STATE OF DELAWARE

DEPARTMENT OF TRANSPORTATION

DESIGN-BUILD PROJECT

for

INDIAN RIVER INLET BRIDGE

Replacement of Bridge 3-156,
SR1 over Indian River Inlet
State Contract # 26-073-03 Readvertised
Federal Contract # BRN-S050(14)

SCOPE OF SERVICES PACKAGE

CONTRACT DOCUMENTS

PART 3 – APPENDIX A

PERFORMANCE SPECIFICATIONS

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AESTHETIC REQUIREMENTS
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1.0 INTRODUCTION

As part of the original bridge design and overall project development, the Department received considerable input from local residents, community groups, local officials, and other groups regarding aesthetic preferences and design themes to be incorporated into the final designs. This Performance Specification specifies the minimum bridge aesthetic requirements to be considered and addressed by the Design-Builder during the design development of the bridge project.

2.0 STANDARDS AND REFERENCES

The Work shall be in accordance with this *Aesthetic Requirements* Performance Specification and the relevant requirements of the following standards, unless otherwise stipulated herein. Standards and References specifically cited in the body of this Performance Specification establish requirements that shall have precedence over all others. Should the requirements in any standard conflict with those in another, the standard highest on the list shall govern. Listed under References are guidelines that the Design-Builder may use in addressing the requirements as the Design-Builder sees fit. It is the Design-Builder's responsibility to obtain clarification of any unresolved ambiguity prior to proceeding with design or construction.

2.1 STANDARDS

A) None specified.

2.2 REFERENCES

A) *"Summary of the Public Information Workshop #1,"* Figg Bridge Engineers, Inc., March 2003 (*see* Scope of Services Package – Reference Documents);

B) "*Summary of the Public Information Workshop #2,"* Figg Bridge Engineers, Inc., April 2003 (*see* Scope of Services Package – Reference Documents);

C) *"Summary of the Public Information Workshop #3,"* Figg Bridge Engineers, Inc., June 2003 (*see* Scope of Services Package – Reference Documents);

D) *"Summary of the Public Information Workshop #4,"* Figg Bridge Engineers, Inc., October 2003 (*see* Scope of Services Package – Reference Documents);

E) A Guide for Achieving Flexibility in Highway Design, AASHTO, May 2004; and

F) NCHRP Report 480: A guide to Best Practices for Achieving Context Sensitive Solutions.

3.0 REQUIREMENTS

The Design-Builder should review the referenced summary reports for each previously held public information workshop (also referred to as design charettes) to understand the issues and concerns raised by the public and suggestions that were made to the Department. As part of the design development, the Design-Builder shall address how the design meets or exceeds the following aesthetic requirements and

cite examples from the *Public Information Workshop Summary Reports*.

3.1 CONTEXT SENSITIVE DESIGN

The Design-Builder shall strive to achieve a context sensitive bridge design with the following minimum considerations:

A) Avoid and/or minimize obstructions to the view from the bridge for pedestrians, bicycles, and motorists;

B) Provide accent or aesthetic lighting. Excessive illumination shall be avoided. Roadway lighting shall not be provided. All proposed bridge lighting shall be approved by the United States Coast Guard;

C) Provisions for long-lasting, low-maintenance uniform coloration of all exterior finished bridge surfaces;

D) Provisions for preventing staining of finished bridge surfaces;

E) Protection from graffiti;

F) Bridge parapets, railings, and barriers that are consistent with or compliment the roadway approach details;

G) Substructure finishes that are consistent with or compliment the roadway approach retaining wall details;

H) A consistent overall architectural theme that is suitable for the surroundings.

3.2 PUBLIC INVOLVEMENT

The Design-Builder may choose, at his option, to include the public in the final selection of architectural and/or aesthetic details as specified in the *Public Outreach Requirements* Performance Specification included in Part 3 of the Contract Documents. Should the Design-Builder propose to involve the public in the selection of aesthetic treatments, the proposed methods of public involvement shall be carried out and the results implemented into the Work at no additional cost to the Department.

BRIDGE DESIGN REQUIREMENTS
PERFORMANCE SPECIFICATION

1.0 INTRODUCTION

The Design-Builder shall design and construct the bridge structure in accordance with the criteria established in this Performance Specification. The bridge structure is defined as all portions of the structure between the north and south roadway approach slabs.

The Design-Builder shall design and construct the bridge for a service life of no less than 100 years, meeting the goals of ease of inspection, maintenance, and durability. The Design-Builder shall also design and construct the bridge to be aesthetically pleasing in accordance with the Aesthetic Requirements Performance Specification (*see* Part 3).

2.0 APPLICABLE STANDARDS AND REFERENCES

Design Criteria shall be in accordance with this Performance Specification and the relevant requirements of the following standards unless otherwise stipulated in this Performance Specification. Standards and references specifically cited in the body of this Performance Specification establish requirements that shall have precedence over all others. Should the requirements in one standard conflict with those in another, the standard highest on the list shall govern. Listed under references are guidelines that the Design-Builder may use to address the requirements, as the Design-Builder sees fit. It is the Design-Builder's responsibility to obtain clarification of any and all unresolved ambiguity prior to proceeding with any design or construction.

2.1 STANDARDS

Specific codes and standards include, but are not limited to, the following listed in order of governing precedence:

A) Design Build Performance Specifications (Part 3 of the Contract Documents);

B) Design-Build Special Provisions (Part 4 of the Contract Documents);

C) "AASHTO LRFD Bridge Design Specifications," Third Edition, 2004 (U.S. Customary Units), with Interims through 2006. Delete Section 5.14.2.3.9 in its entirety (All Shop and Working Drawings will conform to the requirements of the Contract);

D) "AASHTO LRFD Bridge Construction Specifications," Second Edition, 2004 (U.S. Customary Units), with Interims through 2006;

E) "AASHTO Standard Specifications for Highway Bridges, Seventeenth Edition," 2002 (U.S. Customary Units), with Interims through 2006. This Specification shall only apply to design modifications made to the existing sheet pile walls and the design of cofferdams that are to be connected to the existing sheet pile walls;

F) Delaware Department of Transportation "Bridge Design Manual" with Revisions through May, 2005;

G) CEB-FIB "Model Code 1990," First Edition, 1993, Chapter 2: Material Properties, for time dependent properties of concrete only;

H) PTI Guide Specification, "Recommendations for Stay Cable Design, Testing and Installation", Fourth Edition 2001, ("soft" conversion of the Document's metric units is required);

I) PTI Guide Specification, "Grouting of Post-Tensioned Structures," Second Edition, 2003;

J) Bridge Welding Code: AASHTO/AWS D1.5:2002, An American National Standard, with 2003 and 2005 AASHTO Interims; and

K) AASHTO Guide Manual for Condition Evaluation and Load and Resistance Factor Rating (LRFR) of Highway Bridges, 2003.

2.2 REFERENCES

A) Directive and Indicative Plans (*See* Contract Documents – Part 6, Scope of Services Package Plans);

B) Final Environmental Assessment and Nationwide Section 4(f) Evaluation, May 10, 2004;

C) Department of Transportation, Federal Highway Administration, Finding of No Significant Impact for Bridge 156 Over Indian River Inlet, Sussex County, Delaware, June 22, 2004;

D) The Boundary Layer Wind Tunnel Laboratory, "A Study of Wind Effects for Indian River Inlet Bridge, Delaware, USA," May 2005. Only Section 2 – Modeling of the Site and the Wind is applicable to this Project;

E) FHWA Wind Induced Vibration of Stay Cables, RDT 05-004, Feb 2005;

F) Delaware Department of Transportation "Standard Specifications for Road and Bridge Construction" Dated 2001;

G) ACI 207.1 R-96, "Mass Concrete";

H) ACI 305 R-99, "Hot Weather Concreting";

I) ACI 306 R-02, "Cold Weather Concreting";

J) AASHTO, "Guide Specifications for Bridge Temporary Works," 1995;

K) AASHTO, "A Policy on Geometric Design of Highways and Streets (Green Book)," Fifth Edition, 2004;

L) AASHTO, "Roadside Design Guide," Third Edition, 2002;

M) AASHTO, "Model Drainage Manual," 2005 Edition; and

N) "Manual of Uniform Traffic Control Devices (MUTCD)," Third Edition, 2003.

3.0 REQUIREMENTS

The Project shall be designed and detailed using the customary English units. Plans shall be prepared in accordance with the Department's Plan Development Guidelines available from DelDOT's Project Development Resource Center (*http://www.deldot.gov/static/business/project_development/index.shtml*). A Professional Engineer registered in the State of Delaware shall seal final Plans, Shop Drawings, and Working Drawings. All submittals and submittal requirements shall be as per the Contract Documents.

3.1 LAYOUT

A) The bridge section shall be designed to carry four 12-foot traffic lanes (two traffic lanes in each direction), two 10-foot outside shoulders, two 4-foot inside shoulders, one 12-foot combined use recreational bicyclist and pedestrian walkway (on ocean side of structure), a continuous 2-foot wide sand by-pass system utility corridor (on ocean side of

structure), and necessary width to accommodate all traffic barriers, end attenuators, and railings required by the AASHTO Code and the Contract Documents.

B) Traffic barrier(s) having a minimum height of 32 inches shall separate the two opposing directions of traffic (northbound and southbound). Traffic barriers having a minimum height of 54 inches shall be provided at each edge of shoulder and each edge of the combined use recreational bicyclist and pedestrian walkway. No obstructions are permitted within the combined use walkway. All 54-inch barriers shall include an open railing system within the top 24 inches, as a minimum.

C) The two outside shoulders and the combined use walkway on the bridge shall include bicycle-safe details for barriers, expansion joints, drainage systems, and any other applicable features.

D) The bridge shall include the necessary total width to accommodate all traffic barriers, cushions, and railings as per Section 3.1.A of this Specification. All barriers located directly adjacent to SR-1 traffic shall have a minimum TL-4 Test Level rating in accordance with the *AASHTO LRFD Bridge Design Specifications* and shall have been successfully crash-tested in accordance with the Department's policy specified in Section 5.3.7.1 of the *Bridge Design Manual*. All non-traffic barriers located directly adjacent to the combined use walkway shall be designed for TL-2 Test Level loads in accordance with Chapter 13 of the *AASHTO LRFD Bridge Design Specifications*. The crash-testing requirement shall be waived for non-traffic barriers located adjacent to the combined use walkway.

E) For Navigational Clearance requirements refer to the Coast Guard Permit included in Part 3 – Appendix A of the Contract Documents and the *Directive Plans*.

F) The minimum horizontal clearance from any stay cables to the back face of traffic barrier shall be 2'-6" measured at all heights normal to the deck ranging from the top of barrier to 20'-0"above the roadway surface. The minimum horizontal clearance from any stay cables to the back face of combined use walkway barrier shall be 1'-6" measured at all heights normal to the deck ranging from the top of barrier to 16'-6" above the combined use walkway surface. At all heights below the top of protective barrier, the minimum horizontal clearance from any stay cable components to the back of all protective barriers, shall be 1'-6".

G) The sand by-pass system utility corridor shall be adjacent to and accessible from the combined use walkway, but separated by a protective barrier. The limits of the utility corridor may be located directly adjacent to the back face of protective barrier and/or any stay cable components. The utility corridor shall be located above the finished deck level and accessible over the entire bridge length.

3.2 AESTHETIC REQUIREMENTS

Refer to the *Aesthetic Requirements* Performance Specification in Part 3 of the Contract Documents.

3.3 GEOMETRIC DESIGN CRITERIA

Refer to the *Roadway Geometrics* Performance Specification in Part 3 of the Contract Documents.

3.4 GENERAL DESIGN REQUIREMENTS

A) The bridge structure shall be designed in accordance with all applicable Performance Specifications and Design-Build Special Provisions included in the Contract Documents.

B) All reinforced concrete bridge structure members, including the structural characteristics

of the supporting foundation elements, shall be designed in accordance with the applicable limit states as defined by the load groups in the *AASHTO LRFD Bridge Design Specifications* and for the additional extreme event limit state specified in Section 3.5.8. Reinforcement of all concrete components shall satisfy the control of cracking provisions in accordance with the *AASHTO LRFD Bridge Design Specifications* for Class 2 exposure conditions.

C) All prestressed concrete members shall be designed in accordance with the applicable limit states as defined by the load groups in the *AASHTO LRFD Bridge Design Specifications*.

D) Permanent stay cables shall be designed in accordance with the *PTI Guide Specification, "Recommendations for Stay Cable Design, Testing and Installation"* and per this Performance Specification and the Special Provisions.

E) Temporary stay cables shall be designed in accordance with the *PTI Guide Specification, "Recommendations for Stay Cable Design, Testing and Installation"* and per this Performance Specification and the Special Provisions. Temporary stay cables shall be limited to an allowable stress of $0.6F'_s$ during construction.

F) Foundation Elements

1) The structural capacity of all foundation members shall be designed accounting for the soil-structure interaction (load transfer to the soil) parameter recommendations as defined in the Design-Builder's Geotechnical Engineering Report for the Project and the applicable limit states of the *AASHTO LRFD Bridge Design Specifications*;

2) The geotechnical capacity (load transfer to the soil) shall be designed in accordance with the recommendations defined in the Design-Builder's Geotechnical Engineering Report for the Project and applicable limit states of the *AASHTO LRFD Bridge Design Specifications*;

3) Downdrag shall be in accordance with FHWA Guidelines and determined as necessary by the Design-Builder's Geotechnical Engineer in accordance with the *Geotechnical Requirements* Performance Specification;

4) All structural foundation supporting elements shall require load testing in accordance with the *Geotechnical Requirements* Performance Specification; and

5) Additional requirements for foundation elements including acceptable deep foundation types shall be in accordance with the *Geotechnical Requirements* Performance Specification.

3.5 LOADS AND FORCES

3.5.1 Load Modifiers

The Design-Builder will be required to use the following values of load modifiers, η_i, in the *AASHTO LRFD* Strength Load Combinations for the completed structure and construction conditions:

A) Ductility: $\eta_D \geq 1.00$

B) Redundancy: $\eta_R \geq 1.00$

C) Operational Importance: $\eta_I = 1.05$

3.5.2 Load Combinations

A) All load combinations shall be in accordance with *AASHTO LRFD Bridge Design Specifications*;

B) The effects of stay cable force adjustments shall be treated as locked-in erection stresses; and

C) The effect of presstressing shall be considered in all *AASHTO LRFD* combinations with a load factor equal to 1.0. The effect of time dependent concrete creep, shrinkage and elastic shortening shall be included in all the *AASHTO LRFD* load combinations by calculating the redistribution of forces using the dead load factors corresponding to each limit state. Service limit states shall be checked for creep and shrinkage coefficients varying from the mean within the 90% confidence limits defined in the CEB-FIP Model Code 1990. Strength limit states shall be checked considering time dependent effects associated with mean creep and shrinkage coefficients. Inelastic analysis according to Section 4 of *AASHTO LRFD* may be used to determine the effects of time dependent movements, restrain and force redistribution as long as strain compatibility analyses demonstrate the necessary ductility. This replaces the *AASHTO LRFD* load factor range of 0.5/1.2 and 1.0/1.2 for creep and shrinkage..

3.5.3 Permanent Load

The Design-Builder will be responsible for determining and clearly indicating on the plans the magnitudes of the dead load contribution of all traffic barriers, railings, appurtenances, fixtures, equipment, and all other permanent elements that bear, attach, or are otherwise supported by or on the structure with the following additional specific requirements:

A) Unit weight of the materials shall be in accordance with Section 3.5.1 of the *AASHTO LRFD Bridge Design Specifications* with the following additions:

1) Unit weight of soil Not less than 120 pcf

B) The dead load contribution for initial and future wearing surfaces, applied uniformly to all traffic lanes, shoulders, and the pedestrian pathway, shall be considered by the Design-Builder. The initial wearing surface shall be a minimum of 1 5/8" inch thick overlay in accordance with Section 4.2 of this Specification. An additional minimum 25 pounds per square foot dead load allowance shall be provided for the application of a future wearing surface. Under no circumstances may the initial wearing surface thickness encroach on or include the minimum required reinforcing concrete cover specified in Section 3.6 of this Specification.

C) The Design-Builder will be responsible for determining and accounting for the dead load contribution of all utilities to be conveyed and/or supported by the bridge, including, but not limited to, a 200 plf sand by-pass system load allowance. The point of application for the sand by-pass system load allowance shall be centered within the sand by-pass corridor to be provided in accordance with Section 3.1 of this Specification. *See* Part 5 – Utility and Right-of-Way Statements for additional utilities information.

3.5.4 Live Load

The Design-Builder will be responsible for determining and clearly indicating on the plans the magnitudes of all live loads applied to the structure with the following additional specific requirements:

A) Live load shall be HL-93 with impact (design truck or tandem with design lane load) in accordance with *AASHTO LRFD Bridge Design Specifications* except as modified in Section 3.4.

B) The design shall consider all Delaware legal loads specified in the *DelDOT Bridge Design Manual*, including an additional AASHTO HS20 truck with lane load. All inventory and operating load ratings shall be clearly specified on the on the Plans in accordance with the *DelDOT Bridge Design Manual.* The AASHTO Guide Manual for Condition Evaluation and Load and Resistance Factor Rating (LRFR) of Highway Bridges shall be utilized for this Project.

C) The sidewalk will be designed for the worst case of the pedestrian load (PL) or the maintenance inspection vehicle load, not the combined load. The design maintenance inspection vehicle is an Aspen Aerial A-75 Under Bridge Inspection Vehicle (UBIV). The associated wheel loads are:

1) Unit in stowed position:

Axle 1:	15,751 LB	
Axle 2:	15,751 LB	(80" behind Axle 1)
Axle 3:	7,000 LB	(133" behind Axle 2)
Axle 4:	14,400 LB	(55" behind Axle 3)
Axle 5:	14,400 LB	(55" behind Axle 4)
Axle 6:	6,000 LB	(103" behind Axle 5)

2) Unit in deployed position (non-deployment side wheel/deployment side wheel):

Axle 1:	3,800/11,950 LB
Axle 2:	1,500/14,250 LB
Axle 3:	0/7,000 LB
Axle 4:	1,250/14,390 LB
Axle 5:	1,650/14,000 LB
Axle 6:	0/6,000 LB

3) Distance between center of each set of tires:

Axle 1 and 2:	102"
Axle 3 through 6:	98"

D) The placement of the UBIV live load shall be such that no restrictions on the placement of the UBIV are required once the bridge is in service.

E) The bridge shall also be checked for the maximum live load on only one side of the superstructure for the event when the bridge is used as an evacuation route.

F) Stay cables shall be designed for HL-93 live load in accordance with the *PTI "Recommendations for Stay Cable Design, Testing and Installation."*

3.5.5 Longitudinal Forces

Longitudinal forces on the bridge shall be computed in accordance with the *AASHTO LRFD Bridge Design Specifications*.

3.5.6 Water Loads

Water loads shall be determined by the Design-Builder in accordance with the *Bridge Hydraulics and Scour* Performance Specifications. As part of a previous study, overland water depths and current flow velocities were determined and summarized in the report "Scour Analysis Evaluation, Proposed Indian River Inlet Bridge; Sussex County, Delaware," dated January 21, 2005 (*see* Reference Documents, Hydraulics and Scour). The Design-Builder shall utilize the criteria producing the more conservative result for each design consideration. The following considerations shall be used as the basis for development of the Technical and Price Proposals. Should the actual design water loads exceed the minimums specified, any changes will be considered a result of *Differing Site Conditions* and will be paid for in accordance with Part 2, Section 109-8 of the Contract Documents.

A) Mean High Water Elevation shall be based upon the epoch data issued by the National Oceanic and atmospheric Administration National Ocean Service on April 21, 2003.

B) The following minimum overland water depths and current flow velocities are specified for use by the Design-Builder:

1) 100-year return period event:

a) Overland water depth: 5.0 feet

b) Current flow velocity: 3.7 feet/second

2) 500-year return period event:

a) Overland water depth: 7.0 feet

b) Current flow velocity: 4.5 feet/second

C) The magnitude of the forces applied to the structure due to overland current flow shall be determined by the Design-Builder and shall be accounted for in the design of the structure for both the 100-year and 500-year return period events in accordance with the provisions of the *AASHTO LRFD Bridge Design Specification.*

D) Debris loading shall be included in all current flow load combinations in accordance with the recommendations of NCHRP 445, Debris Forces on Highway Bridges.

3.5.7 Scour

The Design-Builder shall be responsible for designing the structure to account for the effects of scour in accordance with the *AASHTO LRFD Bridge Design Specifications* and the requirements of the *Bridge Hydraulics and Scour* Performance Specification. As part of a previous study, overland water depths and current flow velocities were determined and summarized in the report "Scour Analysis Evaluation, Proposed Indian River Inlet Bridge; Sussex County, Delaware," dated January 21, 2005 (*see* Reference Documents, Hydraulics and Scour). The Design-Builder shall utilize the criteria producing the more conservative result for each design consideration. Considerations shall include the following:

A) The design flood for scour shall be the 100-year return period event and the check flood for scour shall be the 500-year return period event as described in Article 2.6.4.4.2 of the *AASHTO LRFD Bridge Design Specifications*.

B) The Design-Builder shall perform a scour analysis in accordance with FHWA Guidelines for the Design-Builder's proposed structure and determine the values of total scour at each primary bridge support. The minimum values of total scour are listed below and these values should be used by the Design-Builder in his design, regardless if any scour mitigation measures are employed or if the Design-Builder's analysis or calculations show a reduction in the total scour values listed. Should the Design-Builder's analysis and/or calculations indicate an increase in the total scour values, then the Design-Builder shall use the larger total scour values for design. The values below are measured from the native ground elevation at the site and are to be used as the basis for development of the Technical and Price Proposals. Should the actual design scour depths exceed the minimums specified, any changes will be considered a result of *Differing Site Conditions* and will be paid for in accordance with Part 2, Section 109-8 of the Contract Documents.

1) Abutment Foundations:

a) 100-year return period event: 30.0 feet

b) 500-year return period event: 35.0 feet

2) Pier Foundations (Pylons, Arch Bases, Piers, Towers, or other Supports):

a) 100-year return period event: 30.0 feet

b) 500-year return period event: 35.0 feet

C) It shall be the responsibility of the Design-Builder to design and install scour mitigation to fortify all bridge abutment foundations and for the transitions and/or tie-ins with the scour mitigation measures installed under DelDOT Contract #23-073-03 (Roadway Approaches Contract). This scour protection shall be provided in addition to the bridge scour depth allowances to be accommodated by the design.

D) The Design-Builder is not required to design or install scour mitigation measures to fortify the piers, as these (pursuant to Section 3.5.7.A-C) shall be directly designed to account for the occurrence of scour.

3.5.8 Wind Loads

See the *Wind Engineering Requirements* Performance Specification for additional requirements.

A) Wind on the structure shall be in accordance with the *AASHTO LRFD Bridge Design Specifications* using the resulting load/wind components/component combinations included in the Project Specific Wind Study Report developed by the Design-Builder.

B) Wind on live load directly per the AASHTO LRFD Bridge Design Specifications.

C) The minimum design wind for the completed permanent structure shall be the site-specific wind profile corresponding with the 100-year return period event as reported in the *Boundary Layer Wind Tunnel Laboratory, "A Study of Wind Effects for Indian River Inlet Bridge, Delaware, USA,"* report. The bridge shall also be checked for an Extreme Event limit state load combination including wind loads with a 2000-year return period and permanent loads. The load factor for all loads in this load combination shall be equal to 1.0. The structure shall not have any structural instability, such as buckling or brittle failure that could result in catastrophic collapse under this loading

D) The design wind for permanent and temporary structures during construction shall be the site-specific wind profile corresponding with, at a minimum, the 25-year return period event as reported in the original Wind Study Report. The *LRFD* Table 5.14.2.3.3-1 Wind Load Factors are to be replaced with 1.0 when using a return period of less than 100 years.

E) Bridge response and wind loading in the completed and critical staged-construction configurations to wind actions shall be determined from wind tunnel model tests (*See Wind Engineering Requirements* Performance Specification).

F) The bridge shall not show any aerodynamic instability (flutter, torsional divergence, etc.) for a wind event having a probability consistent with a return period of 10,000 years.

G) Lift, drag, and moment coefficients determined from the wind tunnel tests and reported in the Design-Builder's Wind Analysis Reports (*see* the *Wind Engineering Requirements* Performance Specification) shall be used to determine design member forces.

H) For bicyclist comfort, bridge deck accelerations exceeding 5% of gravity for wind speeds up to 30 mph and 10% of gravity between 30 mph and 50 mph will be considered unacceptable.

I) For cable-supported bridge types, stay cable vibrations shall be evaluated for the effects of vortex excitation, wake galloping, and rain/wind oscillations. Methods for reducing likelihood of such vibrations shall be implemented as outlined in the Design-Build Performance Specification *Cable-Supported Bridge System Requirements*.

J) The Design-Builder's Wind Analysis Report, the Final Plans, and the Owner's Manual shall clearly indicate the 3-second gust (in mph) that correlates to the mean hourly deck level wind speed at which the bridge should be closed to traffic.

3.5.9 Earthquake Effects

A) Earthquake effects shall be in accordance with *AASHTO LRFD Bridge design Specifications*.

B) The seismic performance category shall be Zone 1 with an acceleration coefficient (A) of 0.05.

3.5.10 Thermal Forces

A) The uniform temperature ranges shall be calculated using Procedure B as specified in *AASHTO LRFD Bridge Design Specifications*. The base construction temperature shall not be less than 56^{o} F.

B) Seasonal variation for temperature rise and fall shall be in accordance with *AASHTO LRFD Bridge Design Specifications* for an 80^{o} Fahrenheit temperature range.

C) Expansion joints shall be in accordance with *AASHTO LRFD Bridge Design Specifications* and the Design-Build Special Provision for *Bridge Expansion Joint Devices* (*see* Part 4).

D) Uniform temperature differential between stay cables and concrete bridge elements for the cable-supported bridges shall be $\pm 14^{o}$ F.

E) The temperature differential (linear gradient) between opposite faces of each primary main span supporting elements (such as pylons, arches, towers, piers, etc.) shall be $\pm 10^{o}$ F.

F) Differential temperature load combinations shall be in accordance with *AASHTO LRFD Bridge Design Specifications*, Article 3.4.1.

G) The temperature gradient for the superstructure shall be as per the *AASHTO LRFD Bridge Design Specifications.*

3.5.11 Creep and Shrinkage

A) Creep and shrinkage properties for concrete shall be determined by the Design-Builder based on the proposed concrete mixes and materials. Minimum creep and shrinkage coefficients shall be as per the 1990 CEB-FIP Model Code.

B) The assumed mean humidity shall be not more than 75%.

3.5.12 Differential Settlement

A) Differential settlement between primary structural supports shall be considered in load combinations that include settlement.

B) Differential settlement between primary structural supports shall be applied in accordance with recommendations in the Geotechnical Engineering Report for the Project submitted by the Design-Builder. The Geotechnical Engineering Report shall include dimensional values for differential settlement.

3.5.13 Vessel Collision

A) The vessel collision requirements of the *AASHTO LRFD Bridge Design Specifications* do not apply because no bridge components may be located in the existing or future waters of the Indian River Inlet.

3.5.14 Construction Loads

A) The Design-Builder shall be responsible for determining the construction loads for the proposed design in accordance with Articles 5.14.2.3.2 through 5.14.2.3.4 of the *AASHTO LRFD Bridge Design Specifications*.

3.5.15 Load Path for Stay Cable Forces

A) The load path for all horizontal and vertical force components introduced or carried by permanent stay cables shall be entirely contained within the structural elements of the bridge. Temporary and/or permanent stay cable anchorage locations or structural details that transfer any principal component(s) of stay cable forces under service or strength limit states directly into soil, earth, sand, etc. shall not be used. Use of soil, regardless of type or name, to directly carry, anchor or transfer forces from temporary and/or permanent stay cable(s) is specifically not permitted by these specifications and shall not be considered under any condition for use on this project.

B) Secondary or incidental forces from stay cable(s) that, by creep, elastic shortening, bearing friction or other means, result in development of forces in foundation(s), pier(s), pylon(s) or other structural member(s) shall be considered as acceptable within the provisions of this specification.

