SPECIFICATIONS

COMPOSITE ARCH BRIDGE SYSTEM

1.0 DESCRIPTION

This work shall consist of procuring and constructing the Composite Arch Bridge System in accordance with these specifications and in conformity with the lines, grades, and dimensions shown on the Contract Drawings. The Composite Arch Bridge System is supplied by:

Advanced Infrastructure Technologies (AIT), LLC
20 Godfrey Drive, Orono, Maine 04473
Phone: 207.866.6526 Fax: 207.866.6501
www.aitbridges.com

The Bridge System shall be designed by AIT in accordance with AASHTO LRFD Bridge Design Specifications, AASHTO LRFD Guide Specifications for Design of Concrete-Filled FRP Tubes for Flexural and Axial Members, and other applicable specifications. The composite arch bridge shall be designed by a licensed professional engineer. Calculations packages and drawings shall be provided to the customer by AIT for the bridge system supplied. As supplier, AIT will deliver to the jobsite all parts of the bridge system as detailed in the Contract Drawings. Each component is custom designed, detailed, and fabricated for the specific bridge project.

The Composite Arch Bridge System is a buried bridge structure consisting of three components:

1. ARCHES - The advanced FRP composite tubes designed, manufactured, and delivered by AIT
2. DECKING PANELS - The decking panels are custom designed, manufactured and delivered by AIT
3. HEADWALLS (OPTIONAL) - FRP headwall options are available if requested by the customer

Terms found within this specification shall be defined as follows:

Composite Arches: A hollow advanced FRP tube structural member comprised of an advanced fiber reinforced polymer shell which functions as external reinforcement and stay-in-place form for expansive self- consolidating concrete.

Manufacturer: A firm licensed by AIT for manufacturing the composite tubes.

1.1 COMPOSITE ARCHES

This work shall consist of fabricating and delivering the composite arch tubes to the dimensions, details, and quantities shown on the plans and according to the requirements of these specifications

1.12 DESIGN

Design loads are in accordance with AASHTO LRFD Bridge Design Specifications, HL-93 live loading. Arch design is in accordance with the AASHTO LRFD Guide Specifications for Design of Concrete-Filled FRP Tubes for Flexural and Axial Members, supplemented by laboratory testing as necessary.

1.13 MATERIALS

Materials shall conform to the following specifications:

Glass Fibers shall be type E-glass manufactured in accordance with ASTM D578 Section 4.2.2 and tested in accordance with ASTM D2343.

Carbon Fibers shall be standard modulus fibers. Tensile strength, tensile modulus, and strain of the fibers shall be documented in accordance with the manufacturer's test specifications.

Resin shall be epoxy vinyl ester resin with viscosity suitable for infusion. Clear casting tensile strength and tensile modulus shall be tested in accordance with ASTM D638. Clear casting flexural strength and modulus shall be tested in accordance with ASTM D790. Heat distortion temperature shall be documented in accordance with ASTM D648.

1.14 QUALITY CONTROL/QUALITY ASSURANCE

Arches shall be manufactured according to the requirements of AIT's QC/QA plan and standard operating procedures. The portions of the suppliers QC/QA plan and procedures which do not contain trade secret material shall be submitted to the customer for review on request prior to beginning fabrication.

The FRP laminate comprising the shell shall be tested for tensile strength. Test result documentation of the mechanical properties and the required design values shall be provided to the engineer. A minimum of five (5) test specimens shall be obtained from each arch. A minimum of two (2) specimens per arch shall be tested. If the mean of the two (2) tests from any one arch fails to meet or exceed the required design value at least three (3) more specimens from the corresponding arch shall be tested. If the mean of the three (3) additional specimens does not meet or exceed the design value the arch shall be rejected and replaced. All tests shall be submitted to the engineer prior to arch installation.

1.15 FABRICATION

The composite arches shall be manufactured according to the requirements of this section using a closed mold vacuum assisted resin transfer method (VARTM) of composite manufacturing.

