

SECTION 02832 CONCRETE SEGMENTAL RETAINING WALL

Notes: This guide specification is for concrete segmental retaining wall applications in Canada that are designed as gravity walls; there is a similar specification for geogrid reinforced retaining walls.

Some editing may be required to suit specific project requirements.

This Section includes the terms "General Contractor", "Owner" and "Owner's Representative" - edit these terms as necessary to correspond to the individuals listed in the General Conditions of the Contract.

PART 1 GENERAL

1.01 SUMMARY

A. Description:

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

1. Design, inspection and certification of installation by a professional engineer.
2. Excavation and removal of native materials.
3. Foundation soil preparation.
4. Furnishing and placement of the leveling base.
5. Furnishing and placement of the drainage system.
6. Furnishing and placement of geotextiles.
7. Furnishing and placement of segmental retaining wall facing and coping units.
8. Furnishing and placement of restoration materials.

B. Definitions:

1. Coping units are the last course of concrete units used to finish the top of the retaining wall.
2. Design Engineer shall refer to the individuals or firms who have been retained by the General Contractor to provide design, inspection and certification services for the retaining wall. The Engineer(s) must be qualified in the area of segmental retaining wall design and construction and must be licensed to practice engineering in the Province that the wall is to be constructed.
3. Drainage aggregate is a free draining soil with natural soil filtering capabilities, or a free draining soil encapsulated in a suitable geotextile, or a combination of free draining soil and perforated pipe all wrapped in a geotextile, placed directly behind the modular concrete units.
4. Drainage pipe is a perforated pipe used to carry water, collected at the base of the retaining wall, to outlets in order to prevent pore water pressures from building up behind the wall facing modules.
5. Foundation soil is the in-situ soil beneath the wall structure.
6. Installer shall refer to the individual or firm who will be constructing the Segmental Retaining Wall including drainage system.
7. Leveling base is a layer of specified soil that is placed below the proposed wall to provide a level working surface.
8. Non-woven geotextiles are permeable synthetic fabrics formed from a random arrangement of fibers in a planar structure. They allow the passage of water from one soil medium to another while preventing the migration of fine particles that might clog a drainage medium.

9. Retained soil is the in-situ soil, or a specified replacement / infill soil, that is placed behind the wall drainage material.
10. Segmental retaining wall units are dry-cast solid concrete modular units that form the external facia of the retaining wall system.

C. Related Sections:

1. Section 02072 – Geotextiles
2. Section 02315 – Excavation, Trenching and Backfilling
3. Section 02600 – Drainage and Containment

1.02 REFERENCE STANDARDS

A. Ontario Provincial Standard Specifications (OPSS)

1. OPSS 1010, Aggregates – Granular A, B, M and Select Subgrade Materials

B. American Society for Testing and Materials (ASTM):

1. ASTM C131, Test Method for Resistance to Degradation of Small Size Course Aggregates by Abrasion and Impacts in the Los Angeles Machine
2. ASTM C 140, Sampling and Testing Concrete Masonry Units
3. ASTM C 979, Standard Specification for Pigments for Integrally Colored Concrete.
4. ASTM C 1372, Standard Specifications for Segmental Retaining Wall Units
5. ASTM D 698, Standard Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,000 ft-lbf/ft³ (600 kN-m/m³)).

C. National Concrete Masonry Association (NCMA):

1. NCMA Design Manual for Segmental Retaining Walls, Second Edition.
2. NCMA TEK 2-4 - Specifications for Segmental Retaining Wall Units.
3. NCMA SRWU-2 - Determination of Shear Strength between Segmental Concrete Units.

1.03 MATERIAL SUBMITTALS

A. The General Contractor shall submit the following items for approval in accordance with the Conditions of the Contract and the Division 1 Submittal Procedures Section.

