



Segmental Retaining Wall Design and Construction



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Purpose and Learning Objectives

Purpose: The concept of stabilized earth structures has been around for centuries. Historically, grass mats, straw, and branches have been used to stabilize soil. Now, soil reinforcement utilizes technologically advanced geosynthetic materials to secure earth in retaining walls, bridge abutments, and many other applications. This course reviews the basic concepts about segmental retaining wall systems, focusing on geogrid reinforcement applications, site conditions, and the construction sequence. Key success factors are also discussed.

Learning Objectives:

At the end of this program, participants should be able to:

- Identify the different features of gravity and stabilized aggregate retaining wall structures, and explain how they are effective and safe soil-retention systems.
- Describe the characteristics of reinforced segmental retaining walls (SRWs) and how they are a safe and efficient method of earth stabilization.
- Discuss the site conditions that influence reinforced SRW system performance and design, detailing how utilizing geogrid provides a strong and secure soil structure.
- Summarize the overall construction sequence related to reinforced segmental retaining walls.



Segmental Retaining Wall Basics



Segmental Retaining Wall History

The concept of reinforced soil structures, which we now call mechanically stabilized earth, or MSE, has been used for many centuries. In the past, reed mats, straw, and branches were used in many parts of the world to reinforce soil, allowing for taller, steeper structures.

Today, through technological advancements, steel and geosynthetics are used for soil reinforcement to secure retaining walls, bridge abutments, parking area supports, and landscape projects.



Modular Retaining Wall Systems

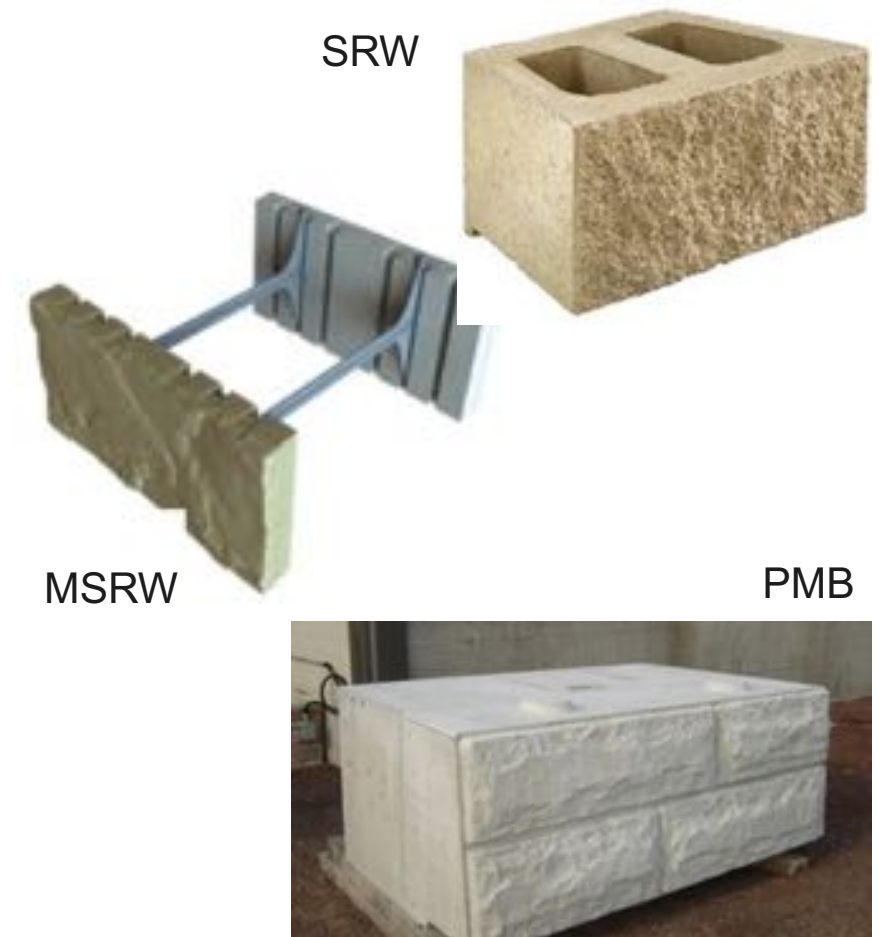
There are three types of modular units used for retaining wall systems.

Segmental retaining wall (SRW) units typically have a smaller face area (1 square foot or less) with a unit depth of less than 24 inches (most are 12 inches in depth), and are generally hand installed and dry-cast by ASTM definition.

Mass segmental retaining wall (MSRW) units have a larger face area (greater than 1 square foot) and a unit depth typically 24 inches or more. Alignment devices utilize regression grooves with plastic protrusions on connectors or other devices that help align the system. They are formed to create panel bins filled with aggregate.

Precast modular blocks (PMBs) are typically a “big block” (or bin blocks), always machine installed and wet-cast (ASTM standard pending).

This course focuses on SRWs.



Aesthetics

Segmental retaining walls offer many aesthetically pleasing options.

This image illustrates a straight split SRW unit, which is the most commonly used facing style.

The image on the far right illustrates a roughened straight split unit that results in more rounded edges and looks similar to roughened stone.



Aesthetics: Matched Architectural Block

In this example, the segmental retaining wall meets the structural and aesthetic needs of the designer because it matches the scale, texture, and color of the building's exterior facade.

In the past, a designer would use a poured-in-place concrete wall with a veneer to achieve the same look. The concrete alone would cost more than the SRW. With no need for the additional cost of the veneer (\$6–\$8 more per square foot), segmental retaining walls offer the client an economical solution for their exterior structural requirements.



Aesthetics: Color Bands

This retaining wall illustrates the use of horizontal colored bands. The choice of color and texture offers architectural interest to the property. Color and/or texture banding is a cost-effective way to soften the look of expansive walls.



Segmental Retaining Wall Systems

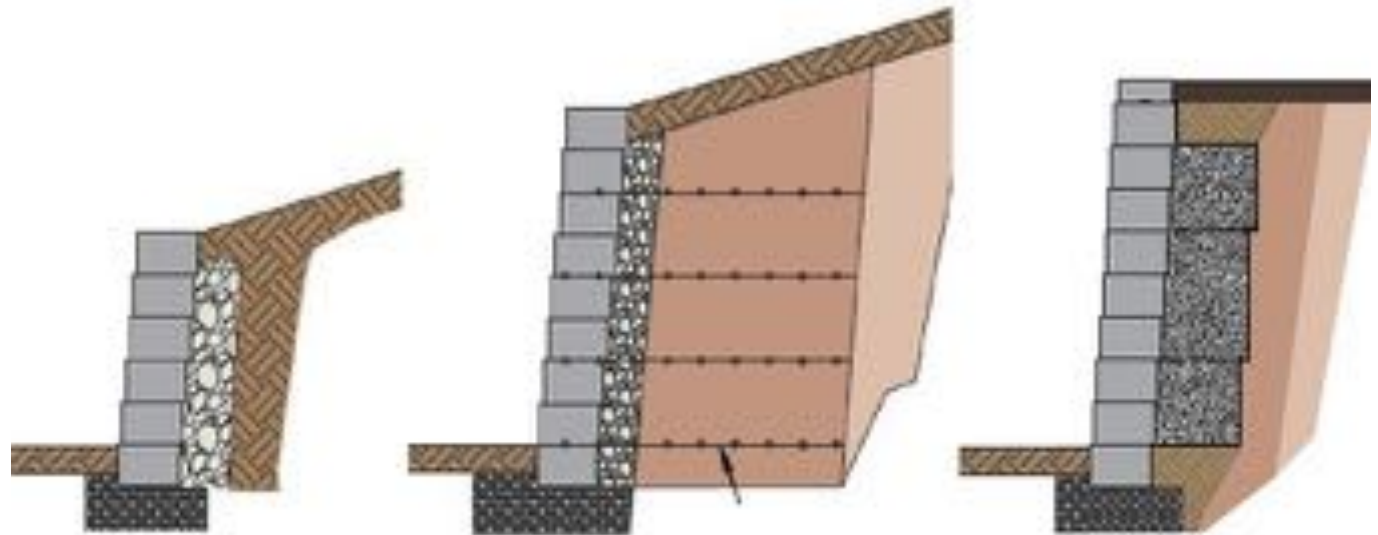
Manufactured to ASTM C1372: Standard Specification for Dry-Cast Segmental Retaining Wall Units, criteria, SRW units are durable and designed for earth-retaining applications. Typically made from zero slump concrete, SRW units are molded to manufacturer specifications, placed in a kiln for 24 to 48 hours, split, and then placed on pallets for a final cure time of five to seven days. Segmental retaining wall blocks come in many shapes, sizes, and face styles. All SRW units have built-in alignment devices such as rear lips, pins, top/bottom lugs, and regression grooves, or use plastic clips. Depending on their size, many have cavities, which can be filled with aggregate to increase the mass of the wall for greater stability.



Gravity Wall Types

When constructing a retaining wall using SRW units, there are basically three construction methods:

- An unreinforced gravity wall. (A general rule of thumb is that a gravity wall can be built to a height roughly equivalent to three times the blocks' depth [face to tail], which is affected by many things, such as soil types, facing batter [the receding face tilt as measured from the vertical], and surcharge loads [any additional loading at the top of the wall]).
- A reinforced soil gravity wall using geogrid (that extends back into the soil at least 60+ percent of the wall height).
- A gravity wall system with stabilized aggregate (SRW units are used to form the face of a poured-in-place block sized to provide stability for the wall height).



Gravity wall
(unreinforced)

Reinforced soil gravity
wall using geogrid

Gravity wall system with
stabilized aggregate

Unreinforced Gravity Walls

The most common type of retaining wall is an unreinforced gravity wall. Gravity walls are typically used for small walls that create grade changes where sloping surfaces are undesirable or impractical.

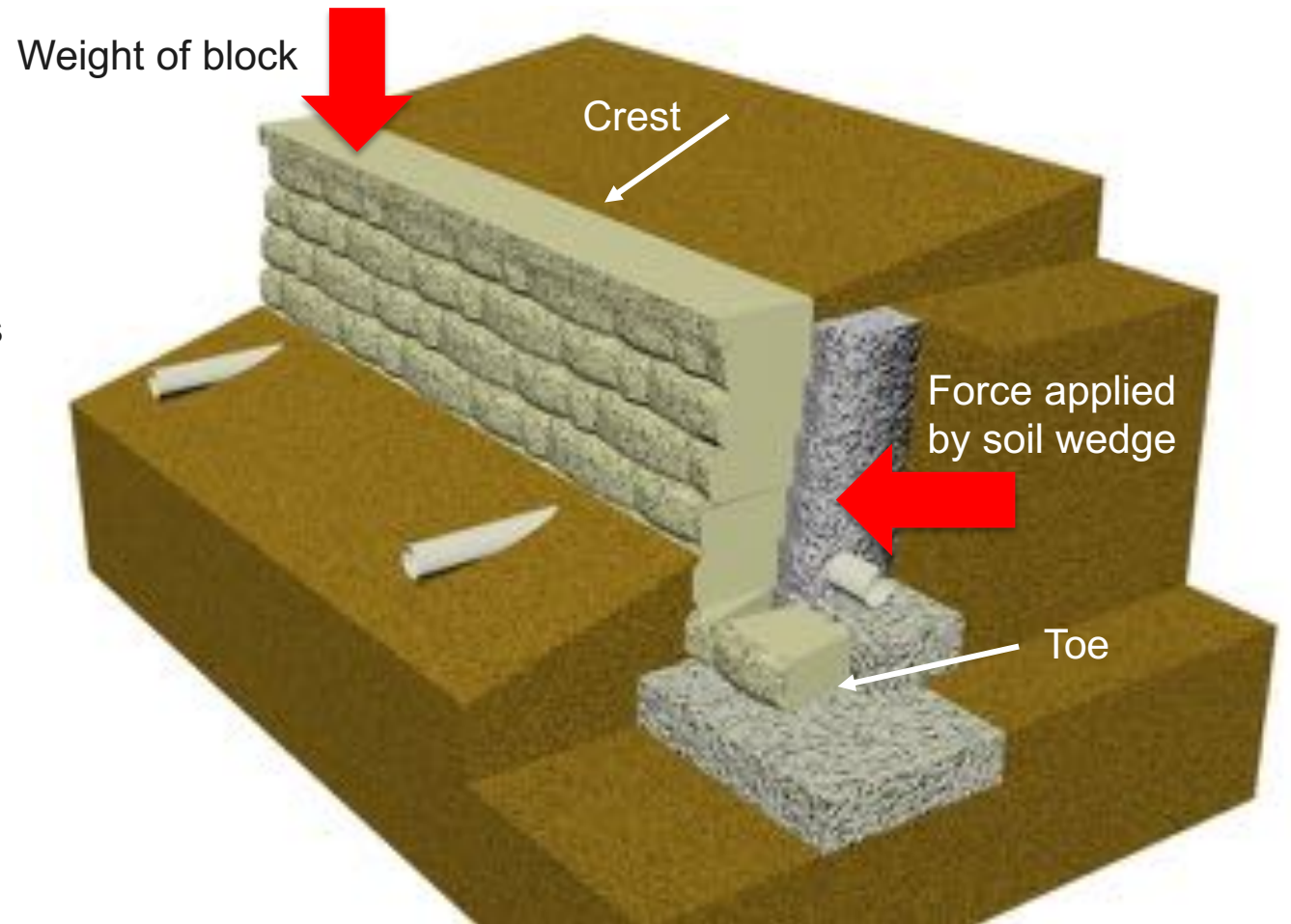
Gravity walls are restricted in height by several key factors: modular unit weight and batter, soil type, loads, and ascending crest slopes or surcharge loads at the wall crests.



Unreinforced Gravity Walls

An unreinforced gravity wall can be used in normal soil environments with concrete blocks that are about one-third of the wall height in depth. As an example, a 12-inch-deep block (as measured from face to tail) can be used to construct walls up to about 36 inches in height; a 20-inch-deep product can be used to construct walls up to about 60 inches in height, and so on. While this is a rule of thumb that is generally applicable to walls having flat crests (back slope, the slope above the top of the wall) and horizontal toes, it is true for nearly any type of wall.

This guidance applies to all types of gravity walls, not just SRWs. However, there are many factors that influence exceptions to this rule. Both the soil strength and surcharge load imparted onto the wall will have an impact on the overall height of the SRW. Poor soil and increased surcharge will most often result in the wall height being reduced.

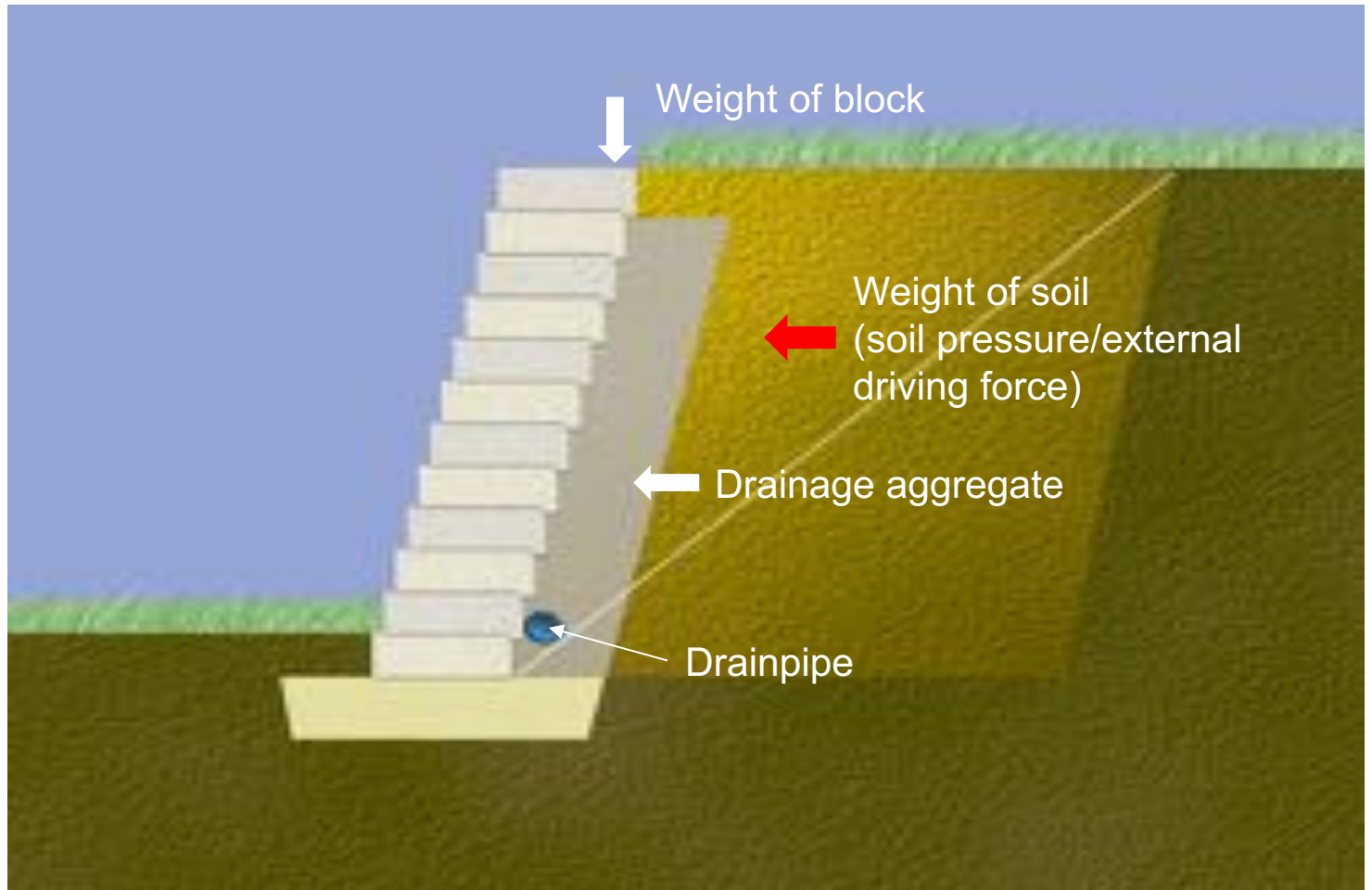


Gravity Wall Design Considerations

All retaining walls need to be designed to withstand various imposing forces. Naturally, the biggest concern is the force imposed by the retained soil.

