIMATING

The length and total height of the wall must be measured first. If the wall changes in height or direction, or has curves, you should consider each change as a wall segment and estimate the amount of wall units by segment. The total height of the wall should include the coping unit and the number of courses buried below finished grade. It will be necessary to count the number of corners and, if included in the wall, the amount of PISA Lites™ and PISA Sounds.™

There are several ways to determine the amount of SRW units that are needed for a project.

Total Area Method - Calculate the total square footage of the wall by totaling the lengths of the wall segments. Next, multiply the total height of each segment by its length to find the area. Then add the segment areas to determine the total face area of the wall.

Now, multiply the total area by the number of pieces/sf for the type of wall unit.

- **Pisa II** or **Roman Pisa**, multiply the total square feet by 3.
- **Stonewall**, multiply the total square feet by 1.62.
- **GravityStone** - Because **GravityStone** walls may be comprised of more than one type of cell assembly, calculate the number of units that will be required by using the following chart. Simply multiply the number of each cell assembly type that will be used in your wall by the number of unit compents shown.

NO. OF UNIT COMPONENTS PER 1 SF FOR GRAVITYSTONE			
CELL TYPE	**FACE**	**TRUNK**	**ANCHOR**
Mini-Cell	1	---	2
Single-Cell	1	1	1
Double-Cell	1	2	2
Triple-Cell	1	3	3

Estimating Chart Method - Another way to estimate the number of units is to use the following charts as guides. With this procedure, calculate the length and height of each segment then refer to the chart to determine the number of units needed. Do this for each wall segment and total the amounts.

Corners - **Pisa II** *Corners* come as *Right* and *Left Hand* units. For corner construction, they are alternated every course. Count the number of corners in the wall. Either type can be used for the first course. Just count the number of courses for each corner. For even numbers, order an equal amount of *Right* and *Left* units. For an odd number of courses, order one more piece of the type used in the starter course.

Roman Pisa and **Stonewall** *Corners* are reversible. To order, simply count the number of corners in the wall, as well as the number of courses. Order one unit for each course of corners.

Note: Both **Pisa II** and **Roman Pisa** require an equal number of *Full Cap* units for every *Corner* unit.

Step-downs - *Corner* units are also used for step-downs. For **Pisa II**, be sure to order the proper type. When facing the wall, if the step-down is to the right, order *Right*-handed units; if to the left, order *Left*-handed units. Figure one per course. For **Roman Pisa** and **Stonewall**, simply order one *Corner* unit for every course that steps down and reverse them as necessary.

Half Units - *Half* units are generally required to maintain a running bond at the end of a wall that ends without a step-down or by curving back into the embankment. They are used in every other course for each end of the wall that terminates in this manner. *Half* units are made specifically in our **Pisa II** and **Roman Pisa** systems. For **Stonewall**, they may be cut from full size units or ordered as corner units, which double as half units.

Coping Units - To calculate the number of pieces needed, use one of the following formulae:

- *Revers-a-Cap:* Multiply the length by 1.6
- **Pisa II** and **Roman Pisa** *Full Caps:* Multiply the length by 1.5
- **Stonewall** *Caps:* Multiply the length by 1
- *Universal Coping Stone:* Multiply the length by .5
- **Roman Pisa** *Coping*: Multiply the length by .75

Geogrid - Geogrid quantities will vary significantly depending on the soil. Consult an engineer for a site-specific geogrid design. A rough estimate can be done using the one of the Strata Grid estimating charts. For the conditions that represent each wall section, multiply the wall segment length by the grid length and the number of layers of each geogrid type. Then add these quantities by geogrid type for the total amount required.

Processed Gravel (For Base 6" thick x 100 lf)

- **Stonewall:** 6-7 tons for 24" wide base
- **Pisa II/Roman Pisa:** 6-7 tons for 24" wide base
- **GravityStone:**
  - **Mini-Cell:** 8-9 tons for 34" wide base
  - **Single-Cell:** 11-12 tons for 44" wide base
  - **Double-Cell:** 17-18 tons for 70" wide base
  - **Triple-Cell:** 23 tons for 96" wide base

Unit Fill (per 100 sf of wall)

- **Stonewall:** 2 1/4 tons 3/4" stone
- **GravityStone:**
  - **Mini-Cell:** 4 tons #57 or #67 graded stone
  - **Single-Cell:** 8 tons #57 or #67 graded stone
  - **Double-Cell:** 16 tons #57 or #67 graded stone
  - **Triple-Cell:** 24 tons #57 or #67 graded stone

Drainage Zone (per 100 sf of wall)

- **Stonewall:** 5 tons of 3/4" stone
- **Pisa II/Roman Pisa:** 5 tons of 3/4" stone

Amounts shown are based on the approx. weights of: 115 lb/cu ft for 1 1/2" processed gravel or crusher run, 100 lb/cu ft for 3/4" crushed stone and 105 lb/cu ft for #57 and #67 graded stone.

SRW Adhesive

- **10 oz tube:** 14 lf @ 3/8" bead or 10 sf of wall area for Ashlars
- **29 oz tube:** 40 lf @ 3/8" bead or 30 sf of wall area for Ashlars

ESTIMATING CHARTS

NO. OF STONEWALL UNITS								
HEIGHT & COURSE		LENGTH						
		5'	10'	15'	20'	30'	40'	50'
8"	1st	5	10	15	20	30	40	50
16"	2nd	10	20	30	40	60	80	100
24"	3rd	15	30	45	60	90	120	150
32"	4th	20	40	60	80	120	160	200
40"	5th	25	50	75	100	150	200	250
48"	6th	30	60	90	120	180	240	300

Shaded row indicates the buried course

PISA II & ROMAN PISA SYSTEM COMPONENTS			
TYPE	SIZE	PCS/SF	APPROX. WEIGHT
Stretcher	6" h x 8" w x 12" d	3	45 lb/pc
Half	6" h x 4" w x 12" d	6	23 lb/pc
Corner - Right & Left	6" h x 8" w x 12" d	N/A	45 lb/pc
Full Cap	6" h x 8" w x 12" d	3	45 lb/pc
Roman Pisa Jumbo	6" h x 12" w x 8" d	2	45 lb/pc
Revers-A-Cap	3" h x 7/8" w x 12" d	1.6 pcs/lf	22.5 lb/pc
Universal Coping	3 1/4" h x 24" w x 13" d	2 lf/pc	79 lb/pc
Roman Pisa Coping	4" h x 12" w x13" d	1 lf/pc	34 lb/pc

NO. OF PISA II & ROMAN PISA UNITS (USING STRETCHERS ONLY)								
HEIGHT & COURSE		LENGTH						
		5'	10'	15'	20'	30'	40'	50'
6"	1st	8	15	23	30	45	60	75
12"	2nd	15	30	45	60	90	120	150
18"	3rd	23	45	60	90	135	180	225
24"	4th	30	60	90	120	180	240	300
30"	5th	38	75	113	150	225	300	375
36"	6th	45	90	135	180	270	360	450
42"	7th	53	105	158	210	315	420	525
48"	8th	60	120	180	240	360	480	600

Shaded row indicates the buried course

NO. OF UNITS IN ROMAN PISA PATTERNS (PER 100 SF)			
TYPE	STRETCHER	HALF	JUMBO
Ashlar Pattern #1	164*	110	56
Ashlar Pattern #2	164*	110	56
Ashlar Pattern #3	160*	42	80
Ashlar Pattern #4	168*	30	60
Stretcher & Half - 2:1 Ratio	240	120	---
Stretcher & Half - 4:1 Ratio	265	66	---

*Includes 8 Full Cap units for every 10' of closure row.