1. Design Submittal – Provide three (3) sets of stamped construction drawings and detailed design calculations, prepared by the Design Engineer in accordance with Section 3.01 of this specification.
2. Installer Certification – Provide the following:
 - a. Demonstration that the Installer’s field construction supervisor has the necessary experience for this project by providing documentation showing that they have successfully completed projects of similar design, material and extent.
 - b. Job references from projects of a similar size and complexity. Provide Owner/Client/General Contractor names, postal address, phone, fax, and email address.
 - c. A letter from the Installer verifying that the field construction supervisor will be onsite throughout the installation.
3. Material Certification – Manufacturer’s certification, for each of the following materials, stating that each meet the requirements of this specification and the Design Engineer’s design:
 - a. Segmental Retaining Wall Units
 - b. Drainage aggregate
 - c. Leveling base aggregate
 - d. Imported retained soil (if specified)
 Test results must be from an independent testing laboratory.
4. Samples – Two representative samples of each segmental retaining wall type and colour. Ensure that the samples indicate the range of colour variation expected in the finished installation.

5. Supporting documentation - Manufacturer's catalog, product data, installation instructions, and material safety data sheets for the specified materials and products.
- B. Accepted samples become the standard of acceptance for the work.

1.04 REGULATORY REQUIREMENTS

- A. Regulatory Requirements and Approvals: [Specify applicable licensing, bonding or other requirements of regulatory agencies].

1.05 DELIVERY, ON-SITE HANDLING & STORAGE

- A. General:
1. Comply with Division 1 Product Requirement Section.
 2. Comply with manufacturer's ordering instructions and lead-time requirements to avoid construction delays.
- B. Delivery:
1. Coordinate delivery and installation schedule to minimize interference with normal use of buildings, roads and structures adjacent to project.
 2. Deliver segmental retaining wall units, geotextile and drainage piping in manufacturer's original, unopened, undamaged packaging with identification labels intact.
 3. At a minimum, deliver segmental retaining wall units to the site in steel banded, plastic banded or plastic wrapped cubes capable of transfer by a clamp lift. General Contractor or Installer to notify manufacturer at the time of order if pallets are required with the cubes to accommodate onsite handling by a forklift.
 4. Unload materials at job site in the location designated by the Installer and in such a manner that no damage occurs to the product or the site
 5. Leveling base aggregate, drainage aggregate and imported retained soil piles to be kept sufficiently separated as to prevent mixing.
 6. The Installer shall check all materials delivered to the site to ensure that the correct materials have been received and are in good condition prior to signing off on the manufacturer's packing slip.
- C. On-site Handling and Storage:
1. Installer shall handle and store materials in accordance with manufacturer's recommendations.
 2. Store materials in a manner to prevent deterioration or damage due to moisture, temperature changes, contamination, breaking, chipping or other causes.
 3. Storage areas to be kept free from mud, dirt, and other foreign materials.

1.06 MEASUREMENT FOR PAYMENT

- A. Payment for earthwork to prepare the site for the retaining wall construction will be based on the contract unit price per cubic metre for site cut and fill earthwork as measured in the field by the Owner or Owner's Representative. Surveys shall be conducted by the Owner or Owner's Representative prior to, and after, the excavation to calculate the total excavated volume, with the survey results being binding. The contract unit price shall include the cost of all engineering, labour, materials, and equipment used to excavate and dispose of the excavated material. Additional earthwork as directed and approved in writing by the Owner or Owner's representative shall be paid for under a separate pay item
- B. Payment for the supply and placement of the retaining wall system will be based on the contract unit price per square metre of vertical wall face area based on onsite measurements. The vertical wall face shall be calculated by multiplying the measured distance from the top of the leveling base to the top of the coping course by the length of the wall. The measurements shall be conducted by the Owner or Owner's Representative, with the measurement results being binding. The contract unit price shall include the cost of all engineering, labour, materials, and equipment used to install the leveling base, drainage system, geotextile, segmental retaining wall facing and

coping units, and restoration materials. Additional items as directed and approved in writing by the Owner or Owner's representative shall be paid for under a separate pay item.

PART 2 PRODUCTS

2.01 SEGMENTAL RETAINING WALL UNITS

- A. Segmental Retaining Wall System as manufactured by Brown's Concrete Products Limited to ASTM C1372, as tested in accordance with ASTM C140, of the following nature.
 - 1. Product line: Parkwall / Parkwall Classic / Pisa Light.
 - 2. Colour: Autumn Range / Blackwood Range / Brown / Charcoal / Granite / Laurentian Range / Robinson Range / Sandstone / Timmins Range.
 - 3. Colour Pigment Material Standard: Comply with ASTM C 979.

