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 4

SPECIAL PROVSIONS

TABLE OF CONTENTS

PART 4 - SPECIAL PROVISIONS

CONSTRUCTION ITEM NUMBERS 1
SECTION 108C - KEY PERSONNEL QUALIFICATIONS AND REQUIREMENTS 2
302500 - DEL NO 3 STONE 4
302501 - DEL NO 8 STONE 4
302502 - DEL NO 2 STONE 4
302503 - DEL NO 57 STONE 4
302504 - DEL NO 67 STONE 4
302505 - DEL NO 10 STONE 4
302509 - DEL NO 1 STONE 4
401651 - SUPERPAVE, TYPE C HOT-MIX, 160 GYRATIONS, PG 70-22 (CARBONATE STONE) .. 5
401654 - SUPERPAVE, TYPE B HOT-MIX, 160 GYRATIONS, PG 70-22 5
401663 - SUPERPAVE, BITUMINOUS CONCRETE BASE COURSE, 160 GYRATIONS, PG 64-22 .. 5
401699 - QUALITY CONTROL/QUALITY ASSURANCE OF HOT-MIX ASPHALT 11
501530 - OVERLAY CONCRETE SURFACE RIDEABILITY 29
501531 - BLANKET GRINDING OF OVERLAY CONCRETE 35
600501 - BRIDGE CONSTRUCTION REQUIREMENTS 36
602543 - FURNISHING LATEX MODIFIED CONCRETE 41
602544 - CONSTRUCTING LATEX MODIFIED CONCRETE OVERLAY 41
602583 - FURNISHING MICRO-SILICA MODIFIED CONCRETE 48
602584 - CONSTRUCTING MICRO-SILICA MODIFIED CONCRETE OVERLAY 48
602588 - ANTI-GRAFFITI COATING 54
602697 - FURNISHING LOW PERMEABILITY CONCRETE OVERLAY 56
602698 - CONSTRUCTING LOW PERMEABILITY CONCRETE OVERLAY 56
605500 - CABLE-SUPPORTED BRIDGE SYSTEM REQUIREMENTS 61
605545 - SOIL BORINGS, LAND 79
605589 - BRIDGE EXPANSION JOINT DEVICES 85
605702 - BRIDGE BEARING DEVICES 93
605704 - BRIDGE COATING 107
618513 - DYNAMIC PILE TESTING 112
618517 - STEEL PIPE PILES 115
618519 - DRILLED SHAFTS 123
FHWA PUBLICATION NO IF-99-025 "DRILLED SHAFTS" 148
619501 – PILE RESTRIKES ORDERED BY THE DEPARTMENT 149
619508 – QUICK PILE LOAD TEST 150
619518 - BITUMEN COATING ON PILES 152
623513 - PRESTRESSING 154
623515 - EPOXY FOR STRUCTURAL BRIDGE APPLICATIONS 181
742500 - FLAGGER, REQUIREMENTS 189
743514 - FURNISH AND MAINTAIN MESSAGE BOARD 191
746574 - BRIDGE ELECTRICAL SYSTEM 192
763503 - TRAINEE 220
763508 - PROJECT CONTROL SYSTEM DEVELOPMENT PLAN 221
763509 - CPM SCHEDULE UPDATES AND/OR REVISED UPDATES 221
763588 - MAINTENANCE OF TRAFFIC 232

CONSTRUCTION ITEM NUMBERS

All construction pay items are assigned a six (6) digit number, shown as Item Number on the Plans and/or in the Special Provisions, and shall be interpreted in accordance with the following:

Standard Item Number:

The first three digits of the construction item numbers indicates the Section number as described in the Standard Specifications, and all applicable requirements of the Section shall remain effective unless otherwise modified by the Special Provisions. The last three digits of the construction item identifies the item by sequential number under that Section. Sequential numbers for all items covered under Standard Specifications range from 000 to 499. A comprehensive list of construction item numbers can be found in Appendix IV of the Standard Specifications. Additions to this list will be made as required.

Special Provisions Item Number:

The first three digits of the construction items, covered under Special Provisions, indicates the applicable Section number of the Standard Specifications, and shall be governed fully by the requirements of the Special Provisions. The last three digit of the items covered under Special Provisions identifies the item by sequential number. Sequential numbers for Special Provision items, range from 500 to 999.

Examples

Standard Item Number - 202000 Excavation and Embankment

202 Indicates Section Number

000 Indicates Sequential Number

Special Provision Item Number - 202500 Grading and Reshaping Roadway

202 Indicates Section Number

500 Indicates Sequential Number

SECTION 108C - KEY PERSONNEL QUALIFICATIONS AND REQUIREMENTS

In the qualifications specified below, the word "shall" indicates a required minimum qualification. The word "should" indicates the Delaware Department of Transportation's preferred qualifications, but such qualification is not a mandatory requirement.

Design-Builder's Project Manager: Should have a minimum of 15 years experience in construction and management of major bridge structures with demonstrated experience on the design and construction engineering of bridge projects that included work of a similar scope, nature, and complexity as this project. The Project Manager shall have served in a similar role on a minimum of one prior design-build project. The Design-Builder's Project Manager shall be the Design-Builder's representative and single point of contact.

Principal-in-Charge: Should have a minimum of 20 years experience in construction and management of major bridge or highway projects that included work of a similar scope, nature, and complexity as this project. The Principal-in-Charge should have served in a similar role on a minimum of one prior design-build project of similar scope, nature, and complexity as this project.

Design Manager: Shall be a Delaware-licensed Professional Engineer who is an employee of the Designer or a firm on the design team. The Design Manager shall have a minimum of 15 years experience in design of large bridge design projects with similar type, scope and complexity as this project. The Design Manager should have served in a similar role on a minimum of one prior design-build bridge project.

Construction Manager: Should have a minimum of 15 years experience in construction of major bridge structures with demonstrated experience on the construction of bridge projects that included work of a similar scope, nature, and complexity as this project. The Construction Manager should have served in a similar role on a minimum of one prior design-build bridge project.

Quality Control Manager: Should have a minimum of 20 years experience in major bridge structure design and/or construction with at least 10 years experience in Quality Assurance (QA)/Quality Control (QC) activities, including preparation and implementation of Quality Plans and procedures for design and/or construction.

Design Quality Control Manager: Shall be a Delaware-licensed Professional Engineer who is not an employee of the Designer or a firm on the design team. The Design QC Manager should have a minimum of 5 years experience in QC/QA activities on large bridge design projects with similar scope and complexity of the Indian River Inlet Bridge Project.

Construction Quality Control Manager: Shall be a Delaware-licensed Professional Engineer who is an employee of the independent firm responsible for construction QC. Should have a minimum of 15 years experience in QC/QA activities (including management of construction QC programs) on large bridge construction projects that have incorporated the type of construction included in the Indian River Inlet Bridge Project. The Construction QC Manager should have demonstrated experience in Materials management, specifications, and testing procedures.

Safety Manager: Shall be a Work Zone Safety Supervisor as certified by any agency or firm approved by the Department. The Safety Manager should have a minimum of 10 years experience in a work zone safety technician or supervisor capacity on construction projects for major bridges over navigable waters and new roadway facilities. The Safety Manager shall be knowledgeable of OSHA standards and shall be present as necessary to ensure the safety of the workers and the job site.

Environmental Coordinator: Shall have at least a Bachelor of Science (B.S.) or Bachelor of Arts (B.A.) degree and demonstrated experience related to the areas of responsibility outlined in the Contract Documents. The Environmental Coordinator should have experience in managing others in environmental activities and experience with major Bridge projects. The Environmental Coordinator should have experience with Bridge and Highway engineering drawings and concepts and working cooperatively and effectively with design engineers and construction staff.

Lead Geotechnical Engineer: Shall be a Delaware-licensed Professional Engineer who is an employee of the Designer or a firm on the design team. The Lead Geotechnical Engineer shall have demonstrated experience in geotechnical investigation and design with demonstrated expertise in deep river foundation design and construction including drilled shafts and caisson type foundations.

Public Outreach Specialist: Shall have at least a B.S. or B.A. degree and demonstrated experience related to the areas of responsibility outlined in the Contract Documents. The Public Outreach Specialist should have experience in managing others in community involvement activities and experience with major Bridge projects. The Public Outreach Specialist should have experience with Bridge and Highway engineering drawings and concepts and working cooperatively and effectively with design engineers and construction staff.

Traffic Control Supervisor: Shall have demonstrated experience in traffic and Highway engineering with contractor, consultant, city, county, or state transportation agencies and possess certification from the American Traffic Safety Services Association (ATSSA).

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302500 - DEL. NO. 3 STONE
302501 - DEL. NO. 8 STONE
302502 - DEL. NO. 2 STONE
302503 - DEL. NO. 57 STONE
302504 - DEL. NO. 67 STONE
302505 - DEL. NO. 10 STONE
302509 - DEL. NO. 1 STONE

Description:

This work consists of furnishing, hauling, placing, and compacting stone, in accordance with the details and notes shown on the Plans and/or as directed by the Engineer.

Materials and Construction Methods:

The stone for Del. No(s). 1, 2, 3, 57, 67, 8 and 10 shall comply with quality and gradation requirements of respective Sections 805, and 813 of the Standard Specifications.

Construction methods shall conform to the requirements of notes on the Plans and/or as directed by the Engineer.

When used in a temporary situation, the stone shall be removed and disposed of by the Contractor as directed by the Engineer.

~~**Method of Measurement**:~~

~~The quantity of stone will be measured as the actual number of tons (metric tons) for stone placed and accepted. The weight will be determined according to Subsection 109.01.~~

~~**Basis of Payment**:~~

~~The quantity of stone will be paid for at the Contract unit price per ton (metric ton). Price and payment will constitute full compensation for furnishing, hauling, and placing all materials, and for all labor, equipment, tools, and incidentals required to complete the work.~~

NE - 1/17/01

401651 - SUPERPAVE, TYPE C HOT-MIX, 160 GYRATIONS, PG 70-22 (CARBONATE STONE)

401654 - SUPERPAVE, TYPE B HOT-MIX, 160 GYRATIONS, PG 70-22

401663 - SUPERPAVE, BITUMINOUS CONCRETE BASE COURSE, 160 GYRATIONS, PG 64-22

NOTE: NOT TO BE USED FOR BRIDGE STRUCTURE WEARING SURFACES.

Description:

The following Subsections of the Standard Specifications shall be applicable: 401.01, 401.03 - 401.10, 401.12, and 401.13. All other subsections have been modified herein.

The Contractor shall read and thoroughly understand the requirements of the QA/QC specification as defined in item 401699. ~~It is the responsibility of the Contractor to determine all costs associated with meeting these requirements and to include them in the per ton bids for the various Superpave bituminous concrete items. The Contractor shall also be aware that the pay adjustment factors in item 401699 will be applied to the Superpave bituminous concrete payments to determine the bonus or penalty for the item.~~

Materials:

Materials for hot-mix, hot-laid bituminous concrete shall conform to the requirements of Subsections 823.01, 823.05- 823.17, and 823.25 - 823.28 of the Standard Specifications and the following.

Asphalt Binder:

The asphalt binder shall meet the requirements of Superpave PG 64-22, PG 70-22, or PG 76-22 performance grade asphalt, as referenced in the Plans, according to M-320, Table 1 and tested according to AASHTO PP6 with the following test ranges:

TEST PROCEDURE	AASHTO REFERENCE	SPECIFICATION LIMITS
Temperature, °C	M-320	Per Grade
Original DSR, G*/sin (δ)	T-315	1.00 - 2.00 kPa
RTFO DSR, G*/sin (δ)	T-315	2.20 - 5.00 kPa
PAV DSR, G*/sin (δ)	T-315	1400 - 5000 kPa
BBR Creep Stiffness	T-313	90.0 - 300.0 kPa
BBR — value	T-313	0.300 - 0.440

Substitution of a higher temperature grade will require prior approval by the Engineer. If PG 76-22 is the specified binder, recycled asphalt pavement (RAP) and natural sand shall not be allowed in the mixture. If a producer would like to submit a mixture with natural sand, the Engineer will perform a deformation test using the Asphalt Pavement Analyzer (APA). The sample will be tested per AASHTO TP xxx "Determining Rutting Susceptibility of Asphalt Paving Mixtures Using the Asphalt Pavement Analyzer (APA)". If the depth of measured permanent deformation is 2 mm or less after 8000 strokes and a fatigue criteria of less than 1.0 mm/stroke after at least 50000 strokes, the mixture may be approved for use.

Shingles:

Only shingles reclaimed from shingle manufacturers such as tabs, punch-outs, and damaged new shingles shall be allowed in the mixture. Post-consumer shingles or used shingles shall not be permitted in the mixture and all shingles shall be free of all foreign material and moisture. Fiberglass-backed and organic felt-backed shingles shall be kept separately and both materials shall not be used in the same mixture at the same time. The shingles shall be broken down in the mixing process with 100% passing the ½ in (12.5 mm) sieve. Shipping, handling, and shredding cost are incidental to the price of Superpave bituminous concrete.

The overall percentage of RAP and recycled shingles (5% maximum) shall not exceed 20% of the mixture. The RAP and recycled shingles mixture are not permitted on wearing course.

Mineral Aggregate:

The mineral aggregate employed in the target gradation of the job mix formula (JMF) shall conform to Section 805 and the following criteria. These criteria apply to the combined aggregate blend.

DESIGN ESAL'S (MILLIONS)	COARSE AGGREGATE ANGULARITY[1] (% MIN)		FINE AGGREGATE ANGULARITY[2] (% MIN)		CLAY CONTENT[3] (% - MIN)	FLAT AND ELONGATED [4] (% - MAX)
	≤ 100 MM	> 100 MM	≤ 100 MM	> 100 MM		
< 0.3	55/-	-/-	-	-	40	-
0.3 to < 3	75/-	50/-	40	40	40	10
3 to <10	85/80[5]	60/-	45	40	45	
10 < 30	95/90	80/75	45	40	45	
≥30	100/100	100/100	45	45	50	

[1]Coarse Aggregate Angularity is tested according to ASTM D 5821.
[2]Fine Aggregate Angularity is tested according to AASHTO TP-33.
[3]Clay Content is tested according to AASHTO T176.
[4]Flat and Elongated is tested according to ASTM D 4791 with a 5:1 aspect ratio.
[5] 85/80 denotes that 85% of the coarse aggregate has one fractured face and 80% has two or more fractured faces.

The following source properties apply to the individual aggregates in the aggregate blend for the proposed JMF.

TEST METHOD	SPECIFICATION LIMITS
Toughness, AASHTO T96 Percent Loss, Maximum	40
Soundness, AASHTO T104 Percent Loss, Maximum for five cycles	20
Deleterious Materials, AASHTO T112 Percent, Maximum	10

TEST METHOD	SPECIFICATION LIMITS
Moisture Sensitivity, AASHTO T283 Percent, Minimum	80

For any roadway with a minimum average daily traffic volume (ADT) of 8000 vehicles and a posted speed of 35 mph (60 kph) or greater, the polish value of the composite aggregate blend shall be greater than 8.0 when tested according to Maryland State Highway Administration MSMT 411 – "Laboratory Method of Predicting Frictional Resistance of Polished Aggregates and Pavement Surfaces." RAP shall be assigned a value of 4.0. The contractor shall supply all polish values to the Engineer upon request.

Mineral Filler:

The mineral filler shall conform to AASHTO M17.

Mixture Requirements:

Gradation: The FHWA Superpave 0.45 Power Chart with the recommended restricted zone shall be used to define permissible gradations for the specified mixture. Type C shall be either a No.4 (4.75 mm), 3/8" (9.5 mm), or 1/2" (12.5 mm) Nominal Maximum Aggregate Size Hot-Mix. Unless otherwise noted in the Plans, the Type C shall meet the 3/8" (9.5 mm) Nominal Maximum Aggregate Size. Type B Hot-Mix shall be the 3/4" (19.0 mm) Nominal Maximum Aggregate Size and the Bituminous Concrete Base Course (BCBC) shall be the 1" (25.0 mm) Nominal Maximum Aggregate Size. Target values for percent passing each standard sieve for the design aggregate structure shall comply with the Superpave control points and should avoid the restricted zone. Percentages shall be based on the washed gradation of the aggregate according to AASHTO T11.

In addition to the results of the material requirements specified above, the following material properties shall be provided by the contractor: bulk specific gravity $G_{sb,}$ apparent specific gravity G_{sa}, and the absorption of the individual aggregate stockpiles to be used, tested according to AASHTO T84 and AASHTO T85 and reported to three decimal places along with the specific gravity of the mineral filler to be used, tested according to AASHTO T100 and reported to three decimal places.

Superpave Gyratory Compactive (SGC) Effort:

The Superpave Gyratory Compaction effort employed throughout mixture design, field quality control, or field quality assurance shall be as indicated below. All mixture specimens tested in the SGC shall be compacted to N_M Height data provided by the SGC shall be employed to calculate volumetric properties at N_I, N_D, and N_M

Superpave Gyratory Compactive (SGC) Effort:

DESIGN TRAFFIC LEVEL (MILLION ESAL'S)	$N_{INITIAL}$	N_{DESIGN}	$N_{MAXIMUM}$
0.3 to < 3	7	75	115
3 to < 30	8	100	160
≥30	9	125	205

Volumetric Design Parameters. The design aggregate structure at the target asphalt cement content shall satisfy the volumetric criteria below:

DESIGN ESAL'S (MILLION)	REQUIRED DENSITY (% OF THEORETICAL MAXIMUM SPECIFIC GRAVITY)			VOIDS-IN-MINERAL AGGREGATE (% - MINIMUM) NOMINAL MAX. AGGREGATE (MM)					VOIDS FILLED WITH ASPHALT (% - MINIMUM)
	$N_{INITIAL}$	N_{DESIGN}	N_{MAX}	25.0	19.0	9.5	12.5	4.75	
0.3 to < 3	≤ 90.5	96.0	≤ 98.0	12.0	13.0	15.0	14.0	16.0	65.0 - 78.0
3 to < 10	≤ 89.0								65.0 - 75.0[1]
10 < 30									
≥ 30									

Air voids (V_a) at N_{design} shall be 4.0% for all ESAL designs. Air voids (V_a) at N_{max} shall be a minimum of 2.0% for all ESAL designs

The dust to binder ratio for the mix having aggregate gradations above the PCS Control Points shall be 0.6-1.2. For aggregate gradations below the PCS Control Points, the dust to binder ratio shall be 0.8-1.6. For the No. 4 (4.75 mm) mix, the dust to binder ratio shall be 0.9-2.0 whether above or below the PCS Control Points.

For 3/8" (9.5 mm) Nominal Maximum Aggregate Size mixtures, the specified VFA range shall be 73.0% to 76.0% and for 4.75 mm Nominal Maximum Size mixtures, the range shall be 75 % to 78% for design traffic levels ≥3 million ESALs.

Gradation Control Points:

The combined aggregates shall conform to the gradation requirement specified in the follow table when tested according to T-11 and T-27.

Nominal Maximum Aggregates Size Control Points, Percent Passing										
	25.0 MM		19.0 MM		12.5 MM		9.5 MM		4.75 MM	
SIEVE SIZE	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX
37.5 MM	100	-	-	-	-	-	-	-	-	-
25.0 MM	90	100	100	-	-	-	-	-	-	-
19.0 MM	-	90	90	100	100	-	-	-	-	-
12.5 MM	-	-	-	90	90	100	100	-	100	-
9.5 MM	-	-	-	-	-	90	90	100	95	100
4.75 MM	-	-	-	-	-	-	-	90	90	100
2.36 MM	19	45	23	49	28	58	32	67	-	-
1.18 MM	-	-	-	-	-	-	-	-	30	60

Nominal Maximum Aggregates Size Control Points, Percent Passing										
	25.0 MM		19.0 MM		12.5 MM		9.5 MM		4.75 MM	
SIEVE SIZE	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX
0.075 MM	1	7	2	8	2	10	2	10	6	12

Note: The aggregates gradation for each sieve must fall withing the minimum and maximum limits.