3.6 MATERIALS

All materials shall be as per the *DelDOT Standard Specifications* and the Corrosion Protection Plan referenced in Section 4.8 of this Specification except as modified below.

A) Concrete:

1) The Design-Builder may develop his own mix designs provided that the materials conform to the *DelDOT Standard Specifications* and with the *Concrete for Structures* Performance Specification.

B) Mass concrete shall be in accordance with the Design-Build Special Provisions (*see* Part 4 of the Contract Documents).

C) Hot weather concreting shall be in accordance with Section 812.05 of the *DelDOT Standard Specifications*.

D) Reinforcing Steel:

1) ASTM A615 Grade 60 (Minimum Yield Stress, F_y = 60 ksi).

2) All reinforcing steel, regardless of the location in the structure, shall have corrosion-resistant properties or coatings. Epoxy coated reinforcing steel shall conform to either:

a) ASTM A775 for reinforcing steel coated prior to fabrication; or

b) ASTM A943 for reinforcing steel pre-fabricated before coating is applied.

3) All bar bends shall be in accordance with ACI Standard Practice for detailing bar bends.

4) Minimum Concrete Cover (unless otherwise specified in the RFP Documents):

a) 2" for all exterior above grade precast element surfaces. The minimum finished clear cover to reinforcing bars for precast concrete decks shall be measured after any bridge deck grinding and before application of additional overlays;

b) 2" for cast-in-place above grade element surfaces. The minimum finished clear cover to reinforcing bars for cast-in-place concrete decks shall be measured after any bridge deck grinding and before application of additional overlays;

c) 1.5" for internal surfaces of voided concrete sections;

d) 2" for all substructure concrete surfaces cast against forms; and

e) 3" for all substructure concrete surfaces cast against earth.

E) Post-Tensioning and Grout shall be in accordance with the *Prestressing* Special Provision (*see* Part 4 of the Contract Documents).

F) Provisional and Future Prestressing for prestressed structures shall be in accordance with Article 5.14.2.3.8 of the *AASHTO LRFD Bridge Design Specifications.*

G) Structural Steel and Bolts:

1) Structural steel shall not be directly exposed to the environment. All structural steel, if used, shall be fully enclosed or encapsulated on all sides (including interior void surfaces) and at all locations with low permeability concrete. For encapsulated steel, the concrete shall be connected (i.e., shear connectors or studs, channels, etc.) to the structural steel member. The concrete shall contribute to the capacity of the structural steel member and shall also be included in the analysis of the composite member as dead load. The minimum concrete clear cover to any portion of any structural steel, including connectors or other appurtenances, shall be 2".

2) All structural steel and bolts shall be designed and constructed in accordance with the *DelDOT Standard Specifications*. As a minimum, structural steel shall be AASHTO M270, grade 50 for primary members and grade 36 for secondary members.

3) All non-encapsulated steel shall be painted in accordance with *Delaware Department of Transportation Standard Specifications* Section 820.

4) Miscellaneous steel, including steel for stairways, landings, handrails, ladders, gratings, hatches, etc., inside void spaces within the structure shall be coated in accordance with the *Inspection, Maintenance and Construction Requirements* Performance Specification. Miscellaneous steel shall not need to meet the requirements of Section G.1 above.

H) Stainless Steel:

1) Any bridge component that does not consist of concrete, is not concrete enclosed, or is not fully concrete encapsulated, excluding traffic barriers, end attenuators, railings, ladders and platforms shall be designed and constructed of marine grade, corrosion resistant stainless steel, minimum Grade 316L, unless otherwise

specified.

2) All bolts, nuts, washers, hinges, backer plates, weld plates, and other miscellaneous items attached to any stainless steel component shall be stainless steel, minimum Grade 316L.

3) Stay cable sheathing shall be HDPE or ASTM A312 Type 2205 stainless steel. *See* the *Cable-Supported Bridge System Requirements* Special Provision in Part 4 of the Contract Documents.

4) If welding is required for stainless steel, then all welding material shall be of an equal or better grade than the base metal. Aluminum and/or steel wire brushes and/or abrasives may not be used on any stainless steel part during fabrication. All heat tint and any weld splatter shall be removed.

5) All stainless steel shall be finished exclusively utilizing silicon carbide abrasives in accordance with ASME B46.1-2002. Wet 180-grit abrasive shall be used for the final finish resulting in a fine polished finish with a maximum surface roughness of Ra 20 micro-inches. This finish shall continue over field weld splices and connections.

6) The direction of the polish grain shall be oriented in the direction of free drainage of the part in its final position on the structure.

7) The visible grain of the polished finish of all stainless steel components shall be uniform in appearance and direction.

8) The Design-Builder will be responsible for protecting stainless steel bridge components from damage and contamination before final acceptance by the Department.

9) Before installation, demonstration samples and full-scale mock-ups, not to exceed 6 feet in length, of all stainless steel components shall be submitted to the Department for approval.

I) Stay cables shall be in accordance with the *Cable-Supported Bridge System Requirements* Performance Specification.

J) Surface Finish:

1) All finished exterior surfaces of the bridge structure shall have a uniform coloration in accordance with the *Aesthetic Requirements* Performance Specification and shall have an anti-graffiti coating applied in accessible exterior areas of the bridge in accordance with the *Anti-Graffiti Coating* Special Provision (*see* Part 4 of the Contract Documents).

3.7 CONSTRUCTION

A) Construction shall be in accordance with all applicable Performance Specifications (*see* Part 3) and Design-Build Special Provisions (*see* Part 4).

B) It is the responsibility of the Design-Builder to prepare a complete construction sequence/erection method and assume responsibility for the detailed design of the structure and erection equipment. The Design-Builder will be responsible for determining and monitoring forces and deflections in the permanent structure at all erection stages caused by his proposed erection method.

C) The Design-Builder shall provide camber to the structure to achieve the final grades and

cross-slopes in accordance with the *Roadway Geometrics* Performance Specification.

D) Erection loads and load combinations during construction shall be in accordance with Section 3.5.2 of this Specification.

E) The Design-Builder shall make provisions for emergency bracing and stabilization of the structure during construction. The structure shall be braced or secured if, during construction, winds in excess of construction design values are to be expected.

F) Temperature effects shall be considered during construction.

G) Whenever the construction of a structural component (such as a wall, footing, or other such component) requires excavation that may endanger the public or existing structure that is in use, the Design-Builder must protect the public and the existing facility. If a temporary retaining structure is, therefore, required during the construction stage only, it shall be removed and may be reused after completion of the work. Such systems as steel sheet pilings, soldier beams, and lagging or other similar systems are commonly used. In such cases, the Design-Builder is responsible for designing the retaining structural system in accordance with the DelDOT Bridge Design Manual. The retaining structural system shall be detailed in the Plans for the project and shall be signed and sealed by the Design-Builder's Design Engineer in responsible charge of the design.

H) The Design-Builder may furnish, erect, operate and utilize an on-site concrete batch plant in accordance with the Section 3.1.5 of the *Concrete for Structures* Performance Specification and Section 812 of the *DelDOT Standard Specifications*.

I) All concrete construction joints shall be prepared in accordance with Section 602 of the *DelDOT Standard Specifications*.

J) All concrete chamfers shall be not less than ¾".

K) The structure shall be designed prohibiting the drilling of concrete for installation of any appurtenances. All appurtenances (either temporary or permanent) shall be attached to the structure using cast-in-place inserts, unistrut or other hardware approved for use by the Department.

4.0 DESIGN CRITERIA

4.1 GENERAL

A) The distribution of force effects to the components of cable-supported bridge types shall be determined by either three-dimensional or two-dimensional structural analysis as justified by consideration of the above deck supporting members geometry, number of planes of cables, and the torsional stiffness of the deck superstructure.

B) Non-linear effects shall be considered in both the global and local analyses of the structural bridge system.

C) The calculation of forces and deformations shall consider the following:

1) Non-linear response of cables;

2) The p-delta effects (geometric non-linearity) for the girder under axial load and bending and for all other elements with significant axial loads ;

3) The variation of load intensity with loaded length when load superposition is no longer valid;

4) The non-linear effect of live load that includes the moment due to dead load thrust acting on the live load displacement; and

5) The change in stiffness due to concrete cracking under factored loads shall be taken into consideration when the deformation of the structure results in a significant change in force effects.

D) The analysis shall include the time dependent effects of creep and shrinkage for the stage-by-stage construction and the completed bridge.

E) Live load analysis shall include checkerboard loading to produce maximum torque.

F) All other loads including construction loads shall be in accordance with Section 3 "Requirements" of this Performance Specification.

4.2 SUPERSTRUCTURE DESIGN

A) Stress Limits for Concrete Members

1) Stress limits for concrete members shall be in accordance with the *AASHTO LRFD Bridge Design Specifications* except that no tension shall be allowed at the Service Limit State after losses for effective prestress and permanent loads. The superstructure shall be designed as fully prestressed. Construction load combinations at the service limit state shall be checked as per Section 5.14.2.3.3 of *AASHTO LRFD Bridge Design Specifications*.

2) The term "fully prestressed" as used herein shall be interpreted as defined in Section 5.9 of the *AASHTO LRFD Bridge Design Specification*. The superstructure shall satisfy the allowable stresses for "fully prestressed" components included in the *AASHTO LRFD Bridge Design Specification* for both longitudinal and transverse directions. In addition to the allowable stresses for the AASHTO Service Limit States, the superstructure tensile stress limit after losses shall be "no tension" for an additional Service Limit State Combination consisting of the sum of effective prestress and permanent loads. The "no tension" tensile stress limit shall apply in both the longitudinal and transverse directions of each component.

B) Bridge Decks

1) For concrete bridge decks, a minimum 1 5/8 inch thick overlay shall be constructed for the bridge deck wearing surface. Acceptable overlay systems are listed below. Alternative deck wearing surfaces or overlay systems shall be submitted to the Department for review and must be approved by the Department prior to use.

a) Latex Modified Concrete Overlay (See Part 4 - Special Provisions, Special Provision 602543);

b) Micro-Silica Modified Concrete Overlay (*See* Part 4 - Special Provisions, Special Provision 602583); and

c) Low Permeability Concrete Overlay (*See* Part 4 - Special Provisions, Special Provision 602697).

2) Orthotropic steel deck shall not be used.

C) Segmental Concrete Box Girders

1) For segmental concrete box girders, the effective width of deck slab for analysis

2) Influence surfaces or other elastic analysis procedures shall be used to evaluate live load plus impact effects in the top flange.

3) Principle tensile stresses in the girder webs and flanges shall be limited to $3.5\sqrt{f'_c}$ under AASHTO LRFD Service State III.

4.3 PERMANENT STAY CABLES

Refer to the *Cable-Supported Bridge System Requirements* Special Provision for additional requirements.

A) Stay cables shall be designed in accordance with the strength, service, extreme event and fatigue limit states stipulated herein and in the *PTI "Recommendations for Stay Cable Design, Testing, and Installation."*

B) The static design of cables shall be made for axial loads and the bending stresses near the anchorages that result from angle changes caused by cable sag changes, geometry changes from joint displacement and change of angle due to rotation of girder and tower.

C) The Design-Builder's stay cable installation procedure shall specify which is the live (stressing) end anchorage for the cable. The stressing end anchorage shall be detailed to provide for future cable replacement.

D) The stay cable anchorages shall allow for future force adjustments (increase or decrease) of at least 2.5% of the guaranteed ultimate strength of each stay cable. The Design-Builder's stay cable installation procedure shall include details and procedures for removing/detensioning strands and re-installing strands.

E) Stay cables shall be designed for HL-93 live load as per the *PTI "Recommendations for Stay Cable Design, Testing, and Installation."* The live load consists of a design truck or design tandem, in combination with a design lane load of 0.64 klf uniformly distributed in the longitudinal direction.

F) Each traffic lane under consideration shall be occupied by either the design truck or design tandem, in addition to the design lane load. The design lane load occupies 10 ft. transversely within the design lane.

G) Impact shall be applied to the design truck or tandem. Impact shall not be applied to the design lane load.

H) The fatigue load shall be a single truck occupying a single lane. The fatigue design truck calculated design value shall be multiplied by the factor 1.4. Impact shall be applied to the calculation of fatigue effects.

I) Permanent Stay Cable Replacement:

1) The design shall provide for the replacement of any individual cable with a reduction of the live load in the area of the cable under exchange. The design shall also be capable of withstanding the loss of any one stay cable without the occurrence of structural instability.

2) Details on final plans shall allow all individual stay cables to be removed by detensioning at the live end anchorage.

3) The following special load factors and combinations shall be used for the following stay cable conditions:

a) Stay Cable exchange:

1.2DC+1.4DW+1.5(LL*+IM) + Cable Exchange Forces

(* Closest design lanes to the line of stay cable anchorages shall be restricted and/or closed along with the corresponding lane in the opposite direction of travel)

The definitions of the symbols are given in Section 3.3.2 of the *AASHTO LRFD Bridge Design Specifications*. A resistance factor Φ=0.80 shall be used for this strength limit state event.

b) Loss of Stay Cable:

1.1DC+1.35DW+0.75(LL**+IM) + 1.1 Cable Loss Dynamic Forces

(**Full live load placed in their actual striped lanes)

The definitions of the symbols are given in Section 3.3.2 of the *AASHTO LRFD Bridge Design Specifications*. A resistance factor Φ=0.90 shall be used for this extreme limit state event.

The dynamic force resulting from the sudden fracture of a cable shall be in accordance with Article 5.5 of the *PTI "Recommendations for Stay Cable Design, Testing and Installation."*

4.4 TEMPORARY STAY CABLES

A) Temporary stay cables, if required for construction, shall be designed in accordance with PTI "Recommendations for Stay Cable Design, Testing, and Installation".

B) Temporary stay cables shall be limited to an allowable stress of 0.6 F'_s during construction.

4.5 BEARINGS

A) The design friction for structural sliding bearings shall be 3% maximum. The Design-Builder shall be responsible for utilizing the necessary methods and materials defined in the *AASHTO LRFD Bridge Design Specifications* Table 14.7.2.5-1 to achieve friction values less than or equal to this design value.

B) Each bearing shall be designed and detailed to be replaceable by jacking the superstructure off the permanent bearings. The longitudinal and transverse analysis of superstructure shall consider the redistribution of reactions and forces when jacks are engaged to replace the bearings. The plans shall indicate the required position, size, and type of the jacks.

C) Bearings shall be in accordance with Part 4 – Special Provisions, *Bridge Bearing Devices*.

4.6 EXPANSION JOINTS

A) Modular and sliding plate expansion joints shall not be used. Finger joints or strip seal expansion joints shall be used in accordance with Part 4 – Special Provisions, *Bridge Expansion Joint Devices*.

B) Steel finger joints shall be hot-dipped galvanized.

C) In the shoulders and the combined use walkway, joints shall accommodate bicyclists.

4.7 SUBSTRUCTURE DESIGN

A) Towers and Piers

1) Reinforced concrete piers and towers shall be designed in accordance with *AASHTO LRFD Bridge Design Specifications.*

2) The bridge shall be checked for an Extreme Event Limit State load combination including wind loads with a 2000-year return period and permanent loads. The load factor for all loads in this load combination shall be equal to 1.0. The structure shall not have any structural instability, such as buckling or brittle failure that could result in catastrophic collapse under this loading.

3) Precast prestressed hollow-section pier columns constructed segmentally are not permitted for use below the mean high water elevation.

4) Non-linear analysis (large deflection analysis) shall be used for the design of the towers and piers. For the computation of factored load moments and shears, cracked section properties shall be used, if applicable.

5) The use of exposed steel towers shall not be permitted.

B) Footings

1) Concrete footings shall be designed in accordance with *AASHTO LRFD Bridge Design Specifications.*

2) P-delta effects shall be considered in accordance with Section 4.1 of this Performance Specification.

3) During construction, the following load combinations for foundation supporting elements shall be utilized in addition to all other applicable limits states included in AASHTO (The definitions of the symbols are given in Section 3.3.2 of *AASHTO LRFD Bridge Design Specifications*):

a) Service: 1.0[(DL+CR+SH)+(CE+CLL)+W+TR/TF)]

Strength: η_i [1.25(DL+CR+SH)+1.50(CE+CLL)+1.25W+1.0(TR/TF)].

C) Tremie Seals

1) Tremie seals, where utilized, shall be designed in accordance with *DelDOT Bridge Design Manual*.

D) Temporary Retaining Structures

1) Temporary retaining structures, such as cofferdams, sheet pile walls, and other such structures, where utilized, shall be designed in accordance with the *DelDOT Bridge Design Manual*.

2) Temporary retaining structures shall also conform to Section 3.7.G of this Performance Specification.

4.8 CORROSION PROTECTION PLAN

For the Corrosion Protection Plan refer to the Performance Specification for *Inspection, Maintenance and Construction Requirements*.

5.0 INSPECTION AND MAINTENANCE MANUAL

For the Inspection and Maintenance Manual refer to the Performance Specification for *Inspection, Maintenance and Construction Requirements*.

BRIDGE DRAINAGE SYSTEM
PERFORMANCE SPECIFICATION

1.0 INTRODUCTION

The Design-Builder shall provide a bridge drainage system designed to safely handle storm runoff consistent with the Design-Builder's bridge design and to satisfy all environmental commitments (*see* Part 7 – Permit Requirements) and other Department requirements. The design and construction of all drainage and other bridge drainage facilities shall adequately address runoff control, safety, functionality, erosion mitigation, durability, ease of maintenance and repair, and maintenance access. The Design-Builder shall abide by the specifications and standards in this Performance Specification and in other applicable sections as they pertain to drainage facilities, including NPDES and other permit requirements.

The Design-Builder shall also design the bridge drainage system in a manner that is consistent with the Aesthetic Requirements for the project and all portions of the bridge drainage system shall be camouflaged, concealed, or inconspicuously provided such that the drainage system does not negatively disturb or detract from the aesthetic appearance of the structure in the opinion of the Department.

2.0 STANDARDS AND REFERENCES

The design and construction of bridge drainage system facilities and appurtenances, including those required for environmental purposes, shall be in accordance with this Performance Specification and the relevant requirements of the following standards, unless otherwise stipulated in this Performance Specification. Standards and references specifically cited in the body of the Bridge Drainage System Performance Specification establish requirements that have precedence over all others. Should the requirements in one standard conflict with those in another, the standard highest on the list shall govern. Listed under references are guidelines that the Design-Builder may use to address the requirements, as the Design-Builder sees fit. It is the Design-Builder's responsibility to obtain clarification of any and all unresolved ambiguity prior to proceeding with any design or construction.

2.1 STANDARDS

Specific codes and standards include, but are not limited to, the following listed in order of governing precedence.

2.1.1 Design

A) Delaware Department of Transportation "Bridge Design Manual" with Revisions through May, 2005;

B) Federal Highway Administration (FHWA) HTA-22, Hydraulic Engineering Circular 21 (HEC-21) FHWA-SA-92-010, "Design of Bridge Deck Drainage," May, 1993;

C) FHWA HTA-22, Hydraulic Engineering Circular 22 (HEC-22) FHWA-NHI-01-021, "Urban Drainage Design Manual," Second edition, August, 2001;

D) AASHTO, "Model Drainage Manual," 2005 Edition;

2.1.2 Specifications

A) Delaware Department of Transportation "Standard Specifications for Road and Bridge Construction" Dated 2001;

B) Delaware Department of Transportation "Supplemental Specifications, Revisions and Corrections to the August 2001 Standard Specifications";

2.1.3 Coordination with other Design Standards

A) Delaware Department of Transportation "Road Design Manual" with Revisions through July, 2004;

B) "AASHTO LRFD Bridge Design Specifications," Third Edition, 2004 (U.S. Customary Units), with Interims through 2006.

2.2 REFERENCES

A) Delaware Department of Transportation, Design Guidance Memorandums;

B) Delaware Department of Transportation, "Standard Construction Details," Dated 2005;

C) AASHTO, "A Policy on Geometric Design of Highways and Streets (Green Book)," Fifth Edition, 2004;

D) AASHTO, "Roadside Design Guide," Third Edition, 2002;

3.0 REQUIREMENTS

3.1 DESIGN CRITERIA

A) The Design-Builder shall determine the design storm for the Project subject to approval by the Department.

B) The minimum allowed design storm recurrence interval shall be the ten-year storm. This value shall be used regardless of any Design-Builder research, analysis or calculations that indicate a lesser design storm recurrence interval. Should the Design-Builder's research, analysis and/or calculations indicate an increase in the recurrence interval for the design storm, then the Design-Builder shall use the higher recurrence interval for design.

3.1.2 Bridge Deck Drainage

A) The Design-Builder shall perform a hydraulic analysis in accordance with HEC-21 to determine the required size and number of scuppers. Bridge deck drainage discharge under barriers or curbs by means of slots, weep holes or by other means shall be considered unacceptable and will not be approved by the Department for use on the project.

B) All scuppers shall be located in a straight line on the low side of the outside shoulders or curbs for pedestrian sidewalks. Scuppers shall not be placed in traffic lanes.

C) All drainage grates shall be ADA-compliant and shall be bicycle-safe.

D) The center of scupper inlet pipes shall be parallel to the vertical faces of bridge traffic barriers and curbs for pedestrian sidewalks. Local depressions around scupper inlet pipes shall be provided to promote positive drainage.

E) Scuppers shall be omitted in areas where free-fall drainage from scupper outlet pipes will be over roadways, permanent paved pedestrian pathways and sidewalks, or immediately

over and/or adjacent to bridge supporting elements such as piers, pylons, towers, arch bases, abutment walls and bearing seats. Centers of free-fall scupper outlet pipes may not be located within 10 feet measured horizontally in plan view within any surface of a bridge-supporting element mentioned above.

F) Scuppers shall be manufactured from simple sections of PVC piping and shall be installed flush with and normal to the depressed bridge deck riding surface. Outlet pipes shall not introduce runoff discharge within structural void spaces of the bridge.

G) The minimum allowable pipe schedule shall be schedule 40. Minimum allowable pipe diameters shall be as follows:

1) Scuppers for areas of the bridge deck carrying vehicular traffic: 4 inch dia.

2) Scuppers for areas of the bridge deck carrying pedestrian traffic: 2 inch dia.

H) The underside surface of the bridge immediately adjacent to free-fall scupper outlet pipes shall receive a 1/2 inch deep "V"-groove around the full perimeter of the outlet pipe to create a drip edge. The "V"-groove shall be located within 4 inches of the outside edge of the outlet pipe. The "V"-groove detail may form either a rectangular or circular perimeter around the scupper outlet pipe.

3.1.3 Bridge Expansion Joint Device Discharge

A) The Design-Builder shall determine the volume of runoff collected at the bridge expansion joint devices for the design of piping, downspouts, collectors, cleanouts, trench drains, splash blocks, and any other such materials for the proper conveyance of collected discharge from the bridge expansion joint devices.

B) The Design-Builder shall design piping, downspouts, scuppers, trench drains, and any other such materials for the conveyance of collected discharge from the bridge expansion joint devices with an efficiency of 50% to estimate the condition when the system may be partially clogged by debris and sediment.

C) All piping, downspouts, cleanouts, floor drains, collectors, connections and other such materials required for the complete assembly of the drainage system for bridge expansion joint device discharge shall be ductile iron conforming to the requirements of *ASTM A746* with asphaltic coating. The asphaltic coating shall be a minimum of 1 mil in thickness after curing.

D) Minimum allowable pipe size for bridge expansion joint discharge shall be 6 inch DIP size. Minimum allowable diameter for cleanouts and round floor drains shall be 6 inches.

E) Slopes of pipe laterals shall be determined by the Design-Builder. The minimum allowable slope for piping laterals shall be 3%.

F) Slopes for trench drains shall be determined by the Design-Builder. The minimum allowable slope for trench drains shall be 1%.

G) The minimum width and depth of trench drains shall be 6 inches. Trench drains shall be supplied with gratings and shall conform to *ASTM A48*, Class 30.

H) Drainage outlet pipes shall be placed such that the free-fall discharge height is less than 2 feet above splash blocks.

BRIDGE HYDRAULICS AND SCOUR REQUIREMENTS
PERFORMANCE SPECIFICATION

1.0 DESCRIPTION

The specific purpose of this scope is to determine design coastal storm surges, flows, and wave heights to predict expected scour around the proposed Indian River Inlet replacement bridge. Minimum design requirements shall be in accordance with the *Bridge Design Requirements* Performance Specification.

2.0 BACKGROUND

Coastal storms in 2004 and 2005 caused failure of major bridges – primarily through the combination of storm surge and wave action. Failure modes included wave action (uplift, impact, and buoyancy forces), erosion of embankments and abutments, and scour. Lessons learned included a realization that coastal storm factors may require a different hydraulic assessment than normally considered for riverine bridges. The Department shall require that the design of the proposed Indian River Inlet Bridge characterize and consider such factors during the design-build process.

3.0 DESIGN-BUILDER'S QUALIFICATIONS AND EXPERIENCE

Appropriate coastal hydraulic analyses require a multi-disciplinary team qualified in Coastal Engineering, Bridge Hydraulics/Hydrology, Structures, and Geotechnology. The team should demonstrate experience in deriving design storms and/or frequencies in a coastal setting; numerical modeling of both storm surge (e.g, ADCIRC, RMA2, etc), waves (e.g., WAM, SWAN, etc), and understand the need to couple such models as necessary; and be able to perform scour analyses and produce scour countermeasure designs. The key individuals within the team having direct oversight of this work must demonstrate by formal education and or experience the ability to meet these qualifications. An individual may qualify in more than one discipline. The analyses of astronomical tides, waves, and hurricane storm surges should use Coastal Engineering analyses as typified by the practices of the USACE and consistent with current coastal engineering practice[1]. The qualifications of the multi-disciplinary Coastal Engineering shall be submitted to the Department for approval.

4.0 TASKS

This scope of work includes several tasks as outlined below. Some of the requirements of the Design-Builder shall include characterizing site conditions, predicting 50, 100 and 500-year return interval storm surge heights and wave parameters at the bridge location, predicting scour depths and extents at structural elements (e.g, piers; abutments, retaining walls), and developing countermeasures and/or shoreline protection.

4.1 TASK 1: DETERMINE DESIGN STORM CHARACTERISTICS

Using accepted coastal engineering approaches and practices, determine the design storm characteristics and/or boundary conditions for the 50, 100, and 500-year events. These may be those surge and wave estimates associated with FEMA Flood Insurance Studies. However, other approaches may be applied to characterize such frequencies. The Department would consider historical, synthetic, or empirical simulation technique (EST) methods (described in "Storm Surge Analyses and Design Water Level

[1] NOTE: These do not include the FHWA document "HEC-25: Tidal Hydrology, Hydraulics, and Scour at Bridges (first edition)" or the tidal waterways section of the FHWA document: "HEC-18: Scour at Bridges (fourth edition)." However, the remainder of HEC-18 SHOULD be used to conduct scour analyses.

Determinations," USACE, EM 1110-2-1412, April 1986, "Chapter 5 - Water Levels and Long Waves," USACE, EM 1110-2-1100 (Part II), April 2002, or "Hurricane Climatology for the Atlantic and Gulf Coasts of the United States," NOAA TR NWS38, April 1987) as describing some accepted procedures to estimate exceedance probability in a coastal environment. Other approaches might apply stochastic analyses of hindcast storm events for the project area.

The resulting design storm characteristics will be applied to the storm surge and wave models developed in Task 2.

4.2 TASK 2: DEVELOP STORM SURGE AND WAVE MODELS

Develop storm surge and wave models for Indian River Inlet. The Department believes that ARCIRC, RMA2, and SWAN represent current state of practice for such studies, but a team may propose application of other, alternative, modeling approaches. The Department must approve use of any proposed models. Submit an interim report for this task for review and comment by the Department and present the methodology and results to the project team.

4.2.1 Gather Available Data

These may include, but are not limited to:

a) Bathymetry-Topography data

b) Validation data

c) Water elevations (tide gages)

d) Discharge measurements

e) Water elevation records during past storm events

f) Aerial photography

g) NOAA charts

h) Digital quad maps

i) FEMA Flood Insurance Studies

j) Other modeling efforts

k) Wind data (including purchasing hindcasted wind / pressure data for storms in NOAA database that have impacted the project area).