NO. OF UNITS FOR CAPS & COPING							
STYLE	LENGTH						
	5'	10'	15'	20'	30'	40'	50'
Pisa Full Cap	8	15	23	30	45	60	75
Revers-A-Cap	8	16	24	32	48	64	80
Universal Coping	3	5	8	10	15	20	25
Roman Pisa Coping	5	10	15	20	30	40	50
Stonewall Cap	5	10	15	20	30	40	50

NO. OF UNITS FOR EACH GRAVITYSTONE COMPONENT PER CELL ASSEMBLY (PER COURSE)							
TYPE	UNIT	LENGTH					
		15'	30'	50'	75'	100'	150'
MINI-CELL	FACE	10	20	34	50	67	100
	ANCHOR	20	40	68	100	134	200
SINGLE-CELL	FACE	10	20	34	50	67	100
	TRUNK	10	20	34	50	67	100
	ANCHOR	10	20	34	50	67	100
DOUBLE-CELL	FACE	10	20	34	50	67	100
	TRUNK	20	40	68	100	134	200
	ANCHOR	20	40	68	100	134	200
ADDITIONAL CELLS	TRUNK	10	20	34	50	67	100
	ANCHOR	10	20	34	50	67	100

Estimating Charts

These charts should be used as guides to estimate the number of units required to build a wall. Remember to allow a few extras for cutting and waste. Walls exceeding the heights shown on the charts require additional construction techniques and engineering consideration. Contact ***Ideal*** for additional information.

Color and Shading

All colored concrete products may have inherent color shading. Always select units from several pallets as you are installing to distribute the color uniformly.

To the best of our knowledge, the information contained in this guide is accurate. Ideal cannot assume liability whatsoever for the accuracy or completeness thereof nor do we guaranty or warrant the recommendations contained herein. A qualified engineer who is familiar with the conditions of a particular site and with the local construction practices should be consulted for guidance with design and construction recommendations. Final determination of the suitability of any information provided in this guide and its manner or use is the sole responsibility of the user.

GLOSSARY OF COMMONLY USED TERMS

Aggregate - Materials such as sand, gravel, and crushed stone.

Angle of Repose - The angle at which aggregate rests in a natural state.

Batter - The facing angle created by SRW unit set-back, measured from a vertical line drawn from the toe of the wall. Typical batter angles are 3° to 15° from vertical, sloping toward the infill soil.

Bearing Capacity - The load that a soil is capable of supporting without failure, significant settlement, or deformation.

Blanket Drain - A foundation pad of 3/4" stone extending behind the wall.

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

Coping - Top course of units on a wall that provide a finished appearance and tie the wall together.

Concave Curve - A wall that curves inward like the inside radius of a circle.

Convex Curve - A wall that curves outward like the outside radius of a circle.

Cut Wall - The embankment of site soil created before the retaining wall is installed.

Density - The quantity of mass per unit volume. Dimensions are expressed as lb/cu ft.

Drainage Chimney - A vertical drain constructed at the back the of the wall infill zone in order to intercept lateral groundwater flow toward the wall. Typically it is comprised of 3/4" stone which is protected by filter fabric. Solid plastic pipe is placed at the bottom of the chimney in order to direct collected water to the drainage pipe at the base of the wall for outfall.

Drainage Composite - A system, typically comprised of a dimpled plastic core with a geotextile fabric applied to prevent soil from clogging the drainage area. It is usually used to collect water behind the backfill, under the reinforced soil zone, or immediately under the SRW system.

Drainage Stone - Clean, uniform stone usually 3/4" in size that is used to fill the space behind the wall known as the drainage zone.

Drainage Zone - The space behind the wall that is filled with crushed stone to prevent water from accumulating behind the wall.

Embedment Depth - The distance the wall is buried below grade. Generally, embedment depth is expressed as the number of courses of units.

Efflorescence - A white deposit on the face of the units created by minerals carried to the surface by water.

External Stability - The summation of all forces acting on the retaining wall system. If unbalanced, a sliding, overturning, or bearing capacity type failure may occur.

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

Facia Connection Failure - A condition when the tensile load on the geogrid exceeds the strength of the geogrid/facing connection.

Fill Wall - Wall erected on a fairly level ground that will be backfilled for the purpose of changing the grade on the site.

Filter Cloth - See geotextile.

Foundation Pad - The base or footing which distributes the weight of the SRW units over the foundation soil and provides a level surface for the SRW units. Typically constructed of granular material, such as processed 1 1/2" gravel or 3/4" crusher run, although it can consist of non-reinforced concrete or flowable fill.

Foundation Soil - The soil which supports the leveling pad and the reinforced soil zone of a soil-reinforced SRW system.

Geogrid - A synthetic material formed into a grid-like structure for use in soil reinforcement. Usually comprised of polypropylene, polyester, or polyethylene.

Geogrid/Soil Pullout Failure - A condition when the tensile load on the geogrid exceeds the strength of the soil/ geogrid connection or development strength.

Geogrid Reinforced Retaining Wall System - An earth retaining structure that incorporates synthetic materials used to reinforce the soil mass behind the structure.

Geosynthetic - A generic term used to describe synthetic or plastic materials used in soil, such as fabrics, geogrids, drainage composites and erosion control mats.

Geotextile - A textile-like material used to separate soils. Usually comprised of polypropylene or polyester, and can be woven or non-woven.

Global stability - Resistance to overall mass movement of the SRW system in a circular mode. May be a problem with tiered walls, walls with weak foundation soils, and walls with a slope at the top or bottom.

Gravity Retaining Wall System - An earth retaining structure that uses its mass to resist the movement of the soil mass behind the structure.

HDPE - High density polyethylene. Usually refers to the material used to manufacture drain pipe or geogrid.

Infill Soil - Soil located behind the SRW units and drainage zone. May be reinforced with soil reinforcement.

Interface - The top and bottom surface area of wall units in contact with other units in adjacent courses.

Internal Friction Angle - A parameter used to identify a soil's shear strength. A higher value will equate to a greater strength.

Internal Stability - The summation of all forces acting within the retaining wall system. If unbalanced, a geogrid-soil pullout, tensile overstress, internal sliding, or facing connection type failure may occur.

Leveling Pad - Same as Foundation Pad.

Long-Term Design Strength - The allowable strength in the soil reinforcement at the end of the service life of the soil-reinforced SRW. It is the maximum load that the reinforcement can carry and is taken into account in the decision process.

MSE - Mechanically stabilized earth. Soil-reinforced SRWs are considered MSE structures.

Native Soil - Soil that exists on site.

Overturning - An external stability failure mechanism of an SRW whereby lateral external forces cause the entire reinforced soil mass to rotate about the base.

Permeable - The ability of a material to pass water.

Phi Angle - The internal friction angle.

Proctor (density) - A method used to determine the compaction or density of soil materials.

PVC - Polyvinyl chloride. Usually refers to the material used to manufacture drain pipe.

Reinforced soil zone - The area of a soil-reinforced SRW which contains the soil reinforcement.

Retained soil - The soil in the embankment behind the wall that is intended to be retained.

Running Bond - A pattern created by stacking wall units so the vertical joints are offset by half a unit from the course below.

Set-back - Same as batter.

Shear Failure - A condition when the force applied to the back of a unit exceeds the connection strength or shear strength between two adjacent courses.

Side Wall - The portion of a wall that returns at an angle from the main wall. On steps, they are the walls on each side.

Sliding - An external stability failure mechanism of an SRW whereby lateral external forces cause the entire soil mass to slide forward along its base or internally along a particular layer of soil reinforcement.

Sloped Toe - A sloped grade in front of the wall.

