FRP MECHANICALLY STABILIZED EARCH ARCH HEADWALLS

**From Fairfield BRO 1448(38)

xx. DESCRIPTION. This work shall consist of designing, detailing, manufacturing, transporting, erecting, and monitoring mechanically stabilized earth (MSE) arch headwalls constructed in accordance with these specifications and in reasonable close conformity with the geometry and dimensions shown in the Plans or established by the Engineer.

The MSE arch headwalls shall consist of placement and compaction of select granular backfill, voided FRP headwall panels, and geogrid soil reinforcement elements mechanically connected to each facing panel. The soil reinforcement shall have sufficient strength and frictional resistance as required by the design as specified herein.

xx. DEFINITIONS. Terms and definitions included herein shall be defined as outlined in the Vermont Agency of Transportation Standard Specifications, with the following added terms:

(a) FRP Mechanically Stabilized Earth Arch Headwall. The earth retaining system, with limits adjacent to the composite arch superstructure, that consists of:

(1) Voided FRP headwall panels fabricated to the shape of the exterior composite arches.

(2) Geogrid reinforcement attached to headwall panels.

(3) Curved FRP fascia plates located at the bottom of the headwall panels and connected to the exterior composite arch.

(4) Connection hardware to secure panels to geogrid reinforcement and concrete slab.

(5) Select backfill material.

(6) Drainage items, including drainage stone and perforated underdrains.

(b) Composite Arch. A hollow arch tube structural framing member comprised of an advanced fiber reinforced polymer shell which functions as external reinforcement and stay-in-place formwork for concrete.

(c) Manufacturer. A firm(s) licensed by Advanced Infrastructure Technologies for the manufacturing of the voided FRP headwall panels, curved fascia plates, and geogrid reinforcement.

xx. MATERIALS. Materials shall meet the following requirements:

(a) Voided FRP Headwall Panels. Structural FRP headwall panel members shall be Composolite®, manufactured by Strongwell.

Strongwell
400 Commonwealth Avenue
P.O. Box 580
Bristol, VA 24203-0580
Telephone: (276)645-8000

Published average values by the Manufacturer are as follows:

Properties	ASTM Test Method	Units	Value
Flexural Strength, LW	D790	ksi	24.5
Flexural Strength, CW	D790	ksi	8.2
Flexural Modulus, LW	D790	ksi	885
Flexural Modulus, CW	D790	ksi	646
Tensile Strength	D638	ksi	31.1
Tensile Modulus	D638	ksi	2,486
Short Beam Shear	D2344	ksi	3.19

Each panel shall be manufactured by the pultrusion process utilizing isophthalic polyester resin with flame retardant and UV inhibitor additives. A synthetic surface veil shall be the outermost layer covering the exterior surface. The FRP panel shall achieve a flame spread rating of 25 or less in accordance with ASTM test method E-84, flammability characteristics of UL 94 V0, and meet the self-extinguishing requirements of ASTM D635.

(b) Geogrid Reinforcement. Geosynthetic reinforcement for geogrid shall be a regular network of internally connected polymer tensile elements with aperture geometry sufficient to permit significant mechanical interlock with the surrounding soil. The geogrid structure shall be dimensionally stable and able to maintain its geometry under manufacture, transport, and installation. All geosynthetic reinforcement shall be made from the same manufacturer and of the same type, manufacturing process, and polymer. The type and placement location requirements of the geogrid shall be provided by the Designer.

(c) Curved FRP Fascia Plates. Curved FRP fascia plates shall be fabricated from bi-directional E-glass/polyester or polyurethane composite sheets. Approved products include:

Pultex® Series 1500 or SUPURTUF by: Creative Pultrusions, Inc. 214 Industrial Lane Alum Bank, PA 15521 Phone: 814-839-4186 Fax: 814-839-4276	Extren® Series 500 by: Strongwell Corporation P.O. Box 580 Bristol, VA 24203 Phone:276-645-8000 Fax:276-645-8132	PROForm™ ST by: Bedford Reinforced Plastics 264 Reynoldsdale Rd Bedford, PA 15522 Phone: 814-623-8125 Fax: 814-623-6032

Or equal, as approved by the Engineer. Alternatively, the plates may be custom fabricated by a qualified composites manufacturing shop.

(d) Connection Hardware. All steel hardware exposed to the elements shall be hot-dip galvanized in accordance with the following applicable standard: AASHTO M232 (ASTM F2329/153C) for hot-dip galvanizing of fasteners or AASHTO M111 (ASTM A123) for hot-dip galvanizing of iron and steel products.

