

**PART 1 • GENERAL****1.01 Description**

- A. The work covered by this section includes the furnishing of all labour, materials, equipment, and incidentals for the design, inspection, and construction of a modular concrete Segmental Retaining Wall (“SRW”) including drainage system and geosynthetic reinforcement as shown in the Construction Documents and as described by this Specification. The work included in this section consists of, but is not limited, to the following:
- 1) Design of an SRW system.
  - 2) Review of the site conditions with respect to suitability of the SRW Design.
  - 3) Inspection of all construction operations and materials related to the SRW.
  - 4) Excavation and foundation soil preparation.
  - 5) Furnishing and placement of the Leveling Base.
  - 6) Furnishing and placement of the Drainage system.
  - 7) Furnishing and placement of Geotextile Filter.
  - 8) Furnishing and placement of SRW units.
  - 9) Furnishing and placement of Geosynthetic Reinforcement.
  - 10) Furnishing, placement, and compaction of Reinforced, Drainage, and Retained Fills.
  - 11) Furnishing of final grading.

**1.02 Related Work**

- A. Section 31 10 00 - Site Preparation
- B. Section 31 20 00 - Earth Moving

**1.03 Reference Standards**

- A. Segmental Retaining Wall Design
- 1) Design Manual for Segmental Retaining Walls, National Concrete Masonry Association, Second Edition which will be referred to as the “NCMA Design Manual”
- B. Segmental Retaining Wall Units
- 1) ASTM C140-06, “Standard Test Methods for Sampling and Testing Concrete Masonry Units and Related Units”
  - 2) ASTM C1262-05a, “Standard Test Method for Evaluating the Freeze-Thaw Durability of Manufactured Concrete Masonry Units and Related Concrete Units”
  - 3) ASTM C1372-2006e1, “Standard Specification for Dry-Cast Segmental Retaining Wall Units”
  - 4) ASTM D6638-06, “Test Method for Determining Connection Strength Between Geosynthetic Reinforcement and Segmental Concrete Units (Modular Concrete Blocks)”
  - 5) ASTM D6916-06c, “Standard Test Method for Determining the Shear Strength Between Segmental Concrete Units (Modular Concrete Blocks)”
- C. Geotextile Filter
- 1) ASTM D4491-99a(2004)e1, “Standard Test Methods for Water Permeability of Geotextiles by Permittivity”
  - 2) ASTM D4751-04, “Standard Test Method for Determining Apparent Opening Size of a Geotextile”
  - 3) ASTM D5261-92(2003), “Standard Test Method for Measuring Mass per Unit Area of Geotextiles”
- D. Geosynthetic Reinforcement
- 1) ASTM D5262-06, “Standard Test Method for Evaluating the Unconfined Tension Creep Rupture Behavior of Geosynthetics”
  - 2) ASTM D6637-01, “Standard Test Method for Determining Tensile Properties of Geogrids by the Single or Multi-Rib Tensile Method”
  - 3) ASTM D6706-01, “Standard Test Method for Measuring Geosynthetic Pullout Resistance in Soil”
- E. Soils
- 1) ASTM D422-63(2002)e1, “Standard Test Method for Particle-Size Analysis of Soils”
  - 2) ASTM D698-00ae1, “Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft<sup>3</sup> (600 kN-m/m<sup>3</sup>))”
  - 3) ASTM D2487-06 “Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)”

- 4) ASTM D4318-05, "Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils"
  - 5) ASTM D4972-01, "Standard Test Method for pH of Soils"
- F. Drainage Pipe
- 1) ASTM D3034-06, "Standard Specification for Type PSM Poly(Vinyl Chloride) (PVC) Sewer Pipe and Fittings"
  - 2) ASTM F405-05, "Standard Specification for Corrugated Polyethylene (PE) Pipe and Fittings"
- G. Where specifications and reference documents conflict, the Owner or Owner's Representative shall make the final determination of applicable document.

#### 1.04 Delivery, Material Handling, and Storage

- A. The Installer shall check all materials delivered to the site to ensure that the materials specified in the Construction Documents have been received and are in good condition.
- B. The Installer shall store and handle all materials in accordance with manufacturer's recommendations and in a manner to prevent deterioration or damage due to moisture, temperature changes, contaminants, handling, or other causes.

#### 1.05 The design and construction of the Segmental Retaining Wall shall be undertaken by the following three entities:

- A. The term Installer shall refer to the individual or firm that will construct the SRW. The Installer must have the necessary experience and understanding of SRWs for the project and have successfully completed projects of similar scope and size.
- B. The term General Review Engineer refers to the individual professional engineer or professional engineering firm that has a comprehensive understanding of the design and construction of SRWs. The General Review Engineer may retain the services of other professionals to augment their own capabilities, skills, and knowledge. The General Review Engineer is retained by the Installer to provide the following services:
- 1) Inform the Designer in writing that they will be acting as the General Review Engineer for the project prior to construction.
  - 2) Evaluate the site conditions to ensure the parameters used in the SRW Design are appropriate. SRW Design parameters that have assumed values must be verified to be accurate for the site.
  - 3) Determine if the SRW Design requires additional analysis, with respect to compound stability and global stability.
  - 4) Testing and acceptance of all materials used to construct the SRW.
  - 5) Inspection of the methods used to construct the SRW.
  - 6) Determine if the wall is constructed in general conformance with the Construction Documents.
- C. The term Designer refers to the individual professional engineer or professional engineering firm that is experienced in the design of SRWs and is responsible for generating a sealed SRW Design based on information that is provided to the Designer, created in accordance with Section 3.01. The Designer may retain the services of other professionals to augment their own capabilities, skills, and knowledge.