Soil-reinforced - An SRW which uses soil reinforcement to increase the mass and stability of the structure.

SRW - The acronym for segmental retaining wall.

Surcharge - External load, usually applied at the top of an SRW. A roadway or building foundation can be a surcharge.

Subgrade Soil - The in-situ, or existing, soil found on site.

Swale - A small ditch or depression formed on top and behind the SRW system to collect water and carry it away.

Unified Soil Classification System - Used to identify similar soil types.

CL – clay, low to medium plasticity
CH – clay, medium to high plasticity
GP – gravel, poorly graded, uniform size
GW – gravel, well graded, various sizes
MH – silt, high plasticity
OH – decomposed organic soil, high plasticity
OL – decomposed organic soil, high plasticity
Pt – peat, not fully decomposed

Wall Embedment - The depth of the courses of units that are buried below grade.

CONSTRUCTION OBSERVATION CHECKLIST

Site Conditions

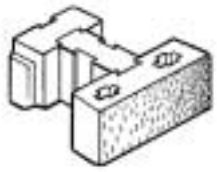
- ❑ Soil and fill material should not be frozen
- ❑ Foundation Soil – matches or exceeds soil type and strength assumed for design
- ❑ Retained Soil – matches or exceeds soil type and properties assumed for design
- ❑ Wall heights – do not exceed design heights
- ❑ Slopes – no steeper than design
- ❑ Loading – does not exceed design

Materials

- ❑ Drainage Aggregate – clean, 1/2" to 3/4", angular gravel (less than 5% fines)
- ❑ Segmental Unit- approved unit manufacturer, proper size and weight, conforms to ASTM-1372
- ❑ Shear Connectors – if pins or clips interlock units, they must be those made expressly for units
- ❑ Drainage Pipe – specified material type and minimum properties
- ❑ Geosynthetic Soil Reinforcement – specified type (any substitutions approved by engineer)

Installation

- ❑ Leveling Pad – installed to plan dimensions and compacted
- ❑ Drainage Aggregate – placed to thickness and depth shown on plans
- ❑ Drainage Collection Pipe – placed at plan location, sloped to create gravity flow of water
- ❑ Fill Placement and Compaction:
    - ❑ Maximum 8" (200mm) thick lifts
    - ❑ Reinforced (infill) soil compacted to 95% standard Proctor density
    - ❑ No heavy, self propelled compaction equipment within 3' (1m) of wall face
- ❑ SRW Unit Installation
    - ❑ Units level from front-to-back and side-to-side
    - ❑ Proper alignment and setback
    - ❑ Unit cores filled with aggregate in each course (if unit is cored)
    - ❑ Shear connection between units properly engaged per SRW manufacturer's details
    - ❑ Curve and corner installed per SRW manufacturer's details
- ❑ Geosynthetic Soil Reinforcement Placement:
    - ❑ Placed horizontally at plan locations
    - ❑ Proper length (L) as shown on plans
    - ❑ Placed in proper orientation – per geosynthetic manufacturers details (highest strength direction perpendicular to wall face)
    - ❑ Placed continuous along the face of the wall (100% coverage)
    - ❑ Placed to front of unit and connected between units per manufacturer's details
    - ❑ Nominally tensioned to remove any slack or wrinkles prior to backfilling
    - ❑ To prevent excessive damage, tracked equipment has not been driven directly on geosynthetic
    - ❑ Curves and corners installed per plan details or geosynthetic manufacturer's details
- ❑ Cap Unit – adhered with specified adhesive

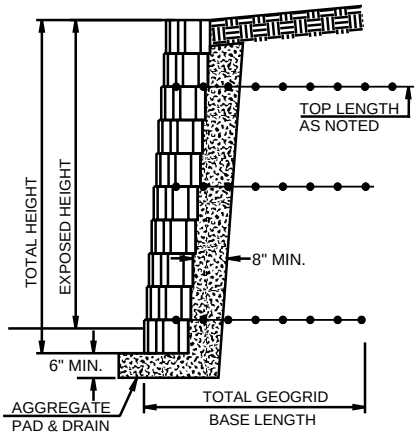


WESTBLOCK Systems

MINI-CELL - GravityStone MSE Retaining Walls

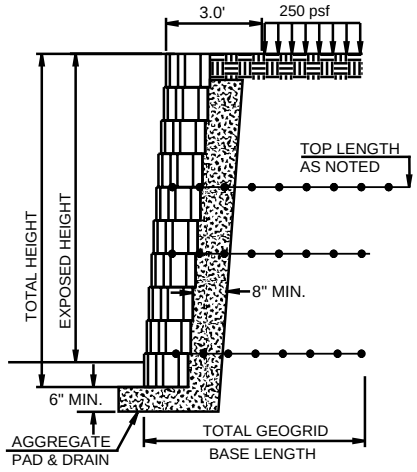
27° SAMPLE DESIGNS FOR CONSTRUCTION ESTIMATING

Use these charts when site soils can be conservatively represented with an angle of internal friction, $\phi \geq 27$ and a moist unit weight, $\gamma \leq 125$ pcf. This would be typical for most low plastic clays, silts, and mixtures with sand (CL, ML, SC, SM). Geogrid may be Miragrid 5xT or Tensar UX-1400SB.



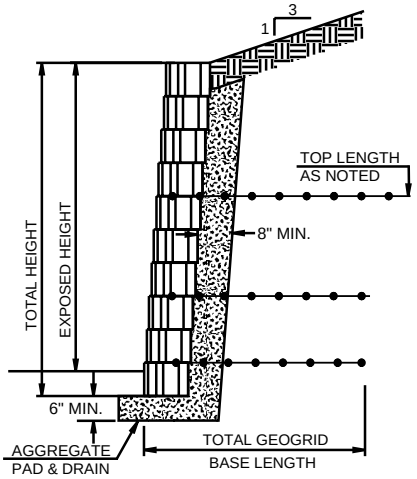
CASE 1: 27°, LEVEL TO 12H:1V BACKSLOPE

TOTAL HEIGHT (FT.)	COURSES OF UNITS	NO. OF LAYERS	GEOGRID BASE LENGTH	TOP LENGTH	GEOGRID PLACEMENT ELEVATION ON TOP OF COURSE NO.	ESTIMATED GEOGRID QUANTITY (SY/LF)	ESTIMATED UNIT FILL QUANTITY (CY/LF)	ESTIMATED REIN.SOIL QUANTITY (CY/LF)
2.0	≤ 3	0	--	--	NONE	0.0	0.14	0.0
4.0	≤ 6	1	--	3.0'	2	0.4	0.23	0.2
6.0	≤ 9	2	3.6'	4.7'	2, 5	1.0	0.31	0.6
8.0	≤ 12	3	4.8'	6.1'	1, 5, 8	1.8	0.40	1.1
10.0	≤ 15	4	6.0'	7.7'	1, 4, 7, 11	2.9	0.49	1.8
12.0	≤ 18	6	7.2'	9.2'	1, 3, 5, 7, 10, 14	5.0	0.58	2.7
14.0	≤ 21	7	8.4'	10.6'	1, 3, 5, 7, 10, 13, 17	6.8	0.66	3.9