4.2.2 Reduce, Analyze, Reconcile, and Assess Available Data

Shift and merge data sets as needed. Compare and rectify boundaries for consistency. Evaluate adequacy of coverage and reliability of available survey data. Determine strategy for obtaining additional bathymetry as needed.

4.2.3 Development of Models

a) Develop Storm Surge Model Mesh. Provide sufficient grid detail to allow acceptable accuracy at bridge substructure units, embankments, and abutments.

b) Develop Wave Model Meshes. Develop large wave model mesh and higher resolution, nested wave model meshes.

c) Couple models as needed. This may include developing wind grid to storm surge grid, storm surge grid to wave grid, and wave grid to storm surge grid.

d) Validate Storm Surge and Wave Models. Use spring tide elevation and discharge data, and any available hurricane high water marks, to validate the storm surge / wave model.

4.2.4 Prepare Report and Present Results to the Department

Submit a draft final report, make a formal presentation of results, and respond to comments on the report.

4.3 TASK 3: MODEL STORM EVENTS

Using the developed models, determine 50, 100, and 500-year hurricane flow velocities, peak water elevations, and wave heights. Submit an interim report for this task for review and comment by the Department and present the methodology and results to the Project Team. Note: the results of Tasks 1 and 2 will be used to evaluate the potential lateral loadings from wind, waves, and potential buoyancy on the Bridge superstructure. Minimum design requirements shall be in accordance with the *Bridge Design Requirements* Performance Specification.

4.4 TASK 4: PERFORM BRIDGE SCOUR ANALYSES

Using approaches in the FHWA document "HEC-18 – Scour at Bridges (4^{th} edition)", calculate scour estimates for the following conditions:

- Worst case scour condition up through the 100-year frequency flood event (Design Scour Flood Event).
- Scour condition for the 500-year frequency flood event (Check Scour Flood Event).

Scour Components: Scour estimates for the above events shall consist of the total scour resulting from the following processes described below:

- Natural channel aggradation and degradation anticipated during the life of the structure (including sea level changes).
- Inlet or channel migration anticipated during the life of the structure.
- Contraction scour.
- Local scour, including pier scour[2] and abutment scour.
- Analyses of surge and wave action on approach embankments and MSE walls.

4.5 TASK 5: DESIGN SCOUR COUNTERMEASURES AND STRUCTURE PROTECTION

Using approaches in the FHWA document "HEC-23 – Scour Countermeasures" and Corps documents, design suitable countermeasures to protect bridge elements from scour and coastal hydraulic forces and effects.

4.6 TASK 6: PREPARE REPORTS

Necessary copies of separate semi-final and final reports shall be submitted and subjected to the Department's Consultation and Written Comment. The reports shall be compiled in hard cover binders and, at a minimum, shall contain discussions and results of the following:

- CDs of all survey data, aerials, model datasets, the final reports, etc.
- Wave and surge information for the specified return interval events in the form of tables and plots.

[2] The team should look at both HEC-18 and Sheppard's methods for estimating pier scour.

CONCRETE FOR STRUCTURES
PERFORMANCE SPECIFICATION

1.0 INTRODUCTION

This Performance Specification specifies the requirements of furnishing, placing, curing and finishing all cast-in-place (CIP) and precast concrete elements proposed by the Design-Builder as part of the Work for the Project. The Design-Builder shall be responsible for designing concrete mixtures that meet all the parameters specified herein and finishing the Work in reasonably close conformity with the lines, grades and dimensions shown on the Design-Builder approved plans.

2.0 REFERENCES AND STANDARDS

The design, furnishing, placement, curing, finishing of all concrete work shall be in accordance with this *Concrete for Structures* Performance Specification and the relevant requirements of the following standards unless otherwise stated in this Performance Specification. Standards and references specifically cited in the body of this Performance Specification establish requirements that shall have precedence over all others. Should the requirements in any standard conflict with those in another, the more conservative standard presented in Section 2.1 of this specification shall govern. References are guidelines that the Design-Builder may use in addressing the requirements as the Design-Builder sees fit. It is the Design-Builder's responsibility to obtain clarification from the Department's Project Manager for any unresolved ambiguities prior to proceeding with design or construction. Items listed as standards or references in this Performance Specification shall be the most recent version available on the Proposal due date.

2.1 STANDARDS

Specific codes and standards include, but are not limited to, the following listed in order of governing precedence:

A) Scope of Services Package Plans (*See* Contract Documents);

B) Supplemental Specifications to the DelDOT Standard Specifications;

C) Delaware Department of Transportation "Standard Specifications for Road and Bridge Construction" Dated 2001;

D) Delaware Department of Transportation "Materials and Research Manual" with Revisions through March, 2005;

E) "AASHTO LRFD Bridge Design Specifications," Third Edition, 2004 (U.S. Customary Units), with Interims through 2006. Delete Section 5.14.2.3.9 in its entirety (All Shop and Working Drawings will conform to the requirements of the Contract);

F) "AASHTO LRFD Bridge Construction Specifications," Second Edition, 2004 (U.S. Customary Units), with Interims through 2006.

2.2 REFERENCES

A) ACI 301 R-05, "Specifications for Structural Concrete";

B) ACI 305 R-99, "Hot Weather Concreting";

C) CEB-FIB "Model Code 1990," First Edition, 1993, Chapter 2: Material Properties for Time Dependent Properties of Concrete Only;

D) PTI Guide Specification, "Grouting of Post-Tensioned Structures," Second Edition, 2003;

E) ACI 207.1 R-96, "Mass Concrete"; and

F) Delaware Department of Transportation "Bridge Design Manual" with Revisions through May 2005.

2.3 DEFINITION OF TERMS

A)	ACI	American Concrete Institute
B)	(AD)	Design Percent Air
C)	ARML	AASHTO Reference Materials Laboratory
D)	Arithmetic Mean	The value obtained by adding individual values and dividing by the number of values to obtain an average.
E)	CCRL	Cement and Concrete Reference Laboratory
F)	Certified Laboratory	Either an ARML laboratory with a PCC certification or a CCRL laboratory with a concrete certification.
G)	Defective Material	Concrete that is placed but fails to meet specification requirements.
H)	Design Permeability	A measurement value of the concrete mixes quality. The value, in Coulombs, which the concrete achieves after 28 days when tested in conformance to AASHTO T 277 and as modified by this specification.
I)	*f'c*	Specified Design Strength at 28 days or specified age (ACI 301 4.2.3.3.a)
J)	*f'cr*	Required average compressive strength at 28 days or specified age (ACI 301 4.2.3.3.a)
K)	Sample Standard deviation (S)	The positive square root of the sample variance.
L)	Sample Variance	the Square of the difference between a individual sample value and the mean of the sample.
M)	Substructure Concrete	Concrete used in the following bridge components: foundation support elements, footings, abutments.
N)	Superstructure Concrete	Concrete used in the following bridge components: precast or CIP superstructure, closure pours, pylon, arch.

2.4 MATERIALS

All materials used for Portland Cement Concrete (PCC) and curing shall meet the applicable requirements under Sections 812.02(a), (b), (c), (d), (e), (f), (g), (h), and (i) of the DelDOT Standard Specifications unless otherwise modified herein. Additional material requirements include the following:

A) Ground granulated blast furnace slag. (Certification by the Manufacturer is required). The one day cube strength results of ASTM C 1073 may be used in lieu of the 7 and 28-day cube strengths required by ASTM C 989.

B) High molecular weight methacrylate resin sealer shall be in accordance with SS 1054.

C) Joint filler shall be ¼" thick and be in accordance with DelDOT Standard Specifications Section 808.04(d).

D) Seals (preformed elastomeric compression joint) shall be in accordance with DelDOT Standard Specifications Section 808.04(a).

E) Bar Reinforcement shall be in accordance with DelDOT Standard Specifications Section 603.

F) Epoxy Coated Bar Reinforcement shall be in accordance with Section 604 of the DelDOT Standard Specifications.

G) Post-Tensioning Steel, Ducts for Post-Tensioning Tendons and Grout for Post-Tensioning Tendons shall be in accordance with Part 4, Special Provisions - *Prestressing*.

H) Polypropylene Fiber shall be in accordance with DelDOT Standard Specifications Section 824.

3.0 REQUIREMENTS

3.1.1 Concrete Mix Design

The Design Builder shall be responsible for the design, production, documentation, and submittal of concrete mixture designs that will produce structural concrete meeting the required design parameters of this Contract. The Design-Builder's submitted mixture design shall satisfy the following minimum performance requirements:

Property	Specification Limit	Test Method
f'_c	As specified by the Design-Builder	AASHTO T22 & T23
Permeability[1]	1500 coulombs (maximum)	AASHTO T277[2]
Water/cementitious ratio	0.42 (maximum)	N/A
Air Content	4.0 – 7.0%	AASHTO T152
Slump	4.0 – 8.0"	AASHTO T119

[1] The permeability requirement may be eliminated, at the Design-Builder's option, for any concrete elements permanently located below finished grade.

[2] Tests will be run after samples are moist cured for 7 days at 73^{o}F followed by moist curing for 21 days at 100^{o}F.

The specific mixture design submitted by the Design-Builder shall meet all applicable specification requirements and take into consideration the weather conditions, delivery time, and placement operations. All individual concrete constituent materials shall be compatible with the other proposed materials to ensure the concrete satisfies all Contract requirements.

Prior to incorporation of concrete into the Work, the Design-Builder shall produce a 5 cubic yard load of each proposed mixture design for testing by the Department. This shall take place a minimum of 60 Calendar Days prior to placement of this concrete in order for the Department to complete the testing and provide written comment.

Any changes to individual constituent materials for the manufacturing of concrete shall be submitted to the Department's Project Manager a minimum of 5 Working Days prior to incorporation into the Work.

3.1.2 Alkali-Silica Reactivity Mitigation

Coarse and fine aggregates for use in Portland Cement Concrete shall also be evaluated by the Design-Builder for potential alkali-silica reactivity (ASR) using at least one of the means referenced below along with any field service records available for the materials in question. If a field service record for a particular source includes evidence of deleterious ASR occurring in that source, then that source shall be classified as potentially reactive regardless of any laboratory test result for that source. Test results of the proposed aggregates shall be provided by the Design-Builder to the Department's Project Manager for review and written comment a minimum of 60 Calendar Days prior to the incorporation of the mixture on the Project.

Tests and Criteria for Proposed Aggregate		
Procedure	**Description**	**Limit**
AASHTO T303	Mortar Bar Expansion	≤ 0.08% at 14 days
ASTM C1293	Concrete Prism Expansion	≤ 0.04% at 1 year

If the proposed concrete mixture design exceeds any of the limits referenced above, or the aggregate has demonstrated deleterious ASR in the field, mitigation steps shall be taken. These mitigation steps shall incorporate one or a combination of the following materials:

- **Low Alkali Cement** having an alkali content of 0.40 or less,

And/or the following supplementary cementitious materials:

- **Blended hydraulic cement** meeting the requirements of ASTM C1157,
- **Ground Granulated Blast Furnace Slag** meeting the requirements of AASHTO M302, Grade 100 or 120,
- **Silica Fume** meeting the requirements of AASHTO M307,
- **Fly Ash** meeting the requirements of Section 822, and with a total alkali content less than 3.0%

And/or the following chemical admixture:

- **Lithium Admixture** at a dosage rate based upon the sodium oxide equivalent (AASHTO M 85) of the Portland cement component of the concrete. The standard lithium dosage is 0.55 gal of 30% lithium nitrate solution per 1 lb of sodium oxide equivalent of the Portland cement, with a minimum dosage of 0.60% by weight of the Portland cement. Other lithium compounds may be used if prior approval by the Department's Project Manager is obtained by the Design-Builder. All lithium salts shall be certified as non-hazardous based on the heavy metal content. Mixing shall be as per manufacturer's recommendation. The amount of lithium admixture used shall be reported as the percent of standard dose.

The exact dosage rates of any of the above referenced products shall be determined by the Design-Builders testing in accordance with the table below, unless otherwise noted. All mixture design testing shall be performed by a laboratory approved by the Department's Project Manager. Test results of the proposed concrete mixture components shall be provided by the Design-Builder to the Department's Project Manager for review and written comment at least 60 Calendar Days prior to the incorporation of

the mixture on the project.

Tests and Criteria for Proposed Concrete Components		
Procedure	**Description**	**Limit**
ASTM C1260 (modifed[1,2])	Mortar Bar Expansion	≤ 0.08% at 28 days
ASTM C1293 (modifed[2])	Concrete Prism Expansion	≤ 0.04% at 2 years

[1]Low alkali cement cannot be evaluated by either of these test methods. If low alkali cement is used with aggregate shown to be potentially reactive as the only measure to minimize the ASR potential of the concrete, then the total alkali loading of the concrete mix design from the Portland cement and other cementitious materials shall not exceed 2.5 lb/yd^3.

[2]The modifications to C1260 and C1293 necessary to meet this table are described in the FHWA publication 'Guidelines for the Use of Lithium to Mitigate or Prevent Alkali-Silica Reaction', publication number FHWA-RD-03-047, July 2003, pages 60-62. An Excel spreadsheet is available from the Department's Project Manager to calculate material amounts for the C1260 modifications. Amounts of components used in modified C1260 tests submitted by the Design-Builder shall match those in this spreadsheet.

3.1.3 Mix Design Documentation

The Design-Builder shall submit to the Department for review and written comment mix design documentation for each Class and Type of concrete proposed for use in the Work. Each mix design submittal shall include certified test data documenting results for air, slump, yield, unit weight, *f'cr*, and the AASHTO T-277 modified permeability. Submittals shall be made a minimum of 21 Calendar Days prior to the scheduled concrete placement.

The certified test data shall also include:

A) Weight, source and type of fine aggregate [lb](SSD)

B) Weight, source, type and size of each coarse aggregate [lb](SSD)

C) Weight, source and type of Cement [lb] *

D) Weight, source and class of Fly ash [lb]

E) Weight, source and grade of Ground Granulated Blast Furnace Slag [lb]

F) Weight and source of Micro Silica [lb]

G) Weight of water [lb]

H) Admixtures including:

   a) Type

   b) Brand name

   c) Dosage during test

I) Concrete temperature

J) Water / Cementitious materials ratio

K) Tested Slump

L) Tested air content

M) Unit weight

N) Yield

O) Tested *f'cr* @ 28 days and at other ages as required by the Design-Builder approved plans

P) Tested design permeability in coulombs @ 28 days

*If blended cement is used, the mix design shall note the components of the blended cement and the proportions of those components along with the proportionate weights.

The submittal shall also include specific gravity for the aggregates, cements, and pozzolanic materials and percent absorption of the aggregates.

The Design-Builder may choose to run trial batches of concrete mixes meeting these specifications to assure workability. If the workability of the trial batch is not acceptable to the Design-Builder, the Design-Builder may modify the mix design or batching sequence and retest. Modifications to aggregate weights, excluding adjustments for specific gravity or absorption changes, by more than 3% or a change in aggregate source will constitute a change to the mix design. Submittal of new certified test data to the Department will be required prior to use of the modified mix.

3.1.4 Quality Control Testing Requirements

The Design-Builder shall be responsible for performing in process quality control sampling and testing of the concrete in accordance with Part 2, DB Section 106 – Control of Materials.

3.1.5 Concrete Production

All concrete shall be produced in accordance with the requirements of Section 812 of the DelDOT Standard Specifications.

3.1.6 Concrete Placement and Curing

The Design-Builder shall be responsible for ensuring the placement and curing of all structural concrete is performed in accordance with the Contract requirements and generally accepted industry standards. Within 24 hours of completing each concrete pour, the Design-Builder shall submit to the Department's Project Manager a report including all concrete test results and documentation associated with the concrete pour. The report must be reviewed and approved by the Design-Builder's Construction QC Manager prior to submission to the Department. Any potential problems identified or concerns raised during or after the concrete pour and planned remedial measures shall be documented in each report.

4.0 CAST-IN-PLACE AND PRECAST CONCRETE

The work specified in this Section shall consist of manufacturing structural cast-in-place (CIP) or precast concrete elements and their incorporation into the completed structure.

4.1.1 Definition of Terms

The following terms apply to cast-in-place segmental bridge construction:

A) Segment: Refers to a modular section of the superstructure and/or substructure consisting of a certain cross section shape and length as detailed on the Design-Builder approved plans.

B) Segment Joint: a full width and depth joint between consecutive concrete placements of an individual element shape.

C) Construction Joint: A joint within an individual section or element, created by consecutive concrete placements.

D) Cantilever (Erection): A method whereby superstructure segments are sequentially constructed in cantilever to a point where a closure joint is cast-in-place between cantilever segments or ends or end segments.

E) Balanced Cantilever (Erection): A method whereby the segments are sequentially erected alternately on either side of the pier in cantilever to a point where a closure is cast in place.

F) Span-by-Span (Erection): A method whereby segments for one complete span are constructed while temporarily supported.

G) Unidirectional Cantilever (Erection): A method whereby the segments are sequentially erected in one direction by connecting to the previously erected segment in one direction.

H) Camber: The amount by which the concrete profile at the time of casting must differ from the theoretical geometric profile grade in order to compensate for all structural dead load, post-tensioning, all long-term and time dependent deformations (creep and shrinkage) including all the intermediate erection stages and effects. (The opposite of deflections.) For cast in place construction, these values must include short and long term deflections of the foundations, substructure elements, bearings, formwork, falsework supports and the other superstructure elements.

I) Match Cast: Refers to a precast concrete fabrication process whereby a segment is cast against the preceding segment producing a matching interface that will permit the reestablishment of the cast geometry at the time of erection. Match casting may be accomplished by either the short line or long line casting method.

J) Short Line Casting: A method of casting segments one at a time in a casting cell between a bulkhead at one end and a previously cast segment at the other. The first segment is cast between the bulkhead and another temporary bulkhead.

K) Long Line Casting: A method of casting segments on a casting bed of sufficient length to permit the cumulative casting of segments for the entire length of a span or cantilever between field closure pours without repositioning the segments on the casting bed. With this method, the first segment is cast between bulkheads and successive segments are cast between a movable bulkhead on one end and the previously cast segment on the other.

L) Casting Cell: Refers to a special formwork arrangement usually consisting of a fixed vertical bulkhead of the cross section shape at one end and adjustable soffit, side and core forms all designed and assembled into a machine for making a single superstructure segment.

M) Wet Joint System: is a method whereby segments are made in a casting cell between two bulkheads and are not match cast. Subsequently, segments are erected in the superstructure with a narrow cast in place joint between each segment. (During erection, all the segments of a span or multiple spans are supported by falsework, truss or other technique until the joints have reached sufficient strength and the longitudinal post tensioning installed to make them self supporting.)

N) Casting Curve: Is the curve of casting geometry that has to be followed in the casting cell, bed, or form in order to achieve the theoretical bridge profile and alignment after all the final structural and time dependent (creep and shrinkage) deformations have taken place. The casting curve is a combination of the theoretical bridge geometrical profile grade, alignment, and the camber.

O) Erection Elevation: The elevation to which a segment or element in the structure is to be set or cast to at the time it is erected or self-supported. (This is not necessarily the profile grade but rather the profile grade corrected by the amount of deflection calculated to occur from that stage onwards.)

4.1.2 Shop / Working Drawing Requirements

Shop drawings shall be in conformance with AASHTO LRFD Bridge Design Specifications and Sections 105.04, 105.05, 105.06 of the DelDOT Standard Specifications, as applicable. The Design-Builder shall submit detailed Shop/Working Drawings that include all details necessary for the successful completion and inspection of all precast and cast-in-place concrete work. Shop/Working Drawings shall clearly identify the methods to be used and identify all items to be cast or formed into each concrete pour. The Design-Builder's detailed Shop/Working Drawings shall include, but not necessarily limited to, the following:

A) Shop drawings shall be prepared, reviewed, and submitted to the Department in accordance with Part 2, DB Section 111 of the Contract Documents.

B) Complete details of the proposed segment or element fabrication system, including casting forms, their foundations, operational details, casting layout and geometry control observation and measuring system. The shop drawings shall dimensionally locate all segment joints and construction joint locations.

C) Complete details for the post-tensioning ducts, anchorage hardware, any additional anchorage reinforcing, inserts or other items to be embedded in the segment or element. A complete geometric layout for each post-tensioning tendon shall also be submitted. This shall include inserts or embedments for temporary items such as climbing forms.

D) For the casting of Precast Superstructure segments, the Design-Builder must develop a geometry control program and an operating manual for the program for use by the Design-Builder for the duration of the precasting of the superstructure segments. This program must be provided to the Department for verification prior to casting any precast elements.

E) Theoretical casting curve geometry, in the form of a table of coordinates defining the surface of the superstructure in a phase by phase format compatible with the data input for the Design-Builders geometry control program will be provided to the Department. Adjustments for camber will be included in these coordinates according to the construction sequence, loads, methods and schedule provided by the Design-Builder. The Design-Builder shall supply to the Department all detailed information requested by the Department including but not limited to the following:

1) Proposed Schedule - including but not limited to all casting dates, erection dates, stressing dates for permanent tendons and temporary stay and load movement (equipment, etc.) dates.

2) All Erection Equipment imposed loads - including but not limited to form travelers, delivery equipment, equipment storage, material storage, cranes,

scaffolding, access platforms, etc.

3) Location of all imposed loads - detailed sketches showing all tie down details and locations, loads prior to casting, and after casting.

4) Complete details of forming segments and elements. These details shall include, for each type of segment or element, the method and sequence of concrete placement.

F) A manual for the geometry control of any segment or element prepared by the Design-Builder, in accordance with the information provided in the Design-Builder Approved Plans and Documents, and as required by this performance specification. This manual shall include a detailed step-by-step casting sequence including all intermediate procedures relating to; any traveler equipment, falsework, stripping of forms, movement of equipment, counterweights, support jacking, stressing of temporary post-tensioning bars, main post-tensioning tendon sequences, stressing forces and elongations, control point erection elevations (and station positions), the field survey and alignment control methods to be employed for setting the initial and subsequent segments, and any other relevant operations.

The detailed step by step procedure for erection of segments shall include the sequence in which these items are to be erected along with a table of theoretical elevations and alignment of the geometry control points as established during casting of each segment and computed at each stage of erection. Stages for which theoretical positions of control points are to be computed shall include the segment in place prior to applying post tensioning and the segment with post tensioning applied.

The theoretical position shall be computed taking into consideration the following, as applicable:

1) Effect of formwork/falsework deformations.

2) Effects of construction loads, dead load and live loads (including torsion).

3) Effects of post-tensioning.

4) Effects of creep and shrinkage.

5) Effect of the final profile of the roadway as shown in the Design-Builder approved plans.

6) Expected foundation settlements.

The procedure shall also include a method for measuring and recording the elevations, positions, and alignment of all control points at each stage of erection.

New casting or erection procedures shall be submitted by the Design-Builder any time it proposes to deviate from the sequence or schedule of operations contained in the casting or erection manual. The proposed deviation(s) shall be approved by the Design-Builder's Design QC Manager and submitted to the Department's Project Manager for review and comment at least 5 Working Days prior to implementing the change.

G) For precast segments, complete details of handling, storing and transporting of the segments. These details shall include, for each type of segment, the method of lifting (location of any inserts, configuration of lifting devices, etc.) and the method of supporting segments during storage and transportation, the planned route for transporting the segments and the axle loads for the segment hauler. The details shall

be accompanied by calculations prepared under the direction of, and signed and sealed by, a Professional Engineer registered in Delaware demonstrating that the forces imposed on a segment during lifting, storage and transportation will not adversely affect the structural integrity of the segment.

H) Complete details related to post-tensioning stressing equipment, stressing methods to be used, the sequence of stressing, and all loads to be imposed on any portion of the permanent structure by the erection equipment.

I) Calculations prepared under the direction of, and signed and sealed by, a Professional Engineer registered in Delaware, which show that the loads imposed on the permanent structure by the erection equipment proposed by the Design-Builder will not adversely affect the structural integrity of the permanent structure, nor exceed nominal resistances during the construction process. These calculations shall include computations of all loads due to the erection equipment.

J) *See* Part 4, Special Provisions - *Cable-Supported Bridge System Requirements* for additional shop drawing and submittal requirements for cable-supported bridge structures.

4.2 CONSTRUCTION METHODS

4.2.1 Casting, Placing, and Curing of Concrete

The Design-Builder shall develop and utilize concrete casting, placement, and curing methods that successfully meet the Contract requirements including, but not limited to, the integrity of the in-place concrete, the durability of the in-place concrete, and achievement of the finished lines and grades within specified tolerances. The Design-Builders means and methods shall be clearly specified on shop drawings and working drawings, as applicable.

The Design-Builder shall satisfy the following requirements for embedded items:

A) In the plane of the reinforcing steel parallel to the nearest surface of concrete, bars shall not vary from Design-Builder approved plan placement by more than +/- ½ ", or 1/12 of the spacing between bars, whichever is less. In the plane of the steel perpendicular to the nearest surface of concrete, bars shall not vary from Design-Builder approved plan placement by more than +/- ¼". The top and bottom clear cover of reinforcing steel shall be within minus 0" to + ¼" of the clear cover limits dimensioned on the Design-Builder approved plans. The end and edge clear cover of the reinforcing steel shall be within minus 0" to + ½" of the concrete cover dimensioned on the Design-Builder approved plans.

In the event of a conflict between post-tensioning ducts and reinforcing bars, the post-tensioning shall generally have priority and the position of the bars shall be adjusted in a manner approved by the Department. All such conflicts shall be brought to the attention of the Department. The Design-Builder's proposed details for its resolution shall be submitted to the Department for review and written comment.

B) Embedded ducts for tendons shall be positioned accurately (within +/- ¼") with respect to their vertical, linear and transverse position within each segment or element. Positive methods shall be utilized to assure that ducts will not be displaced during concrete placement. These methods and their spacing shall be shown on the shop drawings. Tendon deviation pipes that act to change the alignment of tendons shall be marked so that proper positioning is assured prior to casting and can be verified after casting. The Design-Builder shall submit to the Department, for review and written

comment, the method he proposes to use to align deviation pipes and ducts passing between two independently cast segments or elements.

After installation in the forms, the end of the ducts shall at all times be sealed to prevent entry of water and debris. Following each concrete placement, the Design-Builder will be required to demonstrate that all empty ducts are free of water and are unobstructed and undamaged. Immediately prior to installation of the prestressing steel, the Design-Builder shall again demonstrate, to the satisfaction of the Department, that all ducts are unobstructed and that they are free of water and debris.

The anchoring devices for transverse top slab post-tensioning shall be recessed so that the ends of the prestressing steel and all parts of anchoring devices shall be a minimum of 2" inside the end surface of the segment. Following post-tensioning, the recesses shall be filled and protected in accordance with the details noted on the Design-Builder approved plans.

4.2.2 Tolerances

The following tolerances shall apply to the fabrication of superstructure segments or elements (All tolerances shown are maximum deviation):

Width of Web	1/4 in.
Depth of Bottom Slab	3/16 in.
Depth of Top Slab	3/16 in.
Overall Depth of Segment	3/16 in.
Overall Width of Segment	1/4 in.
Length of Segment	3/8 in.
Diaphragm Dimensions	3/8 in.

The following tolerance shall apply to the fabrication of substructure segments or elements:

Height (Individual Element)	1/4 in.
Width and Breadth	1/4 in.
Wall Thickness	1/4 in.

The following shall apply to the fabrication of all Precast segments:

Ends (deviation from a plane per 20 feet width of depth)	+/- 1/4 inch per 20 feet not to exceed 1/2 inch
Flat Surface (deviation from a plane at any location)	+/- 1/4 inch per foot not to exceed a total of 1/4 inch

Dimensions from segment to segment (or element to element) shall be adjusted so as to compensate for any deviations within a single segment (or element) so that the overall dimensions of each completed component will conform to the dimensions shown on the Design-Builder approved plans.

4.2.3 Finishing Concrete

All surfaces of segments and elements shall receive the ordinary surface finish, as specified in Section 602.17(b) of the Department Standard Specifications, unless otherwise specified on the Design-Builder's approved plans. It is further required that all exposed exterior surfaces of the bridge structure, excluding

the bridge deck surface, have a long-lasting, low maintenance uniform coloration in accordance with the Part 3, Appendix A – *Aesthetic Requirements* Performance Specification.

