

Segmental Concrete Retaining Walls

This guide specification has been prepared by Oaks Concrete Products to assist design professionals in the preparation of a specification section covering segmental concrete retaining walls constructed using stabilized backfill.

PART 1—GENERAL

1.01 Summary

- A. Work shall consist of furnishing all materials, labour, equipment and supervision for construction of a Segmental Concrete Retaining Wall (SCRW) System using stabilized backfill in accordance with these specifications and in reasonably close conformity with the lines, grades, design, and dimensions shown on the drawings or as established by the Owner.

1.02 Related Sections

- A. Section 03 30 00 Cast-in-Place Concrete
- B. Section 31 00 00 Earthwork
- C. Section 32 31 00 Site Improvements, Fences and Gates

1.03 Reference Documents

- A. General: Where specifications and reference documents conflict, the Owner and design engineer will make the final determination of the applicable document.
- B. Design
 - 1. AASHTO *Standard Specification for Highway Bridges*;
 - 2. CSA A23.3-14 *Design of Concrete Structures*;
 - 3. CSA A23.4-09 *Precast Concrete – Materials and Construction*;
 - 4. FHWA NHI-00-043 *Mechanically Stabilized Earth Walls and Reinforced Soil Slopes Design and Construction Guidelines*;
 - 5. FHWA NHI-00-044 *Corrosion/Degradation of Soil Reinforcements for Mechanically Stabilized Earth Walls and Reinforced Soil Slopes*;
 - 6. *International Building Code* (latest edition); and,
 - 7. National Concrete Masonry Association's (NCMA) *Design Manual for Segmental Retaining Walls, 3rd Edition*.
- C. Segmental Concrete Units
 - 1. ASTM C-140 Test Method for Sampling and Testing Concrete Masonry Units and Related Units;
 - 2. ASTM C-1262 Standard Test Method for Evaluating the Freeze Thaw Durability of Dry-Cast Segmental Retaining Wall Units and Related Concrete Units;
 - 3. ASTM C-1372 Specification for Dry- Cast Segmental Retaining Wall Units;
 - 4. ASTM D-6638 Connection Strength Between Geosynthetic Reinforcement and Segmental Concrete Units (Modular Concrete Blocks); and,
 - 5. ASTM D-6916 Shear Strength Between Segmental Concrete Units (Modular Concrete Blocks).

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D. Cementitious Materials

1. ASTM C-33 Standard Specifications for Concrete Aggregates;
2. ASTM C-150 Standard Specifications for Portland Cement;
3. ASTM C-494 Standard Specifications for Admixtures in Concrete
4. ASTM C-618 Standard Specifications for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete
5. ASTM C-989 Standard Specifications for Slag Cement for Use in Cement and Mortars
6. ASTM C-1157 Standard Performance Specifications for Hydraulic Cement;
7. CSA A23.1-FA1 Concrete Materials and Methods of Concrete Construction

E. Soils

1. AASHTO T-104 Standard Method of Test for Soundness of Aggregate by Use of Sodium Sulfate or Magnesium Sulfate;
2. AASHTO T-267 Standard Method of Test for Determination of Organic Content in Soils by Loss of Ignition;
3. AASHTO T-289 Determining pH of Soil for Use in Corrosion Testing;
4. ASTM D-442 Test Method for Particle Size Analysis of Soils;
5. ASTM D-698 Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort;
6. ASTM D-2487 Test Method for Classification of Soils for Engineering Purposes (Unified Soil Classification System);
7. ASTM D-4318 Standard Test Method for Liquid Limit, Plastic Limit and Plasticity Index of Soils; and,
8. ASTM D-4972 Standard Test Method for pH of Soils.
9. ASTM D-5084 Standard Test Method for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter.
10. CSA A23.2 Sieve Analysis of Fine and Course Grained Aggregates

F. Drainage Pipe

1. ASTM D-1248 Standard Specifications for Polyethylene Plastics Molding and Extrusion;
2. ASTM D-3034 Standard Specification for Type PSM Poly Vinyl Chloride (PVC) Sewer Pipe and Fittings; and,

G. Where conflict exists between reference standards, the contractor shall obtain clarification from the engineer prior to proceeding with the work. Applicable CSA standards will prevail wherever ANSI or ASTM specifications conflict with CSA standards.