2.02 RETAINED SOIL

- A. The retained soil shall be on-site soil unless specified otherwise in the Construction Specifications or directed by the Owner or Owner's Representative. If imported fill is required, it shall be examined and approved by the Design Engineer to ensure that it meets or exceeds the assumed design conditions prior to use.

2.03 FOUNDATION SOIL

- A. The foundation soil shall be native undisturbed on-site soils. The foundation soil shall be examined and approved by the Design Engineer, prior to placement of the leveling base, to ensure that it meets or exceeds the assumed design conditions.
- B. Where the foundation soil does not meet the design conditions, the unacceptable material will be removed and replaced with acceptable material.

2.04 LEVELLING BASE AGGREGATE

- A. Leveling base aggregate to be composed of inert, clean, tough and durable particles of natural or crushed rock capable of withstanding the deleterious effects of exposure to water, freeze-thaw, handling and spreading.
- B. The material to be capable of compacting to the specified density.
- C. Aggregate shall have a percentage of wear, by the Los Angeles test (ASTM C 131), of not more than 50.
- D. The aggregate particles shall be uniform in quality, free from excess of flat and elongated particles.
- E. The particles shall have a gradation falling within the standard limits for Granular A as outlined in MTO OPSS 1010 unless otherwise specified by the Design Engineer.
- F. The material to capable of compacting to specified density.

2.05 DRAINAGE AGGREGATE

- A. Drainage aggregate to be composed of inert, clean, tough and durable particles of natural or crushed rock capable of withstanding the deleterious effects of exposure to water, freeze-thaw, handling and spreading.
- B. Aggregate shall have a percentage of wear, by the Los Angeles test (ASTM C 131), of not more than 50.
- C. The aggregate particles shall be uniform in quality, free from excess of flat and elongated particles.
- D. The particles shall have a gradation falling within the standard limits for Granular A as outlined in MTO OPSS 1010 unless otherwise specified by the Design Engineer.
- E. The material to capable of compacting to specified density.
- F. The saturated hydraulic conductivity of the aggregate must exceed 0.1 m/s.

2.06 DRAINAGE PIPE

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

2.07 GEOTEXTILE

- A. The non-woven geotextile shall be installed as specified on the construction drawings. Although selection of the appropriate geotextile specifications is site soil specific, a commonly used geotextile for filtration will have an Apparent Opening Size ranging between 0.149 and 0.210 mm (U.S. Sieve Sizes 100 to 70) and a minimum unit weight of 135 grams per square meter (5.0 oz /square yard). The coefficient of permeability will typically range between 0.1 and 0.3 cm/second.

PART 3 EXECUTION

3.01 WALL DESIGN

- A. The Design Engineer is responsible for providing a design that shall consider, at a minimum, all of the following:
 1. Retained and foundation soil conditions (unit weight, friction angle, cohesion).
 2. Slopes above and below the wall.
 3. Surcharges (live and dead) above the wall.
 4. Surface water drainage above and below the wall.
 5. Subsurface high water table, and potential associated hydrostatic pressures
 6. Seismic design requirements.
 7. Potential total and differential settlement.
 8. The desired setback of the wall.
 9. Cut and fill volumes.
 10. Applicable government regulations.
- B. The segmental retaining wall shall be designed in accordance with recommendations of the NCMA Design Manual for Segmental Retaining Walls, Second Edition. The following is a summary of the minimum factors of safety for the various modes of failure evaluated in the proposed design.

