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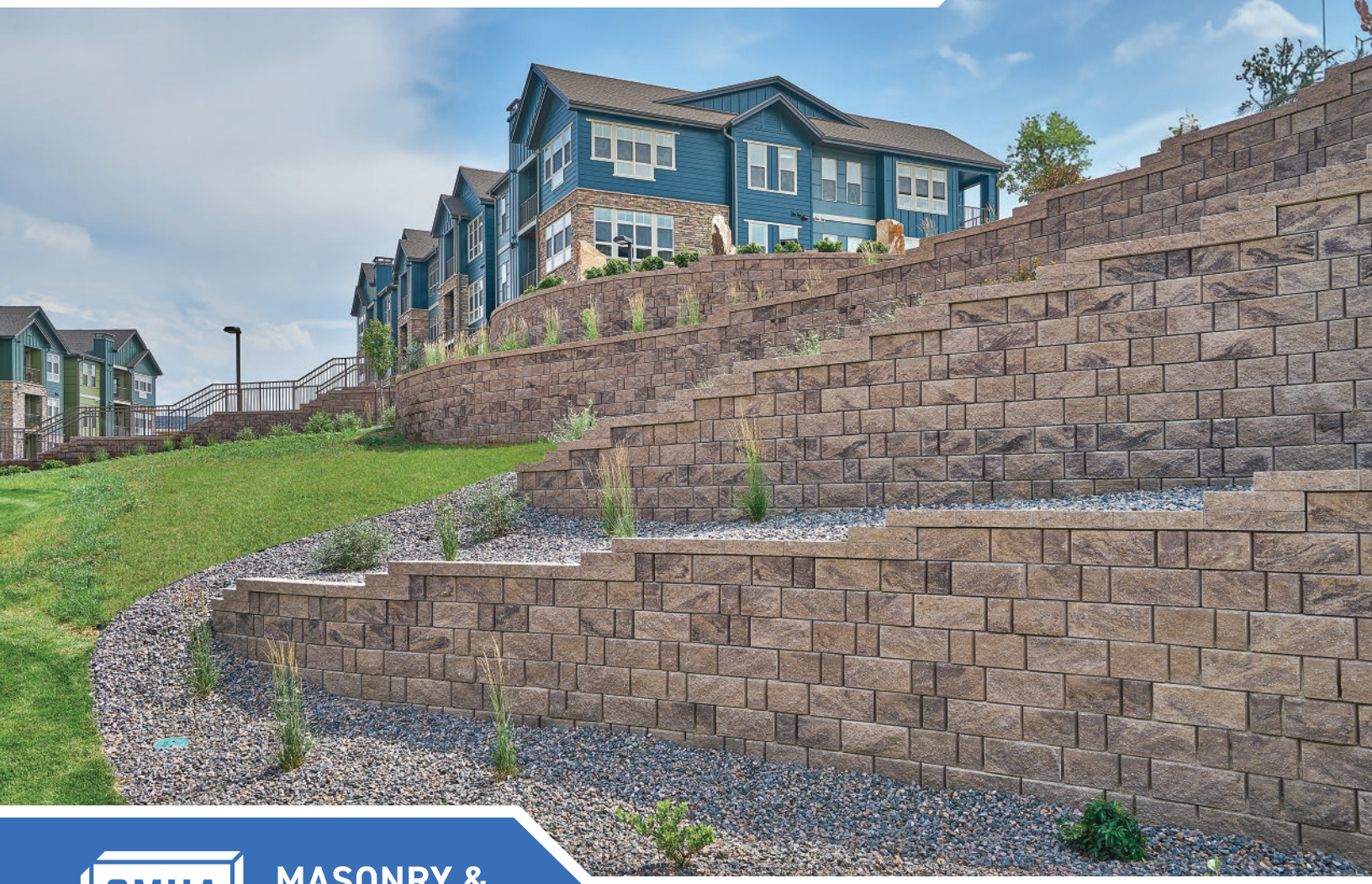
SRW Installation Guide

SRW-MAN-003-10



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INTRODUCTION

This guide provides an overview for contractors and owners for the correct and successful installation of Segmental Retaining Wall (SRW) systems, addressing the specific installation steps for engineered and non-engineered SRW systems. Before starting any size project the user should be familiar with the local code requirements for retaining walls to determine the engineering needs of the job, if no guidelines are given refer to TEK 18-11 for NCMA recommendations. If engineering is not required, the user should reference the design charts of the block and geogrid manufacturers, however, when engineering is necessary the approved documents should be strictly followed. The information provided here covers the general installation guidelines for SRWs, site specific conditions should be appropriately evaluated by a qualified engineer. Users should reference the product-specific information provided by the block, geogrid and geotextile manufacturers for additional information unique to each system.

Segmental retaining walls are gravity retaining walls that rely primarily on their mass (weight) to resist the destabilizing force from retained soils (backfill) and surcharge loads. The system consists of manufactured concrete units that are placed without the use of mortar (dry stacked) and are usually connected through concrete shear keys or mechanical connectors. The units may also be used in combination with horizontal layers of soil reinforcement that extend into the backfill to increase the effective width and weight of the gravity mass.

There are many advantages to segmental retaining walls. The system offers the site designer flexibility in architectural interest, location of the wall, ability to construct the wall in tight spaces, and handling site drainage and related water issues. SRWs are typically constructed on flexible aggregate leveling pads, thus the footing does not need to be placed below the frost line provided there is sufficient foundation bearing capacity. The characteristics of the system allows for rapid and easy installation, even when completed

BEST PRACTICES
Determine if the project needs engineering or not ♦ If yes: FOLLOW APPROVED DOCUMENTS. DO NOT CHANGE ANYTHING UNLESS DESIGNER HAS SIGNED. ♦ If not: FOLLOW MANUFACTURER'S CHARTS WITHOUT EXCEEDING THE HEIGHTS.

by a single person. The performance of mechanically stabilized earth walls (i.e., SRWs) in everyday applications as well as extreme events has proven to be excellent. Following several recent earthquakes, an investigation of the performance of SRW systems has demonstrated that they can be more robust than conventional retaining walls when properly designed.

SRW units are required to meet or exceed the minimum values established in ASTM C1372, Standard Specification for Dry-Cast Segmental Retaining Wall Units (Ref. 1 and 11). Because SRW units are laid dry (without the use of mortar), the unit height should be tightly controlled to maximize the shear capacity and geosynthetic connection strength and ensure uniform weight distribution. The SRW units are manufactured in conformance with industry standards and specifications to assure that the units delivered to a project are uniform in weight, dimensional tolerances, strength and durability–features not necessarily provided in site cast materials.

WALL TYPES

Segmental retaining walls can be designed and installed as either conventional or as soil-reinforced. The structural capacity of the SRW system will vary from one SRW system to another. As such, manufacturer's recommendations should be followed regarding the capacity of their particular system for the soil loads under consideration.

Conventional

Conventional SRWs are constructed with either single or multiple depths of units. For stability, the conventional SRW structure must have sufficient mass to prevent both sliding at the base and overturning at the toe and top of the structure. Because the system consists of individual units dry-stacked one on top another, shear capacity (sliding resistance) between units is an important component to assure that the units act together as a coherent mass. *See Figure 1*.

BEST PRACTICES
Follow manufacturer's recommendation for height capacity of each particular SRW system ♦ Avoid exceeding the recommended heights.

Shear capacity provides a means of transferring lateral forces from each course to the succeeding course. This is provided by the frictional resistance between SRW

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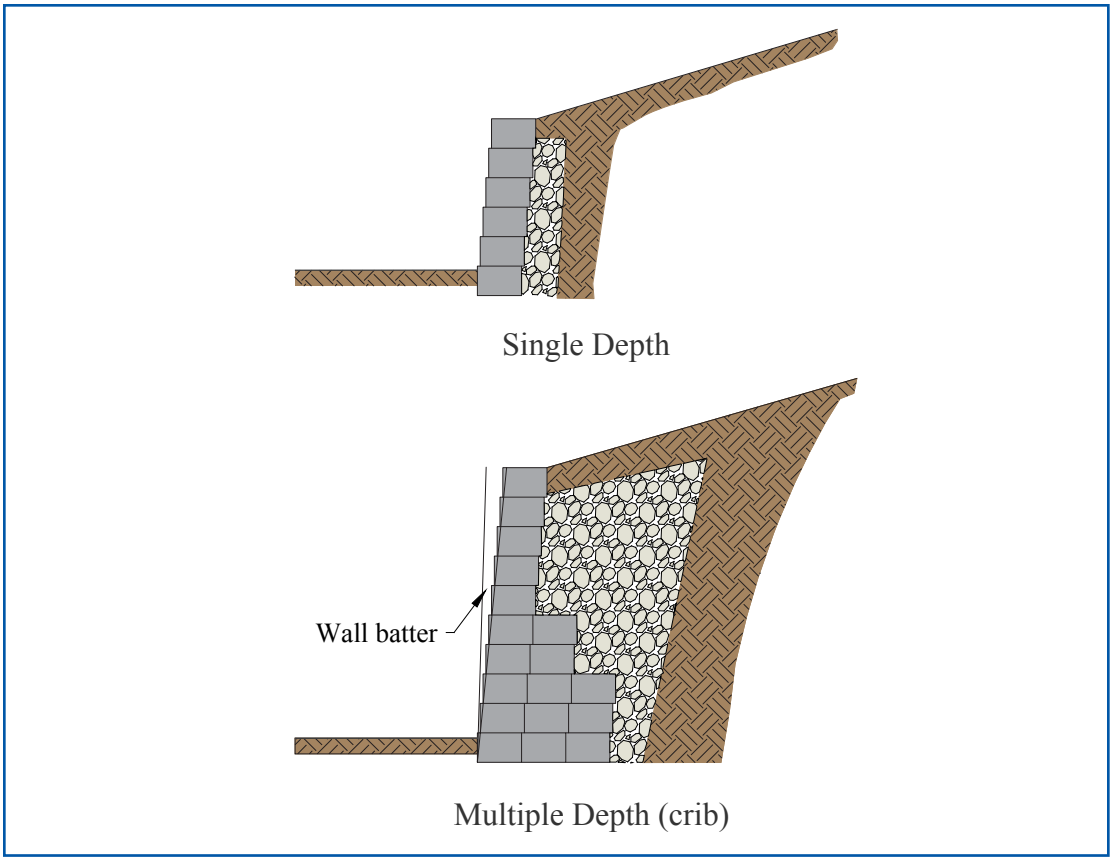

Figure 1: Conventional Segmental Retaining Wall System

units; in the form of shear keys or leading/trailing lips that are an integral part of the units; or by the use of clips, pins or compacted columns of aggregate placed in the open cores of the units. *See Figure 2*.