1.04 Definitions

- A. Compacted Native Backfill – compacted native soil, or designated alternative, which is used as backfill between the SCRW and Retained Soil.
- B. Foundation Soil – compacted native soil that supports the Levelling Pad, Structural Backfill and Compacted Native Backfill.

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- C. Levelling Pad – A level surface, consisting of crushed stone or unreinforced concrete, which distributes the weight of the Segmental Concrete Units over a wider area of the Foundation Soil and provides a working surface during construction.
- D. Low Permeability Soil – compacted layer of soil above the Structural Backfill and Compacted Native Backfill to prevent surface water infiltration.
- E. Retained Soil – the undisturbed soil behind the SCRW.
- F. Segmental Concrete Units –precast concrete retaining wall elements machine made from Portland cement, water, and aggregates that contributes to the mass necessary for structural stability of the SCRW, and serves as the wall facing.
- G. Separation Geotextile - A geotextile filter installed between the SCRW and the Compacted Native Backfill or Retained Soil to protect the Subsurface Drainage System from clogging. Also required below the Low Permeability Soils (where used).
- H. Stabilized Backfill – A formulated mix design of clear stone, cement and water that creates a permeable homogeneous zone (mass) when placed behind the Segmental Concrete Units. Used to facilitate the removal of incidental groundwater, minimize build-up of hydrostatic pressure, and increase the weight and sheer capacity of the system.
- I. Subsurface Drainage System – horizontal pipe at or near the base of Structural Backfill to facilitate water drainage.

1.05 Submittals

- A. Product Data: At the time of bid, the General Contractor shall submit technical specifications and product data from the manufacturers for the following:
 - 1. Stabilized Backfill
 - 2. Segmental Concrete Units
 - 3. Separation Geotextile
 - 4. Subsurface Drainage Pipe
- B. Design Submittals:
 - 1. If Owner furnishes construction drawings for the SCRW, no design submittal is required by the General Contractor.
 - 2. If the General Contractor is to furnish construction drawings for the SCRW, three (3) sets of drawings and design calculations shall be submitted to the Owner at least 45 days prior to construction for review and approval. The drawings and design calculations shall be prepared and stamped by a Professional Engineer registered in the province or state of construction that is experienced in SCRW design (the Design Engineer), and shall include the following:
 - (a) Wall Plan (top view of construction area), including the grading at the top and bottom of the wall, geometry for corners and curved wall lengths, the proximity of any existing or proposed surcharges, structures or utilities that may affect wall construction or performance, and all discharge points for the Subsurface Drainage System.

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- (b) Wall Profile (front view of the wall), including the physical elevations of the top and bottom of the structure to be retained, depth of the buried section of the wall, and the elevation of the Subsurface Drainage System.
 - (c) Sufficient Wall Cross Sections to adequately cover the variation of design heights encountered along the length of the wall. Cross sections to include the thickness (as measured from the back of the Segmental Concrete Units) of the Stabilized Backfill, depth of the buried section of the wall, and details on how and where sleeves are to be installed behind the wall (in particular if within the Stabilized Backfill) for fences, traffic barriers or other similar items.
 - (d) Copies of any geotechnical investigation reports and/or laboratory soil testing data used in the design.
 - (e) A summary of the design criteria used for Internal Stability, External Stability, compound stability, global stability, hydrostatic loading, seismic loading, rapid drawdown, surcharge, and backslopes where appropriate.
 - (f) Recommended gradations for the materials used in the Levelling Pad, Low Permeability Soil (where required) and designated alternative for the Compacted Native Backfill (where required).
- C. Samples:
- 1. A minimum of 30 days prior to construction, the General Contractor shall submit to the Owner for approval, and retain for the balance of the project:
 - (a) A minimum of four sample Segmental Concrete Units that represent the range of texture and color permitted.
 - (b) Samples and laboratory test results of the native soil, if proposed for use in the Compacted Native Backfill, for approval.
 - 2. A minimum of 10 days prior to construction, the General Contractor shall submit to the Owner, for verification:
 - (a) Separation Geotextile – nominal 150mm by 250mm sample of each type required.
 - (b) Subsurface Drainage Pipe – nominal 150mm length of each type required.
 - (c) Levelling Pad materials – 5 kg sample and source pile gradation analysis as tested in accordance with CSA A23.2 [ASTM D-442].
 - (d) Reinforced Soil Zone materials (where imported and required) – 5 kg sample and source pile gradation analysis as tested in accordance with CSA A23.2 [ASTM D-442].
 - (e) Alternative to Compacted Native Backfill (when imported) – 5 kg sample and source pile gradation analysis as tested in accordance with CSA A23.2 [ASTM D-442].
 - (f) Low Permeability Soil materials (where required) – 5 kg sample and source pile gradation analysis as tested in accordance with CSA A23.2 [ASTM D-442].