The Design-Builder shall also consider the effects of the selected curing compound on the finished concrete appearance so that the uniform coloration requirement is met. Finished concrete surfaces with streaking and/or staining directly related to curing compounds shall be considered unacceptable by the Department. An applied bridge coating system may be utilized by the Design-Builder to satisfy the uniform coloration requirement.

Minor breakage, spalling, or honeycomb (not more than 1" deep) shall be repaired by a method approved by the Department. Major breakage or honeycomb will be subject to review by the Department. These areas may be repaired by a method approved by the Department if it is determined that the structural or other functions of the segment will not be impaired. For cast-in-place construction, breakage, spalling or honeycomb on any mating surface of an in-place segment otherwise found acceptable shall be repaired prior to casting the next segment.

4.2.4 Finished Roadway Surface

The finished roadway surface elevations shall satisfy the requirements of Part 4, Special Provisions – *Overlay Concrete Surface* Rideability.

4.3 DAMAGED OR DEFECTIVE SEGMENTS OR ELEMENTS

Isolated defects are defined as imperfections or damage, which occur randomly and/or infrequently, as determined by the Department.

Recurring defects are defined as imperfections or damage of the same general type and nature that continue to be found in the same general location of the segments at a frequency unacceptable to the Department.

At a minimum, the first five segments or elements cast and erected will be jointly inspected by the Design-Builder and the Department after removal of the forms. All defects shall be identified and categorized during this inspection. The Design-Builder shall examine the defects and propose to the Department, in writing:

A) Measures that the Design-Builder proposes to take in order to prevent recurring defects in future segments.

B) The method of repair of all defects discovered as a result of the required inspection.

If recurring defects continue following implementation of the Design-Builder's preventive measures, or new defects are detected at any time during the construction, the Department will instruct the Design-Builder, in writing, to cease operations resulting in defective segments. The Design-Builder shall examine the defects and propose to the Department, in writing: (1) measures the Design-Builder shall take to prevent recurring defects in future segments; and (2) the method of repairing all defects discovered as a result of the inspection as required herein.

The Department will determine what constitutes damage or defect, whether the damage or defect is isolated or recurring, and will categorize the damage or defects. Three categories of defects are recognized by the Department for this purpose:

A) Cosmetic: Cosmetic defects or damages are those that do not affect the ability of the segment or element to resist construction or service loads or reduce the life expectancy

of the structure. This category of defect includes a superficial discontinuity such as cracks, small spalls or honeycombed areas, or any defect that does not extend beyond the centerline of any reinforcing steel, or to any elements of the post-tensioning system. Cosmetic defects of other types and causes may also be designated by the Department.

Repair of cosmetic defects shall be made in such a manner that the aesthetics and the structural integrity of the segments are restored.

B) Structural: This category of defect shall include any defect that will impair the ability of the segment or element to adequately resist construction or service loads or reduce the life expectancy of the structure. Any defect or damage, which extends beyond the centerline of any reinforcing steel or into any element of the post-tensioning system or occurs in the deck portion of the segment, is considered a structural defect. Examples of such defects include cracks, large spalls and honeycombed areas, major segregation or breakage of concrete; however, structural defects of other types and causes may be designated by the Department.

The Design-Builder shall be responsible for construction load analysis, service load analyses, and life expectancy determinations.

Repair of structural defects shall be such that the aesthetics and structural integrity of the segment shall be completely restored to a condition to be expected had the defect or damage not occurred.

C) Rejectable: Rejectable defects are any defect or damage, unacceptable to the Department that will impair the ability of the segment or element to adequately resist service loads or construction loads, or will reduce the life expectancy of the structure and cannot be successfully repaired such that the structural integrity is completely restored.

Any segment or element with a rejectable defect, once deemed unacceptable, shall be removed from the work and replaced at no additional cost to the Department.

Damaged or defective segments may also be rejected by the Department for the following reasons:

1) Failure of the Design-Builder to submit for approval proposed repair procedures.
2) Failure of the Design-Builder to execute the repair according to the Design-Builder's approved procedure.
3) Rejection of the proposed repair procedure or repair by the Department.
4) Failure of the Design-Builder to provide the required certification or demonstration that the repair was successful and that the defect no longer exists, as required below.
5) Failure of the Design-Builder to eliminate recurring defects.
6) Determination by the Department that the work or materials used in the work does not meet other requirements of the Contract Documents and is not acceptable.

Segments or elements with cosmetic defects will be paid for upon completion in accordance with the

approved Schedule of Values for the Work. However, such payment is subject to review by the Department, and failure of the Design-Builder to prosecute the required repairs properly and in a timely manner shall be cause for withholding of payments sufficient to protect the Departments interests.

Segments or elements with structural defects will not be paid for until the repair procedure is complete and the segment is certified or demonstrated to be free of structural defect or replaced by the Design-Builder, as required.

4.4 REPAIRS

Cosmetic repairs shall only be made following procedures prepared by the Design-Builder, submitted in writing to and approved by the Department. The Design-Builder's repair procedure shall identify those areas required to be repaired prior to post-tensioning, and those that must be repaired after post-tensioning.

Structural repairs shall be made following procedures prepared by the Design-Builder. The repair procedure shall be signed and sealed by a Professional Engineer licensed in the State of Delaware, shall be submitted in writing to the Department, and shall include the following minimum information:

A) A detailed description and sketch of the defect.

B) The magnitude and type of the most critical construction loading condition to which the defective area will be subjected.

C) Detailed reinforcement requirements, material types, surface treatments, curing methods and general repair procedures proposed. The procedure shall clearly indicate those areas required to be repaired before erection, and those areas to be repaired after erection.

D) Any specific nondestructive testing method and procedure by which the Design-Builder shall demonstrate to the Department that the defect no longer exists and the segment has been restored to a condition to be expected had the defect or damage not occurred.

In lieu of physical demonstration, on a case-by-case basis, the Department may allow the Design-Builder to substitute a written certification by the Design-Builder that the repair has been performed satisfactorily and that the defect no longer exists. This work shall not be the basis for any request for extension of time or additional compensation.

5.0 PRECAST CONCRETE REQUIREMENTS

Work specified in this Section shall govern the storage, transport and erection of structural precast segments into the completed structure. The final structure shall conform to lines, grades and design dimensions shown on the Design-Builder’s approved plans and with the provisions of these Performance Specifications.

5.1 PRECAST SEGMENT HANDLING, STORAGE, AND SHIPMENT

It is the Department's intent with this Contract that the Design-Builder provide precast segments that are cast and placed into the structure with zero defects.

Care shall be exercised in the handling of segments to prevent damage to them. Handling shall only be done using the devices shown on the approved shop drawings for this purpose. Lifting devices incorporated into any segment shall be adequate to distribute the handling and erection stresses so as not

to damage the segment.

The Design-Builder shall perform visual inspections of each segment for evidence of damage or defect before, during and after critical operations and as often as necessary to ensure adequate quality control. The Design-Builder shall immediately document all such evidence of damage or defect and bring it to the attention of the Department. The extent and frequency of inspection by the Department for quality assurance is the Department's prerogative. Segments may be inspected at any time during construction as deemed necessary by the Department to monitor compliance with this specification.

Superstructure segments shall be stored level in the deck upright position and shall be firmly supported on a symmetrical three point bearing system under the webs at the locations shown on the shop drawings, unless otherwise noted on the Design-Builder approved plans. The storage area of the segments shall be of suitable stability to prevent differential settlement of the segment supports, resulting in any unstable storage condition during the entire period of storage. Segments shall be stored in sequential order so that the uniform appearance of the segments is readily apparent.

Prior to shipment, each segment shall be inspected for damage. The faces of all match cast joints shall be thoroughly cleaned of laitance, bond breaking compound and any other foreign material by wire brushing or light sandblasting. During transport, firm support of the segment shall be provided and the segments shall be fully secured against shifting. Upon arrival at the erection site, each segment shall again be inspected. If any damage has occurred during shipment, the Design-Builder shall immediately notify the Department. Incorporation or utilization of such damaged segments into the structure shall not proceed without prior authorization from the Department.

5.2 ERECTION

An erection scheme for handling and erecting segments shall be shown in the Design-Builder approved plans. The Design-Builder shall be solely responsible for design, fabrication, assembly and operation of all equipment to be used for safe handling and erecting segments.

Erection of segments shall not begin until the required shop drawings and calculations have been reviewed and approved by the Department. No extra payment will be made to the Design-Builder for any cost incurred in modifying the permanent structure due to temporary loadings induced by the Design-Builder's handling and erection equipment or his erection scheme.

Elevations and alignment of segments shall be carefully measured at each stage of erection with instruments capable of providing the degree of accuracy necessary to assure satisfying erection tolerances. Any deviation from the table of elevations and alignment prepared by the Design-Builder shall be corrected so as to prevent accumulation of deviations using a method submitted by the Design-Builder and approved by the Department.

Precast segments shall not be erected until they have cured for a minimum of 14 days and obtained the minimum specified strength in the Design-Builder approved plans.

Erection of segments will be permitted only when the substrate temperatures of the mating surfaces are in accordance with the manufacturer's requirements. Upon approval of the Department, an artificial environment may be provided to maintain the substrate temperature within the permissible limits by creating an enclosure heated by circulating warm air or by radiant heaters. Localized heating shall be avoided and the heat shall be provided in a manner that prevents surface temperatures greater than 95ºF during the epoxy hardening period. Direct flame heating of concrete will not be permitted. The requirements of Part 4, Special Provisions - *Epoxy for Structural Bridge Applications* shall apply to the

epoxy joining of all precast segments.

5.2.1 Cantilever Method Requirements

During erection by the cantilever method, the unbalanced load shall not exceed that shown in the erection drawings scheme included in the design-Builder approved plans. Accurate positioning of the initial cantilever segments adjacent to the pier segment is very important, as it will establish the line and grade for cantilever. Initial segments shall be positioned according to the final longitudinal alignment, grade and cross slope. The horizontal and vertical location of the rivet points on the initial segments shall be within +/- 1/8" of the position required by the approved erection plans and the slopes across these segments shall not exceed 0.003 radians of angular deviation from the theoretical values for horizontal and vertical grades.

The alignment and elevations of the cantilevers shall be checked by the Design-Builder and the Department independently each day segments are to be installed. All measurements made by the Department and the Design-Builder shall agree within 1/16". Any discrepancies between the Department's and the Design-Builder's measurements shall be resolved prior to the continuation of segment installation. Note that a temperature differential between the top slab and the remainder of the box sections will cause the superstructure to deflect, resulting in false elevation readings and leading to erroneous elevation adjustment. Even on overcast days it is possible for a temperature differential to develop within the superstructure. To guard against false readings due to temperature differentials, readings should only be taken when all portions of the box section are stabilized at the same temperature. The Design-Builder is expected to use precautions in devising methods to guard against these possible false readings and corresponding adjustments due to temperature differentials. To prevent false measurements, an ideal time for taking readings is within one hour of sunrise.

If measured elevations deviate from the table of elevations, the Department has the right to suspend further erection of superstructure segments until the cause of the deviation is discovered and a corrective action plan, submitted by the Design-Builder, is approved by the Department. No additional payment or time will be made to the Design-Builder as a result of this suspension for unacceptable erection deviation.

5.2.2 Cantilever Closure Pours

A) The superstructure segment adjacent to the pier segment shall be aligned vertically, and shall be joined to each other by closure joint devices during the construction of the closure pour or closure segment.

B) Cast in place concrete shall be placed for the closure segment at the time of the minimum daily differential temperature between the top and bottom slabs of the superstructure. The Design-Builder is responsible for monitoring these temperatures and resulting deflections well in advance of the closure pour so that it is known when the minimum differential temperature occurs. The intent is to have the final cast in place concrete placed within one hour of the anticipated time that the minimum thermal differential occurs. This is usually at night or very early in the morning. The Design-Builder will submit a plan of action for the closure pour for approval a minimum of 21 calendar days in advance of the scheduled pour. This plan shall document the Design-Builder's proposed methods for; aligning the cantilevers, forming the closure, determining the time of minimum thermal differential, placing the concrete, curing the concrete, and timing of subsequent post tensioning operations.

C) Concrete for closure segments and closure joints shall comply with the same specifications and criteria as the concrete in the precast segments. The same materials and mix will be used to achieve a uniform appearance. The Design-Builder shall

submit a plan for the construction of the closure segments and closure joints, which addresses the methods, materials, and sequencing to be used to construct the closures in conformance with the performance specifications.

D) Formwork shall be adequately supported to take all loads applied and shall not be removed until the concrete in the joints has reached its required strength.

5.2.3 Span By Span Closure Joints

Concrete for closure joints shall comply with the same specifications and criteria as the concrete in the segments. The same materials and mix will be used to achieve a uniform appearance. The Design-Builder shall submit a plan for the construction of the closure segments and closure joints, which addresses the methods, materials, and sequencing to be used to construct the closures in conformance with the specifications. Concrete shall reach the minimum required strength as shown on the Design-Builder approved plans or in the specifications prior to stressing the longitudinal post tensioning. Formwork shall be adequately supported to take all loads applied and shall not be removed until the concrete in the joints has reached its required strength.

5.2.4 Tolerances

The following tolerances shall apply to erection of superstructure segments:

A) The maximum differential between the outside faces of adjacent segments in the erected position shall not exceed 3/16".

B) Transversely, the angular deviation from the theoretical slope difference between two successive segment joints shall not exceed 0.001 Radians.

C) Longitudinally, the angular deviation from the theoretical slope change between two successive segments shall not exceed 0.003 Radians.

D) The difference in roadway elevation at the connection of two adjacent segments (measured perpendicular to the deck surface) and across closure joints shall be no greater than 1/8". If the Design-Builder fails to meet the tolerance, the Department can require grinding of the bridge deck to meet the tolerances. All corrective work shall be at the Design-Builder's expense.

Dimensions from segment to segment shall be adjusted so as to compensate for any deviations within a single segment so that the overall dimensions of each completed span and the entire structure will conform to the dimensions shown on the Design-Builder approved plans such that the accumulated maximum error should not exceed 1/1000 of the span length for either vertical profile and/or horizontal alignment. Deviations exceeding the erection tolerances listed above which are discovered during the match casting operation shall be identified by after cast surveys at the casting site before the matched castings are separated. Corrections for these deviations shall be submitted to the Department prior to casting the next match cast segment.

5.2.5 Cumulative Erection Tolerances for Superstructure Segments

Vertically, the angular deviation from the theoretical slope change between successive segments shall not exceed 0.002 radians. The maximum overall deviation from the vertical, measured in any direction, shall not exceed 0.010" per foot of height. The maximum variation from the Design-Builder approved plan location shall not exceed 1" at the bottom and 2" at the top.

ENGINEERING REQUIREMENTS
PERFORMANCE SPECIFICATION

1.0 INTRODUCTION

This Performance Specification specifies the requirements for Engineering for the project.

The Work performed under this section shall include, without exception, all Engineering required to complete to the satisfaction of the Department, all aspects and all phases of the project, including both temporary and permanent portions thereof. It shall include all labor, travel costs, equipment, computers, other hardware, software, printing and all miscellaneous materials required to conduct, complete, check, document, present and convey the results from each individual aspect of the engineering effort, both to the Department and to all appropriate members of the Design-Builder's team.

2.0 STANDARDS AND REQUIREMENTS

Engineering Work shall be in accordance with all Delaware Professional Engineering ethics standards, regulations and standards of care. All engineering shall be conducted by and/or under the direct supervision of Professional Engineers registered in the State of Delaware.

Each individual aspect of the Engineering Work shall be conducted, prepared and documented in conformance with the provisions of Part 2 - DB Section 111 – Design Management and Design Quality Control.

Each individual aspect of the Engineering Work shall be conducted in conformance with the Project design criteria and design code(s) and shall result in work product/documents that meet all aspects of the specified design codes, construction codes, special provisions, performance specifications and all other Contract requirements.

Qualifications of each "Responsible Engineer" shall be submitted to the Department for approval. Each element and aspect of the design, including calculations, reports, supplemental studies, record drawings and other design drawings, shall be signed and sealed by one of the Design-Builder's Responsible Engineers registered in the State of Delaware.

These standards and requirements apply to all individuals involved in any design activity whether employed directly by the Design-Builder or by the Design-Builder's Designer, Subcontractor(s) or Subconsultant(s).

3.0 RELEASE OF ENGINEERED WORK FOR CONSTRUCTION

It is expected that individual portions of engineered work will be released by the Design-Builder for construction prior to completion of all design and/or construction Engineering Work. Individual groups of working drawings, engineered work methods, plans, specifications or other documents and information presenting engineered work may be "Released for Construction" to the field crews to begin work, provided all aspects of the work have been prepared, reviewed, checked, independently checked, certified and fully coordinated with all other aspects of the works.

This shall include, but not be limited to, for each item to be Released for Construction: Preliminary Design, Semi-Final Design and Final Design submittals and each of the provisions of Part 2 - DB Section 111-12.5.

Each sheet of each document, regardless of type, size, title or nature, which has been authorized by the Design-Builder as "Released for Construction", shall included a stamp with the words "Released for Construction" and shall be both initialed and dated individually by the Design Manager, the Design QC Manager and signed and sealed by the Responsible Engineer(s).

No documents shall be in use for actual construction of any temporary or permanent aspect of the work that do not include the "Released for Construction" stamp including all appropriate initials and dates.

4.0 ENGINEERING WORK AND ASSOCIATED ACTIVITIES

Engineering Work and associated activities shall include, but are not limited to, the following:

A) Verification of Pre-Bid Engineering – Immediately after NTP, the Designer-Builder shall prepare design calculations, including all QA/QC requirements, which check, verify and validate the pre-bid engineering design work, including preliminary material quantities. This work shall be prepared, documented and presented in the first engineering review meetings: Design Mobilization Meeting (*See* Part 2 – DB Section 105-12.2); Preliminary Design Review (*See* Part 2 – DB Section 111-9.1); and Design Workshop (*See* Part 2 – DB Section 111-16).

B) Preparation of Preliminary, Semi-Final and Final Engineering submittals, including QA/QC requirements, for each component of both the temporary and the permanent portions of the work, including falsework, temporary equipment and temporary facilities (including engineering for removal of temporary items).

C) Preparation for, attendance and participation (including presentations) by the Design Manager (and Responsible Engineers as appropriate) in the design mobilization meeting, each design review meeting, each pre-construction meeting, each value engineering meeting, site mobilization meeting, each progress meeting, each independent assurance meeting, partnering meetings and each special meeting initiated by either the Design-Builder or the Department's Project Manager. Attendance by the Designer to any (or all) Construction Review Meetings may also be required by the Department's Project Manager and without additional compensation to the Design-Builder.

   In any meeting, the Designer will be required to present design methodologies, design results and other appropriate information relative to each design related topic(s) discussed at the meeting.

D) Preparation for, attendance and participation (including presentations) by the Designer may be required in public and/or public involvement meetings.

E) Preparation and presentation/discussion of Designer responses to Department review comments, questions, etc. in support of the comment resolution process. Such review of comments and response preparation by the Designer may include supplemental calculations, engineering analyses, computer modeling, drawings, additional meetings/travel and presentation preparation/materials.

F) Preparation of drawings, renderings and computer animations of the design related information.

G) Geotechnical investigations, analyses, reports, review of existing geotechnical information and all related activities. This shall include but not be limited to, temporary and permanent foundation designs, hydraulic/scour evaluations, cofferdams and the development and use of engineering soil-to-structure interaction parameters.

H) Wind engineering and all related activities. This shall include review of existing wind related information, preparation of project specific wind studies, conducting project specific wind tunnel testing, design/engineering analyses of wind-to-structure interaction (both during construction and under permanent conditions) and presentation/justification of all such information to the Department and Department's representatives (*See* the *Wind Engineering Requirements* Performance Specification for additional requirements).

I) Security engineering, related engineering analyses and presentation/justification of all such information to the Department and Department's representatives.

J) Roadway related engineering, including roadway geometry and all surveying.

K) Maintenance of traffic (MOT) plan development, including engineering analyses and presentation/justification of all such information to the Department and Department's representatives.

L) Design, plan preparation and specification preparation for electrical systems, maintenance, navigational and safety lighting systems, aesthetic lighting systems, and lightening protection systems.

M) Utility system design, plan preparation, specification preparation and coordination with utility companies and/or owners and the Department and/or Department representatives.

N) Development and justification of each proposed design exception and/or non-standard feature (as may be identified or classified as such by either the Design-Builder or the Department). Design exceptions will be required to be part of a Value Engineering submittal after selection of the successful Design-Builder.

O) Environmental related permits and environmental control plan(s) development.

P) Designer participation in dispute resolution meetings as may be requested by either the Design-Builder or the Department.

Q) Designer participation in arbitration meetings as may be requested by either the Design-Builder or the Department.

R) Design scheduling, progress tracking and reporting.

S) Design quality records development and documentation.

T) Evaluation of equipment interaction(s) with temporary works and permanent portions of the structure.

U) Construction engineering and development of supporting engineering information. This shall include, but not be limited to: structural camber, erection elevations/geometry, rigging design (for lifting, dragging, tie-down, securing, etc.), monitoring as-built conditions (including Designer site visits), as-built geometry, evaluation of stability during construction, geometry control manual and detailed erection manual.

V) Engineering analyses, drawings, procedures and other support, relevant to corrective actions and/or repairs to non-conforming element(s).

W) Engineering analyses, drawings, procedures and other support, relevant to changed or differing site conditions.

X) All required critical path schedule (CPM) development, monitoring, updates and reports (*See* the *Project Control System Development Plan* and *CPM Schedule Updates and/or Revised Updates* Special Provisions in Part 4 of the Contract Documents).

Y) Engineering analysis and/or review of project related test data.

Z) Load rating and drawings of as-built bridge condition.

5.0 ENGINEERING SOFTWARE

All computer based engineering calculations, checks and studies shall be performed with ~~commercially available and~~ fully documented engineering software. Proprietary software of the Designer (or others) may be used for checking if commercially available software is used for original calculations. The Designer shall be required to validate all computer software (before use of the application is made by the Design-Builder/Designer) and document each validation in accordance with Part 2 - DB Section 113-2.16.

6.0 APPROVAL OF AS-BUILT CONDITIONS

The Design-Builder (including the Design Manager, Construction Manager, and Quality Control Manager) shall be required to provide written acceptance of the as-built conditions after conducting final field reviews, completing Record Drawings (and other such documents) and resolving all Non-Conformance Reports.

The written as-built acceptance by each party shall clearly state that all aspects of the structure were found to comply with all aspects identified in the Contract relative to the design criteria, standards of construction and all project Performance Specifications and Special Provisions. Disclaimers, exceptions, or other such terms, shall not be included or considered acceptable in any written as-built acceptance.

GEOTECHNICAL REQUIREMENTS
PERFORMANCE SPECIFICATION

1.0 INTRODUCTION

The Design-Builder shall perform Geotechnical Work including investigations, analyses, design, construction, and monitoring in accordance with all applicable standards and codes and in accordance with this *Geotechnical Requirements* Performance Specification. The Design-Builder's geotechnical investigations and analyses should be sufficient to adequately characterize the subsurface conditions and provide all the necessary information for a suitable design of the bridge foundations, retaining walls, and embankment including soil improvements and erosion control techniques.

2.0 APPLICABLE STANDARDS AND REFERENCES

The Geotechnical Work shall be in accordance with this Geotechnical Performance Specification and the relevant standards and codes, including the following, unless otherwise stated in this Performance Specification. If there is a conflict with other applicable codes or standards, the standards and references specifically cited herein shall prevail over all others. Should the requirements in any standard conflict with those in another, the Design-Builder's Geotechnical Engineer shall clearly identify such conflicts in the design and provide explanations for following one standard over another. Typically, the standard resulting in the more conservative result shall govern for the design check being considered. References are guidelines that the Design-Builder may use in developing the design as the Design-Builder sees fit. It is the Design-Builder's responsibility to obtain clarification from the Department's Project Manager for any unresolved ambiguities prior to proceeding with design or construction. Items listed as standards or references in this Geotechnical Performance Specification shall be the most recent version available on the Proposal due date.

2.1 STANDARDS

Cited publications refer to the most recent issue, including interim publications, in effect on the Proposal due date, unless otherwise specified.

A) AASHTO LRFD Bridge Design Specifications, Third Edition, 2004, with Interims;

B) DelDOT Bridge Design Manual, May 2005.

C) DelDOT Design-Build Special Provisions (Contract Documents – Part 4);

D) Supplemental Specifications to the DelDOT Standard Specifications; and

E) DelDOT Standard Specifications, August 2001.

2.2 REFERENCES

A) Training Course in Geotechnical and Foundation Engineering: Subsurface Investigations, FHWA-HI-97-021, 1997;

B) Drilled Shafts: Construction Procedures and Design Methods Manual, FHWA IF-99-025, 1999;

C) Design and Construction of Driven Pile Foundations, Volumes 1 and 2, FHWA HI-97-013 & -014, 1998;

D) Training Course in Geotechnical and Foundation Engineering: Subsurface Investigations - Participants Manual, FHWA-HI-97-021, 1997;

E) Training Course in Geotechnical and Foundation Engineering: Earth Retaining Structures – Participants Manual, FHWA-NHI-99-025, 1999;

F) AASHTO Manual on Subsurface Investigations, 1998;

G) Standard Classification of Soils for Engineering Purposes (Unified Soil Classification System) ASTM D2487-00;

H) Standard Practice for Description and Identification of Soils (Visual-Manual Procedure) ASTM D2488-00;

I) XSTABL, Version 5, Interactive Software Designs, Inc. 1994 or PCSTABL4;

J) Mechanically Stabilized Earth Walls and Reinforced Soil Slopes Design and Construction Guidelines, FHWA NHI-00-043, 2001;

K) Corrosion/Degradation of Soil Reinforcements for Mechanically Stabilized Earth Walls and Reinforced Soil Slopes, FHWA NHI-00-044, September 2000;

L) Geosynthetic Design and Construction Guidelines, FHWA HI-95-038, current edition;

M) Geotechnical Instrumentation, FHWA HI-98-034, 1998;

N) Advanced Technology for Soil Slope Stability, Volume 1: Slope Stability Manual FHWA-SA-94-005, 1994;

O) Ground Improvement Methods – Reference Manual, FHWA NHI-04-001, September 2005.

P) Geotechnical Engineering Circular No. 6: Shallow Foundations, FHWA-IF-02-054, 2002;

Q) Geotechnical Engineering Circular No. 5: Evaluation of Soil and Rock Properties, FHWA-IF-02-034, April 2002;

R) Soils and Foundations Workshop Manual, FHWA NHI-00-045, 2000;

S) DelDOT Construction Manual, January 2004; and

T) Geotechnical Summary Reports included in the Reference Documents to the Scope of Services Package.

Additional geotechnical reference documents may be found in the Federal Highway Administration's publications library (http://www.fhwa.dot.gov/engineering/geotech/library_listing.cfm). When further references to these Standards and References are made within this Performance Specification, the edition and date will not be repeated, but are understood to cite the complete reference included in this Section 2.0.

3.0 REQUIREMENTS

3.1 GEOTECHNICAL PLANNING REPORT

The Design-Builder shall prepare a Geotechnical Planning Report for the Project and submit the report for review and written comment from the Department prior to the preliminary design review. The Geotechnical Planning Report shall include a detailed method statement describing the general philosophy and anticipated methods of investigation, analysis, design, construction, and construction monitoring. The report shall include a discussion of the rationale for selection of the proposed construction methods for all geotechnical and foundation aspects of the Project. The method statement shall indicate how material and design details are chosen to match selected construction and monitoring

methods, construction details, soils, and the groundwater environment for the site. The Geotechnical Planning Report shall be prepared, checked, and reviewed in accordance with the Preliminary Design Submission requirements specified in the Contract Documents - Part 2, DB Section 111.

The Design-Builder shall provide details of equipment and methods proposed for foundation and earthwork construction and demonstrate how they are consistent with the design approach and assumptions. The details presented shall demonstrate compliance with the Geotechnical Performance Specification requirements and shall demonstrate an understanding of the ground conditions and Project constraints as defined within this Contract.