<u>External Stability</u>	
Base Sliding	1.5
Overturning	1.5
Bearing Capacity	2.0
Global Stability	1.3

<u>Internal Stability</u>	
Shear Capacity	1.5

- C. The design life of the structure shall be 75 years unless otherwise specified in the construction drawings.
- D. The length, height, overall elevations and layout of the retaining wall must comply with the requirements of the proposed elevation detail, station information and site grading plan.
- E. The minimum wall embedment shall be the greater of:
 - 1) the height of a SRW unit,
 - 2) 150 mm (0.5 ft) or
 - 3) the minimum embedment required because of the slope below the wall:

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

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

- F. The following surcharges shall be applied to the top of each design cross section based on the following proposed uses above the wall.
- | | |
|----------------|--------------------------|
| Use Above Wall | Minimum Surcharge |
| No Traffic | 0 kPa (0 lb/sq. ft) |
| Light Traffic | 4.8 kPa (100 lb/sq. ft) |
| Heavy Traffic | 12.0 kPa (250 lb/sq. ft) |
- G. The lateral earth pressure to be resisted by the self weight of the retaining wall shall be calculated using the Coulomb coefficient of earth pressure, K_a , times the vertical stress at the base of the wall. The coefficient of active earth pressure, K_a , shall be used from the top to the bottom of the wall. The coefficient of active earth pressure, K_a , shall be assumed independent of all external loads except sloping fills. For sloping fills, the coefficient of active earth pressure, K_a , appropriate for the sloping condition, using Coulomb earth pressure shall be used in the analysis.

3.02 ACCEPTABLE INSTALLERS

- A. Pre-approved installers include:
1. **Insert list**
- B. The Owner or Owner's Representative reserves the right to add additional Installers to the pre-approved list subject to the submission by the Installer, and approval by the Owner or Owner's Representative, of the submittals listed in Section 1.03 of this specification.

3.03 EXAMINATION

- A. The Design Engineer shall inspect, accept and certify in writing to the Installer that site conditions meet the specifications for the following items at the indicated time:
1. Prior to commencing construction:
 - a. That the site conditions, insitu soil, and geometric conditions are compatible with the designed wall.
 2. Prior to placement of leveling base:
 - a. That the depth of the excavation conforms to the elevations specified on the Design Drawings.
 - b. That the native soil slope at the back of the excavation is stable.
 - c. That any unacceptable native foundation soil was removed and replace with acceptable fill, and that the foundation soils were compacted to at least 98% standard Proctor density per ASTM D 698.
- B. Prior to construction, the Installer is to satisfy himself with the presence, location, type and elevations of buildings, roads, utility structures, drainage routes and other appurtenances in the general vicinity of the construction area.

3.04 EXCAVATION

- A. The foundation soil shall be excavated or filled as required to the grades and dimensions shown on the Construction Drawings or as directed by the Owner or Owner's Representative.
- B. The foundation soil shall be proof rolled and examined by the Design Engineer to ensure that it meets the minimum strength requirements according to the design assumptions. If unacceptable foundation soil is encountered, the contractor shall excavate the affected areas and replace with suitable quality material under the direction of the Design Engineer.
- C. In cut situations, the native soil shall be excavated to the lines and grades shown on the Construction Drawings and removed from the site or stockpiled for reuse as retained soil.

3.05 LEVELING BASE PLACEMENT

- A. The minimum thickness of the leveling base shall be 150 mm (6 inches).
- B. The leveling base shall extend a minimum of 150 mm (6 inches) from the front, and 300 mm (12 inches) from the back, of the proposed wall.
- C. The material shall be compacted to 98% Standard Proctor Density.

- D. If required, a layer of up to 50 mm (2 inches) of unreinforced concrete may be placed on top of the granular material to provide a durable leveling surface.

3.06 PLACING GEOTEXTILE

- A. Pre cut the geotextile so that the lengths are sufficiently long to be set against the back of the first retaining wall unit, run over the prepared foundation, extend towards the back of the excavation, run up the excavation face and overlap back over the top of the drainage material to the retaining wall, or as shown in the Construction Drawings.
- B. Geotextile overlaps shall be a minimum of 300 mm (1 ft.) and shall be shingled down the face of the excavation in order to prevent the infiltration of retained soil into the drainage layer.
- C. Start installation by laying the geotextile along the bottom of the excavation, allowing some extra material to be set against the back of the first retaining wall unit when installed. Then run the lengths up the back of the exposed cut face and stake against the slope during construction.
- D. When the wall has reached the design grade, fold the excess geotextile over the top of the infill zone and extend up the back face of the coping unit.

