REVISION OF SECTION 102
PLANS AND OTHER DATA

Section 102 of the Standard Specifications is hereby revised for this project as follows:

Subsection 102.05 shall include the following:

After the Contract has been awarded, the contractor may obtain, at no cost, (5) set of plans (11 x 17 or 22 x 34 sheets) and specifications (8-1/2 x 11 double sided). A PDF file of these documents will also be provided for any other reproduction needs. Subcontractors and suppliers shall obtain plans and other data from the successful bidder.

The following information will be available for review at the City Engineer's office or electronically by email:

1. **Geotechnical Investigation Report**:
    - West Midland Pedestrian Bridge, West Midland Avenue, Glenwood Springs, CO, January 6, 2016, RJ Engineering #15-077G-G1.

REVISION OF SECTION 503
MICROPILES

Section 503 of the Standard Specifications is hereby revised for this project as follows:

DESCRIPTION

503.01 This work shall consist of constructing micropiles as shown on the contract plans and approved working drawings and as specified herein. The micropile specialty Contractor is responsible for furnishing of all design, materials, products, accessories, tools, equipment, services, transportation, labor and supervision, and manufacturing techniques required for design, installation and testing of micropiles and pile top attachments for this project.

The selected micropile Contractor shall select the micropile type, size, pile top attachment, installation means and methods, estimate the ground-grout bond value and determine the required bond length and final micropile diameter. The micropile Contractor shall design and install micropiles that will develop the load capacities indicated on the contract plans. The micropile load capacities shall be verified by ~~verification and~~ proof load testing as required and must meet the test acceptance criteria specified herein.

503.02 Micropile Contractor's Experience Requirements And Submittal

The micropile Contractor shall be experienced in the construction and load testing of micropiles and have successfully constructed at least 5 projects in the last 5 years involving construction totaling at least 100 micropiles of similar capacity to those required in these plans and specifications.

The Contractor shall have previous micropile drilling and grouting experience in soil/rock similar to project conditions. The Contractor shall submit construction details, structural details and load test results for at least three previous successful micropile load tests from different projects of similar scope to this project.

The Contractor shall assign an Engineer to supervise the work with experience on at least 3 projects of similar scope to this project completed over the past 5 years. The Contractor shall not use consultants or manufacturers' representatives to satisfy the supervising Engineer requirements of this section. The on-site foremen and drill rig operators shall also have experience on at least 3 projects over the past 5 years installing micropiles of equal or greater capacity than required in these plans and specifications.

The micropiles shall be designed by a Registered Professional Engineer with experience in the design of at least 3 successfully completed micropile projects over the past 5 years, with micropiles of similar capacity to those required in these plans and specifications. The micropile design engineer may be either an employee of the Contractor or a separate Consultant design engineer meeting the stated experience requirements. At least 45 calendar days before the planned start of micropile construction, the Contractor shall submit 5 copies of the completed project reference list and a personnel list. The project reference list shall include a brief project

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description with the owner's name and current phone number and load test reports. The personnel list shall identify the micropile system design engineer (if applicable), supervising project Engineer, drill rig operators, and on-site foremen to be assigned to the project. The personnel list shall contain a summary of each individual's experience and be complete enough for the Engineer to determine whether each individual satisfies the required qualifications. The Engineer will approve or reject the Contractor's qualifications within 15 calendar days after receipt of a complete submission. Additional time required due to incomplete or unacceptable submittals will not be cause for time extension or impact or delay claims. All costs associated with incomplete or unacceptable submittals shall be borne by the Contractor.

Work shall not be started, nor materials ordered, until the Engineer's written approval of the Contractor's experience qualifications is given. The Engineer may suspend the Work if the Contractor uses non-approved personnel. If work is suspended, the Contractor shall be fully liable for all resulting costs and no adjustment in contract time will result from the suspension.

503.03 Definitions

Admixture: Substance added to the grout to control bleed and/or shrinkage, improve flowability, reduce water content, or retard setting time.

Alignment Load (AL): A minimum initial load (no greater than 10 percent of the Design Load) applied to micropile during testing to keep the testing equipment correctly positioned.

Bond Length: The length of the micropile that is bonded to the ground and used to transfer the applied axial loads to the surrounding soil or rock.

Bond-breaker: A sleeve placed over the steel reinforcement to prevent load transfer.

Casing: Steel tube introduced during the drilling process in overburden soil to temporarily stabilize the drill hole. This is usually withdrawn as the pile is grouted, although in certain types of micropiles, some casing is permanently left in place to provide added pile reinforcement.

Centralizer: A device to support and position the reinforcing steel in the drill hole and/or casing so that a minimum grout cover is provided.

Contractor: The person/firm responsible for performing the micropile work.

Coupler: The means by which load capacity can be transmitted from one partial length of reinforcement to another.

Creep Movement: The movement that occurs during the creep test of a micropile under a constant load.

Design Load (DL): The maximum load expected to be applied to the micropile during its service life.

Encapsulation: A corrugated or deformed tube protecting the reinforcing steel against corrosion.

Engineer: The Owner or Owner's authorized agent.

Free (unbonded) length: The designed length of the micropile that is not bonded to the surrounding ground or grout.

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Micropile: A small-diameter, bored, cast-in-place composite pile, in which the applied load is resisted by steel reinforcement, cement grout and frictional grout/ground bond.

Maximum Test Load: The maximum load to which the micropile is subjected during testing.

Ultimate Grout-to-Ground Bond Values: The estimated ultimate geotechnical unit grout-to-ground bond strength selected for use in design.

Overburden: Material, natural or placed, that may require cased drilling methods to provide an open borehole to underlying strata.

Post-grouting: The injection of additional grout into the load transfer length of a micropile after the primary grout has set. Also known as regrouting or secondary grouting.

Primary Grout: Portland-cement-based grout injected into the micropile hole prior to or after the installation of the reinforcement to direct the load transfer to the surrounding ground along the micropile.

Proof Load Test: Incremental loading of a production micropile, recording the total movement at each increment.

Reinforcement: The steel component of the micropile that accepts and/or resists applied loadings.

Sheathing: Smooth or corrugated piping or tubing that protects the reinforcing steel against corrosion.

Spacer: A device to separate elements of a multiple-element reinforcement.

~~**Verification Load Test:** Pile load test performed to verify the design of the pile system and the construction methods proposed, prior to installation of production piles.~~

503.04 Referenced Codes and Standards.

The following publications form a part of this specification to the extent indicated by the references. The latest publication as of the issue date of this specification shall govern, unless indicated otherwise.

American Society for Testing and Materials (ASTM)
American Association of State Highway and Transportation Officials (AASHTO)

ASTM	AASHTO	SPECIFICATION / TEST
A36, A572	M183, M223	Structural Steel
A82	M55	Cold-Drawn Steel Wire for Concrete Reinforcement
A252	–	Welded and Seamless Steel Pipe Piles
A615	M31	Deformed and Plain Billet Steel Bars for Concrete Reinforcement
A722	M275	Uncoated High-Strength Steel Bar for Prestressing Concrete
A775	–	Epoxy -Coated Reinforcing Steel Bars
A934	–	Epoxy-Coated Prefabricated Steel Reinforcing Bars
C 33	M80	Concrete Aggregates

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C 109	T106	Compressive Strength of Hydraulic Cement Mortar
C 188	T133	Density of Hydraulic Cement
C 144	M45	Aggregate for Masonry Mortar
C 150	M 85	Portland Cement
C 494	M194	Chemical Admixtures for Concrete
D 1143	–	Method of Testing Piles Under Static Axial Compressive Load
D 1784	–	Polyvinyl Chloride (PVC) Pipe (Class 13464-B)
D 3350	M 252	Polyethylene Corrugated Tubing
D 3689	–	Method of Testing Individual Piles Under Static Axial Tensile Load
D 3966	–	Standard Test Method for Piles Under Lateral Load
–	T 26	Quality of Water to be Used in Concrete

American Welding Society (AWS)
D1.1 Structural Welding Code-Steel
D1.2 Structural Welding Code-Reinforcing Steel

American Petroleum Institute (API)
5CT (N-80) Specification for casing and tubing
RP 13B-1 Recommended Practice – Standard Procedure for Field Testing Water Based Drilling Fluids

503.05 Available Information

Available information developed by the Owner, or by the Owner's duly authorized representative include the following items:

1. Plans prepared by SGM, Inc., and Pattillo Associates Engineers, Inc., dated June 8, 2016.
2. Geotechnical Report No.(s) 16-005G-G1 titled "Geotechnical Report, Grand Avenue Pedestrian Bridge Relocation, Roaring Fork River, Glenwood Springs, Colorado", dated April 18, 2016, by RJ Engineering, Inc.

503.06 Construction Site Survey

Before bidding the Work, the Contractor shall review the available subsurface information and visit the site to assess the site geometry, equipment access conditions, and location of existing structures and above ground facilities.

The Contractor is responsible for field locating and verifying the location of all utilities shown on the plans prior to starting the Work. Maintain uninterrupted service for those utilities designated to remain in service throughout the Work. Notify the Engineer of any utility locations different from shown on the plans that may require micropile relocations or structure design modification. Subject to the Engineer's approval, additional cost to the Contractor due to micropile relocations and/or structure design modification resulting from utility locations different from shown on the

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plans, will be paid as Extra Work. Prior to start of any micropile construction activity, the Contractor and Engineer shall jointly inspect the site to observe and document the pre-construction condition of the site, existing structures and facilities.

503.07 Micropile Design Requirements

The micropiles shall be designed to meet the specified loading conditions, as shown on the contract plans and approved working drawings. Design the micropiles and pile top to footing connections using the procedures contained in the FHWA "Micropile Design and Construction", Report No. FHWA NHI-05-039.

The required geotechnical factors of safety shall be in accord with the FHWA manual, unless specified otherwise. Estimated soil/rock design shear strength parameters, unit weights, applied foundation loadings, slope and external surcharge loads, corrosion protection requirements, known utility locations, easements, right-of-ways and other applicable design criteria will be as shown on the plans or specified herein.

Structural design of any individual micropile structure elements not covered in the FHWA manual shall be by the service load design method in conformance with appropriate articles of the most current Edition of the AASHTO Standard Specifications for Highway Bridges, including current interim specifications.

Where required as shown on the contract plans, corrosion protection of the internal steel reinforcing bars, consisting of either encapsulation, epoxy coating, or grout, shall be provided in accordance with Materials Section 2.0. Where permanent casing is used for a portion of the micropile, encapsulation shall extend at least 5 ft. into the casing.

(a) Micropile Design Submittals

At least 21 calendar days before the planned start of micropile structure construction, submit complete design calculations and working drawings to the Engineer for review and approval. Include all details, dimensions, quantities, ground profiles, and cross-sections necessary to construct the micropile structure. Verify the limits of the micropile structure and ground survey data before preparing the detailed working drawings.

The drawings and calculations shall be signed and sealed by the contractor's Professional Engineer or by the Consultant designer's Professional Engineer (if applicable), previously approved by the owner's Engineer. If the micropile contractor uses a consultant design engineer to prepare the design, the micropile contractor shall still have overall contract responsibility for both the design and the construction.

(b). Design Calculations

Design calculations shall include, but not be limited to, the following items:

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1. A written summary report which describes the overall micropile design.