This is a cross section of a gravity wall composed of SRW facing units and drainage aggregate. As you can see, the weight of the soil or soil pressure is the driving force that pushes against the drainage aggregate and retaining wall unit.

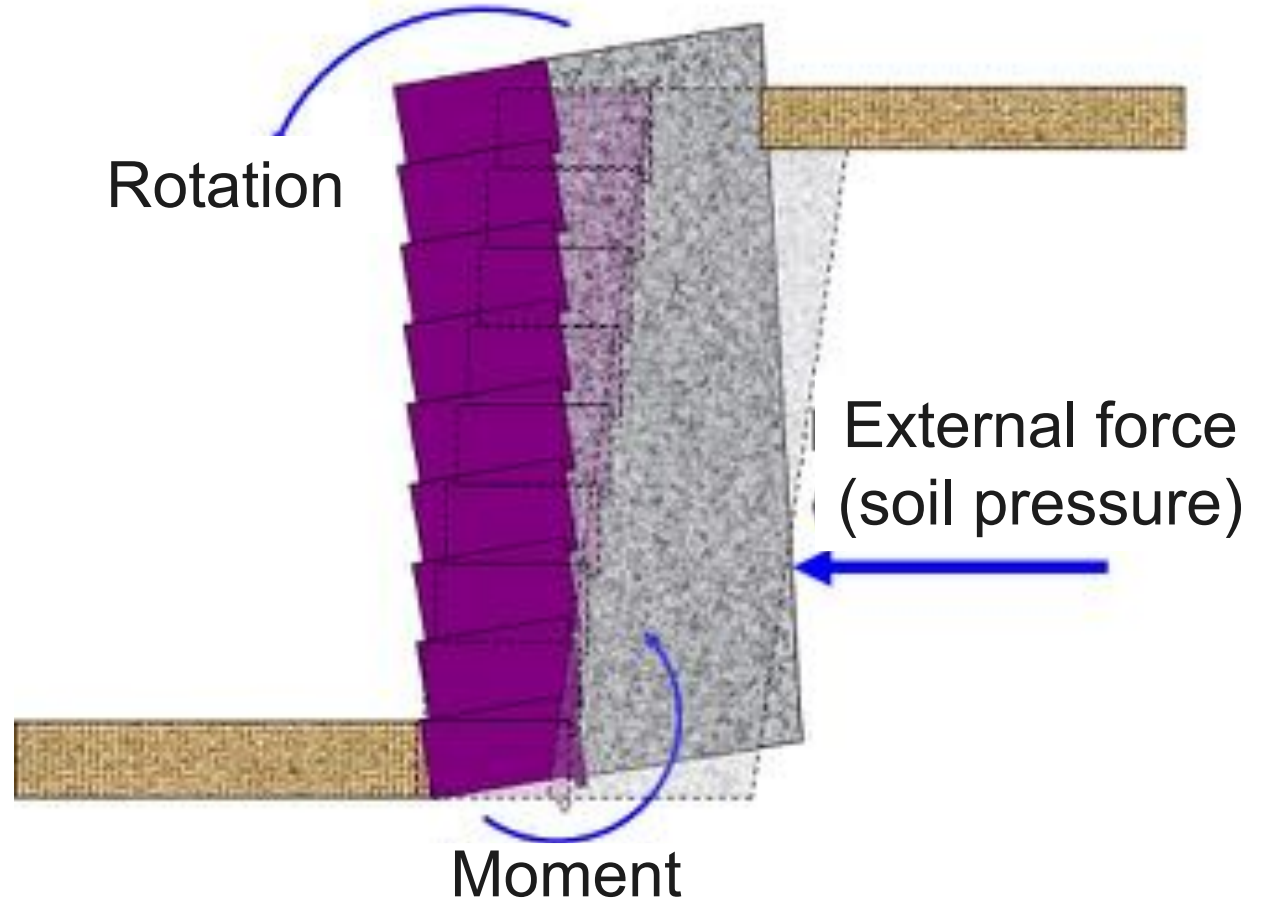
The gravity wall must be constructed to provide enough resistance against this driving force to prevent the wall system from overturning.



Gravity Wall Design Considerations: Overturning

Rotational forces can cause a retaining wall to overturn if the proper calculations have not been made or the wall is inadequately designed. Overturning is a calculation that is performed to demonstrate that a rigid mass of equivalent dimensions might overturn if not sized correctly.

Considerations to ensure a segmental wall system will not be overturned include the weight or mass of the facing units, the depth of the geogrid soil system, and the depth of the resisting moment arm.



Stabilized Aggregate Gravity Walls

When site conditions do not allow for the necessary excavation required for a geogrid system, there is an alternative: stabilized aggregate SRW.

Stabilized aggregate technology was pioneered in Australia and has been in use there for more than a decade. Millions of square feet have been installed worldwide, and it is becoming increasingly popular in the United States.

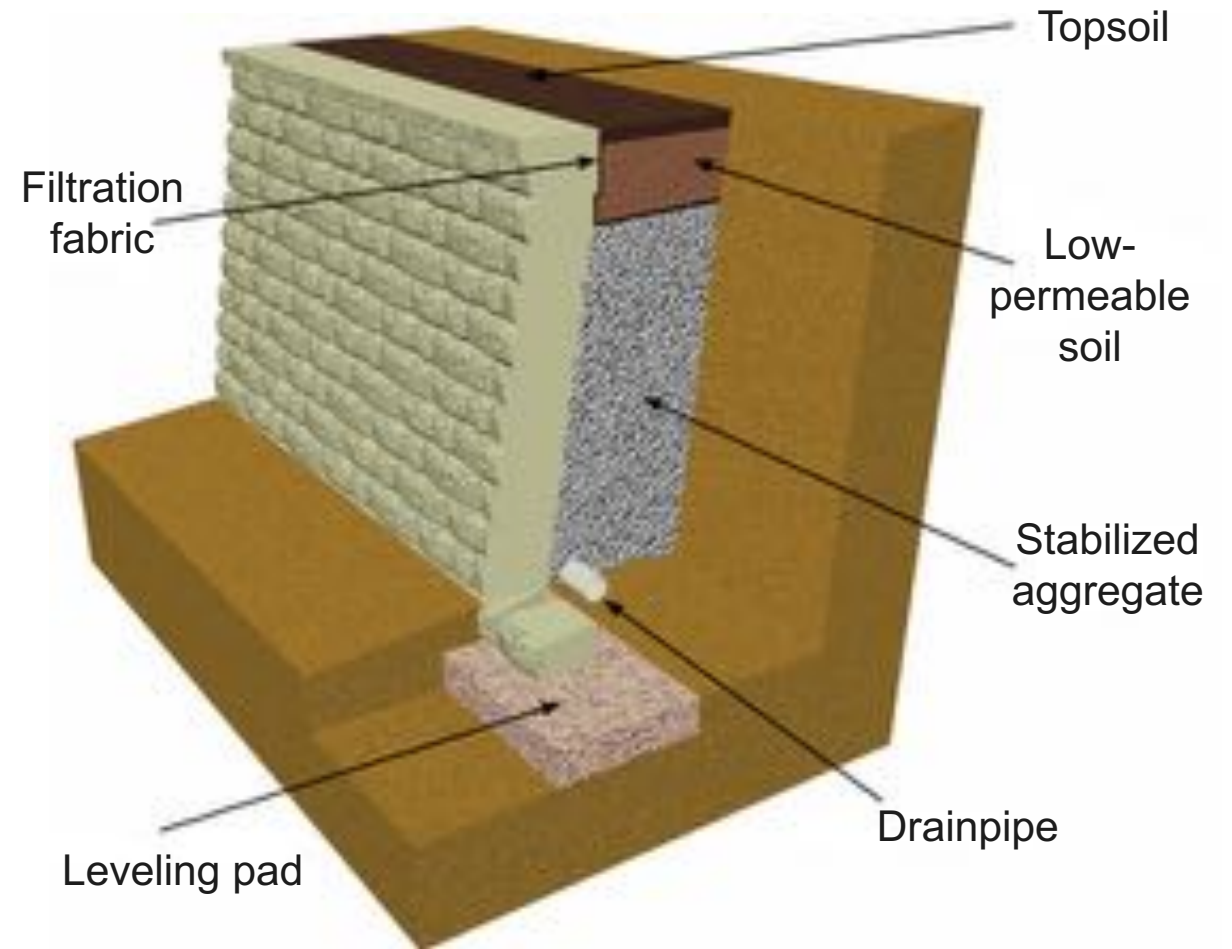
Much of this system's increasing popularity can be attributed to its relatively low cost and reduced excavation requirements compared with geogrid reinforced walls.



Stabilized Aggregate Gravity Walls

The structural backfill mass is created by using standard SRW blocks as facing forms and extending the depth of the unit by pouring a “concrete fill” behind and within the facing system to the depth required to construct a gravity wall. The concrete fill used behind and within the facing blocks is an open graded, permeable cement/stone mix called stabilized aggregate. The stabilized aggregate is formed at the face of the wall with a segmental block facing, thus giving the face of the system an aesthetically pleasing treatment. The aggregate is integrated into the SRW units, forming a singular mass while requiring considerably less excavation, in some cases as much as 60 percent less, than geogrid walls.

Common names for this type of wall system include stabilized aggregate, no-fines concrete, structural backfill, and other similar terms.





Geogrid Reinforced Segmental Retaining Walls



Geogrid Reinforced Walls

The design methodology for a segmental wall requires that the soil behind the wall be excavated and backfilled with soils meeting high-quality standards and incorporating layers of soil-reinforcing geosynthetics. Depending on the site conditions, this reinforcement can extend back into the soil mass at least 60 percent of the wall's total height, and in some cases, greater than the height of the wall. So for a 10-foot-high wall, the length would be a minimum of 6 feet. For a 20-foot-high wall, it would be at least 12 feet in length, and so on.

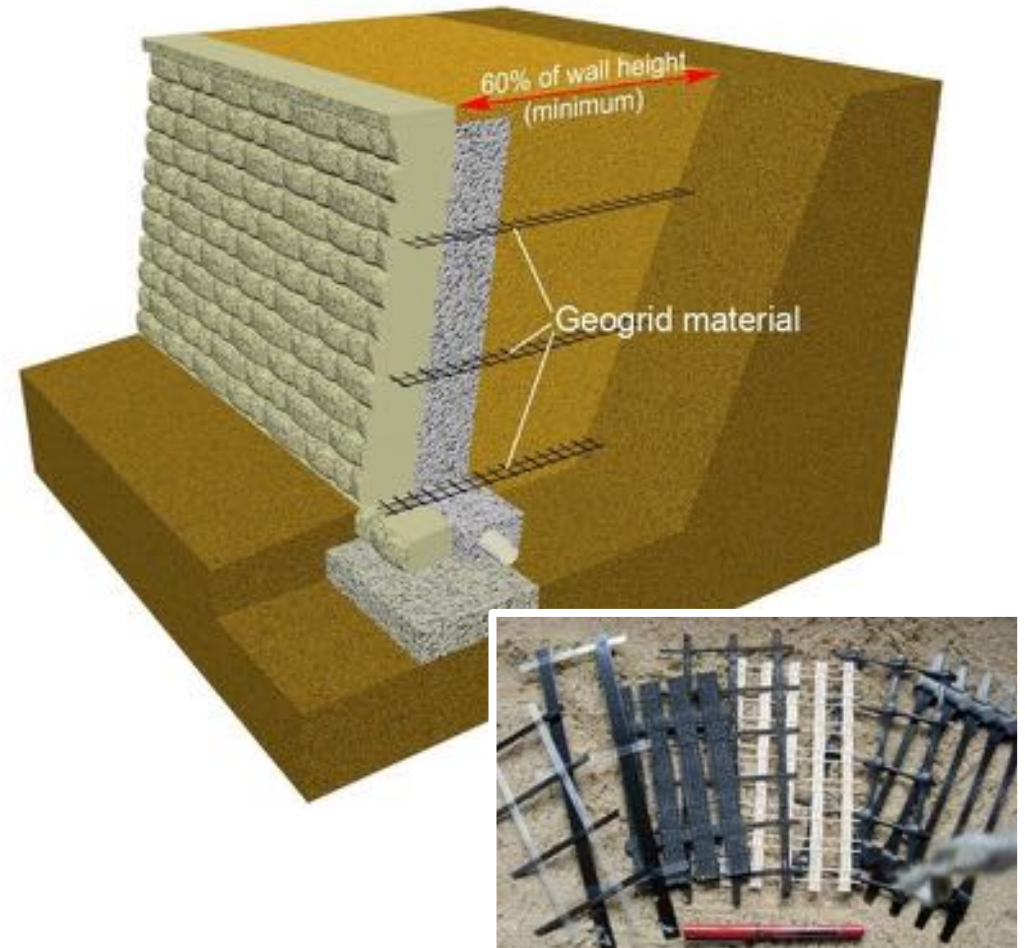
There are a number of things to consider for determining the amount of excavation required. If there is a slope above the wall, if the wall will support a surcharge load, if seismic earth pressures can be expected, or if the soils are poor, the geogrid lengths will be longer, typically 70–100+ percent of the wall height.



Geogrid Reinforced Walls

When a gravity wall is insufficient on its own over a certain height or when appropriately sized concrete blocks are not readily available, the wall and soil need to be reinforced.

Usually, reinforcement is achieved through the use of geogrids. Geogrids are typically synthetic materials, often configured in a grid pattern, that are embedded in the soil incrementally to give it greater stability. With the implementation of geogrids, the soil mass is increased as the geogrid essentially reinforces and binds the soil layers together, preventing separation and shifting, similar to reinforcing bars in concrete. The geogrid also provides additional stability to the wall as the geogrid is integrated into the wall's facing units. Embedding the geosynthetic reinforcing elements into the soil mass prevents the geogrids from pulling out when loads are applied to the system, while friction between the facing units and embedded geogrid helps to tie the facing units to the soil mass.

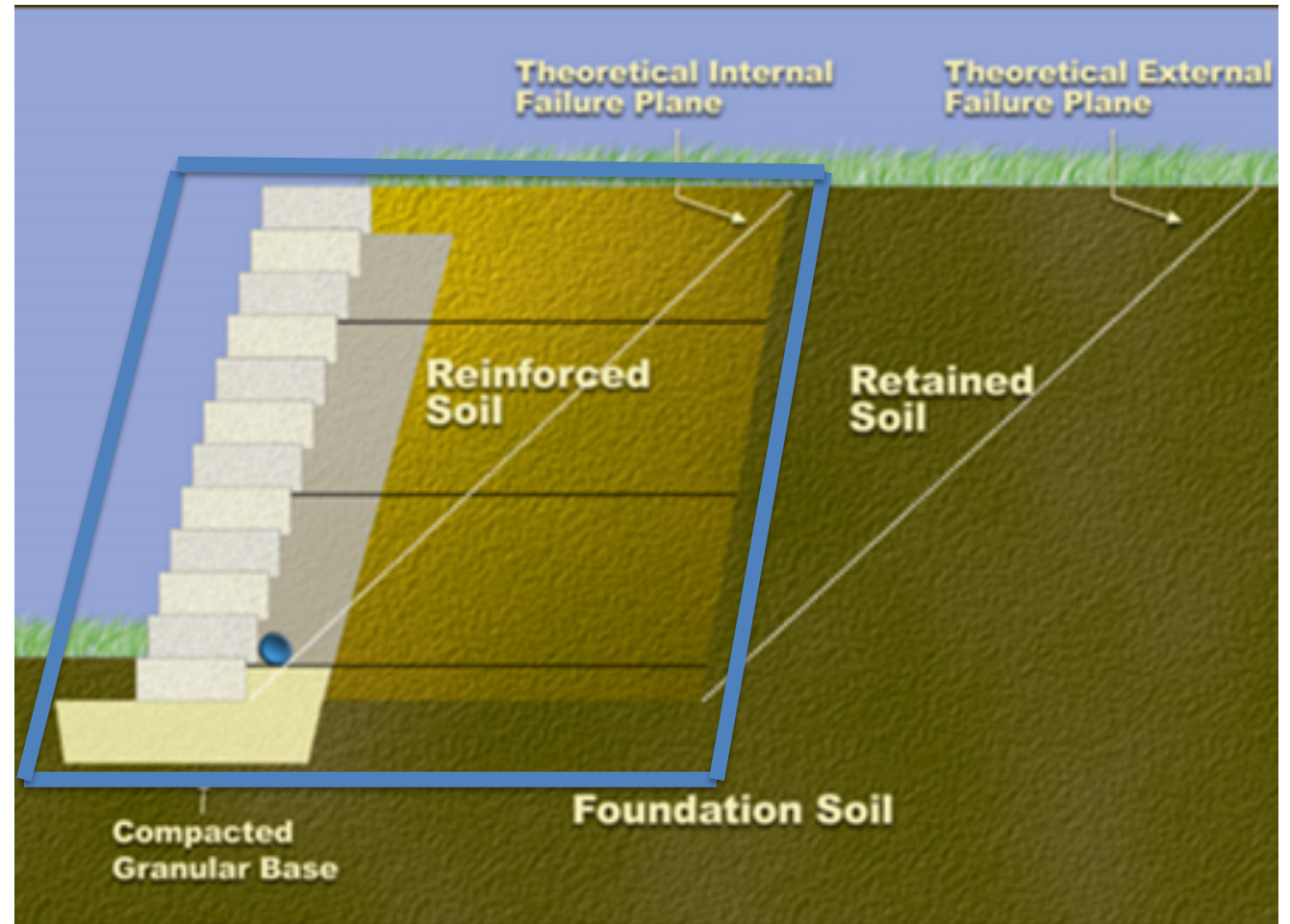


Reinforced Retaining Wall

This is a cross section of a reinforced wall. As shown by the blue box, by adding a geosynthetic reinforcement to the soil, the SRW system becomes a composite system made up of the wall units, the soil, and the geogrid.