#### 1.06 Submittals - per Contract Documents.

#### 1.07 Measurement for Payment - per Contract Documents.

## PART 2 • MATERIALS

### 2.01 Definitions

- A. Segmental Retaining Wall ("SRW") is the entire retaining wall structure(s) including: SRW Units, Coping, Drainage Pipe, Geotextile Filter, Geosynthetic Reinforcement and Drainage, Reinforced, Retained, and Base Fills. A Segmental Retaining wall structure can be classified as a:
- 1) Conventional SRW - SRW Units stacked on a Leveling Base with a Drainage system behind.
  - 2) Multi-Depth SRW - SRW Units of different depths with larger units at the bottom, and smaller units at the top, stacked on a Leveling Base with a Drainage system behind.
  - 3) Reinforced SRW - SRW Units stacked on a Leveling Base with a Drainage system, Reinforced Fill including Geosynthetic Reinforcement located behind.
  - 4) Crib SRW - SRW Units stacked parallel and perpendicular to the SRW direction forming bin like structures, built on a Leveling Base with a Drainage system behind.

- B. Segmental Retaining Wall Units are modular, solid, dry-cast concrete blocks, designed specifically for the task of earth retention, that form the external facia of an SRW system.
- C. Coping Units are the last course of concrete units used to finish the top of the SRW. Coping Units are also referred to as cap units.
- D. Leveling Base is the compacted granular soil, or if specified in the Construction Documents, an unreinforced concrete footing, placed beneath the first course of SRW units.
- E. Drainage Fill is a free draining aggregate with high permeability placed directly behind the modular concrete units. This will include a Drainage Pipe and may be separated from other Fill with a suitable Geotextile Filter.
- F. Reinforced Fill is placed directly behind the Drainage Fill, placed in layers and compacted, that will include horizontal layers of Geosynthetic Reinforcement.
- G. Retained Fill is the soil placed between the Reinforced Fill and the Retained Soil in Reinforced SRWs or between the Drainage Fill and Retained Soil in Conventional SRWs.
- H. Retained Soil in cut situations is the undisturbed native soil embankment. In soil fill situations this will be the compacted engineered site fill.
- I. Foundation Soil is the undisturbed native soil or engineered fill beneath the SRW structure.
- J. Drainage Pipe is a perforated pipe used to carry water, collected from within the SRW, to outlets, to prevent pore water pressures from building up within the SRW and specifically behind the SRW Units.
- E. Geotextile Filter is a permeable planar polymer structure that will allow the passage of water from one soil medium to another while preventing the migration of fine particles that might clog the downstream fill. Selection of a Geotextile Filter is based on the characteristics of the different soils used in and surrounding the SRW.
- F. Geosynthetic Reinforcement is an open planar polymer structure having tensile strength and durability properties that are suitable for soil reinforcement applications. Geogrid is a commonly used type of Geosynthetic Reinforcement.
- G. All values stated in metric units shall be considered as accurate. Values in parenthesis stated in imperial units are the nominal equivalents.

## 2.02 Approved Products

- A. All approved products will be identified in the Construction Documents. No substitutions will be allowed unless approved in writing by both the Designer and General Review Engineer.
- B. The SRW units will be specified in the Construction Documents which shall include the manufacturer's name, product name, dimensions, colour, and finish. Additionally the SRW units must:
  - 1) Meet the minimum standard as defined by ASTM C1372 for:
    - a) Strength
    - b) Absorption
    - c) Freeze - Thaw durability
    - d) Permissible variation in dimensions
    - e) Finish and Appearance
  - 2) Meet the physical properties listed below as tested using ASTM C140:
    - a) Dimensional tolerance shall be +/- 3 mm (1/8 in.) for height, width, and length.
    - b) The minimum 28-day compressive strength of 35 MPa (5000 psi).
    - c) The maximum moisture absorption shall be 1.0 kN/cubic m (6.5 lbs/cubic ft).
  - 3) Use an integral shear key connection that shall be offset to create, as specified in the Construction Documents, either:
    - a) A minimum batter as stated in the Construction Documents, or
    - b) A near vertical alignment. Special construction procedures are required for vertical SRWs. See Section 3.04.D.
  - 4) If required, summary test data shall be provided with the SRW Design and shall include:
    - a) SRW Unit shear strength as per ASTM D6916
    - b) SRW Unit - Geosynthetic Reinforcement connection strength as per ASTM D6638