1.06 Installer Qualifications

- A. Installer Experience: The SCRW Contractor shall provide proof of experience:

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1. Construction of no less than 50,000 square metres total face area of SCRW structures during the preceding five years;
 2. Construction experience with a minimum 10,000 square metres of SCRW structures with the proposed Segmental Concrete Units product, or similar; and,
 3. Construction of five (5) SCRW structures with heights that are comparable (within 1.2 metres) to that proposed.
- B. Experience documentation from the SCRW Contractor shall include:
1. Project name and location
 2. Date of construction
 3. Contact information of Owner or General Contractor
 4. Type of Segmental Retaining Wall product used.
 5. Face area of the structure
- C. Installer shall be a Licensed Contractor in the province or state where the project is located.

1.07 Quality Assurance

- A. The Owner shall appoint, at its cost, an Inspection Engineer who is a registered Professional Engineer and who is experienced with the construction of SCRW structures to perform inspections and testing.
- B. The Inspection Engineer shall perform the following:
1. Inspect the construction of the SCRW structure for conformance with construction drawings and the requirements of this section;
 2. Insure the excavation slopes are bench cut;
 3. Verify Foundation Soil and Retained Soil exhibit the shear strengths specified in the design drawings;
 4. Verify native soil, when proposed for use in the Compacted Native Backfill conforms to these specifications or as specified in the construction drawings;
 5. Compare imported soils to the corresponding samples previously provided, and obtain (at the General Contractors expense) additional test results to verify compliance as required;
 6. Verify the composition of the Stabilized Backfill, in particular the aggregate size, type of cements used, and open space, and obtain (at the General Contractors expense) additional test results to verify compliance as required;
 7. Inspect and document soil compaction in accordance with these specifications.
 8. Notify the SRW Installer of deficiencies and provide the SRW Installer with the opportunity to repair;
 9. Notify General Contractor and Owner of any deficiencies that has not been properly corrected; and,
 10. Document inspection results.
- C. Owner's quality assurance program does not relieve the General Contractor of responsibility for quality control and wall performance.

1.08 Delivery, Storage and Handling

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- A. SCRW Contractor shall check all materials upon delivery to assure that the proper type, grade, color, and certification have been received.
- B. SCRW Contractor shall store and handle all materials in accordance with manufacturer's recommendations, as specified herein, and in a manner that prevents deterioration or damage due to moisture, temperature change, contaminants, corrosion, breaking, chipping, UV exposure or other causes. Store above ground on wood pallets or blocking.
- C. Keep Segmental Concrete Units and Subsurface Drainage Piping off any unpaved surface using wood pallets or blocking.
- D. Stockpile aggregates on hard surfaces or geotextile to prevent contamination from site soils and sediment.
- E. SCRW Contractor shall protect the materials from damage.
- F. Separation Geotextile shall be delivered, stored and handled in accordance with ASTM D-4873.
- G. Deteriorated, damaged or contaminated materials shall not be incorporated into the work.

1.09 Site Safety

- A. Occupational Health and Safety Regulations for Construction Projects are applicable to all site works.
- B. General Contractor to ensure for any wall over 600 mm that the required railing, fence or barrier is in place prior to allowing public access to the area around the completed SCRW. Railing, fence or barrier shall meet *Section 32 31 01 – Site Improvements, Fences and Gates* in addition to any regulatory authorities having jurisdiction, or architectural requirements, unless otherwise indicated on the drawings.