2. Applicable code requirements and design references.

3. Micropile structure critical design cross-section(s) geometry including soil/rock strata and piezometric levels and location, magnitude and direction of design applied loadings, including slope or external surcharge loads.

4. Design criteria including, soil/rock shear strengths (friction angle and cohesion), unit weights, and ground-grout bond values and micropile drillhole diameter assumptions for each soil/rock strata.

5. Factors of safety and allowable stresses used in the design on the ground-grout bond values, surcharges, soil/rock and material unit weights, steel, grout, and concrete materials.

6. Seismic design earthquake acceleration coefficient.

7. Design calculation sheets (both static and seismic) with the project number, micropile structure location, designation, date of preparation, initials of designer and checker, and page number at the top of each page. Provide an index page with the design calculations.

8. Design notes including an explanation of any symbols and computer programs used in the design.

9. Pile to footing connection calculations.

(c) Working Drawings

The working drawings shall include all information required for the construction and quality control of the piling. Working drawings shall include, but not be limited to, the following items unless provided in the contract plans:

1. A plan view of the micropile structure(s) identifying:
   A. A reference baseline and elevation datum.
   B. The offset from the construction centerline or baseline to the face of the micropile structure at all changes in horizontal alignment.
   C. Beginning and end of micropile structure stations.
   D. Right-of-way and permanent or temporary construction easement limits, location of all known active and abandoned existing utilities, adjacent structures or other potential interferences. The centerline of any drainage structure or drainage pipe behind, passing through, or passing under the micropile structure.

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E. Subsurface exploration locations shown on a plan view of the proposed micropile structure alignment with appropriate reference base lines to fix the locations of the explorations relative to the micropile structure.

2. An elevation view of the micropile structure(s) identifying:
   A. Elevation view showing micropile locations and elevations; vertical and horizontal spacing; batter and alignment and the location of drainage elements (if applicable).
   B. Existing and finish grade profiles both behind and in front of the micropile structure.
3. Design parameters and applicable codes.
4. General notes for constructing the micropile structure including construction sequencing or other special construction requirements.
5. Horizontal and vertical curve data affecting the micropile structure and micropile structure control points. Match lines or other details to relate micropile structure stationing to centerline stationing.
6. A listing of the summary of quantities on the elevation drawing of each micropile structure showing pay item estimated quantities.
7. Micropile typical sections including micropile spacing and inclination; minimum drillhole diameter; pipe casing and reinforcing bar sizes and details; splice types and locations; centralizers and spacers; grout bond zone and casing plunge lengths (if used); corrosion protection details; and connection details to the substructure footing, anchorage, plates, etc.
8. A typical detail of ~~verification and~~ production proof test micropiles defining the micropile length, minimum drillhole diameter, inclination, and load test bonded and unbonded test lengths.
9. Details, dimensions, and schedules for all micropiles, casing and reinforcing steel, including reinforcing bar bending details.
10. Details for constructing micropile structures around drainage facilities (if applicable).

The working drawings and design calculations shall be signed and sealed by the Contractor’s Professional Engineer or by the Consultant designer’s Professional Engineer (if applicable), by the Owner. If the micropile Contractor uses a Consultant design engineer to prepare the design, the micropile Contractor shall still have overall contract responsibility for both the design and the construction.

Submit 3 sets of the working drawings with the initial submission. Drawing sheet size shallbe 11" x17". One set will be returned with any indicated corrections. The Engineer will approve or reject the Contractor's submittal within 15 calendar days after receipt of a complete submission. If revisions are necessary, make the necessary corrections and resubmit 5 revised sets. When the drawings are approved, furnish 3 sets and a PDF copy set of the approved drawings. The Contractor will not be allowed to begin micropile structure construction or incorporate materials into the work until the submittal requirements are satisfied and found acceptable to the Engineer. Changes or deviations from the approved submittals must be re-submitted for approval. No adjustments in contract time or delay or impact claims will be allowed due to incomplete submittals.

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Revise the drawings when plan dimensions are changed due to field conditions or for other reasons. Within 30 days after completion of the work, submit as-built drawings to the Engineer. Provide revised design calculations signed by the approved Registered Professional Engineer for all design changes made during the construction of the micropile structure.

503.08 Construction Submittals

The Contractor shall prepare and submit to the Engineer, for review of completeness, 3 copies of the following for the micropile system or systems to be constructed:

(a). Detailed step-by-step description of the proposed micropile construction procedure, including personnel, testing and equipment to assure quality control. This step-by-step procedure shall be shown on the working drawings in sufficient detail to allow the Engineer to monitor the construction and quality of the micropiles.

(b). Proposed start date and time schedule and micropile installation schedule providing the following:

1. Micropile number
2. Micropile design load
3. Type and size of reinforcing steel
4. Minimum bond length
5. Total micropile length
6. Micropile top footing attachment

(c) If welding of casing is proposed, submit the proposed welding procedure, certified by a qualified welding specialist.

(d) Information on headroom and space requirements for installation equipment that verify the proposed equipment can perform at the site.

(e) Plan describing how surface water, drill flush, and excess waste grout will be controlled and disposed.

(f) Certified mill test reports for the reinforcing steel or coupon test results for permanent casing without mill certification. The ultimate strength, yield strength, elongation, and material properties composition shall be included. For API N-80 pipe casing, coupon test results may be submitted in lieu of mill certification.

(g) Proposed Grouting Plan. The grouting plan shall include complete descriptions, details, and supporting calculations for the following:

1. Grout mix design and type of materials to be used in the grout including certified test data and trial batch reports.

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2. Methods and equipment for accurately monitoring and recording the grout depth, grout volume and grout pressure as the grout is being placed.
3. Grouting rate calculations, when requested by the Engineer. The calculations shall be based on the initial pump pressures or static head on the grout and losses throughout the placing system, including anticipated head of drilling fluid (if applicable) to be displaced.
4. Estimated curing time for grout to achieve specified strength. Previous test results for the proposed grout mix completed within one year of the start of grouting may be submitted for initial verification and acceptance and start of production work. During production, grout shall be tested in accord with Section 503.18.
5. Procedure and equipment for Contractor monitoring of grout quality.

(h). Detailed plans for the proposed micropile load testing method. This shall include all drawings, details, and structural design calculations necessary to clearly describe the proposed test method, reaction load system capacity and equipment setup, types and accuracy of apparatus to be used for applying and measuring the test loads and pile top movements in accordance with Section 503.20, Pile Load Tests.

(i) Calibration reports and data for each test jack, pressure gauge and master pressure gauge to be used. The calibration tests shall have been performed by an independent testing laboratory, and tests shall have been performed within 90 calendar days of the date submitted. Testing shall not commence until the Engineer has reviewed and accepted the jack, pressure gauge, master pressure gauge and electronic load cell calibration data.

Work other than test pile installation shall not begin until the construction submittals have been received, reviewed, and accepted in writing by the Engineer. Provide submittal items 1 through 5 at least 21 calendar days prior to initiating micropile construction, item 7 as the work progresses for each delivery and submittal items 6, 8 and 9 at least 7 days prior to start of micropile load testing or incorporation of the respective materials into the work. The Contractor shall allow the Engineer 7 calendar days to review the construction submittals after a complete set has been received. Additional time required due to incomplete or unacceptable submittals shall not be cause for delay or impact claims. All costs associated with incomplete or unacceptable Contractor submittals shall be the responsibility of the Contractor.

503.09 Pre-construction Meeting

A pre-construction meeting will be scheduled by the Engineer and held prior to the start of micropile construction. The Engineer, prime Contractor, micropile specialty Contractor, micropile design engineer, excavation Contractor and geotechnical instrumentation specialist (if applicable) shall attend the meeting. Attendance is mandatory. The pre-construction meeting will be conducted to clarify the construction requirements for the work, to coordinate the construction schedule and activities, and to identify contractual relationships and delineation of responsibilities amongst the prime Contractor and the various Subcontractors - specifically those pertaining to excavation for micropile structures, anticipated subsurface conditions, micropile installation and testing, micropile structure survey control and site drainage control.

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MATERIALS

503.10 Furnish materials new and without defects. Remove defective materials from the jobsite at no additional cost. Materials for micropiles shall consist of the following:

Admixtures for Grout: Admixtures shall conform to the requirements of ASTM C 494/AASHTO M194. Admixtures that control bleed, improve flowability, reduce water content, and retard set may be used in the grout, subject to the review and acceptance of the Engineer. Admixtures shall be compatible with the grout and mixed in accordance with the manufacturer's recommendations. Expansive admixtures shall only be added to the grout used for filling sealed encapsulations and anchorage covers. Accelerators are not permitted. Admixtures containing chlorides are not permitted.

Cement: All cement shall be Portland cement conforming to ASTM C 150/AASHTO M85, Types I, II, III or V.

Centralizers and Spacers: Centralizers and spacers shall be fabricated from schedule 40 PVC pipe or tube, steel, or material non-detrimental to the reinforcing steel. Wood shall not be used.

Encapsulation: Encapsulation (double corrosion protection) shall be shop fabricated using high-density, corrugated polyethylene tubing conforming to the requirements of ASTM D3350/AASHTO M252 with a nominal wall thickness of 0.8 mm. The inside annulus between the reinforcing bars and the encapsulating tube shall be a minimum of 5mm and be fully grouted with non-shrink grout conforming to Materials Section 2.0.

Epoxy Coating: The minimum thickness of coating applied electrostatically to the reinforcing steel shall be 0.3 mm. Epoxy coating shall be in accordance with ASTM A775 or ASTM A934. Bend test requirements are waived. Bearing plates and nuts encased in the pile concrete footing need not be epoxy coated unless the footing reinforcement is epoxy coated.

Fine Aggregate: If sand - cement grout is used, sand shall conform to ASTM C 144/AASHTO M45.

Galvanization: If used, galvanization shall meet the requirements of ASTM A-153.

Grout: Neat cement or sand/cement mixture with a minimum 3-day compressive strength of 2000 psi and a 28-day compressive strength of 4000 psi per AASHTO T106/ASTM C109.

Permanent Casing Pipe: Permanent steel casing/pipe shall have the diameter and at least minimum wall thickness shown on the approved Working Drawings. The permanent steel casing/pipe:

1. Shall meet the Tensile Requirements of ASTM A252, Grade 3, except the yield strength shall be a minimum of 345 MPa to 552 MPa as used in the design submittal.

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2. May be new "Structural Grade" (a.k.a. "Mill Secondary") steel pipe meeting above but without Mill Certification, free from defects (dents, cracks, tears) and with two coupon tests per truckload delivered to the fabricator.

For permanent casing/pipe that will be welded for structural purposes, the following material conditions apply:

1. The carbon equivalency (CE) as defined in AWS D1.l, Section XI5.1, shall not exceed 0.45, as demonstrated by mill certifications
2. The sulfur content shall not exceed 0.05%, as demonstrated by mill certifications

For permanent casing/pipe that will be shop or field welded, the following fabrication or construction conditions apply:

1. The steel pipe shall not be joined by welded lap splicing
2. Welded seams and splices shall be complete penetration welds
3. Partial penetration welds may be restored in conformance with AWS D1.1
4. The proposed welding procedure certified by a welding specialist shall be submitted for approval

Threaded casing joints shall develop at least the required compressive, tensile, and/or bending strength used in the design of the micropile.