- C. Reinforced Fill
- 1) If the SRW Units by themselves provide sufficient stability, the Designer may choose to omit the Reinforced Fill
  - 2) The Reinforced Fill shall be specified in the Construction Documents as “select imported fill”
    - a) Unified Soil Classification System designation as per ASTM D2487
    - b) % passing #200 sieve
    - c) Effective friction angle (direct shear or triaxial test)
    - d) Minimum compacted density
  - 3) Additional information may be required which could include:
    - a) Soil gradation curve (ASTM D422)
    - b) Liquid limit, plastic limit, and plasticity index (ASTM D4318)
    - c) Soil pH (ASTM D4972)
    - d) Permeability coefficient “Q”
- D. Leveling Base
- 1) The leveling base material shall be non-frost susceptible, well-graded, compacted angular gravel-sand mixture (GW as per ASTM D2487).
  - 2) Additional information may be required which could include:
    - a) Effective friction angle (direct shear or triaxial)
    - b) Soil gradation curve (ASTM D422)
    - c) Soil pH (ASTM D4972)
    - d) Permeability coefficient “Q”
    - e) Potential for consolidation
  - 3) Alternately, the Construction Documents may specify the leveling base shall be an unreinforced concrete footing with specified dimensions.
- E. Drainage Fill
- 1) If the Reinforced Fill has adequate drainage characteristics, the Designer may choose to omit the Drainage Fill.
  - 2) The Drainage Fill shall be a free-draining angular, gravel material of uniform particle size smaller than 25 mm (1 inch) and greater than 6mm (1/4 inch). If shown in the Construction Documents, the Drainage Fill shall be separated from the Reinforced Fill or Retained Fill by a specified Geotextile Filter.
  - 3) Additional information may be required which could include:
    - a) Effective friction angle (direct shear or triaxial)
    - b) Soil gradation curve (ASTM D422)
    - c) Soil pH (ASTM D4972)
    - d) Permeability coefficient “Q”
    - e) Potential for consolidation
- F. Drainage Pipe
- 1) The Drainage Pipe shall be specified in the Construction Documents and shall either be a perforated corrugated polyethylene or perforated PVC pipe, with a minimum diameter of 100 mm (4 inches), protected by a Geotextile Filter to prevent the migration of soil particles into the Drainage Pipe.
- G. Geotextile Filter
- 1) If the gradation of adjacent soils permits, the Designer may choose to omit the Geotextile Filter.
  - 2) The Geotextile Filter shall be specified in the Construction Documents and shall include the manufacturer’s name and product name.
  - 3) If required, summary test data shall be provided with the SRW Design and shall include:
    - a) Apparent opening size “AOS” (ASTM D4751)
    - b) Unit weight (ASTM D5261)
    - c) Coefficient of permeability (ASTM D4491)

**Note:** *There are many different types of Geotextile Filters. Geotextile Filters made from similar materials, using a similar method of manufacture will have similar performance characteristics. Some common examples are non-woven needle-punched, woven slit film or monofilament.*

*Although selection of the appropriate geotextile is specific to site soil conditions, a commonly used geotextile for filtration is a non-woven needle-punched geotextile that will have an Apparent Opening Size ranging between 0.149 and 0.212 mm (U.S. Sieve Sizes #100 to #70) and a minimum unit weight of 135 grams per square metre (5.0 oz per square yard). The coefficient of permeability will typically range between 0.1 and 0.3 cm/second.*

## H. Geosynthetic Reinforcement

- 1) If the SRW Units by themselves provide sufficient stability, the Designer may choose to omit the Geosynthetic Reinforcement.
- 2) The Geosynthetic Reinforcement shall be specified in the Construction Documents and shall include the manufacturer's name, product name, and Long Term Design Strength ("LTDS") as calculated according to section 3.01.A.5.
- 3) If required, summary test data shall be provided with the SRW Design and shall include:
  - a) Tensile strength (ASTM D6637)
  - b) Creep potential reduction factor (ASTM D5262)
  - c) Installation damage reduction factor
  - d) Durability reduction factor (chemical and biological)
  - e) Soil pullout resistance (ASTM D6706)
  - f) Connection strength (ASTM D6638)
  - g) Coefficient of interaction "ci"
  - h) Coefficient of interaction "cde"

## I. Concrete Adhesive

- 1) If the Coping Unit by itself provides sufficient stability, the Designer may choose to omit the Coping Adhesive.
- 2) The adhesive is used to permanently secure the coping unit to the top course of the SRW. The adhesive must provide sufficient strength and remain flexible for the expected life of the SRW.

## PART 3 • EXECUTION

## 3.01 Segmental Retaining Wall Design

## A. Design Standard

- 1) The Designer is responsible for providing an SRW Design based on the proposed site development documents and shall consider the external stability, internal stability, and local stability of the SRW system. The design life of the structure shall be 75 years unless otherwise specified in the Construction Documents.
- 2) The Designer shall create the SRW Design in accordance with recommendations of the NCMA Design Manual. The following is a summary of the minimum factors of safety for the various modes of failure evaluated in the proposed design.

| External Mode    | Minimum | Internal Mode      | Minimum | Local Mode               | Minimum |
|------------------|---------|--------------------|---------|--------------------------|---------|
| Base Sliding     | 1.5     | Tensile Overstress | 1.0     | Facing Shear             | 1.5     |
| Overturning      | 2.0     | Pullout            | 1.5     | Connection               | 1.5     |
| Bearing Capacity | 2.0     | Internal Sliding   | 1.5     | Unreinforced Overturning | 1.5     |

- 3) If required, an alternate design method may be used and must be identified in the SRW Design. The alternate design method must be comprehensive and adequately evaluate all possible modes of failure.
- 4) The lateral earth pressure which the SRW must resist is calculated using the Coulomb equation which will include the effect of a sloping surface above the SRW. This defines a theoretical critical linear slip failure plane external to the SRW structure and another internal to the SRW structure. Additionally the SRW must have the room to move forward so that it may fully develop an active lateral earth pressure.
- 5) The SRW's design height, "H", at a given section, shall be measured from the top of the Leveling Base to the top of the SRW where ground surface intercepts the SRW fascia.
- 6) The Designer is not responsible for analyzing the global stability of the SRW structure for circular slip failure and multi-part slip failure planes that are completely external or partially external (referred to as compound failure mechanisms) to the SRW structure. See Note 3 in Section 3.02.B.2 for additional information.

## B. Design Assumptions

- 1) An SRW Design will typically assume the following and shall be noted on the SRW Design drawings:
  - a) The foundation soils will produce acceptable total and differential settlement given the applied load of the SRW.
  - b) The maximum groundwater elevation is at least 2/3 x H (height) below the base of the SRW unless otherwise stated in the Construction Documents.
  - c) There will be no hydrostatic pressure within or behind the SRW.
  - d) The surrounding structures will not exert any additional loading on the SRW (i.e. an adjacent structural foundation is at or below proposed Leveling Base or outside of a theoretical zone of influence as determined by the General Review Engineer).