Gradation Classification:

The Primary Control Sieve (PCS) defines the break point of fine and coarse mixtures. The combined aggregates shall be classified as coarse graded when it passes below the Primary Control Sieve (PCS) control point as defined below. All other gradations shall be classified as fine graded.

PCS CONTROL POINT FOR MIXTURE NOMINAL MAXIMUM AGGREGATES SIZE (% PASSING)					
Nominal maximum Aggregates Size	25.0 mm	19.0 mm	12.5 mm	9.5 mm	4.5 mm
Primary Control Sieve	4.75 mm	4.75 mm	2.36 mm	2.36 mm	1.18 mm
PCS Control Point	40	47	39	47	30-60

Plant Production Tolerances:

Volumeric Property	Superpave Criteria
Air Voids (V_a) at (%) N_m Air Voids (V_a) at N_{design} (%)	2.0 (min) 5.5 (max)
Voids in Mineral Aggregate (VMA) at N_{design} 25.0 mm Bituminous Concrete Base Course 19.0 mm Type B Hot-Mix 12.5 mm Type C Hot-Mix 9.5 mm Type C Hot-Mix 4.5 mm Type C Hot-Mix	 -1.2 +2.0

Design Evaluation:

The contractor shall furnish a Job Mix Formula (JMF) for review and approval. The Engineer may elect to evaluate the proposed JMF and suitability of all materials. All materials requested by the Engineer shall be provided at the contractor's expense to the Central Laboratory in Dover in a timely manner upon request. To verify the complete mixture design and evaluate the suitability of all materials, the following approximate quantities are required:

5.25 gal (20 liters) of the asphalt binder,
0.13 gal (0.5 liter) sample of liquid heat-stable anti-strip additive,
254 lb (115 kg) of each coarse aggregate,

154 lb (70 kg) of each intermediate and fine aggregate,
22 lb (10 kg) of mineral filler, and
254 lb (115 kg) of RAP, when applicable.

The proposed JMF shall include the following:

Plot of the design aggregate structure on the FHWA Superpave 0.45 power chart showing the maximum density line, Superpave control points, and recommended restricted zone.

Plot of the three trial asphalt binder contents at +/- 0.5% gyratory compaction curves where the percent of maximum specific gravity (% of G_{mm}) is plotted against the log base ten of the number of gyrations (log (N)) showing the applicable criteria for N_i, N_d, and N_m.

Plot of the percent asphalt binder by total weight of the mix (P_b) versus the following:

% of G_{mm} at N_d, VMA at N_d, VFA at N_d, Fines to effective asphalt binder (P_{be}) ratio, and unit weight (kg/m²) at both N_d and N_m.

Summary of the consensus property standards test results for the design aggregate structure, summary of the source property standards test results for the individual aggregates in the design aggregate structure, target value of the asphalt binder content, and a table of G_{mm} of the asphalt mixture for the four trial asphalt binder contents determined according to AASHTO T209.

The JMF shall also include the NCAT Ignition Oven calibration for the specific materials utilized for this mix.

Compaction:

Compaction shall be tested and paid per Item 401699 - Quality Control/Quality Assurance of Bituminous Concrete .05 (b) Pavement Construction - Tests and Evaluations.

~~**Method of Measurement and Basis of Payment:**~~

~~Method of Measurement and Basis of Payment will be in accordance with Subsections 401.14 and 401.15 of the Standard Specifications.~~

~~The item 401699, will define adjustment factor to be applied to the bituminous concrete payments for bonus or penalty.~~

12/4/03

401699 - QUALITY CONTROL/QUALITY ASSURANCE OF HOT-MIX ASPHALT

.01 Description.

This item shall govern the Quality Control/Quality Assurance Testing for supplying hot-mix asphalt plant materials and constructing hot-mix asphalt pavements.

The Contractor shall be responsible for providing the quality level of materials and construction incorporated into the Contract that will meet the requirements of the Contract. The Contractor shall perform all necessary quality control inspection, sampling, and testing. The Engineer will evaluate all materials and construction for acceptance. The procedures for Quality Control and Acceptance are described in this Section.

.02 Definitions.

- **Acceptable Quality Level (AQL):** That level of percent within limits (PWL) to which the Engineer will consider the work completely acceptable.
- **Acceptance Plan:** Factors that comprise the Engineer's determination of the degree of compliance with contract requirements and value of the product. These factors include the Engineer's sampling, testing, and inspection.
- **Delaware Asphalt Pavement Association (DAPA):** The organization representing the interests of hot-mix asphalt producers and Contractors. The Engineer has a copy of the DAPA officers' names and point(s) of contact.
- **Dispute Resolution:** The procedure used to resolve conflicts resulting from discrepancies between the Engineer's and the Contractor's results of sufficient magnitude to impact payment. The testing will take place at a location and time mutually agreeable by both the Engineer and the Contractor.
- **Full Depth Construction –** Construction of an adequate pavement box on a subgrade and subbase prepared by the contractor
- **Independent Assurance:** An unbiased and independent verification of the Quality Assurance system used, and the reliability of the test results obtained in regular sampling and testing activities. The results of Independent Assurance are not to be directly used as a basis of material acceptance.
- **Job Mix Formula (JMF)/Mixture Identification (ID):** The target values for individual aggregate size gradation percentages and the asphalt percentage, the sources of each of the component materials, the proposed proportions of component materials to be used to meet those target values, the asphalt proportion, and the mixing temperature. The Engineer will assign uniquely individual mixture identification for each JMF submitted and approved.
- **Lower Quality Index (QL):** The index reflecting the statistic related to the lower boundary to which a sample (or sample statistic) may deviate from the target value and still be considered acceptable.
- **Mean:** A statistical measure of the central tendency – the average value.
- **Operational Day:** A day in which the Engineer has approved a lane closure for the Contractor to perform work within an approved MOT plan.
- **Percent Within Limits (PWL):** That amount of material or workmanship that has been determined, by statistical method, to be within the pre-established characteristic boundary(ies).
- **Qualified Laboratory:** A laboratory mutually agreed upon by both DAPA and the Engineer as having proper test equipment that has been calibrated in accordance to AASHTO.
- **Qualified Technician:** Personnel mutually agreed upon by both DAPA and the Engineer as having adequate training, experience, and abilities to perform the necessary testing. The minimum qualifications are either a recognized nationally accredited or certified Superpave

testing certificate or been working in hot-mix asphalt testing for at least one year.

- **Quality Assurance (QA):** All those planned and systematic actions necessary to provide adequate confidence that a product or service will satisfy given requirements for quality.
- **Quality Control (QC):** The sum total of the activities performed by the Contractor in order to assure that the product meets contract requirements.
- **Quality Control (QC) Plan:** The detailed description of the type and frequency of inspection, sampling, and testing deemed necessary to measure and control the various properties governed by the Specifications. The QC Plan must address the actions needed to keep the process in control, detect when the process is going out of control, and responses to correct the situation(s).
- **Quality Level Analysis:** A statistical procedure that provides a method for estimating the percentage of each lot or sublot of material, product, item of construction, or completed construction that may be expected to be within specified tolerances.
- **Standard Deviation:** A term used in statistics to indicate the value calculated from the square root of the difference between the individual measurements in a group and their average. Standard deviation is calculated by taking the square root of the sum of the squares of the differences of each of n values and the mean value, this sum first divided by (n-1).
- **Target Value:** The acceptable value for a controlling characteristic of a product. The JMF will establish each of these values for the material.
- **Test Methods:** Shall be AASHTO test methods. Copies of these test methods shall be available at each qualified laboratory.
- **Upper Quality Index (QU):** The index reflecting the statistic related to the upper boundary to which a sample (or sample statistic) may deviate from the target value and still be considered acceptable.
- **Volumetric Properties:** Air voids, voids in mineral aggregates (VMA), voids filled with asphalt (VFA), and dust to effective asphalt.

.03 Equipment.

(a) Material Production Test Equipment.

The Contractor shall establish, maintain, and operate a qualified testing laboratory at the production plant site of sufficient size and layout that will accommodate the testing operations of both the Contractor and the Engineer. The Contractor shall maintain all the equipment used for handling, preparing, and testing materials in proper operating condition. For any laboratory equipment malfunction, the Contractor shall remedy the situation within one working day or the Engineer may reject production. In the case of equipment malfunction and, while waiting for equipment repairs, the Engineer may elect to test the material at either another production facility or the Engineer's laboratory to obtain payment factors.

The following shall be the minimum calibrations for the referenced equipment:

SUPERPAVE^{R} Gyratory Compactor: once every year; verified once every month by the Engineer.
Ovens: once every three months, verified once every month.
Vacuum Container and Gauge (Rice Bowls): once every three months, verified once every month.
Balances and Scales: once every year, verified once every month.
Thermometers: once a year; verified once every month.
Gyratory Compactor molds and base plates: once every year
Mechanical Shakers: once every year
Sieve Verifications: once every year

All calibrations shall be documented and on file for review by the Engineer at any time.

(b) Pavement Construction Test Equipment.

The Contractor shall furnish and use in-place density gauges, or coring equipment, or both, as necessary to meet the requirements of these Specifications.

.04 Quality Control (QC) Plan.

(a) Material Production QC.

(1) Job Mix Formula – Material Production.

The Contractor shall submit for approval to the Engineer the job mix formula (JMF) design of the component materials and target characteristic values for each mixture proposed for use. Once the JMF is submitted to the Engineer, the Engineer will have up to three weeks to review the submitted information. However, a provision for a more timely approval is available to the Contractor; first, the Contractor shall submit the proper documentation on Pinepave mixture design software for the Engineer's approval. After that approval from the Engineer, the Contractor shall produce the new mixture for a non-Department project. The Engineer will test the material, by taking three series per the specifications. If the Engineer's test results are within the specifications, then the mixture will be approved by the Engineer for Department projects.

The component materials design shall include designating the source and the expected proportion (within 1 percent for the aggregate components and within 0.1 percent for the other components) of each component to be used in order to produce workable hot-mix asphalt having the specified properties. For plant component feed adjustments, RAP can be considered in the same manner as an individual aggregate component. The JMF target characteristic values include the mixing temperature range, core temperature range for gyration, the percentage of the asphalt cement component (both total and virgin), and the percentages of the aggregate amounts retained on the sieves to be addressed by the JMF as shown in Table 1.

The Contractor shall provide an ignition oven correction number for each JMF. The Contractor shall also supply to the Engineer weighed material of each JMF so correction numbers can be established for the Engineer's equipment for Dispute Resolution samples.

Prior to starting production of a new mixture, the Contractor shall submit a JMF. For any mixture that has a 20% or greater failure rate on any combined volumetric criteria, the JMF will not be approved for use on Department contracts. In order to be approved, a re-design of the mixture will have to be completed by the Contractor for review and approval by the Engineer. The Contractor shall uniquely title each JMF. The Contractor shall submit test data with each JMF and tests performed by a Qualified Laboratory on representative materials, verifying the adequacy of the design. Refer to the specifications for each mix type in order to determine the design requirements. The JMF sieve percentage values shall conform to the ranges shown in Table 1.

If there is a change in the source of any of the component materials, other than asphalt, if there is a change in the proportions of the aggregate components or the percent passing for each sieve by more than 5 percent from the submitted JMF, or if there is a change in the percentage of the asphalt cement component by 0.2 percent or more, which causes the volumetrics to change from the originally submitted JMF, a new JMF is required. Also, if the asphalt cement target percentage is lowered, all volumetric criteria must still be achieved.

According to the Contractor's QC Plan, the Contractor shall inform the Engineer of any proposed changes to an existing JMF. The Contractor shall notify the Engineer by electronic mail of the proposed changes. The Engineer will reply to the proposed changes within one operational day and notify the Contractor of the effective date of the changes.

Although a new JMF is not required, the Contractor must notify the Engineer of any change in the proportions of the components. This notification shall include the total change made from the approved JMF proportions, and the effective time of the change.

All submitted JMF's shall correspond to the Pinepave mixture design software. The Engineer, for evaluation of the submitted JMF, will use the first three test samples. These test results acquired during production shall be within the following range compared to the submitted JMF on the Pinepave mixture design software: G_{mm}: + / -0.030 and G_{mb}: + / - 0.040

Table 1 - Aggregate Gradation - JMF and Control Point Information										
Sieves to be addressed by JMF/Range values are percentages passing by weight										
Sieve Size MM (inch)	**4.75mm**	**4.75mm Range**	**9.5 mm**	**9.5mm Range**	**12.5 mm**	**12.5mm Range**	**19.0 mm**	**19.0mm Range**	**25.0 mm**	**25.0mm Range**
37.5(1.5)	No		No		No		No		Yes	100
25.0(1.0)	No		No		No		Yes	100	Yes	90-100
19.0 (3/4)	No		No		Yes	100	Yes	90-100	Yes	20-90
12.5(1/2)	Yes	100	Yes	100	Yes	90-100	Yes	23-90	Yes	
9.5 (3/8)	Yes	95-100	Yes	90-100	Yes	28-90	Yes		Yes	
4.75(#4)	Yes	90-100	Yes	32-90	Yes		Yes		Yes	
2.36(#8)	Yes		Yes	32-67	Yes	28-58	Yes	23-49	Yes	19-45
(#16)	Yes	30-60	Yes		Yes		Yes		Yes	
(#30)	Yes		Yes		Yes		Yes		Yes	
(#50)	Yes		Yes		Yes		Yes		Yes	
(#100)	Yes		Yes		Yes		Yes		Yes	
.075(#200)	Yes	6-12	Yes	2-10	Yes	2-10	Yes	2-8	Yes	1-7

(2) Process Control – Material Production.

The Contractor shall submit in writing (letter or electronic mail) a QC Plan from each proposed production plant to the Engineer; no hot-mix asphalt material will be accepted until the Engineer approves the QC Plan. This plan must be submitted to the Engineer on an annual basis for review and approval prior to material production. The Engineer will send a signed copy back to the Contractor stating that it is approved. The approved QC Plan shall govern contractor operations.

The following are considered significant violations to the Contractor's QC Plan:

- Using testing equipment that is knowingly out of calibration or is not working properly.
- Reporting false information such as test data, JMF information, or any info requested by DelDOT
- When the Contractor fails to comply to their approved QC Plan in reference to materials testing

- Substantial deviations to AASHTO or DelDOT procedures when running tests, sampling stockpiles, or testing hot mix.
- The use of any material not listed in the JMF.
- The use of the wrong PG graded asphalt.
- If samples fall within the Contractors action points in the QC Plan but the Contractor fails to take the corrective action in the approved QC Plan

If a Contractor is found in violation of any of these items, they will receive a written warning for their first violation. If the Contractor is found in violation a second time on any of the criteria, they will forfeit any bonus from that day's production. If the Contractor is found in violation a third time on any of the criteria, they will receive a five percent (5%) deduction for that day's production. If the Contractor is found in violation a fourth time, the plant will not be approved for production until such time that the Contractor addresses the violation of the QC plan to the satisfaction of the Engineer. If the Engineer approves the changes in advance, the Contractor may make changes to the QC Plan. All changes shall be submitted and approved in writing by the Engineer.

The QC Plan shall include actions that will assure all materials and products will conform to the specifications, whether manufactured or processed by the Contractor, or procured from suppliers, subcontractors, or vendors. The Contractor shall perform the inspection and tests required to substantiate product conformance to contract requirements. The Contractor shall document QC inspections and tests, and provide copies to the Engineer when requested. The Contractor shall maintain records of all inspections and tests for at least one year. The records shall include the date, time, and nature of deficiency or deficiencies found; the quantities of material involved until the deficiency was corrected; and the date, time, and nature of corrective actions taken.

In the QC Plan, the Contractor shall detail the type and frequency of inspection, sampling, and testing deemed necessary to measure and control the various properties of material and construction governed by the Specifications. The QC Plan shall include the following elements as a minimum:

- Production Plant – make, type, capacity, and location.
- Production Plant Calibration – components and schedule; address documentation.
- Personnel – include name and telephone number for the following individuals:
  - Person responsible for quality control.
  - Qualified technician(s) responsible for performing the inspection, sampling, and testing.
  - Person who has the authority to make corrective actions on behalf of the Contractor.
- Testing Laboratory – state the frequency of accuracy checks and calibrations of the equipment used for testing; address documentation.
- Locations where samples will be obtained and the sampling techniques for each test
- Load number of QC samples (1-10 if QA sample is not within trucks 1-10)
- Tests to be performed and their normal frequency; the following, at a minimum, shall be conducted:
  - Mixture Temperature: each of the first five trucks, and each load that is sampled for QC or acceptance testing.
  - Gradation analysis of aggregate (and RAP) stockpiles – one washed gradations per week for each aggregate stockpile; RAP: five gradations and asphalt cement contents for dedicated stockpiles where new material is not being added; one gradation and asphalt cement content test per week for stockpiles where material is continually being added to the stockpile.
  - Gradation analysis of non-payment sieves
  - Dust to effective asphalt calculation
  - Moisture content analysis of aggregates – daily.
  - Gradation analysis of the combined aggregate cold feed – one per year per mixture.

- Bulk specific gravity and absorption of blended material – one per year per mixture.
- Ignition Oven calibration – one per year per mixture.
- Hot-Bins: one per year per mixture.
- Others, as appropriate.

- Procedures for reporting the results of inspection and tests (include schedule).
- Procedures for dealing with non-compliant material or work.
- Presentation of control charts. The Contractor shall plot the results of testing on individual control charts for each characteristic. The control charts shall be updated within one working day as test results for each sublot become available. The control charts shall be easily and readily accessible at the plant laboratory. The following parameters shall be plotted from the testing:
  - Asphalt cement content.
  - Volumetrics (air voids, voids in mineral aggregates [VMA])
  - Gradation values for the following sieves:
    - 4.75 mm (#4).
    - 2.36 mm (#8).
    - 0.075 mm (#200).
- Operational guidelines (trigger points) to address times when the following actions would be considered:
  - Increased frequency of sampling and testing.
  - Plant control/settings/operations change.
  - JMF adjustment.
  - JMF change (See Section .04(a)(1)).
  - Change in the source of the component materials.
  - Calibration of material production equipment (asphalt pump, belt feeders, etc.).
  - Rejection of material.

When any point of non-compliance with the QC plan, or material not meeting the Specifications, comes to the attention of either the Contractor or the Engineer, the other party shall be notified immediately, and the Contractor shall take appropriate corrective actions. Failure to take corrective actions immediately shall be cause for rejection of material or work by the Engineer.

(b) Pavement Construction – Process Control.

The Contractor shall perform Quality Control of pavement compaction by testing in-place pavement with a density gauge or by testing cores extracted from the pavement. The use of the nuclear density gauge shall conform to ASTM D 2950; the use of other density gauges shall be as per the manufacturer's recommendations and approved by the Engineer. The Contractor may use any method to select locations for the Quality Control.

.05 Acceptance Plan.

(a) Material Production – Tests and Evaluations.

