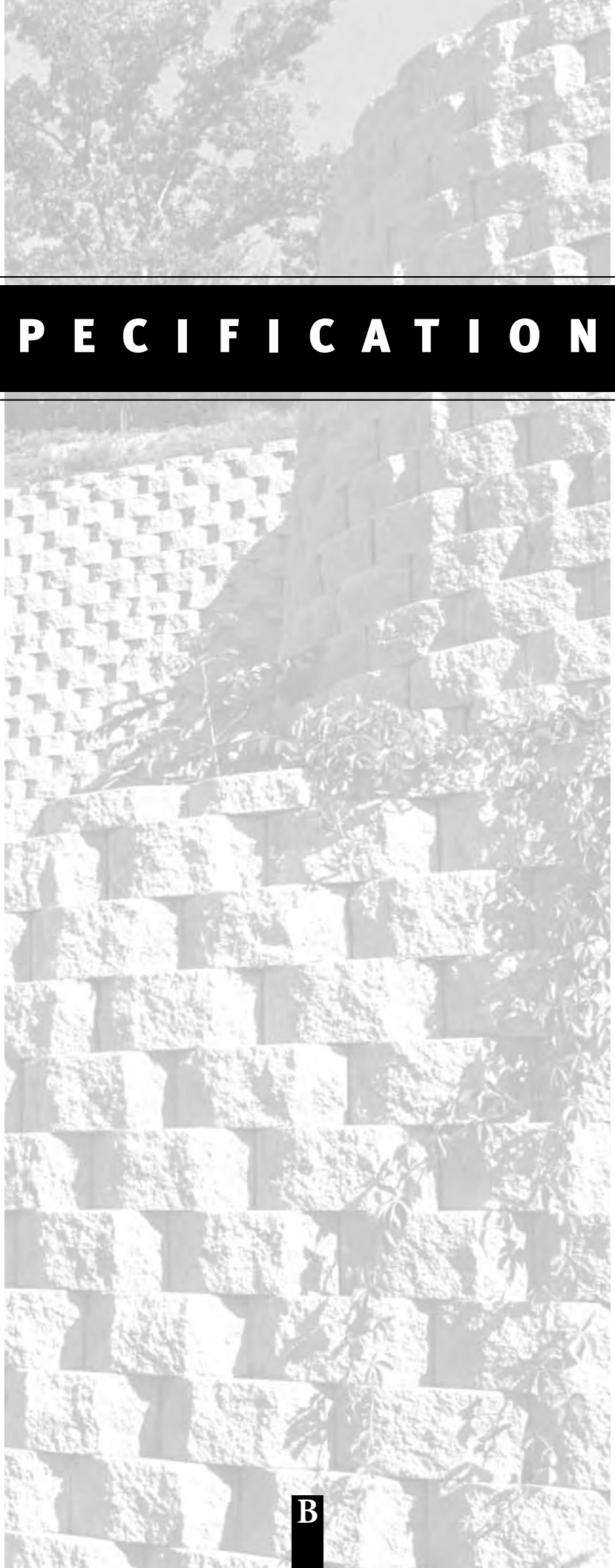

SPECIFICATIONS

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S P E C I F I C A T I O N S

SPECIFICATION GUIDELINES

SECTION 02834
MODULAR CONCRETE RETAINING WALLS

PART ONE: GENERAL

1.1 SECTION INCLUDES
A. Work includes furnishing and installing concrete modular block retaining wall units with fiberglass shear/alignment pins to the lines and grades shown on the construction drawings, within a reasonable field tolerance, and as specified herein.
B. Work includes preparing foundation soil, furnishing and installing leveling pad, unit fill and backfill to the lines and grades shown on the construction drawings.
C. Work includes furnishing and installing geogrid reinforcement and backfill to the lines and grades designated on the construction drawings.