Plates and Shapes: Structural steel plates and shapes for pile top attachments shall conform to ASTM A 36/AASHTO M183, or ASTM A 572/AASHTO M223, Grade 350.

Reinforcing Bars: Reinforcing steel shall be deformed bars in accordance with ASTM A 615/AASHTO M31, Grade 420 or Grade 520 or ASTM A 722/AASHTO M275, Grade 1035. When a bearing plate and nut are required to be threaded onto the top end of reinforcing bars for the pile top to footing anchorage, the threading may be continuous spiral deformed ribbing provided by the bar deformations (e.g., Dywidag or Williams continuous threadbars) or may be cut into a reinforcing bar. If threads are cut into a reinforcing bar, the next larger bar number designation from that shown on the Plans shall be provided, at no additional cost. Bar tendon couplers, if required, shall develop the ultimate tensile strength of the bars without evidence of any failure.

Reinforcing Bar Corrosion Protection:

Sheathing: Smooth plastic sheathing, including joints, shall be watertight. Polyvinyl chloride (PVC) sheathing shall conform to ASTM D 1784, Class 13464-B.

Water: Water used in the grout mix shall conform to AASHTO T 26 and shall be potable, clean, and free from substances that may be injurious to cement and steel.

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CONSTRUCTION REQUIREMENTS

503.11 Site Drainage Control

The Contractor shall control and properly dispose of drill flush and construction related waste, including excess grout, in accord with the standard specifications and all applicable local codes and regulations. Provide positive control and discharge of all surface water that will affect construction of the micropile installation. Maintain all pipes or conduits used to control surface water during construction. Repair damage caused by surface water at no additional cost. Upon substantial completion of the Work, remove surface water control pipes or conduits from the site. Alternatively, with the approval of the Engineer, pipes or conduits that are left in place, may be fully grouted and abandoned or left in a way that protects the structure and all adjacent facilities from migration of fines through the pipe or conduit and potential ground loss.

Immediately contact the Engineer if unanticipated existing subsurface drainage structures are discovered during excavation or drilling. Suspend work in these areas until remedial measures meeting the Engineer's approval are implemented. Cost of remedial measures or repair work resulting from encountering unanticipated subsurface drainage structures, will be paid for as Extra Work.

503.12 Excavation

Coordinate the work and the excavation so the micropile structures are safely constructed. Perform the micropile construction and related excavation in accordance with the Plans and approved submittals. No excavations steeper than those specified herein or shown on the Plans will be made above or below the micropile structure locations without written approval of the Engineer.

503.13 Micropile Allowable Construction Tolerances

1. Centerline of piling shall not be more than 3" from indicated plan location.
2. Pile shall be plumb within 2 percent of total-length plan alignment.
3. Top elevation of pile shall be plus 1" or minus 2" maximum from vertical elevation indicated.
4. Centerline of reinforcing steel shall not be more than ¾" from indicated location.

503.14 Micropile Installation

The micropile Contractor shall select the drilling method, the grouting procedure, and the grouting pressure used for the installation of the micropiles. The micropile Contractor shall also determine the micropile casing size, final drillhole diameter and bond length, and central reinforcement steel sizing necessary to develop the specified load capacities and load testing requirements. The micropile Contractor is also responsible for estimating the grout take. There will be no extra payment for grout overruns.

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503.14 Drilling

The drilling equipment and methods shall be suitable for drilling through the conditions to be encountered, without causing damage to any overlying or adjacent structures or services. The drillhole must be open along its full length to at least the design minimum drillhole diameter prior to placing grout and reinforcement.

Temporary casing or other approved method of pile drillhole support will be required in caving or unstable ground to permit the pile shaft to be formed to the minimum design drillhole diameter. The Contractor's proposed method(s) to provide drillhole support and to prevent detrimental ground movements shall be reviewed by the Engineer. Detrimental ground movement is defined as movement which requires remedial repair measures. Use of drilling fluid containing bentonite is not allowed.

Costs of removal or remedial measures due to encountering unanticipated subsurface obstructions will be paid for as Extra Work.

503.15 Ground Heave or Subsidence

During construction, the Contractor shall observe the conditions in the vicinity of the micropile construction site on a daily basis for signs of ground heave or subsidence. Immediately notify the Engineer if signs of movements are observed. Contractor shall immediately suspend or modify drilling or grouting operations if ground heave or subsidence is observed, if the micropile structure is adversely affected, or if adjacent structures are damaged from the drilling or grouting. If the Engineer determines that the movements require corrective action, the Contractor shall take corrective actions necessary to stop the movement or perform repairs. When due to the Contractor's methods or operations or failure to follow the specified/approved construction sequence, as determined by the Engineer, the costs of providing corrective actions will be borne by the Contractor. When due to differing site conditions, as determined by the Engineer, the costs of providing corrective actions will be paid as Extra Work.

503.16 Pipe Casing and Reinforcing Bars Placement and Splicing

Reinforcement may be placed either prior to grouting or placed into the grout – filled drillhole before temporary casing (if used) is withdrawn. Reinforcement surface shall be free of deleterious substances such as soil, mud, grease or oil that might contaminate the grout or coat the reinforcement and impair bond. Pile cages and reinforcement groups, if used, shall be sufficiently robust to withstand the installation and grouting process and the withdrawal of the drill casings without damage or disturbance.

The Contractor shall check pile top elevations and adjust all installed micropiles to the planned elevations.

Centralizers and spacers (if used) shall be provided at 10' centers maximum spacing. The upper and lower most centralizer shall be located a maximum of 5' from the top and bottom of the

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micropile. Centralizers and spacers shall permit the free flow of grout without misalignment of the reinforcing bar(s) and permanent casing. The central reinforcement bars with centralizers shall be lowered into the stabilized drillhole and set. The reinforcing steel shall be inserted into the drill hole to the desired depth without difficulty. Partially inserted reinforcing bars shall not be driven or forced into the hole. Contractor shall redrill and reinsert reinforcing steel when necessary to facilitate insertion.

Lengths of casing and reinforcing bars to be spliced shall be secured in proper alignment and in a manner to avoid eccentricity or angle between the axes of the two lengths to be spliced. Splices and threaded joints shall meet the requirements of Materials Section 2.0. Threaded pipe casing joints shall be located at least two casing diameters (OD) from a splice in any reinforcing bar. When multiple bars are used, bar splices shall be staggered at least 12 inches.

503.17 Grouting

Micropiles shall be primary grouted the same day the load transfer bond length is drilled. The Contractor shall use a stable neat cement grout or a sand cement grout with a minimum 28-day unconfined compressive strength of 4000 psi. Admixtures, if used, shall be mixed in accordance with manufacturer's recommendations. The grouting equipment used shall produce a grout free of lumps and undispersed cement. The Contractor shall have means and methods of measuring the grout quantity and pumping pressure during the grouting operations. The grout pump shall be equipped with a pressure gauge to monitor grout pressures. A second pressure gauge shall be placed at the point of injection into the pile top. The pressure gauges shall be capable of measuring pressures of at least 150 psi or twice the actual grout pressures used, whichever is greater. The grout shall be kept in agitation prior to mixing. Grout shall be placed within one hour of mixing. The grouting equipment shall be sized to enable each pile to be grouted in one continuous operation.

The grout shall be injected from the lowest point of the drill hole and injection shall continue until uncontaminated grout flows from the top of the pile. The grout may be pumped through grout tubes, casing, hollow-stem augers, or drill rods. Temporary casing, if used, shall be extracted in stages ensuring that, after each length of casing is removed the grout level is brought back up to the ground level before the next length is removed. The tremie pipe or casing shall always extend below the level of the existing grout in the drillhole. The grout pressures and grout takes shall be controlled to prevent excessive heave or fracturing of rock or soil formations. Upon completion of grouting, the grout tube may remain in the hole, but must be filled with grout.

Grout within the micropiles shall be allowed to attain the required design strength prior to being loaded.

If the Contractor elects to use a postgrouting system, Working Drawings and details shall be submitted to the Engineer for review in accordance with Section 1.8, Pre-installation Submittals.

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503.18 Grout Testing

Grout within the micropile ~~verification and~~ proof test piles shall attain the minimum required 3-day compressive strength of 2000psi prior to load testing. Previous test results for the proposed grout mix completed within one year of the start of work may be submitted for initial verification of the required compressive strengths for installation of ~~pre-production verification test piles and~~ initial production piles. During production, micropile grout shall be tested by the Contractor for compressive strength in accordance with AASHTO T106/ASTM C109 at a frequency of no less than one set of three 2" grout cubes from each grout plant each day of operation or per every 10 piles, whichever occurs more frequently. The compressive strength shall be the average of the 3 cubes tested.

Grout consistency as measured by grout density shall be determined by the Contractor per ASTM C 188/AASHTO T 133 or API RP-13B-1 at a frequency of at least one test per pile, conducted just prior to start of pile grouting. The Baroid Mud Balance used in accordance with API RP-13B-1 is an approved device for determining the grout density of neat cement grout. The measured grout density shall be between 135 pcf and 150 pcf.

Grout samples shall be taken directly from the grout plant. Provide grout cube compressive strength and grout density test results to the Engineer within 24 hours of testing.

503.19 Micropile Installation Records

Contractor shall prepare and submit to the Engineer full-length installation records for each micropile installed. The records shall be submitted within one work shift after that pile installation is completed. The data shall be recorded on the micropile installation log. A separate log shall be provided for each micropile.

503.20 Pile Load Tests

Perform ~~verification and~~ proof testing of piles at the locations specified herein or designated by the Engineer. Perform compression load testing in accord with ASTM D1143, tension load testing in accord with ASTM D3689, and lateral load testing in accord with ASTM D3966, except as modified herein. Testing shall be limited to tension load testing only. ~~One verification test will be required at the start of installation and~~ two proof test will be required.

~~503.21 Verification Load Tests~~

~~Perform a verification pile load test of the first production pile to verify the design of the pile system and the construction methods proposed prior to installing the remainder of the production piles. The verification pile shall be constructed in conformance with the approved Working Drawings. The verification test pile shall be the least critical production pile location.~~

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~~Verification load tests shall be performed to verify that the Contractor installed micropiles will meet the required compression and tension load capacities and load test acceptance criteria and to verify that the length of the micropile bond zone is adequate. The micropile verification load test results must verify the Contractor's design and installation methods, and be reviewed and accepted by the Engineer prior to beginning installation of production micropiles.~~

~~The drilling-and-grouting method, casing length and outside diameter, reinforcing bar lengths, and depth of embedment for the verification test pile(s) shall be identical to those specified for the production piles at the given locations. The verification test micropile structural steel sections shall be sized to safely resist the maximum test load.~~

~~The maximum verification and proof test loads applied to the micropile shall not exceed 80 percent of the structural capacity of the micropile structural elements, to include steel yield in tension, steel yield or buckling in compression, or grout crushing in compression. Any required increase in strength of the verification test pile elements above the strength required for the production piles shall be provided for in the contractor's bid price.~~

~~The jack shall be positioned at the beginning of the test such that unloading and repositioning during the test will not be required. When both compression and tension load testing is to be performed on the same pile, the pile shall be tested under compression loads prior to testing under tension loads.~~

503.22 Testing Equipment and Data Recording

Testing equipment shall include dial gauges, dial gauge support, jack and pressure gauge and a reaction frame. The contractor shall provide a description of test setup and jack, pressure gauge calibration curves in accordance with the Submittals Section.