The Engineer will conduct acceptance tests. The Engineer will directly base acceptance on the acceptance test results, the asphalt cement quality, the Contractor's QC Plan work, and the comparisons of the acceptance test results to the QC test results. The Engineer may elect to utilize test results of the Contractor in some situations toward judging acceptance. All acceptance tests shall be performed by qualified technicians at qualified laboratories following AASHTO or DelDOT procedures, and shall be evaluated using Quality Level Analysis.

The Contractor shall supply, capture, and mark samples, as directed, from delivery trucks before the trucks leave the production plant. The sample shall represent the material produced by the Contractor, and shall be of sufficient size to allow the Engineer to complete all required acceptance tests. The

Engineer will direct the Contractor when to capture these samples, on a statistically random, unbiased basis, established before production begins each day based upon the anticipated production tonnage. The captured sample shall be from the Engineer specified delivery truck; if the Contractor visually observes the specified delivery truck sample and does not want this sample to be sampled and tested for acceptance, that delivery truck will not be sent to a Department project and the next visually acceptable delivery truck to the Contractor shall be sampled for acceptance testing.

Except for the first sample of the production, the Engineer will give the Contractor at least 100 tons, or five trucks, advance notice before each individual sample is required. Unacceptable samples may be a basis for rejection of material if the QC plan is not followed as approved for sample retrieval. If the Contractor wishes to perform parallel tests with the Engineer, or to capture samples to be retained for possible Dispute Resolution, each of the samples for these purposes shall be obtained at the same time and location as the acceptance test sample. Either splitting a large sample or getting multiple samples that equally represent the material is acceptable.

The Engineer will evaluate and accept the material on a lot basis. All the material within a lot shall have the same JMF (mixture ID). The lot size shall be targeted for 2000 tons or a maximum period of three days, whichever is reached first. If the 2000th ton target lot size is achieved during a production day, the lot size shall extend to the end of that production day. The Contractor may interrupt the production of one JMF in order to produce different material; this type of interruption will not alter the determination of the size or limits of material represented by a lot. The Engineer will evaluate each lot on a sublot basis. The size for each sublot shall be 100 to 500 tons and testing for the sub lots will be completed on a daily basis. For each sublot, the Engineer will evaluate one sample.

The target number of sublots within each lot is four equal-sized 500 ton sub lots and will be based upon anticipated production, however, more or fewer sublots, with differing sizes, may result due to the production schedule and conditions. If the actual production is less than anticipated, and it's determined a sample will not be obtained (based upon the anticipated tonnage), a new sample location will be determined on a statistically random, unbiased basis based upon the new actual production. If the actual production is going to be 50 tons or greater over the anticipated sub lot production, a new sample location will be determined on a statistically random, unbiased basis based upon the new actual production. The Engineer will combine the evaluation and test results for all of the applicable sublots in order to evaluate each individual lot.

If the Engineer is present, and the quantity exceeds 25 tons, a statistically random sample may be used for analysis. When the anticipated production is less than 100 tons and greater than 25 tons, and the Engineer is not present, the contractor shall randomly select a sample using the Engineer's random location program. The contractor will perform the testing in accordance with all applicable AASHTO or DelDOT standards as referenced in their approved QC Plan. The test results shall be submitted to the Engineer electronically in the format provided by the Engineer (LB-26). The test results from either the Contractor or Engineer on production that is less than 100 tons will be combined with the two most recently completed Engineer tests with the same Mixture ID and from the same contract to calculate payment for the lot encompassing the single test. If that cannot be accomplished, the same results from the most recently completed lot with the same Mixture ID will be used for analysis and payment. Payment for previously closed lots will not be affected by the analysis. A box sample shall also be obtained by the contractor at the same time and will be used as the Dispute Resolution sample if requested by the Engineer. The contractor shall also obtain one liquid asphalt sample (1 pint) per grade of asphalt used per day and properly label it with all pertinent information.

The Engineer will conduct the following tests in order to characterize the material for the pavement compaction quality and to judge acceptance and the pay adjustment for the material:

- AASHTO T312 – Preparing a mixture samples using a gyratory compactor.
- AASHTO T166, Method C (Rapid Method) – Bulk specific gravity of compacted samples.
- AASHTO T308 – Asphalt cement content.

- AASHTO T30 – Aggregate gradations, using samples from the asphalt cement content test.
- AASHTO T209 – Theoretical maximum specific gravity.
- ASTM Provisional Test Method – Rapid Drying of Compacted and Loose Bituminous Asphalt Specimens using Vacuum Drying Method

(b) Pavement Construction – Tests and Evaluations.

The Engineer will directly base acceptance on the compaction acceptance test results, and on the inspection of the construction, the Contractor's QC Plan work, ride smoothness as referenced in the contract documents, lift thickness as referenced in the contract documents, joint quality as referenced in the contract documents, surface texture as referenced in the contract documents, and possibly the comparisons of the acceptance test results to the independent test results. For the compaction acceptance testing, the Engineer will sample the work on a statistically random basis, and will test and evaluate the work using lots.

Prior to paving a road segment, the Contractor shall notify the Engineer of any locations within that road segment that may not be suitable to achieve minimum (93%) compaction due to existing conditions. The Contractor shall schedule and hold a meeting in the field with the Engineer in order to discuss all areas that may potentially be applicable to Table 5a before paving starts. Areas that will be considered for Table 5a will be investigated in accordance to the method described in Appendix B. If this meeting is not held prior to paving, no areas will be considered for Table 5a. Areas of allowable exemptions that will not be cored include the following: partial-depth patch areas, driveway entrances, paving locations of less than 100 tons, areas around manholes and driveway entrances, and areas of paving that are under 400 feet in continuous total length and/or 5 feet in width.

The exempt areas around manholes will be a maximum of 4 feet transversely on either side from the center of the manhole, and 20 feet longitudinally on either side from the center of the manhole. The exempt areas around driveway entrances shall be the entire width of the driveway, and 3 feet from the edge of the longitudinal joint next to the driveway. Areas of exemption that will be cored for informational purposes only shall include: areas where the mat thickness is less than three times the nominal maximum aggregate size as directed by the Engineer, violations of Section 401.08 in the Standard Specifications as directed by the Engineer, and areas shown to contain questionable subgrade properties as proven by substantial yielding under a fully legally loaded truck. Failure to obtain core samples in these areas will result in zero payment for compaction regardless of the exempt status.

The Engineer will evaluate and accept the compaction work on a daily basis. Payment for the compaction will be calculated by using the material production lots as referenced in **.05 Acceptance Plan (a) Material Production – Tests and Evaluation** and analyzing the compaction results over the individual days covered in the material production lot. The compaction results will be combined with the material results to obtain a payment for this item.

The minimum size of a compaction lot shall be 100 tons. If the compaction lot is between 101 and 1000 tons, the Engineer shall randomly determine four compaction acceptance test locations. If the compaction lot is between 1001 and 1500 tons, the Engineer shall randomly determine six compaction acceptance test locations. If the compaction lot is between 1501 and 2000 tons, the Engineer shall randomly determine eight compaction acceptance test locations. If the compaction lot is greater than 2000 tons, the Engineer shall randomly determine two compaction acceptance test locations per 500 tons.

If a randomly selected area falls within an Engineer approved exemption area, the Engineer will select one more randomly generated location to be tested per the requirements of this Specification. If that cannot be accomplished, or if an entire location has been declared exempt, the compaction testing shall be performed as per these Specifications but a note will be added to the results that the location was an Engineer approved exempt location.

Testing locations will be a minimum of 1.5 feet from the newly placed longitudinal joint and 50 feet

from a new transverse joint. If the Contractor chooses to cut companion cores, they shall be located within one foot of the Engineers cores along the longitudinal direction and in-line with the Engineers cores in the longitudinal plane.

Exactly at the locations marked by the Engineer, the Contractor shall cut a core, 6 inches in diameter, through the full lift depth. Cores submitted that are not from the location designated by the Engineer will not be tested and will be paid at zero pay.

The Contractor shall notify the Engineer prior to starting paving operations with approximations of the tonnage to be placed. The Contractor is then responsible for notifying the appropriate Engineer test personnel within 12 hours of material placement. The Engineer will then have 24 hours to mark the core locations. After determination of locations, the Contractor shall complete testing within two operational days of the locations being marked. If the cores are not cut within two operational days, the area in question will be paid at zero pay for compaction testing.

The Contractor shall provide any traffic control required for the structural number investigation, sampling, and testing work at no additional cost to the Department.

The Contractor shall cut each core with care in order to prevent damaging the core. The pavement shall have a maximum temperature of 140□F when cores are cut from it. Immediately upon removal of a core from the roadway, the Contractor shall adequately label it. The Contractor shall protect the core by supplying a 6-inch plastic concrete cylinder mold, or an approved substitute, and placing the core in it. If more than one core is in the same mold, the Contractor shall place paper between them. The Contractor shall attach a completed QC test record for the representative area to the corresponding core. The Engineer will also complete a test record for areas tested for the QA report and provide to Materials & Research. At the end of every production day, the Contractor shall deliver the cores to the Engineer for testing, processing, and report distribution.

The Contractor shall repair the core hole per Appendix A, Repairing Core Holes in Hot-Mix Asphalt Pavements. Core holes shall be filled immediately. Failure to repair core holes at the time of coring will result in zero pay for compaction testing for the area in question.

The Engineer will conduct the following tests on the applicable portion of the cores in order to evaluate their quality:

- AASHTO T166, Method C (Rapid Method) – to determine the bulk specific gravity of the cores.
- AASHTO T209 – to calculate the theoretical maximum specific gravity and the density of the non-compacted mixtures.
- ASTM Provisional Test Method – Rapid Drying of Compacted and Loose Bituminous Asphalt Specimens using Vacuum Drying Method.

The Engineer will use the average of the last five test values of the same JMF (mixture ID) material at the production plant in order to calculate the average theoretical maximum specific gravity of the cores. The average will be based on the production days test results and as many test results needed from previous days production to have an average of five samples. If there are less than five values available, the Engineer will use the JMF design value in addition to the available values to calculate the average theoretical maximum specific gravity.

.06 Payment and Pay Adjustment Factors.

The Contractor shall include the costs for all materials, labor, equipment, tools, and incidentals necessary to meet the requirements of this specification in the bid price per ton for the hot-mix asphalt. Payment to the Contractor for the hot-mix asphalt item(s) will be based on the Contract price per ton and the pay adjustments described in this specification. The Engineer will determine pay adjustments for the hot-mix asphalt item(s) based on the Acceptance Plan. The Engineer will determine both a pay

adjustment for the material and a pay adjustment for the pavement construction. Note that the material portion of the total pay adjustment is 70 percent and the pavement construction portion is 30 percent. For replaced material or work, the Engineer will not apply the Pay Adjustment applicable to the material or work replaced; a new Pay Adjustment will be calculated based on the qualities of the new material. Even if one portion of the pay adjustment (material or construction) is not applied, the Engineer may apply the pay adjustment to the other portion. All adjustments (bonus or penalty) shall be paid under this item number in the contract.

(a) Material Production – Pay Adjustment.

The Engineer will determine the material pay adjustment by evaluating the production material based on the following parameters:

- Gradation of the 2.36 mm (#8) sieve.
- Gradation of the 0.075 mm (#200) sieve.
- Asphalt cement content.
- Air void content

Using the JMF target value, the single test tolerance (from Table 3), and the test values, the Engineer will use the following steps to determine the material pay adjustment factor for each lot of material:

1. For each parameter, calculate the mean value and the standard deviation of the test values for the lot to the nearest 0.1 unit.
2. For each parameter, calculate the Upper Quality Index (QU):
   QU = ((JMF target) + (single test tolerance) – (mean value)) / (standard deviation).
3. For each parameter, calculate the Lower Quality Index (QL):
   QL = ((mean value) - (JMF target) + (single test tolerance)) / (standard deviation).
4. For each parameter, locate the values for the Upper Payment Limit (PU) and the Lower Payment Limit (PL) from Table 2 – Quality Level Analysis by the Standard Deviation Method. (Use the column for "n" representing the number of sublots in the lot. Use the closest value on the table when the exact value is not listed).
5. Calculate the PWL for each parameter from the values located in the previous step:
   PWL = PU + PL – 100.
6. Calculate each parameter's contribution to the payment adjustment by multiplying its PWL by the weight factor shown in Table 3 for that parameter.
7. Add the calculated adjustments of all the parameters together to determine the Composite PWL for the lot.
8. From Table 4, locate the value of the Pay Adjustment Factor corresponding to the calculated PWL.
9. For each lot, determine the final material price adjustment:

Final Pay Adjustment =
(Lot Quantity) x (Item Bid Price) x (Pay Adjustment Factor) x 70%. This final pay calculation will be paid to the tenth of a percent.

In lieu of being assessed a pay adjustment penalty, the Contractor may choose to remove and replace the material at no additional cost to the Department. If the PWL of any single material characteristic is below 60, the Engineer may require the removal and replacement of the material at no additional cost to the Department.

When a sample is out of the acceptable tolerance for any Materials pay criteria, that sample will be isolated. For payment purposes, the test result of the out of acceptable tolerance sample will be combined with the two previous acceptable samples of the same JMF and analyzed per this specification. The material that is considered out of the acceptable tolerance will include the material from the previous acceptable test result to the material in the following acceptable test result. If the previous acceptable test

result is from the previous production day, only the material produced on the second production day will be considered out of tolerance. All future sub lots will not include the isolated test.

If, during production, a QA sample test result does not meet the acceptable tolerances and the Contractors QC sample duplicates the QA sample test result, the Contractor can make an appropriate change to the mixture (within the JMF boundaries), and request to have that sample further isolated. If this request is approved, and the Contractor has made a change, the third load after the change will be tested. If that sample test result shows compliance with the specifications, the material that is considered out of the acceptable tolerance will include the material from the previous acceptable test result to the third load after the initially sampled and tested sample. If the sample does not meet the specification requirements, the Engineer will no longer accept material; however, the Engineer reserves the right to possibly allow production to continue depending upon the results of the changes made.

Table 2 – Quality Level Analysis by the Standard Deviation Method

PU or PL	QU and QL for "n" Samples						
	n = 3	n = 4	n = 5	n = 6	n = 7	n = 8	n = 9
100	1.16	1.50	1.79	2.03	2.23	2.39	2.53
99		1.47	1.67	1.80	1.89	1.95	2.00
98	1.15	1.44	1.60	1.70	1.76	1.81	1.84
97		1.41	1.54	1.62	1.67	1.70	1.72
96	1.14	1.38	1.49	1.55	1.59	1.61	1.63
95		1.35	1.44	1.49	1.52	1.54	1.55
94	1.13	1.32	1.39	1.43	1.46	1.47	1.48
93		1.29	1.35	1.38	1.40	1.41	1.42
92	1.12	1.26	1.31	1.33	1.35	1.36	1.36
91	1.11	1.23	1.27	1.29	1.30	1.30	1.31
90	1.10	1.20	1.23	1.24	1.25	1.25	1.26
89	1.09	1.17	1.19	1.20	1.20	1.21	1.21
88	1.07	1.14	1.15	1.16	1.16	1.16	1.17
87	1.06	1.11	1.12	1.12	1.12	1.12	1.12
86	1.04	1.08	1.08	1.08	1.08	1.08	1.08
85	1.03	1.05	1.05	1.04	1.04	1.04	1.04
84	1.01	1.02	1.01	1.01	1.00	1.00	1.00
83	1.00	0.99	0.98	0.97	0.97	0.96	0.96
82	0.97	0.96	0.95	0.94	0.93	0.93	0.93
81	0.96	0.93	0.91	0.90	0.90	0.89	0.89
80	0.93	0.90	0.88	0.87	0.86	0.86	0.86

Table 2 – Quality Level Analysis by the Standard Deviation Method							
PU or PL	QU and QL for "n" Samples						
	n = 3	n = 4	n = 5	n = 6	n = 7	n = 8	n = 9
79	0.91	0.87	0.85	0.84	0.83	0.82	0.82
78	0.89	0.84	0.82	0.80	0.80	0.79	0.79
77	0.87	0.81	0.78	0.77	0.76	0.76	0.76
76	0.84	0.78	0.75	0.74	0.73	0.73	0.72
75	0.82	0.75	0.72	0.71	0.70	0.70	0.69
74	0.79	0.72	0.69	0.68	0.67	0.66	0.66
73	0.75	0.69	0.66	0.65	0.64	0.63	0.63
72	0.74	0.66	0.63	0.62	0.61	0.60	0.60
71	0.71	0.63	0.60	0.59	0.58	0.57	0.57
70	0.68	0.60	0.57	0.56	0.55	0.55	0.54
69	0.65	0.57	0.54	0.53	0.52	0.52	0.51
68	0.62	0.54	0.51	0.50	0.49	0.49	0.48
67	0.59	0.51	0.47	0.47	0.46	0.46	0.46
66	0.56	0.48	0.45	0.44	0.44	0.43	0.43
65	0.52	0.45	0.43	0.41	0.41	0.40	0.40
64	0.49	0.42	0.40	0.39	0.38	0.38	0.37
63	0.46	0.39	0.37	0.36	0.35	0.35	0.35
62	0.43	0.36	0.34	0.33	0.32	0.32	0.32
61	0.39	0.33	0.31	0.30	0.30	0.29	0.29
60	0.36	0.30	0.28	0.27	0.27	0.27	0.26
59	0.32	0.27	0.25	0.25	0.24	0.24	0.24

Table 3 - Material Parameter Weight Factors		
Material Parameter	Single Test Tolerance (+/-)	Weight Factor
Asphalt Content	0.4	0.30
#8 Sive (19 mm or >)	7.0	0.30
#8 Sieve (12.5 mm or <)	5.0	0.30
#200 Sieve (0.075 mm) Sieve	2.0	0.30
Air Voids (4.0% Target)	1.5	0.10

Table 4 - PWL Pay Adjustment Factors	
PWL	**Pay Adjustment Factor (%)**
100	+5
99	+4
98	+3
97	+2
96	+1
95	0
94	(-1)
93	(-2)
92	(-3)
91	(-4)
PWL (when <91)	(PWL - 100)

(b) Pavement Construction – Pay Adjustments.

The Engineer will determine the pavement construction pay adjustment by evaluating the construction of the pavement, based on the following parameter:

- Degree of compaction of the in-place material

Using the test values for the cores, the Engineer will use the following steps to determine the pavement construction pay adjustment for each lot of work. Note that the material portion of the total pay adjustment is 70 percent and the pavement construction portion is 30 percent.

1. Calculate the average density values from the sublot tests values, to the nearest 0.1 unit.
2. Calculate the Degree of Compaction:
   Degree of Compaction =
   ((Core Bulk Specific Gravity) / (Theoretical Maximum Specific Gravity)) x 100%.
3. The average compaction for the sublots shall be averaged together for the compaction level of the lot. The lots compaction test level shall be averaged to the whole percent.
4. Locate the value of the Payment Adjustment Factor corresponding to the calculated degree of compaction from Table 5 or Table 5a.
5. Determine the pavement construction price adjustment by using the following formula:
   Pay adjustment = (Lot Quantity) x (Bid Price) x (Pay Adjustment Factor) x 30%.

Table 5: Compaction Price Adjustment Highway Locations	
Degree of Compaction (%)	**Pay Adjustment Factor (%)**
>97	-100*

Table 5: Compaction Price Adjustment Highway Locations	
Degree of Compaction (%)	**Pay Adjustment Factor (%)**
96	0
95	+5
94	+3
93	0
92	-5
91	-15
90	-25
89	-30
≤88	-100*

* or remove and replace it at Engineer's discretion

Table 5a: Compaction Price Adjustment Other[1] Locations	
Degree of Compaction (%)	**Pay Adjustment Factor (%)**
>96	-100*
95	+2
94	+2
93	+2
92	+2
91	+1
90	+1
89	0
88	0
87	-15
86	-25
85	-30
84	-100*

* or remove and replace at Engineer's discretion

[1] This chart is to be used for areas where the structural value of the area to be paved is less than 1.75 as determined by the Engineer. See Appendix B – Method for Obtaining Cores for Determination of Roadway Structure. This chart is applicable to rehabilitation work only; full depth construction will not be considered for Table 5a.