This composite system provides stability to the retaining wall, allowing architects to increase wall height, back slope (the slope above the top of the wall), or surcharge.

As soil loads increase with wall height (or surcharge), the depth of the soil reinforcement is lengthened and additional layers of reinforcement are added, safely securing the soil zone. This technology allows for walls to reach about 50 feet before other factors begin limiting the maximum height.

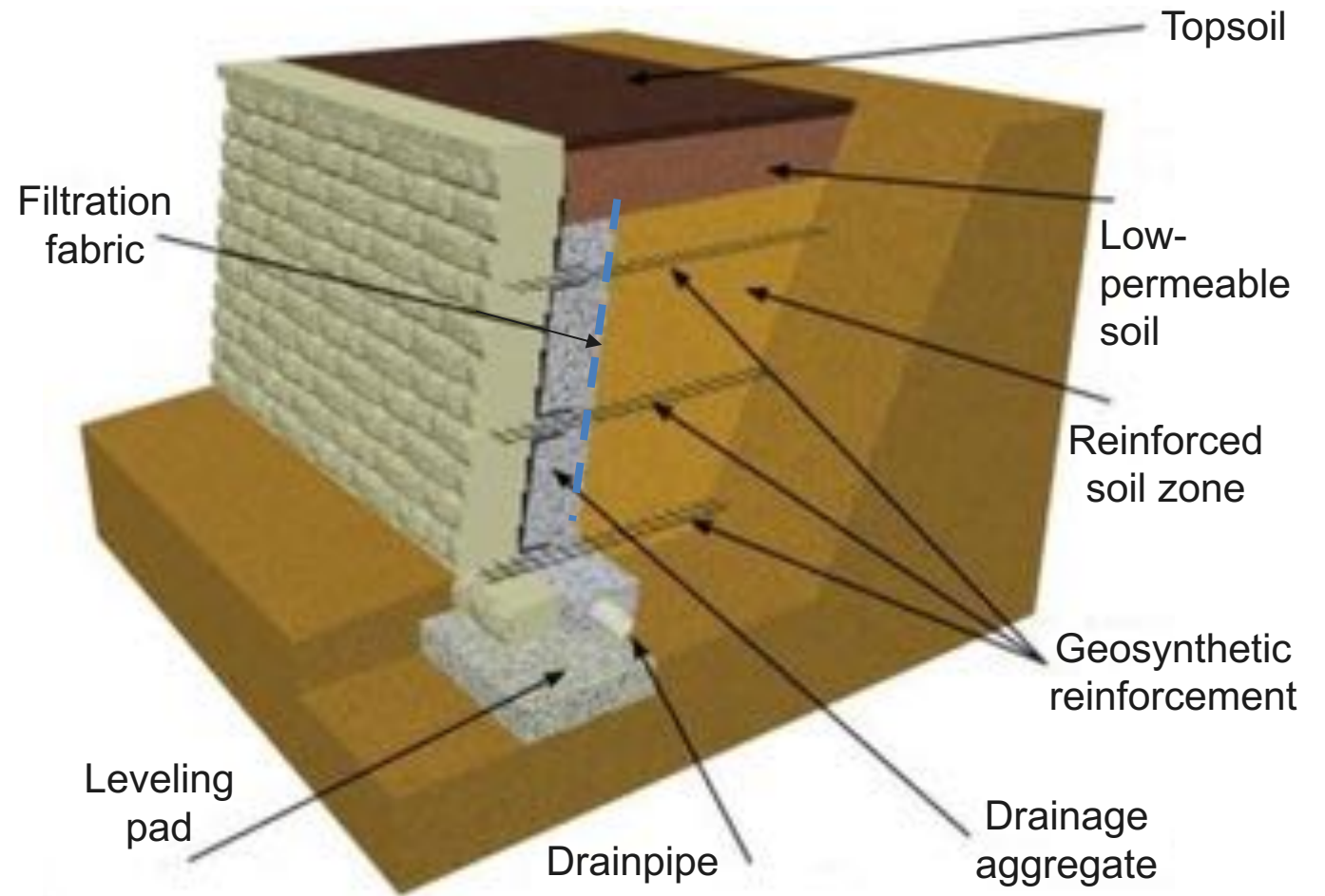


Cross Section of a Reinforced Segmental Retaining Wall

In order to design a segmental wall system, engineers need to know the soil strength (friction angle) and soil unit weight for each zone (including the retained soil, reinforced soil, and foundation soil). Here is a cross section of a typical SRW.

Typically, a free-draining crushed stone, such as #57, will serve as the drainage aggregate or fill, collecting incidental water leaking into the system. However, the aggregate's primary function is to provide facing stability during construction and serve as a low-compressibility zone between the face units and the backfill soil zone.

A 4-inch drainpipe collects and conveys incidental drainage to weep holes set at 50 feet on center max.

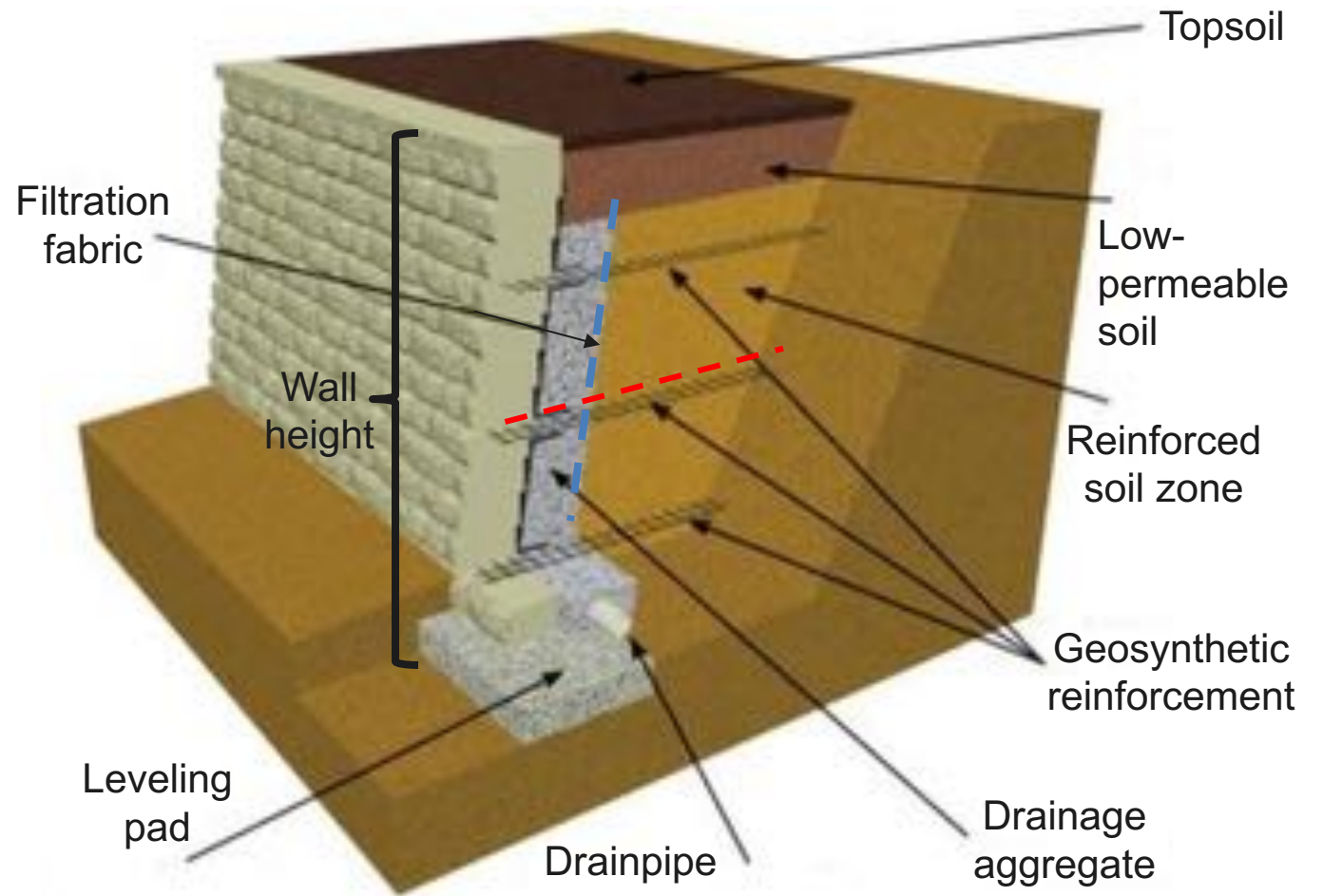


Cross Section of a Reinforced Segmental Retaining Wall

The design wall height or total height includes the embedded portion below grade and the exposed wall height.

All SRW systems have some inherent batter, or angle to which the unit slopes off the vertical. The angle generally ranges from 1 degree to 11 degrees leaning toward (batter) or away from (overhang) the soil zone.

The National Concrete Masonry Association (NCMA) guidelines state that the geogrid embedment length (shown by the red line) must be a minimum of 60 percent of the total wall height but is typically closer to 70–100 percent.



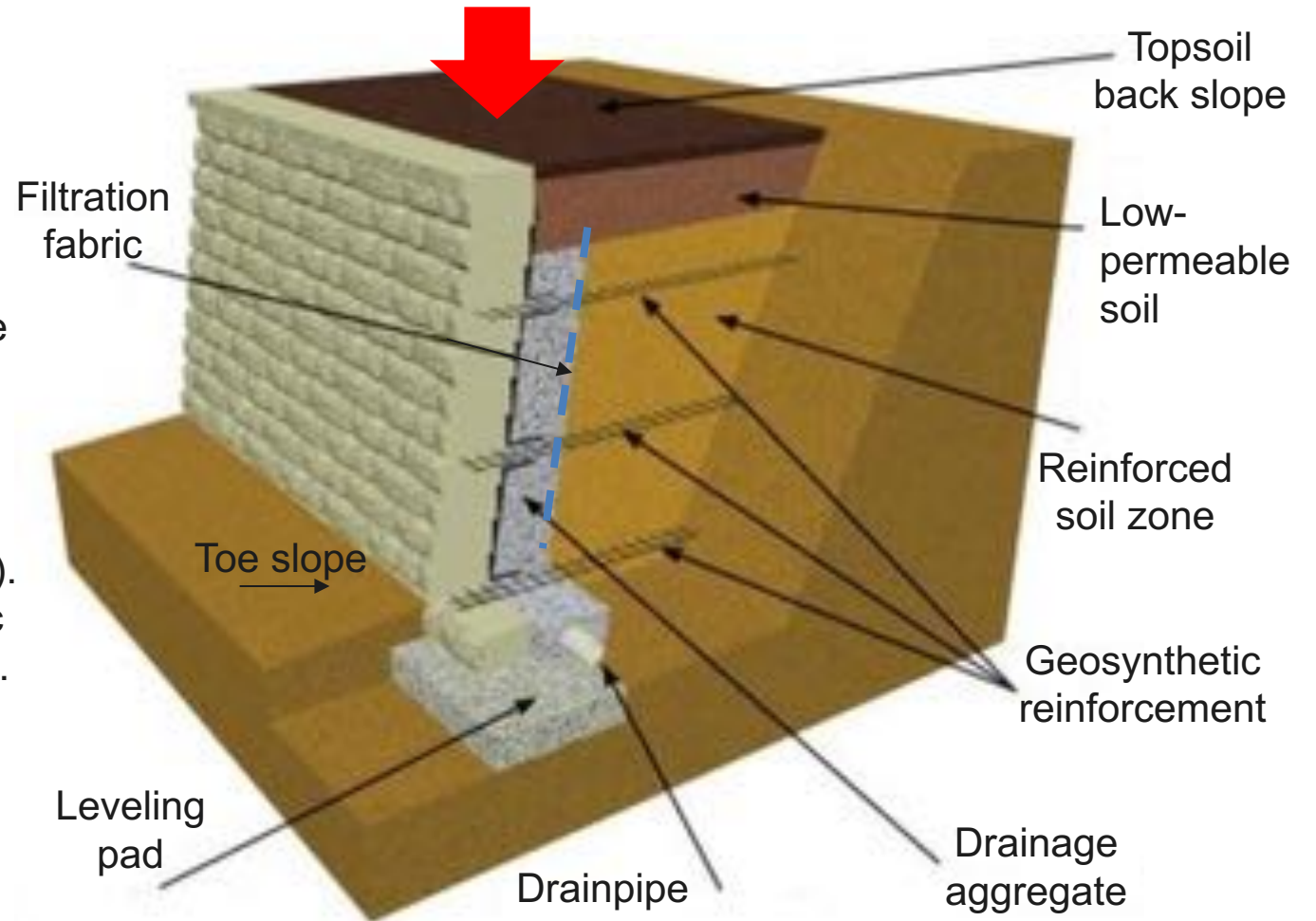
Cross Section of a Reinforced Segmental Retaining Wall

Toe slope refers to the angle at which the grade below the wall slopes away from the wall face. The toe slope angle impacts the depth of course block embedment.

A back slope acts as a driving force that must be resisted by the SRW. Any water draining to the face units because of the back slope must be accommodated.

Any additional loading at the top of the wall is known as surcharge (represented by the red arrow). It can be a temporary load (live load) such as traffic or a permanent load (dead load) such as a building.

Filtration fabric is often used to keep soil fines from the reinforced soil zone from migrating into the drainage gravel at the face.

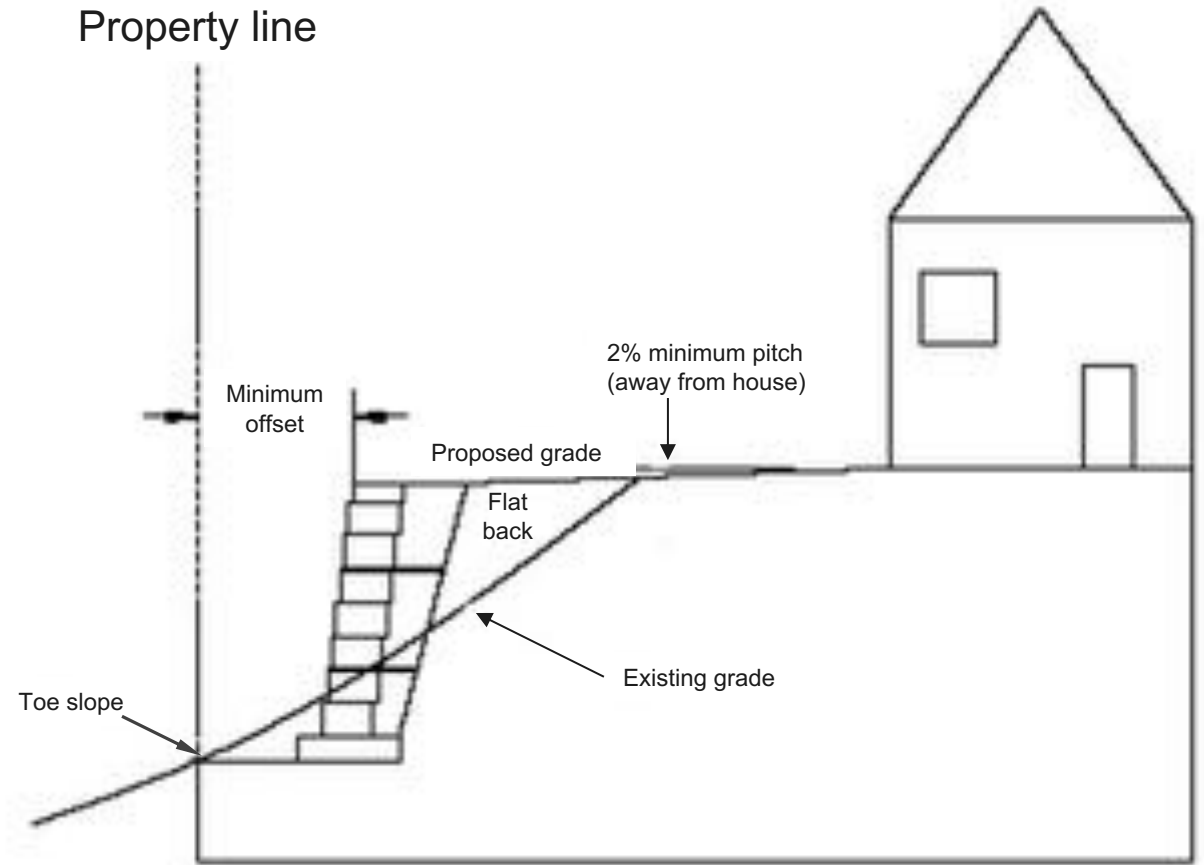


Fill Wall

Retaining wall applications typically fall into two categories: fill or cut.

To determine which type of wall is needed, the simple defining aspect is whether soil is being added or removed. To respect the site conditions and property lines, the grade conditions should remain unchanged at the property limits.

Fill walls are typically used on the topographically low side of the site. In the case of the diagram, it is being used to create usable level space above the retaining wall. Using a reinforced soil wall makes perfect sense since you are adding the fill where the soil reinforcement is placed. Walls on the lower portion of a site often have sloping toe conditions and may have shallow groundwater and soft foundation soil conditions.