Generally, increasing the wall batter (slope of wall face) will increase the stability of the SRW. Batter is achieved through the setback between SRW units from one course to the next. In most cases, the batter is controlled by the location of shear keys, leading/trailing lips, or pins/clips, however, some systems allow for some adjustment to the batter.

Soil-Reinforced

Soil-reinforced walls should be used when the maximum height for conventional gravity walls is exceeded or when the walls are surcharged

BEST PRACTICES

♦ Reinforced SRWs are appropriate when gravity wall height is exceeded or when the wall has surcharges, slopes, or is on difficult foundation soils.

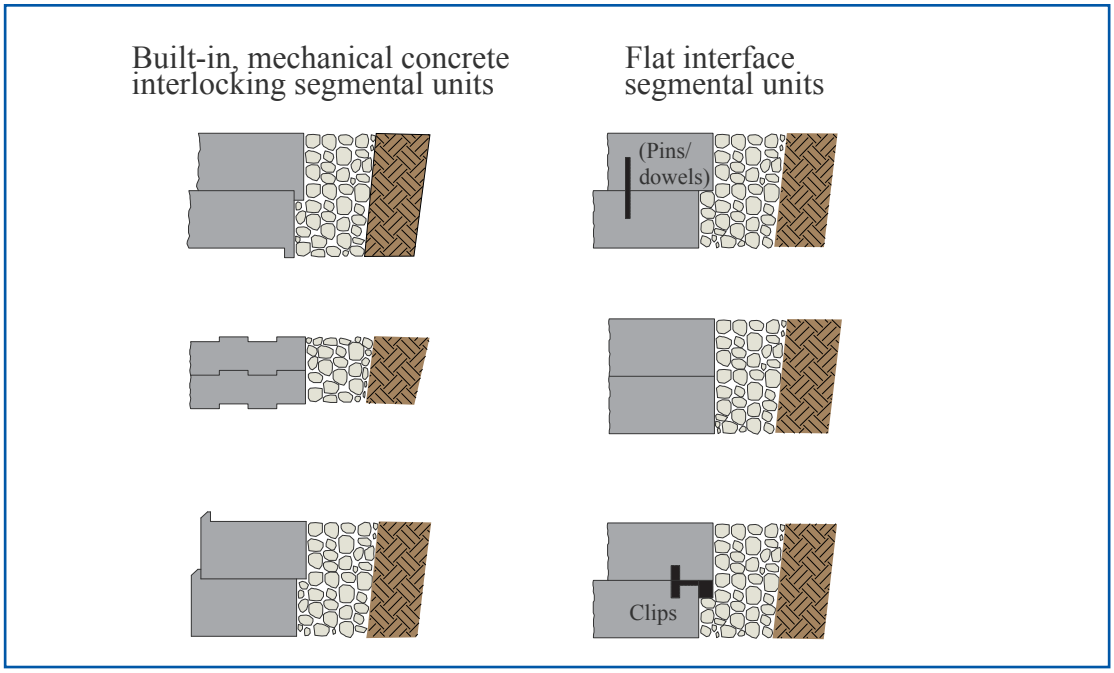

Figure 2: Shear Connectors for SRW Units

by sloping backfills, loads behind the wall, more difficult soil conditions, and/or poor foundation soils. A soil-reinforced SRW is designed and constructed with multiple layers of soil reinforcement placed between the SRW courses and extending back into the soil behind the wall at designated heights and lengths. *See Figure 3*. The enlarged composite gravity wall system, comprised of the SRW units and the reinforced soil

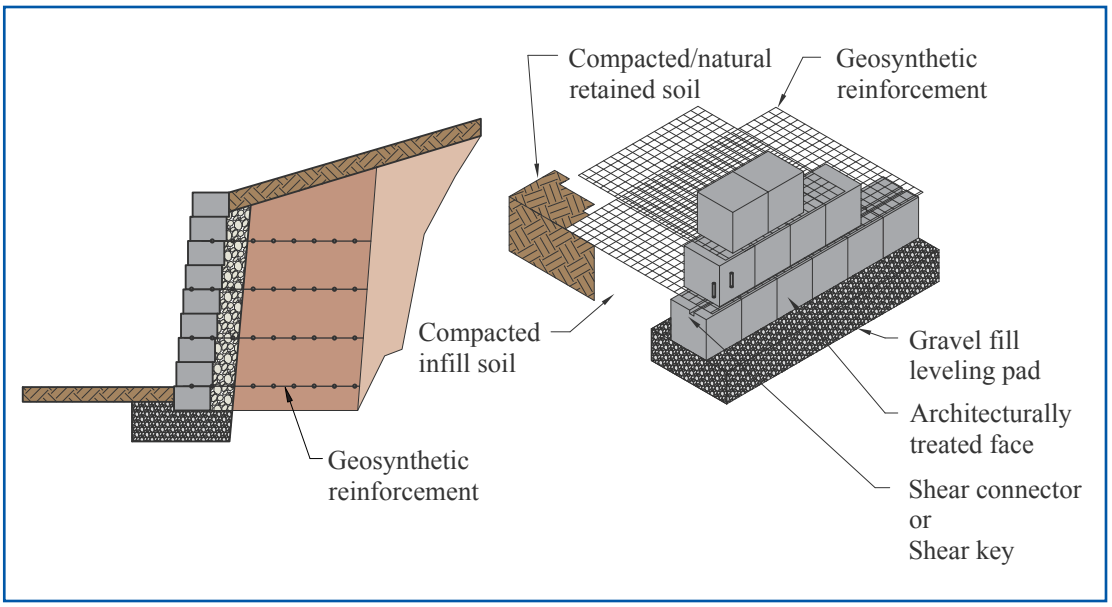

Figure 3: Soil Reinforced Segmental Retaining Wall System

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mass, offers the required resistance to external and internal forces. The most common types of reinforcement are geogrids and geotextiles, though most SRW construction to date has used geogrids.

SYSTEM COMPONENTS

The basic elements of each segmental retaining wall systems are the foundation soil, leveling pad, segmental retaining wall units, retained soil, gravel fill, and for soil reinforced SRWs, the soil reinforcement. *See Figure 4*. This section describes the recommended materials that can be specified, it is the designer's responsibility to select the appropriate materials and design parameters depending on the site conditions and material availability. Because segmental retaining walls are designed as systems, the materials specified on the approved documents can not be exchanged without the evaluation and approval of design engineer.

BEST PRACTICES

♦ On engineered walls, materials can not be exchanged without the approval of the wall designer.

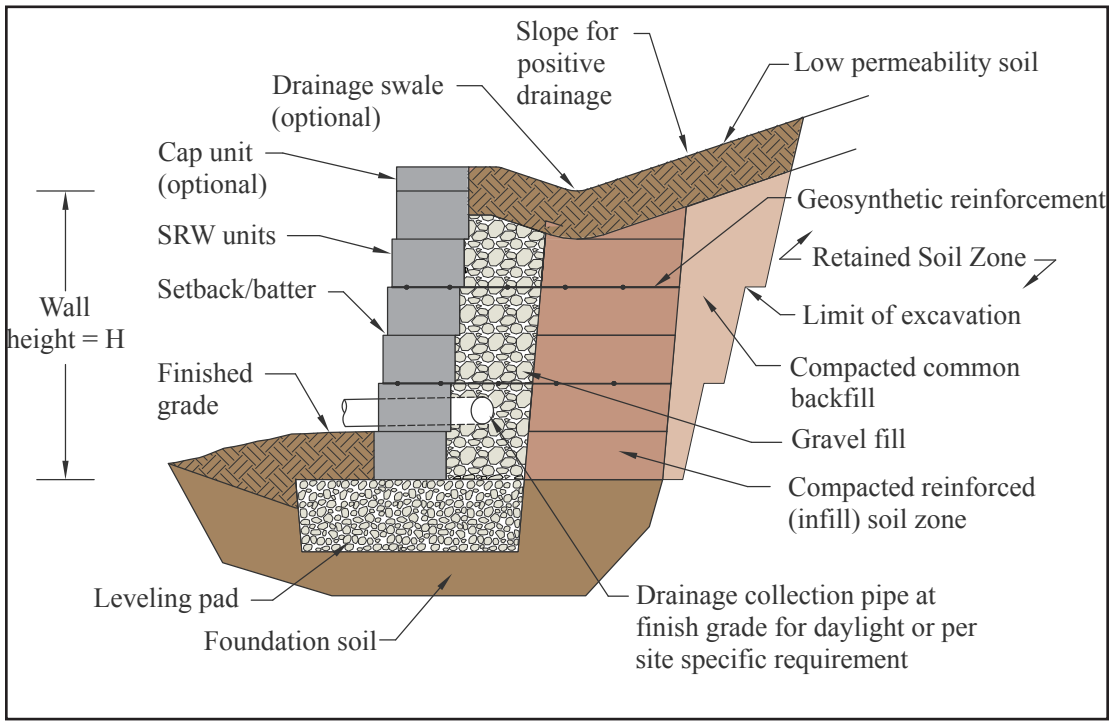

Figure 4: Segmental Retaining Wall System Components

Foundation soil: Soil mass supporting the SRW system: leveling pad, blocks, gravel fill, reinforced soil (for soil-reinforced SRW), and any overlying surcharge. The foundation soil shall provide adequate bearing capacity to support the SRW components, retained soil influences and external surcharges on the system.

BEST PRACTICES
♦ Foundation soils: Organic and expansive soils are unsuitable. ♦ Leveling pad materials: Avoid pea gravel for the leveling pad construction ♦ SRW units: Use pins, clips, adhesives expressly fabricated for the system used. ♦ Use 1 in. (25.4 mm) minus crushed stone or granular fill for gravel fill.

Leveling pad: Level surface consisting of either well compacted gravel or unreinforced low strength concrete used to distribute the weight of the dry-stacked column of SRW units over a wider area and to provide a working surface during construction unless a reinforced rigid concrete footing is called for. The leveling pad typically extends a minimum of 6 in. (152 mm) from the toe and heel (front and back) of the lowermost SRW unit and is at least 6 in. (152 mm) thick.

Segmental retaining wall units: Dry-stacked column of concrete units that create the mass of conventional SRW structures and provide mass and structural stability at the face of reinforced soil SRW structures. The SRW units also provide a visual enhancement at the face of the wall. SRW units are required to meet or exceed the requirements of ASTM C1373, *Standard Specification for Dry-Cast Segmental Retaining Walls Units* (Ref. 1).