PART 2 – PRODUCTS

2.01 Segmental Concrete Units

- A. This section includes wall, cap, corner, and step units available as part of the selected Segmental Concrete Unit system and shown on the drawings.
- B. Segmental Concrete Unit system shall be:
 - 1. Product – Vertica™ Wall System.
 - 2. Colour – Greyfield; Natural; Timberwood.
- C. Segmental Concrete Units shall conform to the requirements of ASTM C-1372, including:
 - 1. 28-day Compressive Strength: Minimum for an individual unit of 17.2 MPa (2,500 psi), and minimum average for three units of 20.7 MPa (3,000 psi), when tested in accordance with ASTM C-140;
 - 2. Freeze-Thaw Durability: weight loss of each of five test specimens at the conclusion of 100 cycles shall not exceed 1% of its initial weight when tested in accordance with ASTM C-1262 using tap water.
 - 3. Dimensional tolerances: Overall dimensions for width, height and length shall not differ by more than 3.2 mm (1/8 in.) from the specified standard dimensions. Dimensional tolerance requirements for width shall be waived for architectural surfaces.

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4. Appearance: All units shall be sound and free of cracks or other defects that interfere with the proper placement of the unit or significantly impair the strength or permanence of the construction. Minor cracks incidental to the usual method of manufacture or minor chipping resulting from customary methods of handling in shipment and delivery, are not grounds for rejection. Exposed surfaces of units shall not show chips or cracks, or other major imperfections, when viewed from a distance of not less than 6.1 m (20 feet) under diffused lighting.
- D. Inter unit shear strength properties between Segmental Concrete Units shall be evaluated in accordance with ASTM D-6916 (NCMA SRWU-2).
- E. General Contractor shall verify approval of submitted technical specifications, product data, samples and test results per Section 1.05 herein with the Owner prior to the installation.

2.02 Structural Backfill

- A. Structural backfill shall be cast-in-place cementitious material meeting the following requirements:
 1. Water-cementitious materials ratio by weight: 0.3 – 0.5
 2. Aggregate-cementitious materials ratio by weight: 4.5 – 6:0:1
 3. Minimum design target unit weight (in place) of 1,800 kg per cubic metre (112 pcf).
 4. Air voids: 15-20%
 5. 50:50 blend by weight of Type 1 Portland Cement and Fly Ash or Slag.
- B. Cementitious material shall be comprised of:
 1. Hydraulic cement satisfying ASTM C-150 or ASTM C-1157.
 2. Fly ash satisfying ASTM C-618.
 3. Slag satisfying ASTM C-989
 4. Normal weigh aggregate comprised entirely of washed, sharp, durable stone between 9.5 and 19.0 mm (3/8 and ¾ in) - #6 stone as defined in ASTM C-33.
 5. Potable water
 6. Water reducers, accelerating and retarding admixtures satisfying ASTM C-494.
Admixtures without a standard designation shall be used only with the permission of the Design Engineer and only when it is used for specific properties.
- C. Where Sulfate Resistant cement is required due to the native soil conditions, use Type II or Type V Portland Cement.

2.03 Separation Geotextile

- A. Geotextile filter fabric shall be minimum 4.0 oz/sy, polypropylene, needlepunched nonwoven fabric. The physical and hydraulic properties of geotextiles shall be specified in accordance with AASHTO M288-06.
- B. General Contractor shall verify approval of submitted technical specifications, product data, samples and test results per Section 1.05 herein with the Owner prior to the installation.

2.04 Subsurface Drainage Piping

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- A. The piping shall be perforated or slotted PVC pipe manufactured in accordance with ASTM D-3034, or corrugated HDPE pipe manufactured in accordance with ASTM D-1248.
- B. Perforations or slots shall be sized to prevent migration of core fill gravel into the pipe.
- C. All connectors and fittings shall match the piping material.
- D. General Contractor shall verify approval of submitted technical specifications, product data, samples and test results per Section 1.05 herein with the Owner prior to the installation.

2.05 Levelling Pad

- A. The levelling pad shall be comprised of compacted crushed stone, or non-reinforced concrete, as shown on the construction drawings.
 - 1. Crushed stone shall satisfy ASTM D-2487 criteria for classification as Well-Graded (GW) or Poorly-Graded (GP).
 - 2. Concrete shall satisfy criteria for Class B as defined in AAASHTO Division II, Section 8.1.2. Minimum compressive strength of 10.3 MPa (1,500 psi).
- B. General Contractor shall verify approval of submitted samples and test results per Section 1.05 herein with the Owner prior to the installation.