.07 Dispute Resolution.

Disputes or questions about any test result shall be immediately brought to the attention of the Contractor and the Engineer. When there is a significant alleged discrepancy regarding the Engineer's acceptance test results, the Contractor must claim a dispute within two operational days of the test date. The following dispute resolution procedures will be used.

The Engineer and the Contractor will review the sample quality, the test method, the laboratory equipment, and the laboratory technician. If these factors are not the cause of the dispute, a third party dispute resolution will be used.

For third party resolution testing, it can be either at another Contractor's laboratory, the Engineer's laboratory, or an independent accredited laboratory. Unless otherwise mutually agreed upon by DAPA and the Engineer, the Engineer's qualified laboratory in Dover and qualified personnel shall conduct the necessary testing for third party Dispute Resolution after the Engineer has provided reasonable notice to allow the Contractor to witness this testing.

When disputes over production testing occur, the samples used for Dispute Resolution testing will be those samples the Contractor properly captured, labeled, and stored, as described in the second paragraph of the section of these specifications titled **.05 Acceptance Plan, (a) Material Production – Tests and Evaluations**. If no samples are available, the original testing results will be used for payment calculations.

Dispute Resolution samples for air void content will be heated by a microwave oven.

If there is a discrepancy between the Engineer's acceptance test result and the Contractor's test result, the Contractor may ask for the Dispute Resolution sample to be tested. If the Dispute Resolution sample substantiates the original acceptance test result, the Contractor, after two such Dispute Resolution samples, will be charged a fee of $125 for all further Dispute Resolution cores that substantiate the acceptance test result. If the Dispute Resolution sample substantiates the Contractor's test result, the Contractor will not be charged a fee.

When disputes over compaction core test results occur, the Engineer's acceptance core will be used for the dispute resolution sample. The Contractor will be advised on when the testing will occur as referenced above to witness the testing.

The results of the dispute resolution testing shall replace all of the applicable disputed test results for payment purposes.

11/17/06

Appendix A - Repairing Core Holes in Hot-Mix Asphalt Pavement

Description.

This appendix describes the procedure required to acceptably repair core holes in a bituminous concrete pavement.

Materials and Equipment.

The following material shall be available to complete this work:

- Patch Material –A DelDOT approved High Performance Cold Patch material shall be used.

The following equipment shall be available to complete this work:

- Sponge or other absorbent material – Used to extract water from the hole.
- Compaction Hammer – Shall be mechanical, with a flat, circular tamping face smaller than 6 inches in diameter. The tamping head shall be connected to an electrical, pneumatic, or gasoline driven tamping device.

Construction Method.

After core removal from the hole, remove all excess water from within the hole, and prevent water from re-entering the hole.

Place the patch material in lifts no greater than 3 inches. If the hole is deeper than 3 inches, use two lifts of approximately equal depths so that optimum compaction is achieved. Make sure that the patch surface matches the grade of the existing roadway. Make every effort to achieve the greatest possible compaction

Performance Requirements.

The Engineer will judge the patch on the following basis:

- The patch shall be well compacted
- The patch surface shall match the grade of the surrounding roadway surface.

Basis of Payment.

No measurement or payment will be made for the patching work. The Contractor must gain the Engineer's acceptance of the patching work before the Engineer will accept the material represented by the core.

Appendix B - Method for Obtaining Cores for Determination of Roadway Structure

The Contractor is responsible for obtaining cores in areas that they propose are eligible for compaction price adjustments according to Table 5a in this specification. Table 5a is not applicable for new full-depth pavement box construction. Cores submitted for this process shall be obtained according to the following process.

1. Contact Materials & Research (M&R) personnel to determine if information about the area is already available. If M&R has already obtained cores in the location that is being investigated, the contractor may opt to use the laboratory information for the investigation and not core the area on their own.

2. If M&R does not have information concerning the section of the roadway, the contractor needs to contact M&R to arrange for verification of coring operations. Arrangements shall be made to allow for an individual from M&R to be on the site when the cores are obtained. Cores will be turned over to M&R for evaluation.

3. The contractor is responsible for providing all traffic control and repairing core holes in accordance to 401699 Appendix A – Repairing Core Holes in Hot-Mix Asphalt Pavements.

4. Cores are to be taken throughout the entire project for the area in question. Cores will be spaced, from the start of the project in increments determined based on field and project specifics. Cores will be evenly distributed throughout the project location. The cores will be taken in the center of the lane in question.

5. Additional cores may be taken at other locations, if surface conditions indicate that there may be a substantial difference in the underlying section. The location of these cores should be documented and submitted to M&R.

6. Cores shall be full depth and include underlying materials. If there is a stone base included in the pavement section, at a minimum 1 core must have information concerning the thickness of the base. This is determined by augering to the subgrade surface.

7. The calculations used to determine the structural capacity of the roadway is as follows. If the contractor finds, upon starting the coring process, that the areas are of greater thickness than applicable to Table 5a, they may terminate the coring process on their own and retract the request.

Structural Number Calculations

Each pavement box material is assigned a structural coefficient based upon AASHTO design guides. The structural coefficient is used to determine the total strength of the pavement section.

Materials used in older pavement sections are assigned lower structural coefficients to compensate for aging of the materials. The coefficients used to determine the structural number of an existing pavement are:

Existing Material	Structural Coefficient
HMA	0.32
Asphalt Treated Base	0.26
Soil Cement	0.16

Existing Material	Structural Coefficient
Surface Treatment (Tar & Chip)	0.10
GABC	0.14
Concrete	0 - 0.7*

* The Structural Coefficient of Concrete is dependent upon the condition of the concrete. Compressive strengths & ASR analysis are used to determine condition – contact the Engineer if this situation arises.

Newly placed materials use a different set of structural coefficients. They are as follows:

New Material	Structural Coefficient
HMA	0.40
Asphalt Treated Base (BCBC)	0.32
Soil Cement	0.20
GABC	0.14

Example:

Location includes placement of a 1.25" Type C overlay on 2.25" Type B. Existing roadway is cored and is shown to consist of 2" HMA on 7" GABC.

Calculation:

For the Type B lift the calculation would be:

Existing HMA	2 * 0.32	=	0.64
GABC	7 * 0.14	=	0.98
			1.62

For the Type C lift the calculation would be:

Newly Placed B	2.25 * 0.4	=	0.90
Existing HMA	2 * 0.32	=	0.64
GABC	7* 0.14	=	0.98
			2.52

501530 - OVERLAY CONCRETE SURFACE RIDEABILITY

Description:

This work shall consist of furnishing diamond grinding equipment and grinding the overlaid concrete deck surface in accordance with these Specifications, notes and details in the Plans, and as directed by the Engineer. Application of this Specification on the overlaid deck surface involves identifying and correcting unacceptable riding surface qualities, and involves providing payment adjustment values based on the tested quality of the riding surface smoothness.

The Contractor shall employ construction and grinding procedures that will produce a maximum average profile ride index (PRI) per 328' segment of 8.0" per mile or less on the final riding surface to receive full compensation.

Equipment Requirements

Measurement Equipment: The Contractor shall furnish, calibrate, and operate equipment capable of producing an accurate profilograph ride index in accordance to test procedures outlined in DelDOT Test Method 13. Prior to use, the Engineer will verify that the equipment selected is capable of producing an accurate, repeatable trace of the roadway. The equipment shall be equipped with a computer-based system capable of calculating the PRI and locating excessive deviations (must-corrects).

Grinding Equipment: Equipment used to perform grinding operations for the correction of excessive deviations shall be self-propelled and contain diamond blades mounted on a multi-blade arbor that has a minimum cutting head width of 36" and that has been designed and approved for grinding pavements. The equipment shall be such that it does not cause strain or damage to the underlying surface of the surface. All slurry or residue resulting from the grinding operations shall be immediately discharged into tank trucks, or other suitable holding tanks, and shall be removed from the project for proper disposal by the Contractor. Grinding equipment that causes excessive raveling, aggregate fractures, spalls, or disturbance of the joints shall not be permitted. Equipment used to perform any grinding operations must have demonstrated previous successful use in grinding similar surfaces.

Construction Methods:

Initial Testing: The Engineer will determine the station counts for the limits of the test segments for all areas subjected to this specification using DelDOT Test Method 13. Each segment will consist of a 328' section. The Contractor shall mark the locations of these limits with approved permanent markings on or in the overlay concrete. This identification may be a scribe mark made at the time of paving into the top surface of the plastic concrete near the side of the slab and shall remain visible until the project is accepted.

Upon completion of the superstructure erection, overlay, and any patching and similar work that may change the smoothness of the riding surface, but before any grinding or similar surface altering work, the Contractor shall test the riding surface of the deck and approach slabs (each wheelpath, in each lane) using equipment meeting the specifications established in this Specification in the presence of the Engineer. The Contractor shall provide 5-business days notice to the Engineer prior to testing.

Results of this initial testing shall be provided to the Engineer within 1 hour of completion of testing. The Engineer will then process the information and provide a summary of test segments indicating areas in need of PRI correction and must-corrects within 7 business days of test completion.

Smoothness Requirements: In addition, the surface shall not have, in the transverse direction, any deviations greater than 0.125" as measured using a 10' straightedge.

Each area having a deviation of more than 0.28"' above a reference line between two points that are up to 25 feet apart is defined as a "must-correct" area. The Engineer will report deviations located from testing by station count where the approximate greatest measured deviation exists. Complete removal of all excessive deviations, whether identified by initial testing or later testing, is required before the area will be considered acceptable.

Before being considered acceptable, each area having an unacceptable PRI must be corrected.

Correction of Excessive Deviations: Any corrective grinding that is to occur shall be performed prior to final grooving of the overlay.

The Contractor shall furnish and use equipment capable of determining the limits of the proposed corrective work. For the precast concrete superstructure deck, the Contractor shall furnish and use a pachometer to locate the top of the embedded steel prior to starting any corrective work. The Contractor shall ensure that minimum cover above the steel (2") and minimum overlay thickness (1") is met after the corrective work has occurred.

Correction Procedures - PRI Improvement: When the Initial PRI is found to be less than 10"/mile (although a negative pay adjustment may be assessed, see Table 1), the Contractor is not to perform any grinding for PRI improvement, and no final testing is required other than that applicable to must-corrects. When the Initial PRI is within the limits requiring additional corrective work (PRI >10"/mile), the contractor must improve the PRI and request final testing.

The Contractor may proceed with PRI correction only after the following steps have been completed:

a. The Contractor has acceptably corrected all "must-correct" areas in the section and presented an acceptable profilograph trace of the full length of the test section verifying this condition to the Engineer for review and approval.

b. The Contractor shall submit to and receive approval from the Engineer for the proposed individual locations of corrective work (limits of work) for the test segment. The Contractor, in attempting to improve the PRI to an acceptable level, shall address the roughest areas within and immediately next to the segment so that an evenly smooth travel way results.

The texture and cross-slope of the surface after PRI improvement work shall conform to the same requirements stated for work at "must-correct" areas. The Engineer reserves the right to reject any area where the Contractor did not conform to the approved improvement plan.

Final Testing: After the Contractor completes PRI improvement work and requests another PRI determination from the Engineer, the Engineer will evaluate the smoothness of the test segment riding surface (but not necessarily before the Engineer has completed outstanding work in determining Initial PRI and validating "must-correct" correction work of other test segments). The result of this evaluation will be a Final PRI. This result will be available to the Contractor within one week (7 business days) of the test being performed. After the Final PRI is requested for a test segment, the Initial PRI cannot be used for payment adjustment for that test segment.

After the Engineer has determined the Final PRI, the Contractor shall request another PRI test when the surface alteration work exceeds a total of 50 ft^2 within the test segment. This requirement does not apply to surface alteration work that is approved work at "must correct" areas. However, other surface alteration work such as full depth patching, partial depth patching, and attempts at PRI improvement require another PRI determination. Whatever the previous value of the PRI for the segment, the Contractor shall request another PRI determination when surface alterations require another PRI test. If any "must-correct" deviations are discovered during Final PRI determination, the Contractor shall correct them before that segment will be accepted for payment. To receive acceptance of any such segment after correction, the Contractor shall request additional testing by the Engineer. The results of the Final PRI testing performed before this correction work will be used to determine the payment adjustment unless the Contractor requests another PRI determination.

Payment Adjustments: Payment adjustments will be made for the deck and approaches containing areas subject to the riding specification.

Values, as calculated from the Payment Adjustment Schedule (Table 1) for a segment's Initial PRI, will be used as a basis for payment adjustment only when the Contractor does not request or require a Final PRI determination.

When the Contractor requests a Final PRI determination after an Initial PRI was determined, or after the Contractor has attempted a correction of the segment's PRI following the initial construction of the test segment, values as calculated from the Payment Adjustment Schedule for a segment's Final PRI will be used.

There may be a negative or a positive adjustment value for each of the test segments (Table 1). The final total adjustment will be the addition of all the individual adjustment values calculated for all of the test segments.

Table 1 - Payment for Tested Surfaces

		Contract Unit Price Adjustment (per yd^2)
Initial Test PRI	Less than 4.0	$1.20
	4.0 to 10.0	($0.30) * (8-Initial PRI)
	Greater than 10	Additional Corrective Work Required
Final Test PRI	Less than 4.0	$1.00
	4.0 to 10.0	($0.30) * (6-Final PRI)
	Greater than 10	Additional Corrective Work Required

Other than through the above described payment adjustment, there will be no additional payment for any work for any attempted corrections of "must-correct" areas, or for the attempted PRI improvement work.

Damage to joint sealant, stripping, etc. caused by corrective work performed on the riding surface shall be acceptably repaired by the Contractor at no additional cost to the Department.

Areas containing spalls, aggregate fractures, disturbed joints, cross-slope discontinuities, or

raveling surfaces shall be repaired by the Contractor at no additional cost to the Department. Corrections to obtain acceptable final surface texture for cross-slope drainage, skid resistance, and appearance shall be performed by the Contractor at no additional cost to the Department.

If the option to perform a blanket grind is selected by the Engineer based on the condition of the roadway after corrective action has taken place, the bonus payment will be calculated using the PRI test results measured after blanket grinding has occurred.

3/11/05

Modified DelDOT Test Method 13: Measuring Pavement Ride Roughness with a Profilograph

This test method matches ASTM E 1274, "Standard Test Method for Measuring Pavement Roughness Using a Profilograph", except for the following additions and modifications:

Background - Overview

The profilograph is a mobile testing instrument designed to register and record deviations of a pavement surface. The profilograph shall be capable of tracing a representation of the pavement profile onto strip-chart paper for permanent record and evaluation. The profile trace shall be drawn automatically by sensing the vertical movement, relative to the 25-foot long frame of the instrument, made by a wheel traveling on the pavement. The sensing wheel shall be a bicycle-type wheel with a 5-foot circumference located at the midpoint of the profilograph frame.

A group of 6 wheels shall support each end of the frame. These wheels shall have no common axle and shall be arranged in a staggered pattern such that no two wheels cross the same bump at the same time. Each wheel group shall be connected to the frame at points 25 feet apart.

Strip-chart paper shall be advanced through the recording device as the profilograph advances over the surface being evaluated. The profile trace shall be drawn in ink as a line with a horizontal scale of 1 inch equaling 25 feet and a vertical scale of one-to-one, i.e., the full amount of deflection is shown along a length that is scaled down by a factor of 300 on the trace. The trace shall be marked to allow distance correlation to the pavement of the test segment.

Unless otherwise directed, the pavement shall be evaluated by guiding the profilograph straight along each outside wheel path of the pavement; for the PCC pavement with multiple lanes, an additional interior pass will be made approximately one foot to the left side of each longitudinal joint (left being relative to the direction of the paving operation); for HMA pavements and rehabilitation work, all other wheel paths shall also be evaluated. The wheel path is located 3 feet from the centerline of the lane being tested.

Changes for ASTM E 1274

Scope

1.1 Add: The supported reference frame shall be 25 feet long; the equipment shall be a California-type profilograph similar to those manufactured by James Cox and Sons, Inc., of Colfax, CA., having a group of six wheels at each end that averages the elevations in the area near each end.

Terminology

3.1.1 Add: The blanking band length will match the length of the test segment. The width of the blanking band is 0.20 inches for new PCC pavement construction and rehabilitation. The blanking band width for new Hot-Mix Asphalt pavement is zero.

Apparatus

5.3 Replace with the following: *Excessive deviation template (optional)* - Clear plastic piece marked with 4 parallel lines of a length of 1.00 inches (plus or minus 0.02 inches) (24.5 to 25.5 mm), spaced at 0.1 inches (2.5mm) on center, all beginning and ending at an imaginary line that is oriented 90 degrees to the ends of the lines.

Calculations

Note 1.Replace with the following: The profilograph trace reduction shall be computerized; the computer's result shall match the results gotten by manually determining the deviations and calculating the roughness index as described herein.

10.1 Apply the blanking band to the test segment represented by the profilograph trace (the record of the surface as produced by the profilograph) so that the maximum number of deviations are covered by the blanking band. With the blanking band in place for each segment, determine the distance that each scallop along the trace extends either above or below the blanking band - representing bumps and dips. Divide the total distance of all deviations determined within the test segment by the total non-exempted length of the test segment, to determine the Profilograph Ride Index (PRI) represented by that trace. Average the values of both wheel paths to determine the PRI for the test segment.

10.2 Apply the excessive deviation template such that the bottom line on the template extends to or beyond the trace line. By comparing points on the profilograph trace to the parallel lines above the bottom line, identify all possible deviations from that line that exceed the tolerance established for excessive deviations.

Report

11.1.2 Replace with the following: Excessive deviation tolerance to the nearest 0.05 inches (1 mm), for example, 0.3 inch.

11.1.3 Replace with the following: Length of each test segment,

11.1.4 Replace with the following: Profilograph Ride Index (PRI) for each wheel path and for the test segment, and

11.1.5 Add the following: Total number of excessive deviations located within each test segment (use the count from both wheel paths).

501531 - BLANKET GRINDING OF OVERLAY CONCRETE

Description:

This work shall consist of furnishing diamond grinding equipment to perform a "blanket" grind of the overlaid concrete deck surface and approach slabs in accordance with these special provisions, notes and details in the Plans, and as directed by the Engineer.

The Contractor shall employ grinding methods that will produce a visually consistent deck surface while maintaining or improving rideability criteria established in Special Provision 501530.

Material Requirements:

Measurement Equipment: The Contractor shall furnish, calibrate, and operate equipment capable of producing an accurate profilograph ride index (PRI) in accordance to test procedures outlined in DelDOT Test Method 13 (Modified). Prior to use, the Engineer will verify that the equipment selected is capable of producing an accurate, repeatable trace of the deck surface. The equipment must be equipped with a computer based system capable of calculating the PRI and locating excessive deviations

Grinding Equipment: Grinding shall be done using self-propelled machinery containing diamond blades, mounted on a multi-blade arbor with a minimum cutting head width of 36" that has been designed and approved for grinding pavements. The equipment shall be such that it does not cause strain or damage to the underlying surface of the deck. Grinding equipment that causes excessive raveling, aggregate fractures, spalls, or disturbance of the joints shall not be permitted. All slurry or residue resulting from the grinding operations shall be immediately discharged into tank trucks, or other suitable holding tanks, and shall be removed from the project for proper disposal by the Contractor. Equipment used to perform any grinding operations must have demonstrated previous successful use in grinding similar surfaces.