Gravel Fill: Clean free-draining, coarse aggregate placed in the open cores of hollow SRW units to increase system weight and strength and extending at least 12 in. (305 mm) behind the units. The clean gravel fill acts as a compaction aid to reduce horizontal compaction stresses on the back of the SRW units during construction and to facilitate drainage at the face of the wall by intercepting incidental water and thereby relieving hydrostatic pressure or seepage forces. The gravel fill alone is not meant to be a primary drainage path for typical applications. The gravel fill shall be a clean 1 in. (25.4 mm) minus crushed stone or granular fill meeting the following gradation.

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Sieve Size	Percent Passing
1 in. (25.4 mm)	100
3/4 in. (19 mm)	75 - 100
No. 4 (4.75 mm)	0 - 60
No. 40 (420mm)	0 - 50
No. 200 (75mm)	0 - 5

Reinforced soil: Compacted structural fill placed behind soil-reinforced SRW units to the tail end of the reinforcement. For the design of reinforced soil SRW structures, SRW units and reinforced soils are treated as a single, homogenous zone contributing to the mass and width of the structure.

The reinforced backfill shall be free of debris and consist of inorganic gravel or sand with a pH between 3 and 9 when tested in accordance with ASTM G51, *Standard Test Method for Measuring pH of Soil for Use in Corrosion Testing* (Ref. 8), meeting the following gradation tested in accordance with ASTM D422, *Standard Test Method for Particle-Size Analysis of Soils* (Ref. 9).

BEST PRACTICES

♦ Reinforced fill: Granular low plasticity soils are encouraged.
♦ Over excavated retained soils need to be compacted to meet specifications too.

The maximum size should be limited to 1.0 in. (254 mm) for geosynthetic reinforced soil SRWs unless tests have been performed to evaluate potential strength reduction in the geosynthetic due to installation damage.

Sieve Size	Percent Passing
1 in. (25.4 mm)	100
No. 4 (4.75 mm)	100 - 20
No. 40 (420 mm)	0 - 60
No. 200 (75 mm)	0 - 35

The plasticity index of the fine fraction of the reinforced soil (PI) shall be less than 20 tested in accordance to ASTM D4318, *Standard Test Methods for Liquid Limit*, Plastic Limit, and Plasticity Index of Soils (Ref. 10); taller applications may be require PI < 5 to 10. The particular properties of the selected reinforced soil

BEST PRACTICES
♦ Geogrids cannot be exchanged without the SRW engineer's evaluation. ♦ Not all geogrid types are compatible with all SRW block systems.

should be incorporated in the design and be accounted for in the specifications of the project.

Retained soil: In-situ undisturbed soil or compacted fill as required by the specifications located behind the reinforced soil zone in reinforced soil SRW systems or soil immediately behind the gravel fill and SRW in conventional gravity SRW units systems.

Soil reinforcement: For reinforced soil SRWs, soil reinforcement is placed in horizontal layers to unify the mass of the composite SRW structure and thereby increase the resistance of the system to destabilizing forces. Geosynthetic reinforcement is a synthetic material usually comprised of polypropylene, polyester or polyethylene.

Geosynthetic reinforcement material should be tested in accordance with ASTM D4595, *Standard Test Method for Tensile Properties of Geotextiles by the Wide-Width Strip Method* (Ref. 6) or ASTM D6637, *Standard Test Method for Determining Tensile Properties of Geogrids by the Single or Multi-Rib Tensile Method* (Ref. 7).

DESIGN CONSIDERATIONS

An important part of the design and construction process is to identify where retaining walls may be required for a particular site. The grading plan and/or a detailed drawing of a site will be necessary for the design engineer to adequately prepare a wall design. There are a number of variables the designer will need to consider: including location of the wall or walls, property lines, buffers, easements limits of excavation, utilities, existing or proposed contour lines (to include slopes in front of and behind the walls), scaled drawing, loading features like roads, buildings, or pools, and other structures or encumbrances. This is a partial list of design and construction considerations and is not meant to be all-inclusive. A compreshensive review of SRW system design is covered in the *Design Manual for Segmental Retaining Walls* (Ref. 2). The final design of a retaining wall could require the participation of other professionals that will address such items as water sources, foundation and soil competency, settlement and compaction, seismic conditions, and global stability. It is crucial for the owner to achieve coordination between construction and design professionals to ensure all necessary and required

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design, engineering analysis, and inspection is provided. Either the owner directly, or the owner's representative, should ensure that the engineering design professionals' scope of work, roles, and responsibilities are clearly defined so that there is no ambiguity regarding responsibility for investigation, analysis, design, and testing.

CONSTRUCTION

The success of any segmental retaining wall installation depends on complete and accurate field information, careful planning and scheduling, the use of specified materials, proper construction procedures, and careful inspection. It is good practice to have the retaining wall location verified by the owner's representative. If during the construction process site conditions (utilities, ground water, etc.), materials (soils, geosynethetics, etc.), structures are not in agreement with the approved contract documents, the wall designer should be notified to evaluate a solution and authorize any modifications.

BEST PRACTICES

♦ Notify design engineer if during construction site characteristics change.
♦ Inspection of earthwork is necessary.
♦ When doing the layout consider the wall batter.
♦ Get wall layout approved before begining construction.

The contractor should coordinate the delivery and storage of materials at the site to ensure unobstructed access to the work area and availability of materials. Materials delivered to the site should be accompanied by the manufacturer's certification that the materials meet or exceed the specified requirements (minimum ASTM C1372). Damaged or inferior SRW units and reinforcement materials should be rejected and the supplier of the products should be notified immediately.

Inspection

On all construction projects, including those involving SRWs, it is highly recommended to have a construction testing agencies perform the testing and monitoring in the project, the following are some of the inspection tasks necessary on a SRW wall:

- Monitoring of earthwork
- Inspection of SRW foundation area, including area below planned geogrid-

reinforced soil fill, to verify bearing, soil, and groundwater conditions meet design assumptions.

- Inspection of native soils in retained zone for consistency with reported soil types and properties.
- Monitoring of fill placement and laboratory and field testing to ensure proper soil types used for fill and proper compaction achieved.
- Overall wall material installation inspection.
- Construction observation of wall unit and geogrid installation.
- Review of material submittals for conformance with specifications.
- Additional review of soil properties and earthwork testing for conformance with wall materials' specifications.

Construction Planning

The execution of construction operations for SRWs is dependent on quality surveying information; both to plan and field-locate the proper position of the SRW. The existing and proposed finish grades shown on the drawings should be verified in the field to ensure the planned design heights are in agreement with topographic information from the project grading plan. Once located in the field, it is good practice to have the retaining wall location verified by the owner or owner's representative. Any changes in the wall location made in the field should be duly noted on as-built drawings prior to finishing the project.

Always check with the local utility companies to be sure that digging does not interfere with, or damage, underground pipe lines or conduits. All states have a "Call BeforeYou Dig" service (8-1-1) that marks underground utilities a few days before digging be sure to allow enough time to have them marked and dig around them with care. When utilities or other features must pass through, under, or within the reinforced zone behind the SRW special details should be included in the construction drawings. If the site planning process and time permits, routing utilities around SRWs may be the most prudent approach. If utilities were not accounted for, the design engineer needs to be notified to provide the appropriate solution.

BEST PRACTICES
♦ Call Before You Dig (8-1-1), to get underground utilities marked before excavating. ♦ If some utilities were not considered in the design, notify wall designer.

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Construction Tolerances

As with any constructed works, some deviation from construction drawing alignments will likely occur. As opposed to cast-in-place concrete walls, alignment of SRWs can be simply corrected or modified during construction. Based upon examination of numerous completed SRWs, the following recommended maximum tolerances can be achieved with good construction techniques and represent the disposition of the sturcture immediately following construction:

- Vertical control:
  ± 1.25 in. (32 mm) over a 10 ft (3 m) distance; ± 3 in. (76 mm) maximum
- Horizontal control:
  straight lines: ± 1.25 in. (32 mm) over a 10 ft (3 m) distance; ± 3 in. (76 mm) maximum
- Rotation:
  from established plan wall batter: ± 2°
- Settlement:
  the maximum differential settlement between two locations should not exceed 1% of the distance between the two reference points on the wall

Horizontal and vertical control can be maintained by surveying the wall during

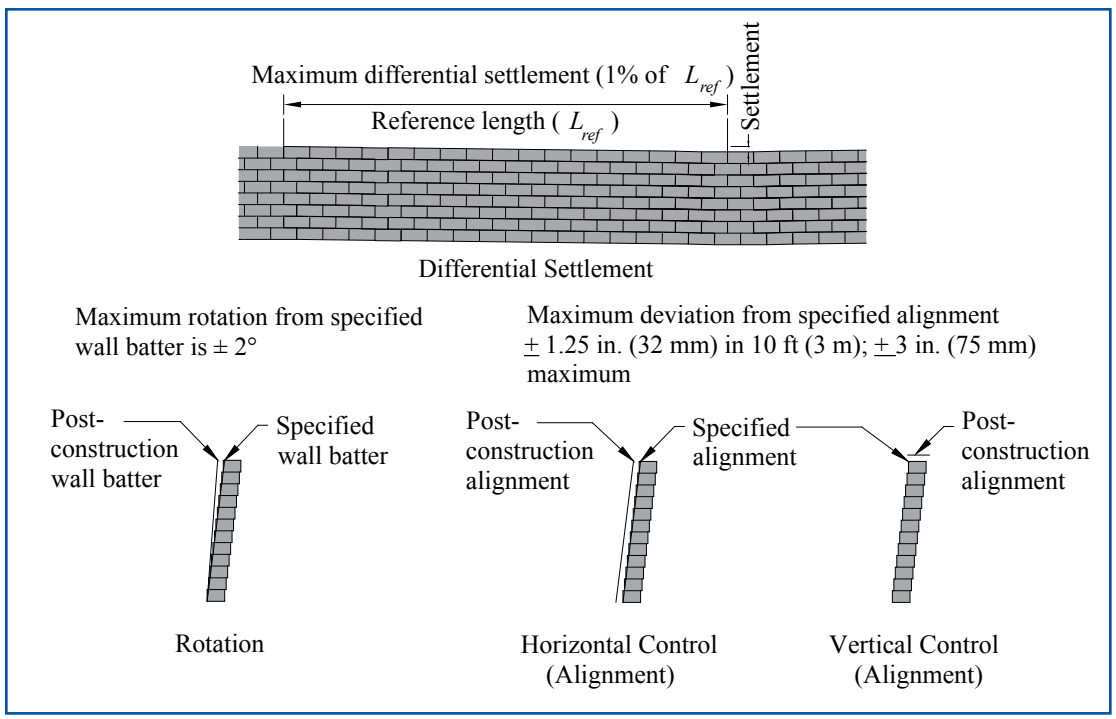

Figure 5: Recommended SRW Construction Tolerances

construction. Control of wall rotation during construction can be influenced by SRW unit dimension tolerances, type of soil fill utilized, soil compaction techniques, and the uniformity in geosynthetic tension applied during backfilling. Non-uniformity in manual pre-tensioning of the reinforcement may result in localized wall movement (i.e. bulging). Consistent construction techniques should be used throughout wall erection.