Reinforcement Storage and Preparation: Fabrics shall be stored in a clean, dry environment in the original packaging. They shall be protected from water, dirt, grease, grinding dust, and other foreign matter. The fabrics shall be cut on a clean cutting surface, free of any deleterious material that could adhere to the fabrics prior to layup. No splices shall be permitted in the longitudinal fabric. Splices may be permitted in the hoop reinforcement.

Chemicals: Vinyl ester resins and other chemicals necessary for catalyzing the infusion matrix shall be stored in accordance with the manufacturer's recommendations.

Vacuum Assisted Resin Transfer: Prior to vacuum infusion of the vinyl ester matrix, the manufacturer must thoroughly seal the tooling and demonstrate that the sealed tooling can obtain a minimum workable vacuum pressure and a drop test. Chemical additives and catalysts to be combined with the vinyl ester resin shall be measured by weight, or the corresponding volume, based on the batch weight of the vinyl ester resin. The manufacturer shall maintain documentation of the promotion rates and

the actual amount of catalyst used for each infusion. The infusion tank must be charged with a sufficient amount of resin at all times to prevent air bubbles from entering the infusion ports in the tooling. Once resin is introduced into the tooling, the infusion process shall continue uninterrupted until it has been demonstrated that all evacuation ports have a surplus of resin flowing past the finished surface of the tooling and that no less than the predicted volume of resin has been introduced into the tool.

Post Processing: Once the laminate of the composite tube has been allowed to harden, the arches shall be removed from the form with care so as not to induce stresses into the curing laminate. The laminate shall reach a minimum Barcol hardness value of 35 prior to de-molding.

Tolerances: The finished arches shall conform to the dimensions set forth in the approved shop drawings. The diameter shall not vary in any one section by more than 1 percent of the dimension given on the shop drawings. The arches shall be checked for shape variations. No arch shall vary from the shop drawing shape, expect for diameter, by more than 1.5 inches or 0.5 percent of the dimension, whichever is smaller. All arches shall be clearly marked by the manufacturer according to the on the shop drawings.

1.16 COMPOSITE ARCH ERECTION

This work shall consist of installing the composite arches of the Composite Arch Bridge System in accordance with these specifications and in conformity with the lines, grades, and dimensions shown on the Contract Drawings. The contractor is responsible for the complete installation of the composite arches including but not limited to unloading the arches and storing on the jobsite, erecting and casting the arches into the foundation, filling the arches with self-consolidating concrete, inspecting the filled arches for voids, and post filling voids if any are found.

Care shall be taken when handling the hollow composite arches such that no damage is caused to the unfilled tubes. When moved or placed by hand, arches shall be stabilized to prevent tipping over. When moved by hoist, straps shall provide at least 2 inches of padded contact area.

Installation: The arches shall be installed in a vertical position and decking installed prior to filling with concrete. The maximum allowable variation of installed arches shall be +/- ½ inch in plane and out of plane. The custom FRP decking as specified in section 2 shall be installed over the arches after the arches are erected and aligned. The arches shall be embedded into the foundations as shown on the Contract Drawings and the foundation placed and achieving the minimum strength as noted on the Contract Drawings prior to filling the arches with self-consolidating concrete as specified in section 3. Care shall be taken when placing the foundation and vibrating around the base of the arches as to not damage or displace the arches.

2.0 FRP DECK PANELS

This work shall consist of furnishing and installing the FRP deck panels, fasteners, and adhesive for the Composite Arch Bridge System in accordance with the Contract drawings and these specifications. The custom panels are designed and supplied by AIT in accordance with the AASHTO LRFD Bridge Design Specifications and the ASCE Pre-Standard for LRFD of Pultruded FRP Structures to carry the required loading.