Fill Applications

For a fill wall, as the name implies, soil needs to be added to construct and complete the wall.

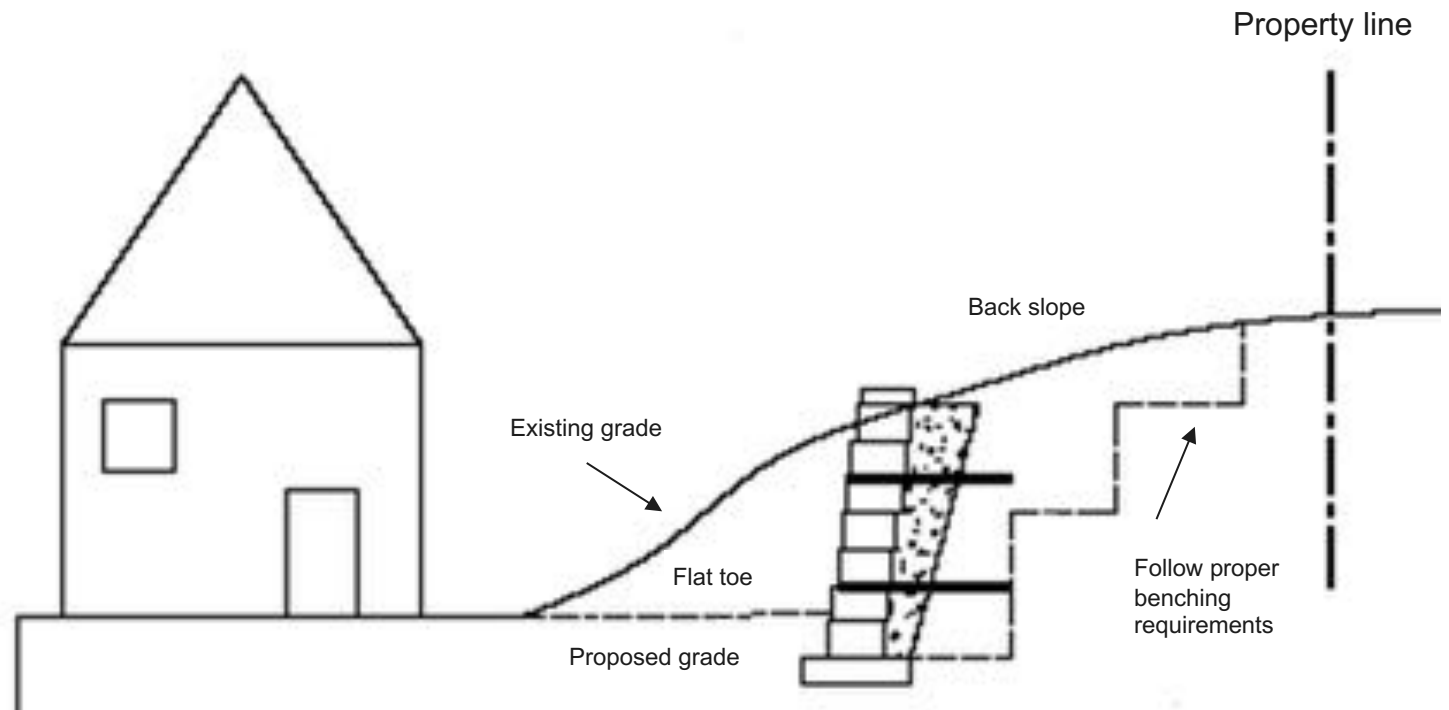
This is typically the case where flat back slopes and often a descending toe slope exist. Notice in the photo that the area behind the wall is flat and the toe area is sloped.



Cut Wall

Alternatively, when soil is excavated or removed, it is considered a cut wall. A cut wall requires that the area where the wall will be placed must be excavated to make room for placement of the geogrid or stabilized aggregate in order to get the wall installed. A cost-effective approach may include excavating the soil, stockpiling it, and then reusing it to construct the soil reinforcement zone.

Cut wall situations are commonly found along property lines. This can bring up construction easement issues. Taller cuts may require benching and can also trigger safety issues.



Cut Applications

Here is a typical cut wall. Please note the flat toe and the significant slope above the wall. Any surface area drainage must also be accounted for in the design plans for cut wall applications.

For a geogrid-reinforced wall, the area behind the wall needs to be removed to a minimum depth of 60 percent of the wall's height. For stabilized aggregate applications, the excavated depth can be as little as 24 percent of the wall's height, a reduction in depth of 60 percent.

Other areas of consideration include: the potential for existing utilities and groundwater sites located within the excavation zone and potential no-disturbance zones located within the construction site.





What is the difference between a stabilized aggregate retaining wall and a reinforced retaining wall?

Review Question

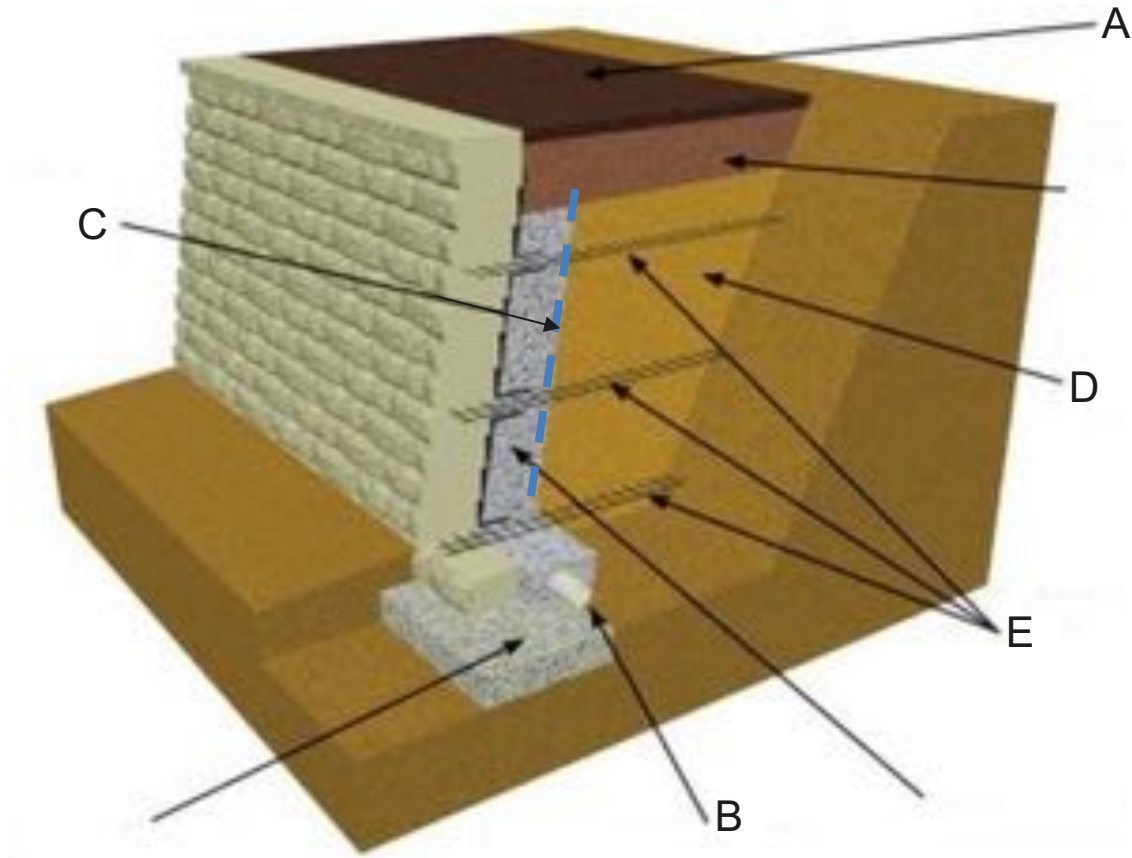


Answer

What is the difference between a stabilized aggregate retaining wall and a reinforced retaining wall?

A stabilized aggregate retaining wall uses poured concrete or stabilized aggregate as a structural backfill mass.

A reinforced segmental retaining wall requires that the soil behind the wall be excavated and backfilled with soils meeting high-quality standards and incorporating layers of soil-reinforcing geosynthetics.



Please label the diagram,
choosing from the words
below.

**Drainpipe, Filtration fabric,
Geogrid, Topsoil, Reinforced
soil zone**

A:

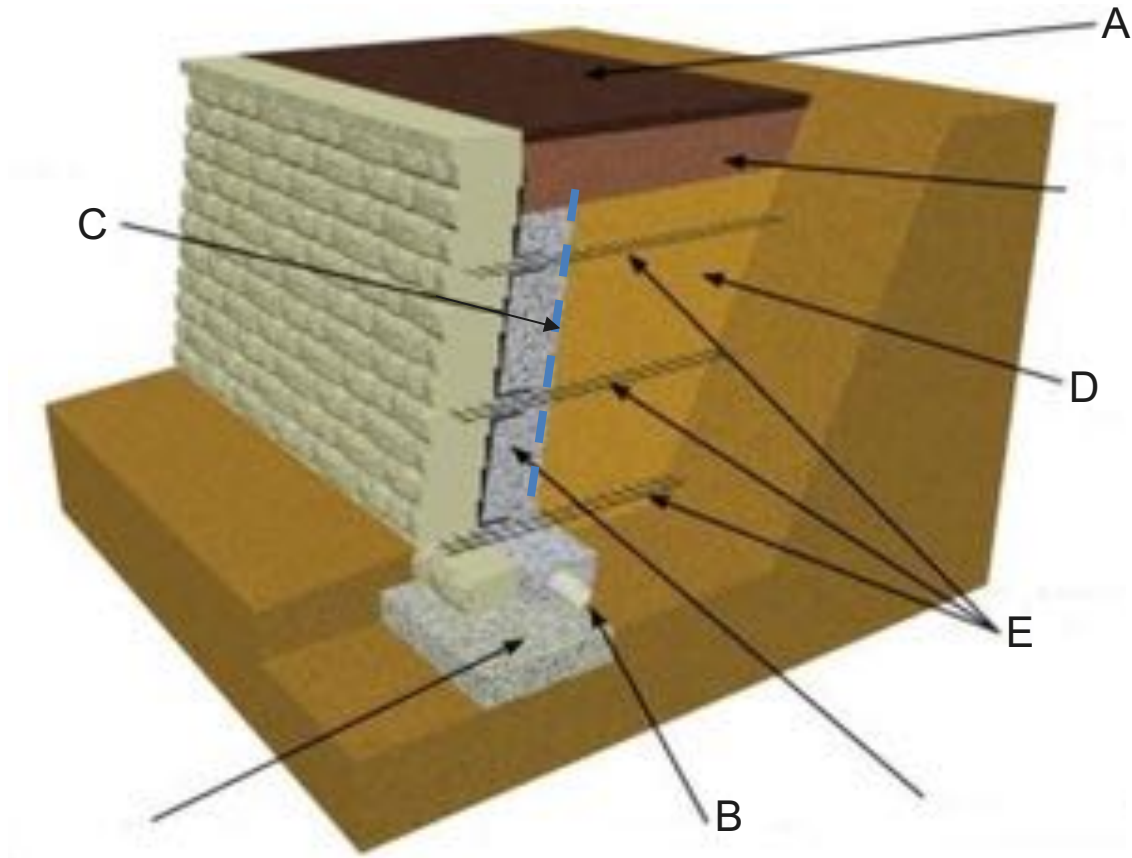
B:

C:

D:

E:

Review Question



Please label the diagram,
choosing from the words
below.

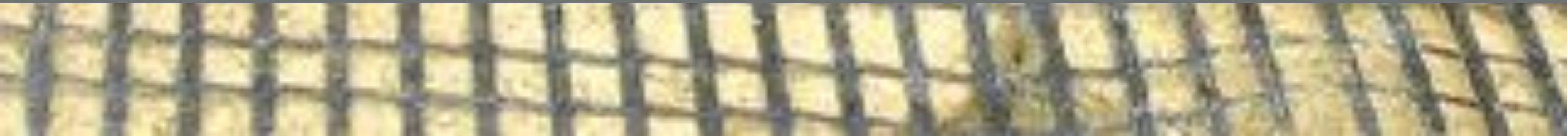
**Drainpipe, Filtration fabric,
Geogrid, Topsoil, Reinforced
soil zone**

A: Topsoil
B: Drainpipe
C: Filtration fabric
D: Reinforced soil zone
E: Geogrid

Answer

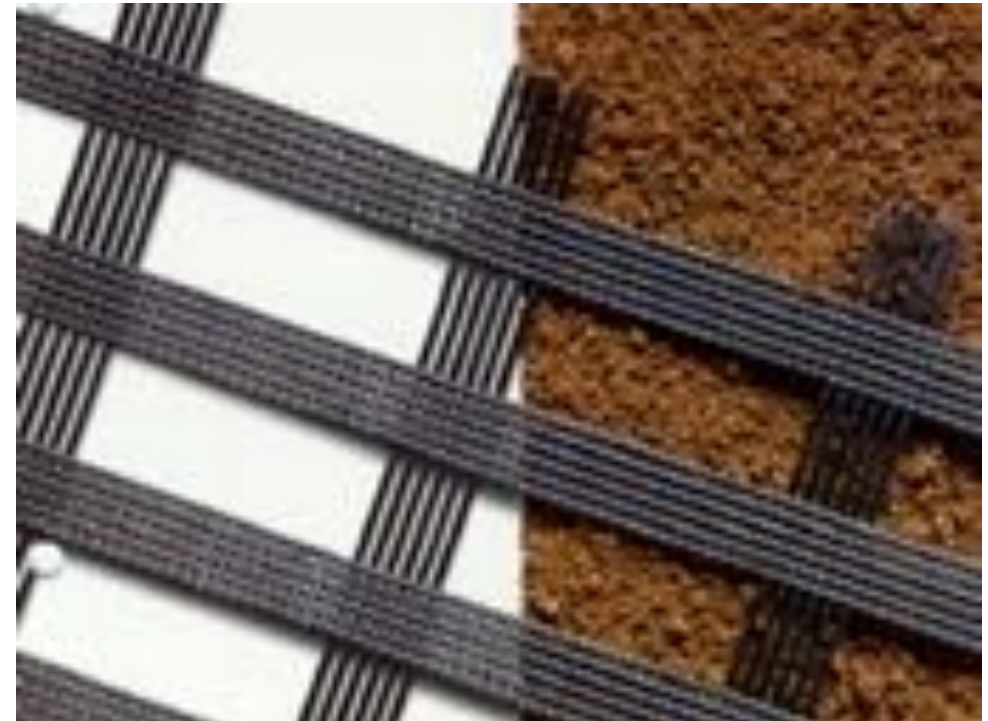


Geogrid Reinforcement



Geogrid Reinforcement

As previously mentioned, for SRWs above 3 feet or when conditions exist such as a surcharge or a slope above a wall, reinforcement is required. This section provides an in-depth discussion about geosynthetic materials. Geogrids are generally made from polymers such as polypropylene, polyethylene, or polyester and provide tensile reinforcement to the soil.



Geogrid

Geogrids have directional strength, meaning most of the primary strength is in the thicker threads that are laid perpendicular to the wall face (as shown in the image).

Large apertures in the geogrid allow for drainage and soil strikethrough. Multiple layers of soil geogrid combinations bind the soil into a more cohesive mass unit. The larger the mass unit of soil, the more stable the wall.

Similar to reinforcing steel for concrete, the geogrids come in different strengths. Stronger geogrids are used in the lower portions of the retaining wall because of the increased soil weight. However, for most SRWs up to about 12 feet or so in height, it is common to need only one strength of geogrid.



Using Geogrid Reinforcement

As mentioned, the geogrid and the SRW facing make a composite system. Reinforcement adds strength to the soil in a direction the soil typically does not have. Similar to concrete, soil is generally strong in compression, but weak in tension. The soil reinforcement adds tensile strength to the soil much as reinforcing steel adds tensile strength to concrete. The result is a reinforced composite mass.

The best way to explain this is to show you how it works.

Using Geogrid Reinforcement

Let's demonstrate how reinforcement provides strength in the soil.

The right side of this picture shows a hinged wooden box of crushed stone without any reinforcement.



Using Geogrid Reinforcement

As you can see, when a downward force is applied to the box of regular soil, the soil moves apart.

There is no reinforcement in this soil, and it spreads laterally because the soil has no tensile strength to resist moving sideways under a load.



Using Geogrid Reinforcement

Now the soil is reinforced with a geogrid and the demonstration is repeated.



Using Geogrid Reinforcement

When the sides of the box are released, the reinforced soil, which now has improved tensile strength, behaves as a composite. A load can even be placed on the soil mass, and it does not move. Although there is some surface raveling of the edges, the composite mass remains structurally sound. In on-site applications, the SRW facing would resist that surface raveling.

This example demonstrates how a reinforced SRW safely and effectively manages large volumes of stabilized earth.





Performance Factors



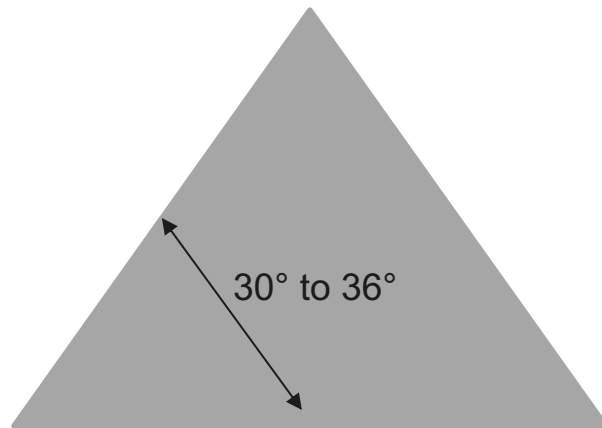
Performance Factors

The facing blocks and geogrids are some of the components of a retaining wall, but the reinforced soil comprises up to 90 percent of the composite structure. Unlike other wall system components that are manufactured in a plant and subjected to quality control, architects must use the soil that is present on the job site.