Careful planning and attention should be paid to the compaction equipment and procedures used during construction. Compaction within three feet (1 m) of the front of the wall face should be limited to lightweight, low energy hand operated equipment, preferably a vibrating plate compactor with a minimum weight of 250 lb (113 kg). This does not, however, reduce the compaction density requirements in this zone. It is important that the soil within the first three feet (1 m) is well compacted in order to minimize the potential of settlement of the reinforced fill directly behind the SRW units, which may cause the connection between the reinforcement and the SRW units to be overstressed. The remainder of the reinforced soil zone can be compacted with walk-behind or riding compaction equipment, depending upon soil type and available operating area. Nonuniform compaction procedures can result in vertical and horizontal alignment control problems. Upon completion of the wall, heavy construction equipment should be kept at least five feet (1.5 m) behind the wall face.

BEST PRACTICES

♦ Avoid heavy construction equipment on top of the finished retaining wall unless it was considered in the design.
♦ Start excavating and building at the lowest point of the wall.
♦ Follow OSHA recommendations for excavating and bench cutting of slopes.

Excavation

The contractor excavates to the lines and grades shown on the approved plans, taking the necessary precautions to minimize over-excavation and maintain safe slopes per OSHA requirements. There are two basic topographical conditions in which SRWs may be constructed; “cut” and “fill”. The differences between these two conditions are illustrated in *Figure 6*.

The construction approach, schedule, and cost will be dictated by the type of wall that is required at the site. Additionally, the effects of construction on existing nearby structures and parking areas must be carefully considered for “cut” walls such that the foundation support of those structures are not undermined or encroached upon in any way.

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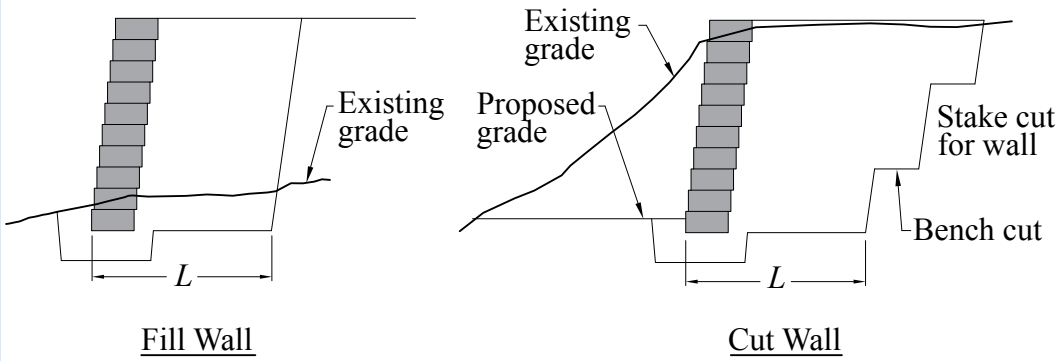


Wall Layout and General Excavation

1. Survey stake SRW location and general excavation limits for wall construction.
2. Ensure SRW is along proper alignment and within appropriate property boundries and construction easements.
3. Perform general excavation for wall.

Figure 6: Wall Layout and General Excavaion

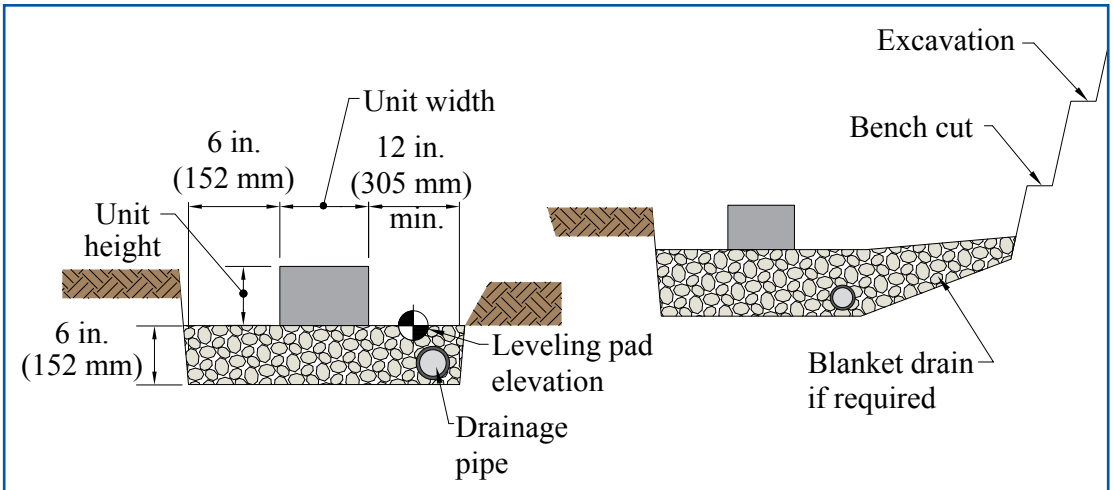
Foundation Soil And Leveling Pad Construction

Foundation soil is then excavated as required for base course leveling dimensions and limits of the reinforced soil zone as shown on the construction drawings or as directed by the designer on the approved documents. As excavation progresses, the foundation soils are examined to verify that the actual conditions meet or exceed the assumed design conditions by an inspector. Foundation soils not meeting required properties shall be evaluated by the project's geotechnical engineer to determine the appropriate solution to ensure an optimum stress distribution and drainage of the wall. Compaction efforts are typically specified to achieve the specified soil densities usually expressed as a percentage of the maximum standard or modified proctor density in accordance with ASTM D698 or D1557.

Then the aggregate base leveling pad should be constructed to a width a minimum of 6 in (152 mm) in front of unit, plus depth of

BEST PRACTICES

♦ Foundation soil has to be inspected and meet or exceed the specified properties.
♦ If foundation soil has problems, the project geotechnical engineer will need to be involved to provide a solution.
♦ The foundation soil extends underneath the reinforced soil zone too.



Leveling Pad Construction

1. Stake wall location for leveling pad excavation.
2. Excavate trench to create a minimum leveling pad thickness of 6 in. (152 mm) and to the minimum width shown.
3. Install drain pipe with positive gravity flow to outlet.
4. Place, level and compact leveling pad material for SRW units.
5. Place and compact aggregate blanket drain and install geotextile, if required.

Figure 7: Leveling Pad Construction

unit plus 12 in. (305 mm) behind unit. So for a typical 12 in. (125 mm) unit the pad would be 30 in. (762 mm) wide. The leveling pad should be densely compacted using the specified materials. Caution should be exercised in leveling the leveling pad to ensure full contact between the units and aggregate. Alternately, thin/weak concrete leveling courses may be poured in place of the compacted leveling pad to speed construction. Special cases that may require different designs include: foundation soils with a low bearing capacity, areas with the water table close to the foundation, or submerged foundations. *See Figure 7*.

Gravel Fill And Drainage Pipe Installation

Water can increase loads on a retaining wall, be a source of scour or erosion, or decrease stability of soils surrounding a SRW. Whenever possible water should be directed away from SRWs. When water does reach a SRW, proper drainage components will reduce the loading on the wall. The gravel fill and drainage pipe on *Figure 8* should not be relied on as the primary drainage medium for the wall system. If water is a concern, then addition

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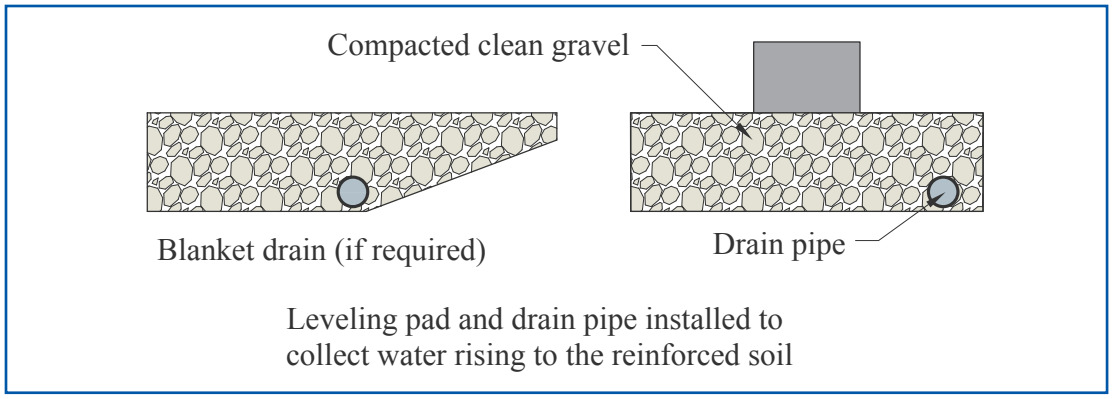
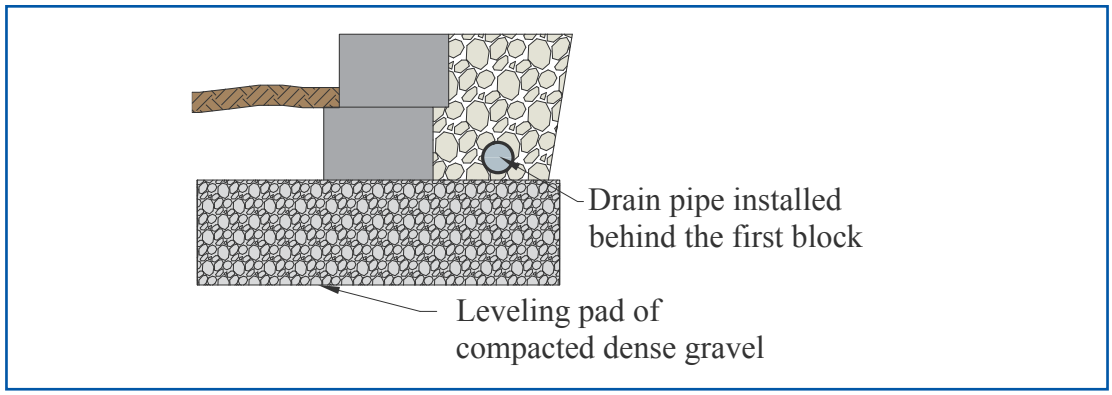
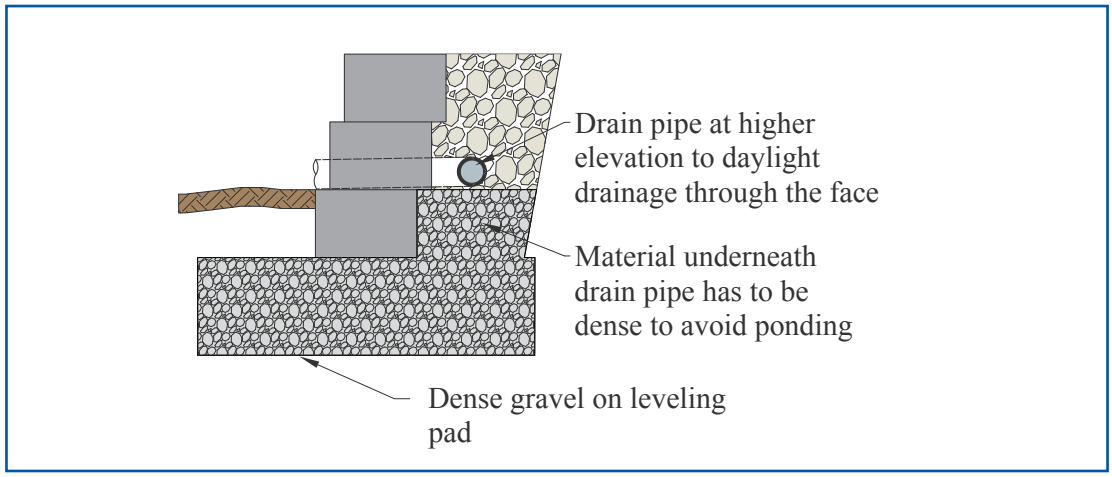