1.2 RELATED SECTIONS
A. Section 02300 - Earthwork.
B. Section 03300 - Cast-In-Place Concrete.

1.3 REFERENCES
A. ASTM C 1372 - Standard Specification for Segmental Retaining Wall Units; 2004.
B. ASTM D 422 - Standard Test Method for Particle-Size Analysis of Soils; 1963 (Reapproved 2002).
C. ASTM D 698 - Standard Method of Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft3) 600kN-m/m3)); 2000.
D. ASTM D 3034 - Standard Specification for Type PSM Poly(Vinyl Chloride) (PVC) Sewer Pipe and Fittings; 2004.
E. ASTM D 4318 - Standard Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils; 2000.
F. ASTM D 4595 - Standard Test Method for Tensile Properties of Geotextiles by the Wide Strip Method; 2001
G. ASTM D 5262 - Standard Test Method for Evaluating the Unconfined Tension Creep Behavior of Geosynthetics; 2004.
H. ASTM F 405 - Standard Specification for Corrugated Polyethylene (PE) Pipe and Fittings; 1997.
I. GRI-GG4 - Determination of Long Term Design Strengths of Geogrids; Geosynthetic Research Institute.
J. GRI-GG5 - Determination of Geogrid (Soil) Pullout; Geosynthetic Research Institute.
K. NCMA SRWU-1 - Test Method for Determining Connection Strength of SRW; National Concrete Masonry Association.
L. ASTM D4475-02 – Standard Test Method for Horizontal Shear (Short-Beam Method) of Pultruded Reinforced Plastic Rods.
M. ASTM D4476-03 – Standard Test Method for Flexural Properties of Fiber Reinforced Pultruded Plastic Rods.
N. ASTM D3916-02 - Standard Test Method for Tensile Properties of Pultruded Glass-Fiber-Reinforced Plastic Rods.
O. ASTM D570-98 – Standard Test Method for Water Absorption of Plastics.
P. ASTM D3917-02 – Standard Specification for Dimensional Tolerance of Thermosetting Glass-Reinforced Plastic Pultruded Shapes.

1.4 DEFINITIONS
A. Modular Unit: A concrete retaining wall element machine made from Portland cement, water, and aggregates.
B. Unit Fill: A drainage aggregate which is placed within and immediately behind the modular concrete units.
C. Reinforced Backfill: A compacted soil which is placed within the reinforced soil volume as outlined on the plans.
D. Structural Geogrid: A structural element formed by a regular network of integrally connected tensile elements with apertures of sufficient size to allow interlocking with surrounding soil, rock, or earth and to function primarily as reinforcement.
E. Shear/Alignment Pin: A pultruded high strength isopthalic polyester resin glass reinforced pin which fits in manufactured holes in the concrete units and interconnects units and courses.

1.5 SUBMITTALS
A. Submit under provisions of Section 01300.
B. Shop Drawings: Dimensioned plans, sections, and design calculations prepared and stamped by a professional engineer registered in the state of the project location; provide engineering designs, techniques, and material evaluations performed in accordance with the KEYSTONE Design Manual, NCMA Design Guidelines For Segmental Retaining Walls,or the AASHTO Standard Specifications for Highway Bridges, Section 5.8, 1993 Interim, whichever is applicable.
C. Product Data: Submit manufacturer's product data for proposed materials and method of installation.
D. Samples: Submit samples of each product used in the work of this section.
E. Certifications: Submit a manufacturer's certification, prior to start of work, that the retaining wall system components meet the requirements of this specification and that the retaining wall system (modular concrete units and specific geogrid):
1. Has been successfully utilized on a minimum of five (5) similar projects, i.e., height, soil fill types, erection tolerances, etc.; and
2. Has been successfully installed on a minimum of 1 million (1,000,000) square feet (92,000 sq m) of retaining walls.

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F. Test Reports: Submit test reports documenting strength of specific modular concrete unit and geogrid reinforcement connection. The maximum design tensile load of the geogrid shall be equal to the laboratory tested ultimate strength of geogrid/concrete retaining wall unit connection at a maximum normal force limited by the "Hinge Height" of the structure divided by a safety factor of 1.5. The connection strength evaluation shall be performed in accordance with NCMA SRWU-1.