Design the testing reaction frame to be sufficiently rigid and of adequate dimensions such that excessive deformation of the testing equipment does not occur. Align the jack, bearing plates, and stressing anchorage such that unloading and repositioning of the equipment will not be required during the test.

Apply and measure the test load with a hydraulic jack and pressure gauge. The pressure gauge shall be graduated in 100 psi increments or less. The jack and pressure gauge shall have a pressure range not exceeding twice the anticipated maximum test pressure. Jack ram travel shall be sufficient to allow the test to be done without resetting the equipment. Monitor the creep test load hold during verification tests with the pressure gauge, using it to accurately maintain a constant load hold during the creep test load hold increment of the verification test.

Measure the pile top movement with a dial gauge capable of measuring to 0.001". The dial gauge shall have a travel sufficient to allow the test to be done without having to reset the gauge. Visually align the gauge to be parallel with the axis of the micropile and support the gauge independently from the jack, pile or reaction frame. Use a minimum of two dial gauges when the

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test setup requires reaction against the ground or single reaction piles on each side of the test pile. The required load test data shall be recorded by the Engineer.

~~**503.23 Verification Test Loading Schedule**~~

~~Test verification piles designated for compression or tension load testing to a maximum test load of 2.0 times the micropile Design Load shown on the Plans or Working Drawings.~~

~~The verification pile load tests shall be made by incrementally loading the micropile in accordance with the following cyclic load schedule for both compression and tension loading:~~

~~Step~~	~~Loading~~	~~Applied Load~~	~~Hold Time (min.)~~
~~1~~	~~Apply AL~~		~~2.5~~
~~2~~	~~Cycle 1~~	~~0.15 DL~~ ~~0.30 DL~~ ~~0.45 DL~~ ~~AL~~	~~2.5~~ ~~2.5~~ ~~2.5~~ ~~1~~
~~3~~	~~Cycle 2~~	~~0.15 DL~~ ~~0.30 DL~~ ~~0.45 DL~~ ~~0.60 DL~~ ~~0.75 DL~~ ~~0.90 DL~~ ~~1.00 DL~~ ~~AL~~	~~1~~ ~~1~~ ~~2.5~~ ~~2.5~~ ~~2.5~~ ~~25~~ ~~2.5~~ ~~1~~
~~4~~	~~Cycle 3~~	~~0.15 DL~~ ~~1.00 DL~~ ~~1.15 DL~~ ~~1.30 DL~~ ~~1.45 DL~~ ~~AL~~	~~1~~ ~~1~~ ~~2.5~~ ~~10 to 60 minutes~~ ~~2.5~~ ~~1~~
~~5~~	~~Cycle 4~~	~~0.15 DL~~ ~~1.45 DL~~ ~~1.60 DL~~ ~~1.75 DL~~ ~~1.90 DL~~ ~~2.00 DL~~ ~~1.50 DL~~ ~~1.00 DL~~ ~~0.50 DL~~ ~~AL~~	~~1~~ ~~1~~ ~~1~~ ~~2.5~~ ~~2.5~~ ~~10~~ ~~5~~ ~~5~~ ~~5~~ ~~5~~

~~Pile top movement shall be measured at each load increment. The load-hold period shall start as soon as each test load increment is applied. The verification test pile shall be monitored for creep~~

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~~at the 1.30 Design Load (DL). Pile movement during the creep test shall be measured and recorded at 1, 2, 3, 4, 5, 6, 10, 20, 30, 50, and 60 minutes. The alignment load shall not exceed 5 percent of the DL load. Dial gauges shall be reset to zero after the initial AL is applied.~~

~~The acceptance criteria for micropile verification load tests are:~~

~~1. The pile shall sustain the first tension 1.0 DL test load with no more than ¼" total vertical movement at the top of the pile, relative to the position of the top of the pile prior to testing.~~

~~2. At the end of the 1.30 DL creep test load increment, test piles shall have a creep rate not exceeding 0.04"/log cycle time (1 to 10 minutes) or 0.08"/log cycle time (6 to 60 minutes or the last log cycle if held longer). The creep rate shall be linear or decreasing throughout the creep load hold period.~~

~~3. Failure does not occur at the 2.0 DL maximum test load. Failure is defined as load where the slope of the load versus head settlement curve first exceeds .03"/kip. The Engineer will provide the Contractor written confirmation of the micropile design and construction within 3 working days of the completion of the verification load tests. This written confirmation will either confirm the capacities and bond lengths specified in the Working Drawings for micropiles or reject the piles based upon the verification test results.~~

~~**503.24 Verification Test Pile Rejection**~~

~~If a verification-tested micropile fails to meet the acceptance criteria, the Contractor shall modify the design, the construction procedure, or both. These modifications may include modifying the installation methods, increasing the bond length, or changing the micropile type. Any modification that necessitates changes to the structure shall require the Engineer's prior review and acceptance. Any modifications of design or construction procedures or cost of additional verification test piles and load testing shall be at the Contractor's expense. At the completion of verification testing, test piles shall be removed down to the elevation specified by the Engineer.~~

503.25 Proof Load Tests

Proof testing shall be conducted of one test for each abutment~~every 2 pile installations~~. ~~Location of additional proof test piles shall be as designated by the Engineer.~~ The maximum proof test loads applied to the micropile shall not exceed 80 percent of the structural capacity of the micropile structural elements, to include steel yield in tension, steel yield or buckling in compression, or grout crushing in compression.

503.26 Proof Test Loading Schedule

Test piles designated for compression or tension proof load testing to a maximum test load of 1.60 times the micropile Design Load shown on the Plans or Working Drawings. Proof tests shall be made by incrementally loading the micropile in accordance with the following schedule, to be used for both compression and tension loading

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Step	Loading	Applied Load	Hold Time (min.)
1	Apply AL		2.5
2	Load Cycle	0.15 DL 0.30 DL 0.45 DL 0.60 DL 0.75 DL 0.90 DL 1.00 DL 1.15 DL 1.30 DL 1.45 DL 1.60 DL	2.5 2.5 2.5 2.5 2.5 2.5 2.5 2.5 10 to 60 minutes 2.5 2.5
3	Unload Cycle	1.30 DL 1.00 DL 0.75 DL 0.50 DL 0.25 DL AL	4 4 4 4 4 4

Depending on performance, either a 10 minute or 60 minute creep test shall be performed at the 1.30DL Test Load. Where the pile top movement between 1 and 10 minutes exceeds 0.04", the Maximum Test Load shall be maintained an additional 50 minutes. Movements shall be recorded at 1, 2, 3, 5, 6, 10, 20, 30, 50 and 60 minutes. The alignment load shall not exceed 5 percent of DL. Dial gauges shall be reset to zero after the initial AL is applied. The acceptance criteria for micropile proof load tests are:

1. The pile shall sustain the tension 1.0 DL test load with no more than ½" total vertical movement at the top of the pile, relative to the position of the top of the pile prior to testing.

2. At the end of the 1.30DL creep test load increment, test piles shall have a creep rate not exceeding 0.04"/log cycle time (1 to 10 minutes) or 0.08"/log cycle time (6 to 60 minutes).The creep rate shall be linear or decreasing throughout the creep load hold period.

3. Failure does not occur at the 1.60DL maximum test load. Failure is defined as load where the slope of the load versus head settlement curve first exceeds .03"/kip.

503.27 Proof Test Pile Rejection

If a proof-tested micropile fails to meet the acceptance criteria, the Contractor shall immediately proof test another micropile within that footing. For failed piles and further construction of other piles, the Contractor shall modify the design, the construction procedure, or both. These modifications may include installing replacement micropiles, incorporating piles at not more than 50% of the maximum load attained, postgrouting, modifying installation methods, increasing the

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bond length, or changing the micropile type. Any modification that necessitates changes to the structure design shall require the Engineer's prior review and acceptance. Any modifications of design or construction procedures, or cost of additional ~~verification test piles and verification and/or~~ proof load testing, or replacement production micropiles, shall be at the Contractor's expense.

METHOD OF MEASUREMENT

Measurement will be made as follows for the quantity, as specified or directed by the Engineer:

Micropiles will be measured per each, installed, tested and accepted

The final pay quantities will be the design quantity increased or decreased by any changes authorized by the Engineer.

BASIS OF PAYMENT

The quantities accepted for payment will be paid for at the contract unit prices for the following items:

Pay Item	**Unit**
Micropiles.....	Each

The contract unit prices for the above items will be full and complete payment for providing all design, materials, labor, equipment and incidentals to complete work.

The unit contract amount for "Micropiles" shall include the drilling, furnishing, and placing the reinforcing steel and casing, grouting, and pile top attachments. The micropile contractor is also responsible for estimating the grout take. There will be no extra payment for grout overruns.

REVISION OF SECTION 504
CONCRETE BLOCK FACING MSE WALL

Section 504 of the Standard Specifications is hereby revised for this project to include the following:

DESCRIPTION

504.06 This work consists of constructing a Concrete Block Facing Mechanically Stabilized Earth (MSE) Retaining Wall System at the locations and to the lines and grades shown on the plans. Either metallic or geosynthetic reinforcement (woven fabrics or geogrids) as specified in this specification may be used as MSE reinforcement in the reinforced structure backfill zone. The retained structure backfill zone is the structure backfill retained by the reinforced structure backfill zone as shown on the plans.

MATERIALS

504.07 Shop Drawings. The Contractor shall submit six sets of shop drawings and certified material test reports for review prior to construction of the wall. See subsection 504.12 for a complete list of submittal requirements. Shop drawings shall be submitted in accordance with subsection 105.02.

The shop drawings shall provide the details necessary to demonstrate compliance with the Contract, including:

(a) *Wall Layouts*. Wall layouts shall conform to the lines and grades on the plans including start, corner, and end stations, leveling pad step breaks, total number of blocks and top and bottom of wall elevations. For walls with rail anchoring slabs, the top of block elevations or the cast in place leveling course shall be within 2 inches of the elevation shown on the plans measured from the bottom of the anchoring slab. The construction batter required to achieve the batter shown on the plans shall be shown on the shop drawings. If temporary walls are required for the construction of permanent walls, the permanent wall vendor shall provide the shop drawings and certified material test reports for temporary walls.

(b) *Block Reinforcement Locations*. Unless otherwise shown on the plans, each layer of soil reinforcement shall be connected to the facial blocks. The block placement sequence, if other than bottom up and end to end of wall, shall be shown. The block to block reinforcement connections and the cut block limits at curved wall corners shall be shown.

(c) *Wall Elevations*. Except for the top of the leveling pad, wall elevations given on the plans are based on an 8 inch nominal block height. The actual reinforcement elevations shall be marked on the shop drawings by taking into account the supplied block height, number of reinforced layers, thickness of soil reinforcing and shimming material, and, for curved corners, the interposing layers of reinforcement.

(d) *Soil Reinforcement Material*. The soil reinforcement type, Minimum Average Roll Value of the Ultimate tensile strength, T_{ULT} (MARV), for geosynthetic soil reinforcement or yield strength for metallic soil reinforcement, spacing, lengths, elevations, and the corresponding wall design height segments shall be shown on the shop drawings. The starting and ending stations for change in grade of reinforcement material shall be shown for walls with different grade of reinforcement material at the same elevation. Material grade shall be clearly identified on each roll of reinforcement to avoid errors in placement. Elevations of the reinforcement layers shall be as specified on the shop drawings.