Plates and other raw material shall be manufactured in accordance with AASHTO M183 (ASTM A36).

Threaded rod used as anchor bolts shall be manufactured in accordance with AASHTO M314 (ASTM F1554Gr36).
Bent bolts shall be manufactured in accordance with ASTM A307Gr.A.

Nuts shall be manufactured in accordance with AASHTO M291 (ASTM A563Gr.A)

Round washers shall be manufactured in accordance with AASHTO M293 (ASTM F436-1) and lock washers shall be manufactured in accordance with ASME B18.21.1.

Pipe shall be manufactured in accordance with ASTM A53Gr.B.

(e) Select Backfill Material. Select backfill material used in the MSE earth structure shall meet the requirements of Subsection 704.18.

(f) Perforated Underdrains. Perforated underdrains shall meet the requirements of Subsection 710.06 for PVC plastic underdrain.

(g) Drainage Stone. Drainage stone shall meet the requirements of Subsection 704.16.

(h) Geotextile. Geotextile shall meet the requirements of Section 720 for Geotextile for Underdrain Trench Lining.

xx. GENERAL FABRICATION REQUIREMENTS.

(a) General. The following shall design and supply the MSE arch headwalls that meet these specifications:

Advanced Infrastructure Technologies (AIT)
20 Godfrey Drive
Orono, ME 04473
Telephone: 207-866-6526
Fax: 207-866-6501
Contact: Jonathan Kenerson
E-mail: Jon@aitbridges.com

No substitutions for the above will be accepted.

(b) Quality Control. The Manufacturer(s) shall demonstrate a level of quality control testing that satisfies the Agency as to its ability and commitment to produce the MSE headwall system. The Fabricator(s) shall submit a Quality Control Plan to the Agency's Structures Engineer for review and approval prior to the commencement of work. The plan shall clearly define the quality

control procedures, personnel, frequency of activities, and remedial actions required.

xx. DESIGN REQUIREMENTS. The MSE headwall system shall be designed by AIT in accordance with the AASHTO Standard Specifications for Highway Bridges; LRFD Bridge Design Specifications, Sixth Edition, Dated 2012 and its latest revisions; and the VTrans Structures Design Manual, dated 2010. The MSE headwall system shall be designed for a design life of 75 years using the corrosion rates for non-aggressive soil.

(a) Backfill. The friction angle of the select granular backfill used for the stability of the wall shall be assumed as 34 degrees, unless determined otherwise by tests. When a friction angle greater than 34 degrees is proposed, the friction angle shall be determined by the standard direct shear test, AASHTO T 236, utilizing a sample of the material compacted to 95 percent of AASHTO T 99, Methods C or D (with oversize correction per AASHTO T 224), at the optimum moisture content. Before construction begins, the select granular backfill material shall be subject to approval by the Engineer. Compliance with the test requirements shall be the responsibility of the Contractor. The Engineer shall be furnished a copy of the test results for the backfill prior to construction.

(b) Connections. All connections shall be positive, structural connections subject to the same loss rates and tension requirements as the primary soil reinforcement for MSE retaining walls.

xx. SUBMITTALS. The Contractor shall submit three (3) copies of the design calculations and five (5) sets of panel Fabrication Drawings and wall Construction Drawings for approval prior to beginning construction.

(a) Working Drawings and design calculations shall be submitted to the Engineer for review and approval a minimum of four (4) weeks before work is to begin and shall include, but not be limited to, the following:

(1) Complete design calculations substantiating that the proposed design satisfies the design parameters specified in the Contract Documents.

(2) Details of revisions or additions to drainage systems or other facilities to accommodate the headwall system.

(3) An elevation view of the headwall, which shall include the top and bottom elevations at the headwall joints, the location and elevations and lengths of the geogrid reinforcement.

(4) Cross section(s) showing the elevation relationship between the existing ground and proposed grades. Existing ground elevations shall be verified by the Contractor for each location.

(5) General notes pertaining to design criteria and wall construction.

(6) A listing of the summary of quantities on the elevation sheet for each headwall.

(7) The details for diverting soil reinforcement around obstructions including, but not limited to, drainage structures and guardrail.

(8) The details for connections between the FRP panels and geogrid reinforcement.

(9) Other information required in the Contract Documents or requested by the Engineer.

(b) Panel Fabrication Drawings shall show all dimensions necessary to construct the element, and the location of soil reinforcing connection devices embedded in the panels.

(c) The Contractor shall submit, for review and approval by the Engineer prior to construction, headwall design calculations, signed and sealed by a Professional Engineer registered in the State of Vermont. The Contractor shall not start work on any headwall system for which Working Drawings are required until the Engineer has approved such drawings.