1.6 QUALITY ASSURANCE

A. Design Engineer Qualifications: Minimum of five years documentable experience in the design of reinforced soil structures and able to provide proof of current professional liability insurance with an aggregate coverage limit of not less than $2,000,000.

B. Installer Qualifications: Able to provide a list of 5 previously constructed successful projects of similar size and magnitude using the retaining wall system specified, with contact names and telephone numbers.

1.7 DELIVERY, STORAGE AND HANDLING

A. Check materials upon delivery to assure that proper materials have been received.

B. Prevent excessive mud, wet cement, epoxy, and similar materials (which may affix themselves) from coming in contact with the materials.

C. Protect materials from damage; do not use damaged materials.

PART 2: PRODUCTS

2.1 MANUFACTURER

A. Provide modular concrete retaining wall units and accessory materials fabricated by authorized licensed manufacturers of Keystone Retaining Wall Systems, Inc., 4444 West 78th Street, Minneapolis, MN 55435. Tel: (952) 897-1040. Fax: (952) 897-3858.

1. Substitutions will not be acceptable.

2.2 MATERIALS

A. Modular Concrete Retaining Wall Units: Comply with ASTM C 1372 and the following:

1. Color: Manufacturer's standard color pallette.
2. Face Finish: Sculptured rock face in angular tri-planar configuration for Standard and Compac units. Weathered straight face for Keystone Century Wall and Country Manor units. Other face finishes not be allowed without written approval.
3. Bond Configuration: Running, with bonds nominally located at midpoint vertically adjacent units, in both straight and curved alignments.
4. Exposed surfaces free of chips, cracks or other imperfections when viewed from a distance of 10 feet (3050mm) under diffused lighting.
5. Compressive strength: 3000 pounds per square inch (20MPa) minimum.
6. Alignment and Grid Positioning Mechanism: Fiberglass pins, typically two per unit unless using small units that have provision for only one.
7. Design to provide installed vertical setback of 1/8 inch (3 mm) plus/minus per course (near vertical) or 1.25 inches (31.75 mm) plus per course per the design drawings.

**** NOTE TO SPECIFIER ** Delete one of the following two paragraphs. 6 percent absorption should be specified in northern states.**

9. Absorption: 8 percent maximum for standard weight aggregates.
10. Absorption: 6 percent maximum for standard weight aggregates.

**** NOTE TO SPECIFIER ** Select appropriate unit type and delete others.**

11. Keystone Standard Units:
    a. Width: 18 inches (457 mm), plus/minus 1/8 inch (3 mm).
    b. Depth: 18 – 24 inches (508 mm) minimum, plus/minus 1/8 inch (3 mm), not including rough split face.
    c. Height: 8 inches (203 mm), plus/minus 1/16 inch measured to top and bottom planes.
    d. Weight: 100 pounds (45 kg) per unit minimum using standard weight aggregates.
    e. Inter-Unit Shear Strength: 1500 pounds per linear foot (21,000 N/m), minimum, at 2 pounds per square inch (13 kPa) normal pressure.
    f. Geogrid/Unit Peak Connection Strength: 1000 pounds per linear foot (14600 N/m), minimum, at 2 pounds per square inch (13 kPa) normal force.
12. Keystone Compac Units:
    a. Width: 18 inches (457 mm), plus/minus 1/8 inch (3 mm).
    b. Depth: 12 inches (305 mm) minimum, plus/minus 1/8 inch (3 mm), not including rough split face.
    c. Height: 8 inches (203 mm), plus/minus 1/16 inch measured to top and bottom planes.
    d. Weight: 75 pounds (34 kg) per unit minimum using standard weight aggregates.
    e. Inter-Unit Shear Strength: 600 pounds per linear foot (8700 N/m), minimum, at 2 pounds per square inch (13 kPa) normal pressure.
    f. Geogrid/Unit Peak Connection Strength: 500 pounds per linear foot (7250 N/m), minimum, at 2 pounds per square inch (13 kPa) normal force.