CASE 2: 27°, LEVEL, 250 psf SURCHARGE

TOTAL HEIGHT (FT.)	COURSES OF UNITS	NO. OF LAYERS	GEOGRID BASE LENGTH	TOP LENGTH	GEOGRID PLACEMENT ELEVATION ON TOP OF COURSE NO.	ESTIMATED GEOGRID QUANTITY (SY/LF)	ESTIMATED UNIT FILL QUANTITY (CY/LF)	ESTIMATED REIN.SOIL QUANTITY (CY/LF)
2.0	≤ 3	0	--	--	NONE	0.0	0.14	0.0
4.0	≤ 6	1	3.9'	5.3'	2, 4	1.1	0.23	0.5
6.0	≤ 9	2	4.3'	6.0'	1, 4, 6	1.7	0.31	0.8
8.0	≤ 12	3	5.3'	7.8'	1, 3, 6, 9	2.7	0.40	1.4
10.0	≤ 15	4	6.4'	9.2'	1, 3, 5, 7, 9, 12	4.6	0.49	2.5
12.0	≤ 18	6	8.1'	10.7'	1, 3, 5, 7, 9, 12, 15	6.6	0.58	3.2
14.0	≤ 21	7	9.1'	12.0'	1, 3, 5, 7, 9, 11, 13, 15, 18	9.5	0.66	4.2



CASE 3: 27°, 3H:1V BACKSLOPE

TOTAL HEIGHT (FT.)	COURSES OF UNITS	NO. OF LAYERS	GEOGRID BASE LENGTH	TOP LENGTH	GEOGRID PLACEMENT ELEVATION ON TOP OF COURSE NO.	ESTIMATED GEOGRID QUANTITY (SY/LF)	ESTIMATED UNIT FILL QUANTITY (CY/LF)	ESTIMATED REIN.SOIL QUANTITY (CY/LF)
1.3	≤ 2	0	--	--	NONE	0.0	0.11	0.0
2.0	≤ 3	1	--	2.6'	1	0.3	0.14	0.1
4.0	≤ 6	2	3.6'	4.5'	2, 4	0.9	0.23	0.4
6.0	≤ 9	3	4.6'	5.7'	1, 3, 6	1.7	0.31	0.8
8.0	≤ 12	4	6.3'	7.6'	1, 3, 6, 9	3.0	0.40	1.5
10.0	≤ 15	6	7.9'	9.4'	1, 3, 5, 7, 9, 12	5.5	0.49	2.5
12.0	≤ 18	7	10.0'	11.3'	1, 3, 5, 7, 9, 12, 15	8.0	0.58	3.9
14.0	≤ 21	9	13.1'	13.1'	1, 2, 4, 6, 8, 10, 12, 15, 18	13.5	0.66	6.0

Estimated Quantity of geogrid in square yards per lineal foot of wall at that height
Excludes blanket and chimney drains
Excludes slope above top of wall

NOTES:
1. Sample designs prepared to the exact standards for non-critical structures in the "Design Manual for Segmental Retaining Walls" as published by NCMA (1997). Applicable building codes govern when they produce a more conservative design.
2. Sample designs for construction cost estimating of single-height walls only. All projects should be designed by a qualified engineer using actual design conditions for the proposed site. Tiered walls require specialized design procedures.
3. Sample designs have been exclusively for the engineering properties of GravityStone in conjunction with either Tensar UX1400-SB or MIRAGRID 5xT geogrid reinforcement. Geogrid reinforcement lengths are measured and installed from front face of the wall, backwards.
4. Sample designs require adequate drainage provisions for both reinforced wall fill and retained soil.
5. Compact drainage and reinforced fill in maximum 8-inch lifts according to project specifications, or as directed by the engineer.

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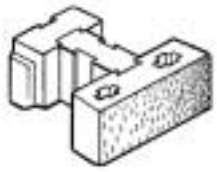
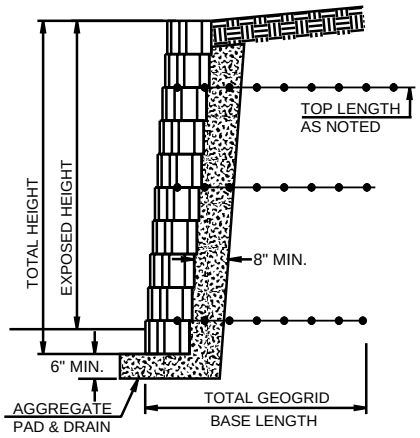


WESTBLOCK Systems

MINI-CELL - GravityStone MSE Retaining Walls

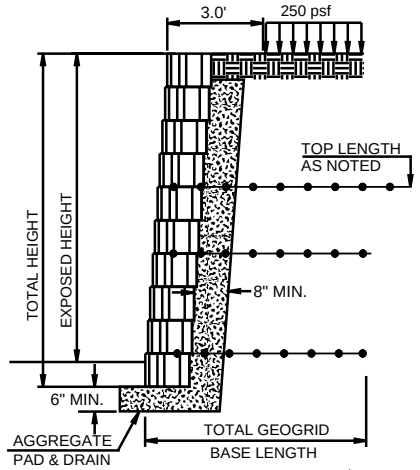
33° SAMPLE DESIGNS FOR CONSTRUCTION ESTIMATING

Use these charts when site soils can be conservatively represented with an angle of internal friction, $\phi \geq 33$ and a moist unit weight, $\gamma \leq 125$ pcf. This would be typical for most low plastic clays, silts, and mixtures with sand (CL, ML, SC, SM). Geogrid may be Miragrid 5xT or Tensar UX-1400SB.



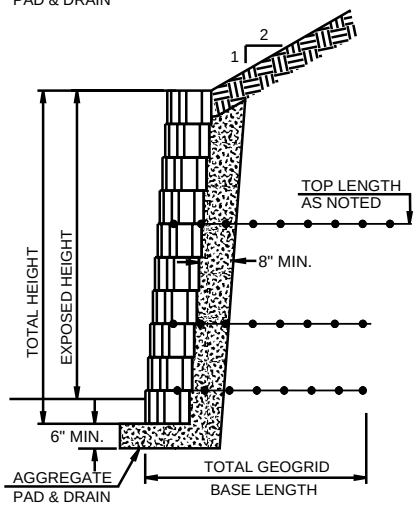
CASE 1: 33°, LEVEL TO 12H:1V BACKSLOPE

TOTAL HEIGHT (FT.)	COURSES OF UNITS	NO. OF LAYERS	GEOGRID BASE LENGTH	TOP LENGTH	GEOGRID PLACEMENT ELEVATION ON TOP OF COURSE NO.	ESTIMATED GEOGRID QUANTITY (SY/LF)	ESTIMATED UNIT FILL QUANTITY (CY/LF)	ESTIMATED REIN.SOIL QUANTITY (CY/LF)
2.7	≤ 4	0	--	--	NONE	0.0	0.17	0.0
4.0	≤ 6	1	--	3.5'	3	0.4	0.23	0.3
6.0	≤ 9	2	3.6'	4.5'	3, 6	0.9	0.31	0.6
8.0	≤ 12	3	4.8'	5.3'	2, 5, 8	1.7	0.40	1.0
10.0	≤ 15	4	6.0'	6.6'	2, 5, 8, 11	2.8	0.49	1.7
12.0	≤ 18	5	7.2'	7.8'	1, 5, 8, 11, 14,	4.1	0.58	2.6
14.0	≤ 21	6	8.4'	9.0'	1, 4, 7, 11, 14, 17	5.7	0.66	3.6