The Design-Builder shall submit the following technical information with the Geotechnical Planning Report:

A) Description of geology and various ground types to be encountered within the project limits;

B) A description of the geotechnical information that was collected and/or analyzed in developing the interpretation used to develop the Design-Builder's Proposal and pricing for the Project;

C) Assessment of the engineering properties of all soil types, including the expected average and range of soil strengths and deformation properties;

D) Recommended design parameters (preliminary) for all soil types;

E) Anticipated ground behavior and categorization of ground during excavation, filling, and foundation and retaining structure construction;

F) Support of excavation and groundwater control considerations;

G) A narrative describing how any interpretation was derived from the geotechnical data;

H) Consideration for, discussion of, and rationale for protection of existing structures, embankments, bodies of water, and utilities; and

I) Any pertinent geotechnical data used as a basis for selection, design, and installation of the proposed foundation elements.

The Geotechnical Planning Report shall define the engineering and design approach that will be followed in order to develop technically and environmentally acceptable and durable foundations, cut and fill slopes, retaining structures, and geotechnical designs for the Project. The Geotechnical Planning Report shall discuss all aspects of the required geotechnical effort and design and analysis, including the following:

1) Subsurface investigations;

2) Determination of geotechnical and foundation design parameters;

3) Erosion control measures including design and analysis;

4) Embankment, fill settlement, slope stability analysis, and MSE retaining wall stability during pile driving or drilled shaft installation or if modifications to the approach roadway embankments are proposed;

5) Effects of the proposed bridge and retaining wall structures on the existing approach embankment;

6) Retaining wall design and analysis;

7) Planned field testing programs, including pile and drilled shaft integrity and load testing and ground improvement testing;

8) Ground improvement or treatment of in-situ soils;

9) Selection, design, and analysis of foundation systems;

10) Lateral and vertical earth pressures on structures;

11) Instrumentation and monitoring programs;

12) Expected serviceability and durability of proposed solutions; and

13) Other items related to soil structure interaction or site conditions that may effect design or construction.

The Final Geotechnical Report shall incorporate the findings from the above investigations and analyses. The Final Geotechnical Report shall be prepared and signed and sealed by a Delaware-licensed Professional Engineer meeting the qualification requirements in Special Provision 108C Key Personnel. The report shall be submitted to the Department for review and comment.

3.2 SUBSURFACE INVESTIGATION AND DATA ANALYSIS

3.2.1 General

The Department has performed a systematic subsurface investigation of the Project site. Information generated from previously completed investigations is included in the Reference Documents to the Scope of Services Package.

The Department will consider requests from each Proposer to provide up to two (2) additional soil borings within the Project Limits and furnish the results separately to each prospective Design-Builder. Each boring will include split spoon soil samples with standard penetration testing taken at five-foot intervals for the first twenty-five feet, and every ten feet, thereafter. Undisturbed soil samples will be taken in each unique cohesive soil deposits, as well. Requests for additional subsurface information must be made to the Department within two weeks of the pre-proposal meeting and shall include locations in plan, requested depths, and requested laboratory testing. Typical testing procedures performed by the Department's Materials & Research Section are listed in Section 6.1.3 of the *DelDOT Bridge Design Manual*. Once all fieldwork and lab analysis has been completed, each prospective Design-Build Team will only be furnished additional pre-proposal subsurface investigation information requested by their team and gathered by the Department.

The Design-Builder shall conduct additional post-award investigations in accordance with the minimum scope specified herein and any additional investigations the Design-Builder deems necessary to establish the geotechnical conditions and to perform all geotechnical and foundation design and analyses.

These additional investigations and testing shall be conducted in accordance with the reference items identified in Section 2.2 and shall include proper coordinates, stations, offsets, and elevations based off of the horizontal and vertical survey control systems established for the Project.

The Design-Builder shall form its own interpretation of the existing geotechnical data and satisfy itself as to the nature of the ground and sub-soil, the form and nature of the site, and nature of the Work that may affect its detailed design, construction method, and tools. The Department neither assumes nor implies any warranty regarding the data provided, other than that the information was obtained at locations and depths indicated and to the accuracy of the data at the time of testing.

The additional investigations, if any, to be performed by the Design-Builder shall supplement the data provided by the Department. The Design-Builder shall determine the number and location of additional investigations in accordance with the requirements presented in Table 3.2.1. Existing investigation borings may be combined with the additional investigations to comply with the requirements presented in Table 3.2.1. In borings, split spoon soil samples with standard penetration testing shall be taken at five-foot intervals for the first twenty-five feet and every ten feet, thereafter as a minimum, and undisturbed soil samples shall be taken in each unique cohesive soil deposits. Cone Penetration Test soundings may be considered as an alternative to borings where the Design-Builder considers it appropriate provided that a sufficient number of borings are performed at Cone Penetration Test sounding locations to develop reliable correlation between the boring and Cone Penetration Test results and that the Cone Penetration Testing reaches a suitable depth for design of the foundation elements. The Design-Builder shall provide the results of investigations to the Department in a memo as follows:

A) The logs of borings, Cone Penetration Test soundings, and the field records of any field investigations; and

B) Laboratory test results and classifications for all samples.

The Design-Builder shall classify soils in accordance with *Standard Classification of Soils for Engineering Purposes (Unified Soil Classification System) ASTM D2487-00*, and, *Standard Practice for Description and Identification of Soils (Visual-Manual Procedure) ASTM D2488-00.*

Except as specified herein, the Department and AASHTO standards shall be followed with respect to planning and performing subsurface exploration programs.

Table 3.2.1 Minimum Requirements for Additional Investigations

Geotechnical Feature	Minimum Investigation Locations
Bridge Foundations	For piers and abutments, representative pre-construction soil borings and/or Cone Penetration Tests shall be performed within 100 feet (horizontally) of any proposed foundation element with a minimum of two representative tests being performed at each foundation unit. At a minimum, all investigations shall extend 20 feet below anticipated tip elevations for the portions of the foundation they are to represent. Additional investigations shall be provided at foundations areas showing erratic subsurface conditions. Existing borings with adequate depth and proximity to the proposed bridge foundations may be considered to meet this criterion.
Geotechnical Feature	**Minimum Investigation Locations**
Retaining Walls	A minimum of two borings or Cone Penetration Tests shall be performed for each retaining wall. For retaining walls more than 100 feet in length, the spacing between borings or Cone Penetration Tests shall be no greater than 100 feet and shall be of adequate depth to properly design for bearing, settlement, and stability.
Roadways	The spacing of borings or Cone Penetration Tests along the roadway alignment within the Secondary Project Limits shall not exceed 200 feet. The spacing and location of the borings shall be selected considering the geologic complexity within

Geotechnical Feature	Minimum Investigation Locations
	the Project area with the objective of defining the vertical and horizontal boundaries of distinct soil units within the Project limits.
Embankments and Cuts	The spacing between borings shall be no greater than 200 feet. At critical locations, provide a minimum of three borings in the transverse direction to define the existing geological conditions for stability analysis. Borings shall be of adequate depth to properly design for settlement and stability.

Note: Except as specified herein, the Department and AASHTO standards shall be followed with respect to planning and performing subsurface exploration programs.

3.3 FOUNDATION DESIGN

Foundation embedment, layout, and geotechnical design for all permanent Project structures shall conform to the *AASHTO LRFD Bridge Design Specifications*. Horizontal and vertical pile loads, settlements, lateral deformations and squeeze, downdrag, pile group action and all other foundation design considerations shall be based on all applicable load combinations including service, strength, and extreme event limit states specified in the *AASHTO LRFD Bridge Design Specifications*. Temporary structures shall meet the requirements set forth in Part 4 – Special Provisions, *Temporary Works*.

Foundations for bridge structures shall be deep foundations consisting of either driven piles or drilled shafts. The Design-Builder shall not use auger cast piles, screw piles, timber piles or existing foundations. Spread footing foundations shall not be used for bridge foundations, but may be considered for support of retaining walls in accordance with Section 3.4 of the *Geotechnical Requirements* Performance Specification. Pile bent structures, if used, shall utilize pre-cast, pre-stressed concrete piles or drilled shafts.

3.3.1 Wave Equation Analyses

The Design-Builder shall be responsible for performing wave equation analyses to obtain the relationship between blow counts and estimated ultimate capacities for each test pile in each pile group identified in the Design-Builder's Plans. Separate wave equation analyses shall be performed for each hammer, pile type and driving system to be used. Wave equation analyses shall be performed using a wave equation analysis program (WEAP) in accordance with Section 619.09 of the *DelDOT Standard Specifications*. The use of dynamic pile driving formulae will not be an acceptable method for developing driving criteria or performing drivability studies to determine hammer energy requirements.

3.3.2 Deep Foundation Testing and Monitoring

Field testing shall be performed for deep foundations to evaluate foundation capacity and integrity, to verify design assumptions, to determine foundation installation characteristics, to evaluate the pile driving system performance, and to establish foundation depths. The foundation testing and monitoring shall include test and monitor piles or drilled shafts; dynamic testing; static load testing; non-destructive integrity testing; and Quality Control (QC) testing. The Design-Builder's testing and monitoring program shall satisfy the following minimum requirements:

A) For each pile-supported foundation, a minimum of 5% of all piles within that foundation unit shall be driven as test piles and shall be dynamically tested;

B) For each pile-supported foundation, a minimum of 5% of all production piles within that foundation unit shall be treated as monitor piles with dynamic testing;

C) If pile-supported foundations are to be used, a minimum of two (2) static load tests shall be performed on sacrificial test piles, one (1) test on each side of the inlet. Static load

tests shall be performed in accordance with the *Quick Pile Load Test* Special Provision. Upon completion of the *Quick Pile Load Test*, sacrificial test piles shall be removed to a minimum depth of at least two feet below finished grade;

D) If drilled shafts are utilized, a minimum of two (2) technique shafts of the most prevalent size to be used as permanent shafts shall be installed and tested in accordance with the *Drilled Shafts* Special Provision. A minimum of one (1) technique shaft shall be installed and tested on each side of the inlet. Technique shafts shall be removed to a minimum depth of two feet below finished grade;

E) Non-destructive integrity testing and QC testing shall be performed on all drilled shafts in accordance with this Performance Specification and the *Drilled Shaft* Special Provision.

All foundation monitoring and testing shall be performed by the Design-Builder, using testing personnel or Subconsultants, qualified with a minimum of five (5) years experience in performing and interpreting the results of the required foundation testing. Documentation of such experience shall be submitted to the Department's Project Manager for approval prior to beginning work.

The Design-Builder shall prepare and submit a detailed description of the proposed Foundation Testing and Monitoring Program. The description shall include specifications and plans presenting the type, purpose, number, location, and procedures for each test and the recording and reporting procedures and forms. Testing and monitoring of deep foundations shall be in accordance with the applicable DelDOT, ASTM, and AASHTO specifications. The Foundation Testing and Monitoring Program shall include a Working Plan and Response Plan as specified in Section 3.9 of this specification. The entire Foundation Testing and Monitoring Program shall be submitted to the Department for review and comment a minimum of 30 Calendar Days prior to the implementation of the program.

3.3.2.2 Driven Piles

Dynamic pile testing and static load testing shall be performed in accordance with the *DelDOT Bridge Design Manual* and the *DelDOT Standard Specifications*, except as specified herein. Dynamic testing shall be performed by the Design-Builder on all test piles and monitoring piles. A representative test pile shall be driven and monitored using a Pile Driving Analyzer (PDA) for each pile group. Pile groups shall be limited to a 50-foot radius as measured from each test pile. Not less than five percent of the production piles shall be used as monitoring piles. Test piles may be considered acceptable for use as production piles, if the PDA test results demonstrate the required capacity as identified in the Geotechnical Design Report has been safely achieved without pile damage. Dynamic testing of monitor piles shall be independent of all test pile monitoring.

The Design-Builder shall perform dynamic testing during the initial drives and restrikes of all test and monitor piles. The PDA measurements shall be recorded and the data analyzed using the Case Pile Wave Analysis Program (CAPWAP) to determine any time-related gains or losses in soil resistance. The Design-Builder shall apply PDA and CAPWAP results and revise driving criteria only for piles within the related pile group. The Design-Builder shall ensure that all test and monitor piles are re-struck and that such restrikes occur no sooner than 48-hours after initial installation. Additional pile restrikes with dynamic testing may be performed at the Design-Builder's option to quantify longer-term gains (or losses) in soil resistance. Without additional verification of capacity gains with time, PDA measurements and CAPWAP computations at the time of restrike must indicate the ultimate bearing capacity requirements for the piles have been met in order for the piles within the group to be considered acceptable.

The Design-Builder shall require that all pile driving monitoring be performed by a Design Professional with at least five (5) years experience using PDA and in performing analyses with the CAPWAP in similar

soil conditions. Documentation of such experience shall be submitted to the Department's Project Manager for approval prior to beginning work.

The Design-Builder shall ensure that the Design-Builder's geotechnical engineer or representative is on-site during PDA testing of initial and re-strike pile installation. The Design-Builder shall ensure the geotechnical engineer reviews and approves the data obtained through the test pile program and uses it to establish driving criteria and pile lengths for production pile installation. The Design-Builder shall provide the information obtained from the test pile program to the Department's Project Manager prior to production pile driving.

The Design-Builder shall provide pile driving records on the standard Pile Driving Record Forms H-47, H-49, and H-51 included in the *DelDOT Construction Manual*. The Design-Builder shall provide all information required for the Department's Pile Driving Records, including the hammer stroke, fuel setting, final pile tip elevations, load achieved and pile lengths used. The Design-Builder shall provide completed Pile Record Forms to the Department's Project Manager within 48 hours of driving the piles. The Design-Builder shall assign separate Inspectors to each active pile driving hammer.

The Design-Builder shall conduct static load tests to allow for increased resistance factors as specified in the *AASHTO LRFD Bridge Design Specifications*. Each static load test shall be performed in accordance with the requirements of the *Quick Pile Load Test* Special Provisions. Sacrificial test piles to be used for static load testing shall be located as close as possible to the pile groups they are intended to represent. In such cases, the Design-Builder shall verify that the load-carrying capacity of the pile meets or exceeds the design values using the applicable AASHTO load and resistance factors for the Strength Limit State. The Design-Builder shall furnish all Equipment to perform the load test(s), including load frames, reaction piles, structural connections, dial gauges, an independent reference beam for the support of the dial gauges, and methods of protection from weather as to be specified in the Geotechnical Planning Report. The Design-Builder shall ensure that the test pile and monitor pile installation be monitored with PDA and that initial drive and re-strikes are analyzed using CAPWAP, in order to allow the static load test results to be correlated with PDA results, CAPWAP results, and blow counts recorded during pile installation.

3.3.2.3 Drilled Shafts

All drilled shafts shall be designed in accordance with the AASHTO LRFD Bridge Design Specifications and constructed in accordance with Part 4 – Special Provisions, *Drilled Shafts*. The Design-Builder shall provide the minimum testing and monitoring of all drilled shafts and techniques shafts as specified in Section 3.3.2 of this specification.

Minimum integrity testing requirements shall include Crosshole Sonic Logging (CSL) and shall be performed on all drilled shafts. The testing shall be performed in accordance with Part 4 – Special Provisions, *Drilled Shafts*.

Technique shafts and associated load tests shall be performed in accordance with Part 4 – Special Provisions, *Drilled Shafts*.

The Design-Builder shall perform each required integrity test with Design Professionals having at least five (5) years of similar experience for the tests they will be performing. Documentation of such experience shall be submitted to the Department's Project Manager for approval prior to beginning work.

A report of CSL results shall be furnished to the Department's Project Manager within 7 days of each test. Reports shall include all anomalies and suspected defects identified by the CSL and any remedial measures and repairs required by the Design-Builder's Geotechnical Engineer. The Department shall

have the right to perform additional integrity testing in accordance with Part 4 – Special Provision, *Drilled Shafts* to confirm the findings included in the CSL reports and/or assumptions made. Should discrepancies be found through the Department's testing, the Department will issue a Non-Conformance Report (NCR) for each drilled shaft questioned in accordance with Part 2 – DB Section 112.

3.4 RETAINING WALL DESIGN

The following criteria shall apply to all permanent retaining wall structures proposed by the Design-Builder and shall apply to new structures and/or modifications to existing structures. The Design-Builder shall ensure proper performance and safety of temporary retaining structures in accordance with the *Temporary Works* Special Provision.

3.4.1 Wall Types

All permanent walls shall be conventional cast-in-place concrete or Mechanically Stabilized Earth (MSE) wall systems and shall be consistent with the Indicative Plans included in Part 6 of the Scope of Services Package. The wall type utilized for modifications or additions to the approach roadway retaining walls, including materials and construction methods, shall be the same as those constructed under Contract #23-073-03. *See* Reference Documents in Scope of Services Package for specifications used for Contract #23-073-03.

3.4.2 Design Criteria

All permanent retaining structures shall be designed in accordance with the *AASHTO LRFD Bridge Design Specifications* and shall include considerations of earthquake effects. The AASHTO seismic performance category shall be Zone 1 with an acceleration coefficient (A) equal to 0.05. Additional wall design considerations shall include the following:

A) Internal and External Stability and Settlements of Walls
The Design-Builder shall provide retaining wall designs to address internal and external stability and settlements (i.e., total and differential) of the walls in accordance with the *AASHTO LRFD Bridge Design Specifications*.

B) MSE Walls (Including Modular Block MSE Walls)
The Design-Builder shall provide MSE Wall designs in accordance with the *AASHTO LRFD Bridge Design Specifications*. Additional reference information pertaining to MSE Wall design considerations may be found in *FHWA's Mechanically Stabilized Earth Walls and Reinforced Soil Slopes Design and Construction Guidelines, Corrosion/Degradation of Soil Reinforcements for Mechanically Stabilized Earth Walls and Reinforced Soil Slopes*, and the *Geosynthetic Design and Construction Guidelines.* The use of metallic reinforcing strips shall not be permitted.

3.4.3 Geometry

The Design-Builder shall provide retaining wall layout to address slope maintenance above and below the wall and provide returns into the retained fill or cut at retaining wall ends. The Design-Builder shall provide walls that have minimum vertical and horizontal tolerance of 1 inch in 10 feet. The design shall reserve a minimum of 5-ft of terrain from the ROW line for wall maintenance and inspection. The Design-Builder shall include surface and subsurface drainage provisions in the design and construction of the wall. The Design-Builder shall provide a system to intercept or prevent surface water from entering behind the wall (or reinforced zone) and drainage shall be provided along the retaining wall and into a drain during all stages of construction. The coping and barrier shall be consistent with the Indicative Plans for the Roadway Approach Contract.

3.4.4 Plans and Calculations

The Design-Builder shall provide plans and design calculations meeting *AASHTO LRFD Bridge Design*

Specifications, including a global stability and seismic analysis, as applicable, sealed by a Delaware-licensed Professional Engineer.

3.4.5 Aesthetics

All retaining walls shall be of the same surface finish and appearance as the Directive Plans for the Roadway Approach Contract.

3.5 FILL/EMBANKMENT DESIGN

3.5.1 Excavation and Embankment

Excavations and embankment construction shall be in accordance with the requirements of Section 202 of the *DelDOT Standard Specifications.* Embankment cross sections shall be in accordance with the requirements of the *Roadway Geometrics* Performance Specification.

3.5.2 Slope Stability

The Design-Builder shall design slopes in accordance with *FHWA's Soil Slope and Embankment Designs.* Embankment slopes shall be no steeper than 2:1 (horizontal:vertical). The analyses shall consider the effects of deterioration and loss of soil resistance due to local climatic and construction conditions. All slopes shall be designed to minimize erosion by rainfall and runoff. Adequate drainage and erosion control provisions should be incorporated in the design and construction of the embankments in accordance with Subsection 3.7 of this Special Provision.

Slope stability analyses shall be conducted using the *XSTABL* or *PC STABL4* computer program, or an equal or better verified computer program. Circular and wedge type failures shall be analyzed for potential occurrence for each embankment configuration and slope. The evaluation of global slope stability shall consider potential seepage forces and any weak deposits and seams that are adversely impacted by water flow. The minimum factors of safety for static load conditions shall be 1.3 for non-critical slopes and 1.5 for critical slopes (at bridge abutments, wingwalls and existing structures) for permanent embankment slopes. The minimum factor of safety for a rapid drawdown condition shall be 1.1. For non-permanent embankment and earthwork slopes, the minimum safety factor shall be 1.3 under static load conditions. Seismic effects shall also be considered. The AASHTO seismic performance category shall be Zone 1 with an acceleration coefficient (A) equal to 0.05.

3.5.3 Settlement

The Design-Builder shall conduct analyses to estimate the soil settlement induced by additional embankment loads, including immediate settlement in granular soils, and both immediate and consolidation settlements in cohesive soils. The Design-Builder shall design embankments in order to limit total long-term settlements to 2 inches during a period of 50 years after completion of the pavement construction for that portion of the Project. Differential settlement within new fill sections, between new and previously placed fill sections, and across fill/Structure interfaces shall be limited to 0.04-feet between sections or supports of a span. Embankment settlement shall be monitored and assessed during the duration of the Contract to verify that the specified settlement criteria will be achieved.

3.6 SOIL IMPROVEMENT

The use of soil improvement to increase soil strength and reduce compressibility in order to increase the safety factors for external and internal stability and reduce settlements to the allowable range specified herein will be allowed in the design. It shall be necessary to demonstrate the suitability of the improvement methods for local conditions and means of installation. Techniques such as vertical drains, surcharge, stone columns, vibro-compaction, lime columns, cement columns, deep-soil mixing, rammed aggregate pier, grouting, and the use of lightweight fill may be included in the design in order to expedite

consolidation of the subsoils, where it is required to increase bearing capacity or reduce post-construction settlements.

All soil improvement systems shall be designed using current practice and procedures as specified in *FHWA's Ground Improvement Methods*. The performance of all ground improvement techniques shall be verified with a pre-production field testing program developed to demonstrate that the proposed methods and design will provide the ground improvement level required to satisfy the performance requirements specified herein.

3.7 EROSION CONTROL AND DRAINAGE

Slopes in both cut and fill areas are subject to erosion and deterioration through the action of water, wind and freeze/thaw cycles. Erosion control and drainage measures shall be evaluated, considered and designed for all new and existing slopes within the Project Limits. Erosion of slopes presents a significant maintenance issue and stability problem on slopes. Each cut and fill slope that requires erosion control and drainage measures shall be evaluated for the following:

A) Reduction of Water Flow across Slope;

B) Slope Revegetation;

C) Slope Armor;

D) Subsurface Water Control.

3.8 MISCELLANEOUS CONSTRUCTION CONSIDERATIONS

The Design-Builder shall design temporary excavation support required for construction, and such design will consider short-term loading due to earth pressures, groundwater pressures, surcharge pressures, and construction equipment loading. Design Builder shall ensure Working Plans for temporary decking, sheeting, and bracing are signed and sealed by a Delaware-licensed Professional Engineer. Special attention is drawn to the as-built information for the adjacent sheet pile wall and approach roadway MSE Walls included in the Scope of Services Package – Reference Documents.

The Design-Builder shall include surcharge pressures due to Structures, point, line and area loads in lateral earth pressure diagrams. Appropriate construction materials and equipment loads shall be determined by the Design-Builder's Geotechnical Engineer and shall be consistent with the methods actually used.

Design Builder shall indicate special requirements on the Working Plans for the installation and removal of temporary bracing systems that relate to the designs of underpinning and protection walls, such as levels of bracing tiers, the maximum distances of excavation below an installed brace, and the amount of preloading in anchors or braces.

See Part 4 – Special Provisions, Temporary Works

3.9 CONSTRUCTION INSTRUMENTATION MONITORING PROGRAM

The Design-Builder shall prepare a geotechnical instrumentation program to monitor vibration, accelerations, vertical settlement, and lateral movement of temporary support structures and adjacent ground, and permanent Structures during and after construction, according to accepted industry standards referenced in Sections 2.1 and 2.2 of this Special Provision. The Design-Builder shall prepare a Working Plan that details the proposed program of instrumentation and monitoring, shall establish threshold values of the monitored parameters, and shall describe the Response Plan that will be implemented when threshold parameters are exceeded. The design and distribution of instrumentation within the Working Plan shall demonstrate an understanding of the need, purpose and application of each proposed type. The

Design-Builder shall provide, install and monitor the instrumentation during and after construction and the Geotechnical Engineer shall review and interpret the data. The Working Plan and Response Plan shall be part of the Foundation Testing and Monitoring Program as specified in Section 3.3.2 of this Specification.

The Design-Builder shall provide weekly Construction Instrumentation Monitoring Reports to the Department's Project Manager. Should any pre-determined threshold values be exceeded, the Design-Builder shall notify the Department's Project Manager immediately. The Design-Builder shall take corrective action in accordance with the Response Plan where the instrumentation data indicate adverse conditions.

3.10 SUBMITTALS

- Geotechnical Planning Report (*See* Section 3.1) to the Department's Project Manager for review and comment;
- Final Geotechnical Report (*See* Section 3.1) to the Department's Project Manager for review and comment;
- Revised Geotechnical Report to the Department's Project Manager, as required for conformity with the Contract Documents;
- Foundation Testing and Monitoring Program (*See* Section 3.3.2) to the Department's Project Manager for review and comment;
- Provide drivability analysis (WEAP) to the Department's Project Manager for review and comment at least 14 Calendar Days prior to driving test piles and production piles (*See* Section 3.3.1);
- Test Pile Program and/or Technique Shaft results to the Department's Project Manager for review and comment prior to the start of production pile driving and/or permanent drilled shaft installation;
- Provide Pile Driving Record Forms (*See* Section 3.3.2.2) for all test piles and production piles;
- Provide CSL Reports to the Department's Project Manager within 7 days of each test (*See* Section 3.3.2.3);
- Provide Construction Instrumentation and Monitoring Reports to the Department's Project Manager on a weekly basis (*See* Section 3.9); and
- Qualifications and experience for all specialty services.

INSPECTION, MAINTENANCE AND CONSTRUCTION REQUIREMENTS

PERFORMANCE SPECIFICATION

1.0 INTRODUCTION

The Design-Builder shall design and construct the Project so as to meet ease of inspection and maintenance goals for the Project in accordance with all applicable Criteria and Standards cited herein and in accordance with this specification.

2.0 APPLICABLE STANDARDS AND REFERENCES

2.1 STANDARDS

A) International Testing Association (NETA), Maintenance Testing Specifications.

B) National Electric Code (NEC), NFPA-70.

C) Standard for the Installation of Lightning Protection Systems, NFPA-780.

D) Illuminating Engineering Society of North America, IES-RP-8-00.

E) American Society of Mechanical Engineers (ASME), A17.1 Safety Code for Elevators and Escalators.

F) ASME, A17.2 Guide for Inspection of Elevators.

G) ASME, A17.3 Safety Code for Existing Elevators and Escalators.

H) DelDOT Bridge Design Manual, May 2005.

I) FHWA Bridge Inspector's Reference Manual, October 2002.

J) AASHTO Manual for Condition Evaluation of Bridges 2nd Edition (2000).

K) AASHTO Revisions to the Manual for Condition Evaluation of Bridges, 2nd Edition (2003).

L) AASHTO Guide Manual for Condition Evaluation and Load and Resistance Factor Rating (LRFR) of Highway Bridges (2003).

M) Occupational Safety and Health Association (OSHA) Standards, Part 1910.

N) United States Coast Guard (USCG) 33 CFR 118.

O) Post-Tensioning Manual, Sixth Edition, Post-Tensioning Institute (PTI)

P) DelDOT Standard Specifications, August 2001.

2.2 REFERENCES

A) DelDOT Bridge Inspection and Maintenance Procedures.

B) Recording and Coding Guide for the Structure Inventory and Appraisal of the Nation's Bridges, FHWA-PD-96-001, December 1995.

C) Pontis Bridge Management System (BMS), Release 4, AASHTO/FHWA.

D) DelDOT Standard Specifications, dated August 2001.

3.0 REQUIREMENTS

The Design-Builder is to design and build permanent structures in accordance with the requirements outlined in Performance Specifications for Structures. Structures so designed are expected to perform for periods as follows:

Bridge Structure	100 years
Stay Cables	75 years
Stay Cable Vibration Suppression System	25 years
Multi-Rotational Bearings	20 years
Elastomeric Bearings	30 years
Expansion Joints (Excluding Finger Joints)	10 years
Finger Joints	30 years
Coating Systems	20 years

During the above service life of the structures, inspection and maintenance activities will need to be performed. The Design-Builder is required to take the activities into consideration during the design and construction.