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13. Keystone Century Wall Units:
    a. Width: Varies – 7 to 18 inches (178-457 mm), plus/minus 1/8 inch (3 mm).
    b. Depth: 12 inches (305 mm) minimum, plus/minus 1/8 inch (3 mm), not including rough split face.
    c. Height: 8 inches (203 mm), plus/minus 1/16 inch measured to top and bottom planes.
    d. Weight: 35 - 90 pounds (16 - 40 kg) per unit minimum using standard weight aggregates.
    e. Inter-Unit Shear Strength: 600 pounds per linear foot (8700 N/m), minimum, at 2 pounds per square inch (13 kPa) normal pressure.
    f. Geogrid/Unit Peak Connection Strength: 500 pounds per linear foot (7250 N/m), minimum, at 2 pounds per square inch (13 kPa) normal force.
14. Keystone Country Manor Units:
    a. Width: 4 - 16 inches (102 - 406 mm), plus/minus 1/8 inch (3 mm).
    b. Depth: 10 inches (254 mm) minimum, plus/minus 1/8 inch (3 mm), not including rough split face.
    c. Height: 6 inches (152 mm), plus/minus 1/16 inch measured to top and bottom planes.
    d. Weight: 25 - 60 pounds (11 - 27 kg) per unit minimum using standard weight aggregates.
    e. Inter-Unit Shear Strength: 600 pounds per linear foot (8700 N/m), minimum, at 2 pounds per square inch (13 kPa) normal pressure.
    f. Geogrid/Unit Peak Connection Strength: 300 pounds per linear foot (4300 N/m), minimum, at 2 pounds per square inch (13 kPa) normal force.
15. Accessory Units: Provide matching units.
    a. Corners: Provide 90 degree corners, finished two sides, where indicated.
    b. Cap units: Provide solid cap units with parallel sides for straight walls and convex walls, angular sides for concave walls. Caps may be solid or have 1/2 depth voids for connection to alignment/shear pins from course below.

B. Shear Connectors:
1. Non-Shouldered Pins: 1/2 inch (13 mm) diameter x 5.25 inches (133 mm) long thermoset isopthalic polyester resin-pultruded fiberglass reinforcement rods.
2. Shouldered Pins: Similar to pin noted above, except this pin has a 3/4" diameter cap/shoulder for specific unit connection.
    a. Flexural Strength: 128,000 pounds per square inch (882 MPa), minimum.
    b. Short Beam Shear: 6,400 pounds per square inch (44 MPa), minimum.
    c. Provide products that are capable of maintaining strength over design temperature range of minus 10 degrees F (minus 23 degrees C) to plus 100 degrees F (plus 38 degrees C).
    d. Provide products that are capable of holding the geogrid in the proper design position during grid pre-tensioning and backfilling.
    e. All pins to be supplied by "Approved Vendors" with verification notice issued by Keystone Retaining Wall Systems, Inc.

C. Construction Adhesive: Keystone KapSeal as supplied by manufacturer of modular concrete units.

D. Base Leveling Pad Material: Compacted crushed stone base or non-reinforced concrete as shown on the drawings.

E. Unit Drainage Fill: Clean 1-inch minus crushed stone or crushed gravel meeting the gradation listed below.
1. 1 inch (25 mm) sieve, 100 percent passing.
2. 3/4 inch (19 mm) sieve, 75-100 percent passing.
3. No. 4 (4.75 mm) sieve, 0 - 10 percent passing.
4. No. 50 (300 micro-m) sieve, 0 - 5 percent passing.