CASE 2: 33°, LEVEL, 250 psf SURCHARGE

TOTAL HEIGHT (FT.)	COURSES OF UNITS	NO. OF LAYERS	GEOGRID BASE LENGTH	TOP LENGTH	GEOGRID PLACEMENT ELEVATION ON TOP OF COURSE NO.	ESTIMATED GEOGRID QUANTITY (SY/LF)	ESTIMATED UNIT FILL QUANTITY (CY/LF)	ESTIMATED REIN.SOIL QUANTITY (CY/LF)
2.0	≤ 3	0	--	--	NONE	0.0	0.14	0.0
4.0	≤ 6	1	3.0'	4.0'	2, 4	0.8	0.23	0.3
6.0	≤ 9	2	3.6'	4.7'	2, 4, 6	1.4	0.31	0.6
8.0	≤ 12	3	4.8'	6.4'	2, 5, 9	1.8	0.40	1.1
10.0	≤ 15	4	6.0'	7.6'	2, 4, 8, 12	2.9	0.49	1.8
12.0	≤ 18	5	7.2'	8.8'	2, 4, 7, 11, 15	4.2	0.58	2.6
14.0	≤ 21	6	8.4'	10.0'	1, 4, 7, 10, 14, 18	5.8	0.66	3.6



CASE 3: 33°, 2H:1V BACKSLOPE

TOTAL HEIGHT (FT.)	COURSES OF UNITS	NO. OF LAYERS	GEOGRID BASE LENGTH	TOP LENGTH	GEOGRID PLACEMENT ELEVATION ON TOP OF COURSE NO.	ESTIMATED GEOGRID QUANTITY (SY/LF)	ESTIMATED UNIT FILL QUANTITY (CY/LF)	ESTIMATED REIN.SOIL QUANTITY (CY/LF)
2.0	≤ 3	0	--	--	NONE	0.0	0.14	0.0
4.0	≤ 6	1	--	4.0'	3	0.5	0.23	0.4
6.0	≤ 9	3	3.7'	5.4'	1, 3, 6	1.5	0.31	0.7
8.0	≤ 12	4	5.3'	7.1'	1, 3, 6, 9	2.6	0.40	1.3
10.0	≤ 15	5	6.0'	8.8'	1, 3, 6, 9*, 12	3.9	0.49	2.0
12.0	≤ 18	7	7.3'	10.5'	1, 3, 5, 7, 9, 12*, 15	6.2	0.58	3.0
14.0	≤ 21	8	9.2'	12.2'	1, 3, 5, 7, 9, 12, 15*, 18	8.7	0.66	4.3
					*Add 1.5' to base length for these layers only			

Estimated Quantity of geogrid in square yards per lineal foot of wall at that height
Excludes blanket and chimney drains
Excludes slope above top of wall

NOTES:
1. Sample designs prepared to the exact standards for non-critical structures in the "Design Manual for Segmental Retaining Walls" as published by NCMA (1997). Applicable building codes govern when they produce a more conservative design.
2. Sample designs for construction cost estimating of single-height walls only. All projects should be designed by a qualified engineer using actual design conditions for the proposed site. Tiered walls require specialized design procedures.
3. Sample designs have been exclusively for the engineering properties of GravityStone in conjunction with either Tensar UX1400-SB or MIRAGRID 5xT geogrid reinforcement. Geogrid reinforcement lengths are measured and installed from front face of the wall, backwards.
4. Sample designs require adequate drainage provisions for both reinforced wall fill and retained soil.
5. Compact drainage and reinforced fill in maximum 8-inch lifts according to project specifications, or as directed by the engineer.

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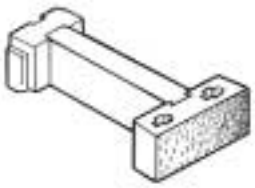

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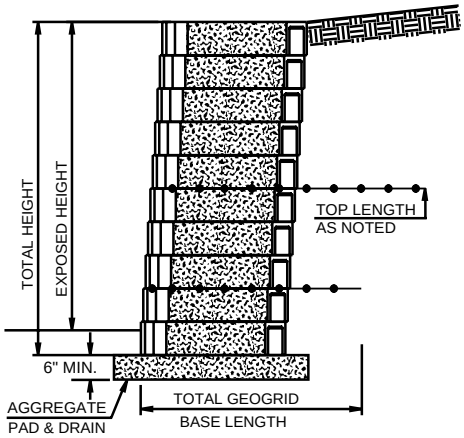
SINGLE-CELL - GravityStone MSE Retaining Walls

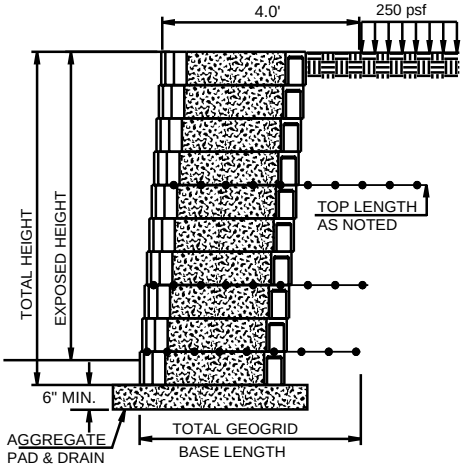
27° SAMPLE DESIGNS FOR CONSTRUCTION ESTIMATING

Use these charts when site soils can be conservatively represented with an angle of internal friction, $\phi \geq 27$ and a moist unit weight, $\gamma \leq 125$ pcf. This would be typical for most low plastic clays, silts, and mixtures with sand (CL, ML, SC, SM). Geogrid is to be Miragrid 8xT or unless indicated as 5xT.



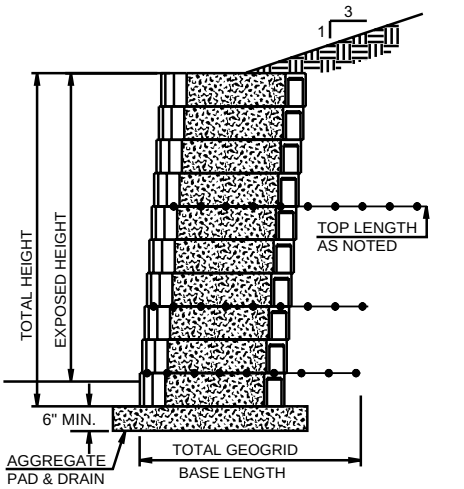
CASE 1: 27°, LEVEL TO 12H:1V BACKSLOPE

TOTAL HEIGHT (FT.)	COURSES OF UNITS	NO. OF LAYERS	GEOGRID BASE LENGTH	TOP LENGTH	GEOGRID PLACEMENT ELEVATION ON TOP OF COURSE NO.	ESTIMATED GEOGRID QUANTITY (SY/LF)	ESTIMATED UNIT FILL QUANTITY (CY/LF)	ESTIMATED REIN.SOIL QUANTITY (CY/LF)
6.0	≤ 9	0	--	--	NONE	0.0	0.51	0.0
8.0	≤ 12	2	6.0'	6.9'	2, 5 MIRAGRID 5xT	1.5	0.65	1.2
10.0	≤ 15	2	7.0'	8.5'	4, 8	1.8	0.79	1.9
12.0	≤ 18	3	7.2'	10.2'	3, 6, 11	2.8	0.94	2.6
14.0	≤ 21	3	8.4'	11.0'	3, 7, 12	3.1	1.08	3.6
16.0	≤ 24	4	9.6'	12.4'	3, 6, 10, 15,	4.6	1.22	4.8