- e) There are no structures (utilities such as gas/water mains, storm sewers, electrical/communications cables, etc.) to be placed within or below the Reinforced Fill during or after construction.

C. Design Parameters

1) Site Parameters

- a) The length, height, and overall elevations of the SRW Design must be derived from the provided site grading plan, elevation details, cross-section details, and station information.
- b) Surcharges, anticipated usage and slopes above, as well as slopes below, all sections of the SRW must be indicated on the site grading plan.
- c) The minimum SRW embedment shall be the greater of:
  - i. The height of an SRW unit, or
  - ii. The minimum embedment required based on the slope below the SRW.

| Slope Below SRW  | Minimum Embedment |
|------------------|-------------------|
| No Slope         | H/10              |
| 3 : 1 (18.4 deg) | H/10              |
| 2 : 1 (26.5 deg) | H/7               |

- iii. The Designer or General Review Engineer may determine it is necessary to increase embedment due to erosion potential or global stability requirements.

2) Site Soil Parameters

- a) All site soil parameters used in the design shall be stated in the SRW Design. This should include soil classification (ASTM D2487), effective friction angle, compacted density, and cohesion.
- b) Site-specific soil parameters obtained from site geotechnical investigations shall be used in the design calculations. If a site geotechnical investigation is not available or does not provide specific parameters for the SRW, assumed soil parameters may be used and the SRW Design shall state the assumed values and that assumed soil parameters have been used.
- c) If select on-site soils are to be used as SRW fill materials, additional testing of the re-compacted soil will be required for the design calculations. Soil parameters for the select on-site fill shall be used in the design calculations. If fill parameters are not available, assumed fill parameters may be used and the Design Drawings shall state the assumed values and that assumed fill parameters have been used.

3) Product Design Parameters

- a) All relevant Product Design Parameters for materials incorporated in the SRW shall be obtained from the supplier or manufacturer and used in the design calculations. All values used shall be obtained from testing conducted in accordance with the Reference Standards identified in Section 1.03. If product test results are not available, assumed parameters may be used and the Design Drawings shall state the assumed values and that assumed product design parameters have been used.

### 3.02 Segmental Retaining Wall Design Review

- A. This section states the minimum review process that is required prior to construction of an SRW. Other parties such as municipalities, architects, developers, owners, and other designers should review the SRW Design prior to acceptance to ensure specific requirements of each party are met.
- B. The General Review Engineer will need to
  - 1) Review the SRW Design to ensure:
    - a) The design assumptions are not contrary to the conditions on the site.
    - b) The site geometric parameters used in the SRW Design are appropriate for the site.
    - c) The site soil parameters used in the SRW Design are appropriate for the soil conditions on the site.
    - d) The foundation soils will not require special treatment to control total and differential settlement.
    - e) The fill parameters used in the SRW Design are appropriate for the materials to be used in the construction of the SRW.
    - f) The SRW Design complies with local building and health and safety regulations.
  - 2) The General Review Engineer is responsible for ensuring the global stability of the SRW structure including circular slip failure and multi-part slip failure planes that are completely external or partially external (also called compound failure mechanisms) to the SRW structure is adequately investigated.

**Note:** As recommended by the NCMA, it is the General Review Engineer's responsibility to ensure the global stability of the SRW structure for circular slip failure and multi-part slip failure planes that are completely external or partially external (referred to as compound failure mechanisms) to the SRW structure. This analysis will extend beyond the region of the SRW structure (natural or man made slopes that extend well beyond the area of SRW construction, geotechnical conditions that may promote deep seated instability, etc.).

Experience has shown that in most cases, the geotechnical reports conducted to provide "general" information about a site, provided to the Installer for bidding purposes and the Designer to generate the SRW Design, do not provide sufficient information to accurately assess global or compound stability. Additional excavation, test pits, and/or boreholes that are conducted for the specific purpose of assessing the global and compound stability may be required.

The General Review Engineer may request the Designer to assist with the global stability analysis.

- 3) The General Review Engineer must contact the Designer to address any outstanding issues, questions, or concerns regarding the SRW Design and resolve these issues prior to issuing Construction Documents or authorize the SRW Design to be used as Construction Documents.
- C. The Project Civil Engineer must be provided with a copy of the SRW Design so they may review it for general compatibility with the site.
- 1) Review should including the following specific elements:
    - a) All surface drainage must direct water away from the SRW including slopes and paved surfaces.
    - b) The SRW drainage system delivers outflow to approved locations.
    - c) All site services must be located outside of SRW construction area.
    - d) The SRW structure or excavation limits must not cross over property boundaries.
    - e) All structures located near the SRW must be shown in the Construction Documents.
    - f) Anticipated use above wall during and after construction must be as shown in the Construction Documents.

**Note:**

**Surface drainage** - The SRW Design will typically require that surface water be directed away from the SRW. If a slope exists behind the SRW, a swale system will be required which must be included as part of the site grading plan. If the inclusion of a swale was not considered in the site grading plan, the Civil Engineer must provide for this, including required dimensions based on the anticipated volume of water to be collected as well as any grading changes required to accommodate the swale (i.e. potential minor increases in SRW height). The dimensions of the swale are dependent on the anticipated water flow and must be determined by the Civil Engineer responsible for site drainage. A swale can be constructed from concrete or a soil with a low permeability to restrict the rate of water infiltration into the SRW structure. The low permeability material used to cap off the top of the SRW is typically between 200mm (8 inches) and 400mm (16 inches) thick.