(e) *Soil Reinforcement Length (RL)*. The soil reinforcement length shall be measured from the front face of the concrete block face to the end of the soil reinforcement as measured to the last cross member. Except for secondary reinforcement, soil reinforcement lengths shall not be less than the lengths specified on the plans.

For wall segments with a Design Height (DH) greater than or equal to 8 feet, the soil reinforcement shall be the same length from top to bottom of the wall.

For wall segments with a Design Height (DH) less than 8 feet, the length of the top layer of soil reinforcement shall be 8 feet and all other layers of soil reinforcement shall be the same length from top to bottom of the wall.

Unless shown otherwise on the plans, the soil reinforcement lengths shall be as follows:

Design Height (DH)	Reinforcement Length (RL)	Reinforcement Length Top Layer
DH ≤ 6'-0"	6'-0"	8'-0"
6'-0" < DH < 8'-0"	DH	8'-0"
DH ≥ 8'-0"	0.7 x DH but not less than 8'-0"	0.7 x DH but not less than 8'-0"

The Reinforcement Lengths shown on the shop drawings shall be the reinforcement length required for internal stability and pull-out only, but they shall not be less than those shown in the table above. External Stability (bearing pressure, sliding and overturning) and global stability have already been considered and checked in the design.

(f) *Soil Reinforcement Spacing*.

1. The first (bottom) layer of soil reinforcement shall be one or two times the block height, not to exceed 16 inches, above the top of the leveling pad.

2. The last (top) layer of soil reinforcement shall be no further than three times the block height, not to exceed 24 inches, below the top of the uppermost concrete block.

3. The vertical spacing between layers of adjacent soil reinforcement shall be less than four times the block height, not to exceed 32 inches. For walls deriving their connection capacity by friction the maximum vertical spacing of the reinforcement shall be limited to two times the block depth (front face to back face), not to exceed 24 inches, to assure construction and long-term stability. For tributary strength computations, the top row of reinforcement shall be one-half the vertical spacing immediately below the top of the wall.

(g) *Long Term Design Strength (LTDS) of Reinforcement*.

1. The design charts on the plans define the strengths required for the zone of mechanical reinforcement of soil. Based on the total summed LTDS, the reinforcement proposed by the shop drawings for a specific wall height shall meet or exceed the total LTDS shown on the plans. This proposed reinforcement shall allow for a maximum of plus or minus 15 percent variation in each individual layer.

2. Metallic (Inextensible) Soil Reinforcement. The net section at the soil reinforcement to block connection shall be used for the sacrificial thickness calculation. The following minimum sacrificial thickness for reinforcement shall be applied to the 75 year LTDS calculations:

Galvanization Loss	15 µm/year for first 2 years 4 µm/year for subsequent years
Carbon steel loss	12 µm/year after zinc depletion

3. C. Geosynthetic (Extensible) Soil Reinforcement. Geosynthetic soil reinforcement shall be a geogrid or woven geotextile. For polyester (PET), polypropylene (PP), and high-density polyethylene (HDPE) reinforcement, the LTDS of material shall be determined using the following K percentages to ensure the required design life. Unless otherwise specified, LTDS shall not exceed the following K percent of its ultimate tensile strength, T_{ULT} (MARV), i.e.

   LTDS = K * T_{ULT} (MARV)

   (1) Geogrid reinforcement (HDPE, PET):

Products	K
Tensar	20%
Fortrac, Miragrid, Strata, Synteen and Raugrid	24%

(2) All products not listed above:

Products	K
All geogrid or woven geotextile products meeting AASHTO Standard Specifications for Highway Bridges, 16th Edition	10%
Products not meeting AASHTO Standard Specifications for Highway Bridges, 16th Edition including Non-woven geotextile products	5%

(h) *Design Heights and Supplied Reinforcing Material*. Unless otherwise defined on the plans, the wall design height shall be measured vertically from the top of the leveling pad to the top of the concrete rail anchoring slab for walls with railing, or to the top of the cast-in-place concrete coping for walls without railing. For walls that are in front of a bridge abutment that is founded on a deep foundation, the design height used to determine the soil reinforcement length shall be measured vertically from the top of the leveling pad to the top of the roadway carried by the bridge and the wall. Bridge approach slabs shall not be considered in the design of the MSE wall.

For both geosynthetic and metallic reinforcement, the required reinforcement LTDS and the supplied LTDS (determined in accordance with the K factors or depletion of material as defined above) with corresponding brand and grade of material shall be marked clearly on the elevation view or in a tabulation summary. The LTDS of the supplied reinforcement grade must meet or exceed the required LTDS corresponding to the reinforcement spacing provided.

(i) *Tiered Walls*. For the reinforcement layouts of tiered walls, the overall geometry, the reinforcement length and the sum of the LTDS provided from all layers in all tiers shall be in close conformity with the retaining wall system shown on the plans in order to ensure that local, global, and internal stability requirements have been met.

(j) *Obstructions*. Details for the placement of soil reinforcement around obstructions (i.e. steel piles, concrete piers, concrete boxes, pipes, etc.) shall be shown on the shop drawings. Design calculations shall be provided showing that the internal stability of the wall meets the required safety factors in the area of the obstruction.

(k) *Table of Quantities*. A table comparing the Structural Backfill (Class 1), Mechanical Reinforcement of Soil, Geomembrane, and Block Facing quantities shown on the plans to the quantities shown in the shop drawings and percent difference (positive percent indicates an increase in shop drawing quantities from the plans) shall be shown on the shop drawings. Structure Backfill (Class 1), Mechanical Reinforcement of Soil, Geomembrane, and Block Facing quantities shall be calculated in accordance with the Contract. The Contractor shall notify the Engineer of the difference in plan and shop drawing quantities before wall construction begins.

(l) *Placement Schedule*. Geomembrane placement schedule and clearances to soil reinforcements shall be shown.

(m) *Vertical Slip Joints*. Locations of stack bond blocks with vertical slip joints for differential settlement relief shall be as specified in subsection 504.19.

504.08 Backfill. Unless otherwise specified on the plans, wall backfill material in the reinforced structure backfill zone and the *associated* trapezoidal retained structure backfill zone shall conform to the requirements for Structure Backfill (Class 1) of Section 206. For reinforcement tensile stress and associated pullout, a friction angle of 34 degrees shall be assumed for Structure Backfill (Class 1). Structure Backfill (Class 1) shall be considered to be

non-aggressive soil for corrosion and durability computations. All reinforcing elements shall be designed to ensure a minimum design life of 75 years for permanent structures.

504.09 Leveling Pad. Concrete for the leveling pad shall be Concrete (Class D) conforming to the requirements of Section 601. Unless specified on the plans, the maximum vertical step shall be no greater than either 24 inches or three blocks, whichever is less. The leveling pad shall be reinforced only at the steps. When the toe of the wall is founded on a slope steeper than 1.5 (H) to 1 (V), the leveling pad shall be constructed with reinforced concrete with same reinforcing schedule as at its steps. Leveling pad concrete shall be cured for at least 12 hours before placement of the concrete blocks.

504.10 Geomembrane and Joints. A Geomembrane shall be installed on all walls at the top of the reinforced structure backfill zone and retained structure backfill zone to intercept surface runoff and prevent salt penetration into the backfill of the wall as shown on the plans. The Geomembrane shall meet the requirements of subsection 712.08 for geomembrane, and shall have a minimum thickness of 30 mils. It shall be spliced with a dual track field seamed joint in accordance with ASTM D4437 or ASTM D7717. For small local coverage areas, less than 30 square feet, the membrane may be spliced using a 6 inch minimum overlap and an adhesive or a single seam portable thermal welding tool, as suggested by the membrane manufacturer and approved by the Engineer. Unless otherwise shown on the plans, the membrane shall have a minimum coverage length measured perpendicular to the wall face of at least the wall Design Height (DH) plus Soil Reinforcement Length (RL) plus 1.5 feet. The membrane shall be installed with a slope between 20:1 (minimum) and 10:1 (maximum), as shown on the plans, from the block facing to a drainage system located at the cut or pre-filled slope as shown on the plans.

The drainage system shall consist of a 12 inch wide Geo-Composite strip drain inserted into a slot in the Geomembrane, at 10 foot maximum spacing, that collects the water from the membrane and conveys it to a water collector system at the toe of the 1:1 slope as shown on the plans. The water collector system shall consist of a 4 inch diameter perforated collector pipe surrounded by Filter Material Class B and wrapped with Class 3 Geotextile. A 4 inch diameter non-perforated drain pipe, at 100 foot maximum spacing, shall be used to discharge the water in the water collector system out the face of the wall.

Alternatives for the drainage system shown on the plans may be used by the Contractor. A detailed layout of this equivalent water collection system shall be provided by the Contractor and approved by the Engineer.

For tiered walls, a Geomembrane shall be installed between the top of the bottom wall and the toe of the top wall as shown on the plans.

504.11 Prefabricated Concrete Facing Blocks. Concrete blocks including partial blocks shall conform to the requirements shown on the plans and these specifications including the color, texture, and pattern. The Contractor shall provide certification that the results of tests performed in accordance with this subsection meet the requirements of the appropriate specification.

(a) Cementitious material shall meet the requirements of Section 701.

(b) Aggregates used in concrete blocks shall conform to ASTM C33 for normal weight concrete aggregate.

(c) The 28 day compression strength for concrete blocks shall be equal to or greater than 4500 psi. The quality of blocks shall be maintained such that the variations of the compression strengths are within 10 percent. The minimum oven dry unit weight shall be 125 pcf with a maximum water absorption rate by weight of 6 percent. Testing shall be performed in accordance with ASTM C140.

(d) All units shall be sound and free from cracks or other defects that would interfere with proper placement of the unit, or impair the strength or permanence of the construction. Cracks, chips, or color blemishes will be cause for rejection.

Any architectural or graffiti resistant treatments shall meet the requirements shown on the plans. If architectural coating is used and graffiti resistant treatments or water repellant sealer is required, the

Contractor shall provide the Engineer with four sample blocks for each different color and texture prior to beginning wall construction. Water-resistant or repellant coatings shall conform to ASTM C1262.

The permissible variations in the exterior dimensions of the concrete blocks shall not differ more than plus or minus ⅛ inch, except the height of the block shall be within plus or minus $^{1}/_{16}$ inch from the specified dimensions for an individual block. The minimum thickness of any walls or webs within the block shall be on average 2.5 inches at the face and 1.5 inches and 2 inches at stem and back. The vertical edges, if applicable, shall be chamfered for splitting and precise dimensioning.

(e) The Engineer shall be allowed access to the manufacturer's facilities to inspect and sample units from lots prior to delivery with a minimum 2 working days advance notice. The Engineer will reject any concrete blocks, which do not meet the requirements of this specification. The Contractor shall notify the Engineer in writing at least 3 working days before shipment of blocks begins.

504.12 Certifications, Calculations and Testing Reports. The Contractor shall provide the following reports, certifications, calculations and checklists as needed to accompany the shop drawing submittal. All engineering calculations, as stated in subsections 504.07(g)2, 504.07(j), 504.07(k), 504.12(e) and 504.12(f) shall be certified and stamped by a Professional Engineer licensed in the State of Colorado.