CASE 2: 27°, LEVEL, 250 psf SURCHARGE

TOTAL HEIGHT (FT.)	COURSES OF UNITS	NO. OF LAYERS	GEOGRID BASE LENGTH	TOP LENGTH	GEOGRID PLACEMENT ELEVATION ON TOP OF COURSE NO.	ESTIMATED GEOGRID QUANTITY (SY/LF)	ESTIMATED UNIT FILL QUANTITY (CY/LF)	ESTIMATED REIN.SOIL QUANTITY (CY/LF)
2.7	≤ 4	0	--	--	NONE	0.0	0.28	0.0
4.0	≤ 6	1	--	6.8'	2 MIRAGRID 5xT	0.8	0.37	0.7
6.0	≤ 9	2	5.5'	7.0'	2, 4, MIRAGRID 5xT	1.4	0.51	0.9
8.0	≤ 12	2	6.2'	8.3'	3, 6,	1.6	0.65	1.3
10.0	≤ 15	2	6.3'	9.3'	3, 7,	1.8	0.79	2.2
12.0	≤ 18	3	8.0'	11.0'	3, 7, 11,	3.0	0.94	3.2
14.0	≤ 21	3	8.5'	12.6'	3, 7, 13,	3.3	1.08	4.7
16.0	≤ 24	4	9.8'	14.5'	2, 7, 11, 17	4.9	1.22	6.3



CASE 3: 27°, 3H:1V BACKSLOPE

TOTAL HEIGHT (FT.)	COURSES OF UNITS	NO. OF LAYERS	GEOGRID BASE LENGTH	TOP LENGTH	GEOGRID PLACEMENT ELEVATION ON TOP OF COURSE NO.	ESTIMATED GEOGRID QUANTITY (SY/LF)	ESTIMATED UNIT FILL QUANTITY (CY/LF)	ESTIMATED REIN.SOIL QUANTITY (CY/LF)
4.7	≤ 7	0	--	--	NONE	0.0	0.42	0.0
6.0	≤ 9	2	5.9'	5.9'	2, 3 MIRAGRID 5xT	1.3	0.51	0.8
8.0	≤ 12	2	5.9'	7.5'	2, 4	1.5	0.65	1.3
10.0	≤ 15	2	7.5'	8.9'	2, 6	1.9	0.79	2.2
12.0	≤ 18	3	9.2'	10.4'	3, 6, 9,	3.2	0.94	3.2
14.0	≤ 21	3	10.8'	12.7'	2, 6, 12,	3.8	1.08	4.7
16.0	≤ 24	4	12.5'	14.4'	2, 5, 9, 15,	5.8	1.22	6.3

Estimated Quantity of geogrid in square yards per lineal foot of wall at that height
Excludes blanket and chimney drains
Excludes slope above top of wall

NOTES:
1. Sample designs prepared to the exact standards for soil-reinforced structures in the "Design Manual for Segmental Retaining Walls" as published by NCMA (1997). Applicable building codes govern when they produce a more conservative design.
2. Sample designs for construction cost estimating of single-height walls only. All projects should be designed by a qualified engineer using actual design conditions for the proposed site. Tiered walls require specialized design procedures.
3. Sample designs have been exclusively for the engineering properties of GravityStone in conjunction with MIRAGRID 8xT geogrid reinforcement, or 5xT where shown. Geogrid reinforcement lengths are measured and installed from front face of the wall, backwards.
4. Sample designs require adequate drainage provisions for both reinforced wall fill and retained soil.
5. Compact drainage and reinforced fill in maximum 8-inch lifts according to project specifications, or as directed by the engineer.

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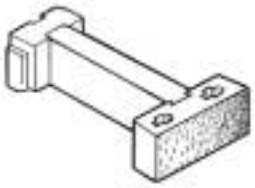
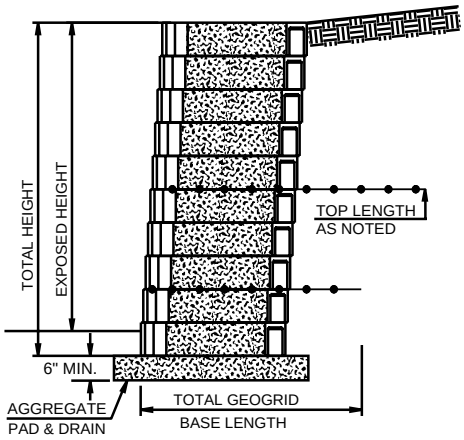


WESTBLOCK Systems

SINGLE-CELL - GravityStone MSE Retaining Walls

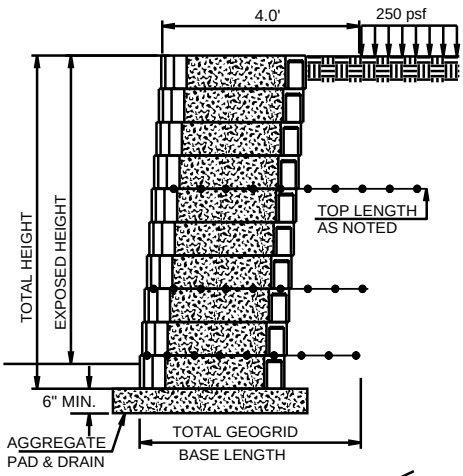
33° SAMPLE DESIGNS FOR CONSTRUCTION ESTIMATING

Use these charts when site soils can be conservatively represented with an angle of internal friction, $\phi \geq 33$ and a moist unit weight, $\gamma \leq 125$ pcf. This would be typical for most low plastic clays, silts, and mixtures with sand (CL, ML, SC, SM). Geogrid is to be Miragrid 8xT or unless indicated as 5xT.



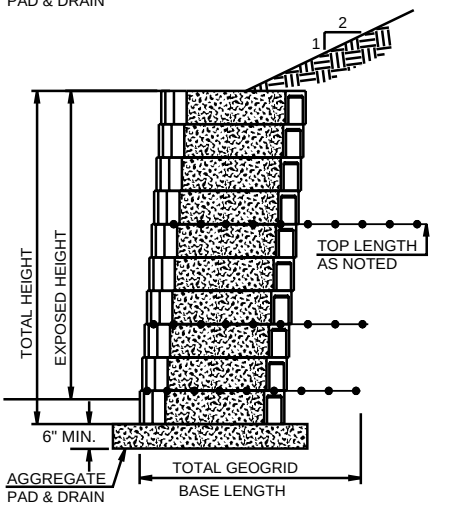
CASE 1: 33°, LEVEL TO 12H:1V BACKSLOPE

TOTAL HEIGHT (FT.)	COURSES OF UNITS	NO. OF LAYERS	GEOGRID BASE LENGTH	TOP LENGTH	GEOGRID PLACEMENT ELEVATION ON TOP OF COURSE NO.	ESTIMATED GEOGRID QUANTITY (SY/LF)	ESTIMATED UNIT FILL QUANTITY (CY/LF)	ESTIMATED REIN.SOIL QUANTITY (CY/LF)
8.0	≤ 12	0	--	--	NONE	0.0	0.65	0.0
10.0	≤ 15	1	--	6.0'	3,	0.7	0.79	1.3
12.0	≤ 18	2	7.2'	7.2'	2, 6	1.6	0.94	2.0
14.0	≤ 21	2	8.4'	8.4'	4, 9,	1.9	1.08	3.0
16.0	≤ 24	3	9.6'	9.6'	3, 7, 12	3.2	1.22	4.1



CASE 2: 33°, LEVEL, 250 psf SURCHARGE

TOTAL HEIGHT (FT.)	COURSES OF UNITS	NO. OF LAYERS	GEOGRID BASE LENGTH	TOP LENGTH	GEOGRID PLACEMENT ELEVATION ON TOP OF COURSE NO.	ESTIMATED GEOGRID QUANTITY (SY/LF)	ESTIMATED UNIT FILL QUANTITY (CY/LF)	ESTIMATED REIN.SOIL QUANTITY (CY/LF)
4.7	≤ 8	0	--	--	NONE	0.0	0.42	0.0
6.0	≤ 9	1	--	4.8'	2, 4, MIRAGRID 5xT	1.4	0.51	0.7
8.0	≤ 12	1	--	6.5'	3, 6, MIRAGRID 5xT	1.6	0.65	0.9
10.0	≤ 15	2	6.0'	7.6'	3, 7	1.8	0.79	1.6
12.0	≤ 18	2	7.2'	9.6'	3, 7, 11,	3.0	0.94	2.4
14.0	≤ 21	3	8.4'	11.1'	3, 7, 13,	3.3	1.08	3.4
16.0	≤ 24	4	9.6'	12.6'	2, 7, 11, 17	4.9	1.22	4.5