2.06 Compacted Native Backfill

- A. Material is typically site-excavated soils, unless they are unsuitable soils for backfill (high plastic clays or organic soils). Where unsuitable soils exist, design engineer shall specify a designated alternative.
- B. General Contractor shall verify approval of submitted samples and test results per Section 1.05 herein with the Owner prior to the installation.

2.07 Low Permeability Soil

- A. Material is typically clay soil with a coefficient of permeability of less than 10^{-6} cm/s as tested in accordance with ASTM D5084.
- B. General Contractor shall verify approval of submitted samples and test results per Section 1.05 herein with the Owner prior to the installation.

PART 3 – EXECUTION

3.01 Pre-Construction Meeting

- A. Prior to commencement of any work, the General Contractor shall conduct a pre-construction meeting with the Owner, Design Engineer, Inspection Engineer, SCRW Installer the Segmental Concrete Unit supplier, and any affected sub-trades. The General Contractor shall provide notification to all required attendees at least 14 days prior to the meeting.
- B. The pre-construction meeting agenda shall include:
 - 1. Design Engineer to explain all aspects of the SCRW construction drawings.
 - 2. Design Engineer to convey the required bearing capacity of the Foundation Soil, and the required shear strength of the Retained Soil, to the Inspection Engineer.

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3. Design Engineer to explain any measures that are required to coordinate the installation of utilities or other obstructions in the Structural Backfill.
4. General Contractor to verify the location of the Mock Up, and whether it will be part of the final construction or needs to be removed.
5. General Contractor to verify the location of material storage areas, and when materials can start to be delivered to the site.
6. SCRW Installer to verify the expected start date of construction.
7. An inspection of the site to verify that all site-specific conditions have been considered in the design. Unique design considerations include:
 - (a) Structures that will exert surcharge loads behind the SCRW (buildings, fences, trees).
 - (b) Live loads (traffic, snow piles).
 - (c) Utilities that will be located near, or pass under, the SCRW.
 - (d) Presence of surface water flows, or groundwater discharge, in the area of the SCRW.
8. The SCRW Contractor will not proceed with the work until the Design Engineer has either confirmed the original design accounted for any unique design considerations identified during the inspection, or adjusts the design accordingly.

3.02 Excavation and Foundation Soil Preparation

- A. SCRW Contractor shall excavate to the lines and grades shown on the construction drawings in accordance *Division 2, Section 02300 - Earthwork*.
- B. Inspection Engineer shall inspect the excavation and approve prior to placement of Levelling Pad. SCRW Contractor to proof roll Foundation Soils as directed to determine if remedial work is required.
- C. Over excavation of unsuitable Foundation Soils and replacement with approved compacted fill will be compensated as agreed upon with the Owner.
- D. Embankment excavations shall be bench cut.
- E. General Contractor shall protect the SCRW work area and structure against surface water runoff at all times by using berms, diversion ditches, temporary drains, and other measures necessary to prevent drainage to the SCRW structure.

3.03 Levelling Pad

- A. Levelling pad material shall be placed to the lines and grades shown on the construction drawings.
- B. Levelling pad shall extend a minimum of 150mm (6 in) beyond both the front and back of the lowermost Segmental Concrete Units.
- C. Where crushed stone is shown on the drawings for the Levelling Pad, material shall have a minimum thickness of 150mm (6 in) and shall be compacted to a minimum of 95 % Standard Proctor density per ASTM D-698.