(a) *Certification of T_{ULT} (MARV) or Ultimate Tensile Strength*. For geo-synthetic reinforced systems only, the Contractor shall submit a certification letter from the manufacturer which provides the T_{ULT} (MARV) and certifies that the T_{ULT} (MARV) of the supplied materials have been determined in accordance with ASTM D4595 or ASTM D6637 as appropriate. For metallic wall reinforcement, a mill test report containing the ultimate tensile strength for the soil reinforcement shall be included in the certification.

(b) *Report Of The Block-Reinforcement Connection Test*. The test report shall be prepared and certified by an independent laboratory. The block to reinforcement connection test method shall conform to the requirements of ASTM D6638 with a service state connection strength displacement criterion of ¾ inch or National Concrete Masonry Association (NCMA) Methods SRWU-1.

(c) *Report For Block-Block Connection Test*. An independent laboratory shall prepare the test report. The block-to-block connection test method shall conform to the requirements of NCMA Methods SRWU-2. The service state connection strength displacement criterion shall be ¾ inch.

(d) *Report For Soil To Reinforcement Interface Pullout Test*. The test report shall be prepared and certified by an independent laboratory. The soil to reinforcement interface pullout test method shall conform to the requirements of ASTM D6706. Tests shall include the full range of overburden pressures as defined by the wall design heights.

(e) *Certification of Facial Block To Reinforcement Long-Term Connection Strength*. A certification shall be provided with detailed calculations according to the latest AASHTO Standard Specification including Interim and independent laboratory test results performed in accordance with FHWA NHI-00-043, Appendix A3 to demonstrate that the facial block to reinforcement connection meets or exceeds the current AASHTO 75 year design life requirements.

(f) *Certification of Reinforcement Pullout*. A certification shall be provided with detailed calculations to demonstrate that reinforcement pullouts meet or exceed the current AASHTO requirements. The metal reinforcement breakage and pullout calculations shall include a combination of 75 years of material depletion for carbon steel and galvanization loss.

(g) *Report and Certification for Concrete Block 28 Day Compression Strength and Water Absorption Rate*. For the 28 day compressive strength test, either a full block or a saw cut coupon compressive test is acceptable to verify the 28-day concrete strength provided the sample allows the test to conform to ASTM C90. The sampling shall be done at manufacturer’s casting yard and testing results shall be pre-approved before shipment. The Engineer will approve the sample selections for the coupon tests. Coupons shall be cut from the two sides or the back of block (not the front split face) with maximum two original concrete surfaces. The

average compressive strength of three tests from three randomly selected blocks, with load applied in the bearing direction shall be equal to or greater than 4500 psi with the minimum of 4000 psi for individual tests in accordance with ASTM C90 and ASTM C140. For the water absorption rate test, a minimum of two coupons shall be prepared and marked for each block, one coupon for successfully conducting the supplier's tests and one spared for future Engineer's test. The spared coupons from the three tests shall be labeled and delivered to the Engineer with the certification. The minimum oven dry density of concrete coupons shall be 125 pcf with a maximum water absorption rate by weight of 6 percent as determined by ASTM C140. Coupons shall be cut from relatively the same location of each block and prepared with uniform workmanship. Each individual sample must test within 12 percent of the average of the three.

(h) *Efflorescence and Freeze and Thaw Test*. The block shall be visually efflorescence free. Efflorescence control agent shall be used in concrete mix design. An independent laboratory shall provide reports and certifications using one of the following tests in accordance with ASTM C1262 using tap water or 3 percent saline solution and ASTM C1372 as appropriate:

(1) Test results for freeze and thaw durability shall be graphed and supplied with test data points every 50 cycles up to 300 cycles to confirm that blocks with concrete additives alone can survive 150 cycles with weight loss for each of 4 of the five samples not exceeding 1.0 percent of the initial weight in a tap water solution.

(2) Test results for freeze and thaw durability shall be graphed and supplied with test data points every 25 cycles up to 100 cycles to confirm that blocks with concrete additives alone can survive 60 cycles with weight loss for each of 4 of the five samples not exceeding 1.0 percent of the initial weight in a 3 percent saline solution.

A project specific freeze and thaw durability test shall be required for walls meeting one of the following requirements:

(1) Projects with a total facing area greater than 6000 square feet, as calculated in subsection 504.25, item (1), or

(2) Projects with any wall in front of or adjacent to bridge abutments and piers.

Wall construction may begin when acceptable freeze and thaw durability test results of units made with the same material, concrete mix design, manufacturing process, and curing method, conducted not more than 12 months prior to delivery until the test results of the actual blocks used in the wall can be obtained and submitted. The test results shall be submitted within one week of being recorded. The frequency of the freeze and thaw durability test shall be a minimum of one test every 6000 square foot of facing, as calculated in subsection 504.25, item (1).

For walls not requiring a project specific freeze and thaw durability test, the Contractor shall submit a certification letter from the facing manufacturer. The certification letter shall include acceptable freeze and thaw durability test results conducted not more than 12 months prior to delivery, that meet the requirements of subsection 8 A or 8 B above. The Certification shall be for units made with the same material, concrete mix design, manufacturing process, and curing method. The Engineer shall be allowed access to the manufacturer's facilities and records to verify that the mix design used in the certified freeze and thaw durability test results is the same as the mix design used for the actual blocks used in the project.

(i) *Submittal Checklist*. The Contractor shall submit the Block Faced MSE Wall Submittal Checklist, Form 1401, with the Certifications, Calculations and Testing Report submittal package included with the shop drawing submittal.

514.13 Conditions to Waive the Block-Reinforcement Connection Testing Reports. Unless otherwise noted on the plans the Contractor's Professional Engineer seal requirement for the Facial Block to Reinforcement Long-Term Connection Strength certified test report required by subsection 504.12(e) may be waived if the following conditions are met:

(1) Every block shall be connected by friction with either a main or a secondary reinforcement starting at 2 inches maximum from the front face of block.

(2) The spacing for main reinforcement is two blocks maximum or 16 inches, whichever is less.

(3) The secondary reinforcement shall be applied in between the main reinforcement. The same grade of material as used for main reinforcement shall be used for the secondary reinforcement: however only a minimum of 36 inches total length measured from the face of block is required.

(4) Aggregate filled cells shall be filled with ¼ inch aggregate. In lieu of aggregate filled cells, the cells in the top four blocks of the wall shall be doweled with steel or fiberglass bars and grouted with cement. Punched or poked holes through fabric reinforcement are allowed to accommodate grout and dowel bars.

504.14 Hybrid MSE Wall Systems.

A hybrid system is one which combines elements of both externally and internally stabilized systems.

An externally stabilized system uses a physical structure to hold the retained soil. The stabilizing forces of this system are mobilized either through the weight of a shape stable structure or through the restraints provided by the embedment of wall into the soil, if needed, plus the tieback forces of anchorages.

An internally stabilized system involves reinforced soils to retain fills and sustain loads. Reinforcement may be added to either the selected fills as earth walls or to the retained earth directly to form a more coherent stable slope. These reinforcements can either be layered reinforcements installed during the bottom-to-top construction of selected fills, or be driven piles or drilled caissons built into the retained soil. All this reinforcement must be oriented properly and extend beyond the potential failure mass.

Hybrid MSE wall systems may be used unless otherwise noted on the plans. Hybrid MSE wall systems are subject to the same design requirements for MSE walls and this specification. The shop drawings for Hybrid MSE wall system shall include a combination of design calculations and appropriate test results to demonstrate that it meets or exceeds the block facing system. Each unit in the hybrid MSE wall system shall have a facing area of 3.5 square feet and be stabilized by a counterfort. Hybrid MSE wall facing units shall be factory made with Class B Concrete with the following additional requirements:

(1) Minimum Cementitious Material Content: 610 lb./cu. yd.
(2) No more than 50 percent fine aggregate (AASHTO M6) by volume of total aggregate.
(3) Ambient temperature shall be a minimum of 40° F and rising when casting.
(4) Hybrid MSE wall facing shall be cured in accordance with AASHTO M170.

The following Certifications, Calculations and Testing Reports in subsection 504.12(c), (e), (g), and (h) are not required for Hybrid MSE wall systems. The facing to soil reinforcement connection test, subsection 504.12(b), may be waived only if the soil reinforcing spacing is less than or equal to 8 inches or the facing is secured and stabilized by hybrid components with primary reinforcement spacing less than 24 inches. The Contractor shall provide the following additional reports, certifications and calculations to accompany the shop drawing submittal for Hybrid MSE wall systems:

The Contractor shall submit the Block Faced MSE Wall Submittal Checklist, Form 1401, and the Panel Faced MSE Wall Submittal Checklist, Form 1402, with the Certifications, Calculations and Testing Report submittal package included with the shop drawing submittal.

CONSTRUCTION REQUIREMENTS

504.15 Approval and Qualifications of MSE Wall Installer. The job site wall foreman shall have experience in construction of at least five transportation related MSE walls within the last three years. Transportation related MSE walls are walls that carry or are adjacent to vehicular traffic and are constructed with MSE reinforcement in

the reinforced structure backfill zone. The foreman must have prior experience or adequate training on the products that the Contractor elects to use on the project. The resume and credentials of the foreman shall be submitted to the Engineer for approval prior to the pre-construction meeting. The foreman shall be on the site for 100 percent of the time during which the wall is being constructed.

504.16 Wall Test Segment. The wall test segment shall be the first segment of the wall constructed. The wall test segment shall be constructed in the presence of the Technical Representative and the Engineer and shall include construction of each of the 5 elements listed in subsection 504.17. The minimum length of the wall test segment shall be 40 feet or the full length of the wall if less than 40 feet. A wall test segment shall be constructed for the first wall constructed from each wall product used on the project.

504.17 Technical Representative of Wall Product Supplier. The Contractor shall arrange for a technical representative (Tech Rep) of the manufacturer of the wall products to be present during the construction of each wall test segment. If the wall products are supplied from different manufactures, a Tech Rep from each wall product shall be present. The Tech Rep shall be present for construction of the wall test segment and each of the following elements:

(1) Placement of a minimum of the first two layers of primary soil reinforcement and backfill,

(2) If obstructions (i.e. steel piles, concrete piers/abutments, concrete boxes, pipes, etc.) exist, placement of primary soil reinforcement and backfill at one of the obstructions,

(3) Placement of a minimum of the first six courses of blocks or a minimum of a four foot wall height,

(4) If a vertical slip joint is required, construction of the vertical slip joint in a minimum of a six course portion of block or a minimum of a four foot wall height, and

(5) If corners are required, construction of a corner representative of the corners in the wall in the project in a minimum of a six course portion of block or a minimum of a four foot wall height..

Before construction of the wall test segment the Tech Rep shall provide the Contractor and the Engineer the following:

(1) Technical instructions as required in the construction of the earth retaining wall system.

(2) Product specific specifications in the placement of the soil reinforcement and backfill in accordance with the wall system.

(3) Guidelines in placing the facing units and attaching them to the soil reinforcement in accordance with the system requirements.

(4) Provide technical assistance to the facing unit fabricator.

At the completion of the wall test segment the Tech Rep shall provide the following:

(1) Documentation that the wall test segment was constructed in accordance with the product specific specifications. This documentation shall include a location description (starting and ending stations and elevations) of the wall test segment.

(2) Documentation that the job site wall foreman is familiar with the wall products used to construct the walls on the project.