**Drainage of other structures** - The design requires that other structures such as pavements adjacent to the SRW have independent drainage systems (perimeter drain) to ensure the SRW drainage system is not relied on to perform an outletting function for these other structures. Further to this, down spouts from buildings must be outlet away from the SRW into other specified drains.

**Outletting/connection of internal drainage system pipes** - The Civil Engineer must provide direction as to the connection points or outletting of the SRW internal and external drainage system as part of the overall site drainage plan. This must be provided to the Installer.

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

**Property lines** - The SRW must not encroach on property lines unless consent is given by all stakeholders. Temporary access may be required during excavation and must be confirmed prior to start of construction. The proposed excavation and final structure location (including depth of Geosynthetic Reinforcement, SRW batter and stepping of SRW, actual block thickness) must be reviewed and approved by the Civil Engineer for the site. Temporary shoring may be required to ensure compliance with property line restrictions, building and safety regulations.

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

**Use of area above/around SRW** - The SRW was designed for the loading specified in the SRW Design. This loading was chosen based on the site grading plan and identified use. The design requires that the Civil Engineer verify that the assumed use is acceptable for the site. Also, it must be determined if the area above the SRW will ever be used as a depot for the storage of other materials or equipment during or after construction.

**Snow dumps present particular hazards to SRW structure** - SRWs are typically not designed to bear the unknown weight of a snow storage area, nor has the drainage system been designed to accommodate the subsequent snow melt.

- 2) The Project Civil Engineer must contact the Designer to address any outstanding issues, questions, or concerns regarding the SRW Design and resolve these issues prior to the General Review Engineer issuing Construction Documents or authorising the SRW Design to be used as Construction Documents.
- D. The Project Landscape Architect must be provided with a copy of the SRW Design so they may review it for general compatibility with the site.
- 1) The review should include the following specific elements:
    - a) Ensure plant and tree species to be placed above the SRW are suited to the environment created by the SRW.
    - b) Limit irrigation near SRW structure.
    - c) Grading above and below the SRW structure.
    - d) It may be necessary to incorporate a root barrier (as required by others) to prevent the migration of tree roots into the drainage layer.
    - e) Larger plants and trees must be kept outside of the Reinforced Fill to ensure
      - i. The Geosynthetic Reinforcement is not damaged by excavation for the root ball
      - ii. The SRW is not subjected to any additional load from plants or trees.
- Note:** The SRW will be designed to remove water from the SRW area in order to limit water's effect on the SRW structure. Irrigation systems are counter-productive to the details of the SRW Design. The SRW will be designed to promote runoff and drain quickly, leaving little moisture in the soil. The topsoil layer above the SRW will be of a nominal thickness 0.2 to 0.3m (8 to 12 inches). The plants must have a shallow root system so they do not interfere with the drainage systems.
- 2) The Project Landscape Architect must contact the Designer to address any outstanding issues, questions, or concerns regarding the SRW Design and resolve these issues prior to the General Review Engineer issuing Construction Documents or authorising the SRW Design to be used as Construction Documents.
- E. After the review of the SRW Design is completed by all associated parties and all issues are resolved by revisions to the SRW Design, the General Review Engineer will issue sealed Construction Documents based on the SRW Design or authorize the SRW Design to be used as the Construction Documents.

### 3.03 Inspection

- A. Testing and inspection services shall be performed by trained and experienced technicians currently qualified for the work to be performed.
- B. The Owner may engage a testing and inspection agency for their own quality assurance, but this does not replace the General Review Engineer's inspection function described below.

**Note:** In many cases, owner-sponsored construction quality assurance testing is generally insufficient in scope to address the inspection service required, and also to meet the detailed documentation requirements needed to establish a thorough geotechnical testing and general review program.

- C. General Review Engineer's Inspection
  - 1) The General Review Engineer shall ensure that the site conditions are in general conformance with those stated in the SRW Design.



- 2) The General Review Engineer shall ensure that the SRW is constructed in accordance with the Construction Documents.
- 3) The General Review Engineer shall inform the Designer in writing if conditions on site differ in any way or at any time from the Construction Documents. The Designer is to be consulted with regard to all discrepancies between the Construction Documents and actual site conditions to determine how the differences affect the SRW Design. Changes in conditions on site may include, but are not limited to:
  - a) Seepage from the excavation, or
  - b) Higher than assumed groundwater elevations,

*Note: If unexpected sources of water are identified, such as a higher water table or weeping soil layers, additional drainage structures may be required such as blanket drains or chimney drains. The specific details will need to be determined among the Designer, the General Review Engineer and the Project Civil Engineer and included in the Construction Documents.*

- c) Soil conditions, both in situ and/or engineered,
  - d) Surface drainage control on the site require measures greater than those specified,
  - e) Site required SRW geometry (heights, alignment, lengths, etc.),
  - f) Structures exist not shown in the Construction Documents that apply load to, interfere with, or are influenced by the SRW (catch basins, light standards, buildings, fences, etc.),
  - g) Loading conditions (i.e. roadways or pathways closer to back of SRW than originally assumed),
  - h) Slopes above or below the SRW that are steeper.
- 4) General Review of Construction Procedures:
    - a) The General Review of Construction must be carried out in accordance with the guidelines set out by the governing professional engineering body. The purpose of the general review is to ensure, through periodic visits on a rational sampling basis, whether the work is in general conformity with the Construction Documents.
    - b) Prior to construction the General Review Engineer should identify critical stages in the construction of the SRW at which the General Review Engineer must be present to observe and inspect the work. The General Review Engineer must be given sufficient notice prior to these events to ensure they will be on site.
    - c) During construction the General Review Engineer should verify and continually monitor the following:
      - i. Ensure materials and fill are of the type and strength specified and they are placed as specified in the Construction Documents.