F. Pea rock rounded stone is not acceptable.

G. Reinforced Backfill: Free of debris and meet the following gradation requirements:
1. 2 inch (50 mm) sieve, 100-75 percent passing.
2. 3/4 inch (19 mm) sieve, 100-75 percent passing.
3. No. 4 (4.75 mm) sieve, 100-20 percent passing.
4. No. 40 (425 micro-m) sieve, 0-60 percent passing.
5. No. 200 (75 micro-m) sieve, 0-35 percent passing.
6. Plasticity Index (PI) les than 10 and liquid limit less than 40.
7. Maximum Aggregate Size: 3/4 inch (19 mm), unless field tests have been or will be performed to evaluate potential strength reductions to the geogrid design due to damage during construction.
8. Material may be site excavated soils where the above requirements can be met.
9. Do not use unsuitable soils (high plastic clays or organic soils) for backfill or in the reinforced soil mass.
10. Shall submit reinforced fill sample and laboratory test results to the Architect/Engineer for approval prior to the use of any proposed reinforced fill material.

H. Geogrid: Geotextile fabric of high tenacity polyester yarn or high density polyethylene specifically fabricated for use as soil reinforcement.
1. Polyester: Knitted from high tenacity polyester filament yarn with a molecular weight exceeding 25,000 Meg/m and a carboxyl end group values less than 30; coated with an impregnated PVC coating that resists peeling, cracking, and stripping.

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2. Ta, Long Term Allowable Tensile Design Load, shall be determined as follows:
   a. Ta = Tult/(RFcr x RFd x RFid x FS)
   b. Ta shall be evaluated based on a 75 year design life.
3. RFcr, Reduction Factor for Creep Limited Tensile Load: Determined from 10,000 hour creep testing performed in accordance with ASTM D 5262; 1.60 minimum.
4. RFd, Reduction Factor for Durability/Aging: Determined from polymer specific durability testing covering the range of expected soil environments; 1.10 minimum.
5. RFid, Reduction Factor for Installation Damage: Determined from product specific construction damage testing performed in accordance with GRI-GG4; 1.05 minimum. Test results shall be provided for each product to be used with project specific or more severe soil type.
6. FS, Overall Factor of Safety: 1.5 unless otherwise noted.
7. Maximum Design Tensile Load: Not more than the laboratory tested ultimate strength of the geogrid/facing unit connection as limited by the "Hinge Height" divided by a factor of safety of 1.5, using connection strength testing and computation procedures in accordance with NCMA SRWU-1.
8. Soil Interaction Coefficient, Ci: Determined in accordance with GRI-GG5 at maximum 0.75 inch (19 mm) displacement.
9. Manufacturing Quality Control: Test each 40,000 square feet (3700 sq m) of production, each lot, or each production day; include tensile strength testing, melt flow index (HDPE), and molecular weight (polyester).

** **NOTE TO SPECIFIER** ** **Delete the following if not required.**

I. Drainage Pipe: Perforated or slotted PVC pipe complying with ASTM D 3034 or corrugated high density polyethylene pipe complying with ASTM F 405.

PART THREE: EXECUTION

3.1 EXAMINATION

A. Verify that layout dimensions are correct and substrate is in proper condition for installation. Do not proceed with installation until unsatisfactory conditions have been corrected.

3.2 EXCAVATION

A. Excavate to the lines and grades shown on the construction drawings. Obtain the Architect/Engineer's approval of excavation prior to placement of leveling material or fill soils. Proof roll foundation area as directed to determine if remedial work is required.
B. Over-excavation of deleterious soils and replacement with suitable fill, when approved in advance by the Architect/Engineer, will be paid at unit cost rates.
C. Be careful not to disturb embankment and foundation materials beyond lines shown.

3.3. BASE LEVELING PAD

A. Place leveling pad material to the lines and grades shown on the construction drawings. Extend leveling pad minimum of 6 inches (150 mm) in beyond front and back faces of units and minimum of 6 inches (150 mm) thick.
B. Compact granular leveling pad material to a minimum of 95 percent Standard or 90 percent Modified Proctor.
C. Prepare leveling pad to ensure full contact to the base surface of the concrete units.