After completion of the wall test segment the Tech Rep shall be available whenever there is any special field condition such as change of geological condition, when there are equipment or personnel changes, or when requested by the Engineer.

504.18 Facial Block Quality Control, Placing Plan and Daily Placement Logs. Before the start of each wall construction, the Contractor shall provide a block-placing plan and shall supply daily placement logs to the Engineer weekly and at the completion of the wall. The daily placement log shall consist of an elevation view of the wall showing the dates, number of blocks placed, and the lot numbers of the blocks placed. The block quality control shall contain multiple submittals if required by subsection 504.12(g). Blocks shall be labeled with the manufacturer's lot number for each pallet and corresponding certification with one set of random samples tested for each 6000 blocks. At least one certification with supporting test results is required for each wall. Test results shall be reviewed and pre-approved by the Engineer before shipment. The Engineer may conduct separate tests with the spared coupons from the original samples. Block testing shall be increased to one set of sampling for every 3000 blocks if the Engineer identifies substandard blocks or when block color or concrete mix changes. With the Engineer's approval, block sampling may be reduced to one set of sampling for every 12,000 blocks after the first acceptable sampling results. The blocks used for Engineer's verification purposes shall be a maximum of 0.5 percent of the total number of blocks. The Engineer will conduct block sampling as early as possible and acquire blocks regularly. However, when tests are not performed within 90 days of the sampling date, the blocks will be returned untested. The Contractor shall coordinate and mark the block and backfill placing sequence on the daily placement logs. The log serves as means for the Engineer to identify where each lot of blocks was placed.

504.19 Wall with Curved Alignments, Tight Curved Corners, and Sections Adjacent To Bridge Abutment. The Contractor shall provide a placement plan that shows curved layouts, special block or saw cut block dimensions, sequence of block placement, and construction off-sets as recommended by the manufacture. For tight curved corners, 8 foot radius or less, and dissimilar foundations such as bridge abutment, to avoid blocks with random cracks, the Contractor shall install stack bond blocks with vertical slip joints as shown on the shop drawings; however reinforcement spacing shall be reduced to one block height, or other properly designed methods of block stabilization shall be used as approved by the Engineer. Short secondary reinforcements used to tied-back cut blocks in between main reinforcements are acceptable. A vertical slip joint for stress relief may be built either with pre-cut or partial pre-cut individual blocks or by saw cutting block face of breaking running bond vertically right after installation.

504.20 Excavation and Backfill. The base of the leveling pad shall receive the same compaction as cut areas required by subsection 203.07. The Contractor shall report to the Engineer in writing density test results for any unsatisfactory bearing material not meeting the minimum 90 percent compaction for walls less than 16 feet high and 95 percent of T-180 for walls higher than 16 feet. If the excavation for the placement of the leveling pad exposes an unsatisfactory bearing material, the Engineer may require removal and replacement of that material. The removed material shall be replaced with Structure Backfill (Class 1) compacted in conformance with subsection 206.03. The Engineer with the assistance of the geotechnical engineer of record will provide the limits including the depth of removal. As directed by the Engineer, and if required, Structure Backfill (Class 1) shall be reinforced with soil reinforcements in conjunction with wick drains and outlet pipes.

The Contractor shall grade the foundation for the bottom of the wall for a width equal to or exceeding the limits of the Reinforcement Length (RL) plus 18 inches as shown on the plans. This graded area shall be compacted with an appropriate vibratory roller weighing a minimum of 8 tons for at least five passes or as directed by the Engineer. For cut wall with continuous seepage, phasing of foundation construction or a different drainage and foundation improvement plan may be necessary.

The reinforced structure backfill zone and the retained structure backfill zone portion immediately behind the wall as defined on the plans shall be Structure Backfill (Class 1). Recycled asphalt, recycled concrete and flow-fill material shall not be substituted for Structure Backfill (Class 1). Each compacted layer of backfill within a distance equal to the reinforcement spacing away from the back of the block shall not exceed 4 inches. The triangular or trapezoidal portion behind the concrete blocks and above the spill of backfill, as shown on the plans, shall be filled with $\frac{3}{8}^{+}$ inch crushed rock, filter aggregates with filter fabric, or wall system specific fill as approved by the Engineer. Density tests behind and parallel to the wall in the triangular or trapezoidal portion above the backfill spill zone are not required. Each compacted layer of backfill shall not exceed 8 inches and shall be roughly leveled with the top of block elevation of the lift. The fill and compaction operation shall start 3 feet from the wall back face and progress toward the end of the reinforcement. All Structure Backfill (Class 1) including fill material under the wall and on-site material as allowed under subsection 504.08 shall be compacted to a density

of at least 95 percent of the maximum density as determined according to AASHTO T 180. For on-site foundation material containing more than 30 percent retained on the ¾ inch sieve, a method of compaction consisting of a conventional heavy vibratory roller starting with minimum 5 passes shall be used to establish the number of passes required to exceed the 95% T180 density requirement.

At least 6 inches of material shall be in place prior to operation of tracked vehicles over soil with reinforcement. Only power operated roller or plate compaction equipment weighing less than 1,000 pounds is allowed within 3 feet of the front face of the wall. The reinforcement shall not be connected to the wall until the compacted fill is at or slightly higher than the location of the connector.

Backfill containing frost or frozen lumps shall not be used. Backfill that has been placed and becomes frozen shall be removed and replaced at the Contractor's expense. If cold weather conditions prevent the placement of Structure Backfill (Class 1), the Contractor may use Filter Material Class B as backfill without compaction at the Contractor's expense and approved by the Engineer. The Contractor shall provide a test report, prepared and certified by an independent laboratory, that the internal friction angle of soil for the Filter Material Class B meets or exceeds that shown on the plans.

The Contractor shall place additional blocks including partial height blocks and properly compacted fill material to return the finished grade to the plan elevations if settlement, as determined by the Engineer, has occurred. A final inspection before the installation of rail anchoring slab will be made after construction settlement, if any, has occurred or 30 days after the completion of the wall. The Contractor shall provide immediate temporary storm water protection and wind erosion control at the end of each day during construction. If settlement occurs as the result of loss of backfill due to wind or water erosion, non-conforming backfill such as frozen fill or over-saturated fill, or if the backfill does not meet compaction requirements, the Contractor shall remove the backfill, wash the soil reinforcement, and bring the elevation to the finished grade at the Contractor's expense. Before final project acceptance, the Contractor shall repair any backfill losses due to wind and water erosion.

To avoid the foundation of the leveling pad being washed out by rain, the area in front of the wall and around the leveling pad shall be backfilled as soon as practicable.

504.21 Reinforcement. Steel reinforcement shall be slack free and geosynthetic reinforcement shall be slightly pre-tensioned. The minimum coverage ratio for geogrid reinforcement shall be 67 percent and the spaces between rolls shall be staggered between layers of soil reinforcement. The minimum coverage ratio for woven fabric reinforcement shall be 100 percent and an overlap between rolls is not required. Woven fabric sheet reinforcement shall be laid to within 1inch of the front face of block. Soil reinforcement shall not be cut to avoid obstructions unless shown on the shop drawings.

504.22 Leveling Pad. The foundation of the leveling pads shall meet the requirements of subsection 504.20. The leveling pad shall be level within the tolerance of $^{1}/_{16}$ inch for any two block lengths, and within ¼ inch for any two points that are 10 feet apart.

Cushion or shimming material (Expansion Joint Material, Concrete Mortar Grout, Roofing Felt, or Geosynthetic Reinforcement) shall be used to support the blocks that are to be directly founded on the leveling pad. Before starting a new course of blocks, the Contractor shall take measures to ensure that the wall elevations will be matched at the next leveling pad step. Cushion or shimming material or grinding as necessary shall be used to obtain the necessary block elevations at the next leveling pad step.

504.23 Block Facing. For walls that support a roadway, the wall layout line at the leveling pad shall be set back and pre-measured with appropriate batter (5 to 8 percent) from the top of the blocks according to the offset with respect to the centerline of the road. For walls adjacent to a roadway, the wall layout line at the leveling pad shall be directly offset from the centerline of the road. An overall negative batter (wall face leaning outward) between the bottom and the top of the wall is not allowed. For vertical walls, unless otherwise noted on the plans, the final wall face shall be vertical or shall have a positive batter that is not greater than 5 percent for construction control purposes. For walls higher than 16 feet, the 5 percent batter requirement shall be relaxed to a maximum of 8 percent as required for special block products. The surface of the wall face shall be tested with a 10 foot straightedge laid along the surface in the horizontal and vertical directions. Except as necessary for horizontal

alignment of the wall, a convex deviation (wall belly) of the wall face from the straightedge shall not be allowed, and any concave deviation (wall depression) from the straightedge shall be less than ¾ inch.

Unless otherwise noted, all blocks shall be dry-stacked and placed with each block spanning the joint in the row below (running bond). Shimming or grinding shall control the elevations of any two adjacent blocks within 1/24 inch. The top of blocks shall be tested with a 3 foot or longer straight edge bubble level. All high points identified by the straight edge shall be ground flat. Tilting of the blocks, from front to back of the wall, shall be checked at each course, correction by shimming shall be done no later than three completed courses. For walls without a rail-anchoring slab, the top two courses, or a cast-in-place reinforced concrete cap course and the two courses directly below it, shall be pinned and internally grouted together with a minimum of two #4 rebars per block. The concrete block shall have cells to accommodate grouted pins and modifications shall be made for blocks that do not have such cells. Grout is limited to penetrate a maximum depth of three blocks measured from the top of fill for each operation. For grout more than three blocks in height, if specified on the plans, multiple grout operations are required. A layer of fabric shall retain the grout in the lowest grouted block layer. The aggregate for grout shall be modified according to cell size and geogrid aperture. Grout in any 20 foot long wall segment shall be placed and consolidated by a minimum of two simultaneously working concrete vibrators. Precast cap blocks shall not be used in lieu of a cast-in-place reinforced concrete cap. All concrete used for cast-in-place cap and grout shall have a minimum 28 day compression strength of 4500 psi.

For walls with rail anchoring slabs, the top of block elevations shall be within 2 inches of the bottom of the anchoring slab. Cast-in-place concrete or sawcut partial height blocks may be used to accomplish this without extra cost to the project.

Where the Geomembrane for drainage interferes with the continuation of reinforcement, the blocks beyond the termination shall be reinforced or shimmed with the same grade of soil reinforcing material to maintain the reinforcing at the constant block elevation.

As shown on the plans, facing blocks directly exposed to spray from deiced pavements and indirect windborne spray shall have three coats of water resistant or repellant concrete sealer applied to the front face of the wall before the wall is opened to traffic.

504.24 Fill under Leveling Pad. For walls requiring fill under the planned elevation of the leveling pad, the Contractor may lower the elevation of the leveling pad as approved by the Engineer, except that the finished elevation at the top of the wall shall not be altered. As requested by the Contractor, and with the Engineer's approval, the higher wall shall be redesigned with longer reinforcement length and revised reinforcement schedule.

METHOD OF MEASUREMENT

504.25 MSE retaining walls will not be measured for payment in the field, but will be paid for by the calculated quantities shown on the plans for the five major components of the wall: structure excavation, structure backfill, block facing, mechanical reinforcement of soil, and geomembrane. The Contractor's construction of a system that requires increased or decreased quantities of any of the components to complete the wall to the dimensions shown will not result in a change in pay quantities. Exceptions will be made when field changes are ordered or when it is determined that there are discrepancies on the plans in an amount of at least plus or minus five percent of the plan quantity.