3.1 INSPECTION AND MAINTENANCE MANUAL

3.1.1 Inspection Requirements

The Design-Builder shall perform a detailed "inventory" inspection upon Final Acceptance of the Work. This detailed inspection shall be in accordance with NBI, Pontis, and Department guidelines. Any special or unique NBI and Pontis ratings or requirements shall be defined by the Design-Builder for use by the Department on future bridge inspections and shall be discussed in the Maintenance Manual.

3.1.2 Maintenance Manual

The Design-Builder shall develop a project specific Inspection and Maintenance Manual (Manual) for the Project. The Manual shall provide guidelines and suggested procedures for inspecting and maintaining the bridge structure and shall identify any new Pontis elements to be created in the Department's database. At a minimum, the Manual shall cover the following:

A) Chapter 1: Introduction:
   1) Purpose of the Manual; and
   2) Description of Bridge.

B) Chapter 2: Bridge Design Considerations:
   1) Overall Concept of Design; and
   2) Descriptions of Design Loadings.

C) Chapter 3: Structural Role of Major Bridge Elements:
   1) Substructure Elements;
   2) Superstructure Elements; and
   3) Identification of Critical Inspection and Maintenance Elements.

D) Chapter 4: Construction:
   1) General;

2) Unique Construction Techniques (Superstructure and Substructure)

3) Design Modifications During Construction

4) Repairs Made During Construction

5) Permanent Record of Stay Cable Installation, if applicable

E) Chapter 5: Inspection Personnel and Equipment

1) Inspection Personnel

2) Inspection Access

3) Special Inspection Equipment

F) Chapter 6: Inspection Program and Schedule

1) Inspection Program

2) Inspection Schedule

G) Chapter 7: Inspection Procedures

1) General

2) Deficiencies (Common, Superstructure, Substructure)

3) Other Considerations

4) Detailed Inspection Procedures for all Components and Materials

5) Checklist – Forms to Record Observations

6) Survey of Bridge

7) Waterway

8) Post-Event Inspection (e.g. Hurricanes, Storm Surges, Floods, Earthquakes, etc.)

H) Chapter 8: Maintenance and Repair Procedures

1) General

2) Deficiencies in Concrete

3) Corrosion and Deterioration Prevention

4) Concrete Box Girder

5) Bearings

6) Expansion Joint Assemblies

7) Post-Tensioning Systems

8) Stay Cable System

9) Stay Cable Vibration Suppression System

10) Mechanical / Electrical System (Including access elevators)

11) Lightning Protection System

12) Bridge Lighting System Checks and Procedures

13) Vermin Protection/Deterrent System

14) Differential Settlements

15) Deck Rehabilitation Procedures

16) Bearing Replacement Procedures/Details

17) Stay Cable Replacement Procedures/Details

18) Expansion Joint Replacement Procedure/Details

19) Stay Cable Vibration Suppression System - Dampers Replacement Procedure/Details

20) Innovative Material Replacement Procedures/Details

3.2 LOAD RATING ANALYSIS AND SPECIALIZED TRAINING

The Design-Builder shall provide load rating analysis of the bridge in accordance with *AASHTO Manual for Condition Evaluation and Load and Resistance Factor Rating (LRFR) of Highway Bridges* for the as-built condition. The results of the analysis including all back-up calculations shall be included as an appendix in the Manual. The Design-Builder shall be required to provide a specialized training seminar to select Department staff on the load rating analysis of the bridge. The Design-Builder shall provide a minimum of 2 seminars of 8 hours for 25 attendees for the load rating analysis.

3.3 CORROSION PROTECTION PLAN

The Design-Builder shall provide to the Department, for review and approval, a detailed Corrosion Control Plan including material selection modeling process and estimates of life-cycle costs, to assure the stated service lives for any structural steel components of the bridge. Cathodic protection is not required. Any permanent steel bridge components directly affecting the structural integrity and load carrying capability of the bridge shall not be exposed to atmospheric conditions.

For post-tensioned bridges, the Corrosion Protection Plan shall include specific detailed provisions for post-tensioning tendon corrosion protection. The plan shall specify corrosion allowances and outline detailed provisions with regards to reinforcing steel and structural steel protection. In regards to concrete performance, the plan shall assess the effects on concrete permeability, corrosion thresholds, corrosion rate, impacts on cracked concrete, time-to-repair and provide recommendations on the use of calcium nitrate, silica fume, sealers, membranes, reinforcing coatings, increased cover, corrosion inhibitors, etc.

3.4 SECURITY

Access to the bridge shall be limited to authorized personnel only. The bridge shall be detailed to deny access to voided areas/components of the bridge, such as box girders and voided towers, ladders, platforms, walkways, and/or travelers. Access shall be detailed as required within this Performance Specification.

See the *Bridge Security Program* Performance Specification in this Part 3 for additional requirements.

4.0 BRIDGE STRUCTURE

This section includes requirements applicable to cable-stayed bridge types. Similar provisions shall be made by the Design-Builder for other structure types.

4.1 TOWERS

4.1.1 Inspection and Maintenance Access

All superstructure and substructure components of the bridge structure shall be accessible by way of normal and customary inspection and maintenance access equipment. Design-Builder shall provide suitable access into any enclosed areas for inspection.

4.1.1.1 Voided Towers

For voided towers, inspection and maintenance access for the full height of each tower leg, including access to the exterior top of each tower leg shall be provided. Permanently mounted interior access ladders and platforms shall be provided from the bottom to the top of each voided tower leg. A supplemental elevator system, equipped with emergency egress capability and access to the ladder system, shall also be provided and shall be capable of transporting a minimum of two (2) workers and associated equipment with a total combined live load of at least 1500 pounds. The access limits for the elevator system shall extend from the bottom of each voided tower leg to the top of each tower leg or within 25 feet of any cable anchorage zones. Where elevator access is not provided, the Design-Builder shall provide an automated lift system capable of lifting at least 1000 pounds of equipment and/or materials at one time.

Access doors for voided tower access shall be readily accessible by maintenance personnel, vehicles and equipment. The access doors shall be hinged vertically to open horizontally and shall be provided with locks to prevent unauthorized entry. An inspection/maintenance platform or landing shall be provided at critical points, such as cable anchorages, and at each access door. Access doors shall be made with minimum ½ inch thick aluminum alloy, a minimum of 3ft. - 0in. in width by 4ft. - 0in. in height.

4.1.1.2 Solid Towers

In order to enhance bridge aesthetics and minimize potential corrosion issues, the use of external platforms and ladders shall not be permitted unless specifically required by this Specification. Accordingly, the use of solid towers shall not be permitted.

4.1.1.3 Safety Railing and Anchor System

A safety railing system shall be provided at the top of each tower leg. Additionally, an anchor system will be provided at the top of each tower leg to provide attachment of maintenance and inspection platforms that will support a minimum load of 1500 lbs. The safety railing system and anchor system components shall be steel painted in accordance with Section 826 of the DelDOT Standard Specifications, or other corrosion resistant material.

4.1.2 Critical Maintenance and Inspection Components

The following items are representative items that have been identified which require special design and/or detailing in the interest of inspections and maintenance. This is not an all inclusive listing and may not be completely applicable to the proposed bridge structure type. The Design-Builder shall be responsible for identifying and discussing all critical components in the Inspection and Maintenance Manual for the actual bridge type utilized.

4.1.2.1 Tower/Stay Cable Anchorage Connection

The anchorage connection/assembly must be fully protected internally within the tower and accessible for inspection. The connection assembly shall be detailed to shed water and sealed to prevent water and moisture intrusion.

4.1.2.2 Composite Steel Member Stay Cable Attachment

Composite steel member to stay cable attachments shall be detailed to shed water and sealed to prevent water and moisture intrusion to the steel/concrete interface.

4.1.2.3 Elevator System (Electrical/Mechanical)

All elevator machinery, cables, and electrical components shall be readily accessible with work platforms, hatches, and ladders necessary to perform routine inspections and maintenance. The elevator shall be provided with emergency lighting. All electrical components shall be UL-listed for the application, and comply with *NEC* workspace clearances. Cables and raceways shall comply with *NEC* requirements for

the application. The installation shall include all structures, clamps, bolts, hangers, drive mechanisms, control devices and safety devices as required for the operation of the elevators and shall be in compliance with *ASME A17.1, A17.2, and A17.3* and all local codes and ordinances. Megger test all cables before putting them into service. Test results shall become part of the Inspection and Maintenance Manual for reference.

During construction through Final Acceptance, the elevators shall be inspected and maintained by qualified service personnel. Maintenance shall be performed per the manufacturer's recommendations and inspections shall be at durations as required by the permitting authority. These same requirements shall be outlined in the Inspection and Maintenance Manual.

4.1.3 Moisture Control and Interior Drainage System

4.1.3.1 Ventilation

The design and detailing of voided towers shall promote natural ventilation to aid in preventing in the accumulation of moisture within the towers and stagnant air. Openings to promote ventilation shall be provided with appropriate screening to prevent entry of birds, pests, or other vermin.

4.1.3.2 Access Doors

All horizontal access doors shall be provided with appropriate seals to prevent moisture from entering the towers.

4.1.3.3 Drainage Details

Floors of voided towers shall be contoured and weep holes provided to promote the drainage of water and prevent moisture accumulation. Any holes shall be screened to prevent the entry of birds, pests, or other vermin.

4.1.3.4 Attachments

Any attachments to towers shall be waterproofed.

4.1.4 Painting and Coating of Steel Elements

As a minimum means of protection, all interior steel elements and steel surfaces of voided towers shall be painted in accordance with Section 820 of the *DelDOT Standard Specifications*. The top coat shall consist of a light color that is easily visible within the tower.

4.2 STAY CABLES

4.2.1 Permanent Record of Stay Cable Installation

Permanent records shall be established for each cable installation. Such records shall include survey records, date, time and ambient temperature; cable forces; cable elongation measurements; shim pack or lock nut settings; and all other special notations necessary and sufficient to establish the conditions under which the cable was installed.

4.2.2 Stay Cable Vibration Suppression System

All connections and openings for the stay cable vibration suppression system shall be sealed to prevent water and moisture intrusion. The system shall be detailed to allow for easy inspection and replacement.

4.2.3 Stay Cable Vibration Testing and Structural Damping Evaluation

The Design-Builder shall provide a full vibration testing and structural damping evaluation of the Stay Cable system at the completion of construction.

4.2.4 Duct Coupler and Connection System

The duct coupler and connection system shall be designed and detailed to ensure a minimum of two

nested qualified (per Post-Tensioning Institute) barriers are provided to prevent corrosion of the main tensile element and provide for the stated service life of the stay cable. Duct couplers and splices shall be minimized.

4.3 SUPERSTRUCTURE

4.3.1 Inspection and Maintenance Access

The Design-Builder shall demonstrate the full underside and all fascia areas of the superstucture is fully accessible with a readily available under bridge inspection vehicle (UBIV). For areas not accessible from a UBIV, the Design-Builder shall provide the necessary platforms, walkways, travelers and/or other means of ensuring full access is possible for inspection and maintenance in the future. Suitable means shall be provided to access bearings, expansion joints, navigation lights and other components.

Regardless of the complete inspection and maintenance means provided by the Design-Builder for the bridge type, the combined use walkway shall be fully traverse-able by the UBIV. The design live loads for the bridge shall be in accordance with the *Bridge Design Requirements* Performance Specification and shall include provisions for UBIV loadings in accordance with the *Bridge Design Requirements* Performance Specification.

4.3.1.1 Inspection and Maintenance Platform/Traveler

The Design-Builder shall design, furnish, and install maintenance and inspection self-propelled travelers, where UBIV access is not possible, to provide for future inspection and maintenance access to the full underside of the superstructure of the bridge. The inspection and maintenance self-propelled travelers shall be designed in detail to provide easy connection and implementation when needed. The travelers shall provide "hands on" accessibility to all areas of the underside not accessible from a UBIV or permanent platforms, ladders, and walkways. The travelers shall be able to accommodate up to three (3) workers and associated equipment. The total minimum load requirement, including three workers and associated equipment is 1500 lbs. The travelers shall provide full access between abutments.

If used, the work shall include designing and fabricating structural, mechanical, hydraulic and electrical components, assembling of components, erecting the assembled platforms and or travelers and testing.

Travelers shall not be used for construction of the bridge. The travelers shall ride on an independent rail system and shall not ride directly on bridge girders. The primary structural components of the traveler and the support rails shall consist of stainless steel or other corrosion resistant materials. Galvanized steel and painted steel will not be permitted for primary traveler components. Secondary components must be readily replaceable from the traveler and shall not compromise or reduce the load carrying capacity of the traveler. Secondary components might include decking and protective railings. Materials and coatings for secondary components shall be appropriate for use in a marine environment.

The Design-Builder shall provide operations and maintenance information on the system within the Inspection and Maintenance Manual.

4.3.1.2 Underdeck Inspection Access

Any permanent underdeck inspection access systems shall be located outside the clearance envelope specified in the Part 6 Directive Plans.

4.3.1.3 Interior Access Considerations

The interior of all box girder sections, regardless of construction material or methods, shall provide a minimum vertical clearance of 6'-0". Access openings for box sections shall be a minimum of 3'-0" horizontally by 4'-0" high. Access doors should be located at or near each foundation unit. Entrances to all box girders shall be made with in-swinging, hinged, solid doors. Doors in diaphragms shall be in-

swinging, hinged, 0.25-inch mesh screen doors. Equip all doors at abutments and entrances with a lock and hasp. All locks on the bridge shall be keyed alike.

Provide an access opening through all interior diaphragms of any box sections. If the bottom of the diaphragm access opening is not flush with the bottom flange, provide ramps to facilitate equipment movement. Indicate on plans that diaphragm access openings are to remain clear and are not to be used for utilities or other attachments.

If utilities are required, provide additional areas or openings. Analyze access opening sizes and bottom flange locations for structural effects on the girder. Avoid entrance locations over traffic lanes and locations that will require extensive maintenance of traffic operations or that would otherwise impact the safety of inspectors or the traveling public.

4.3.2 Critical Inspection and Maintenance Components

4.3.2.1 Stay Cable/Superstructure Anchorage Connection

Any anchorage connections/assemblies must be fully and easily accessible for inspection. The connection assemblies shall be detailed to shed water and sealed to prevent water and moisture intrusion.

4.3.2.2 Composite Steel Member Stay Cable Attachment

Any composite steel member to stay cable attachments shall be detailed to shed water and sealed to prevent water and moisture intrusion to the steel/concrete interface.

4.3.3 Moisture Control and Interior Drainage System

See Section 4.1.3 of this Performance Specification for requirements.

4.4 SUBSTRUCTURE

4.4.1 Maintenance and Inspection Access

Interior safety platforms and ladder systems, including a fall protection system, shall be provided for inspection and maintenance access for all voided substructure units.

4.4.2 Moisture Control and Interior Drainage System

4.4.2.1 Ventilation

The design and detailing of voided columns/piers shall be done to promote natural ventilation to aid in preventing in the accumulation of moisture and stagnant air within the components. Openings to promote ventilation shall be provided with appropriate screening to prevent entry of birds, pests, or other vermin.

4.4.2.2 Access Doors

All horizontal access doors shall be provided with appropriate seals to prevent moisture from entering the substructure components and shall be provided with locks in order to prevent unauthorized entry. An access hole shall be located in the pier cap with minimum access hole dimension of 2’-6” diameter.

4.4.2.3 Drainage Details

Floors of voided columns and other enclosed substructure components shall be contoured and weep holes provided to promote the drainage of water and prevent moisture accumulation. Any holes shall be screened to prevent the entry of birds, pests, or other vermin. If voided substructure units are utilized, the voids shall not extend below a height that is 15’-0” above the established high water elevation.

4.4.2.4 Attachments

Any attachments to substructure components shall be waterproofed.

4.4.2.5 Post-Tension Pourbacks

Post-Tension pourback areas at the top of columns shall be a two-barrier system and shall be detailed to shed water and to prevent water and moisture intrusion. Barrier system shall be qualified per PTI.

4.5 BEARINGS AND EXPANSION JOINTS

4.5.1 Bearings

Any exposed areas of steel components shall be hot-dipped galvanized or metallized. Bearing placement and details shall provide for ease of inspection and maintenance. Provisions shall be made to facilitate jacking of the superstructure for bearing replacement. Provisions for jacking, including jacking location, sequence and load shall be clearly shown on the final plans.

4.5.2 Expansion Joints

All expansion joints shall provide a watertight seal and finger joints shall be provided with a neoprene trough drainage system. Modular and Sliding Plate joints are not permitted. Expansion Joint systems shall be designed and detailed to promote ease of inspection and maintenance and to provide for replacement with minimum interruption of traffic. A minimum of one lane in each direction shall be able to remain in use during replacement operations. Steel components of expansion joint assemblies shall be hot-dipped galvanized in accordance with *AASHTO M-111* (*ASTM A123).*

4.6 LIGHTNING PROTECTION SYSTEM, GPS, AND NAVIGATION LIGHTS

4.6.1 Lightning Protection System

The Design-Builder shall provide a UL master labeled lightning protection system. The installation shall comply with NFPA-780. All connections and components of the system shall be accessible for inspection and maintenance.

For cable-stayed bridge structure types, lightning protection of concrete pylons and stay cables shall consist of the following:

A) Installation of collector lines from each stay cable anchorage to a transition line. Installation of a collector line from the reinforcement near the top of the pylon to the transition line. Collector lines should be made of copper and have a cross section of at least 0.08 inches;

B) Installation of a transition line, in direct contact with the reinforcement cage, from the pylon tip down to the foundation. The transition line should have a cross section of at least 0.3 square inches and may consist of specifically designated reinforcing steel bars properly welded together to assure adequate electrical conductivity. The transition line should be connected to the foundation earth which typically consists of a horizontal closed loop of reinforcing steel bars (min 0.3 inches cross section) placed low in the foundation, inside the concrete.

The concrete deck does not need any specific protection in general. In case electrically isolated bearings are used, they need to be electrically connected to earth with cables (min. cross section of 0.08 square inches or copper bar with a minimum diameter of ¼ inches). Composite structures are suggested to be protected similarly to concrete structures.

For alternate bridge structure types, lightning protection provisions comparable to those listed in this Section 4.6.1 shall be made as appropriate.

4.6.2 GPS Installation

The Design-Builder shall provide a Global Positioning System (GPS) for monitoring bridge movement.

The antennas, electronics cabinets and other major system components shall be accessible by way of normal and customary inspection and maintenance access equipment

4.6.3 Navigation Lights & Aviation Beacons

The Design-Builder shall design, furnish and install navigation and aviation lighting systems for the bridge and any temporary erection towers. The system shall be suitable for marine environment.

The installations, equipment, materials and workmanship shall be in accordance with the applicable provisions of the National Electrical Code, the United States Coast Guard and the Federal Aviation Administration.

Marine navigation red and green lanterns shall be provided on each side of the span over the navigable channel in accordance with 33 CFR 118. Two suspended duplex red channel margin marker lights (180 degrees) and one suspended duplex center channel green lantern (360 degrees) shall be displayed below the superstructure on each side of the bridge. A mounting bracket with a system allowing bulb replacement shall be provided to hold the lantern in proper operating position. The mounting bracket shall be hot-dip galvanized steel with stainless steel hardware complete with all required accessories.

The navigational lights shall be placed so as to mark the navigation channel.

Temporary and permanent aviation beacons lights shall be in accordance with Federal Aviation Administration requirements. All housings shall be constructed of non-corrosive material.

Temporary navigation lights and other navigation signals shall be installed during construction as required by the United States Coast Guard (USCG).

Permanent lighting shall not be solar powered.

4.7 INTERIOR INSPECTION LIGHTING

4.7.1 Towers & Superstructure

All enclosed areas subject to inspection and maintenance shall be provided with a low voltage (120 Va.c.) inspection and maintenance lighting system, and electrical outlets. The lighting levels shall be 30 foot candles horizontal. Bulbs for interior lighting system shall be high-endurance bulbs. The system wiring shall be sized so that voltage drop shall not be more than 5%. Megger test all system conductors before putting them into service. Test results shall become part of the Inspection and Maintenance Manual for reference. Installation shall meet all requirements of the latest edition of the National Electric Code (NEC) and local ordinances.

Electrical receptacles shall be provided and be 120V duplex receptacles, in non-metallic outlet boxes at 50’ maximum on centers. Each receptacle shall have a weather-protective gasketed outdoor plate.

Switches shall be mounted at each end of each span and at each access door. Provisions for automatically tuning off interior lighting systems shall be made if left unattended for extended periods of time.

4.8 AESTHETIC LIGHTING

The Design-Builder shall be responsible for providing aesthetic bridge lighting features within the Primary Project Limits. The bridge lighting Work shall include design, furnishing and installation of all conduits, junction boxes, pull boxes, pole bases, supports, anchor bolts, cabling, wiring, poles, luminaries, and other light fixtures and assemblies as required by the Contract Documents.

Any aesthetic lighting fixtures used shall be accessible by way of normal and customary inspection and

maintenance access equipment. Aesthetic lighting fixtures shall be water tight, and marine grade. Aesthetic lighting shall pose no veiling luminance to roadway or navigable channel users.

No roadway lighting is required as part of the Project.

5.0 ROADWAY

5.1 DRAINAGE SYSTEM

Design-Builder shall provide drainage structures at all drainage channels and equalizers as needed to prevent backwater flooding. Bends in drain pipes should be <45 degrees. *See* Part 4 – Special Provisions, *Item 605524 – Bridge Drainage System* for additional requirements.

5.2 GUARDRAIL / BARRIER RAIL

Details utilized in Approach Roadway Contract #23-073-03 shall be maintained throughout the Secondary Project Limits. *See* Part 6 – Scope of Services Package Plans, Directive Plans for guardrail and barrier details.

5.3 SLOPE PROTECTION (EROSION CONTROL)

Design-Builder shall provide a construction erosion control plan. Paved ditches and revetments will be provided by the Design-Builder where needed for erosion control and slope protection.

6.0 CONSTRUCTION REQUIREMENTS

6.1 WORK OVER AND IN THE INLET

Navigable waters shall be maintained in accordance with the USCG Bridge Permit. The Design-Builder shall provide for temporary protection against falling objects when working over the inlet. The use of cofferdams, temporary piling, temporary caissons, or any other methods that might alter the existing scour behavior within the existing inlet limits shall not be permitted.

Approval for use of barges within the navigable channel must be obtained from the USCG. Should the Design-Builder elect to deliver materials via barge directly to the work zone, appropriate approvals from the USACE and USCG must first be obtained. The Design-Builder shall be aware of the turbulence and rapid changes in flow through the inlet.

See Part 3 – Design Requirements and Performance Specifications, Environmental Documents for permit information.

6.2 WORK OVER EXISTING ROADWAY

The Design-Builder shall maintain a temporary protective shield over pathways and emergency access routes north and south of the inlet. If temporary closures of these areas are required during construction, the Design-Builder shall coordinate with the Department, and the DNREC Division of Parks and Recreation. Law enforcement and emergency personnel must also be notified of such closures.

See Part 6 – Scope of Services Package Plans, Directive Plans for temporary protective shield limits.

See Part 4 – Special Provisions, Temporary Protective Shield for additional requirements.

6.3 NO WORK AREAS

No Work Areas are delineated in the referenced Environmental Assessment and on the Indicative Plans for the Roadway Approaches and previous Bridge Plans. The Design-Builder shall take all necessary

precautions to avoid these areas as stipulated in the Environmental Assessment.

See Part 3 – Design Requirements and Performance Specifications, Environmental Documents and Part 6 – Scope of Services Package Plans for additional information.

6.4 MAINTENANCE DURING CONSTRUCTION

The Design-Builder shall comply with the maintenance requirements specified in Part 2 – DB Section 105-8.

7.0 SUBMITTAL REQUIREMENTS

7.1 CORROSION CONTROL PLAN

With the submission of the applicable structural design packages, the Design-Builder shall provide to the Department for review and approval a detailed Corrosion Control Plan, which is to include discussion of the following:

A) Estimates of life-cycle costs and assurance of stated service lives.

B) Post-tensioning tendon corrosion protection methods.

C) Corrosion allowances/thresholds.

D) Concrete permeability, corrosion rate, time-to-repair, etc.

E) Inhibitors, sealers and coatings, etc.

7.2 INVENTORY INSPECTION

A) Detailed bridge inspection report to be submitted within six months of Final Acceptance of the Work.

7.3 MAINTENANCE MANUAL

A) To be submitted within two months after substantial completion of construction.

B) Cable Installation records in accordance with Section 4.2.1 of this Performance Specification.

7.4 LOAD RATING / SEMINAR

A) Minimum of two seminars of 8 hours for 25 attendees.

B) Load rating shall reflect as-built conditions.

C) Rating shall follow *AASHTO LRFR*.

8.0 WARRANTY INFORMATION

A) List of replaceable items and associated warranties.

MASS CONCRETE
PERFORMANCE SPECIFICATION

1.0 INTRODUCTION

This item covers the procedures for the control of the curing of mass concrete by monitoring of internal temperatures.

It is the Design-Builder's responsibility to determine which elements will be considered as Mass Concrete based on the temperature requirements of this specification and to ensure that elements do not crack as a result of temperature differentials. The Design-Builder shall submit to the Department his procedure and list of elements that will be considered Mass Concrete prior to the placement of any concrete elements. The Department shall have 20 calendar days to review and comment on this submittal.

2.0 CONSTRUCTION METHODS

The Design-Builder shall provide his Plan for the mass concrete mix design, analysis, monitoring and control, including insulation and methods to the Department for review and comment a minimum of 45 days prior to the placement of any Mass Concrete. This Plan shall include a minimum of one level of redundancy for all equipment and materials to maintain continuous placement as per the Design-Builder's proposal.

A) Mix Design: Ground granulated blast furnace slag or fly ash may be used in the mix to reduce the heat of hydration. Slag or fly ash may be used as a cementitious replacement material for cement up to a maximum limit of 75% by weight of total cementitious material in the mix. Slag and/or fly ash shall be from single sources approved by the Department, shall be compatible with the type of cement used and thoroughly blended in the mix. Other precautions for reducing the heat of hydration may be taken, such as the addition of controlled quantities of ice in lieu of equal quantities of mixing water or cooling tubes. However, the mix shall contain no frozen pieces of ice after blending and mixing components. The use of liquid nitrogen to cool the concrete will be permitted if included in the Design-Builder's Plan.

   All concrete constituent materials shall be compatible with the proposed cements, workability enhancing additives and water reducing agents as necessary to provide concrete satisfying all requirements of the Contract Documents.

B) Analysis and Monitoring: The Design-Builder's Plan shall provide an analysis of the anticipated thermal developments within the mass concrete elements for the anticipated project temperature ranges, along with the proposed mix design, casting procedures and materials. A copy of any software model input and output (such as the Schmidt model) with the site and element specific data shall be transmitted to the Department for review and comment. This submittal shall include electronic files and complete documentation defining the theory, means and methods used by any software models. Additionally, the Plan shall describe the measures and procedures intended to maintain, monitor and control the temperature differential between the interior and exterior of the mass concrete elements, with a maximum temperature of 160^{o}F during curing. During curing, the maximum differential temperatures shall not exceed:

First 24 hours	30° F
24 to 48 hours	40^{o} F

2 to 7 days	50º F
7 to 14 days	60º F

C) Monitoring Devices: The Design-Builder shall provide temperature monitoring devices to record temperature development between the interior and the exterior of the element at various points approved by the Design-Builder's Engineer. A minimum of two independent sets of interior and exterior points shall be monitored for each element to provide redundancy in case of failure of a device. The monitoring points shall be located at the geometric center of the element for the interior point and 2" from the surface along the shortest line from the geometric center to the nearest surface of the element for the exterior point.

Monitoring devices shall be automatic sensing and recording instruments that record information at a maximum interval of one hour. These devices shall operate for a range of 0 to 200^{o} F with an accuracy of ± 2^{o} F. In addition, the Design-Builder shall take manual readings and record data at intervals not greater than 6 hours to ensure that the automatic devices are working properly and that the temperatures are within allowable limits. The intervals of one and six hours shall begin immediately before casting concrete and shall continue until the maximum temperature differential and maximum temperature are reached and begin to drop. These readings shall be transmitted to the Department within 2 days of the time the readings were taken.