*Note: The General Review Engineer will provide field inspection and quality control services to ensure the Reinforced, Drainage, Retained, and Foundation Soils are in conformance with the Construction Documents and meet the minimum requirements for strength, unit weight, type, and consistency stated in the design. This is achieved through regular compaction testing, monitoring of fill placement and compaction procedures, inspection and testing of materials (USCS classification, fine content, plasticity), and verification of subgrade bearing capacity. The extent and scope of the testing program must be to the satisfaction of the General Review Engineer such that they are confident that the materials testing aspects of the overall construction inspection have been properly conducted. The ultimate goal of the materials testing program will be to reasonably ensure the assumed geotechnical parameters, specified soil types, bearing capacity requirements, compaction requirements, and water/groundwater assumptions included in the design have been met throughout the SRW. The extent of materials / compaction testing will be a function of the type of soil, weather conditions, consistency of results, General Review Engineer's judgment, etc. As a recommended minimum guideline, compaction tests should occur at the front of the Reinforced Fill (within 1.2m [4.0ft] of the face) and near the back of the Reinforced Fill (for Reinforced Fill with depth greater than 1.5m) at least every 10m - 15m o/c horizontally along the length of the SRW. Vertically, tests should be performed on at least every second lift (300mm - 400mm) as the Reinforced Fill is placed and compacted. The type of material being used as Reinforced Fill must be constantly checked against the specification. For imported fill materials, documentation (tickets) from the aggregate supplier must be reviewed and kept by the General Review Engineer. When using approved on-site soils, depending on the homogeneity of the soils, the physical properties of the soils (type, plasticity, internal angle of friction, unit weight, permeability, etc.), must be checked on a regular basis to ensure those parameters assumed in the design are being met or exceeded on site (either through testing, visual inspection, or both).*

- ii. Identify loose or unsuitable foundation or retained soils and subsequent removal and replacement of these areas. See Section 3.04.A.6 for additional information.

*Note: The allowable bearing capacity of the subgrade specified in the design must be verified under both the facing of the SRW and the Reinforced Fill (entire SRW footprint). The allowable bearing capacity of the subgrade must be verified at intervals not exceeding 3m along the length of the SRW or as determined suitable by the General Review Engineer.*

- iii. Ensure the other structural elements of the SRW, including Geosynthetic Reinforcements and SRW Units, are being installed in accordance with the Construction Documents.

**Note:** *General Review of Geosynthetic Reinforcements (geogrid) would include ensuring the correct type (manufacturer and strength), length, placement in the SRW structure, and installation method. General Review of the SRW Units would include confirming the correct type, ensuring tolerances listed in this specification are being met on a random sampling basis, and the installation method. This also includes safe use of handling and placing equipment such as frictional clamps.*

- iv. Ensure the SRW and associated excavation remains outside of the loading influence of other adjacent structures, unless they have been specifically accounted for in the SRW Design and shown in the Construction Documents.
  - v. Ensure stability of excavations and conformance with applicable regulations.
  - vi. Ensure groundwater conditions and/or other water sources have been identified and compared with the assumptions made in the design. Additional water sources noted on site such as seepage from the cut embankment must be identified and the Designer notified if these are not noted in the Construction Documents.
  - vii. Ensure that surface water runoff and/or other sources of water are being controlled during construction and directed away from the SRW to a functioning drain.
  - viii. Ensure that all fill materials are adequately protected from the elements and frozen materials or materials that do not meet the moisture content requirements stated in the Construction Documents are not used in the construction of the SRW.
- 5) The General Review Engineer shall submit written reports of inspections and material testing to the Installer on a weekly basis, or more frequently, as agreed with the Installer. Such reports shall include description of the work observed, deficiencies noted in construction, and corrective action taken to resolve such deficiencies. Reports must make specific reference to the location, type, and results of all tests taken on the project.
  - 6) At the completion of construction, the General Review Engineer shall provide a Letter of General Review to the Installer stating the completed SRW had been installed in general conformity with the Construction Documents.

D. Installer's Quality Assurance Program

- 1) The Installer is responsible to ensure the SRW is constructed in accordance with the Construction Documents. The Installer must be qualified in the construction of SRWs, knowledgeable of acceptable methods of construction, and have thoroughly reviewed and understood the Construction Documents.

**Note:** *General installation guides illustrating proper methods and techniques for good construction are available to the Installer from Risi Stone Systems or the SRW Manufacturer upon request.*

- 2) The Installer shall keep a construction journal to document the construction of the SRW as part of a thorough quality control program. The General Review Engineer shall be provided with copies of the construction journal throughout the construction process.

**Note:** *The construction journal is the Installer's permanent record of all information related to the project. It should include a written account of each day's activities, weather conditions, specific tasks completed, materials received at the site, details of visitors to the site and discussions, material tags, and photographs.*

- 3) The Installer's field construction supervisor shall have demonstrated experience and be qualified to direct all work related to the SRW construction.
- 4) The Installer must notify the General Review Engineer of critical stages in the construction of the SRW in order that they may be present to observe and inspect the work. The General Review Engineer must be notified reasonably well in advance of the scheduled date(s) for construction.