3.07 INSTALLATION OF DRAINAGE SYSTEM

- A. The drainage pipe shall be placed behind the leveling base, or lower course of facing units, as shown in the Construction Drawings or as directed by the Design Engineer.
- B. The pipe shall be laid at a minimum gradient of 2% to ensure adequate drainage to free outlets. Removal of some of the leveling base to create a sloped trough into which to place the drainage pipe is permitted.
- C. T - Sections and outlet pipes shall be installed on the drainage pipe at 15 m (50 ft.) centers or as shown on the Construction Drawings.

3.08 INSTALLATION OF SEGMENTAL RETAINING WALL UNITS

- A. The bottom row of retaining wall modules shall be placed on the prepared leveling base as shown on the Construction Drawings. Care shall be taken to ensure that the wall modules are aligned properly, leveled from side to side and front to back and are in complete contact with the base material.
- B. The wall modules above the bottom course shall be placed such that the tongue and groove arrangement provides the design batter (i.e. setback) of the wall face. Successive courses shall be placed to create a running bond pattern with the edge of all units being approximately aligned with the middle of the unit in the course below it.
- C. The wall modules shall be swept clean before placing additional levels to ensure that no dirt, concrete or other foreign materials become lodged between successive lifts of the wall modules.
- D. It is recommended that the drainage material be installed behind each completed course as the wall progresses to allow for easier correction of wall movement should it occur during compaction.
- E. The contractor shall check the level of wall modules with each lift to ensure that no gaps are formed between successive lifts.
- F. Care shall be taken to ensure that the wall are not broken or damaged during handling and placement.

3.09 INSTALLATION OF DRAINAGE SOIL

- A. The drainage soil will be placed behind the retaining wall modules with a minimum width of 300mm (1 ft.) and separated from other soils using the approved non-woven geotextile.
- B. Drainage soil shall be placed behind the wall facing in maximum lifts of 6 inches and compacted to a minimum density of 95% Standard Proctor.
- C. No heavy compaction equipment shall be allowed within 1 metre (3 ft.) of the back of the wall facia.

3.10 INSTALLATION OF RETAINED SOIL

- A. Retained soils shall be placed and compacted behind the drainage material in maximum lift thickness of 150 mm (6 inches). The retained soils shall be undisturbed native material or engineered fill compacted to a minimum density of 95% Standard Proctor.
- B. No heavy compaction equipment shall be allowed within 1 m (3 ft.) of the back of the wall modules.

3.11 WALL COMPLETION

- A. Coping units shall be secured to the top of the wall with two 10mm (3/8 inch) beads of the approved flexible concrete adhesive positioned 50mm (2 inches) in front and behind the tongue of the last course of retaining wall units.
- B. Complete the geogrid installation as outlined in Section 3.06 of these specifications.
- C. Finish grading above the wall to direct surface run off water away from the segmental retaining wall. Use a soil with a low permeability to restrict the rate of water infiltration into the retaining wall structure.

3.12 FIELD QUALITY CONTROL

- A. Over the course of the project, the Design Engineer is to inspect the site conditions, materials incorporated into the retaining wall, and the construction practices to ensure they meet the requirements of the specifications.

3.13 FINAL INSPECTION

- A. At the completion of the project, the Design Engineer shall provide the General Contractor with a letter certifying the design meets the requirements of this specification, the design was compatible with the site, and the wall was constructed according to the design and within acceptable tolerances.
- B. The following tolerances are the maximum allowable deviation from the planned construction,
 - 1. Vertical Control: +/- 32 mm over a 3 m distance, +/- 75 mm total
 - 2. Horizontal Control: +/- 32 mm over a 3 m distance, +/- 75 mm total
 - 3. Rotation: +/- 2 degrees from planned wall batter
 - 4. Bulging: 25 mm over a 3 m distance

3.14 PROTECTION

- A. During installation, the Installer is responsible for taking whatever actions are required to protect the work from damage.
- B. After work in this section has been approved by the Engineer, the General Contractor shall be responsible for protecting work from damage due to subsequent construction activity on the site.

END OF SECTION