(d) Approval of the Contractor's Working Drawings shall not relieve the Contractor of any responsibility under the Contract for the successful completion of the work.

xx. INSPECTION. The voided FRP headwall panels shall be inspected by the Agency in accordance with Subsection 106.04.

xx. HANDLING, STORING, AND SHIPPING.

(a) Handling. Care shall be taken when handling all products such that no damage is caused, and that the products are protected from cuts, scratches, gouges, abrasions, and impacts. Wire slings will not be permitted unless material is fully protected.

(b) Storing. All products shall be stored under cover, dry, and stacked off the ground with one end elevated to permit draining of incidental water.

(c) Shipping. The Contractor shall secure the necessary hauling permits.

xx. INSTALLATION.

(a) Installation Plan. A written installation plan (in conjunction with the construction of the Composite Arch Superstructure and Arch Slab on FRP decking) shall be submitted to the Engineer within 30 days following the bid award. The written installation plan shall provide, as a minimum, the following information:

(1) Construction plan, sequence, and schedule.

(2) Temporary storage conditions.

(3) Any temporary bracing plans that might be required during FRP headwall panel erection, prior to reinforcement/backfill placement.

(4) A list of all equipment to be used.

(5) The name(s) of the responsible person/people in charge for the Contractor.

(b) Methods, Equipment, and Erection. Cranes, lifting devices, and other equipment for MSE arch headwall construction shall be of adequate design and capacity to safely erect, align, and secure all members and components in their final positions without damage. The Contractor is solely responsible for the methods and equipment employed for the erection of the MSE arch headwall system.

(c) Wall Erection. Voided FRP headwall panels shall be placed vertically with the aid of an approved lifting device(s) set into the upper edge of the panels. As the backfill material is placed behind the panels, the panels shall be maintained in a vertical position. External bracing will likely be required. Vertical tolerance (plumbness) and horizontal alignment tolerances shall not exceed 3/4 inch. The overall vertical tolerance in the wall (plumbness from top to bottom) shall not exceed 1/2 inch per 10 feet of wall height.

(d) Placement of Reinforcement.

(1) Prior to the first layer of reinforcements, backfill shall be placed and compacted in accordance with part (f) of this Subsection.

(2) Geogrid reinforcements shall be placed normal to the face of the wall, unless otherwise shown in the Plans or directed by the Engineer. If skewing of the soil reinforcements is required due to obstructions in the reinforced fill, or in other cases justified by calculation, the minimum skew angle shall not exceed fifteen (15) degrees from the normal position, except in the case of acute corners where redundant reinforcements are used, or in other cases justified by calculation.

(3) Place only that amount of geogrid reinforcement required for immediately pending work to prevent undue damage. After a layer of geogrid reinforcement has been placed and the next succeeding layer of backfill material has been placed, the next geogrid reinforcement layer shall be installed. The process shall be repeated for each subsequent layer of geogrid reinforcement and backfill material.

(4) Geogrid reinforcement shall be pulled tight at a uniform tension prior to backfilling, using a method acceptable to the Engineer. After a layer of geogrid has been placed, suitable means shall be used to hold the geogrid in

position until the subsequent layer of backfill material can be placed.

(5) Under no circumstances shall any tracked construction equipment or vehicles be allowed directly on the geogrid before at least six (6) inches of backfill material has been placed.

(6) Correct orientation of the geogrid reinforcement shall be verified by the Contractor.

(e) Panel Connections.

(1) Panel-to-Panel Connection. Panels shall be delivered pre-machined and labeled. Adjacent panels are designed to connect with the toggle inserted between them. The toggle can be cut to length for ease of insertion.

(2) Panel-to-Deck Connection. Panels shall not be connected to the deck until the lower anchor bolts are set in the deck concrete; therefore adequate bracing is necessary during construction.

(3) Panel-to-Reinforcement Connection. Geosynthetic reinforcement shall be connected to the backside of the panels per the Manufacturer's installation manual.

All connections shall be tightened and secured after backfilling is complete.

(f) Backfill Placement.

(1) The Select Backfill Material is significant to the reinforced soil mass for the MSE wall, and shall be placed shortly after the erection of the panels. Backfill shall be placed in such a manner as to avoid any damage or disturbance to the wall materials or misalignment of the facing panels. Any wall materials which become damaged or disturbed during backfill placement shall be corrected or removed and replaced at the Contractor's expense, as directed by the Engineer.

(2) No backfill shall be placed until test results from a qualified independent testing laboratory have been submitted for the proposed material. Test results shall demonstrate conformance with the backfill friction angle requirements included in these provisions and meet the requirements of Select Backfill Material.