A. Construction Tolerances

- 1) Installation of SRW fascia shall be within all the following acceptable tolerances:

|                                 |  |
|---------------------------------|--|
| <b>Vertical Control</b>         | +/- 1.25 inches over a 10 ft distance  |
| <b>Horizontal Control</b>       | Straight lines: +/- 1.25 inches over a 10 ft distance  |
| <b>Rotation of the SRW Face</b> | Maximum 2.0 degrees from established SRW plan batter or +/-10.0% from total established horizontal setback |
| <b>Bulging</b>                  | +/- 1.25 inch over a 10 ft distance  |

### 3.04 Construction

#### A. Site Preparation

- 1) Comply with all current Federal, Provincial/State, and local regulations for execution of the work, including local building codes and excavation regulations. Provide excavation support as required to maintain stability of the area during excavation and SRW construction and to protect existing structures, utilities, landscape features, property, or improvements.
- 2) Prior to grading or excavation of the site, confirm the location of the SRW and all underground features, including utility locations within the area of construction. Ensure surrounding structures are protected from effects of SRW excavation.
- 3) Coordinate installation of underground utilities with SRW installation.
- 4) Control surface water drainage and prevent inundation of the SRW construction area during the construction process.
- 5) The Foundation Soil shall be excavated or filled as required to the grades and dimensions shown in the Construction Documents.
- 6) The Foundation Soil shall be proof rolled and examined by the General Review Engineer to ensure that it meets the minimum strength requirements specified in the Construction Documents. If unacceptable Foundation Soil is encountered, the General Review Engineer should contact the Designer to discuss options and determine the most appropriate course of action.

**Note:** *The footprint of the SRW includes the Reinforced Fill and is not limited to the facing. Therefore, foundation treatments must encompass the entire SRW foundation and extend a minimum of 0.6m in front of the SRW facia and behind end of the Geosynthetic Reinforcement respectively. The replacement material must extend down at a 1H:1V line to competent native material.*

- 7) In cut situations, the native soil shall be excavated to the lines and grades shown in the Construction Documents and removed from the site or stockpiled for reuse as Reinforced or Retained Fill as identified in the Construction Documents. Care should be taken not to contaminate or overly saturate the stockpiled fill material.

#### B. Installing Drainage System

- 1) If specified in the Construction Documents, the approved Geotextile Filter shall be set against the back of the first SRW Unit, over the prepared foundation soil extending towards the back of the excavation, up the excavation face and eventually over the top of the Drainage Fill to the back of the SRW Units near the top of the wall or as shown in the Construction Documents. Geotextile overlaps shall be a minimum of 300 mm (1 ft.) and shall be shingled down the face of the excavation in order to prevent the migration of particles from one fill type to another.
- 2) The Drainage Pipe shall be placed as shown in the Construction Documents, in accordance with the overall drainage plan for the site. The main collection drain pipe shall be a minimum of 100mm (4 inches) in diameter. The pipe shall be laid to ensure gravity flow of water from the Reinforced Fill. Connect drainage collection pipe at a storm sewer catch basin or daylight along slope at an elevation lower than lowest point of pipe within Reinforced Fill mass, every 15 m (50 feet) maximum.
- 3) If other sources of water are discovered during excavation or anticipated, other drainage measures/systems such as chimney or blanket drains may be required. The General Review Engineer should contact the Designer to discuss options and determine the most appropriate course of action.

#### C. Leveling Base or Spread Footing Placement

- 1) The Leveling Base shall be the specified material placed in the location to the dimensions shown in the Construction Documents.

#### D. Installation of Segmental Retaining Wall Units

- 1) The bottom row of SRW Units shall be placed on the Leveling Base as shown in the Construction Documents. The units shall be placed in the middle of the Leveling Base. Care shall be taken to ensure that the SRW Units are aligned properly, leveled from side to side and front to back, and are in complete contact with the Leveling Base.
- 2) The SRW Units above the bottom course shall be placed to interconnect the shear key and then pushed forward, creating the specified batter of the SRW face.
- 3) The SRW Units shall be swept clean before placing additional courses to ensure that no dirt, concrete, or other foreign materials become lodged between successive lifts of the SRW Units.
- 4) Successive courses shall be placed to create a running bond pattern with the edge of all units being approximately aligned with the middle of the unit in the course below it. Cut SRW Units may need to be placed to ensure the vertical line between adjacent SRW Units remains within the middle third of the SRW Unit below.
- 5) A maximum of three courses of SRW units can be placed above the level of the Reinforced Fill at any time.
- 6) The Installer shall check the level of SRW Units with each lift to ensure that no gaps are formed between successive lifts that may affect the performance of the SRW.
- 7) Care shall be taken to ensure that the SRW Units and Geosynthetic Reinforcement, where applicable, are not damaged during handling and placement.
- 8) No heavy equipment, for compaction, fill placement or other, shall be allowed within 1 metre (3 ft.) of the back of the SRW Units.

### Special Construction Procedures - Near Vertical Installation

1. Vertical alignment is achieved by rotating every second course 180 degrees so the back of the SRW Unit is at the face of the wall.
2. SRW units with a split rock finish will require the back of the unit to be split off to achieve the same face appearance as the normally installed units.
3. A slight negative batter (as specified in the Construction Documents) must be constructed into the gravel base when aligning the blocks vertically to account for minor forward movement of the SRW during and following construction.

### Special Construction Procedures - Multi-depth SRW Systems

1. Multi-depth SRW systems utilise SRW units of identical face dimensions and varying depths to create a stable structure.
2. Place SRW Units as specified in the Construction Documents. SRW Units with the greatest depth are placed at the bottom of the SRW with shorter SRW Units being placed above.

### Special Construction Procedures - Crib SRW Systems

1. Crib SRW systems utilise a tie-back unit, installed perpendicular to the wall face that “tie” the facing at the front of the SRW to dead-men at the back of the SRW structure and create a stable structure. Both the facing and dead-men are the standard SRW units. When assembled the SRW Units create a interlocked “bin” like structure
2. Place SRW Units (facing and dead-men) and Tie-back Units as indicated in the Construction Documents.
3. Tie-back units may be connected into each other to create longer tie-back elements.
4. Place specified gravel fill within the crib structure and compact as directed in the Construction Documents. Placement of SRW Units must be done in conjunction with the placement of fill, at each course, to ensure that all fill is compacted below and between the tie-back units.