Construction Methods:

Blanket Grinding: The Contractor shall ensure, prior to transverse grooving operations that all areas of overlaid surface consist of a uniform texture. This shall be accomplished by performing a blanket grind of the overlay concrete.

After the blanket grinding operations, the overlaid deck surface shall again be tested in accordance to Special Provision 501530.

~~Basis of Payment:~~

~~The payment for item "Blanket Grinding of Overlay Concrete" shall be made for at the Contract Unit Price which price and payment shall be full compensation for furnishing and operating the grinding/scarification equipment; all testing equipment and personnel necessary to operate the equipment; and the removal and disposal of slurry or residue from the operations; and for all labor, equipment, tools, and incidentals necessary to complete the work.~~

~~Final adjustments to the payment will be executed by change order.~~

3/11/05

600501 - BRIDGE CONSTRUCTION REQUIREMENTS

1.0 GENERAL

The following provisions shall apply to the bridge erection, temporary supports and falsework, cable installation, and geometric controls. The cable-stay references shall apply to all cable-supported structures as appropriate.

A) The erection of the structure and the field workmanship shall be in accordance with the best practice and shall conform to the Performance Specifications and Special Provisions.

B) The safe erection of the structure is the sole responsibility of the Design-Builder.

C) The Design-Builder shall submit complete, detailed and checked shop and erection drawings of his proposed erection sequence, including complete and checked erection design calculations to the Department for review and comment. The review and comment by the Department of the Design-Builder's erection sequence and Plans shall not relieve the Design-Builder from his responsibility for performing the work required by this Special Provision and the Contract Documents.

D) The following items shall be performed by the Design-Builder and submitted to the Department for review:

1) Complete, detailed erection sequence drawings are required. Erection and erection wind stresses in permanent and temporary members including temporary piers and false work reactions shall be determined for each stage. Moments, shears, axial loads and other forces shall be computed and tabulated for all pertinent members at a sufficient number of points to demonstrate that the load demand will not exceed the capacity or allowable stresses for each stage of the erection. Details of contemplated elevations, cable-stay lengths, adjustments etc. required shall also be shown for each stage. If final cable-stay adjustments are required after superimposed dead loads are placed, the Design-Builder shall take proper steps to prevent unintended stiffness created by superimposed dead loads (e.g. parapets and barriers) from affecting the accuracy of stay cable adjustment.

2) The Design-Builder shall prepare, check and then submit detailed shop and erection drawings to the Department for review and comment.

3) All submittals by the Design-Builder shall be submitted sufficiently in advance of the start of construction as to allow for review and resubmission if required. The review shall be conducted in accordance with Part 2 – DB Section 111 of the Contract Documents.

E) The Design-Builder shall meet with the Department to discuss the proposed erection procedure, erection design criteria, and structure capabilities to support the proposed erection scheme. The Department will review the preliminary erection procedure proposal for general compliance with the contract requirements.

F) The Design-Builder shall develop and submit to the Department a complete description and stress calculations of the proposed process and sequence of erection including positions and weights of equipment at each position and at each stage in sufficient details to allow review of the effects of the erection procedure on the structure.

G) The Design-Builder shall submit to the Department for review and comment the detailed design of all erection equipment, falsework, temporary bracing and other items required for erection.

H) The Design-Builder shall ensure the intermediate static and dynamic stability of the structure is adequate for the various stages of the construction. To fulfill this requirement, the Design-Builder may have to construct temporary support bents or install auxiliary cables to stabilize the bridge. Such cables or other means shall not be permitted within the waters of the Indian River Inlet or within the clearance envelope required over the navigable waterway.

Should stabilization be required, the Design-Builder shall develop a scheme for stabilizing the cable-stayed structure against wind loads at all construction stages. All details and layouts of any tie down assembly including all connections, foundation elements, and material properties shall also be submitted to the Department for review and comment.

I) All computations shall be prepared, signed and sealed by a Professional Engineer registered in the State of Delaware who is experienced in the design and construction of the proposed bridge type. Calculations shall be submitted in a neat organized manner that is easy to follow.

J) The Design-Builder will be responsible for determining and monitoring forces and deflections in the permanent structure at all erection stages as are caused by his proposed erection process.

K) No construction work shall be performed until the Design-Builder's erection sequence is totally reviewed and approved in writing by the Quality Control Manager and any related Non-Conformance Report items have been resolved with the Department. The erection sequence must be consistent with the design.

L) Any subsequent modifications to the structure for erection purposes shall be submitted to the Department for review. The Design-Builder shall demonstrate that such modifications will have no adverse effect on the completed structure. Any additional materials required shall be provided at no cost to the Project. Completed details and stress computations will be required for all revisions to the Plans. The Design-Builder shall submit for Department review all proposed modifications to details shown on the Plans. No such work shall be performed until it is also reviewed and approved in writing by the Quality Control Manager and any related Non-Conformance Report items have been resolved with the Department.

1.1 CABLE-STAY INSTALLATION

Cable-stay installation shall conform to the Performance Specification for *Cable-Supported Bridge System Requirements* and the provisions below.

A) Cable-stays shall be installed in accordance with an engineered cable installation procedure prepared by the Design-Builder that shall prescribe cable force and elongation for the installation of each cable-stay. The engineered procedure shall include consideration of actual construction loads and static conditions at the time of cable-stay installation.

B) Changes to construction and erection sequence or procedure from those assumed in the development of the cable-stay procedure shall be incorporated in revisions to the cable-stay installation program.

C) Jacks and gauges for cable-stay installation shall be calibrated using a load cell or calibrated static load machine within one month prior to the beginning of the cable-stay installation, and every 6 months thereafter, for the duration of cable-stay installation. The 6-month recalibration may be performed using a master gauge, provided that the master gauge is calibrated with the field gauges at the time of initial jack calibration.

D) The cable-stay installation program shall prescribe both force and cable elongation, for each jacking operation, and shall establish the priority of force over elongation for control of the jacking operation. This program shall stipulate the permissible variance between force and elongation for each cable to be installed.

E) A strand and cable force verification method shall be utilized. The verification procedure shall be performed by an independent Subcontractor (i.e., independent of the Design-Builder and stay cable system supplier). A laser-based force measurement system shall be used for this purpose. The forces in individual strands shall also be measured in the laboratory on the cable-stay systems to be tested for fatigue and strength. This will verify the uniformity of strand forces. The forces in all cable-stays shall be measured after completion of stay erection iterations for comparison with the Designer's predicted and erection tabulated forces. The Design-Builder shall develop procedures to ensure that the initial stressing is equalized for all tensile elements in a given cable-stay within a range of 2.5%.

F) The cable-stay installation procedure shall include provisions for monitoring the installation of each cable.

G) 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; lock nut setting; and all other special notations necessary and sufficient to establish the conditions under which the cable was installed.

1.2 FALSEWORK

Temporary supports and/or falsework may be required to erect the structure. Falsework shall be properly designed for all anticipated loads obtained from stage-by-stage erection analyses. The Design-Builder shall submit detailed Plans for all falsework to be used showing all loadings assumed by the Design-Builder's design. Review of the Plans by the Department shall not relieve the Design-Builder of his responsibility for the Work.

1.3 GEOMETRIC CONTROLS AND LOADS

A) The Design-Builder shall be responsible for geometric control of construction so that the completed structure will conform to the lines, grades, and dimensions and cable stresses on the Plans. The Design-Builder shall furnish, on-site, competent engineering and surveying personnel and equipment to establish and verify elevations and alignment of the structure and cable-stays at every stage of construction. The Design-Builder shall be responsible to determine the need for the amount of adjustments that may be required in the erection stages. The Department shall be provided the opportunity to review and comment on each such use of adjustments in advance of its implementation.

B) At the reference temperature (e.g. 70° F) shown on the Plans, the structure shall have a geometric configuration that is in general conformance with the dimensions shown on the Plans for the dead load conditions. The target elevations and loads during each erection stage shall be adjusted to account for the actual temperature at the time of construction. The Design-Builder shall provide sufficient computations and analyze the structure with sufficient detail to reasonably assure that final adjustments can be made to also obtain the target dead load cable stress and deck elevations defined in the Plans with the following tolerances:

1) Absolute tolerance in deck elevation at the centerline of bridge at center span shall be ± 5.5", provided that the deck elevation at cable attachment points follows, within a tolerance of ± 1" (unless a tighter tolerance is required to satisfy drainage) the elevation based on the bridge cross-slope. A smooth parabolic

curve shall pass through the final deck elevation at the centerline of the bridge and the deck elevation at the end of the cable-stayed span and be within 1”at all other points along the bridge. In no case, shall the bridge deck elevation tolerance allow for the low chord of the bridge, or any of its attachments, to extend within the clearance envelope over the navigable waters of the Indian River Inlet.

2) Cable-stays shall be adjusted for the dead load condition such that each individual cable shall not exceed values of ± five percent (5%) of the cable dead load computed and shown on approved Working Drawings. It is possible that one individual cable may have to be adjusted to lesser tolerances to prevent stress in other cables from exceeding the ± five percent (5%) tolerance.

3) Final fabrication lengths for the cable-stays shall be calculated by the Design-Builder after erection loads and methods are known and detailed erection stress calculations have been completed. The tolerance in the fabrication length of the cable in the unstressed condition shall be as follows:

Length between bearing faces (ft)	Permissible tolerance (inches)
150	plus 1.0, minus 0.0
300	plus 1.5, minus 0.0
500 and over	plus 2.0, minus 0.0

C) The Design-Builder shall prepare and furnish to the Department complete detailed erection sequence drawings.

D) Based on the Design-Builder's construction equipment and procedures, the Design-Builder shall compute and prepare tables of anticipated cable tensions in each cable at corresponding stages of erection of the bridge including, but not limited to the stages immediately:

1) Before and after erection of precast segments or completion of in-situ casting of segments;

2) Before and after each cable-stay stressing operation;

3) After full dead load including concrete parapets and concrete overlay; and

4) After completion of all time dependent behavior (i.e. day 10,000).

E) The tables of anticipated cable tensions and computations shall be submitted to the Department for review and comment.

F) If as-built cable forces exceed the design forces as shown in the Plans, the Design-Builder shall investigate adequacy of all cable components and anchorages. Cost for all and any additional engineering, field work and material required shall be borne by the Design-Builder.

G) As part of the Design-Builder’s Quality Control requirements, the tension in each cable shall be checked at intermediate stages of the superstructure erection to ensure that it is within the anticipated range. Any cable requiring adjustment at these intermediate stages shall be properly adjusted.

H) Each cable-stay anchoring at the same segment (and/or station) of deck shall be installed and stressed simultaneously. The difference in force in the cable-stays at any time shall not exceed five percent (5%) of the corresponding design cable forces.

I) Promptly after erection of each cable, the tension in the cable shall be checked to ascertain that it is within the range of anticipated tension for the corresponding stage of superstructure erection. Maximum cable tension during construction shall not exceed fifty-six percent (56%) of the cable's guaranteed ultimate tensile strength.

J) Cable-stays shall be erected at the appropriate times to suit the Design-Builder's erection scheme.

K) The Design-Builder's cable installation procedure shall specify which is the live (stressing) end anchorage of the cable, i.e. at the tower anchorage or deck girder anchorage, and the live end anchorage shall be detailed to provide for future cable replacement.

L) Cable-stay anchorages shall allow for future force adjustments (increase or decrease) of 2.5% of the guaranteed ultimate strength of the cable-stay without the use of shims. The Design-Builder shall include in the cable-stay installation plan fully developed details and procedures for removing/detensioning strands and re-installing strands.

M) Care shall be exercised during cable erection to prevent damage to the sheathing and to prevent damage to the other components of the cable-stay. All damage to the sheathing or cable components shall be immediately repaired to the satisfaction of the Department. Damaged sheathing and components shall be replaced, at the Design-Builder's expense.

N) Cable-stays shall be installed so that there are no wedge marks within the stressed portion of any strand. Any strand that results with wedge marks on the permanently stressed portion of the strand shall be replaced.

1.4 SPAN CLOSURES

A) To make up the closure pours, the ends of the bridge shall be brought into vertical, horizontal and cross-slope alignment by jacking, counterweighing or adjusting selected cable-stays. This shall be included in the Design-Builder’s erection scheme submitted to the Department for review and comment.

B) After the closure concrete has attained the required strength and other construction operations have been completed as necessary, certain selected cable-stays shall be adjusted to produce the required stresses in the structure.

C) Upon completion of final post-tensioning, closure concrete and the placement of the concrete parapets and overlay, the cable-stays shall be adjusted as required to their planned tension.

D) After all final adjustments have been made, wedges shall be post-blocked.

E) Fully developed details for side span and central span closures, including placement of alignment devices as required, jacking, and counterweighing and stay cable adjustments shall be included in the Design-Builder's erection scheme submittal to the Department.

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602543 - FURNISHING LATEX MODIFIED CONCRETE
602544 - CONSTRUCTING LATEX MODIFIED CONCRETE OVERLAY

Description:

The item "Furnishing Latex Modified Concrete" shall consist of furnishing latex modified Portland cement concrete (hereafter referred to as overlay concrete) at the site of construction; and the item "Constructing Latex Modified Concrete Overlay" shall consist of preparing, placing, consolidating, curing, and texturing the latex modified concrete on the bridge deck and/or other specified areas in accordance with these specifications, applicable requirements of Section 602 of the Standard Specifications, and notes on the Plans and as directed by the Engineer.

The overlay shall be constructed as a single monolithic element of the structure with respect to depth. Any joints between placements shall be placed to not be within the wheel paths of the traffic. The overlay shall be uniform, strong, dense, and well-bonded to the existing deck, and shall have a smooth, free-draining, crack-free surface.

Materials:

Cement shall be either Type I or II, non-air entraining Portland cement conforming to Section 801. It shall be stored in a suitable weatherproof enclosure which will protect the cement from dampness.

Fine Aggregates shall conform to Section 804.

Coarse Aggregate shall conform to Section 805 of the Standard Specifications, except that only non-carbonate rock shall be used, and that its percentage of wear (Los Angeles Test - AASHTO T96) shall be not more than 30%. Non-carbonate rock shall be understood to be rock from any one of the following geological classifications: trap rock, granite, gneiss, quartzite or argillite. The use of serpentine aggregate shall not be permitted. The coarse aggregate grading shall conform to the requirements of Section 813, Delaware Number 8.

Coarse and fine aggregate shall be stored separately in such a manner as to avoid contamination with each other or with foreign matters and also avoid frequent variation in its moisture content.

Water shall conform to the requirements of Section 803.

Latex Modifier for Concrete shall be non-toxic, film forming, polymeric emulsion to which all stabilizers have been added at the point of manufacture, and shall be homogeneous and uniform in composition.

Mix Design

Latex concrete shall be composed of Portland Cement Type I, coarse and fine aggregates, and a non-toxic polymer emulsion prepared in accordance with these Special Provisions.

After the materials furnished by the Contractor have been submitted for the project, the actual batch weights will be designed by the Contractor based on tests in accordance with the limits shown in Table 1 of these Special Provisions. The design shall be submitted to the Engineer for approval. The proportions will be stated in terms of aggregates in a saturated surface-dry condition, and the batch weights will have to be adjusted periodically to take into account the actual moisture of the aggregates at

the time of use.

The proportions and the slump for the latex concrete as submitted to, and approved by the Engineer, shall not be changed during the progress of the work; nor shall a change in the source or character of the material be made, until the Engineer has accepted such materials, and/or new proportions based on tests for the mix is resubmitted by the Contractor to the Engineer's approval.

The design mix for the latex concrete shall be as noted below in Table 1:

TABLE 1

	Latex Modified Concrete Mix
Formulated Latex - gallons/sack of cement	3.50
Percent of Fine Aggregate as percent of Total Aggregate by weight	50 - 60
* Weight ratio of cement: fine aggregate: Coarse aggregate dry basis (agg.Sp.Gr. 2.65)	1.0:2.5:2.0
Air Content - Maximum Percent of Plastic Mix (there is no minimum)	6 1/2 %
** Slump B inches	4 - 6
Water - cement ratio	0.40 Max.
Minimum compressive strength @ 28 days	4000 psi
* The dry weight ratios are approximate and should produce good workability but due to gradation changes may be adjusted within limits by the Engineer. The fine aggregate ratio may be increased by as much as 0.2 if the coarse aggregate is reduced by an equivalent volume.	
** The slump shall be measured 4 to 5 minutes after discharge from the mixer. During this waiting period, it shall not be disturbed. Care shall be exercised that traffic vibrations do not affect the measurement.	

Chloride permeabilities shall be no greater than 1500 coulombs when tested according to the Virginia Modified Method of AASHTO T277. The permeability test samples will be field-cast cylindrical specimens with a 4" diameter and at least 4" in length. They will be air cured at a temperature of 73 ± 3□F for one week and the last three weeks of the air cure will be at 100 ± 9□F. Cylinders will be tested at 28 days in accordance with the AASHTO T277 Test Method.

Construction Methods:

All equipment for surface preparation, mixing, placing, and finishing of the latex concrete shall be approved by the Engineer prior to the start of any work.

Proportioning and mixing equipment shall be a self contained, mobile, continuous mixing type subject to the following:

a. The mixer shall be self-propelled and be capable of carrying sufficient unmixed dry, bulk cement, sand, coarse aggregate, latex modifier and water to produce on the site not less than 6 cubic yards of modified Portland Cement Concrete.

b. The mixer shall be capable of positive measurement of cement being introduced into the mix. A recording meter shall be visible at all times, and equipped with a ticket print-out shall indicate the quantity.

c. The mixer shall provide positive control of the flow of water and latex emulsion into the mixing chamber. Water flow shall be indicated by flow meter and be readily adjustable to provide for minor variations in the moisture of the sand and aggregate.

d. The mixer shall be capable of being calibrated to automatically proportion, and blend all components of indicated composition on a continuous or intermittent basis as required by the finishing operation, and shall discharge mixed material through a conventional chute directly in front of the finishing machine.

e. The mixer shall be capable of spraying water over the entire placement width, as it moves ahead to insure that the surface to be overlaid is wetted prior to receiving the latex concrete.

f. Mixers shall be calibrated to accurately proportion the specified mix. Certification of the calibration by approved testing laboratory will be accepted, as evidence of this accuracy if the yield is shown to be true within a tolerance of 1.0 percent according to the following test:

With the cement meter set on zero and all controls set for the desired mix activate the mixer discharging mixed material into a 0.25 cubic yard container - 36" x 36" x 9". When the container is level-struck full, making provision for settling the material into all corners, the cement meter must show a discharge of 1.875 bags of cement.

An approved finishing machine complying with the following requirements shall be used for finishing the wearing surface:

1. The finishing machine shall be self-propelled and capable of forward and reverse movement under positive control. Provision shall be made for raising all screeds to clear the screeded surface for traveling in reverse. An approved self-propelled finishing machine with one or more rotating rollers, augers, and 1,500 to 2,500 VPM vibrating pans may be used. Any modification shall be subject to approval by the Engineer.

2. Supporting rails upon which the finishing machine travels will be required and shall be sufficiently rigid so that they do not deflect under the weight of the machine. When placing overlay concrete in a lane abutting a previously completed lane, that side of the finishing machine adjacent to the completed lane, shall be specially equipped to travel on the completed lane.