Prior to the first pour of mass concrete, the Design-Builder shall perform a demonstration placement to verify accuracy of the predicted temperature and methods of controlling temperature, and to test the automatic and manual thermal sensing and recording equipment.

D) Construction: The Design-Builder shall take measures to control differential and absolute temperatures by appropriate use of insulated forms, curing blankets or internal cooling.

If, during the first 14 days after the concrete pour, the internal concrete temperature differential nears the maximum differential limits, corrective measures shall be taken by the Design-Builder to immediately retard further growth in the temperature differential such that the differential ultimately remains within the above limits. Furthermore, the Design-Builder shall make revisions to the Plan to maintain the required limits on differential temperature on any remaining placements of Mass Concrete. The Design-Builder shall obtain the Department's review and comment on revisions to the Plan prior to implementation.

The Design-Builder's attention is drawn to the fact that strength gain and cooling of the Mass Concrete pours can take a long time. The Design-Builder shall take all such time and strength considerations into account when planning construction activities.

E) Grout Inlets and Outlets: All inlets and outlets for grouting of post-tensioning tendons (or bars) that are embedded in mass concrete elements shall be Schedule 10 Rigid Steel Pipe (galvanized).

F) Portion of tendons embedded in mass concrete elements not required to use Type A ducts based on the Tendon Bending Radius shall use Type B ducts. For duct type descriptions, *see* Part 4 - Special Provisions, *Prestressing*.

G) Any cracking or damage due to exceeding maximum temperature and/or temperature

differential, as determined by the Department, shall be repaired by the Design-Builder to the satisfaction of the Department at no cost to the Department. These repair procedures may include, but are not limited to, epoxy injection of cracks or removal and replacement of the damaged element.

PUBLIC OUTREACH REQUIREMENTS
PERFORMANCE SPECIFICATION

1.0 INTRODUCTION

This Performance Specification specifies the minimum requirements for the Design-Builder's Public Outreach Plan, establishes responsibilities for the Design-Builder and the Department, identifies content requirements for informational materials, and establishes communication protocols for the implementation of the Public Outreach Plan.

The Public Outreach Program consists of both Department and Design-Builder activities, including the following:

A) Public Update meetings (semi-annual);

B) Public Advisory Group meetings (monthly);

C) Response to inquiries and comments (as needed);

D) Site tours (weekly);

E) Newsletters (quarterly);

F) Public notices (as needed);

G) Media relations (as needed);

H) Photographs and video documentation (continuous); and

I) Other activities included in Part 8 - The Design-Builder's Proposal.

Awareness and support of highway users, residents, and communities within the area are critical to the successful completion of the Project. The initial bridge design was developed and evolved in large part from the continuous involvement of local residents, community groups, local officials, and other groups. It is important that the Design-Builder continues this cooperative approach in handling community participation.

2.0 STANDARDS AND REFERENCES

The Work shall be in accordance with this Public Outreach Performance Specification and the relevant requirements of the following standards, unless otherwise stipulated herein. Standards and References specifically cited in the body of this Performance Specification establish requirements that shall have precedence over all others. Should the requirements in any standard conflict with those in another, the standard highest on the list shall govern. Listed under References are guidelines that the Design-Builder may use in addressing the requirements as the Design-Builder sees fit. It is the Design-Builder's responsibility to obtain clarification of any unresolved ambiguity prior to proceeding with design or construction.

2.1 STANDARDS

A) Design-Builder's Public Outreach Plan.

2.2 REFERENCES

A) A Guide for Achieving Flexibility in Highway Design, AASHTO, May 2004; and

B) NCHRP Report 480: A guide to Best Practices for Achieving Context Sensitive Solutions.

3.0 REQUIREMENTS

The community involvement and participation element is intended to continue the close working relationships with residents, landowners, community groups, local officials, and other like groups that were initiated during the initial design phase. This effort shall include activities such as, but not limited to, periodic meetings, site tours, job progress documentation, and response to informational requests. In addition, the Design-Build team shall assist in identifying and responding to public issues or activities that might affect the safe, efficient completion of the Project.

Public Outreach is intended to keep the public and media informed of major activities, decisions, and project changes through design and construction. This element will involve the preparation and distribution of Project information to the assigned Department representative for further dissemination to the public and media.

The Design-Builder shall make a good faith effort to address any concerns the public may have, and take under consideration any suggestions or wishes they express if those suggestions are reasonable in regard to cost, time, and construction effort. Documentation shall be in the form of meeting minutes and correspondence, including e-mails. The Design-builder shall respond to these requests through the Department. All design or construction modifications are subject to written acceptance by the Department in consultation with the Design-Builder.

3.1 DEPARTMENT RESPONSIBILITIES

The Department and the Design-Builder both have responsibility for the Public Outreach Program. The Department's Project Manager and Office of Public Relations will be the lead on the Public Outreach effort. The Design-Builder shall have primary responsibility for performing the activities specified in this Performance Specification as well as in the Contract Documents.

The Department's responsibilities shall include the following activities:

A) Maintain QA/QC of any approved Design-Builder communication efforts;

B) Monitor the Design-Builder's performance for compliance with the Contract's Public Outreach requirements and the Design-Builder's Public Outreach Plan;

C) Secure facilities for meetings;

D) Review and distribute meeting minutes;

E) Compile information provided by the Design-Builder for use in printed materials;

F) Coordinate all printed materials including, but not limited to, newsletters, informational maps, press releases, public notices, advertising and correspondence;

G) Review, approve, and distribute responses to inquiries and comments;

H) Issue and advertise Public Meeting Notices;

I) Provide official spokespersons for the Project. The Department-designated representatives will be the first point of contact for all media inquiries including, but not limited to, newspaper, magazine, radio, Internet, and television reporters and others as required in the Public Outreach Plan; and

J) Host and maintain the Project Website and Web-cams.

3.2 DESIGN-BUILDER RESPONSIBILITIES AND REQUIREMENTS

3.2.1 Public Outreach Program

Within 30 Calendar Days of Notice to Proceed, the Design-Builder shall submit to the Department's Project Manager any request to modify or append the Public Outreach Plan originally included in the Design-Builder's Technical Proposal and included in Part 8 of the Contract Documents. The Department's Project Manager shall have the sole responsibility of determining the acceptability of any proposed changes to the Plan. The approved Public Outreach Plan and the Department's responsibilities specified in Section 3.1 of this Performance Specification shall comprise the overall Public Outreach Program.

3.2.2 Public Update Meetings

The Department intends to hold periodic Public Update Meetings for the duration of the Project. The Design-Builder shall coordinate and prepare for each meeting through its designated Public Outreach Specialist and in close cooperation with the Department.

The Design-Builder shall provide the necessary staff, displays, renderings, models, and hand-outs to adequately portray the bridge concept and the Project's status at the time of each meeting. The Design Builder shall identify the number and types of materials to be used for Public Update Meetings as part of the Public Outreach Plan. Major design and construction update information shall be presented to the public. All materials to be used and/or distributed must be reviewed and approved for use by the Department prior to the Update Meeting.

The initial Public Update Meeting is to be held within 45 Calendar Days of the Notice to Proceed for the Project and will be held approximately every six months thereafter. Each meeting is to be held at facilities obtained by the Department.

The Design-Builder shall submit a meeting summary within 2 Working Days of each Update Meeting. As a minimum, the summary shall include a list of attendees, comments received, issues or concerns raised, copies of hand-outs, displays, or other presentation materials.

The Design-Builder shall provide electronic versions (in Adobe Acrobat .pdf format) of display boards and other materials presented at Public Meetings to the Department's Project Manager and Office of Information Technology Web Team for posting to the project Website.

3.2.3 Advisory Group Meetings

As part of the overall Project, the Department holds a monthly Advisory Group Meeting with members of local Homeowner Associations, Chambers of Commerce, elected officials, members of the media, and other interested parties to discuss on-going design and construction activities associated with the Project. The purpose of this meeting is to provide a forum for increasing the public's awareness regarding the Project, identifying public activities and events that might be affected by proposed construction activities, and identifying potential safety concerns. These meetings are informal, approximately 1 hour long, and are held in the Department's field office. The Design-Builder will be expected to provide a verbal update and to answer questions at each meeting. Typical items for discussion might include the following:

A) Anticipated impacts to traffic, including pedestrians and bicyclists;

B) Anticipated impacts to Delaware Seashore State Park;

C) Construction access areas;

D) Site security and safety concerns;

E) Proposed hauling routes;

F) Noise and dust control; and

G) Schedule and duration of activities.

Information regarding Project design and construction schedules shall be offered in a form that can be easily understood by the public and shall be consistent with information contained in the Baseline Progress Schedule and schedule updates.

The Design-Builder shall be aware of the recreational and seasonal tourism issues associated with the project location. It is essential that the Design-Builder cooperates with the Department and remains proactive in attempting to minimize disruption to other activities in the area.

3.2.4 Response to Inquiries and Comments

A) The Design-Builder will have direct contact with the community in meetings and as otherwise required by this Public Outreach Performance Specification.

B) If a resident, business, or other member of the public has a question or comment on the Project outside of a public meeting forum, the first and preferred point of contact should be the Department's Public Relations Office or the Department's Project Manager. The Design-Builder shall take necessary steps to facilitate such contact.

C) If Design-Builder receives a complaint regarding Design-Builder's conduct of Work on the Project, the Design-Builder shall notify the Department's Project Manager within 24 hours. The Design-Builder shall provide necessary information, staff support, and representation to assist in resolving the issue.

D) The Design-Builder shall provide a commitment of the Design-Builder's Project Manager to serve as a spokesperson for the Project, at the Department's request, for technical and Project safety issues.

The Design-Builder shall maintain a consistent system for documenting all contact with business owners, residents, media and property owner. The Design-Builder shall provide the Department's Project Manager, an electronic copy of all public contact records. The electronic file should be received by the 1st of each month and should include all contacts made prior to the 25th of the previous month.

3.2.5 Site Tours

It is the Department's goal to fully utilize the educational opportunities this Project might offer. The Design-Builder shall assist the Department in achieving this goal by organizing and leading periodic tours of the construction project site. Knowledgeable guides shall be made available by the Design-Builder to explain the Work progress, ensure visitor safety, and answer questions related to the Design-Build portions of the project. The Design-Builder shall have appropriate safety devices (e.g. hard hats, safety vests, personal flotation devices, gloves, glasses, etc.) available for use by visitors.

The Design-Builder shall allow for approximately one tour group per week on average for the duration of the construction activities. Group sizes are expected to include up to 30 visitors at any given time. Each group may be divided into smaller groups as deemed appropriate by the Design-Builder. Anticipated visitors might include the following:

A) Professional Societies;

B) Industry Representatives;

C) University Organizations;

D) Department Personnel;

E) Community Groups;

F) Local Schools; and

G) Elected Officials.

A portion of the anticipated tours may be conducted and led by Department personnel. The Design-Builder shall assist the Department, as necessary, by furnishing safety devices, identifying reasonable visitation times and schedules, and determining which areas are safe for visitors.

3.2.6 Newsletters

As part of the overall Project, the Department will prepare and distribute a newsletter approximately once every three (3) months for the duration of the Project. As directed by the Department's Project Manager and Office of Public Relations, the Design-Builder shall provide information and relevant digital photographs in a format to be specified by the Department for inclusion in the newsletter.

Newsletter information shall be provided to the Department's Project Manager and Office of Public Relations fifteen (15) Working Days in advance of the planned distribution date for each newsletter.

3.2.7 Public Notices

The Design-Builder's planned construction activities may periodically result in temporary impacts to utility services, driveway entrances, and vehicular, pedestrian, and bicycle traffic. In such cases, the Design-Builder shall immediately notify the Department's Office of Public Relations and Project Manager. The Design-Builder and the Department will coordinate contacting the affected parties or general public of anticipated impacts or disruptions of services. Utility shut-off/diversion announcements shall be made in the form of a personal contact by the Design-Builder that shall include a written notice to the affected parties. Copies of the notice shall be provided to the Department's Project Manager and Public Relations Office. The Design-Builder shall provide the specific notifications listed in Table 3.2.7-1.

Table 3.2.7-1 - Notifications

Notice	Requirement
Closure	Written notices posted at least 7 days in advance of planned traffic lane or pedestrian walkway closures. Notice provided to the Department's Traffic Management Center (TMC) and Public Relations Office 7 days in advance. Lane closures to be signed using Variable Message Signs (VMS) in addition to standard signage.
Critical Utility Shut-off/Diversion	Written notice at least 72 hours in advance of, but not more than 96 hours before, shut-off and/or diversions. Copy of notice to Department's Project Manager and Public Relations Office.
72-hour Business/Commercial Utility Shutdown	Written notification of Utility shutdown or diversion for businesses and commercial property. Copy of notice to Department's

Table 3.2.7-1 - Notifications

Notice	Requirement
	Project Manager and Public Relations Office.
48-hour Residential Utility Shutdown	Written notification of Utility shutdown or diversion for residential property. Copy of notice to Department's Project Manager and Public Relations Office.
Weekly Construction Updates	A construction update will be provided to the Department.
Emergency Unforeseen Utility Disruptions, Hazardous Conditions, Traffic Emergencies, Security, and Loss of Access	See Section 3.2.11.
Road and Driveway Closures	Written notice and personal contact at least 72-hours in advance of, but no sooner than seven calendar days prior to, closure. Copy of notice to Department's Project Manager and Public Relations Office.

3.2.8 Media Relations

An ongoing media relations campaign will occur and be managed by the Department. The Design-Builder's Public Relations Specialist shall assist in giving timely information to the Department regarding construction activities and situations that may have the potential for unplanned public focus or media coverage.

Neither the Design-Builder nor any Subcontractor nor their employees shall conduct or participate in media events or radio or television broadcasts without the written consent of the Department. In emergencies, the Design-Builder shall immediately notify the Department's Project Manager and Office of Public Relations to coordinate responses.

3.2.9 Photographs and Video Documentation

The Design-Builder shall provide to the Department's Project Manager high-resolution construction progress photographs in electronic format at least bi-weekly or at any time that a new significant activity commences. Bi-weekly submission should include a minimum of 20 (twenty) new progress photos. In addition, the Design-Builder will accommodate requests for specific photographs and make arrangements for the Department to take additional photos on an as-requested basis

The Design-Builder shall coordinate with and accommodate the Department by allowing video camera stations to be set up and maintained by the Department within the established limits of disturbance for the Project. Cameras may be positioned within the work zone and/or within staging areas as required by the Department. The Department anticipates a minimum of two camera set-ups within the Project Limits for the purpose of transmitting continuous video feeds through the Department-maintained Project Website.

3.2.10 Other Activities

The Design-Builder is encouraged to provide additional, cost-effective services to enhance the overall Public Outreach Program. Additional public involvement activities might include soliciting feedback on multiple aesthetic treatment options and/or lighting schemes developed by the Design-Builder and implementing designs consistent with indicated preferences. Additional services are to be consistent with other requirements specified in this Performance Specification. Any such Public Outreach Program enhancements may be implemented at any time during the Project, subject to the Department's written

acceptance.

3.2.11 Emergency, Unforeseen Utility Disruptions, Hazardous Conditions, Traffic Emergencies, Security, and Loss of Access Notifications

The Design-Builder shall provide immediate response to emergencies by trained personnel from an incident response team within 30 minutes of receiving notification from the Department, law enforcement or fire suppression agencies, federal land management agencies, Utility Owners, and/or affected businesses and/or residents. The Design-Builder shall notify the Department's Project Manager or designated alternative contact person immediately of such occurrences.

The Design-Builder shall establish and manage an emergency response telephone tree. All appropriate emergency response agencies, including federal land management agencies, shall be included on this telephone tree for immediate response in the event of an emergency. The telephone tree shall be divided into areas of expertise so the proper people are called for specific emergency situations.

All emergency and/or unforeseen disruptions shall be explained to affected residents or businesses immediately. The person making the contact shall provide to the affected parties the following information:

A) Cause of disruption (i.e., whether it is construction oriented or not);

B) Actions being taken to alleviate the problem

C) Responsible party for the actions; and

D) Anticipated duration of the disruption.

3.2.12 Changes to Access

Any proposed changes in access shall be submitted to the Department's Project Manager, along with an access map, at least five Working Days prior to start of construction for the Department's Project Manager's written acceptance.

ROADWAY GEOMETRICS
PERFORMANCE SPECIFICATION

1.0 INTRODUCTION

The Design-Builder shall design and construct any roadway related Work in accordance with these requirements and these specifications. Included in this Project is the design, construction or reconstruction of all bridge approach roadways as required within the Design-Builder's proposed Project Limits. This Roadway Geometrics Performance Specification specifies the requirements for the design and construction of the roadway, bicycle and pedestrian facilities including bridge geometry.).

Part 6 – Scope of Services Packages Plans contains geometric elements (such as, horizontal alignments, vertical alignments, superelevation, and typical sections) that have evolved through the project development phases needed for environmental approval. The final Right-of-Way (ROW) Plans have been established in compliance with Department policy to provide for an ultimate four lane divided roadway section as depicted in the Scope of Services Package Plans. The design of this Project shall be performed in a manner that maintains the specified roadway geometrics and properly ties to the adjacent Roadway Approach (Contract #23-073-03) Work.

The current design provides a workable solution to the corridor's needs and the roadway geometry meets the established design criteria. The Design-Builder may, however, find ways to improve this geometry. Any innovative alternatives that increase benefits or savings to the Department or the Contractor are encouraged and will be accepted if they do not deviate from these Performance Specifications.

2.0 STANDARDS AND REFERENCES

The design of roadway geometrics shall be in accordance with this Roadway Performance Specification and the relevant requirements of the following standards, unless otherwise stipulated in this Performance Specification. Standards and references specifically cited in the body of the Roadway Performance Specification establish requirements that shall have precedence over all others. Standards list are placed in the descending order of precedence. In case of conflict between or among standards listed, the order of precedence established by the Department shall govern. Listed under references are guidelines that the Design-Builder may use in addressing the requirements as the Design-Builder sees fit. It is the Design-Builder's responsibility to obtain clarification of any unresolved ambiguity prior to proceeding with design or construction.

2.1 STANDARDS

Specific codes and standards include, but are not limited to, the following listed in order of governing precedence:

A) Performance Specifications for the Project;

B) Delaware Department of Transportation "Road Design Manual," July 2004 with Revisions (including all Design Guidance Memoranda);

C) Part 4 - Supplemental Specifications;

D) Delaware Department of Transportation "Standard Specifications for Road and Bridge Construction," dated 2001;

E) AASHTO, "A Policy on Geometric Design of Highways and Streets (Green Book)," Fifth Edition, 2004;

F) "Manual of Uniform Traffic Control Devices (MUTCD)," Third Edition, 2003; and

G) Delaware Department of Transportation "Traffic Controls for Street & Highway Construction, Maintenance, Utility & Emergency Operations," dated July 2001.

2.2 REFERENCES

The following design standards shall be used as reference materials that contain requirements that, by way of their application, may directly affect the designs of the roadways.

A) AASHTO, "Roadside Design Guide," Third Edition, 2002;

B) AASHTO, "Model Drainage Manual," 2005 Edition;

C) DelDOT ES2M Design Guide (Erosion & Sediment Control, Stormwater Management);

D) Delaware Erosion & Sediment Control Handbook;

E) Highway Capacity Manual, Special Report 209. Third Edition. Transportation Research Board, National Research Council, Washington, D.C.;

F) Delaware Department of Transportation "Bridge Design Manual," May 2005, with Revisions;

G) Delaware Department of Transportation "Materials and Research Manual" with Revisions.

3.0 REQUIREMENTS

3.1 PERFORMANCE

The Design-Builder shall design all roadway geometrics including, but not limited to, horizontal alignments, superelevation, typical sections, bicycle and pedestrian facilities, and all other required features not specifically defined in other performance specifications. The roadway designs required by this section shall be performed and completed such that the bridge approach roadways and other features are designed and constructed in a manner that is equal to a standard of care which is practiced by engineers performing successful designs for the Department. All roadway geometrics shall be designed in accordance with the Standards listed and referenced in this Roadway Performance Specification.

The objective of this design work is to result in constructed Project facilities within specified criteria while allowing the Design-Builder the flexibility to make changes that produce benefits or savings to the Department or the Design-Builder without impairing essential functions and characteristics of the Project, including, safety, traffic operations, desired appearance, and maintainability.

Any significant Basic Project Configuration Changes to the Scope of Services Package Plans may require a review in relation to the Finding of No Significant Impact (FONSI) and other environmental approvals. If it is determined by the Department that the Environmental Assessment (EA) must be supplemented, the Design-Builder, in coordination with the Department, will be responsible for conducting the supplemental process.

The Department has or will acquire the necessary rights-of-way to perform the Work as designated on the ROW Directive Plans included in Part 6 – Scope of Services Packages Plans. No additional ROW will be acquired by the Department beyond that which is shown on the Directive Plans.

3.2 DESIGN CRITERIA

The Department has developed design traffic data for the overall project. The following traffic data and

design criteria shall be maintained for this Contract:

A)	Functional Classification:	Principal Arterial
B)	Current A.A.D.T. (Year 2002):	13,137
C)	Projected A.A.D.T. (Year 2025):	20,000
D)	Projected D.H.V. (Year 2025):	4,255
E)	Percent Trucks:	8.0%
F)	Directional Distribution:	60%
G)	Design Speed:	60 mph
H)	Width of Clear Zone	30 feet
I)	Minimum Stopping Sight Distance	580 feet
J)	Minimum Horizontal Curve Radius	1348 feet (assumes e=0.06)
K)	Minimum K (crest)	156
L)	Minimum K (sag)	120
M)	Maximum % of Grade	4.00%
N)	Maximum Front Slope (Unprotected)	6:1 (Minimum)
O)	Maximum Back Slope	4:1
P)	Barrier Offset (Roadway Approaches only)	2 feet

The profile grade line included in the Directive Plans shall be maintained. Adequate bridge camber shall be included to provide proper finished grades on both the approach roadways and the bridge.

3.3 TYPICAL SECTION

The Department has established the required number and minimum widths for travel lanes, shoulders, and sidewalks. These requirements are depicted in the Directive Plans included in Part 6 – Scope of Services Packages Plans and are summarized as follows:

3.3.1 Northbound Roadway

A) Provide a minimum 12-foot pedestrian sidewalk on the outside edge (ocean side) of the bridge;

B) Provide two minimum 12-foot travel lanes;

C) Provide a minimum 10-foot outside shoulder to be located and between the travel lanes and the pedestrian sidewalk;

D) Provide a minimum 4-foot inside median shoulder; and

E) Provide traffic barriers in the median area, between the outside shoulder and the pedestrian sidewalk, and on the outside edge of the bridge.

See the Bridge Design Requirements Performance Specification for additional traffic barrier requirements.

3.3.2 Southbound Roadway

A) Provide two minimum 12-foot travel lanes;

B) Provide a minimum 10-foot outside shoulder;

C) Provide a minimum 4-foot inside median shoulder; and

D) Provide traffic barriers in the median area and on the outside edge of the bridge.

See the Bridge Design Requirements Performance Specification for additional traffic barrier requirements.

3.4 PRELIMINARY DESIGN REVIEW

The concept design shall be submitted to the Department for Preliminary Design Review in a format based on the plan preparation guidelines and shall contain at a minimum the following design layouts on plan sheets:

A) Accurate topographic mapping;

B) Typical cross sections with finish slopes, side ditches, and grades;

C) Horizontal alignment geometry data, lanes, shoulders, directional arrows, traffic barriers and railings, retaining walls, slope limits, and bridge limits;

D) Profile grades, original ground, and bridge profiles;

E) Anticipated drainage inlet locations;

F) Unforeseen environmental constraints to roadway designs;

G) Unforeseen existing utilities and proposed relocations;

H) Limits of disturbance and Right-of-Way; and

I) Cross sections cut at 100 foot intervals along centerline with existing Right-of-Way shown.

3.4.2 Review and Comment of Roadway Configuration

The Design-Builder shall not submit any subsequent roadway design for reviews after the Preliminary Design Review until after comments made during the definitive design review have been resolved by the Design-Builder and incorporated, if necessary, into the design.

Deviations from any roadway designs from designs depicted in the Readiness for Construction review shall not be allowed without written approval by the Department.

3.5 QUALIFICATIONS OF THE ROADWAY DESIGN ENGINEER

The Design-Builders roadway design Engineer of Record shall be a registered professional engineer in civil engineering in the State of Delaware and have a minimum of ten (10) years of professional practice in roadway design engineering for the Department. Engineering intern experience shall not be included.

TEMPORARY WORKS
PERFORMANCE SPECIFICATION

1.0 INTRODUCTION

The Design-Builder shall be responsible for furnishing all design, construction, installation, monitoring, supervision, and quality control reviews for all Temporary Works associated with the Work. Temporary Works shall be considered any non-permanent structure that provides support of any materials and/or excavations used to complete the Work.

2.0 STANDARDS AND REFERENCES

The design and construction of all Temporary Works shall be in accordance with this Performance Specification and the relevant requirements of the following standards, unless otherwise stipulated in this Performance Specification. Standards and references specifically cited in the body of this *Temporary Works* Performance Specification establish requirements that have precedence over all others. Should the requirements in one standard conflict with those in another, the standard highest on the list shall govern. Listed under references are guidelines that the Design-Builder may use to address the requirements, as the Design-Builder sees fit. It is the Design-Builder's responsibility to obtain clarification of any and all unresolved ambiguity prior to proceeding with any design or construction.

2.1 STANDARDS

Specific codes and standards include, but are not limited to, the following listed in order of governing precedence:

A) "AASHTO LRFD Bridge Construction Specifications," Second Edition, 2004 (U.S. Customary Units), with Interims through 2006;

B) "AASHTO LRFD Bridge Design Specifications," Third Edition, 2004 (U.S. Customary Units), with Interims through 2006. Delete Section 5.14.2.3.9 in its entirety (All Shop and Working Drawings will conform to the requirements of the Contract); and

C) Delaware Department of Transportation "Standard Specifications for Road and Bridge Construction" Dated 2001.

2.2 REFERENCES

A) Delaware Department of Transportation "Bridge Design Manual" with Revisions through May, 2005; and

B) AASHTO, "Guide Design Specifications for Temporary Works," 1995.

3.0 REQUIREMENTS

3.1 DESIGN AND CONSTRUCTION

3.1.1 Retaining Structures

The following specifications shall govern for design and construction of retaining structures as indicated:

A) Cofferdams and Shoring shall be in accordance with Section 3.3 of the *AASHTO LRFD Bridge Construction Specifications.*

B) Temporary Water Control Systems for excavations shall be in accordance with Section 3.4 of the *AASHTO LRFD Bridge Construction Specifications*.

C) Sheet Pile and Soldier Pile Walls shall be in accordance with Section 7.6.2 of the *AASHTO LRFD Bridge Construction Specifications.*

D) Cantilevered Walls and Anchored Walls shall be in accordance with Section 11 of the *AASHTO LRFD Bridge Design Specifications*.

E) Ground Anchors shall be in accordance with the applicable *2004 Post Tensioning Institute* (PTI) provisions.

F) Earth Pressures used in the design of all retaining structures shall be in accordance with Section 3 of the *AASHTO LRFD Bridge Design Specifications*.

3.1.2 Falsework

All falsework shall be designed and constructed in accordance with Section 602.09 of the *DelDOT Standard Specifications.*

3.2 MONITORING

The Design-Builder shall develop and submit to the Department for review and written comment a Monitoring and Contingency Plan for all work related to excavations or other activities that might cause ground movements. This plan shall be signed and sealed by a Delaware-licensed Professional Engineer having at similar monitoring experience on at least 5 similar projects in the past 10 years. The Design-Builder shall submit the Qualifying Experience for this Work to the Department for approval.

The purpose and objectives of the Monitoring Program are to:

A) Establish pre-construction baseline data for comparison with construction and post-construction data.

B) Provide early information on the interaction of the construction process with, and its effect on the ground and adjacent structures.

C) Detect and provide warning of unforeseen conditions that may require remedial or precautionary measures.