3.4 MODULAR UNIT INSTALLATION

A. Place first course of units on leveling pad and check alignment and level. Use pins or molded surfaces of modular concrete units for alignment control; do not attempt alignment from rockface split surface, due to its irregular split finish.
B. Ensure that all units are in full contact with base and properly seated.
C. Place fronts of units side-by-side. Do not leave gaps between units. Lay out corners and curves in accordance with manufacturer's recommendations.
D. Install shear connectors. Verify specified setback position as indicated on drawings.
E. Place and compact drainage fill within and behind units. Place minimum of 1 cubic foot (0.03 cu m) per unit of drainage fill within the cores of the units, between units, and behind units.
F. Place and compact backfill soil behind drainage fill.
G. Follow wall and drainage fill installation closely with backfill. Maximum stacked vertical height of wall units prior to drainage fill and backfill placement and compaction not to exceed 2 courses.

3.5 STRUCTURAL GEOGRID INSTALLATION

A. Orient geogrid with the highest strength axis perpendicular to the wall alignment.
B. Place geogrid reinforcement at the elevations and to the extent shown on the construction drawings or as directed by the Engineer.
C. Lay geogrid horizontally on compacted backfill and attached to the wall units. Place the next course of modular concrete units over geogrid. Pull geogrid taut and anchor prior to backfill placement on the geogrid.

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D. Install geogrid reinforcements continuous throughout embedment lengths and side-by-side for 100 percent coverage at each level. Do not splice shorter pieces of geogrid or leave gaps between ends of pieces.

3.6 REINFORCED BACKFILL PLACEMENT

A. Place, spread, and compact backfil in such a manner that minimizes the development of slack in the geogrid and other damage.
B. Place and compact reinforced backfill in lifts not to exceed 6 inches (150 mm) where hand compaction is used, or 8 to 10 inches (200 to 250 mm) where heavy compaction equipment is used. Decrease lift thickness where necessary to achieve required density.
C. Compact reinforced backfill to 95 percent of the maximum density as determined by ASTM D 698. The moisture content of the backfill material prior to and during compaction shall be uniformly distributed throughout each layer and shall be within +0/-3 percentage points dry of optimum.
D. Allow only lightweight hand-operated equipment within 3 feet (900 mm) from the tail of the modular concrete unit.
E. Do not operate tracked construction equipment directly upon the geogrid reinforcement. A minimum fill thickness of 6 inches (152 mm) is required prior to operation of tracked vehicles over the geogrid. Tracked vehicle turning should be kept to a minimum to prevent tracks from displacing the fill and damaging the geogrid.
F. Rubber tired equipment may pass over geogrid reinforcement at slow speeds, less than 10 miles per hour (16 kph). Sudden braking and sharp turning shall be avoided.
G. At the end of each day's operation, slope the last lift of reinforced backfill away from the wall units to direct runoff away from wall face. Do not allow surface runoff from adjacent areas to enter the wall construction site.

3.7 CAP INSTALLATION

A. Glue cap units to underlying units with an all-weather adhesive recommended by the manufacturer.

3.8 FIELD TOLERANCES

A. Vertical Alignment : Plus/minus 1.5 inches over any 10 foot (37.5 mm in 3 m) distance.
B. Wall Batter: Within 2 degrees of design batter.
C. Horizontal Alignment: Plus/minus 1.5 inches over any 10 foot (37.5 mm in 3 m) distance; corners, bends, and curves plus/minus 1 ft (305 mm) to theoretical location.
D. Maximum Horizontal Gap Between Erected Units: 1/2 inch (12 mm).

3.9 FIELD QUALITY CONTROL

**** NOTE TO SPECIFIER ** Delete this article entirely if the Owner will not be providing field testing or inspection. Testing and inspections services should only be performed by qualified and experienced technicians and engineers. As a minimum, quality assurance testing should include foundation soil inspection, soil and backfill testing, verification of design parameters, and observation of construction for general compliance with design drawings and specifications.**

A. The Owner will engage inspection and testing services, including independent laboratories, to provide quality assurance and testing services during construction. This does not relieve the Contractor from securing the necessary construction control testing during construction.

END OF SECTION

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