Mixing of Materials

The applicable provisions of Section 602 and 812 of the Standard Specifications shall apply with the following exceptions and additional provisions:

The overlay concrete shall be thoroughly mixed in an approved mixer at the site. Mixers shall be clean and the ingredients accurately proportioned. The ingredients shall be added to the mixer in accordance with the recommendations of the manufacturer of the latex modifier.

Bags or other containers holding ingredients, including those identified by the manufacturer as dissolving or breaking during mixing, shall not be placed in the mix.

The mixing time shall be the minimum needed to secure the air content and slump desired, and in accordance with the recommendations of the manufacturer of the latex modifier.

The overlay concrete shall be, when discharged from the mixer, uniform in composition and consistency. Mixing capacity shall be such that finishing operations can proceed at a steady pace with final finishing operations completed before the formation of the plastic surface film.

Surface Preparation

If required in the Plans, the Contractor shall scarify the existing deck to a depth of 1/4". After this initial removal, the Contractor shall sound the deck and outline areas of unsound concrete for removal, subject to the approval of the Engineer. Removal and repair work below the initial 1/4" of scarification will be measured and paid for under other items of work in this Contract.

On any bridge decks or approach slabs where a hot mix surface is removed, and no additional concrete milling is specified, the Contractor shall scarify the exposed concrete surface an additional 1/8" to 1/4" in depth to remove all hot mix latency prior to sounding the concrete as specified above and final cleaning as specified below. Cost of the scarification shall be incidental to item 602544.

Any portions of bridge decks or approach slabs that have a smooth surface shall be scarified to a depth 1/8" to 1/4" prior to placing the latex concrete overlay. It is the intent that the surface to receive the overlay has a sufficiently rough texture to assure a good mechanical bond between the existing concrete and the latex concrete overlay. Cost of the scarification shall be incidental to Item 602544.

Not more than 24 hours before placement begins, the entire surface of the bridge deck and the areas to receive latex concrete shall be thoroughly cleaned by shot or grit blasting. The edge of any previously placed lanes of concrete overlay shall be blasted to remove the trowel cut surfacing to promote bond. If necessary to remove rust, oil or other foreign materials detrimental to achieving bond, detergent cleaning followed by shot or grit blasting and air blast cleaning shall be used. Immediately prior to placement of latex modified concrete, the clean surface shall be thoroughly hosed down with water and kept wet for a period of not less than one hour. Any standing water in depressions, holes or area of concrete removal shall be blown out with compressed air free of oil. The Contractor shall take all necessary precautions with the deck preparations to ensure a good bond with the overlay.

Contamination of the cleaned and wetted deck shall be prevented by placement of a clean 4 mil (minimum) thick polyethylene film (or other covering as approved by the Engineer) completely covering the surface of the deck to be overlaid.

Transverse and longitudinal joints of previously placed overlay shall be sawn to straight and vertical edges before overlay is placed against them.

Limitations of Placing Overlay Concrete

The Contractor shall be responsible for the quality of the concrete placed in any weather or atmospheric conditions. A smooth, durable riding surface of uniform texture, true to the required grade and cross-section, shall be obtained on all bridge decks.

The overlay concrete shall not be placed when rain is forecast within the intended working

period. Adequate preparations shall be made to provide protection of the freshly placed overlay in the event of sudden or unexpected rain. If rain occurs during placing of the overlay, all operations other than protection of the already placed overlay shall immediately cease. Materials damaged by the rain shall be rejected and replaced at no additional cost to the Department.

The overlay concrete shall be placed only when the local ambient temperature is above 45°F for the entire curing period. The overlay shall not be placed if the ambient air temperature is 85°F, or higher or predicted to go above 85°F during the overlay placement regardless of the surface evaporation rate. The overlay concrete shall not exceed 85°F.

The overlay concrete shall be placed only if the overlay surface evaporation rate, as affected by ambient air temperature, concrete temperature, relative humidity, and wind velocity, is 0.15 pound per square foot per hour or less. The Contractor shall determine and document the atmospheric conditions, subject to verification by the Engineer. The chart contained in "Plastic Cracking of Concrete" by Delmar Bloem for the National Ready Mixed Concrete Association, and published in ACI 305R-89, shall be used to determine the loss of surface moisture for the overlay. The chart may be obtained from the Department's Materials and Research Section.

An overlay shall not be placed adjacent to a previous overlay which has cured for less than 3 cure-days.

Placement of Overlay Concrete

Placement shall conform to applicable requirements of Section 602. The maximum overlay depth placement, per lift, shall be 2°.

Prior to placing the concrete overlay, the Contractor shall schedule a "Preplacement Meeting" with the Engineer to discuss the plan and procedure for the work. This discussion shall acceptably establish the Contractor's ability to place the overlay on a continuous basis and to consolidate, finish, texture, and commence curing within the time intervals specified.

If placement of the overlay is to be made at night, the Contractor shall submit a plan which provides adequate lighting for the work area. The plan shall be submitted at least 15 calendar days in advance and be approved by the Engineer before concrete is placed. The lights shall be so directed that they do not adversely affect traffic.

The latex manufacturer’s technical representative shall be present during the placement of the overlay at no additional cost to the Department. Work which is considered by this representative as being detrimental to the integrity of the overlay will be rejected.

The maximum time allowed between the start of mixing to the completion of discharge of the overlay concrete at the worksite shall be sixty minutes (both when used as grout or as overlay).

Immediately before the overlay is placed, the concrete surfaces shall be cleaned with an air blast (oil free), cleared of any standing water, and then covered with a coating of bonding grout. The grout shall consist of the overlay, placed and brushed onto the deck. The coarse aggregate shall be removed from the deck. The overlay shall be placed only when the existing deck is "surface dry". The grout shall be scrubbed onto surface dry decks (surfaces which are dry enough to absorb some of the moisture from the grout with enough care to ensure that all surfaces are evenly covered and that excess grout will not collect in low areas. The bonding grout shall be applied for only a short distance in advance of the placement of the overlay. Reapplication is required when the grout dries prior to overlay placement.

The maximum allowable time between the discharge and the final finishing of the overlay concrete shall be ten minutes.

A construction dam or bulkhead shall be installed in case of major delay in the placement operation exceeding one hour in duration. During minor delays of one hour or less the end of the placement may be protected from drying with several layers of wet burlap.

If overlay concrete placement is stopped or delayed for a duration of 90 minutes or more, further placement shall be discontinued and may not resume until after a period of not less than 12 hours. This restriction does not prohibit continuation of placement provided a gap is left in the lane. The gap shall be sufficient in length for the finishing machine to clear the previously placed concrete.

Consolidating and Finishing Overlay Concrete

Immediately following application of the bonding grout, the overlay shall be placed, consolidated and finished to the Plan grades with vibrating devices. Spud vibration will be required in deep pockets, edges and adjacent to joint bulkheads. Hand finishing with a float may be required along the edge of the pour or on small areas of repair. Edge tooling is required at joints, except next to metal expansion dams, curbs, and previously placed lanes

A 10' straightedge shall be supplied and used by the Contractor to check the overlay directly behind the finishing machine. It shall also be used to check transversely along the edges of the overlay where hand finishing is done. Any irregularities exceeding 1/8" in 10' shall be corrected immediately. Any ponding problem which is noted prior to final acceptance of the overlay shall be corrected by the Contractor at no cost to the Department. The Contractor shall test the overlay concrete surface for smoothness in accordance with Subsection 602.20 of the Standard Specifications.

Curing the Overlay Concrete

As soon as the finishing operation is completed, the finished overlay surface shall be covered with a layer of clean, fully wet, saturated, burlap. After initial set, a 4 mil (minimum) thick white opaque polyethylene film shall completely cover and seal the wet burlap to maintain a 100% relative humidity environment for a period of 2 cure-days (a cure-day shall be defined as a 24 consecutive hour period of time). The curing material shall then be removed for an additional 72 hours of air cure. Wet burlap-polyethylene sheets may be substituted for the polyethylene film with the approval of the Engineer but shall not replace the initial wet burlap.

The temperature at the overlay surface shall be maintained above 35°F until the curing period is completed. Any day during which the air temperature at the overlay surface falls below 45°F shall not be counted as a cure-day.

Any cracking which occurs prior to opening to traffic shall be sealed or repaired in a manner approved by the Engineer at no cost to the Department. The deck shall be sounded and any delaminated areas removed and replaced at no cost to the Department.

Traffic will not be permitted on the finished overlay surface until after the wet burlap cure period is complete.

The surface shall be textured in accordance with Subsection 602.20.

Any improperly cured overlay is subject to replacement at no cost to the Department.

~~**Method of Measurement:**~~

~~The item "Furnishing Latex Modified Concrete" will be measured by the cubic yard as determined from the theoretical yield of the design mix and documented by the ticket printout of the cement used and the yield tests performed. Material wasted or rejected due to any cause will not be paid for.~~

~~The item "Constructing Latex Modified Concrete Overlay" will be measured by area in square yard regardless of the depth of the placed mixture. The actual area finished and accepted will be measured, exclusive of areas of metal expansion dams exposed.~~

~~**Basis of Payment:**~~

~~The payment of the item "Furnishing Latex Modified Concrete" shall be made for at the Contract unit price bid per cubic yard, which price and payment shall be full compensation for furnishing, hauling and storing all latex modified concrete materials at the job site, for all labor, equipment, tools, and necessary incidentals to complete the work.~~

~~The payment for the item "Constructing Latex Modified Concrete Overlay" shall be made for at the Contract unit price bid per square yard, which price and payment shall constitute full compensation for the preparation of the area to receive latex modified concrete including scarifying, shot or grit blasting, removal of rust, oil and other contaminants, protection of area, bonding grout, placing of latex modified concrete, consolidating, curing, and texturing and for all labor, equipment, tools, and incidentals necessary to complete the work.~~

NE - 3/17/05

602583 - FURNISHING MICRO-SILICA MODIFIED CONCRETE
602584 - CONSTRUCTING MICRO-SILICA MODIFIED CONCRETE OVERLAY

Description:

The item "Furnishing Micro-Silica Modified Concrete" shall consist of furnishing micro-silica modified Portland cement concrete (hereafter referred to as overlay concrete) at the site of construction; and the item "Constructing Micro-Silica Modified Concrete Overlay" shall consist of preparing, placing, consolidating, curing, and texturing the micro-silica modified concrete on the bridge deck and/or other specified areas in accordance with these specifications, applicable requirements of Section 602 of the Standard Specifications, and notes on the Plans and as directed by the Engineer.

The overlay shall be constructed as a single monolithic element of the structure with respect to depth. Any joints between placements shall be placed to not be within the wheel paths of the traffic. The overlay shall be uniform, strong, dense, and well-bonded to the existing deck, and shall have a smooth, free-draining, crack-free surface.

Materials:

Micro-silica Components:

A. Micro-silica (silica fume) shall conform to AASHTO M307

B. Cement shall be either Type I or II, non-air entraining Portland cement conforming to Section 801.

C. Fine Aggregates shall conform to Section 804.

D. Coarse Aggregates shall conform to Section 805, except that only non-carbonate rock shall be used, and that its percentage of wear (Los Angeles Test - AASHTO T96) shall be not more than 30%. Non-carbonate shall be understood to be rock from any one of the following geological classifications: trap rock, granite, gneiss, quartzite, or argillite. The use of serpentine aggregate shall not be permitted. The grading shall conform to Section 813, Delaware No. 8.

E. Air Entraining Agents shall conform to AASHTO M154.

F. Water shall conform to Section 803.

G. High Range Water Reducer shall conform to ASTM C 495.

H. Fiber Reinforcement shall conform to ASTM C 1116, Type III with a minimum fiber length of 2" and a maximum length of 1 1/2".

I. Evaporative Retardant shall be a product specifically marketed for the use of retarding evaporation from a concrete surface; plain water is not acceptable.

Mix Design

The mix design shall be performed by the Contractor based on the submitted component sources; the overlay concrete shall conform to Section 812, Class A, except for the following modifications:

A. Water/ (Cement & Micro-silica) Ratio - Maximum 0.40
B. Micro-silica - 7% of the weight of Portland cement
C. Slump B 4 to 6 inches
D. Air Content - 4% to 7%
E. Compressive Strength - Minimum 4000 psi @ 28 days
F. Chloride permeabilities shall be no greater than 1500 coulombs when tested according to the Virginia Modified Method of AASHTO T277. The permeability test samples will be field-cast cylindrical specimens with a 4" diameter and at least 4" in length. They will be air cured at a temperature of 73 ± 3□F for one week and the last three weeks of the air cure will be at 100 ± 9°F. Cylinders will be tested at 28 days in accordance with the AASHTO T277 Test Method.
G. Fiber Reinforcement Content - 1.5 lb/yd³

NOTE: The Contractor shall obtain a written statement from the manufacturer of the micro-silica that it is compatible with the other materials from the sources proposed by the Contractor and acceptable in the sequence in which they will be combined.

The overlay shall be centrally batched, and shall be mixed in a central mixing plant or by mixer-trucks capable of producing a workable mixture of uniform composition and consistency. Batching and mixing equipment shall conform to Section 812. Admixtures shall be introduced into the concrete in such a manner that will disperse it throughout the entire load. The mixer-truck charge shall be limited to a maximum of 75 percent of its rated capacity or to 6 cubic yards, whichever is smaller.

Bags or other containers holding ingredients, including those identified by the manufacturer as dissolving or breaking up during mixing shall not be placed in the mix.

Air entrainment and slump of the first material delivered to the deck will be determined by the Engineer. The overlay will not be placed until acceptability of the production has been verified.

Construction Methods:

All equipment for surface preparation, mixing, placing, and finishing of the concrete overlay shall be approved by the Engineer prior to the start of any work. This equipment includes the following:

A. Power-driven scarifier;
B. Chipping hammers (maximum nominal 35 lb. class);
C. Abrasive blaster;
D. Overlay mixer-trucks;
E. Mechanical fogger; and
F. Finishing machine

An approved finishing machine complying with the following requirements shall be used for finishing the wearing surface

1. The finishing machine shall be self-propelled and capable of forward and reverse movement under positive control. Provision shall be made for raising all screeds to clear the screeded surface for traveling in reverse. An approved self-propelled finishing machine with one or more rotating rollers, augers, and 1,500 to 2,500 VPM vibrating pans may be used. Any modification shall be subject to approval by the Engineer.

2. Supporting rails upon which the finishing machine travels will be required and shall be

sufficiently rigid so that they do not deflect under the weight of the machine. When placing overlay concrete in a lane abutting a previously completed lane, that side of the finishing machine adjacent to the completed lane, shall be specially equipped to travel on the completed lane.

The Contractor shall provide access to the Engineer in order to obtain grade/elevation survey information before and after deck preparation has been performed.

Surface Preparation

If required in the Plans, the Contractor shall scarify the existing deck to a depth of 1/4". After this initial removal, the Contractor shall sound the deck and outline areas of unsound concrete for removal, subject to the approval of the Engineer. Removal and repair work below the initial 1/4" of scarification will be measured and paid for under other items of work in this Contract.

On any bridge decks or approach slabs where a hot mix surface is removed, and no additional concrete milling is specified, the Contractor shall scarify the exposed concrete surface an additional 1/8" to 2" in depth to remove all hot mix latency prior to sounding the concrete as specified above and final cleaning as specified below. Cost of the scarification shall be incidental to Item 602584.

Any portions of bridge decks or approach slabs that have a smooth surface shall be scarified to a depth 1/8" to 2" prior to placing the micro-silica concrete overlay. It is the intent that the surface to receive the overlay has a sufficiently rough texture to assure a good mechanical bond between the existing concrete and the micro-silica concrete overlay. Cost of the scarification shall be incidental to Item 602584.

Not more than 24 hours before placement begins, the entire surface of the bridge deck and areas to receive micro-silica modified concrete shall be thoroughly cleaned by shot or grit blasting. The edge of any previously placed lanes of concrete overlay shall be blasted to remove the trowel cut surfacing to promote bond. If necessary to remove rust, oil or other foreign materials detrimental to achieving bond, detergent cleaning followed by shot or grit blasting and air blast cleaning shall be used. Immediately prior to placement of micro-silica modified concrete, the clean surface of the entire deck shall be thoroughly hosed down with water and kept wet for a period of not less than six hours. Any standing water in depressions, holes or areas of concrete removal shall be blown out with compressed air free of oil prior to placing the overlay concrete. The Contractor shall take all necessary precautions with the deck preparations to ensure a good bond with the overlay.

Contamination of the cleaned and wetted deck shall be prevented by placement of a clean 4 mil (minimum) thick polyethylene film (or other covering as approved by the Engineer) completely covering the surface of the deck to be overlaid.

Transverse and longitudinal joints of previously placed overlay shall be sawn to straight and vertical edges before overlay is placed against them.

Limitations on Placing the Overlay Concrete

The Contractor shall be responsible for the quality of the concrete placed in any weather or atmospheric conditions. A smooth, durable riding surface of uniform texture, true to the required grade and cross-section, shall be obtained on all bridge decks

The overlay concrete shall not be placed when rain is forecast within the intended working

period. Adequate preparations shall be made to provide protection of the freshly placed overlay in the event of sudden or unexpected rain. If rain occurs during placing of the overlay, all operations other than protection of the already placed overlay shall immediately cease. Materials damaged by the rain shall be rejected and replaced at no additional cost to the Department.

The overlay concrete shall be placed only when the local ambient temperature is above 45° for the entire curing period. The overlay shall not be placed if the ambient air temperature is 85°F, or higher or predicted to go above 85°F during the overlay placement regardless of the surface evaporation rate. The overlay concrete shall not exceed 80°F.

The overlay concrete shall be placed only if the overlay surface evaporation rate, as affected by ambient air temperature, concrete temperature, relative humidity, and wind velocity, is 0.15 pound per square foot per hour or less. The Contractor shall determine and document the atmospheric conditions, subject to verification by the Engineer. The chart contained in "Plastic Cracking of Concrete" by Delmar Bloem for the National Ready Mixed Concrete Association, and published in ACI 305R-89, shall be used to determine the loss of surface moisture for the overlay. The chart may be obtained from the Department's Materials and Research Section.

An overlay shall not be placed adjacent to a previous overlay which has cured for less than 3 cure-days.

Placement of Overlay Concrete

Placement shall conform to applicable requirements of Section 602. The maximum overlay depth placement, per lift, shall be 2".

Prior to placing the overlay concrete, the Contractor shall schedule a "Preplacement Meeting" with the Engineer to discuss the plan and procedure for the work. This discussion shall acceptably establish the Contractor's ability to place the overlay on a continuous basis and to consolidate, finish, texture, and commence curing within the time intervals specified.

If placement of the overlay is to be made at night, the Contractor shall submit a plan which provides adequate lighting for the work area. The plan shall be submitted at least 15 calendar days in advance and be approved by the Engineer before concrete is placed. The lights shall be so directed that they do not adversely affect traffic.

The micro-silica manufacturer’s technical representative shall be present during the placement of the overlay at no additional cost to the Department. Work which is considered by this representative as being detrimental to the integrity of the overlay will be rejected.

The maximum time allowed between the start of mixing to the completion of discharge of the overlay concrete at the worksite shall be sixty minutes (both when used as grout or as overlay).

The maximum water-cement ratio of 0.40 shall not be exceeded. Any admixture added at the job site shall be mixed a minimum of 5 minutes, or 30 revolutions. After all components have been added, the slump range shall be 6 ± 2".