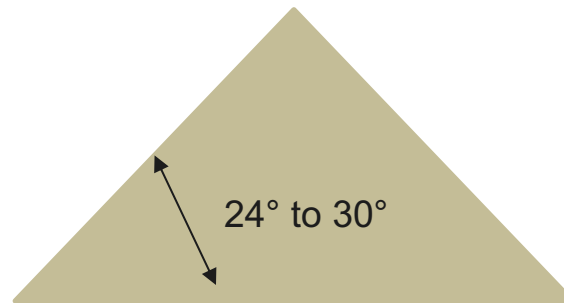
The soil must be examined and tested prior to and during construction as part of important quality assurance and quality control measures. Site soil conditions play a primary factor in the performance of the retaining wall. The following factors need to be examined as part of the planning process for an SRW installation: soil property and composition, including soil friction angle; site conditions, including level back (crest) and toe, potential surcharge, and tiers; global stability factor; and seismic potential.

Soil Design Properties

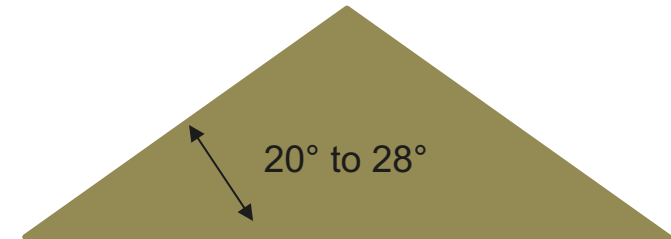
The strength of the soil is related to its friction angle. For example, the higher the friction angle, the stronger the soil. The friction angle is directly related to the soil's composition and how well it is compacted. Sands and gravels have high friction angles and are thus preferred materials for reinforced retaining walls because they are less likely to pull away from any sloped areas.



Gravel and sand



Silt



Clay

Reinforced Soil Requirements

NCMA has recommended criteria for soil in the reinforced zone. Site soils up to 35 percent passing the #200 sieve with a Plasticity Index (PI) less than 20 can be used. (PI gives a good indication of how claylike the soil behaves, including in terms of its permeability and compressibility. The greater the PI, the more claylike the soil.) Soils that pass through a #200 sieve and are thus smaller than the sieve opening size are referred to as fines. NCMA best practice recommends tightening those requirements or lowering the PI to 6 for retaining walls more than 10 feet and further limiting the maximum fines content to less than 15 percent for walls more than 20 feet.

Reinforced Soil Gradation Recommendations	
Sieve size	Percent passing
#1 inch (24 mm)	100
#4	20–100
#40	0–60
#200	0–35

On-Site Soils

Typically, there are two main categories of soil: coarse-grained soil (a sand/gravel mix, dominant fraction larger than the #200 sieve) and fine-grained soil (silt/clay mix, dominant fraction smaller than the #200 sieve).

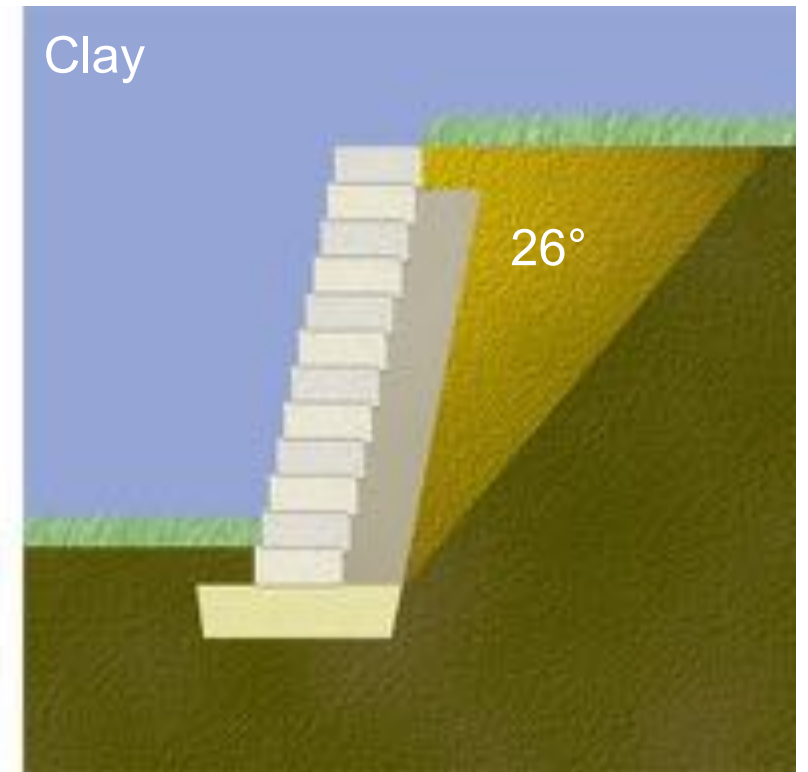
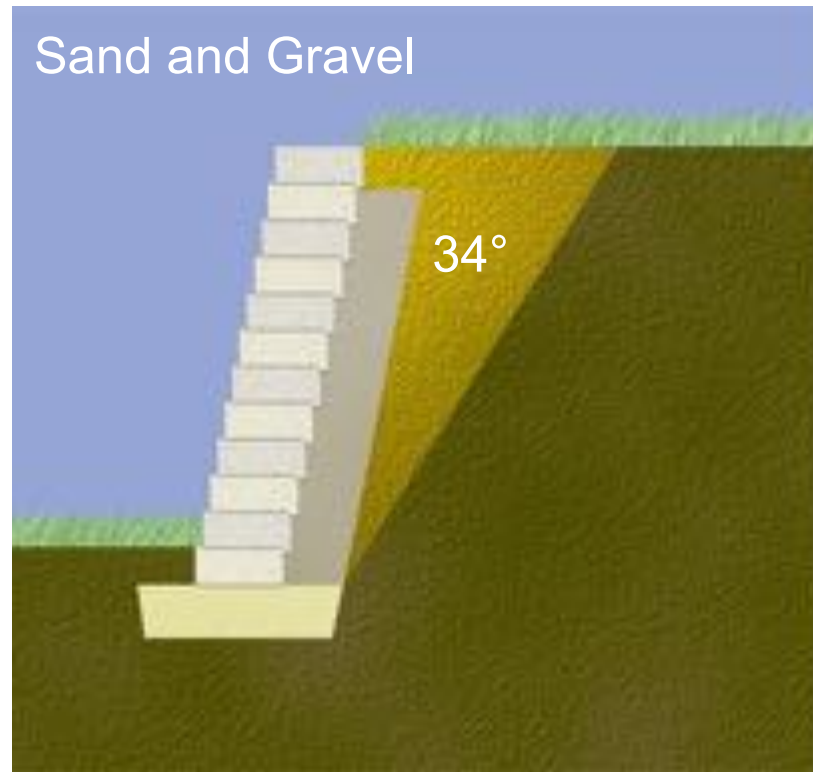
Coarse-grained soil is preferred for reinforced soil walls. The particles are angular and next to each other, and they generate a lot of friction, which means they provide the soil with strength. These materials also drain water efficiently.

Fine-grained soil comprises small particles of soil that have a putty consistency when water is added. This type of soil is harder to work with and compact, and it does not drain water well.

On-Site Soils

Compare the active soil wedge of a sand/gravel soil and a clay soil. As you can see on the right, the active wedge in a clay soil is much larger than in the sand/gravel soil, and thus the soil load on the wall is greater.

In a gravity wall situation, this means you cannot build a wall as tall with a clay soil because the active soil wedge is transferring more load to the wall.



Other Performance Factors: Site Conditions

This image shows a multitiered wall.

The next few slides will examine five typical site conditions that deserve proper consideration:

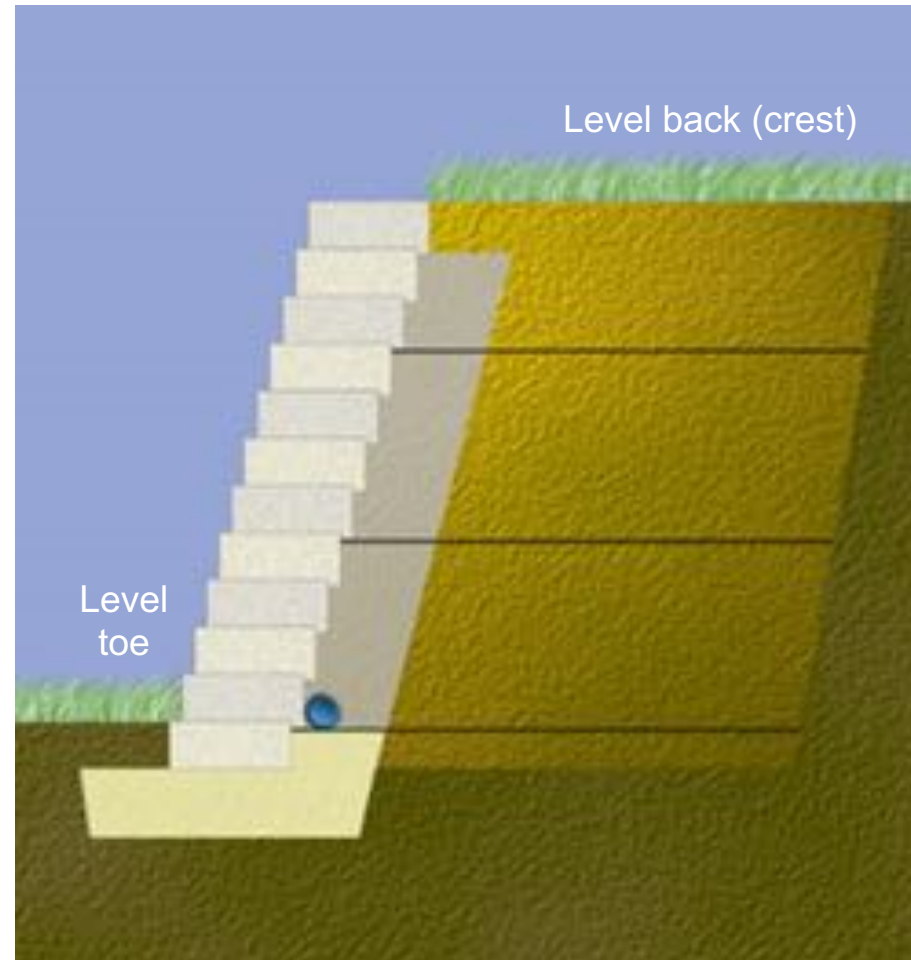
- Level back and toe conditions
- Surcharge (live or dead) on top of wall
- Slope behind the wall (back slope)
- Slope below the wall (toe slope)
- Tiered walls



Level Back and Toe Conditions

A level back (crest) and toe is a basic application from a design and installation standpoint. However, always be mindful of potential drainage issues.

On the far right is an example of a simple level back and toe installation at a golf course in Florida.



Surcharge on the Wall

The surcharge is the downward force of a live or dead load on the SRW. This force is typically from the top of the wall but can also be from the side as a deadload soil mass.

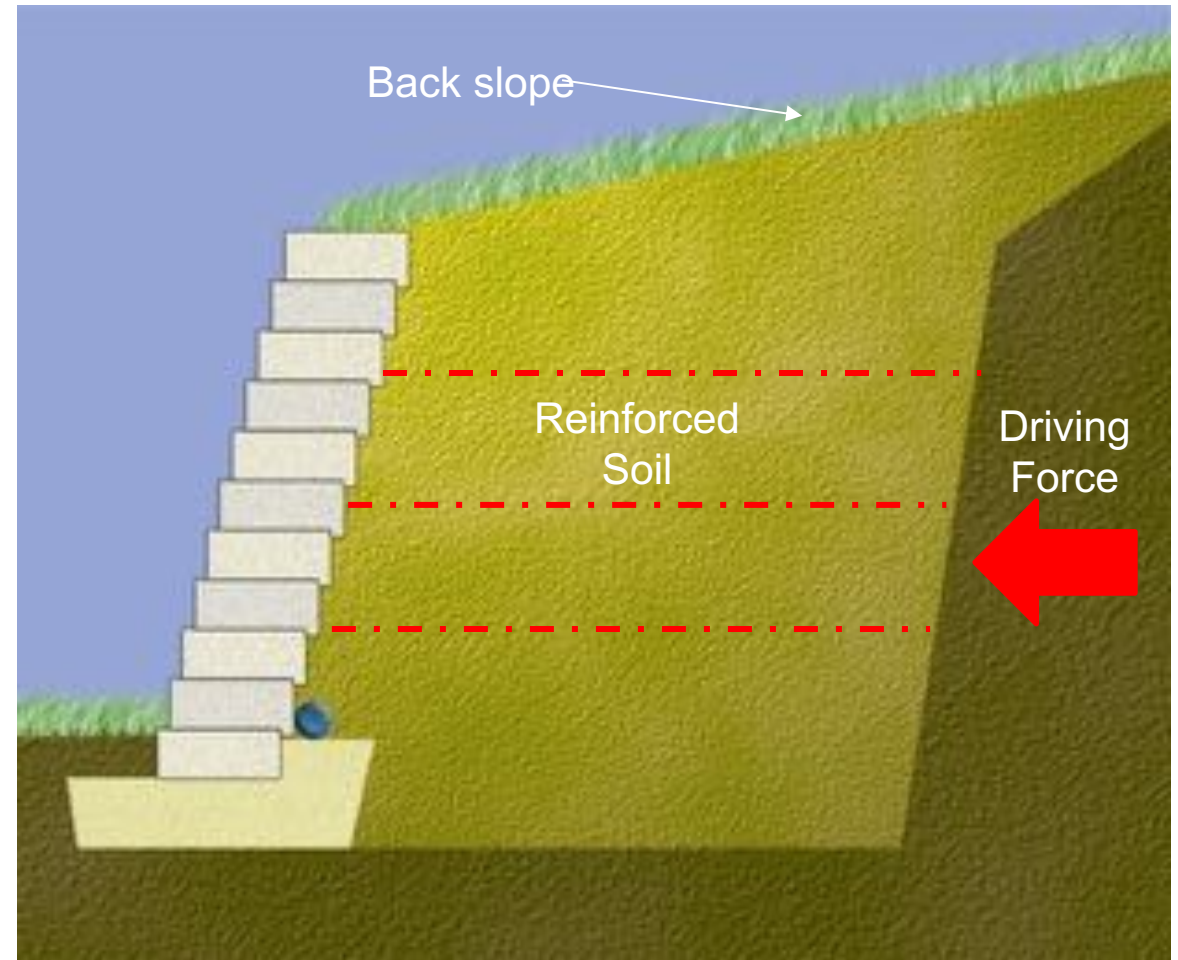
The images show that surcharge load size can vary greatly.



Slope Behind the Wall (Back Slope)

Another common site condition is a slope behind the wall. In back slope situations, the soil wedge exerts increased pressure on the SRW. When designing an SRW for this type of application, engineers determine the length and number of the reinforcement layers depending on the strength of the onsite soil and the external force of the dead load.

Fine-grained silts and clay soils are not as strong as sands and gravels and thus require longer and sometimes more reinforcement layers than sand and gravel soils.



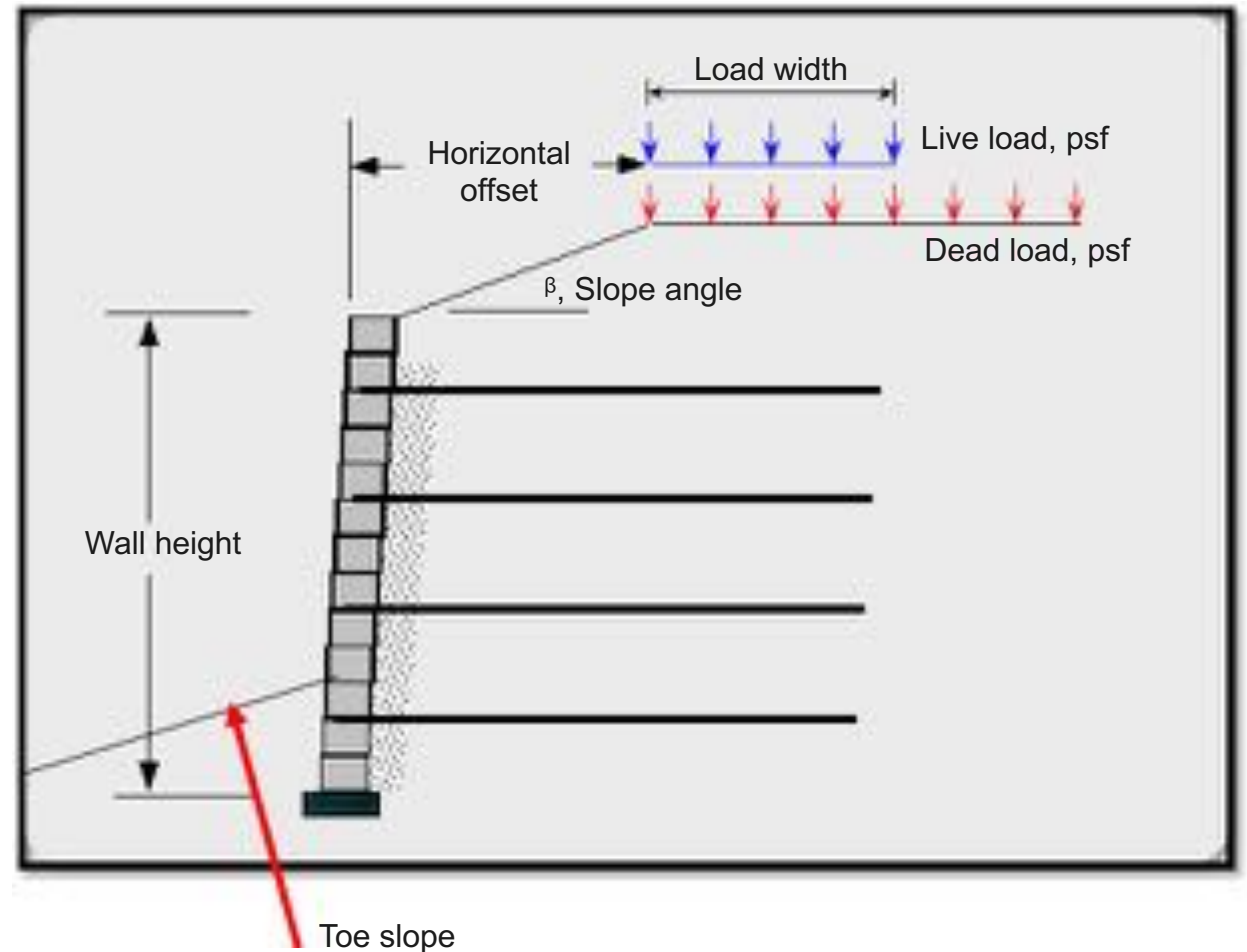
Slope Behind the Wall

This is an example of a slope on top of a 4-foot property boundary wall. You can see the flat toe, as well as the 3:1 back slope.