(3) Backfill shall be compacted to 95 percent of maximum density as determined in accordance with AASHTO T 99, Method C or D (with oversize correction).

(4) The moisture content of the backfilling material prior to and during compaction shall be uniform throughout each layer. Backfill material shall have a moisture content less than or equal to the optimum moisture content.

Backfill material with a placement moisture content in excess of the optimum moisture content shall be removed and reworked until the moisture content is uniform and acceptable throughout the entire lift.

(5) The frequency of sampling of Select Backfill Material, necessary to assure gradation control throughout construction, shall be as directed by the Engineer.

(6) Backfill shall be placed in maximum 8 inch loose lifts within 3 feet behind the headwall. Heavy compaction equipment shall not be operated in this area. Lifts may be increased to 12 inches at interior areas away from headwalls.

(7) Backfill soil shall be placed in maximum 8 inch loose lifts within 3 feet behind the headwall. Heavy compaction equipment shall not be operated in this area. Lifts may be increased to 12 inches at interior areas away from headwalls.

(8) Infill soil shall be placed, spread, and compacted in such a manner that minimizes the development of slack or movement of the geogrid.

(9) Mechanical tampers or approved compacting equipment shall be used to compact all backfill and embankment immediately adjacent to each side of the headwall and over the top of the arches until it is covered to a minimum depth of one foot.

(10) At the end of each day’s operation, the Contractor shall slope the last level of backfill away from the wall facing to direct runoff of rainwater away from the wall face. In addition, the Contractor shall not allow surface runoff from adjacent areas to enter the wall construction site.

(11) Lightweight dozers and graders may be operated over arches having one foot of compacted cover, but heavy earth moving equipment (larger than a D-4 Dozer, weighing in excess of 12 tons, or having track pressures of 8 psi or greater) shall require two feet of cover. In no case shall equipment operating in excess of the design load (HL-93 Modified) be permitted over the bridge.

(12) At no time shall the difference between the height of backfill on opposite sides of the arches exceed 2 feet.

(g) Drainage. Perforated PVC pipe shall be installed with a minimum of 2 percent slope at the bottom of the headwall above the arches to allow for proper water drainage behind the headwall. The PVC pipe shall extend to the end of the wingwalls and daylight at the proposed grade line.

(h) Horizontal and Vertical Control. Immediately following the erection of the MSE headwall system, the Contractor shall establish horizontal and vertical survey points at three (3)

locations across the top and a mid-elevation on the wall to monitor future movements. These points shall be tied into a minimum of two (2) control markers that are sufficiently removed from the wall so as not to be influenced by wall movement. The control shall be located to allow additional measurements to be made after all construction is complete. A plan with the locations of all survey points and ties, along with distances and elevations recorded to the nearest 0.01 foot, shall be provided to the Engineer within 48 hours of the completion of the MSE Arch Headwall system.

(i) Technical Assistance. The Contractor shall make the necessary arrangements with the Designer and Fabricator to have a technical representative(s) on the project to supervise the initial placement of the MSE headwall system. The technical representative shall also be required to be on-site any time during the wall installation as requested by the Engineer. The representative shall be available for a minimum of two (2) work days.

xx. METHOD OF MEASUREMENT. The quantity of Special Provision (FRP Mechanically Stabilized Earth Arch Headwalls) to be measured for payment will be the number of square meters (square feet) of wall surface area in the complete and accepted work, measured as the sum of the areas of panels actually erected in the headwalls.

xx. BASIS OF PAYMENT. The accepted quantity of Special Provision (FRP Mechanically Stabilized Earth Arch Headwalls) will be paid for at the Contract unit price per square meter (square foot). Payment will be full compensation for designing, fabricating, furnishing, and installing the materials specified, including but not limited to the FRP headwall panels, geogrid reinforcement, connector reinforcement, curved fascia plates, and backfill material; and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work.

Erecting rigified fiber reinforced polymer tubular arches (RFTA) and filling the hollow tubes with expansive self-consolidating concrete (SCC) will be paid for separately under Contract item 900.645 Special Provision (Composite Arch Superstructure).

Corrugated FRP decking and reinforced concrete arch slab will be paid for separately under Contract item 900.645 Special Provision (Concrete Arch Slab on FRP Decking).

Payment will be made under:

Pay Item	Pay Unit
900.670 Special Provision (FRP Mechanically Stabilized Earth Arch Headwalls)	Square Foot
900.675 Special Provision (FRP Mechanically Stabilized Earth Arch Headwalls)	Square Meter