(1) The block facing quantity was calculated for the square foot of wall front face area from the top of the leveling pad (or average pad elevations) as shown on the plans to the top of the anchoring slab for walls with railing, or to the top of the cast in place coping for walls without railing.

(2) The structure excavation quantity was calculated for the total volume of earth to be removed before the installation of the reinforced zone as shown on the plans.

(3) The structure backfill quantity was calculated for the total volume behind the wall (the retained structure backfill zone) including the material in the reinforced zone as shown on the plans.

(4) The mechanical reinforcement of soil quantity was calculated for the total volume of the reinforced zone as shown on the plans.

(5) Geomembrane was calculated as the design height (DH) plus soil reinforcement length (RL) plus 1.5 feet, disregarding the slope of the membrane.

The square foot and cubic yard quantities computed for payment are the wall plan quantities based on the height measured at 20 foot maximum intervals along the wall layout line.

BASIS OF PAYMENT

504.26 The accepted quantities will be paid for at the contract unit price per unit of measurement for the pay items listed below:

Payment will be made under:

Pay Item	**Pay Unit**
Block Facing	Square Foot

Structure excavation will be paid for under the Section 206 Pay Item Structure Excavation. Structure backfill will be paid for under the Section 206 Pay Item Structure Backfill (Class 1). Soil reinforcement will be paid for under the Section 206 Pay Item Mechanical Reinforcement of Soil. Geomembrane will be paid for under the Section 420 Pay Item Geomembrane.

Rail anchoring systems (slabs) at the tops of walls and leveling pads at the bottom of wall will be measured and paid for separately under the Section 601Pay Item Concrete and the Section 602 Pay Item Reinforcing Steel.

Payment will be full compensation for all work and materials required to construct the concrete block facing MSE wall. Miscellaneous items such as, dual track welding of Geomembrane, drainage ditches, rundowns, filter material, filter fabric, grout, pins, shimming material, concrete block coating and providing a technical representative will not be measured and paid for separately but shall be included in the work.

504.27 Block Facing Payment Reductions. In this subsection, “block” refers to either a concrete block or a hybrid unit.

(1) A dislocated block is where the edge of an individual block is offset outward more than ¼ inch or placed with a vertical joint more than ¼ inch from the edge of adjacent blocks.
(2) A cracked block is an individual block with any visible crack visible in natural light from a distance equal to the wall height.
(3) A corner knock-off is a block with any missing facial corners or any side longer than ½ inch at the corner.
(4) Substandard blocks are concrete blocks installed in any wall segments that do not meet the certified values of compression strength, water absorption rate, or freeze/thaw cycles; substandard blocks include blocks actually in the wall for which the Contractor does not provide reports and certifications as required in subsection 504.12.

In the completed wall, or completed portion of the wall, if the number of defective blocks (cracked blocks, corner knock-off blocks, dislocated blocks, efflorescence or cement blemished blocks and substandard blocks) and blocks failing the straightedge test exceeds 3 percent of the total number of blocks in any wall segment of 40 foot horizontal or arc length, a price reduction will be applied to that portion of the wall. The price reduction shall be 3 percent for each percent of defective blocks in this portion of the wall exceeding 3 percent. This percentage shall accumulate thereafter to a maximum reduction of 21 percent. For blocks subject to price reduction, if the defects are repairable or the overall quality of wall can be improved, with the consent from the Engineer, the Contractor may repair and reduce the percentage of price reduction. A walkthrough inspection will be made as requested by the Contractor before final payment.

% of Defective	$x \leq 3$	$3 < x \leq 4$	$4 < x \leq 5$	$5 < x \leq 6$	$6 < x \leq 7$	$7 < x \leq 8$	$8 < x \leq 9$	$9 < x \leq 10$	$x > 10$

Blocks (x) in 40 foot section									
% of Price Reduction for that section	0	3	6	9	12	15	18	21	Rejection

The overall payment reduction percentage shall be calculated by dividing the sum of all defective blocks by the total number of blocks in that portion of the wall. When this percentage exceeds 10 percent, the Engineer will reject the entire wall or portions thereof. The Contractor shall replace the rejected wall at his own expense.

TRAFFIC CONTROL PLAN – GENERAL

The key elements of the Contractor's Method of Handling Traffic (MHT) are outlined in Subsection 630.09. In addition the Contractor's MHT's will also be in the following format:

1. All MHT's shall be computer generated
2. All MHT drawings shall be scalable.
3. All MHT's will be produced on 11 X 17 paper.

The Contractor will furnish the MHT, with precise references to other documents such as the MUTCD, CDOT Standard Plans, etc., for any devices incorporated into the MHT, which are not included in the Traffic Control Plans provided in this contract.

If required, the Contractor shall develop detailed Construction Phasing Plans and submit to the Engineer for approval. The Contractor's phasing plans and work areas shall be approved by the Engineer.

The minimum components of the Traffic Control Plan (TCP) for this project are included in the following:

1. Subsection 104.04 and Section 630 of the Specifications
2. Standard Plan S-630-1, Traffic Controls for Highway Construction
3. Standard Plan S-630-2, Barricades, Drums, Concrete Barriers (Temp) and Vertical Panels

Special Traffic Control Plan requirements for this project are as follows:

Construction Operations: Traffic control shall be coordinated by the Contractor such that the delays to the traveling public through the construction zones will be minimized, except as approved by the Engineer and in accordance with other relevant provisions of this specification. The traveling public includes motorists, bicyclists, pedestrians and river users. Requests for authorization to implement traffic control measures must be approved by the Engineer prior to implementation.

For shoulder and lane closures, the Standard Plan S-630-1 shall be used as a guide for the application of traffic control. Shoulder and lane closures shall be maintained at the minimum length possible to minimize impact to traffic.

During the construction of this project, traffic shall use the present traveled roadway. The paved travel way next to the work zone shall not be reduced to less than 10 feet.

All traffic operations, detours, and associated MHT's shall be submitted to the Engineer for review and approval. The Contractor shall schedule and coordinate all traffic closures and MHT's at least seven days prior to the closure or MHT taking effect.

2
TRAFFIC CONTROL PLAN – GENERAL

The Contractor's Superintendent and TCS shall carry mobile phones with pager capability with them at all times during the life of the project.

The Contractor shall furnish hand held FM radios as required for traffic and safety control in the project area as follows: two (2) for the Engineer, one (1) for the TCS, one (1) for each flagger, one (1) for the Superintendent, and for other personnel as required. The radios shall have adequate range to communicate a minimum of two miles. The proposed distribution and use of radios shall be included in the Contractor's MHT. Direction to Flaggers is to be through the TCS only.

All lane and sidewalk/trail closures are subject to the approval of the Engineer. An MHT shall be approved by the Engineer prior to any request for a lane closure.

A written request for a single lane closure shall be made at least 48 hours in advance of the time the lane closure is to be implemented. Lane closures will not be allowed to remain unless they are continuously utilized for the intended purpose for which they were approved. Single lane closures are allowed with the exception of 7a-9a and 3p-6p.

A written request for a full road (two-lane) closure shall be made at least one week in advance of the time the lane closure is to be implemented. Lane closures will not be allowed to remain unless they are continuously utilized for the intended purpose for which they were approved. Full road (two-lane) closure is allowed 10p-6a.

The Contractor shall install construction traffic control devices where they do not block or impede other existing traffic control devices, or sidewalks for pedestrians, disabled persons or bicyclists.

The Contractor and his subcontractors shall equip their construction vehicles with flashing amber lights. Flashing amber lights on vehicles shall be visible from all directions.

All flagging stations used at night shall be adequately illuminated in accordance with the MUTCD. Adequate illumination of flagging stations shall include the use of light plants whenever other sources of adequate lighting are not available. Adequate illumination shall be as approved or determined by the Engineer.

All personal vehicles and construction equipment parking is prohibited where it conflicts with safety, access, or the flow of traffic. The Contractor shall not have construction equipment nor materials in the lanes open to traffic nor parked or stored within the clear zone adjacent to active lanes of travel at any time. Materials or equipment stored within the ROW outside of the clear zone shall be delineated as approved by the Engineer. The Contractor's and employees' vehicles shall be parked in a safe place away from active traffic and shall not directly access roadways except at designated intersections. If required, suitable transportation to and from work sites for personnel shall be provided by the Contractor.

3
TRAFFIC CONTROL PLAN – GENERAL

The Contractor shall remove and reset or cover all existing signs which conflict with the MHT before performing any work under the MHT. All signs damaged due to Contractor operations shall be replaced in kind or repaired by the Contractor at no cost to the project. An inventory of existing signs shall be made by the Contractor and the Engineer prior to starting work.

During all non-working hours, the highway shall be restored to safe travel conditions for the free flow of traffic. All maintenance required to restore the roadways to this condition, including sweeping, shall be done before opening the areas to traffic or completing work for the day.

Fines doubled signs shall be placed according to CDOT Standard Special Provisions. The Contractor shall limit fines doubled signs to activities where and when workers are present on the roadway.

Access to all work areas will be limited to that which can be safely accomplished without hazard to traffic and which does not interfere with traffic during the times specified. Access will not be allowed to any work areas where such access requires the implementation of traffic control measures that interfere with the flow of traffic.

Subsection 630.09 shall include the following:

- Traffic control required for the placement of all signing, traffic control devices, raised pavement markers, channelizing devices, temporary pavement markings, and any other related devices or required work items
- Traffic control for the placement of barriers, impact attenuators, glare screens, etc.
- Portable Message Sign Panels and other specialty device placements and use including typical messages
- Oversize load restrictions, notification, and handling of specific work activities and proposed overall project handling
- Road closure points and barricade placement
- Use of special construction signsWork Zone Protection
- Site specific details, and handling of isolated work elements
- Flagging stations and illumination if required
- Control of construction access points and prevention of unauthorized use
- Emergency vehicle handling
- Accident resolution and emergency road closure details
- Method of handling bicycles
- Method of handling pedestrians
- Traffic control during structure and paving operations
- Flagging and signing of haul routes
- Special construction activities
- Construction striping and detour implementation plan
- Traffic control during phase changes
- Number of flaggers and support personnel for all work
- Night work requirements and device placement

4
TRAFFIC CONTROL PLAN – GENERAL

All Construction zone Traffic Control Devices shall be continuously maintained in accordance with Section 630 of the Standard Specifications.

The Contractor shall develop detailed Traffic Control Plan and submit to the Engineer for approval.

METHOD OF MEASUREMENT

Traffic Control will not be measured but will be paid for on a lump sum basis.

BASIS OF PAYMENT

Payment will be made under:

Pay Item	**Pay Unit**
Traffic Control (Special)	Lump Sum

Payment for Traffic Control will be full compensation for all work, materials and equipment to provide traffic control throughout the project in accordance with this specification.

The Engineer will monitor the traffic control services. When the Contractor provides acceptable traffic control services in accordance with these specifications, partial payments for the pay item Traffic Control will be made as the work progresses. Failure to provide acceptable traffic control services will result in withholding of payment for this item. These partial payments will be made as follows:

Partial payments for traffic control services will be made once each month as work progresses. The monthly partial payments will be determined by pro-rating the lump sum bid amount by the number of months in the actual construction schedule.