Slope Below the Wall (Toe Slope)

A toe slope is the sloping grade at the toe of the wall. Steeper toe slopes tend to decrease stability of the wall system, often require longer geogrid layers, and increase the amount of the wall that should be embedded.



Tiered Walls

Terraced—or tiered—walls are a popular, decorative design option, but you need to know if the walls are close enough together to be dependent on each other.

If they are close enough together to affect each other, they are dependent walls. If they are far enough apart to act independently, they are independent walls.

To determine which case it is, there is a key rule of thumb: the 2-to-1 rule.

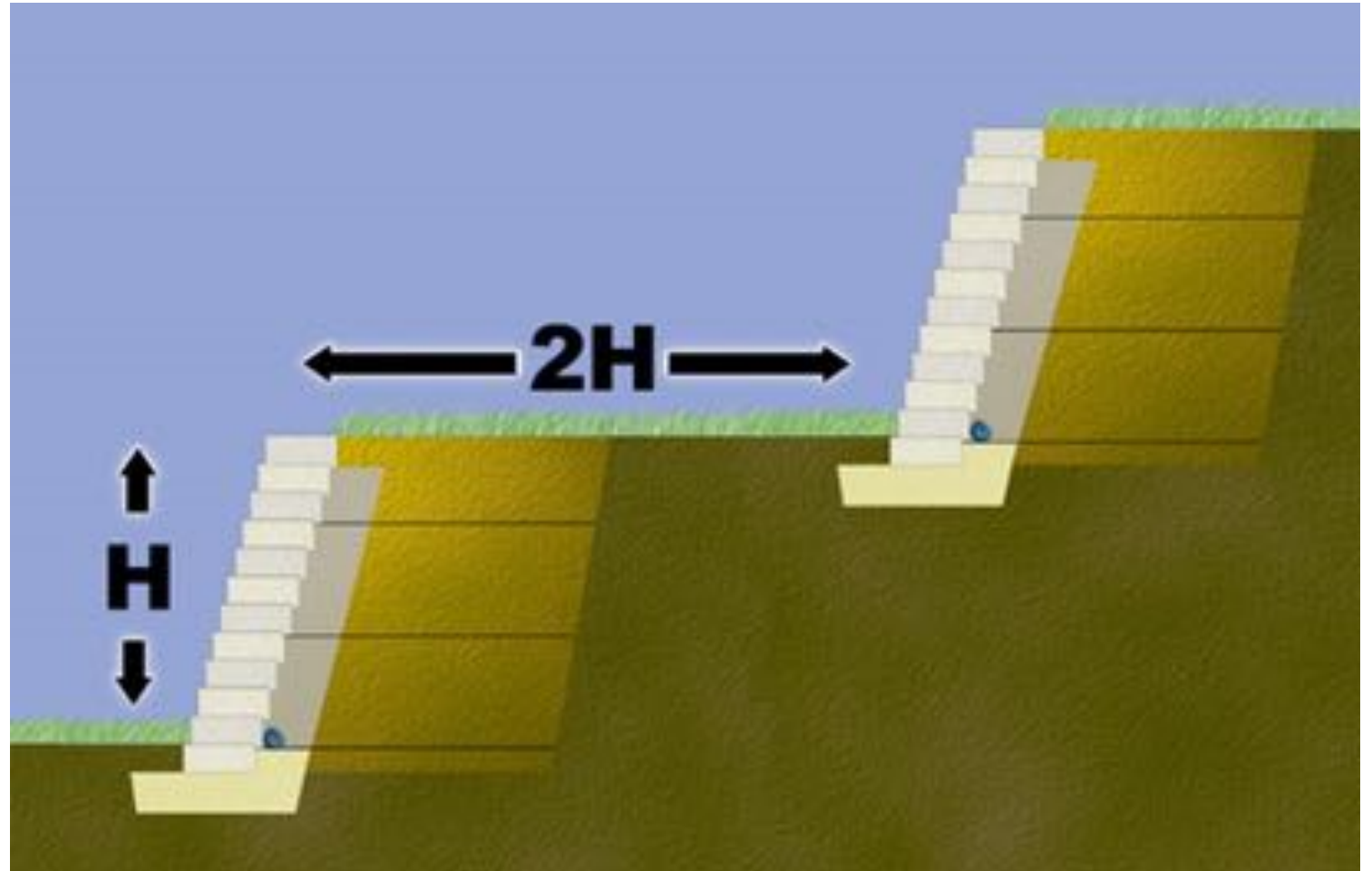


Tiered Walls: The 2:1 Rule

If the horizontal distance between the two tiers is two times or more the height of the lower wall, then the walls are independent and loads from one do not affect the other.

If that distance is less than two times the lower wall height, then the walls are dependent and therefore must be designed together as a system.

The rule does not mean that the walls cannot be designed or constructed closer together. The additional loads from the upper wall(s) must be taken into account when designing the load capacity of the lower wall(s).



Dependent Tiered Walls

This is an example of a dependent terraced wall that is engineered using reinforcement. Notice how close the walls are together; they were designed to function as one system.



Global Stability Failure

Global stability failure is movement of the entire segmental retaining wall mass, including the soil behind and beneath the structure. It can occur if the length and layers of reinforcement are not sufficient to support the entire slope/wall system.

Soil stability is particularly important when designing and constructing structurally dependent walls. Tiered-wall situations often include structurally dependent walls, where two or more walls are built to achieve a stair-step landscaping effect.

Global stability should always be evaluated during the design phase whenever tiered walls are considered, when slope conditions exist (specifically toe slopes), or when foundation and reinforced/retained soils are weak and or subject to inundation.

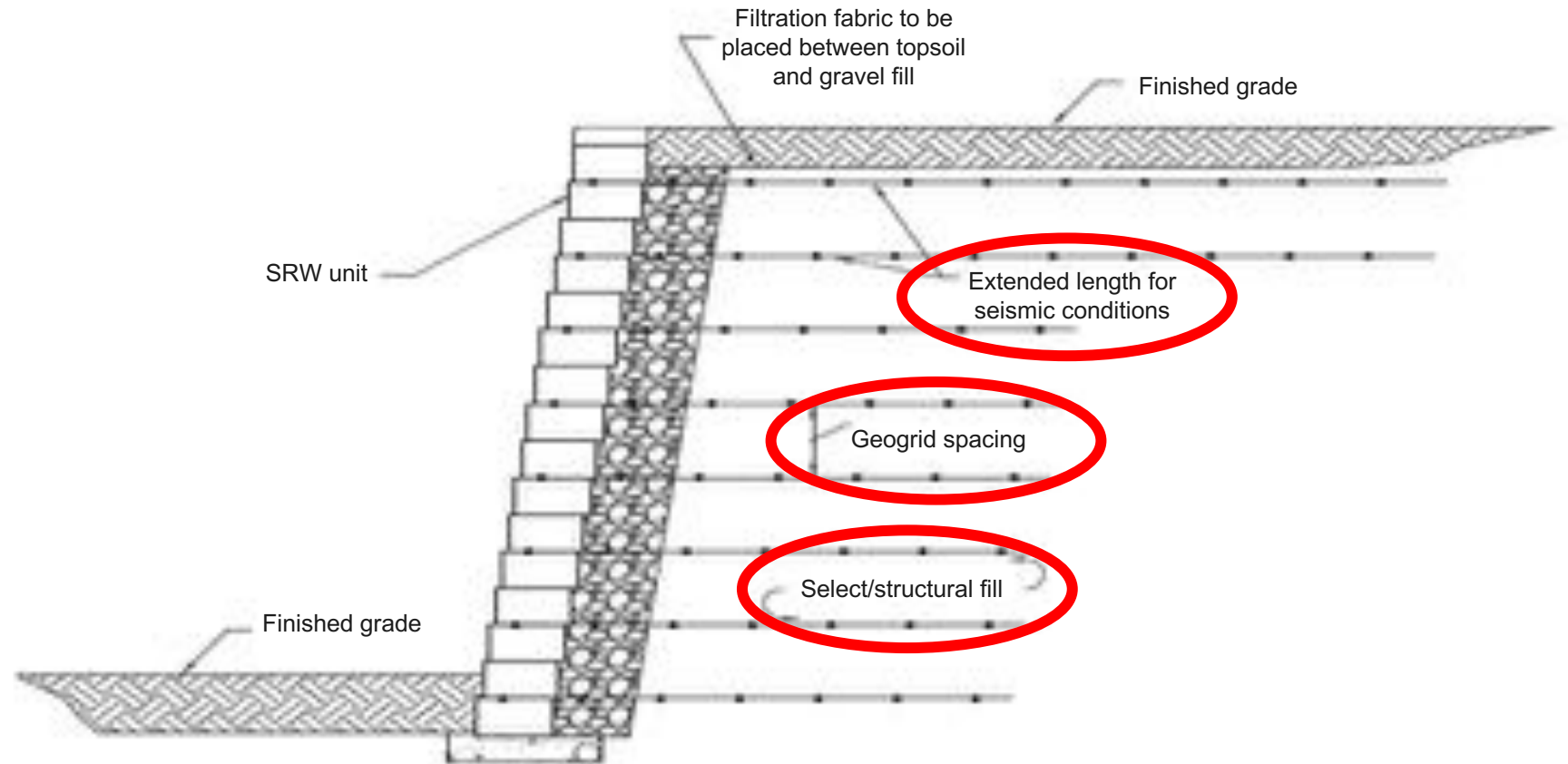


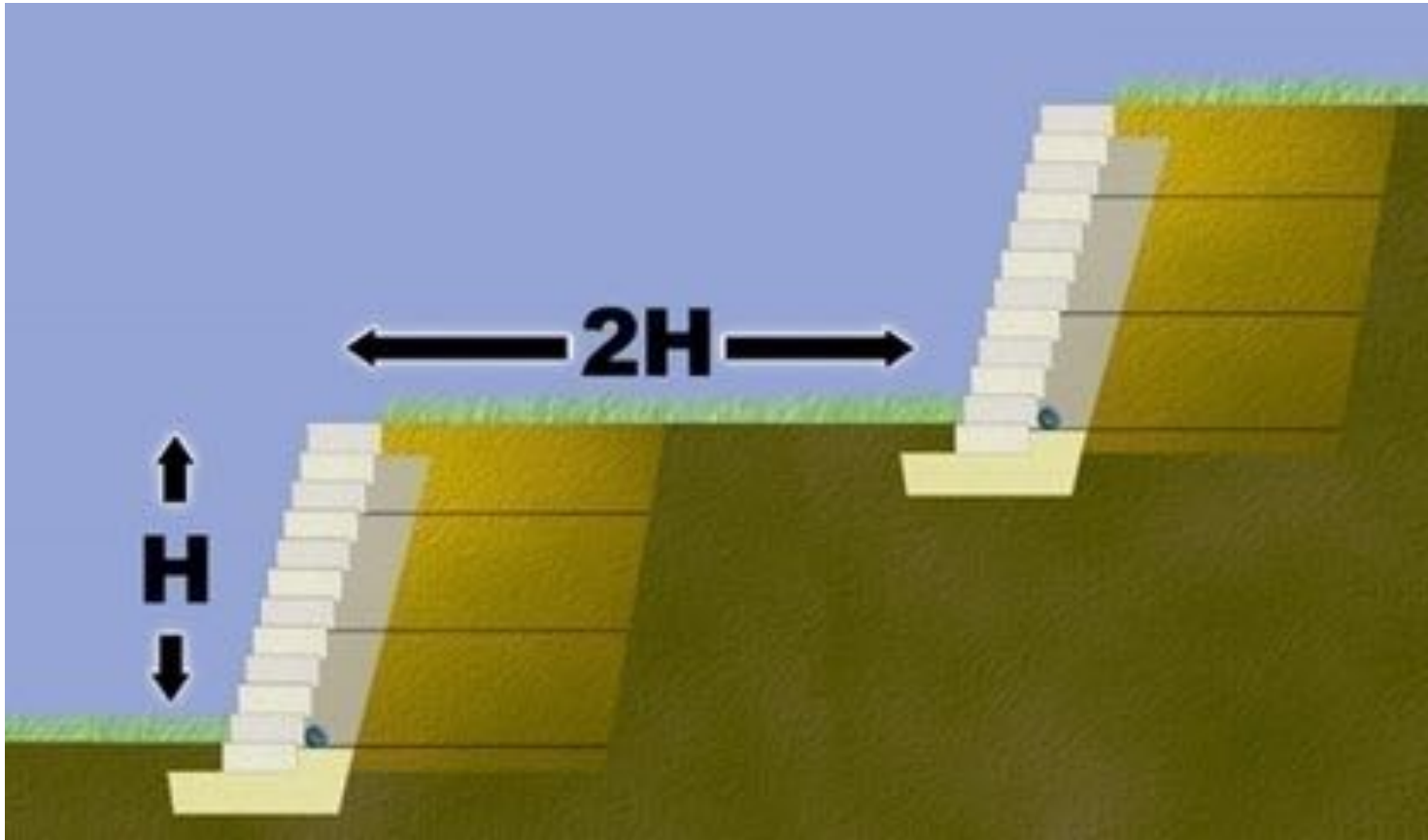
Seismic Conditions

Seismic conditions can play a role in some areas of the country, and designers must check local seismic code requirements.

Typically, the top layer(s) of the geogrid will be extended to satisfy the seismic design requirements.

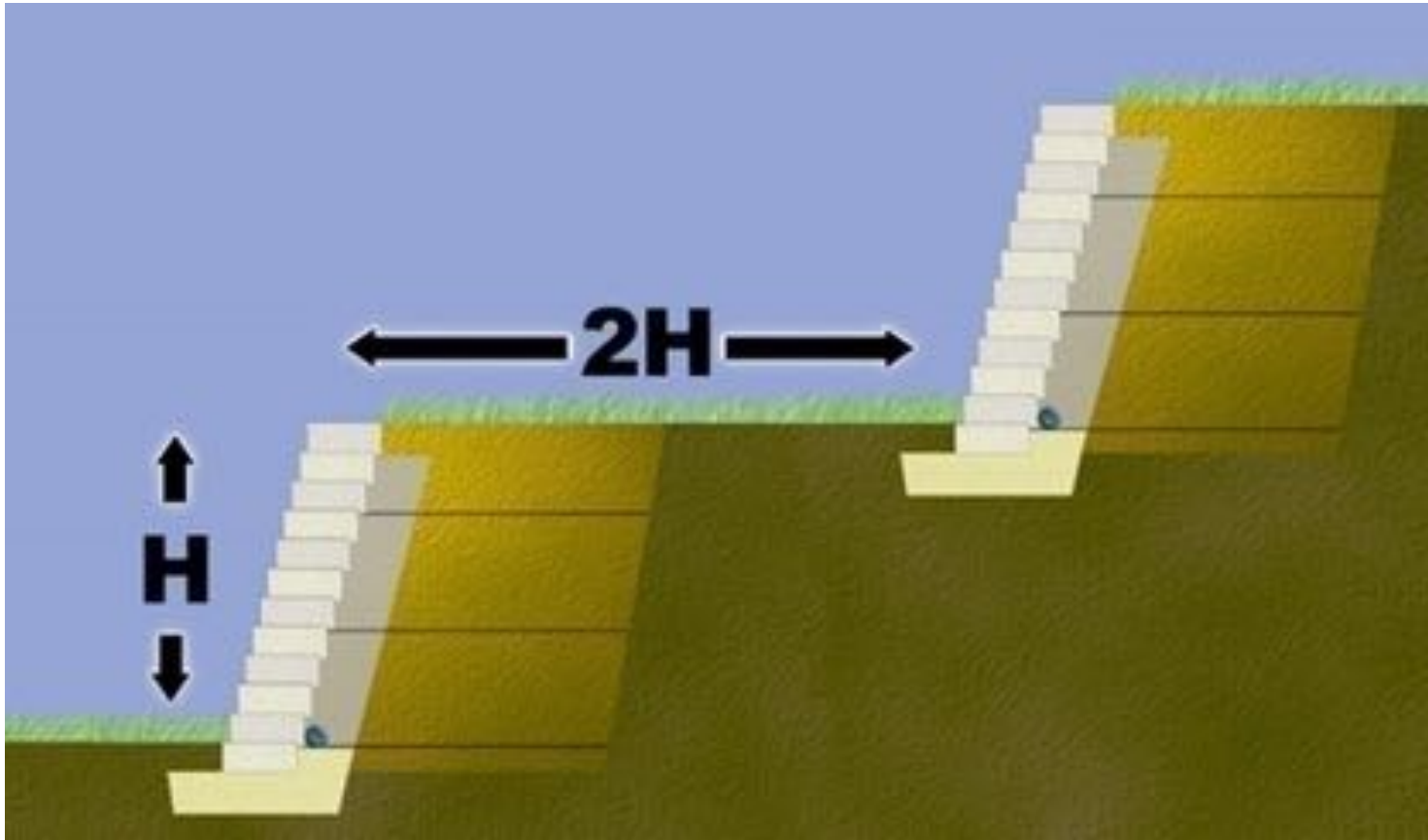
Closer geogrid spacing and the use of select backfill will help to reduce the effects of dynamic loading.