#### E. Drainage Fill

- 1) Drainage Fill may not be required as indicated in the Construction Documents.
- 2) The Drainage Fill will be placed behind the SRW Units with a minimum width of 300 mm (1 ft.) and separated from other soils using the specified Geotextile Filter.
- 3) Drainage Fill shall be placed behind the SRW facing in maximum lifts of 150 mm (6 inches) and compacted to a minimum density of 95% Standard Proctor.

#### F. Reinforced Fill

- 1) Reinforced Fill may not be required as indicated in the Construction Documents.
- 2) Reinforced Fill shall be placed behind the SRW Units or Drainage Fill with a maximum lift thickness of 150 mm (6 inches) and compacted to a minimum density of 95% Standard Proctor Maximum Dry Density (ASTM D698) at a moisture content from 2% below to 2% above optimum.
- 3) The Reinforced Fill shall be placed and compacted level with the top of the SRW Units at the specified Geosynthetic Reinforcement elevations to ensure no voids exist under the Geosynthetic Reinforcement as it extends out over the Reinforced Fill.
- 4) Care shall be taken to ensure that the Geosynthetic Reinforcement lays flat and taut during placement of the Reinforced Fill. This is best achieved by placing the Reinforced Fill on top of the Geosynthetic Reinforcement near the SRW facia and spreading toward the back of the Reinforced Fill.
- 5) At the end of each day's operation, slope the last lift of Reinforced Fill away from the SRW facing to rapidly direct runoff away from the SRW facia. Do not allow surface runoff from adjacent areas to enter the SRW construction area.

#### G. Geosynthetic Reinforcement

- 1) Geosynthetic Reinforcement may not be required as indicated in the Construction Documents.
- 2) Verify type and primary strength direction of the Geosynthetic Reinforcement.
- 3) Cut Geosynthetic Reinforcement in sheets to the length shown in the Construction Documents.
- 4) Geosynthetic Reinforcement sheets shall be placed horizontally with the primary strength direction perpendicular to the SRW face, at the elevations shown in the Construction Documents. The sheets are to be placed adjacent to one another, without overlapping and without gaps between them.

**Note:** Ensure the strong (machine) direction of the Geosynthetic Reinforcement is placed perpendicular to the SRW facing. Do not roll Geosynthetic Reinforcement out along the length of the SRW (parallel).

- 5) Sweep the top of the SRW Units to ensure the SRW Units are clean and free of debris.
- 6) The Geosynthetic Reinforcement shall be placed over the compacted Reinforced Fill and the SRW Units with the outside edge extending over the shear key of the SRW Unit to within 25 mm (1 in.) of the front facing unit.

- 7) The next course of SRW Units shall be carefully placed on top of the lower course to ensure that no pieces of concrete are chipped off and become lodged between courses and the Geosynthetic Reinforcement is in complete contact with the top and bottom surfaces of the successive SRW courses.
  - 8) With the Geosynthetic Reinforcement secured in place, the Geosynthetic Reinforcement shall be pulled taut away from the back the SRW Units during placement of Reinforced Fill. Alternatively, suitable anchoring pins or staples can be used to ensure that there are no wrinkles or slackness prior to placement of the Reinforced Fill. The Geosynthetic Reinforcement shall lay flat when pulled back perpendicular to the back of the SRW facia.
  - 9) No construction equipment shall be allowed to operate directly on top of the Geosynthetic Reinforcement until a minimum thickness of 150 mm (6 inches) of fill has been placed. Equipment may drive on Reinforced Fill at slow speeds and should exercise care not to stop suddenly or make sharp turns. No heavy equipment shall be allowed within 1 metre (3 ft.) of the back of the SRW Units.
- H. Retained Fill
- 1) Retained Fill may not be required as indicated in the Construction Documents.
  - 2) Retained Fill shall be placed and compacted behind the Reinforced Fill or Drainage Fill in Conventional SRW applications, in maximum lift thickness of 150 mm (6 inches).
- I. Continuing Wall Construction
- 1) Repeat section 3.04.D through to 3.04.H until the grades indicated in the Construction Documents are achieved.
- J. Secure Coping
- 1) The Coping Adhesive may not be required as indicated in the Construction Documents.
  - 2) Coping units shall be secured to the top of the SRW with two 10 mm (3/8 inch) beads of Concrete Adhesive positioned 50mm (2 inches) in front and behind the tongue of the last course of SRW units.
- K. Finishing SRW
- 1) Finish grading above the SRW to direct surface runoff water away from the SRW. A swale system must be used above the SRW if the grade slopes toward the back of the wall. Construct the swale with the materials and to the dimensions specified in the Construction Documents. Final grading must be established immediately to ensure the Reinforced Fill is protected from water infiltration.
  - 2) Upon completion of the SRW, additional structures (fences, handrails, vehicular guardrails, buildings, pools/ponds, etc.) or changes to grading/loading (increased height, slopes, parking areas, changes in proximity to water flow, etc.), other than those shown in the Construction Documents, can not be installed/implemented without the review and consent of the General Review Engineer who will typically have to consult the Designer.
  - 3) If the Installer is not responsible for the final landscaping and grading above or around the SRW, the Installer must ensure the firm who is responsible for the final landscaping and grading understands the SRW's limitations with respect to allowable depth of topsoil, excavation behind the SRW for planting, offset for heavy equipment and allowable surcharge. This also extends to firms who will be responsible for installations like handrails, fences, and signs that will apply additional loads to the SRW and will impact the SRW's performance.