a) Drain pipe installed on compacted clean gravel



b) Drain pipe installed behind first block to daylight into a storm sewer manhole or along a slope



c) Drain pipe installed at a higher elevation to daylight through the wall face

Figure 8: Different Drain Pipe Installation Options Depending on the Site Conditions

BEST PRACTICES
♦ Leveling pad material and drain pipe location depend on the site conditions, water sources, embedment depth, and where the water can be evacuated and they have to be defined by the wall designer. ♦ Weak concrete can be used as leveling pad.

drainage precautions may need to be included. Refer to the NCMA Design Manual for SRWs (Ref. 2) for more details on how to address different ground water conditions. The gravel fill and drainage pipe on *Figure 8* is meant to direct incidental accumulated water away from the structure and decrease internal forces, different options are presented there that should be specified by the designer depending on the site conditions (water source, slopes, embedment depths, etc.). A well designed gravel system directly behind the SRW units will facilitate compaction of the fill directly behind the units, prevent hydrostatic buildup, and prevent the retained soils from washing through the face of the wall, only when a proper filtration design has been performed to determine the compatibility between the two fill materials.

The construction of perforated pipe should be specificed to meet one of the following standards; ASTM F758, *Standard Specification for Smooth-Wall Poly(Vinyl Chloride) (PVC) Plastic Underdrain Systems for Highway, Airport, and Similar Drainage* (Ref. 4), or ASTM F405, *Standard Specification for Corrugated Polyethylene (PE) Pipe and Fittings* (Ref. 5). The drainage collection pipe is installed in such a manner so that gravity flow of water to an area outside of the reinforced soil zone is maintained. The drainage collection pipe should daylight into a storm water manhole or to a sloped area lower than the pipes behind the walls located, which can be above or below grade as directed by construction drawings. The main collection drain pipe just behind the block facing should be a minimum of 3 in. (76 mm) in diameter or as specified on the construction drawings (*see Figure 8)*. The secondary collection drain pipes should be sloped a minimum of two percent to provide gravity flow into the main collection drain pipe. Drainage pipe outlet or pipe through wall shall be spaced between 20 and 50 ft (9.1 and 15.2 m) spacing along the wall face.

Setting, Leveling And Backfilling First Course Of SRW Units

All SRW units are to be installed at the proper elevation and orientation as shown in the approved construction plans or as directed by the designer and in general accordance with the manufacturer's recommendations.

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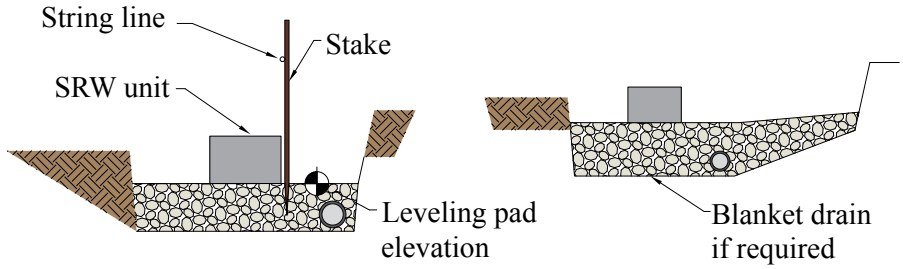


Setting First Course of SRW Units

1. Check leveling pad elevation and smooth leveling pad surface.
2. Stake and stringline the wall location, pay close attention to exact location of curves, corners, vertical and horizontal steps. String line must be along a molded face of the SRW unit, and not along a broken block finish surface.
3. Install first course of SRW units, checking level as placed.

Figure 9: Setting First Course of SRW Units

The first course of SRW units is placed on the leveling pad 6 in. (152 mm) from the front face edge and 12 in. (305 mm) from the rear edge. The units are then checked for level and alignment from front to back and side to side. The first course is the most important to ensure accurate and acceptable results as the wall construction progresses. The installer should verify that the units are in full contact with the base. Units are then placed side-by-side for the full length of the straight wall alignment being constructed. Alignment may be maintained by means of a string line or offset from the base line to a molded finished face of the SRW unit. For curved sections, adjust the spacing between adjacent units according to the manufacturer's recommendations. *See Figure 15*.

Use clean gravel fill to fill any openings in, between, and 12 in. (305 mm) behind the SRW units as required. The gravel fill should be a clean 1 in. (25.4 mm) minus crushed stone or granular fill meeting the gradation recommended early.

The clean gravel fill is placed to a minimum depth of 12 in. (305 mm) measured from the back of the SRW unit. Carefully place and compact the gravel fill behind and up to the height of the last installed SRW unit.

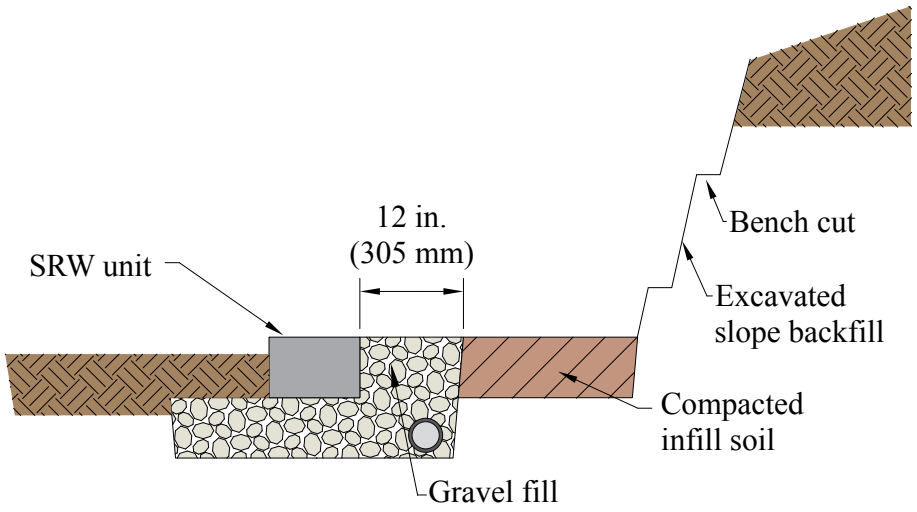
BEST PRACTICES

♦ Gravel fill and drain pipe are only to collect and evacuate incidental water.
♦ If during the excavation water is found that wasn't considered in the design, the wall designer has to be notified.
♦ The leveling pad has to be level.

The infill soil is then placed behind the clean gravel fill, as shown in the construction plans in 6 to 8 in. (152 to 203 mm) lifts, compacting each lift to meet the specified densities usually equilvalent to a minimum 95% of standard proctor density (ASTM D698). Only hand operated compaction equipment should be allowed within 3 ft (914 mm) of the back of wall face, preferably a vibrating plate compactor with a minimum weight of 250 lb (113 kg), if smaller equipment is used lift heights may need to be smaller to reach the specified densities. As necessary, place fill soil in front of the SRW units. *See Figure 10*.

BEST PRACTICES

- ♦ Gravel fill behind the SRW units has to be at least 12 in. (305 mm) thick regardless of the unit type.
- ♦ The first course of SRWs is the most important course to ensure alignment and levelness.
- ♦ Use a stringline to align the blocks.



Backfilling First Course of SRW Units

1. Recheck wall location.
2. Use gravel fill to fill any openings in and between SRW units, as required.
3. Carefully place clean gravel fill behind and up to the height of SRW unit to create wall face drain. Install geotextile if required.
4. Place and compact infill soil behind wall drain.
5. Place fill soil in front of SRW unit.
6. Compact gravel fill and infill soil.

Figure 10: Backfilling First Course of SRW Units

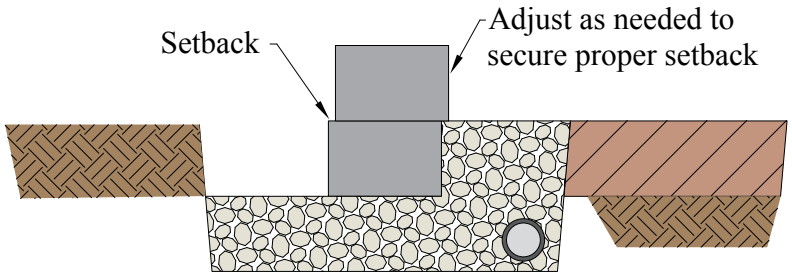
This manual provides general guidelines, site specific conditions should be evaluated by qualified engineer.