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- D. Where non-reinforced concrete is shown on the drawings for the Levelling Pad, material shall have a minimum thickness of 50mm (2 in), and shall be made from low strength concrete.
 - E. Final surface of Levelling pad shall be prepared to insure full contact to the base surface of the concrete Facing Units and have a tolerance within +/- 25mm (1") over a 3 metre (10') span.
- 3.04 Segmental Concrete Retaining Wall, Structural Backfill and Compacted Native Backfill
- A. Place Separation Geotextile as required by the design drawings.
 - B. First course of Segmental Concrete Units shall be placed on the Levelling Pad at the appropriate line and grade.
 - C. Alignment and level shall be checked in all directions.
 - D. Ensure that all units are in full contact with the Levelling Pad and properly seated.
 - E. Ensure the front faces of the Segmental Concrete Units are side-by-side. Do not leave gaps between adjacent units along the exposed face(s). Layout of corners and curves shall be in accordance with manufacturer's recommendations.
 - F. Check each course for level and alignment. Adjust units as necessary to maintain level and alignment prior to proceeding with each additional course.
 - G. Place the Subsurface Drainage System within the Stabilized Backfill at the elevations shown on the design drawings. Ensure proper slope to create gravity flow of water to outside of the SCRW system, and verify there are no low spots or dips in the pipes. Provide daylight outlets at each low point, and at 15 m (50 ft) intervals along the wall through either the face of the wall, or around the ends of the wall, where required.
 - H. Maximum stacked vertical height of wall units, prior to Stabilized Backfill and Compacted Native Backfill placement and compaction, shall not exceed 600mm (24 in).
 - I. Place temporary wood formwork, as required, to define the extent of the Stabilized Backfill. Support formwork such that it does not move during Stabilized Backfill installation.
 - J. Pour Stabilized Backfill between, and for the designated depth behind, the Segmental Concrete Units. Fill to top of units, then compact or rod Stabilized Backfill to insure all voids are completely filled. When properly formulated, the Stabilized Backfill material will not leak through the face of the wall; if leakage is observed, adjust the cementitious material composition accordingly and wash the wall face before the cement can set.
 - K. Allow 2 to 3 hours for the concrete to set before proceeding.
 - L. Compacted Native Backfill shall be placed and compacted in lifts not to exceed 150mm (6 in) where walk behind compaction equipment is used, or 250mm (10 in) where heavy (i.e. ride on) compaction equipment is used. Lift thickness shall be decreased to achieve the required density as required. Fill completely and level from Segmental Concrete Units to Retained Soil.
 - M. Compacted Native Backfill shall be compacted to 95% of the maximum density respectively as determined by ASTM D-698. The moisture content of the material prior to and during compaction shall be uniformly distributed throughout each layer and shall be within +/- 2% of the optimal moisture content.

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- N. Only lightweight hand operated equipment shall be allowed within 1 metre (3 feet) from the rear of the Segmental Concrete Units.
- O. For subsequent courses, brush top surface of underlying Segmental Concrete Units clean. Set next units squarely and verify there is no rocking on the underlying row. Ensure the interlock between units is engaged by pulling the units forward.
- P. Asphalt shingles may be used as shims between courses of block. Use of other shim material is not permitted.
- Q. At the end of each day's operation, the SCRW Contractor shall slope the last lift of Compacted Native Backfill away from the wall units to direct runoff away from wall face. The SCRW Contractor shall not allow surface runoff from adjacent areas to enter the wall construction site.
- R. Cap units shall be secured with an adhesive. Cut cap units as necessary to obtain proper fit.

3.05 Low Permeability Soil Installation

- A. Low Permeability Soil (where required) shall be compacted to 95% of the maximum density as determined by ASTM D-698.
- B. Moisture content of the material prior to and during compaction shall be uniformly distributed throughout each layer and shall be within + 2%, - 1% of the optimal moisture content.
- C. Surface of Low Permeability Soil shall be sloped to provide surface water drainage as per design drawings.
- D. Vegetate surface of Low Permeability Soil to prevent erosion.

3.06 As-built Construction Tolerances

- A. Vertical alignment: $\pm 31\text{mm}$ (1.25 in) over any 3m (10 ft) distance, with a maximum differential of 75mm (3 in) over the entire length of the wall.
- B. Wall Batter: within 2 degrees of design batter.
- C. Horizontal alignment: $\pm 25\text{mm}$ (1 in) over any 3m (10 ft) distance.
- D. Corners, bends, curves $\pm 300\text{mm}$ (1 ft) to theoretical location.
- E. Maximum horizontal gap between erected units shall be 12mm (1/2 in).
- F. Bulging: $\pm 31\text{mm}$ (1.25 in) over any 3m (10 ft) distance

END OF SECTION