Explain the 2:1 Rule.

Review Question



Answer

Explain the 2:1 Rule.

The 2:1 rule is used to determine whether SRWs are dependent or independent of each other.

If the horizontal distance between the two tiers is two times or more the height of the lower wall, then the walls are independent and loads from one do not affect the other.

If that distance is less than two times the lower wall height, then the walls are dependent and therefore must be designed together as a system.



Segmental Retaining Wall Installation



SRW Construction Sequence

Let's quickly review the segmental retaining wall construction process.



Subgrade Compaction

Everything starts with the subgrade conditions and soil strength assumptions.

Fill subgrades must be compacted to 95 percent Proctor density, and cut subgrades must be inspected via proof rolling or similar to verify foundation soil integrity.



Leveling Pad Installation

Once excavation and subgrade compaction have been completed, the leveling pad is installed. The leveling pad is not a footing, but rather a stable working platform used as a starting point for the placement of the SRW facing units. This leveling pad is typically a crushed aggregate base, usually 6 inches in thickness. It is wider than the facing unit, extending a further 6 inches on the front and back sides. The top of the pad is 6 inches or 5 percent of the wall height ($H/20$) below grade and compacted to 95 percent standard Proctor density.

On large applications, a poured unreinforced concrete (2,000 psi minimum) bearing pad can be used to speed installation. Once the pad has been installed and all debris removed, the facing units can be installed.

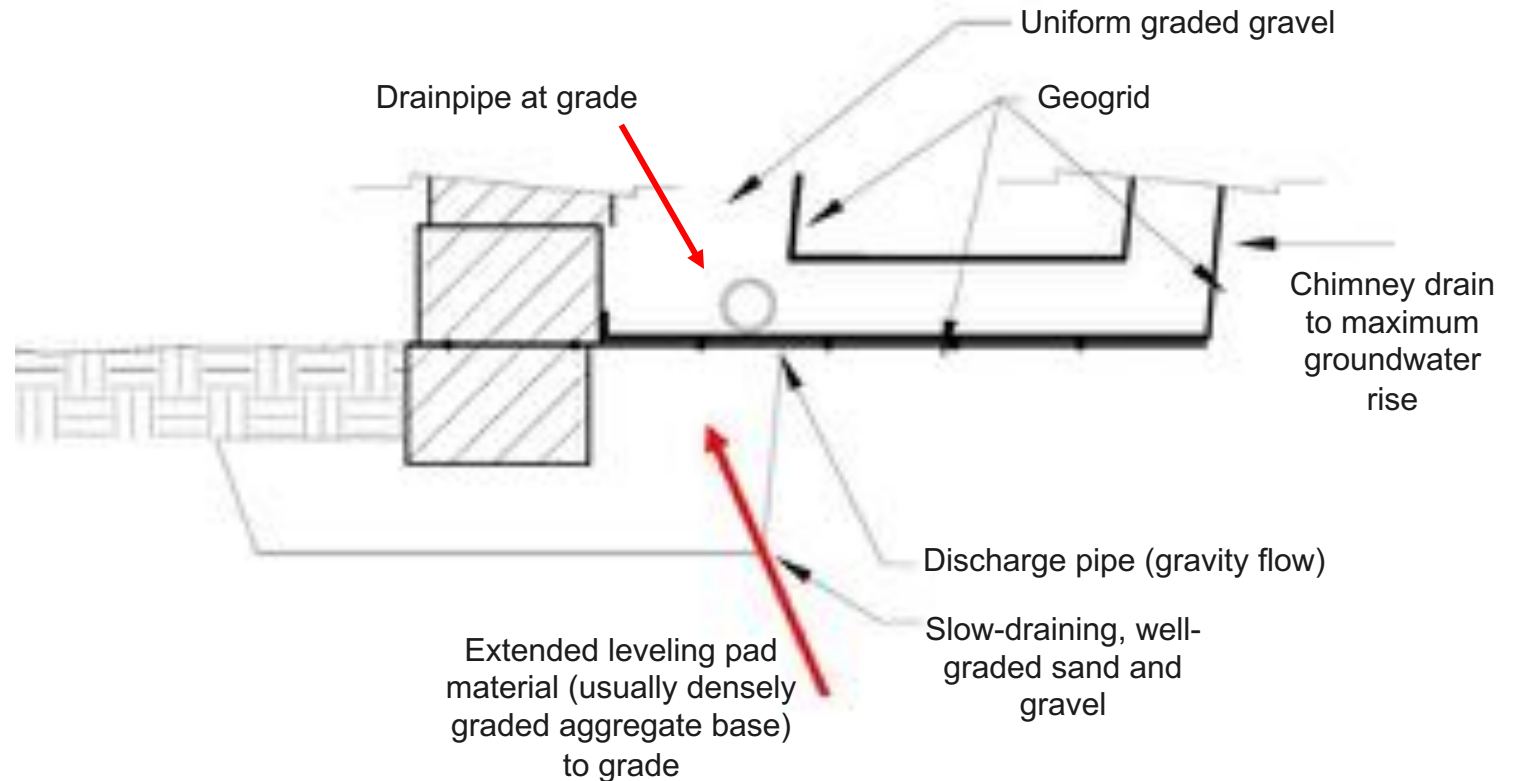


Leveling Pad Detail

Proper drainage is always an important consideration.

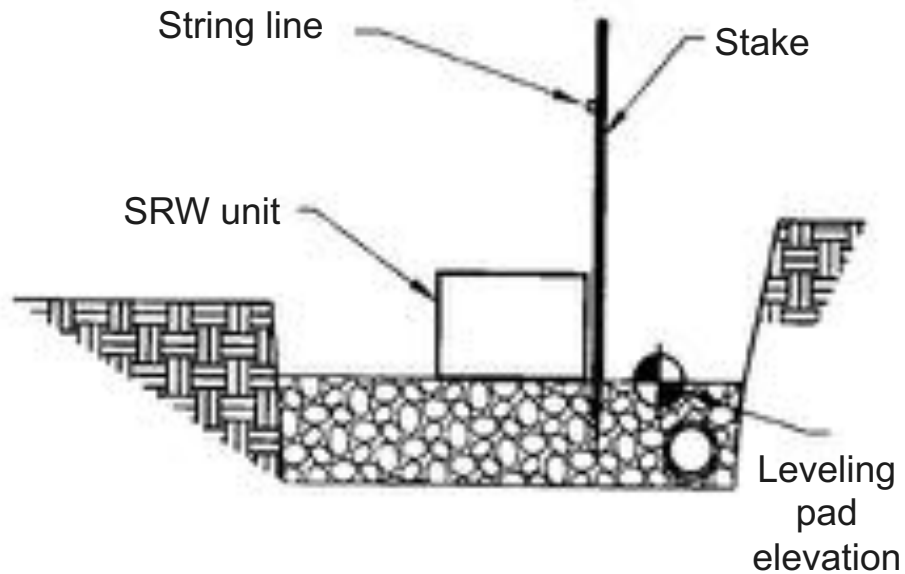
If the lowest elevation for the drainage pipe is the finished grade in front of the wall (a common situation), it is best to extend the leveling pad material to grade while also ensuring the drainage pipe is above grade—unless otherwise connected to a deeper underdrain system.

This avoids water collecting below grade, unable to drain.



Base Course Installation

The base course is the most important course in the wall. The first course of units will determine the trueness of the finished wall. Use a string line in both directions to ensure the base is level and correctly aligned. Uniform bearing on the leveling pad is essential. Once the base course is properly laid, the facing units are dry-stacked to form the wall; level the units front-to-back and side-to-side.



Drainage Aggregate Installation

When installing drainage aggregate, there are many performance factors to consider.

The aggregate, typically #57 gravel, is installed behind the facing units to a depth of 12 inches; however, for tall walls (less than 20 feet), this drainage zone could be as deep as 36 inches behind the block. The drainage material has low compressibility, damping the differential settlement in addition to allowing increased water flow capacity.

The permeability of the gravel is critical, as undrained water can lead to an increase in hydrostatic pressure behind the wall, causing damage such as bulging or cracking.

A 4-inch drainpipe is set at the base of the wall to enhance water flow.



Drainage Pipe

A 4-inch drainpipe will need to be daylighted at 50 feet on center and at the low end of the SRW.



Backfill and Compaction

Backfilling should occur one course at a time to a maximum lift (or layer) thickness of 6–8 inches with a compaction of 95 percent standard Proctor density.

When compacting fill material, make sure heavy mechanical equipment does not come within 3 feet of the wall face. Lighter, walk-behind equipment such as a vibratory plate compactor is used in this zone.

Heavy equipment can apply damaging forces to the wall and result in bulging or distortion of wall face alignment.



Proper Soil Compaction Is Key

Heavier, more efficient, compaction equipment can be used beyond 3–4 feet from the face.

Proper compaction is 95 percent of standard Proctor density maximum and should be achieved throughout the backfill zone, including the light compaction equipment zone near the wall face.



Proper Geogrid Installation

Before the geogrid is placed, the soil should be examined. The soil should be roughly level with the top of the block with no dips or bumps.

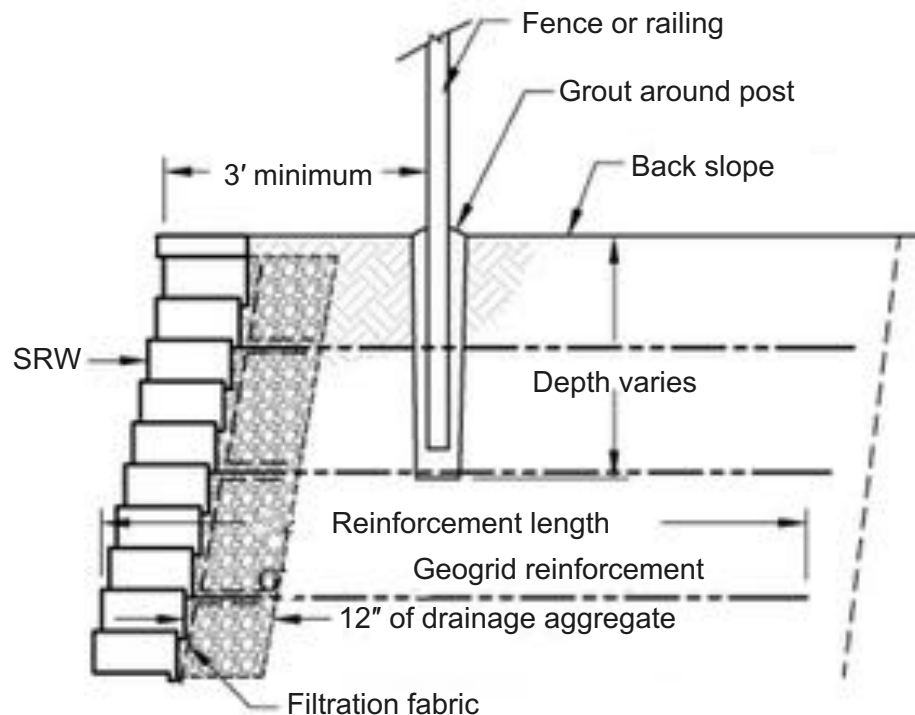
The geogrid is then placed over the soil approximately one inch from the unit face. There should be 100 percent soil coverage, with no gaps or areas where the geogrid overlaps—the geogrid has thickness that will influence the wall's alignment.

Maintain nominal tension immediately behind the unit face to avoid wrinkles and humps.



SRW Fence Integration

All walls taller than 30 inches should have a fence for fall protection. Typically 3 feet from the block face, post holes are inserted along the length of the fence. Fence integration must be detailed in the original design stage as special maintenance and space (or loss of space and real estate) considerations could be necessary. The post does penetrate the top geogrid, but only every 8 feet, so although important, the top geogrid layer does not carry much load.



Traffic Barrier

In some cases, a traffic-rated parapet is needed. This can be made by stacking blocks back-to-back. However, for the wall to truly act as a vehicular barrier, it must be reinforced with rebar and concrete and supported with a moment slab.

Therefore, a steel guardrail system is more typically used.



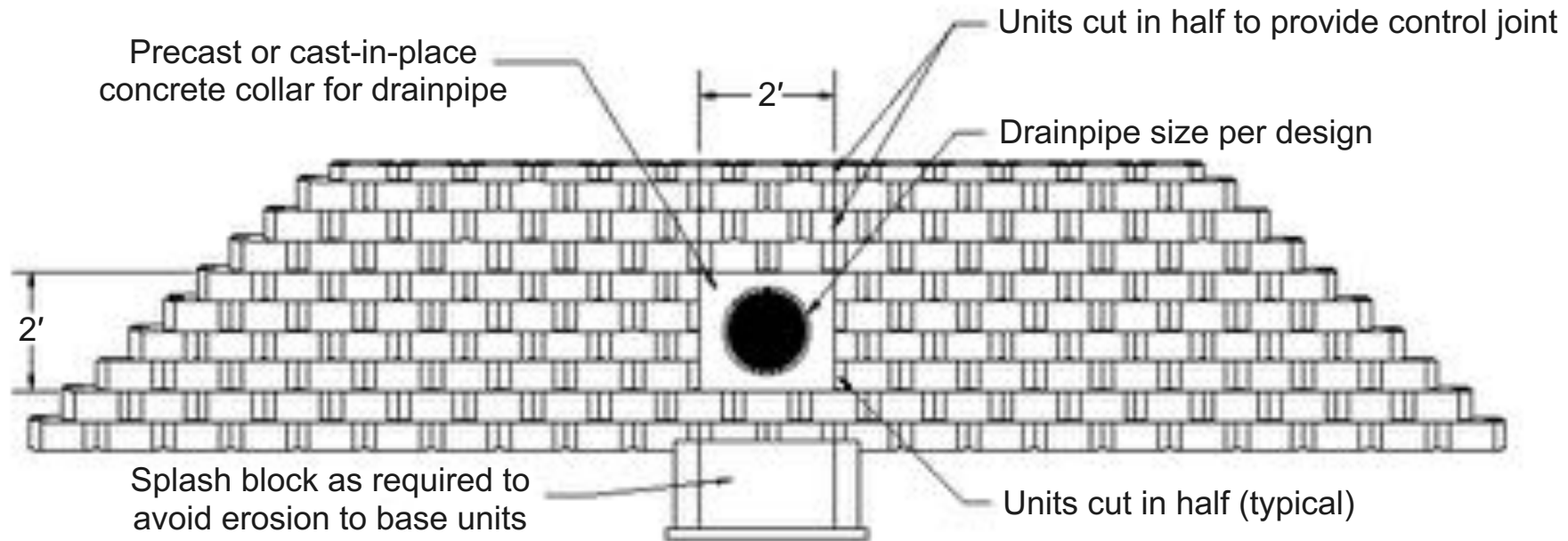
Utilities

Pipe penetration in commercial SRWs is common, and the details for these intersections should be addressed in the initial design. This segmental retaining wall was built around a drainpipe with a concrete collar.



Pipe Intersection

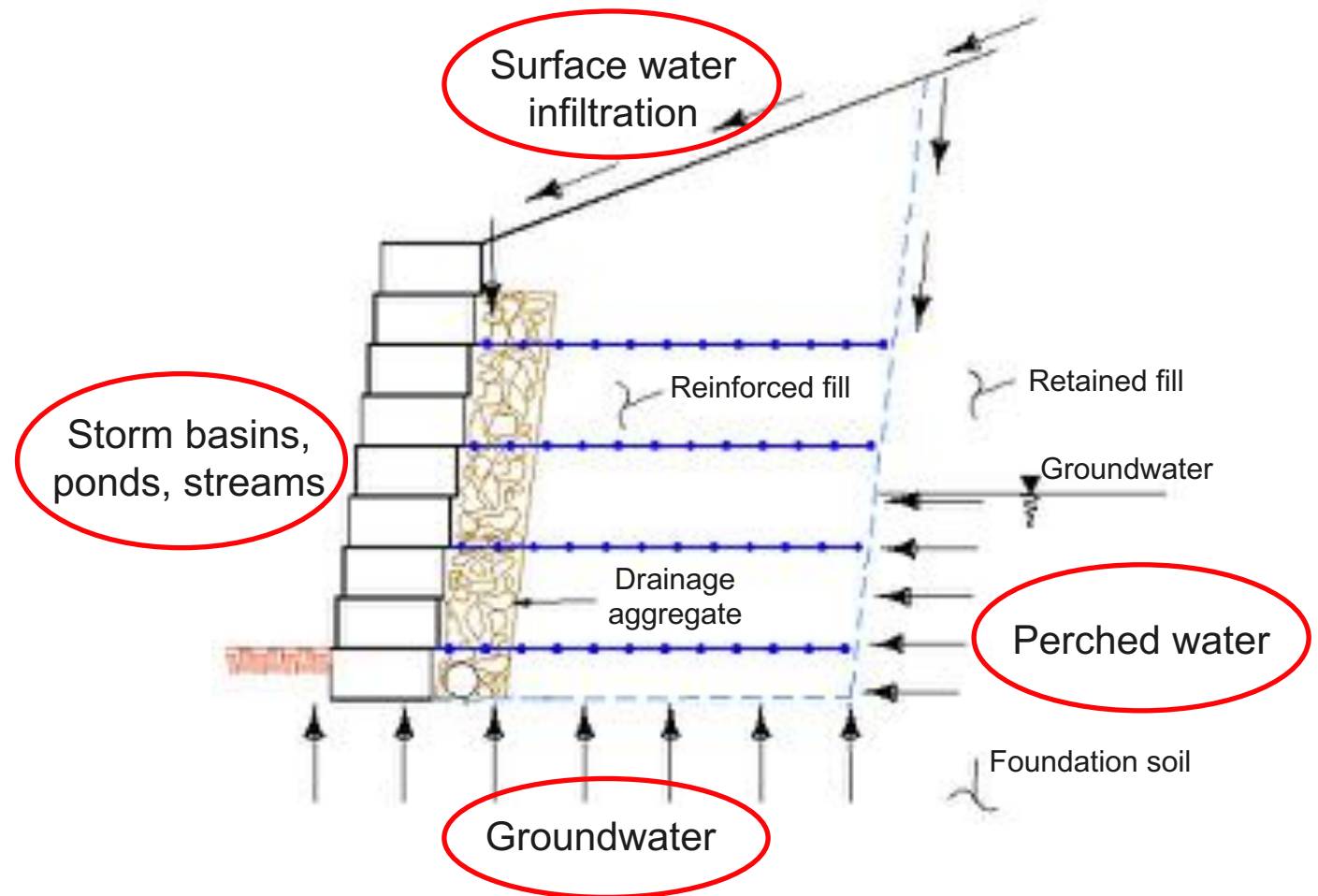
Typically, the only pipes that would penetrate through the face of the wall would be storm drains. Not only should concrete collars be considered but also erosion protection at the outlet end of the pipe. In this image, a splash block is used to avoid uncontrolled erosion immediately in front of the wall. This type of erosion can lead to serious SRW performance problems.