CASE 3: 33°, 2H:1V BACKSLOPE

TOTAL HEIGHT (FT.)	COURSES OF UNITS	NO. OF LAYERS	GEOGRID BASE LENGTH	TOP LENGTH	GEOGRID PLACEMENT ELEVATION ON TOP OF COURSE NO.	ESTIMATED GEOGRID QUANTITY (SY/LF)	ESTIMATED UNIT FILL QUANTITY (CY/LF)	ESTIMATED REIN.SOIL QUANTITY (CY/LF)
5.3	≤ 8	0	--	--	NONE	0.0	0.46	0.0
6.0	≤ 9	1	--	4.8'	1 MIRAGRID 5xT	0.6	0.51	0.5
8.0	≤ 12	1	--	6.5'	3	0.8	0.65	1.2
10.0	≤ 15	2	6.0'	7.6'	3, 6	1.5	0.79	1.7
12.0	≤ 18	2	7.2'	9.6'	3, 9,	1.9	0.94	2.6
14.0	≤ 21	3	8.4'	11.1'	2, 6, 12,	3.1	1.08	3.7
16.0	≤ 24	4	9.6'	12.6'	2, 6, 10, 15,	4.6	1.22	4.9

Estimated Quantity of geogrid in square yards per lineal foot of wall at that height
Excludes blanket and chimney drains
Excludes slope above top of wall

NOTES:
1. Sample designs prepared to the exact standards for soil-reinforced structures in the "Design Manual for Segmental Retaining Walls" as published by NCMA (1997). Applicable building codes govern when they produce a more conservative design.
2. Sample designs for construction cost estimating of single-height walls only. All projects should be designed by a qualified engineer using actual design conditions for the proposed site. Tiered walls require specialized design procedures.
3. Sample designs have been exclusively for the engineering properties of GravityStone in conjunction with MIRAGRID 8xT geogrid reinforcement, or 5xT where shown. Geogrid reinforcement lengths are measured and installed from front face of the wall, backwards.
4. Sample designs require adequate drainage provisions for both reinforced wall fill and retained soil.
5. Compact drainage and reinforced fill in maximum 8-inch lifts according to project specifications, or as directed by the engineer.

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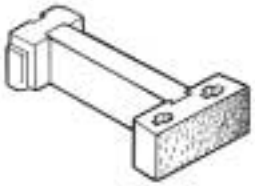
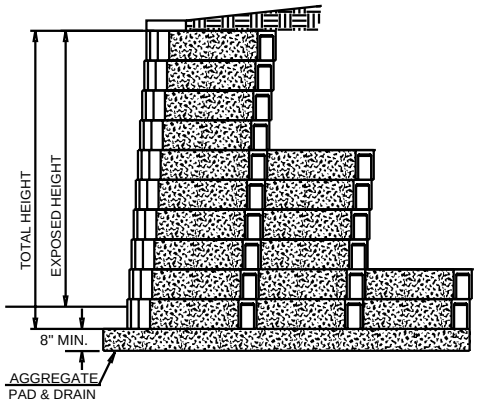


WESTBLOCK Systems

MULTI-CELL - GravityStone Modular Retaining Walls

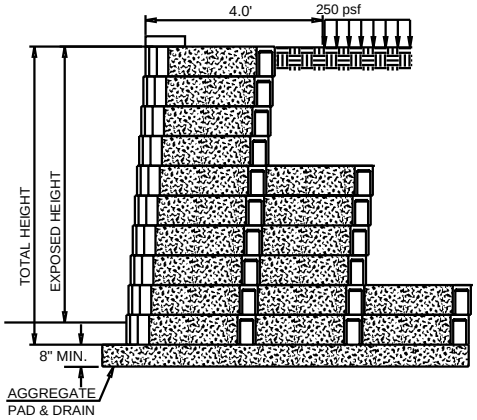
27° SAMPLE DESIGNS FOR CONSTRUCTION ESTIMATING

Use these charts when site soils can be conservatively represented with an angle of internal friction, $\phi \geq 27$ and a moist unit weight, $\gamma \leq 125$ pcf. This would be typical for most low plastic clays, silts, and mixtures with sand (CL, ML, SC, SM). Walls are to have a level footing pad.



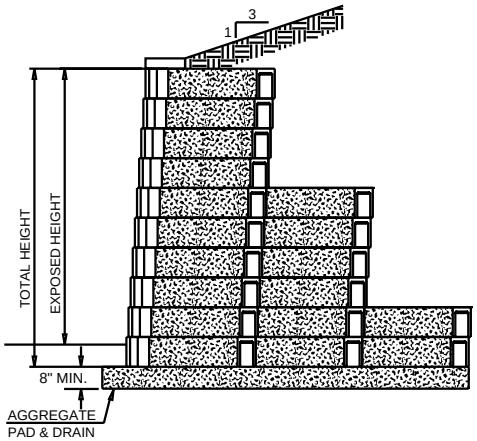
CASE 1: 27°, LEVEL TO 12H:1V BACKSLOPE

TOTAL HEIGHT (FT.)	COURSES OF UNITS	COURSE NUMBER REQUIRING						ESTIMATED		
		1 CELL	2 CELL	3 CELL	4 CELL	5 CELL	6 CELL	FACE UNIT QTY. (#/LF)	TRUNK A/J QTY. (#/LF)	UNIT FILL QTY. (CY/LF)
6.0	≤ 9	1-9						6.0	7.4	0.8
8.0	≤ 12	7-12	1-6					8.0	12.0	1.1
10.0	≤ 15	8-15	3-7	1-2				10.0	16.0	1.5
12.0	≤ 18	11-18	5-10	3-4	1-2			12.0	22.7	2.0
14.0	≤ 21	17-21	15-16	9-14	1-8			14.0	39.4	3.1
16.0	≤ 24	20-24	17-19	12-16	5-11	1-4		16.0	49.4	3.8



CASE 2: 27°, LEVEL, 250 psf SURCHARGE

TOTAL HEIGHT (FT.)	COURSES OF UNITS	COURSE NUMBER REQUIRING						ESTIMATED		
		1 CELL	2 CELL	3 CELL	4 CELL	5 CELL	6 CELL	FACE UNIT QTY. (#/LF)	TRUNK A/J QTY. (#/LF)	UNIT FILL QTY. (CY/LF)
2.7	≤ 4	1-4						2.7	2.7	0.4
4.0	≤ 6	3-6	1-2					4.0	5.4	0.6
6.0	≤ 9	7-9	1-6					6.0	10.0	1.0
8.0	≤ 12	7-12	3-6	1-2				8.0	13.4	1.3
10.0	≤ 15	13-15	11-12	1-10				10.0	24.7	2.0
12.0	≤ 18	19-18	13-15	5-12	1-4			12.0	32.7	2.6
14.0	≤ 21	20-21	17-19	14-16	1-13			14.0	46.0	3.5
16.0	≤ 24	23-24	20-22	17-19	5-16	1-4		16.0	56.7	4.3