If a slump loss occurs after mixing and before placement of the overlay, the charge may be "re-tempered" with the high range water reducing admixture to restore plasticity; re-tempering with water shall not be allowed. The slump and air content will be rechecked to ensure conformance to the specifications. If the consistency of the charge after "re-tempering" is such as to cause segregation of the components, this will be cause for rejection of the load. The overlay material must still be placed within

the original 60 minute limitation or it will be rejected.

Immediately before the overlay is placed, the concrete surfaces shall be cleaned with an oil free air blast, cleared of any standing water. The bonding grout shall consist of the overlay concrete mortar, placed and brushed onto the deck. The remaining coarse aggregate from the mortar shall be removed from the deck. The overlay shall be placed only when the existing deck is "saturated surface dry". The grout shall be scrubbed or broomed onto the deck. The overlay concrete bonding grout shall be applied for only a short distance in advance of the placement of the overlay. The distance must not allow the bonding grout to dry out before the overlay concrete is placed. If the concrete bonding grout dries out, it shall be removed from the deck placement area with water blasting, and new grout applied.

The maximum allowable time between the discharge of the concrete and the final finishing, including wet curing of the overlay concrete, shall be less than twenty minutes.

A construction dam or bulkhead shall be installed in case of major delay in the placement operation exceeding one hour in duration. During minor delays of one hour or less the end of the placement may be protected from drying with several layers of wet burlap.

If overlay concrete placement is stopped or delayed for a duration of 90 minutes or more, further placement shall be discontinued and may not resume until after a period of not less than 12 hours. This restriction does not prohibit continuation of placement provided a gap is left in the lane. The gap shall be sufficient in length for the finishing machine to clear the previously placed concrete.

Consolidating and Finishing the Overlay Concrete

Immediately following application of the bonding grout, the overlay shall be placed, consolidated and finished to the Plan grades with vibrating devices. Spud vibration will be required in deep pockets, edges and adjacent to joint bulkheads. Hand finishing with a float may be required along the edge of the pour or on small areas of repair. Edge tooling is required at joints, except next to metal expansion dams, curbs, and previously placed lanes

A 10' straightedge shall be supplied and used by the Contractor to check the overlay directly behind the finishing machine. It shall also be used to check transversely along the edges of the overlay where hand finishing is done. Any irregularities exceeding 1/8" in 10' shall be corrected immediately. Any ponding problem which is noted prior to final acceptance of the overlay shall be corrected by the Contractor at no cost to the Department. The Contractor shall test the overlay concrete surface for smoothness in accordance with Subsection 602.20 of the Standard Specifications.

If needed, a water fog may be applied by the use of mechanical fogging equipment attached to the paving machine to achieve an atomized water mist/fog above, but no on, the surface of the overlay concrete. The water fog shall be discharged at high velocity by the airstream of the mistblower. Hand-pump sprayers shall not be used for the spraying.

Curing the Overlay Concrete

As soon as the finishing and curing operation is completed, and less than twenty minutes after initial concrete discharge, the finished overlay surface shall be covered with a layer of clean, fully wet, saturated burlap. For a period of 3 cure-days (a cure-day shall be defined as a 24 consecutive hour period of time), the burlap shall be kept wet by the continuous application of water through soaker hoses. After the initial set, 4 mil (minimum) thick white opaque polyethylene film shall completely cover the wet burlap for the entire period. After the 3-day cure period, remove the polyethylene and burlap and apply curing compound in accordance with Subsection 602.18(b) except that the surface can be subjected to

traffic as soon as the curing compound has setup.

The temperature at the overlay surface shall be maintained above 35°F until the curing period is completed. Any day during which the air temperature at the overlay surface falls below 45°F shall not be counted as a cure-day.

Any cracking which occurs prior to opening to traffic shall be sealed or repaired in a manner approved by the Engineer at no cost to the Department. The deck shall be sounded and any delaminated areas removed and replaced at no cost to the Department.

Traffic will not be permitted on the finished overlay surface until after the wet burlap cure period is complete.

The surface shall be textured in accordance with Subsection 602.20.

Any improperly cured overlay is subject to replacement at no cost to the Department.

~~**Method of Measurement:**~~

~~The item "Furnishing Micro-Silica Modified Concrete" will be measured by the cubic yard as determined from the theoretical yield of the design mix and documented by the batch records. Material wasted or rejected due to any cause will not be paid for.~~

~~The item "Constructing Micro-Silica Modified Concrete Overlay" will be measured by area in square yard regardless of the depth of the placed mixture. The actual area finished and accepted will be measured, exclusive of areas of metal expansion dams exposed.~~

~~**Basis of Payment:**~~

~~The payment of the item "Furnishing Micro-Silica Modified Concrete" shall be made for at the Contract unit price bid per cubic yard, which price and payment shall be full compensation for furnishing and hauling all micro-silica modified concrete materials, for all labor, equipment, tools, and necessary incidentals to complete the work.~~

~~The payment for the item "Constructing Micro-Silica Modified Concrete Overlay" shall be made for at the Contract unit price bid per square yard, which price and payment shall constitute full compensation for the preparation of the area to receive micro-silica modified concrete including scarifying, shot or grit blasting, removal of rust, oil and other contaminants, protecting the area, bonding grout, placing of micro-silica modified concrete, consolidating, curing, and texturing and for all labor, equipment, tools, and incidentals necessary to complete the work.~~

NE - 3/17/05

602588 - ANTI-GRAFFITI COATING

Description:

This work shall consists of furnishing all materials and applying anti-graffiti coating to the exterior surfaces of the masonry structure in accordance with the notes on the Plans and as directed by the Engineer.

Materials:

Anti-graffiti coating shall be one of the following products.

			Dry Film Thickness mils (µM)
1.	Primer:	AQUATHANE Primer	2-4 (51-102)
	Intermediate Coat:	AQUATHANE	3-5 (76-127)
	Top Coat:	AQUATHANE	3-5 (76-127)

As manufactured by TAMMS Industries (Telephone 1-800-654-0402; 1-301-470-3377);

OR

2.	Primer:	Ply-Mastic 650 Epoxy Primer	2-4 (51-102)
	Intermediate Coat:	Ply-Thane 890 Polyurethane	3-5 (76-127)
	Top Coat:	Ply-Thane 890 Polyurethane	3-5 (76-127)

As manufactured by M-A-B Paints & Coatings (Telephone - 1-800-MAB-1899; 1-215-353-5100);

OR

3.	Primer:	FX-441 (one component)	2-4 (51-102)
	Intermediate Coat:	FX-441 (two components)	3-5 (76-127)
	Top Coat:	FX-441 (two components)	3-5 (76-127)

As manufactured by Fox Industries (Telephone [no toll free number] 1-410-243-8856);

OR

Approved Equal.

All materials shall be brought to the job site in the original sealed and labeled containers of the manufacturer, and subject to inspection by the Engineer. Top coat color of anti-graffiti coating shall be as specified on the Plans.

Construction Methods:

Prior to applying the anti-graffiti coating to new concrete, surface shall be fully cured and all surface, new and existing, shall be free of dust, dirt, paint, oil, grease and any other foreign materials.

Unless otherwise directed on the Plans, removal of contaminants shall be achieved by sandblasting the surface to sound concrete with a surface finish texture of medium grade sandpaper. Those areas of P.C.C. masonry where aggregate is exposed and deep pits exist shall be filled with approved material to a uniform surface unless otherwise directed by the Engineer. If there is a conflict between these requirements and the requirements recommended by the manufacturer of anti-graffiti coating for surface preparation, the surface preparation shall be performed in accordance with the manufacturer's recommendation unless otherwise directed by the Engineer.

Application of the anti-graffiti coating including temperature/humidity restrictions, mixing, thinning, curing and clean-up, etc., shall be performed in accordance with the recommendation of the manufacturer.

~~Method of Measurement:~~

~~The quantity of Anti-Graffiti Coating to be paid for shall be the actual number of square yards (square meters) of surface area covered with anti-graffiti coating as measured in the field and accepted.~~

~~Basis of Payment:~~

~~The quantity of Anti-Graffiti Coating applied as provided above, shall be paid at the Contract unit price per square yard (square meter). Price and payment shall constitute full compensation for furnishing and placing all materials including surface preparation, for all labor, equipment, tools, and necessary incidentals to complete the work.~~

NE- 4/19/05

602697 - FURNISHING LOW PERMEABILITY CONCRETE OVERLAY
602698 - CONSTRUCTING LOW PERMEABILITY CONCRETE OVERLAY

Description:

The item "Furnishing Low Permeability Concrete" shall consist of furnishing low permeability Portland cement concrete (hereafter referred to as overlay concrete) at the site of construction; and the item "Constructing Low Permeability Concrete Overlay" shall consist of preparing, placing, consolidating, curing, and texturing the low permeability concrete on the bridge deck and/or other specified areas in accordance with these specifications, applicable requirements of Section 602 of the Standard Specifications, and notes on the Plans and as directed by the Engineer.

The overlay shall be constructed as a single monolithic element of the structure with respect to depth. Any joints between placements shall be placed to not be within the wheel paths of the traffic. The overlay shall be uniform, strong, dense, and well-bonded to the existing deck, and shall have a smooth, free-draining, crack-free surface.

Materials and Mix Design:

All Sections of Section 812 shall be applicable except as modified herein:

- AASHTO #8 stone will be used in the overlay concrete;
- 28 day compressive strength shall be a minimum of 4000 psi;
- Slump shall be between 4-8"; air content shall be 4-7%;
- W/C(M) ratio will be less than 0.40; and
- Bonding agent shall be used.

Chloride permeabilities shall be no greater than 1500 coulombs when tested according to the Virginia Modified Method of AASHTO T277. The permeability test samples will be field-cast cylindrical specimens with a 4" diameter and at least 4" in length. They will be air cured at a temperature of 73 ± 3□F for one week and the last three weeks of the air cure will be at 100 ± 9□F. Cylinders will be tested at 28 days in accordance with the AASHTO T277 Test Method.

The overlay shall be centrally batched, and shall be mixed in a central mixing plant or by mixer-trucks capable of producing a workable mixture of uniform composition and consistency. Batching and mixing equipment shall conform to Section 812. Admixtures shall be introduced into the concrete in such a manner that will disperse it throughout the entire load. The mixer-truck charge shall be limited to a maximum of 75 percent of its rated capacity or to 6 cubic yards, whichever is smaller.

Construction Methods:

All equipment for surface preparation, mixing, placing, and finishing of the concrete overlay shall be approved by the Engineer prior to the start of any work. This equipment includes the following:

A. Power-driven scarifier;
B. Chipping hammers (maximum nominal 35 lb. class);
C. Abrasive blaster;
D. Overlay mixer-trucks;
E. Mechanical fogger; and
F. Finishing machine.

An approved finishing machine complying with the following requirements shall be used for finishing the wearing surface:

1. The finishing machine shall be self-propelled and capable of forward and reverse movement under positive control. Provision shall be made for raising all screeds to clear the screeded surface for traveling in reverse. An approved self-propelled finishing machine with one or more rotating rollers, augers, and 1,500 to 2,500 VPM vibrating pans may be used. Any modification shall be subject to approval by the Engineer.

2. Supporting rails upon which the finishing machine travels will be required and shall be sufficiently rigid so that they do not deflect under the weight of the machine. When placing overlay concrete in a lane abutting a previously completed lane, that side of the finishing machine adjacent to the completed lane, shall be specially equipped to travel on the completed lane.

The Contractor shall provide access to the Engineer in order to obtain grade/elevation survey information before and after deck preparation has been performed.

Surface Preparation

If required in the Plans, the Contractor shall scarify the existing deck to a depth of 1/4□. After this initial removal the Contractor shall sound the deck and outline areas of unsound concrete for removal, subject to the approval of the Engineer. Removal and repair work below the initial 1/4" of scarification will be measured and paid for under other items of work in this Contract.

On any bridge deck or approach slab where a hot mix surface is removed, and no additional concrete milling is specified, the Contractor shall scarify the exposed concrete surface an additional 1/8" to 3" in depth to remove all hot mix latency prior to sounding the concrete as specified above and final cleaning as specified below. Cost of the scarification shall be incidental to Item 602698.

Any portions of bridge decks or approach slabs that have a smooth surface shall be scarified to a depth of 1/8" to 3" prior to placing the low permeability concrete overlay. It is the intent that the surface to receive the overlay has a sufficiently rough texture to assure a good mechanical bond between the existing concrete and the low permeability concrete overlay. Cost of the scarification shall be incidental to Item 602698.

Not more than 24 hours before placement begins, the entire surface of the bridge deck and areas to receive low permeability concrete shall be thoroughly cleaned by shot or grit blasting. The edge of any previously placed lanes of concrete overlay shall be blasted to remove the trowel cut surfacing to promote bond. If necessary to remove rust, oil or other foreign materials detrimental to achieving bond, detergent cleaning followed by shot or grit blasting and air blast cleaning shall be used. Immediately prior to placement of low permeability concrete, the clean surface of the entire deck shall be thoroughly hosed down with water and kept wet for a period of not less than six hours. Any standing water in depressions, holes or areas of concrete removal shall be blown out with compressed air free of oil prior to placing the overlay concrete. The Contractor shall take all necessary precautions with the deck preparations to ensure a good bond with the overlay.

Contamination of the cleaned and wetted deck shall be prevented by placement of a clean 4 mil (minimum) thick polyethylene film (or other covering as approved by the Engineer) completely covering the surface of the deck to be overlaid.

Transverse and longitudinal joints of previously placed overlay shall be sawn to straight and vertical edges before overlay is placed against them.

Limitations on Placing the Overlay Concrete

The Contractor shall be responsible for the quality of the concrete placed in any weather or atmospheric conditions. A smooth, durable riding surface of uniform texture, true to the required grade and cross-section, shall be obtained on all bridge decks

The overlay concrete shall not be placed when rain is forecast within the intended working period. Adequate preparations shall be made to provide protection of the freshly placed overlay in the event of sudden or unexpected rain. If rain occurs during placing of the overlay, all operations other than protection of the already placed overlay shall immediately cease. Materials damaged by the rain shall be rejected and replaced at no additional cost to the Department.

The overlay concrete shall be placed only when the local ambient temperature is above 45° for the entire curing period. The overlay shall not be placed if the ambient air temperature is 85°F, or higher or predicted to go above 85°F during the overlay placement regardless of the surface evaporation rate. The overlay concrete shall not exceed 80°F.

The overlay concrete shall be placed only if the overlay surface evaporation rate, as affected by ambient air temperature, concrete temperature, relative humidity, and wind velocity, is 0.15 pound per square foot per hour or less. The Contractor shall determine and document the atmospheric conditions, subject to verification by the Engineer. The chart contained in "Plastic Cracking of Concrete" by Delmar Bloem for the National Ready Mixed Concrete Association, and published in ACI 305R-89, shall be used to determine the loss of surface moisture for the overlay. The chart may be obtained from the Department's Materials and Research Section.

An overlay shall not be placed adjacent to a previous overlay which has cured for less than 3 cure-days.

Placement of Overlay Concrete

Placement shall conform to applicable requirements of Section 602. The maximum overlay depth placement, per lift, shall be 2".

Prior to placing the overlay concrete, the Contractor shall schedule a "Preplacement Meeting" with the Engineer to discuss the plan and procedure for the work. This discussion shall acceptably establish the Contractor's ability to place the overlay on a continuous basis and to consolidate, finish, texture, and commence curing within the time intervals specified.

If placement of the overlay is to be made at night, the Contractor shall submit a plan which provides adequate lighting for the work area. The plan shall be submitted at least 15 calendar days in advance and be approved by the Engineer before concrete is placed. The lights shall be so directed that they do not adversely affect traffic.

The maximum time allowed between the start of mixing to the completion of discharge of the overlay concrete at the worksite shall be sixty minutes (both when used as grout or as overlay).

The maximum water-cement ratio of 0.40 shall not be exceeded. Any admixture added at the job

site shall be mixed a minimum of 5 minutes, or 30 revolutions. After all components have been added, the slump range shall be 6 ± 2".

If a slump loss occurs after mixing and before placement of the overlay, the charge may be "re-tempered" with the high range water reducing admixture to restore plasticity; re-tempering with water shall not be allowed. The slump and air content will be rechecked to ensure conformance to the specifications. If the consistency of the charge after "re-tempering" is such as to cause segregation of the components, this will be cause for rejection of the load. The overlay material must still be placed within the original 60 minute limitation or it will be rejected.

Immediately before the overlay is placed, the concrete surfaces shall be cleaned with an oil free air blast, and cleared of any standing water. The overlay shall be placed only when the existing deck is "saturated surface dry". The bonding grout shall be applied onto the deck. The overlay concrete bonding material shall be applied for only a short distance in advance of the placement of the overlay. The distance must not allow the bonding material to dry out before the overlay concrete is placed. If the concrete bonding material dries out, it shall be removed from the deck placement area with water blasting, and new bonding material applied.

The maximum allowable time between the discharge of the concrete and the final finishing, including wet curing of the overlay concrete, shall be less than twenty minutes.

A construction dam or bulkhead shall be installed in case of major delay in the placement operation exceeding one hour in duration. During minor delays of one hour or less the end of the placement may be protected from drying with several layers of wet burlap.

If overlay concrete placement is stopped or delayed for a duration of 90 minutes or more, further placement shall be discontinued and may not resume until after a period of not less than 12 hours. This restriction does not prohibit continuation of placement provided a gap is left in the lane. The gap shall be sufficient in length for the finishing machine to clear the previously placed concrete.

Consolidating and Finishing the Overlay Concrete

Immediately following application of the bonding material, the overlay shall be placed, consolidated and finished to the Plan grades with vibrating devices. Spud vibration will be required in deep pockets, edges and adjacent to joint bulkheads. Hand finishing with a float may be required along the edge of the pour or on small areas of repair. Edge tooling is required at joints, except next to metal expansion dams, curbs, and previously placed lanes

A 10' straightedge shall be supplied and used by the Contractor to check the overlay directly behind the finishing machine. It shall also be used to check transversely along the edges of the overlay where hand finishing is done. Any irregularities exceeding 1/8" in 10' shall be corrected immediately. Any ponding problem which is noted prior to final acceptance of the overlay shall be corrected by the Contractor at no cost to the Department. The Contractor shall test the overlay concrete surface for smoothness in accordance with Subsection 602.20 of the Standard Specifications.

If needed, a water fog may be applied by the use of mechanical fogging equipment attached to the paving machine to achieve an atomized water mist/fog above, but no on, the surface of the overlay concrete. The water fog shall be discharged at high velocity by the airstream of the mistblower. Hand-pump sprayers shall not be used for the spraying.

Curing the Overlay Concrete

As soon as the finishing and curing operation is completed, and less than twenty minutes after initial concrete discharge, the finished overlay surface shall be covered with a layer of clean, fully wet, saturated burlap. For a period of 3 cure-days (a cure-day shall be defined as a 24 consecutive hour period of time), the burlap shall be kept wet by the continuous application of water through soaker hoses. After the initial set, 4 mil (minimum) thick white opaque polyethylene film shall completely cover the wet burlap for the entire period. After the 3-day cure period, remove the polyethylene and burlap and apply curing compound in accordance with Subsection 602.18(b) except that the surface can be subjected to traffic as soon as the curing compound has setup.

The temperature at the overlay surface shall be maintained above 35°F until the curing period is completed. Any day during which the air temperature at the overlay surface falls below 45°F shall not be counted as a cure-day.

Any cracking which occurs prior to opening to traffic shall be sealed or repaired in a manner approved by the Engineer at no cost to the Department. The deck shall be sounded and any delaminated areas removed and replaced at no cost to the Department.

Traffic will not be permitted on the finished overlay surface until after the wet burlap cure period is complete.