Installing Successive Courses Of SRWs

Prior to installing the next course of SRW units, ensure the gravel fill is level with or slightly below the top of the SRW unit below. Clean all debris off the top of the unit and install any pins/clips required by system. Then place and slide the SRW unit forward toward the exposed face to engage shear connectors and establish the proper setback consistent with manufacturer's recommendations. Check the alignment and level of units and adjust as needed. *See Figure 11*. Place clean gravel fill and infill soil as previously described and per the designer's and/or manufacturer's specifications. *See Figure 12*.

BEST PRACTICES

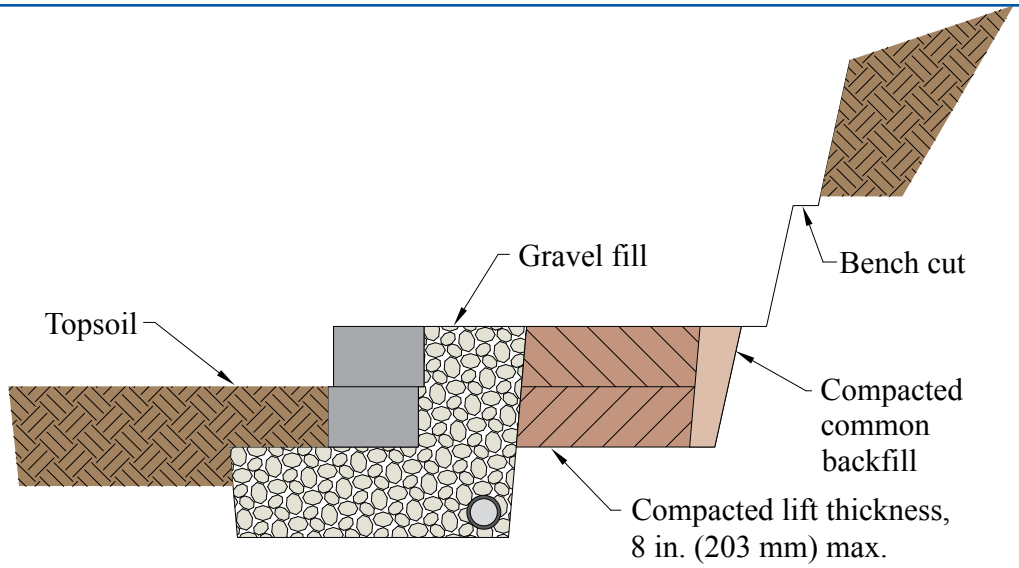
- ♦ Fill and compact SRW cores with gravel fill (if applicable)
- ♦ Fill and compact from the SRW units to the back of the reinforcement.
- ♦ Use small compaction (walk-behind) equipment within 3 ft (914 mm) of the SRW units. Compact parallel to the face of the wall, passing closest to the wall first.
- ♦ Lift thickness should not exceed 6 to 8 in.
- ♦ The lift thickness could be reduced to reach the specified densities.
- ♦ Engage shear connectors in between SRWs.
- ♦ Continuously check for alignment of the wall.



Installing Successive Courses of SRW Units

1. Ensure the gravel fill is level with, or slightly below the top of SRW unit below.
2. Clean debris off top of unit.
3. Place SRW unit shear connectors, if applicable.
4. Move SRW unit to engage shear connectors and establish proper setback consistent with manufacturer's recommendations.

Figure 11: Installing Successive Courses of SRW Units



Fill Placement and Compaction

1. Use gravel fill to fill openings in and between SRW units as required.
2. Place gravel fill behind and up to the height of SRW unit to continue wall face drain.
3. Place and compact infill soil behind wall drain.
4. Compact gravel fill and infill soil.

Figure 12: Fill Placement and Compaction

Placement of Reinforcement And Placement of Backfill

When SRWs require reinforcement, it is normally required on multiple levels extending from the face of the wall back into the compacted reinforced soil mass.

The soil reinforcement is installed at the proper elevation and orientation as shown on the approved design and/or construction plans. The geosynthetic reinforcement is installed in general accordance with the manufacturer's recommendations. Any conflict between the two requirements should be resolved by the engineer. Cut geosynthetic reinforcement to design length (L) as shown on the plans and install with design strength direction perpendicular to the wall face. The design strength direction is that length of geosynthetic

BEST PRACTICES

♦ The strength of the geosynthetic have to be perpendicular to the face of the wall.
♦ The minimum geogrid length is 60% of the total wall height but never less than 4 ft (1.2 m).
♦ Bring geosynthetic to the front of the block and secure by manufacturer's details with the top block.

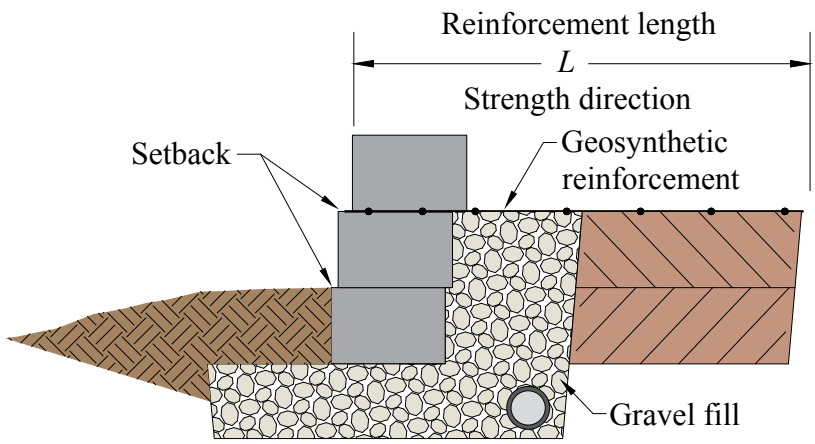
This manual provides general guidelines, site specific conditions should be evaluated by qualified engineer.

reinforcement perpendicular to the wall face consisting of one continuous piece of material. Seams or overlaps of geosynthetic reinforcement on the SRW units are not permitted. Adjacent sections are to be butted in a manner to assure 100% coverage after placement. When overlaps in the reinforced zone occurs (in curves or corners), 3 in. (76 mm) of backfill material should be placed between the layers of geosynthetic material.

Geosynthetic reinforcement should be installed in a manner that removes wrinkles or folds in the material. The geosynthetic should be pulled taut, pulling from the wall face to the rear of the reinforced fill zone. Geosynthetic should be secured in place with staples, stakes, or small soil piles prior to placement of backfill. Backfill placement should be performed in a manner that minimizes the development

BEST PRACTICES

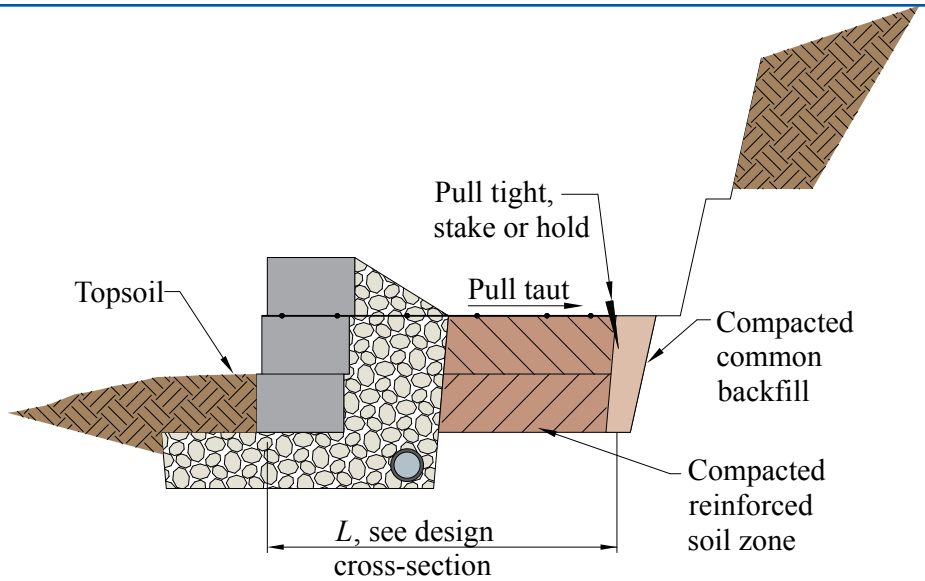
♦ Pull geosynthetic taut and secure the back until backfilled.
♦ Geosynthetics should not overlap at the face of the wall.



Placement of Geosynthetic Reinforcement

1. Ensure wall face gravel fill is level with, or slightly above the top of SRW unit.
2. Clean debris off top of unit.
3. Cut geosynthetic reinforcement to design length L as shown on plans and install with strength direction perpendicular to wall face.
4. Place shear connectors, if applicable, as recommended by the manufacturer.
5. Place SRW unit on top of geosynthetic.
6. Move SRW unit to engage shear connectors and establish proper setback.

Figure 13: Place of Geosynthetic Reinforcement



B. Backfilling over Geosynthetic Reinforcement

1. Pull geosynthetic reinforcement taut, removing wrinkles or folds, hold or stake throughout fill placement process.
2. Place gravel fill for wall face drain in and between SRW units as required.
3. Place infill soil.
4. Compact infill soil.
5. Compact gravel fill.
6. Place remainder of gravel fill.

Figure 14: Backfilling Over Geosynthetic Reinforcement

of folds or wrinkles. Fill placement should generally advance from the wall units towards the rear of the reinforced fill zone. The tension applied may be released after the geosynthetic reinforcement has been covered and held in place with soil fill. *See Figures 13 and 14*.

Place clean gravel fill for wall face drain in and between and 12 in. (305 mm) behind the SRW units as previously discussed in this guide.

BEST PRACTICES
♦ Adjust lift height to meet specified densities but do not use lifts of more than 6 to 8 in (152 to 203 mm). ♦ Do not drive equipment on geosynthetics until there is at least 6 in. (152 mm) of fill. ♦ On curves, insert at least 3 in. (76 mm) of soil between geogrids before overlapping.

The reinforced soil zone is placed as shown in the construction plans in 6 to 8 in. (152 to 203 mm) lifts and compacted to meet project specifications. Height lift may need to be reduced when using small equipment. The

This manual provides general guidelines, site specific conditions should be evaluated by qualified engineer.

soil is placed, front to back; spread and compacted in such a manner that eliminates the development of wrinkles and/or movement of the geosynthetic reinforcement. Only hand operated equipment should be allowed within 3 ft (1 m) of the back of the wall units. Compact clean gravel fill following compaction of the infill soil. *See Figure 14*.