2.1 MATERIALS

The FRP Deck Panels shall conform to the following:

1. The resin type shall be noted on the shop drawings as premium grade, chemically resistant, UV stabilized: polyurethane (TYPE A PANEL), vinyl ester (TYPE B PANEL), or polyester (TYPE C PANEL)
2. The glass reinforcement shall be E Glass that is straight and continuous, with fibers oriented in three directions (0, 45, 90 degrees with respect to the length of the panel). The glass content shall be a minimum of 70% by weight
3. The panels shall have a class B flame spread rating (75 or less when tested in accordance with ASTM E84)
4. The panels shall be 0.25 inches thick, 3.75 inches high to top of corrugation and 20 7/8 inches wide
5. The fasteners for attaching the deck panels to the arches shall be 2 inch long ¼-14 thread and a #3 drill point stainless steel screws
6. The adhesive for sealing the longitudinal joint shall be urethane, Pliogrip or equal, as approved by the engineer

2.2 DELIVERY and INSTALLATION

AIT will supply the custom FRP Deck Panels and the required stainless steel fasteners to the job site on the date requested by the contractor. A notice of 60 days is required prior to the desired delivery date. The Contractor is responsible for receiving, unloading, and storing the deck panels. All FRP deck panels shall be handled with care and protected from cuts, scratches, and abrasions. Panels shall be stored on blocking off the ground and kept clean and dry. Damaged panels shall be replaced at the contractor's expense.
Deck shall be installed as shown on the shop drawings using fasteners provided. Adhesive provided shall be used per the manufacturer's recommendations to seal the longitudinal joint between the panels. Panels shall be installed starting at the bottom at both sides of the arch and proceeding to the apex. The contractor shall assure that the starter panels are placed as shown on the shop drawings to a level line. A closure plate is provided at the apex to be trimmed to fit in the field and attached after the arches are filled with SCC.

3.0 SELF-CONSOLIDATING CONCRETE

The hollow composite arch tubes shall be filled with Self-Consolidating Concrete (SCC). The arch fill SCC shall conform to the Standard Specifications and this section.

3.1 MATERIALS

Total Cementitious Materials (CM) shall include cement, fly ash, and an expansive cement component.
Cement shall be Type I/II Portland Cement, AASHTO M 85 (ASTM C150)
Fly Ash (ASTM C618 Class F) or Ground Granulated Blast Furnace Slag (GGBFS, ASTM C989 Grades 100 or 120) may be added at the rates allowed in this specification.
Expansive Cement (ASTM C845 Type K) shall be added at the rate as specified in this section. An acceptable product is CTS Komponent manufactured by CTS Cement Manufacturing, 11065 Knott Ave, Suite A, Cypress CA 90630.

3.2 MIX DESIGN

Design the SCC mix in accordance with the Standard Specifications and the following requirements:

1. 28 Day Compressive Strength = 6000psi
2. Maximum size of Coarse Aggregate = 3/8 inches
3. Minimum Cementitious Material (CM) = 850 lb. /CY
4. Use of a High Range Water Reducer at a dosage recommended by the supplier is mandatory for producing SCC. *(ADVA 405 by Grace or equivalent)*
5. A Viscosity Modifying Admixture may be added at a dosage recommended by the supplier to improve mix stability. *(ADVA 405 by Grace or equivalent)*
6. The use of a hydration stabilizer (retarder) is required to ensure sufficient water and time to begin ettringite formation of the Type K cement.
7. Fine Aggregate shall not be less than 50% of the total aggregate by volume.
8. The mix shall contain expansive cement Type K at a rate of 15% by weight of total cementitious material.
9. The mix may include fly ash at a rate less than 25% by weight of cementitious material or grade 100 or 120 GGBFS at a rate less than 50% by weight of cementitious material.
10. The water/cementitious material ratio (W/CM) shall be between 0.42 and 0.45
11. Air content shall be 0% to 5.0%

The concrete shall meet the following requirements in accordance with ASTM C1611 or AASHTO T 347 and AASHTO T 351 for slump flow and visual stability index:

Slump Flow = 24-30 inches
Visual Stability Index = 0-1.0

3.3 TESTING and ACCEPTANCE

Trial batches shall be performed prior to use to verify Compressive Strength, Slump Flow, Air Content, and Visual Stability Index. Results shall be made available to the engineer for review. The trial batch requirement may be waived at the discretion of the engineer if the concrete supplier is experienced in producing SCC. Each batch of SCC delivered to the jobsite shall be tested for Slump Flow, Visual Stability Index, and Air Content. If the concrete fails to meet the requirements re-dosing with additives is permitted. The Engineer may reject concrete that does not meet specifications.

3.4 CONCRETE PLACEMENT

All arches shall be filled with SCC under the supervision of the engineer. They shall be filled in one continuous operation. Vibration may be necessary for shallow arches and its use shall be determined by the engineer. The arches shall be filled through the fill holes that are field drilled by the contractor to the sizes and locations shown on the shop drawings. The concrete placement shall be accomplished using a method capable of directing the concrete into the 3.0 inch fill hole and regulating placement speed to prevent voids. The acceptable methods include the use of a boom type pump truck, a trailer pump, or a standard concrete bucket. The contractor shall have a backup method available in the event of an equipment malfunction. All tubes shall undergo auditory tap testing after SCC placement to ensure

complete filling of tubes. In the event that voids are discovered, they shall be injected with grout such as SikaGrout 328 or approved equal for large voids or Sikadur 35 for small voids. The maximum permitted hole size for grout injection is ¾ inch. AIT shall be given 48 hours notice, and offered the opportunity to be present for the filling of the arches and tap testing.

4.0 BACKFILLING and COMPACTION

Arch Tube concrete must reach a minimum compressive stress of 3000psi prior to any backfilling or compaction activities on the structure other than minor headwall connection work.

4.1 MATERIALS

Backfill material shall conform to the Standard Specifications and classified as gravel borrow, maximum size of aggregate is 4 inches. The backfill material shall exhibit an angle of internal friction of not less than 32 degrees as determined by the standard direct shear test AASHTO T 236 on the portion finer than the number 10 sieve (2mm) compacted to 95 % per AASHTO T 99 Method C or D at optimum moisture content. Soil tests shall be submitted to the engineer for approval prior to the placement of any material.

4.2 PLACEMENT

Backfill shall extend to the lines and grades shown on the contract drawings, and shall be performed according to the standard specifications, and the additional requirements of this specification.

Backfill soil shall be placed in maximum 8 inch loose lifts. Compaction within four (4) feet of the structure shall be accomplished with hand compactors only. Vibratory rollers may be used outside of this zone and above the structure provided there is at least 12 inches of compacted cover above the structure.

All backfill shall be carefully placed to avoid damage to the structure.

Lightweight equipment (less than 12 tons) may be operated over the structure provided there is at least 12 inches of cover. Construction equipment greater than 12 tons may be used after 24 inches of compacted backfill has been placed over the structure. In no case should the loading exceed the AASHTO design loading of HL-93 without the engineer's written permission.

Backfill shall be placed in lifts such that at no time will the elevation difference exceed 24 inches between opposite sides of the structure.

5.0 METHOD OF MEASUREMENT

The Composite Arch Bridge System shall be measured as one LUMP SUM erected and accepted in close conformity with the contract documents.

6.0 BASIS OF PAYMENT

The accepted quantity of Composite Arch Bridge System will be paid for LUMP SUM complete in place. The price will be full compensation for furnishing, installing, and erecting the Composite Arch Bridge System

including the arches, arch tube concrete, decking and all necessary hardware, and the furnishing of all labor, materials, tools, equipment, and incidentals necessary to complete the work.

PAY ITEM- (XXX)	COMPOSITE ARCH SUPERSTRUCTURE-	LUMP SUM