CASE 3: 27°, 3H:1V BACKSLOPE

TOTAL HEIGHT (FT.)	COURSES OF UNITS	COURSE NUMBER REQUIRING						ESTIMATED		
		1 CELL	2 CELL	3 CELL	4 CELL	5 CELL	6 CELL	FACE UNIT QTY. (#/LF)	TRUNK A/J QTY. (#/LF)	UNIT FILL QTY. (CY/LF)
6.0	≤ 9	5-9	3-4	1-2				6.0	10.0	1.1
8.0	≤ 12	11-12	9-10	1-8				8.0	20.0	1.7
10.0	≤ 15	1415	12-13	5-11	1-4			10.0	28.7	2.4
12.0	≤ 18	17-18	13-16	9-12	5-8	1-4		12.0	38.7	3.1
14.0	≤ 21	20-21	15-19	7-14	5-6	3-4	2-1	14.0	44.0	3.6
16.0	≤ 24	23-24	21-22	18-20	15-17	11-14	1-10	16.0	71.4	5.3

Excludes blanket and chimney drains

NOTES:
1. Sample designs prepared to the exact standards for modular retaining structures in the AASHTO Standard Specifications for Highways and Bridges (1996). Applicable building codes govern when they produce a more conservative design.
2. Sample designs for construction cost estimating of single-height walls only. All projects should be designed by a qualified engineer using actual design conditions for the proposed site. Tiered walls require specialized design procedures.
3. Sample designs have been prepared exclusively for the engineering properties of GravityStone.
4. Erect wall and unit fill in maximum 8-inch lifts according to project specifications, or as directed by the engineer.

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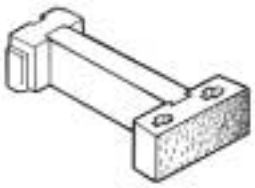
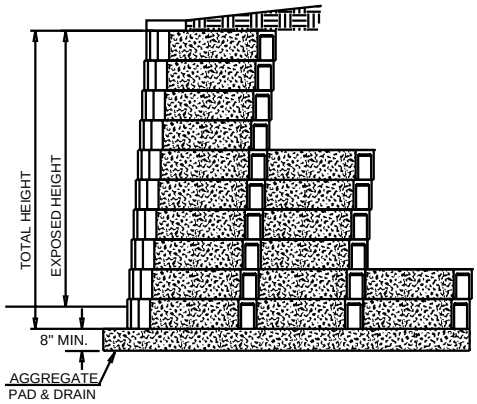


WESTBLOCK Systems

MULTI-CELL - GravityStone Modular Retaining Walls

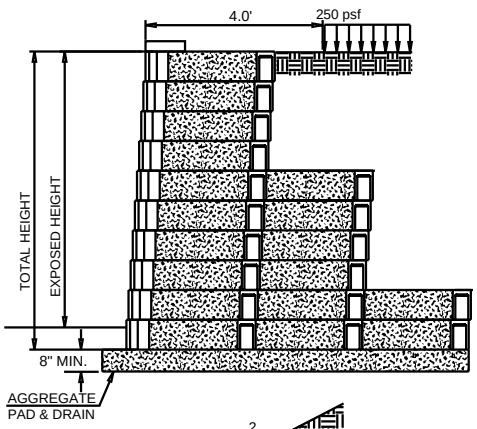
33° SAMPLE DESIGNS FOR CONSTRUCTION ESTIMATING

Use these charts when site soils can be conservatively represented with an angle of internal friction, $\phi \geq 33$ and a moist unit weight, $\gamma \leq 125$ pcf. This would be typical for most low plastic clays, silts, and mixtures with sand (CL, ML, SC, SM). Walls are to have a level footing pad.



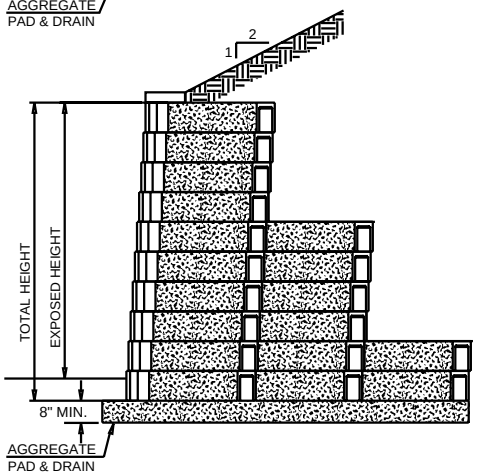
CASE 1: 23°, LEVEL TO 12H:1V BACKSLOPE

TOTAL HEIGHT (FT.)	COURSES OF UNITS	COURSE NUMBER REQUIRING						ESTIMATED		
		1 CELL	2 CELL	3 CELL	4 CELL	5 CELL	6 CELL	FACE UNIT QTY. (#/LF)	TRUNK A/J QTY. (#/LF)	UNIT FILL QTY. (CY/LF)
8.0	≤ 12	3-12	1-2					8.0	9.4	1.0
10.0	≤ 15	6-15	1-5					10.0	13.4	1.2
12.0	≤ 18	9-18	3-8	1-2				12.0	18.7	1.7
14.0	≤ 21	13-21	6-12	1-5				14.0	25.4	2.1
16.0	≤ 24	16-24	9-15	4-8	1-3			16.0	33.5	2.7



CASE 2: 33°, LEVEL, 250 psf SURCHARGE

TOTAL HEIGHT (FT.)	COURSES OF UNITS	COURSE NUMBER REQUIRING						ESTIMATED		
		1 CELL	2 CELL	3 CELL	4 CELL	5 CELL	6 CELL	FACE UNIT QTY. (#/LF)	TRUNK A/J QTY. (#/LF)	UNIT FILL QTY. (CY/LF)
4.7	≤ 7	1-7						4.7	4.7	0.5
6.0	≤ 9	3-9	1-2					6.0	7.4	0.8
8.0	≤ 12	6-12	1-5					8.0	11.4	1.1
10.0	≤ 15	11-15	1-10					10.0	16.7	1.4
12.0	≤ 18	12-18	5-11	1-4				12.0	22.0	1.9
14.0	≤ 21	15-21	11-14	1-10				14.0	30.0	2.4
16.0	≤ 24	23-24	22	1-21				16.0	44.7	3.3



CASE 3: 33°, 2H:1V BACKSLOPE

TOTAL HEIGHT (FT.)	COURSES OF UNITS	COURSE NUMBER REQUIRING						ESTIMATED		
		1 CELL	2 CELL	3 CELL	4 CELL	5 CELL	6 CELL	FACE UNIT QTY. (#/LF)	TRUNK A/J QTY. (#/LF)	UNIT FILL QTY. (CY/LF)
6.0	≤ 9	4-9	1-3					6.0	8.0	0.8
8.0	≤ 12	8-12	1-7					8.0	12.7	1.2
10.0	≤ 15	11-15	4-10	1-3				10.0	18.7	1.7
12.0	≤ 18	15-18	11-14	1-10				12.0	28.0	2.2
14.0	≤ 21	17-21	13-16	3-12	1-2			14.0	34.0	2.8
16.0	≤ 24	22-24	19-21	12-18	1-11			16.0	49.4	3.7

Excludes blanket and chimney drains

NOTES:

1. Sample designs prepared to the exact standards for modular retaining structures in the AASHTO Standard Specifications for Highways and Bridges (1996). Applicable building codes govern when they produce a more conservative design.
2. Sample designs for construction cost estimating of single-height walls only. All projects should be designed by a qualified engineer using actual design conditions for the proposed site. Tiered walls require specialized design procedures.
3. Sample designs have been prepared exclusively for the engineering properties of GravityStone.
4. Erect wall and unit fill in maximum 8-inch lifts according to project specifications, or as directed by the engineer.

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