Tracked construction equipment should not be operated directly on the geosynthetic reinforcement. A minimum backfill thickness of 6 in. (152 mm) is required prior to op-

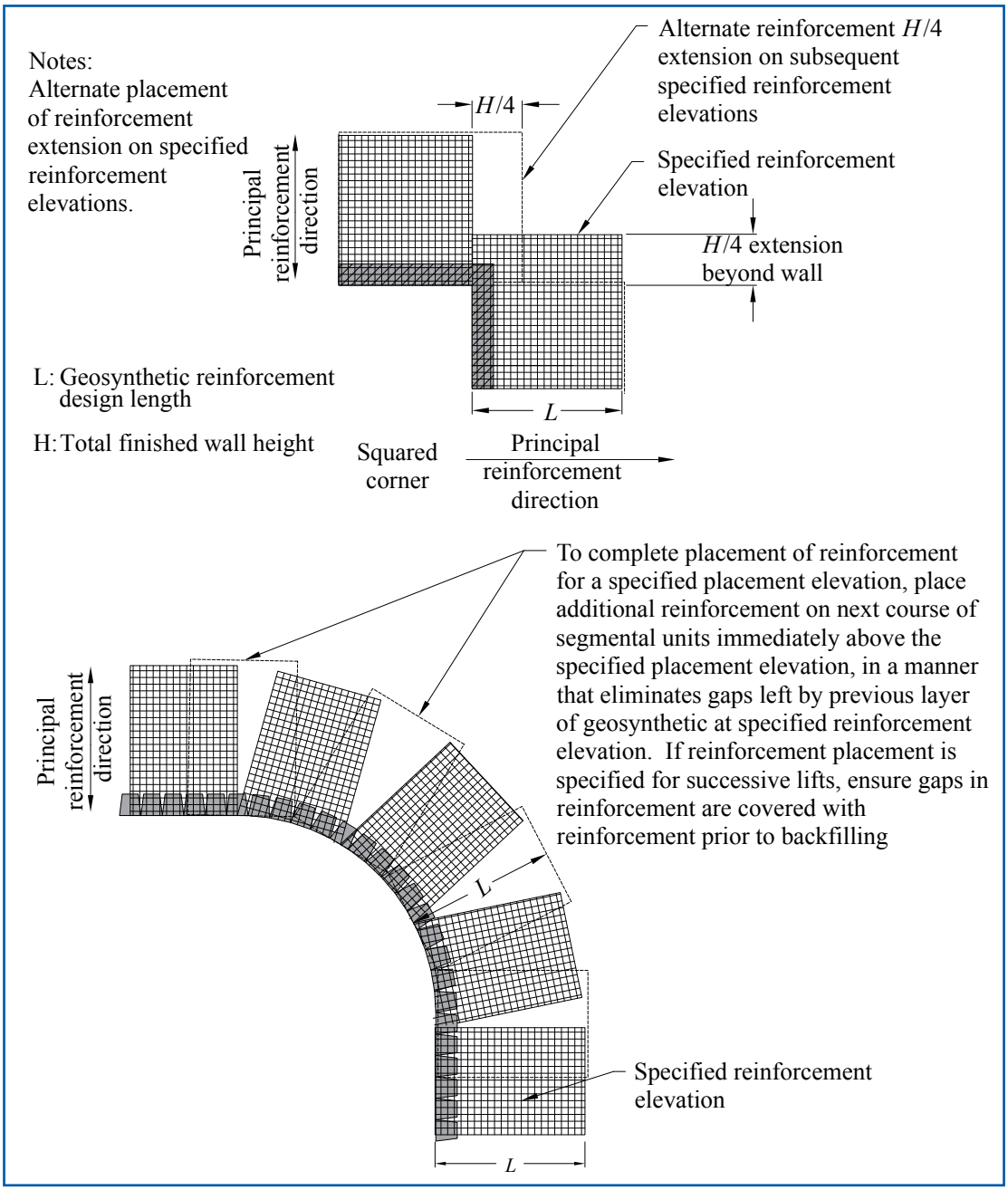


Figure 15: Reinforcement Placement for Concave Corners

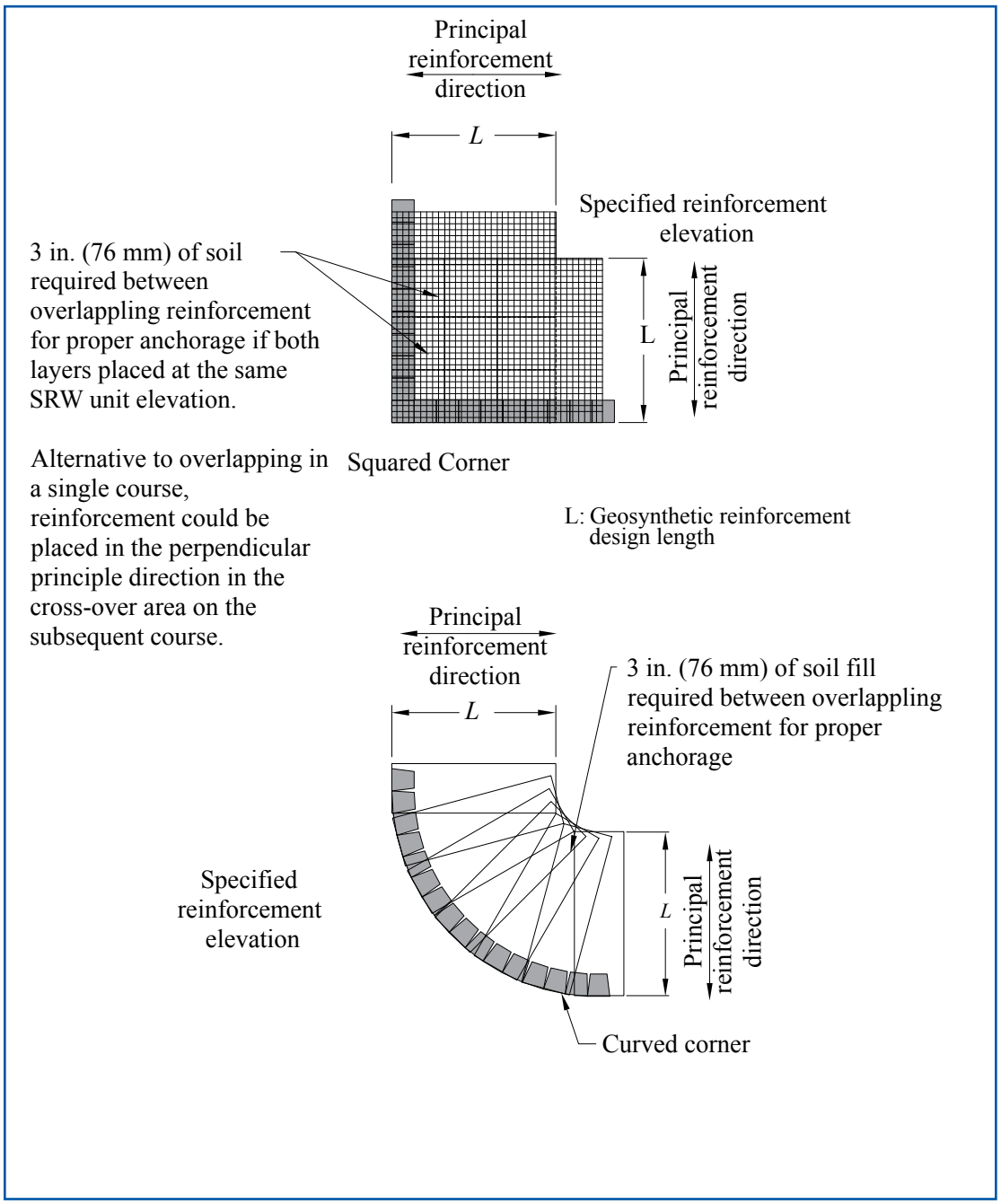


Figure 16: Reinforcement Placement for Convex Corners

This manual provides general guidelines, site specific conditions should be evaluated by qualified engineer.

eration of vehicles over the geosynthetic reinforcement. Turning of vehicles should be kept to a minimum to prevent displacing the units or fill and damaging the geosynthetic reinforcement. Sudden breaking and sharp turns should be avoided. For guidelines on the placement of reinforcement at corners and curves see *Figures 15 and 16*.

When structures and/or encumbrances are to be placed behind and/or on top of a SRW wall, preplanning and detailed construction procedures designed by a knowledgeable engineer should be in place to make sure the wall contractor and subcontractors work together to achieve optimum installation. Manufacturers of SRW systems can provide additional installation guidelines for special applications.

Capping and Finish Grading

Install SRW cap/coping unit (optional) secure per manufacturer's recommendations.

The grade at the top and bottom of the SRW is finished as shown on the plans and to provide for positive drainage of water away from the SRW system. Where the backfill above the wall slopes to the wall face, a swale should be provided to collect and direct runoff from flowing over the face of the system.

BEST PRACTICES

- ♦ Install caps using manufacturer's details using the approved adhesive.
- ♦ Finish wall grading directing water away from the wall.
- ♦ Add specified details.
- ♦ Coordinate with landscaper and other contractors to grade and finish front and back of the wall.

The top of the wall should be finished with approximately 8 in. (203 mm) of a low permeable soil to cap the SRW system to minimize infiltration of surface water into the SRW reinforced soil zone. The system is now ready to have top soil, vegetation, driveway, parking, or other structures placed, which should be as soon as possible to protect and avoid erosion on top and at either end of the wall. *See Figure 17*.

Measurement

Measurement of a completed SRW is on a vertical square foot (square meter) basis. Measuring

BEST PRACTICES

- ♦ The measurement of a completed SRW is usually on a vertical square foot of face basis (exposed and unexposed).