D) Permit timely implementation of the proper procedures, changes in excavation methods, additional support to prevent damage to structures, equipment, utilities.

E) Document ground movement and any structure movement that may occur as a result of construction.

The Design-Builder's monitoring Work shall consist of furnishing all necessary engineering and design services, supervision, labor, materials, and equipment needed to furnish, install, and monitor geotechnical instrumentation, including extensometers, inclinometers, monitoring and reference targets, readings, and reporting and interpretation of collected data.

3.2.1 Instrumentation Requirements

Where global instability of the excavation is possible or where there are adjacent structures, roadways, utilities, etc, that may be impacted by failure of any excavation, the Design-Builder shall install

inclinometers behind the excavation face at a distance no greater than one third the height of the excavation. The depth and spacing of inclinometers shall be determined by the Design-Builder's Geotechnical Engineer and shall be subject to review and comment by the Department; however, the inclinometers shall extend a minimum of one half the excavation height below the bottom of the excavation. The Design-Builder shall be independently responsible for determining whether additional instrumentation such as extensometers, etc, are needed to protect property and to ensure the safe performance of all Work.

When the instrumentation data indicate potentially damaging ground or structure movements, the Design-Builder shall adjust the excavation and support procedures as per the Contingency Plan requirements specified in the "Submittals" section of this Performance Specification, to reduce the ground and structure displacements.

At a minimum, instrumentation shall remain in place and monitoring shall be performed from the time excavation begins until all associated structure work and backfilling is completed. Additional monitoring may continue to be performed upon completion of the related Work as deemed necessary by the Design-Builder's Geotechnical Engineer or the Department's Project Manager.

3.2.2 Permissible Movements

The maximum allowable deflection of each excavation support or cofferdam shall be established by the Design-Builder based on specific analyses of the system and previous documented experience, and shall consider the existence of any nearby structures or utilities susceptible to settlement or lateral movement. However, the deflection of any point on the face of the cofferdam or temporary excavation support system shall not exceed 0.2 percent of the excavation of cofferdam height or 3 inches, whichever is less. Allowable vertical deflections will be established by the Design-Builder based on the excavation support or cofferdam system used and subject to review and comment by the Department.

For excavations or cofferdams higher than 12 feet, the deflection shall be measured or surveyed, at a minimum, by means of survey targets established within the top 7 feet, within 5 feet of midheight, and within 7 feet of the bottom of the excavation support or cofferdam. For excavations or cofferdams less than 12 feet in height, the targets at midheight may be omitted. The horizontal spacing between the targets shall not exceed 30 feet. The targets shall allow monitoring of horizontal and vertical deflections.

3.2.3 Pre-Existing Survey

The Design-Builder shall perform a survey of all structures and utilities existing within a 100-foot of the perimeter of the excavation. The Design-Builder shall submit the survey report to the Department for record purposes at least 7 days before the start of excavation support work.

4.0 SUBMITTALS

For all Temporary Works, the Design-Builder shall develop Working Drawings and design calculations that have been signed and sealed by a Professional Engineer licensed in the State of Delaware and reviewed and approved by the Design QC Manager. All Working Drawings shall reflect the Final Design Plans Issued for Construction and shall be resubmitted to reflect any revisions to the Final Design Plans. Working Drawings and supporting calculations shall be submitted to the Department for review and written comment at least 15 Calendar Days prior to the Temporary Works being constructed. Note that any additional time required by the Design-Builder to address and resolve comments shall not be cause for delay or impact claims. All costs associated submittals not conforming to the Contract requirements shall be the responsibility of the Design-Builder.

At lest 30 Calendar Days prior to installation, the Design-Builder shall submit to the Department for review and written comment an Instrumentation and Monitoring plan. The plan shall include the following minimum information:

1) Detailed description of each instrument type to be used, including company name, model number, sensitivity, accuracy, and power requirements.

2) Detailed plan for installation and commissioning of each instrument type, and the plan for interim recalibration.

3) Detailed description of how and how often the instruments are to be read, the data processed, and the results calculated, displayed, archived, reported, and interpreted.

4) Details of permissible threshold values and movements.

5) Detailed Contingency Plan for reasonably conceivable events and for movement approaching or exceeding threshold values. The first action item in the Contingency Plan shall be to cease all excavation operations in the affected areas and notify the Department's Project Manager followed by the Engineer of Record. The subsequent steps shall include implementation of the planned actions.

6) Quality Control procedures.

7) Present the experience of the Design-Builder's subconsultant and/or subcontractor in monitoring of similar work in the past 5 years.

8) Working Drawings showing the layout of the monitoring system, system components, component material, and details of connections.

    a) Provide plan and elevation drawings showing the types, locations, and layout of the monitoring targets, inclinometers, extensometers, and any other instrumentations.

    b) Provide identification numbers for each device and target.

    c) Provide elevation, station, and offset for each device and target.

UNIVERSITY OF DELAWARE BRIDGE MONITORING PROGRAM
PERFORMANCE SPECIFICATION

1.0 INTRODUCTION

A permanent bridge instrumentation system will be installed on the New Indian River Inlet Bridge. The purpose of the system is to enable the Department to effectively manage and maintain the bridge by better understanding its performance under a variety of loading conditions including construction loads, dead loads, traffic loads, and environmental loads.

2.0 DESCRIPTION

The bridge instrumentation system (BIS) will be developed by the University of Delaware (UD), working cooperatively with the Design-Builder. A monitoring program manual will be developed that describes in detail the monitoring program, all associated instrumentation, the responsibilities of all parties with regards to system installation, and the reporting protocols. The manual developed as part of the original bridge design concept is included in the *Reference Documents* Section of the Scope of Services Package for reference purposes.

Additional information regarding the instrumentation system and monitoring program was presented at the pre-proposal meeting.

3.0 RESPONSIBILITIES

UD will install internal and external sensors on the bridge (both on site and at fabrication yards) and possibly on temporary structures in order to quantify bridge behavior during and after construction. The University will be responsible for supplying all sensors and installing the vast majority of the sensors.

The Design-Builder will be responsible for installing sensors, such as heavy load cells, that require exceptional means of installation. The Design-Builder shall provide UD with access to the bridge construction site and to on-site power, as well as the means to physically reach the locations where the sensors will be installed to perform readings during the appropriate construction phases. Means of access might include lifts, ladders, or other devices. The Design-Builder shall also be responsible for the movement of bulky equipment to required locations.

The Design-Builder shall be responsible for working with UD to incorporate into the design plans necessary details such as through holes, block outs, and communication conduit for the BIS. The Design-Builder shall be responsible for installing communication conduits that run throughout the bridge and connect to a data acquisition cabinet located at a site to be determined that is close to the bridge. The Design-Builder shall provide the necessary utility hook-ups and ensure that the communication cabinet sits on an appropriate pad. Utility services anticipated for this work include electric and telephone services.

All UD staff working on and off site shall be independently safety certified and insured at no cost to the Design-Builder.

4.0 METHOD OF MEASUREMENT AND BASIS OF PAYMENT

The Design-Builder shall include a Project Component titled “University of Delaware Bridge Monitoring Program Activities” on the submitted Schedule of Values (Form SV) included in Appendix C to the

Instructions to Proposers. This activity shall have a fixed Project Component Value of One Hundred Thousand Dollars ($100,000.00) and shall be included in the Total Lump Sum Proposal Price included on the Schedule of Values.

All Design-Builder costs associated with coordination and the incorporation of details such as through holes, block outs, and communication conduit into the Design Plans and/or Working Drawings shall be incidental to the Contract.

All construction related activities including, but not limited to, the furnishing and/or installation of labor, materials, and equipment for the installation of the Bridge Instrumentation System shall be performed by the Design-Builder on a force account basis in accordance with Part 2 – DB Section 109-8.2.2 of the Contract Documents. Requests for Periodic Payment shall be made on Form RPP for the specified Project Component in accordance with DB Section 109. The actual value of the force account(s) will be divided by the $100,000 value to establish the percentage of the Total Lump Sum that will be paid when the work occurs. The contractor will only be paid for the value of the work established by the force account(s).

WARRANTY REQUIREMENTS
PERFORMANCE SPECIFICATION

1.0 INTRODUCTION

The Design-Builder shall be required to meet minimum warranty requirements associated with the contract Work. This Performance Specification identifies items and systems to be warranted by the Design-Builder and the minimum terms associated with those items.

2.0 REQUIREMENTS

The Design-Builder shall unconditionally warrant to the Department all items specified within this Performance Specification, for the minimum period specified, to be free of defects and deficiencies in the design, manufacture or workmanship that would result in the loss of an essential quality or function. The minimum warranty periods specified shall be from the date of Final Acceptance by the Department.

With respect to any portion of the Work that is repaired or replaced, the remaining warranty period shall be the longer of one year from repair or replacement of the Work or the remainder of the original warranty period.

Nothing in these warranty requirements is intended to limit any manufacturer's warranty nor any warranty implied by Delaware law. The Design-Builder will provide the Department with all manufacturer's warranties prior to Final Acceptance of the Work.

See Part 2 – DB Section 104-6 of the Contract Documents for additional requirements.

2.1 CABLE SYSTEM

The Design-Builder shall guarantee the installed stay cable system performs within the cable vibration performance requirements established for the Work for a minimum period of ten (10) years. The Design-Builder shall be responsible for modifying and/or replacing damping system(s), cable surface treatments and cable stiffening ropes, as required, to achieve the established performance requirements for cable vibration at no additional cost to the Department. The Design-Builder will replace or repair to like-new condition all cable elements, appurtenances, or bridge components damaged by cable vibration or damaged by other environmental loading conditions in combination with cable vibration for the duration of the warranty period at no cost to the Department.

2.2 EXPANSION JOINTS

The Design-Builder shall guarantee the performance of all expansion joint systems, including drainage troughs, for a minimum period of five (5) years. If any expansion joint fails to perform properly for any reason, including but not limited to normal wear and tear, then the Design-Builder shall replace the expansion joint system at no cost to the Department.

2.3 BRIDGE BEARINGS

The Design-Builder shall guarantee the performance of all bridge bearings for a minimum period of five (5) years. If any bridge bearing fails to perform properly for any reason, including but not limited to normal wear and tear, then the Design-Builder shall replace the bridge bearing at no cost to the Department.

2.4 DECK OVERLAY

The Design-Builder shall guarantee the performance of the entire bridge deck overlay system for a

minimum period of two (2) years. If any portion of the deck overlay system fails to perform properly for any reason, including but not limited to normal wear and tear, cracking, or delamination, then the Design-Builder shall replace the failed portion of the bridge deck overlay at no cost to the Department.

2.5 COATINGS

The Design-Builder shall guarantee the performance of all bridge coating systems for a minimum period of five (5) years. If any portion of the bridge coating system fails to perform properly for any reason including, but not limited to, blistering, cracking, peeling, or discoloration then the Design-Builder shall replace the failed bridge coatings at no cost to the Department.

2.6 LIGHTING FIXTURES

The Design-Builder shall guarantee the performance of all lighting fixtures for a minimum period of two (2) years. If any internal or external lighting fixture fails to perform properly for any reason, including but not limited normal wear and tear or improper grounding then the Design-Builder shall replace the failed lighting fixture at no cost to the Department. Additionally, the Design-Builder shall furnish to the Department adequate replacements bulbs and parts for unique lighting fixtures. Replacement bulbs and fixtures shall be sufficient to meet the anticipated maintenance schedule included in the Design-Builder's Maintenance Manual. *See* Part 3 – Performance Specifications, *Inspection, Maintenance and Construction Requirements* for additional Maintenance Manual Requirements.

2.7 MECHANICAL AND ELECTRICAL SYSTEMS

The Design-Builder shall guarantee the performance of all mechanical and electrical equipment, apparatus, materials, and workmanship provided under the Contract for a minimum period of one (1) year. During the warranty period, any repairs or replacement needed to maintain satisfactory operation of the mechanical and electrical systems furnished shall be made by the Design-Builder at no cost to the Department.

2.8 ADDITIONAL ITEMS

Other items included in the Design-Builder's warranty proposal shall be guaranteed for the period and terms specified in the Technical Proposal included in Part 8 of the Contract Documents.

2.9 EXTENDED WARRANTY PERIODS

Any extended warranty periods beyond the minimum requirements specified in this Performance Specification shall be in accordance with the terms of the Design-Builder's warranty proposal included in Part 8 of the Contract Documents.

2.10 MAINTENANCE BOND

A Maintenance Bond shall by submitted to the Department per DB Section 103-2 for all guaranteed and warranted items.

WIND ENGINEERING REQUIREMENTS

PERFORMANCE SPECIFICATION

1.0 PRELIMINARY DESIGN SERVICES

During the preliminary design phase, the Design-Builder shall undertake the following wind related activities:

A) Review of the Meteorological Site Analysis (see Reference Documents – Wind Effects);

B) Preliminary Wind Design of the Bridge Structure;

C) Preliminary Sectional Model Tests; and

D) Select Cable-Stay Vibration Evaluation and Control Methods.

1.1 INITIAL DESIGN REVIEW

In the preliminary design stage, the Design-Builder shall review the Meteorological Site Analysis and provide aerodynamic input on how alternative deck cross-sections and above deck supporting member(s) details (such as towers, pylons, arches, and other such supporting elements) will perform in the wind.

The conclusion of this effort shall determine what deck cross-section shall be initially tested.

1.1.1 Preliminary Sectional Model Tests

This phase of the study shall include preliminary wind tunnel sectional model tests to examine the vertical and torsional motions of the bridge deck. Three configurations shall be tested, as follows:

A) The deck without railings and barriers representing construction stages;

B) The deck with railings and barriers for the completed bridge; and

C) The deck with railings, barriers and a typical traffic pattern.

The tests shall be conducted in smooth flow conditions representative of those at the bridge site in order to determine the aerodynamic characteristics and any tendency to instability. Smooth flow tests shall be used to investigate the potential for vortex shedding induced response as well as lower bound estimate of the onset of any aeroelastic instability. Smooth flow tests shall be used to estimate the wind force coefficients on the completed structure as well as the sensitivity to turbulence of any instability identified in the smooth flow tests. Critical wind speeds for instability shall be established.

Should the stability and/or response characteristics prove be unsatisfactory, modifications to the aerodynamic cross-sections should be made. Naturally occurring turbulence in the wind shall not be relied upon to meet the stability and vortex induced motion criteria.

1.1.2 Cable Vibrations

Using the latest available research, testing, and analytical techniques, the preliminary wind studies shall include an evaluation for wind-induced cable-stay vibrations caused by coupled wind and rain effects, vortex shedding and wake galloping. The study shall include recommended methods to suppress or mitigate vibrations. Additional requirements for suppressing cable-stay vibrations, if applicable, are outlined in the Cable-Supported Bridge System Requirements Special Provision.

2.0 FINAL DESIGN SERVICES

During the final design phase, the Design-Builder shall undertake the following wind studies:

A) Static and Dynamic Sectional Model Tests;

B) Buffeting Analysis;

C) Aeroelastic Model Tests - Construction Stages; and

D) Aeroelastic Model Tests - Completed Bridge.

ALTERNATE ANALYTICAL PROCEDURES
(in lieu of tasks identified in 2.1.3, 2.1.4, 2.1.4.1 (not 2.1.4.2), and 2.1.5)

A) Buffeting Analyses - Completed Bridge

B) Stability Analyses - Completed Bridge

C) Buffeting Analyses - Construction Services

D) Stability Analyses - Construction Services

The Design-Builder's wind engineering laboratory must declare whether they wish to use the small-scale, full-bridge, aeroelastic model approach in their analyses, or the alternate analytical procedure. They laboratory must have used the chosen procedure in the wind engineering studies for at least three comparable bridges. The laboratory must provide a list of the three most recent bridge wind engineering studies using the selected procedure, and the appropriate contact information for the owners and clients for those projects. The Department shall approve the laboratory and the analytical and testing procedures to be used.

2.1 STATIC AND DYNAMIC SECTIONAL MODEL TESTS

2.1.1 Detailed Sectional Model Tests

This phase of the study shall include a comprehensive series of sectional model tests on the final design of the deck. The sectional model shall have the section of the deck corresponding to the final design. The detailed sectional model tests shall be conducted to examine the vertical and torsional dynamic motions of the bridge. The models shall not be constructed to a scale of less than 1:60. A single test series will involve testing at a minimum of 5 angles of inclination, -5 to 5 degrees in 2.5 degree increments. In the primary test series, the damping shall be set at a conservative value and smooth flow simulated. These parameters shall be referred to as the benchmark conditions. Several test series shall be performed to examine the influence of damping, and the torsional to vertical frequency ratio. Then the effect of turbulence on the stability of the section shall be measured.
The test program shall provide as a minimum the following:

A) Test the section for the benchmark conditions for 5 angles of attack;

B) Adjust the benchmark conditions by increasing the damping to the probable maximum value and test for 5 angles of attack;

C) Adjust the benchmark conditions by lowering the frequency ratio and test for 3 angles (from -2.5 to 2.5 degrees in 2.5 degree increments) of attack;

D) For benchmark conditions, introduce turbulence into the wind flow and test for horizontal winds;

E) If unacceptable levels of vortex shedding are found at this point, additional tests to examine refinements to the deck cross-section shall be carried out; and

F) Turbulence should not be relied upon to meet the design criteria.

2.1.2 Measurement of Time-Averaged Force Coefficients

After the stability of the section has been confirmed, measurements shall be carried out for the time averaged vertical and horizontal wind forces and pitching moments on the bridge deck model in order to determine the mean wind load coefficients. The tests shall be conducted in smooth flow wind for 11 angles of inclination, -10 degrees to +10 degrees in 2 degrees increments. Three configurations shall be tested, as follows:

A) The deck without railings and barriers representing construction stages;

B) The deck with railings and barriers for the completed bridge; and

C) The deck with railings, barriers and a typical traffic pattern. Some measurements shall be included in turbulent flow.

2.1.3 Buffeting Analysis

The following tasks shall be undertaken in order to determine the wind loads acting on the bridge deck and above deck supporting member(s):

A) Based on buffeting theory and using the static force coefficients determined from the sectional model tests, wind loads acting on the bridge shall be estimated for construction stages as well as in its completed configuration. Two construction stages shall be examined. Typically, the stage prior to connecting to the temporary tie-down (if used or required by the Design-Builder's design) and the stage prior to building the closures shall be evaluated. Effective wind load distributions shall be provided for the design wind speeds for each of the two construction stages, the completed bridge with and without traffic and for any other critical conditions that are identified. Approximately the ten lowest modes of vibration shall be considered. Aeroelastic effects (motion dependent aerodynamic loads) shall be included in the buffeting analysis.

B) Review the design of the above deck supporting member(s) to assess their susceptibility to unstable aerodynamic behavior and also to provide estimated wind loads.

2.1.4 Aeroelastic Model Study-Construction Stages

In order to investigate the wind loads on the partial structure during construction, the aeroelastic model study shall include two parts:

A) Partially completed bridge deck; and

B) Free-standing above deck supporting member.

2.1.4.1 Partially Completed Bridge

A) Examine the aeroelastic stability and measure the responses of the bridge during erection at the two most critical construction stages. The critical stages will be selected on the basis of the dynamic analysis, sectional model results and the buffeting analysis described above.

B) An aeroelastic model of the bridge shall be designed and constructed with a scale of 1:200 or greater. The model shall be capable of representing two erection stages including any temporary supports or construction equipment that might be used.

C) A section model shall be made to the scale as the full-bridge aeroelastic model and tested at the same Reynolds Number at which the full-bridge model will be tested. Tests shall be performed in horizontal winds in smooth flow, and are to be performed to validate the use of a small-scale model. If the ratio of small-scale model critical flutter wind speed to

large-scale critical flutter wind speed is less than unity, then the full-bridge critical flutter wind speeds must be scaled by the same ratio. Similarly, if the ratio of the small-scale section model buffeting response to the large-scale buffeting response is less than unity, then the full-bridge buffeting results must be scaled by the inverse of this ratio. Beneficial results from the small-scale section model tests (relative to the large-scale section model results) shall not be allowed.

D) The pertinent elastic properties of the deck and the above deck supporting member(s) shall be scaled down and incorporated in the structural components (spines) of the model. The correct mass and geometry of the deck and above deck supporting member(s) shall be represented by segmented sections attached to the spines. The geometric portions of the model shall be constructed of wood, plastic and/or metal, bearing in mind durability, weight and maintenance of model accuracy. Initially, the sources of damping shall be minimized in the model, and if necessary, damping could be later increased to represent full scale. The main cable stiffnesses shall be correctly scaled and the cable ends, cable drag and mass be brought up to the properly scaled values by attaching specially proportioned weights at intervals along their length.

E) The aeroelastic model shall be instrumented with strain gages at the base and deck levels of the above deck supporting member(s) and accelerometers at the top of the above deck supporting member(s). Displacement transducers shall be used to measure the horizontal, vertical and torsional deflections of the deck.

F) The model shall be tested in a properly scaled simulation of the natural turbulent wind. Critical wind speeds, vortex shedding and turbulent response shall be measured for the construction stages. The mean wind tunnel wind speed shall have a full-scale equivalent averaging time that is long with respect to the longest bridge natural period, but not greater than the period of the longest gust that can modeled in the wind tunnel with accuracy. The turbulence intensity modeled must be consistent with the upwind exposures and the mean wind speed averaging time.

G) Each model configuration shall be tested for a series of wind speeds covering the design range and beyond. The effects of the wind normal to the span and from other directions shall be investigated. Tests shall be carried out to assess the impact of changes in the turbulence levels.

H) The mean, root mean square, and peak vertical and horizontal deflections of the deck shall be measured for each test direction and the corresponding bending and torsional moments of the above deck supporting member(s) obtained.

I) The meteorological wind data shall be combined with the wind tunnel data to derive the effective design wind loads and distributions. These effective wind loads and distributions shall incorporate the effects of the dynamic excitation of the bridge in its various modes of vibration.

J) Turbulence shall not be relied upon to meet the design criteria.

2.1.4.2 Tests on a Free Standing Above Deck Supporting Member

One of the above deck supporting member models constructed for the Construction Stages tests shall be modified and used for these tests by removing the deck.

A) During the tests, the base shears normal and parallel to the span and corresponding moments shall be measured in each leg of the supporting member. In addition, motions at the top accelerations at the top of the above deck supporting member shall be measured normal and parallel to the span. The tests shall be performed for wind azimuths from 0

degrees through 90 degrees with 0 degrees being normal to the span. The tests shall be carried out on the completed above deck supporting member as well as on the above deck supporting member modeled in its most critical interim stage.

B) Supplementary tests shall be carried out in low turbulence flow to check the vortex shedding response. Again, turbulence shall not be relied upon to meet the design criteria.

C) The test data shall be used to derive the recommended wind forces for structural design and to provide predictions of the above deck supporting member's dynamic response.

2.1.5 Aeroelastic Model Tests - Completed Bridge

In order to confirm the response of the bridge in its completed form, confirm and refine the findings of the sectional model tests and assess three-dimensional and topographic effects, the following tasks shall be undertaken:

A) The test model assembled for the investigation of the construction stages shall be expanded to represent the completed bridge.

B) The force and displacement measurements on above deck supporting member(s) and deck outlined for the construction stages shall also be carried out with the complete center span modeled.

C) The test program in terms of wind speeds, wind direction and turbulence levels shall be as outlined for the tests on the construction stages.

2.2 ALTERNATE ANALYTICAL PROCEDURE

This alternative analytical procedure may be used in lieu of the tasks outlined in 2.1.3, 2.1.4, 2.1.4.1, and 2.1.5 - not 2.1.4.2).

As outlined in previous sections, the section model studies are assumed to simulate the fundamentals vertical and torsional modal responses of the bridge under a number of conditions. These are approximate results, and should they be used as such, then small-scale full-bridge aeroelastic model studies must be performed.

The large-scale section model studies can, however, be used to obtain static and dynamic aerodynamic characteristics of the bridge deck section (static drag, lift, and moment coefficients, and aeroelastic flutter derivatives). These can be used with an analytical description of the wind environment and a detailed finite element model of the bridge structure to predict the behavior of the full bridge in strong winds, in its final configuration and in its various construction configurations.

2.2.1 Buffeting Analyses - Completed Bridge

The buffeting analysis of the full bridge using the analytical procedures defined in Section 2.2 shall be performed for the 5 angles of incidence, for the bridge with and without the traffic pattern. Included in the analyses shall be a minimum of the lowest 3 sway, 3 vertical, and 3 torsional modes of vibration, and the fundamental modes of vibration that define the motion of the above deck supporting members. Aeroelastic effects and aerodynamic coupling amongst all the modes shall be included.

If any buffeting analysis produces unacceptable results, then the bridge deck shall be modified until the buffeting results are acceptable.

2.2.2 Stability Analyses - Completed Bridge

Stability analyses shall be performed using the analytical procedures described previously in smooth flow for the 5 angles of incidence using the modes of vibration identified in Section 2.2.1, with and without the traffic pattern. Effects of turbulence (on the aeroelastic flutter derivatives) on the analytically generated critical flutter wind speeds shall be identified.

If any analysis produces results that do not meet the design criteria, the bridge design shall be modified until all stability analyses meet the design criteria. The design criteria shall apply to all 5 angles of incidence without reduction unless it can be shown that the mean deck rotation, at the critical flutter wind speed, is less than 5 degrees.

2.2.3 Buffeting Analyses - Construction Services

The analyses defined in Section 2.2.1 shall be repeated for the two most critical construction configurations identified in Section 2.1.4.1 (A). From the peak modal responses identified in these analyses, the internal actions in the deck and above deck supporting member(s) can be computed. The static and dynamic aerodynamic coefficients used shall be those obtained without the deck furniture.

If any response is unacceptable, construction procedures shall be changed to make all responses (and resulting internal actions) acceptable.

2.2.4 Stability Analyses - Construction Services

The analyses defined in Section 2.2.2 shall be repeated for the two most critical construction configurations identified in Section 2.1.4.1.(A). Aerodynamic coefficients for the bridge deck shall be those obtained for the bridge deck without deck furniture.

If any critical flutter wind speeds do not meet the design criteria, the construction procedures must be changed, or the bridge deck section must be temporarily changed, until the design criteria are met for all cases considered. Again, turbulence in the natural wind shall not be relied upon to meet the design criteria.

3.0 AVAILABILITY OF INFORMATION

Interim information shall be made available to the Department as the preliminary and final design wind studies evolve. This will include, as a minimum, a summary report following the completion of the following

A) Meteorological /Site Analysis (if different from the Department-furnished report)

B) Initial Design Review;

C) Preliminary Section Model Tests;

D) Final Static and Dynamic Sectional Model Tests;

E) Buffeting Analyses (completed bridge and construction stages);

F) Stability Analyses (completed bridge and construction stages)

Items E) and F) shall describe results from the full-bridge aeroelastic model studies, or from the alternate analytical studies.

Two final reports shall also be prepared, one at the completion of the preliminary design phase wind studies and the other at the completion of the final design phase wind studies. The final preliminary design phase and final design phase wind reports shall provide a complete review of the studies performed at the respective phase, including modeling principles, test methods, test results, analysis and recommendations.

To assist in describing the wind tunnel tests and test results, video tape recordings of the key aspects of the preliminary design and final design tests shall be produced during these activities. At the completion of the final design phase wind studies, the video shall be edited and be of professional quality to be used in presentations.

The Design-Builder shall maintain a close contact with the Department throughout the course of the wind studies via telephone and fax and make provisions for a minimum of four or five (4 or 5) design review meetings as outlined below:

1) **Meeting #1**: At the Department's Administration Building in Dover, Delaware upon completion of the Initial Design Review to discuss the initial assessments on the deck cross-section and above deck supporting member(s) and discuss design modifications, if necessary.

2) **Meeting #2**: At the wind laboratories during the preliminary sectional model tests to review the initial results and discuss design modifications, if necessary.

3) **Meeting #3**: At the wind laboratories during the final sectional model tests to review the model and its instrumentation, and confirm the test program.

4) **Meeting #4**: At the wind laboratories during the full-bridge aeroelastic test to review the model and its instrumentation and confirm the test program (if the full-bridge aeroelastic model option is chosen).

5) **Meeting #5**: At the Department's Administration Building in Dover, Delaware to make a presentation of the complete test program and its results.