Managing Water and Segmental Retaining Walls

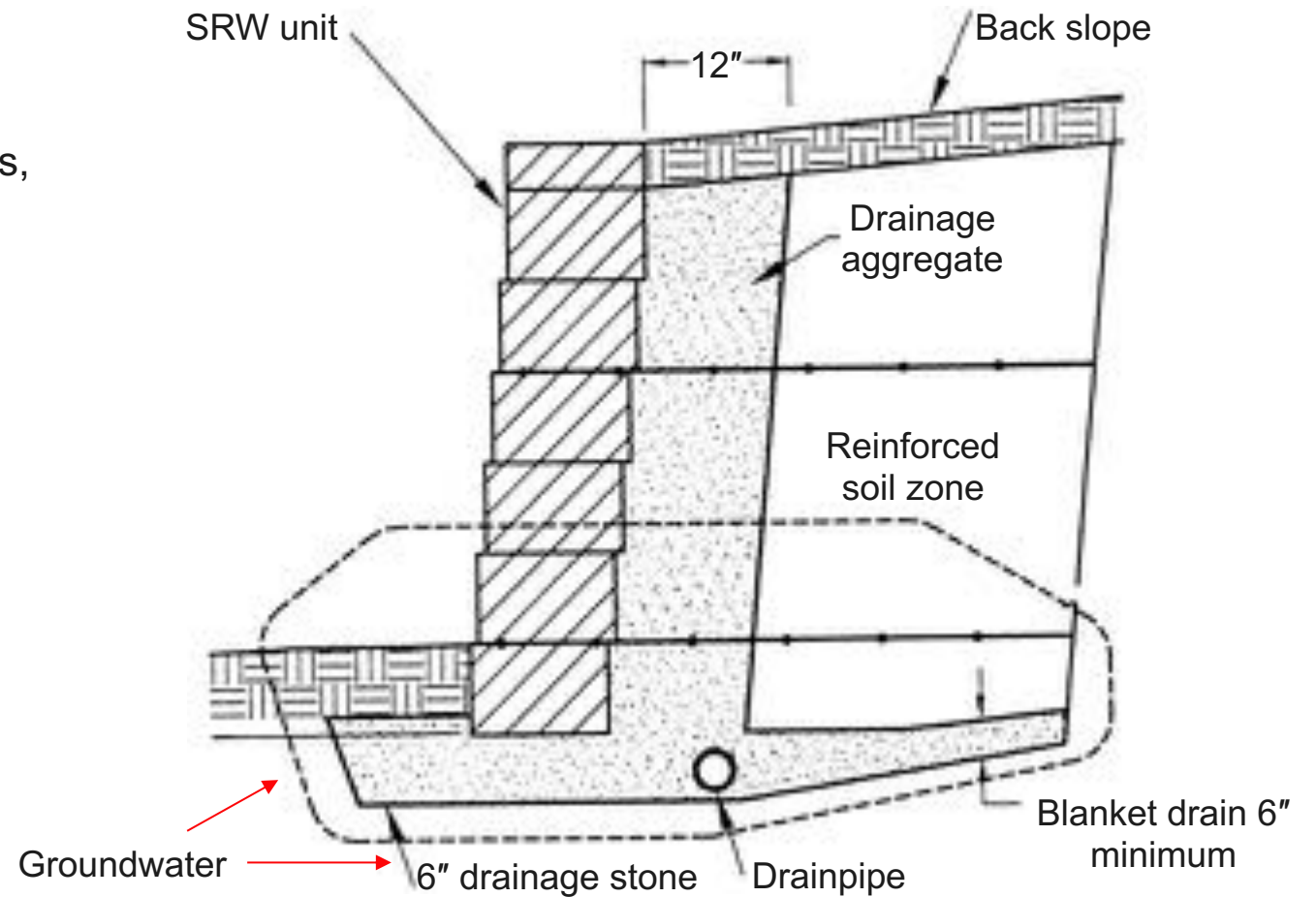
How do you manage water and SRWs?
First, identify site conditions that could expose the SRW to water:

- Surface water infiltration
- Perched water
- Groundwater
- Storm basins, ponds, streams



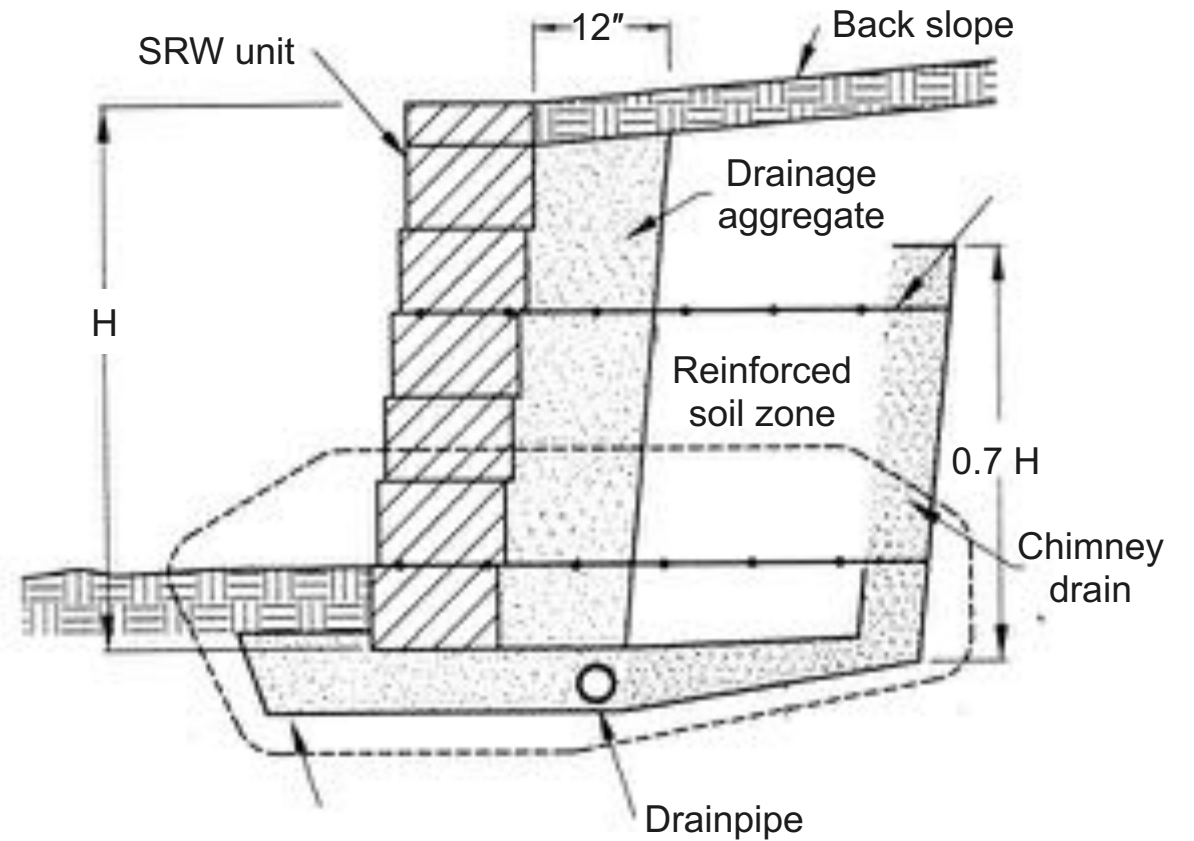
Water Applications: Blanket Drain

This image shows how the risk of shallow groundwater moving up into the wall is mitigated with a 6-inch layer of drainage stone or blanket drain, made from free-draining aggregate materials, along the entire base of the reinforced zone.



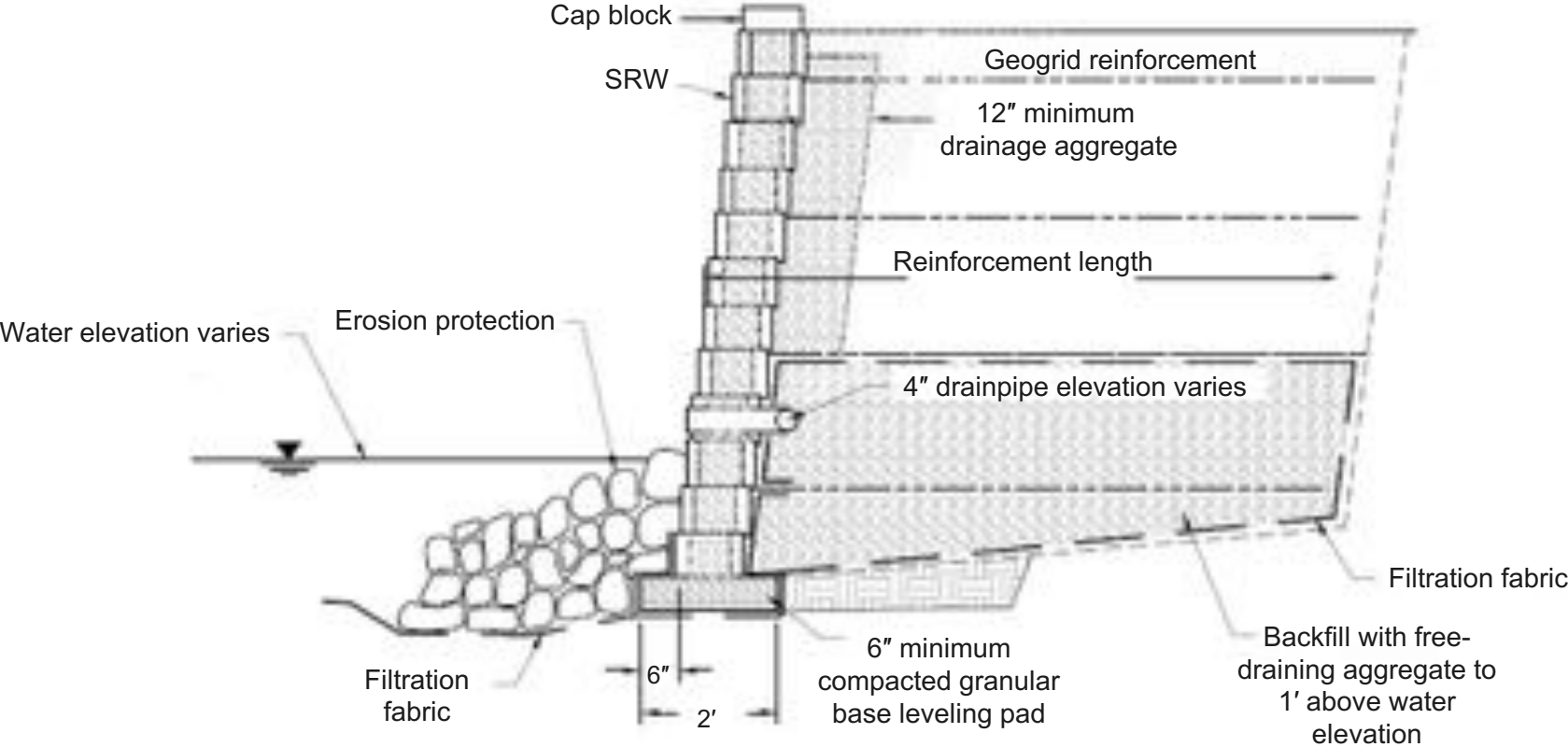
Water Applications: Chimney Drain

In cut walls, it is common to install a chimney drain up the back of the reinforced zone to intercept perched water from impacting the reinforced mass. Most commonly a geocomposite drain is used in these applications.



Water Applications: Water Body

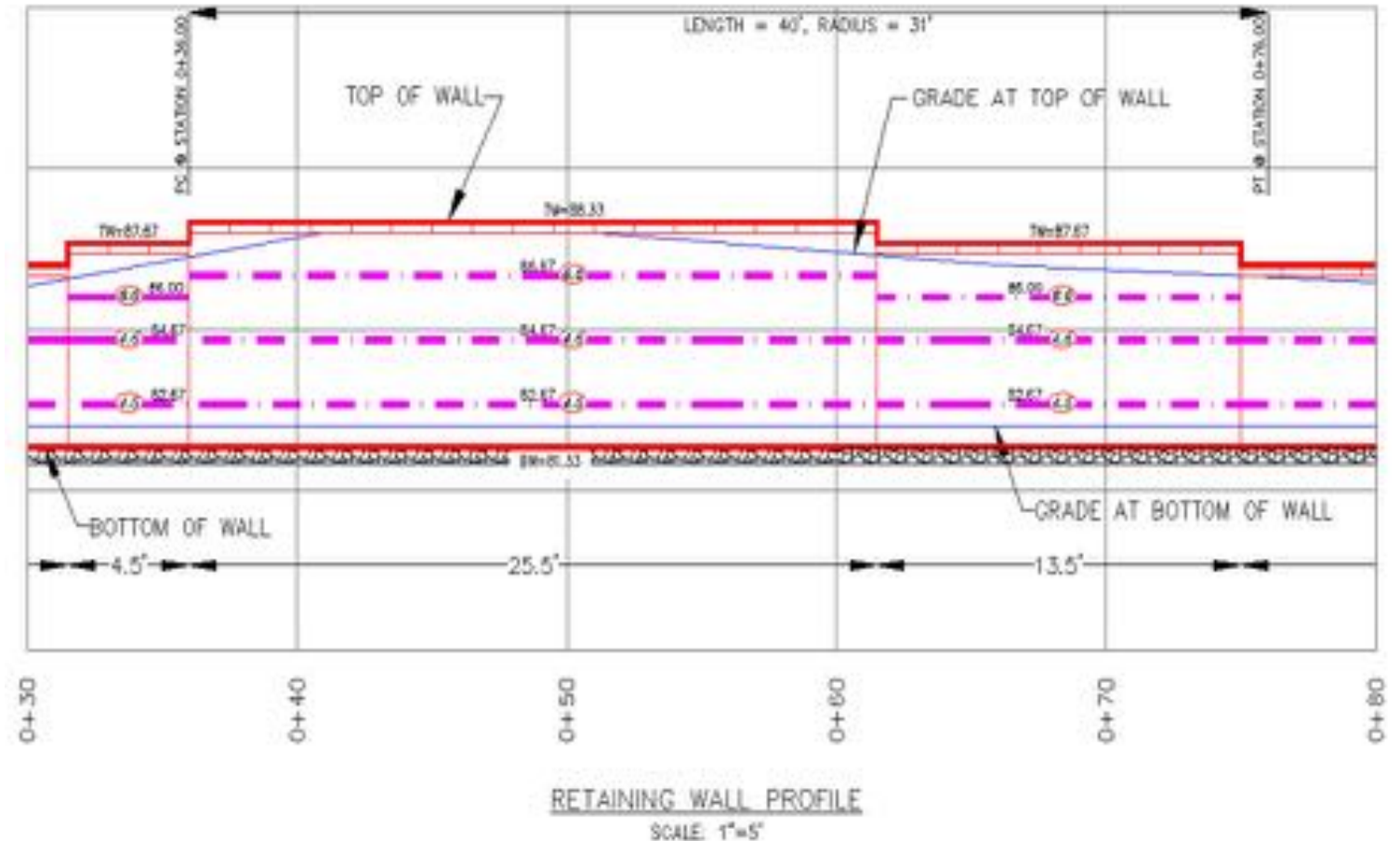
Along creeks, lakes, or storm basins, installing drainage stone up to the high water elevation is often recommended if a rapid draw-down effect is possible.



Key to Success: SRW Design Before Bid

One of the key recommendations of NCMA best practices is having the SRW designed prior to bidding. The image on the right details a wall profile, which shows the top and bottom of the wall and the elevations for geogrid reinforcement.

All engineered commercial walls should have an elevation profile and cross sections prepared by a licensed PE.



Key to Success: Construction Inspection

Another key to success is having full-time inspection of the SRW construction, not just part-time testing of the backfill compaction.

This ensures that all stages of construction meet applicable standards and code requirements.

By following the proper guidelines and procedures, reinforced segmental retaining walls can provide a safe, effective, and economical solution to your construction project.



Conclusion



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