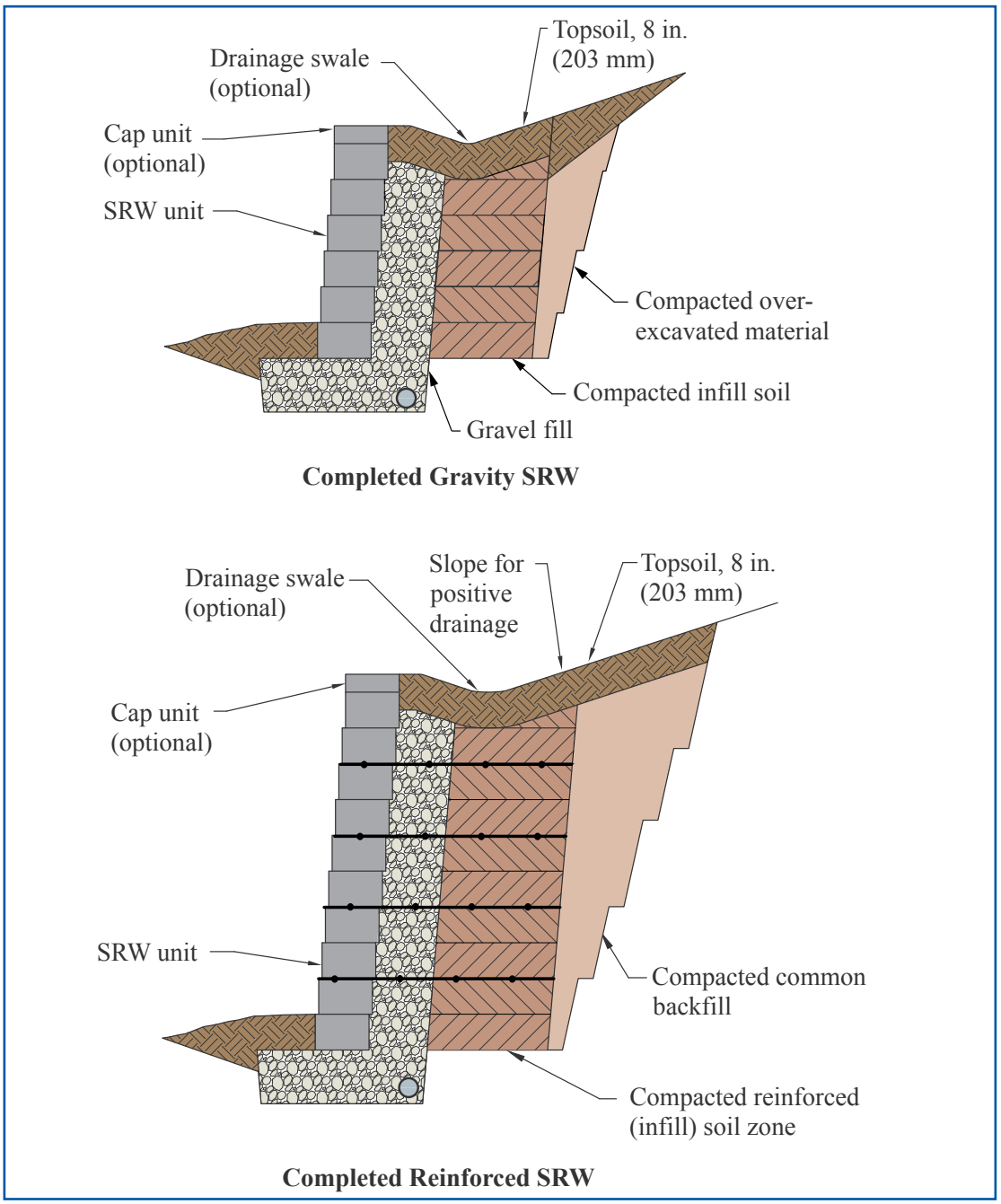


Figure 17: Capping and Grading

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the wall face vertically keeps the amount of wall area consistent as some SRWs have canted faces. This area includes any unexposed wall that may be below grade.

Final quantities may change from the plans depending on actual site conditions and should be determined by the owner (or owner's representative) either through a final wall survey or by computing the materials drawn. The materials drawn can be determined from the difference between the original amount stored and the amount remaining.

GLOSSARY OF COMMONLY USED TERMS

Batter The facing angle created by SRW unit setback, measuredfrom a vertical line drawn from the toe of thewall. Typical batter angles are 3° to 15° from vertical, sloping toward the infill soil.

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

Foundation soil The soil that 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 polyproplene, polyester, or polyethylene.

Geotextile A textile-like material used in soil drainage and reinforcement applications. Usually comprised of polyproplene or polyester, it can be woven or nonwoven.

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

Gravel fill Clean gravel placed within and immediately behind the SRW units and in other areas for drainage.

HDPE	High density polyethylene. Usually refers to the material used to manufacture drain pipe or geogrid.
Infill	Soil located behind the SRW units and gravel fill. May be reinforced with soil reinforcement.
Leveling pad	The level surface (gravel or concrete) used to distribute the weight of the dry-stacked column of SRW units over a wider foundation area and to provide a working surface during construction. The pad is typically constructed with free draining granular soil to facilitate compaction and drainage.
MSE	Mechanically stabilized earth. Soil-reinforced SRWs are considered MSE structures.
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.
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 undisturbed soil for cut walls or the common backfill soil compacted behind infill soils.
Sliding	An external stability failure mechanism of an SRW whereby lateral external forces cause the entire soil mass to slide along its base or internally along a particular layer of soil reinforcement.
Soil-reinforced	An SRW system that uses soil reinforcement to increase the mass of the SRW, thereby increasing stability.
Surcharge	External load, usually applied at the top of an SRW. A roadway or building foundation can be a surcharge.
Swale	A small ditch or depression formed on top and behind the SRW system to collect water and carry it away.

This manual provides general guidelines, site specific conditions should be evaluated by qualified engineer.

GUIDE SPECIFICATIONS

The traditional product/method specification, designating materials and installation requirements, stipulates that a site-specific design be performed by an engineer for each SRW application. Designs should be such that specified SRW and soil reinforcement properties can be met by a number of manufacturers and should include properties of the on-site soil. SRW and soil reinforcement properties are then specified as the minimum properties that must be met. The end-result specification can be used to solicit proposals from various segmental retaining wall suppliers. Each supplier is then required to furnish a project-specific engineering design for that supplier's particular system. This type of specification requires one source, experienced in the design and construction of SRWs, to be responsible for the wall and assures it will be built economically due to open competition.

A guide material specification (product/method) for retaining walls is available in standard Construction Specifications Institute (CSI) format in the *Design Manual for Segmental Retaining Walls* (Ref. 2).

BEST PRACTICES

Determine if the project needs engineering or not

- ♦ If yes: FOLLOW APPROVED DOCUMENTS. DO NOT CHANGE ANYTHING UNLESS DESIGNER HAS SIGNED.
- ♦ If not: FOLLOW MANUFACTURER'S CHARTS WITHOUT EXCEEDING THE HEIGHTS.

Follow manufacturer's recommendation for height capacity of each particular SRW system

- ♦ Avoid exceeding the recommended heights.
- ♦ Reinforced SRWs are appropriate when gravity wall height is exceeded or when the wall has surcharges, slopes, or is on difficult foundation soils.
- ♦ On engineered walls, materials can not be exchanged without the approval of the wall designer.
- ♦ Foundation soils: Organic and expansive soils are unsuitable.
- ♦ Leveling pad materials: Avoid pea gravel for the leveling pad construction.
- ♦ SRW units: Use pins, clips, adhesives expressly fabricated for the system used.
- ♦ Use 1 in. (25.4 mm) minus crushed stone or granular fill for gravel fill.
- ♦ Reinforced fill: Granular low plasticity soils are encouraged.
- ♦ Over excavated retained soils need to be compacted to meet specifications too.
- ♦ Reinforced fill: Granular low plasticity soils are encouraged.
- ♦ Geogrids cannot be exchanged without the SRW engineer's evaluation.
- ♦ Not all geogrid types are compatible with all SRW block systems.
- ♦ Notify design engineer if during construction site characteristics change.
- ♦ Inspection of earthwork is necessary.
- ♦ When doing the layout consider the wall batter.
- ♦ Get wall layout approved before begining construction.
- ♦ Call Before You Dig (8-1-1), to get underground utilities marked before excavating.
- ♦ If some utilities were not considered in the design, notify wall designer.
- ♦ Avoid heavy construction equipment on top of the finished retaining wall unless it was considered in the design.
- ♦ Start excavating and building at the lowest point of the wall.
- ♦ Follow OSHA recommendations for excavating and bench cutting of slopes.
- ♦ Foundation soil has to be inspected and meet or exceed the specified properties.
- ♦ The foundation soil extends underneath the reinforced soil zone too.
- ♦ Leveling pad material and drain pipe location depend on the site conditions, water sources, embedment depth, and where the water can be evacuated and they have to be defined by the wall designer.

This manual provides general guidelines, site specific conditions should be evaluated by qualified engineer.

- ♦ Weak concrete can be used as leveling pad.
- ♦ Gravel fill and drain pipe are only to collect and evacuate incidental water.
- ♦ If during the excavation water is found that wasn't considered in the design, the wall designer has to be notified.
- ♦ The leveling pad has to be leveled.
- ♦ Gravel fill behind the SRW units has to be at least 12 in. (305 mm) thick regardless of the unit type.
- ♦ The first course of SRWs is the most important course to ensure alignment and levelness.
- ♦ Use a stringline to align the blocks.
- ♦ Fill and compact SRW cores with gravel fill (if applicable)
- ♦ Fill and compact from the SRW units to the back of the reinforcement.
- ♦ Use small compaction (walk-behind) equipment within 3 ft (914 mm) of the SRW units. Compact parallel to the face of the wall, passing closest to the wall first.
- ♦ Lift thickness should not exceed 6 to 8 in. (152 to 203 mm) compacted.
- ♦ The lift thickness could be reduced to reach the specified densities.
- ♦ Engage shear connectors in between SRWs.
- ♦ Continuously check for alignment of the wall.
- ♦ The strength of the geosynthetic have to be perpendicular to the face of the wall.
- ♦ The minimum geogrid length is 60% of the total wall height but never less than 4 ft (1.2 m).
- ♦ Bring geosynthetic to the front of the block and secure by manufacturer's details with the top block.
- ♦ Pull geosynthetic taut and secure the back until backfilled.
- ♦ Geosynthetics should not overlap at the face of the wall.
- ♦ Adjust lift height to meet specified densities but do not use lifts of more than 6 to 8 in. (152 to 203 mm)
- ♦ Do not drive equipment on geosynthetics until there is at least 6 in. of fill.
- ♦ On curves, insert at least 3 in. (76 mm) of soil between geogrids before overlapping.
- ♦ Install caps using manufacturer's details using the approved adhesive.
- ♦ Finish wall grading directing water away from the wall.
- ♦ Add specified details.
- ♦ Coordinate with landscaper and other contractors to grade and finish front and back of the wall.
- ♦ The measurement of a completed SRW is usually on a vertical square foot of face basis (exposed and unexposed).

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