The surface shall be textured in accordance with Subsection 602.20.

Any improperly cured overlay is subject to replacement at no cost to the Department.

~~**Method of Measurement**:~~

~~The item "Furnishing Low Permeability Concrete" will be measured by the cubic yard as determined from the theoretical yield of the design mix and documented by the batch records. Material wasted or rejected due to any cause will not be paid for.~~

~~The item "Constructing Low Permeability Concrete Overlay" will be measured by area in square yard regardless of the depth of the placed mixture. The actual area finished and accepted will be measured, exclusive of areas of metal expansion dams exposed.~~

~~**Basis of Payment**:~~

~~The payment of the item "Furnishing Low Permeability Concrete" shall be made for at the Contract unit price bid per cubic yard, which price and payment shall be full compensation for furnishing and hauling all micro-silica modified concrete materials, for all labor, equipment, tools, and necessary incidentals to complete the work.~~

~~The payment for the item "Constructing Low Permeability Concrete Overlay" shall be made for at the Contract unit price bid per square yard, which price and payment shall constitute full compensation for the preparation of the area to receive low permeability concrete including scarifying, shot or grit blasting, removal of rust, oil, and other contaminants, protecting the area, bonding grout, placing of low permeability concrete, consolidating, curing, and texturing and for all labor, equipment, tools, and incidentals necessary to complete the work.~~

NE - 3/17/05

SPECIAL PROVISION

605500 - CABLE-SUPPORTED BRIDGE SYSTEM REQUIREMENTS

1.0 GENERAL

The requirements of this Special Provision shall apply to any cable-supported bridge structure type. For the purpose of these Contract Documents, a cable-supported bridge structure shall be defined as any bridge that includes any cable element, regardless of the constituent components of the cable, for which any part of the cable is external to the superstructure, and the cables shall be referred to as stays or cables.

The Design-Builder shall be responsible for designing, furnishing, fabricating, testing, storing, installing, erecting, monitoring, stressing, re-stressing, adjusting, and completing the assembly of all components of the complete cable-supported bridge system, including cable vibration suppression (damper) system and repair and/or replacement of damaged components (if necessary), for the cable-supported bridge in accordance with the Contract requirements and the criteria established in this Special. The cable-supported bridge system shall allow control on the tension of the cable and facilitate future replacement that does not limit operation of the bridge or compromise bridge integrity.

The complete cable-supported bridge system includes, but is not limited to, main tensile elements (assumed hereinafter to be strand, but it may be wire), selected strand sheathing and/or strand coating, complete anchorage components, wedges, bearing plates, guide pipes, sealing components, stay cable vibration suppression (damper) system and components, corrosion protection provisions, temporary corrosion protection provisions during storage and construction, stay cable pipe, elastomeric boots with braided covers, bolts, nuts, washers, clamping bands, erection devices and equipment, and all permanent and incidental materials and labor necessary to complete the cable-supported bridge system in accordance with the Contract requirements.

The cable-supported bridge system shall allow control on the tension of the individual strands and future strand replacement. The system should provide independency for the strands regarding anchoring, corrosion protection, installation, tensioning, and replacement. A minimum of fifteen (15) “reference” strands shall be distributed throughout the bridge for corrosion and service life monitoring purposes. These strands shall be installed, stressed, and protected and shall experience identical conditions to other strands of the stay cables. The Department in the future, may remove one or more reference strands for the purpose of evaluating the status of the cable-supported bridge system. Stay cables shall be designed such that reference strands that have been removed do not have to be replaced.

The Design-Builder shall design and construct the cable-supported bridge system meeting the goals of ease of inspection, low maintenance, and durability. Proposed innovations and features of the cable-supported bridge system, that are included in the successful Design-Builder’s Proposal, are not permitted to be abandoned, diminished, or removed from the design and/or the construction of the project by the Design-Builder after selection of the Design-Builder’s Proposal.

Shop drawings showing all dimensions, materials and operations for fabrication of the cable-supported bridge system components shall be submitted to the Department for review and comment. Shop drawings shall show the strand pattern for each cable (symmetrical about vertical and horizontal axis.) and shall conform to the requirements of Part 2 - DB Section 105 - Control of Work. The Design-Builder shall provide detailed procedures that are recommended by the Supplier for installing all components, insertion of the strands, installation of wedges, stressing and filling of the cable void. Complete shop drawings with supporting calculations shall be submitted showing all equipment (jack, stressing chair, etc.) and

procedures required for cable force adjustments and for complete de-tensioning. No installation will be permitted by the Department for any portion of the production stay cables or anchor assemblies until all required submittals of procedures and test reports are made and found to fully conform to the requirements of the Contract Documents.

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

Secondary or incidental forces from stay cable(s) caused 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.

2.0 STANDARDS

Stay cables are to be provided in accordance with the PTI Guide Specification, "Recommendations for Stay Cable Design, Testing and Installation", the latest edition with Revisions as of the issue date of this RFP, ("soft" conversion of the Document's metric units is required).

Testing of the cable-supported bridge system shall be in accordance with the *PTI "Recommendations for Stay Cable Design, Testing and Installation"* associated with fatigue, ultimate post fatigue strength and static load testing for both the acceptance-testing phase and all cable-supported bridge system materials and components to be incorporated into the structure. The corrosion protection (or water leak) test, as well as other designated tests, shall also be performed in accordance with the requirements of *PTI* and this Special Provision.

These Special Provisions and the *PTI "Recommendations for Stay Cable Design, Testing and Installation"* are intended to be complementary. In case of discrepancy between these Special Provisions and the *PTI "Recommendations for Stay Cable Design, Testing and Installation",* these Special Provisions shall govern. The Design-Builder shall obtain clarification from the Department of any and all unresolved discrepancies prior to proceeding with design or construction.

2.1 EXCEPTIONS

The following acknowledgements and exceptions are taken to the *PTI "Recommendations for Stay Cable Design, Testing and Installation"*:

A. High strength bars shall not be used for the main tension elements of the stay cables;

B. Stay cable pipe shall be HDPE or *ASTM A 312* Type 2205 stainless steel. All associated components of the stay cable pipe protection system, such as guide pipes, bolts, nuts, washers, backer plates, weld plates, banding clamps, braid covers and other exposed items shall be stainless steel with similar corrosion resistance to *ASTM A 312* Type 2205;

C. Saddles or Cradles shall not be used for stay cables;

D. For epoxy coated strand (if selected by the Design-Builder), the film thickness of coating after curing shall be 25 to 45 mils inclusive; and

E. Portland cement grout will not be considered an acceptable corrosion protection barrier.

2.2 TESTING

An independent testing laboratory (or laboratories) selected by the Design-Builder and approved by the Department shall test all materials, strands and cable specimen assemblies required for both the initial acceptance-testing phase and the stay cable component fabrication/production phase. The Design-Builder shall be responsible for all coordination between the Design-Builder's laboratory (or laboratories), Design-Builder's supplier(s), and Department representatives.

The Design-Builder shall furnish, and make available for Department review, all materials and written test procedures, as prepared by the Design-Builder's supplier(s). Each component of the assembly, including items such as wedges, shall have an *AASHTO* or *ASTM* material and test specification. The Design-Builder's supplier(s) and the design-Builder's laboratory (or laboratories) shall prepare separate reports. Each of these reports shall independently describe all the testing data and testing results. All reports shall be submitted by the Design-Builder to the Department within 14 days of completing each test as independent records of the testing. The Design-Builder shall be responsible for subcontracting and coordinating with the Design-Builder's laboratory (or laboratories) and Design-Builder's supplier(s) for all testing laboratory services.

Material or cable-supported bridge system components tested during the acceptance-testing phase shall not be incorporated into the actual structure. All items, which comprise the permanent production cable-supported bridge system, shall be identical in nature, origin, and composition to those that were the basis of the cable-supported bridge system acceptance tests. The Design-Builder's supplier(s) shall provide written and detailed recommendations to the Design-Builder regarding storage, handling, transporting, assembly, stressing, and re-stressing of the cable-supported bridge system components that conform to *PTI*, as a minimum standard. The Design-Builder's supplier(s) shall simultaneously provide copies of all such recommendations directly to the Department for the project files.

2.3 QUALITY CONTROL PROGRAM

The Design-Builder is responsible for installing stay cable material in an undamaged condition. In order to assure that only conforming material is introduced into the work, the Design-Builder shall develop a comprehensive Quality Control program that covers the procurement, packaging, transport, delivery and storage of all stay cable materials and components of the stay cables. This program shall include, but not be limited to, all procedures and practices necessary for the final installation of stay cables that meet the requirements of these Special Provisions and Section 6 of the *PTI "Recommendations for Stay Cable Design, Testing and Installation"* without residual damage to any component of the cable-supported bridge system.

A. As a minimum, the Quality Control program shall include the following items:

1) Packaging and shipping for main tension elements and all protective materials.

2) Records for traceability and shelf life of all materials.

3) Inspection of materials to assure conformance to these Special Provisions and to assure the materials are undamaged as they are installed on the bridge.

4) Limitations on storage and handling, including time periods for storing materials, temperature and humidity limitations for materials, temporary corrosion protection, and any limitation on temporary storage or protection that shall be permitted to affect performance of the completed stay design.

5) Coiling limitations for materials subject to set or plastic deformations, including prefabricated cables, HDPE pipe, Polyethylene-sheathed strand or epoxy-coated strands.

6) Limitations on coatings, repairs of coating damage, and supplemental protection for coated materials.

B. The Quality Control program shall be submitted to the Department for review and evaluation. Review and evaluation by the Department does not relieve the Design-Builder from the responsibility for the accuracy and adequacy of the work.

C. The Quality Control program shall be approved by the Department and the Design-Builder's Engineer of Record prior to procuring any stay cable materials.

D. Permanent records shall be established and maintained by the Design-Builder for all procurement, inspection, sampling, testing and installation in accordance with the requirements of Section 6 of the *PTI "Recommendations for Stay Cable Design, Testing and Installation"*.

3.0 MATERIAL

3.1 STEEL

All steel products to be used or supplied in connection with the cable-supported bridge system shall be steel products rolled, formed, shaped, drawn, extruded, forged, fabricated, or other similar process or processed by a combination of two or more such operations, from steel by the open hearth, basic oxygen, electric furnace, Bessemer or other steel making process.

3.2 STRAND

The Design-Builder has the option to select the strand sheathing or strand coating material for stay cables from the strand types specified in this Special Provision. Only one type of strand may be selected for use in the permanent cable-supported bridge system for the entire project. Acceptable stay cable strands meeting the following requirements shall be considered acceptable for use by the Department. Requests to use strands having other material properties or coatings, such as galvanization, must be submitted to the Department for approval.

3.2.1 Epoxy Coated Strand

A. Epoxy coated strand for stay cables shall be 0.60" in diameter, Grade 270, fy = 0.9fs, weldless grade, low relaxation, seven wire strand conforming to the requirements of *ASTM A 882/A 882M, "Standard Specification for Epoxy Coated Seven Wire Prestressing Steel Strand,"* and Supplement 1 thereof. During the process of manufacture of individual wires for "weldless" strand, welding is permitted only prior to or at the site of the last thermal treatment of the rod, for example, patenting or controlled cooling. There shall be no welds in the wire after it has been drawn through the first die in the wire drawing process;

B. Epoxy coated strand shall be of the "filled" type where the interstitial space between individual wires is completely filled with the epoxy coating meeting the requirements of the *PTI "Recommendations for Stay Cable Design, Testing and Installation"*;

C. All coating materials shall be from one manufacturer to assure uniformity;

D. A written certification shall be furnished by the strand coater that clearly identifies each batch of coating material as to material, quantity, date of manufacturer, shelf life (date) and that all supplied coating material meets all requirements specified herein;

E. The epoxy coating manufacturer and the coating material shall be reviewed and evaluated by Department prior to furnishing the material. For plant approval, the plant shall furnish Quality Control procedures to insure compliance with these specifications;

F. The material shall be tested by a private testing laboratory approved by the Department and test data furnished to the Department for review prior to use. Review and evaluation by the Department does not relieve the Design-Builder from the responsibility for the accuracy and adequacy of the work;

G. The coating applicator shall furnish, at the time of shipment, written certifications that the coated strands were cleaned, coated and tested in accordance with the requirements of these Special Provisions. The certification shall include Quality Control reports indicating preheat temperatures, cure times, coating thickness measurements, holidays detected, and bend test results; and

H. The epoxy coating shall extend over the entire length of the strand. No welds or joints shall be present in the finished strand. All strand epoxy coating shall be visually inspected at the point of stay installation for cracks, holidays, discoloration, variation in thickness or signs of delamination or embrittlement. All damaged or deteriorated strand shall be rejected, and not installed into the structure.

3.2.2 Individually Sheathed Strand

A. Sheathed strand for stay cables shall be 0.60" in diameter, Grade 270, fy = .9fs, weldless grade, low relaxation, seven wire strand conforming to the requirements of *AASHTO M203, "Specification for Steel Strand, Uncoated Seven Wire Stress Relieved for Prestressed Concrete,"* except that it shall be coated with a corrosion inhibiting material. During the process of manufacture of individual wires for "weldless" strand, welding is permitted only prior to or at the site of the last thermal treatment of the rod, for example, patenting or controlled cooling. There shall be no welds in the wire after it has been drawn through the first die in the wire drawing process;

B. Strand coating shall be of the "filled" type where the interstitial space between individual wires is completely filled with the coating or corrosion inhibiting material meeting the requirements of the of Table 1 from the *PTI* "Guide Specification - Specification of Unbonded Single Strand Tendons;"

C. Strands shall be individually sheathed with a corrosion inhibiting material. Acceptable sheathing includes High Density Polyethylene (HDPE) or High Density Polypropylene (HDPP) meeting the requirements of the *PTI "Recommendations for Stay Cable Design, Testing and Installation"*;

D. The amount of corrosion inhibiting material shall be sufficient to ensure complete filling of the annular space between the individual wires of the strand and the sheathing material; and

E. The coating, corrosion inhibiting material, and the sheathing shall extend over the entire length of strand. No welds or joints shall be present in the finished strand.

3.2.3 Continuity of Strand Coating

The coating shall be free of holes, voids, cracks and damaged areas discernible to the unaided eye. During the coating process, a continuous holiday detection procedure shall be employed using an appropriate holiday detector such as the 67 1/2 volt holiday detector using water as the conductor following the manufacturer's recommended procedure. During the continuous holiday detection procedure, if more than two holidays are detected per hundred feet, the strand shall be rejected and the coating manufacturing procedure shall be corrected. Coated strand with two holidays or less per hundred feet shall be shop patched in accordance with the patching material manufacturer's recommendations. The patch or repair shall have the same mechanical properties as the original coating and have sufficient bond and flexibility to resist effects of handling and stressing.

3.2.4 Strand Coating in the Vicinity of Wedges

The strand coating must be removed in the vicinity of the wedges. The Design-Builder shall provide recommendations for equipment and procedures required to do so that will not damage the strand. The actual procedures to be used by the Design-Builder during production must be similarly used for the acceptance testing. The Design-Builder shall also propose an acceptable method for providing temporary and permanent corrosion protection of the area where coating has been removed in order to accommodate the wedge grips. The Design-Builder's system shall be qualified in accordance with Section 4.1 of the *PTI "Recommendations for Stay Cable Design, Testing and Installation"*.,

3.3 EXTERNAL CABLE PIPE

Pipe sections shall have consistency of external diameter and uniformity (roundness) to permit the completed pipe to have a smooth, continuous appearance at each weld location. This will require more strict dimensional tolerances than standard values. The Design-Builder is responsible for achieving these dimensional requirements without exception. Cable pipe meeting the following requirements in 3.3.1-3.3.2 or the requirements in Section 3.5 of the *PTI "Recommendations for Stay Cable Design, Testing and Installation"* shall be considered acceptable for use by the Department. Requests to use cable pipe having other material properties must be submitted to the Department for approval.

3.3.1 Stainless Steel Components

A. All portions of steel exterior stay cable pipes, including termination pipe, for each individual parallel strand stay cables shall be stainless steel conforming to the requirements of *ASTM A 312*, Type 2205 with diameters in accordance with *ANSI/ASME B36.10M 1995*;

B. Where stainless steel exterior stay cable pipes are used, any portion of the guide sleeves (or pipes) embedded or not embedded in concrete shall be *ASTM A 312* Type 2205 stainless steel with diameters in accordance with *ANSI/ASME B36.10M 1995*; and

   1) All associated components of the stay cable pipe protection system, such as bolts, nuts, washers, backer plates, weld plates, banding clamps, braid covers and other exposed items shall be stainless steel with similar corrosion resistance to *A312* Type 2205.

   2) 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.

C. Stainless steel bands for securing the neoprene boots in place around the stainless steel sheath pipe and the neoprene sleeve shall be a minimum 1.0 inch wide by 0.03 inch thick stainless steel strapping material with stainless crimp type seal of a type proposed by the supplier of the cable-supported bridge system.

3.3.2 Stainless Steel Component Finish

A. If stainless steel is used for exterior stay cable pipes, then 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.

B. 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. For stay cable pipe, the direction of polishing shall be in the direction of the longitudinal axis of the pipe.

C. The visible grain of the polished finish of all stainless steel components shall be uniform in

appearance and direction.

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

E. 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 review and comment.

3.4 GALVANIZED COMPONENTS

Bearing Plates and all exposed carbon steel elements of the stay system shall be galvanized per *AASHTO M 111* (*ASTM A 123)*.

3.5 ELASTOMERIC COMPONENTS

Elastomeric components, such as boots, shall be manufactured from 100% virgin chloroprene of the thickness, shapes and hardness required by the Design-Builder's cable-stay system design. Neoprene, the sole polymer shall be 100% virgin chloroprene, which shall be not less than 60% by volume of the total compound. The elastomer shall meet the following requirements of ASTM C 864 and as amended below (ASTM designated test procedure indicated in parenthesis, if applicable):

	Physical Requirements	Procedure as per ASTM Design
Hardness, Durometer A	60±5	D 2240
Tensile Strength, psi, min.	2,500	D 412 (die C)
Ultimate Elongation, Percent, min.	350	D 412 (die C)
Accelerated Test to Determine Long-term Characteristics Oven-aged – 70 hours at degrees 212° F	---	D 573
Change Durometer Hardness, maximum points	+15	---
Change in Tensile Strength, maximum percent	-15	---
Change in Elongation at Break, maximum percent	-40	---
100 ppm ozone in air by volume, 20 percent strain, ± 100° F, 100 hours mounting	No cracks	D 1149 – samples to be solvent wiped before test to remove any traces of impurities
Procedure A - Compression Set - 22 hrs at 212° F, Maximum %	35	D 395, Method B

3.6 CAP SCREWS AND BOLTS

Material for cap screws, used in the cable anchorages, shall be high-strength, low alloy structural steel conforming to *ASTM A 307*. High strength bolts, used in the cable anchorages, shall be high-strength, low alloy structural steel conforming to *AASHTO M164*.

3.7 WASHERS AND SHIMS

Material for split washers and split shims, if used in the cable stay anchorage, shall be high-strength, low alloy structural steel conforming to *AASHTO M223*. All split washers and split shims shall be designed with a positive closure detail that will prevent shim loss upon unloading.

3.8 MATERIAL STORAGE

The storage facility provided by the Design-Builder shall provide indoor, protected space for all materials. The storage facility shall provide appropriate temperature controlled space for any and all materials that are temperature sensitive in nature. The Design-Builder is responsible for all cable-supported bridge system materials (including cost of leasing storage facility). The Design-Builder will allow immediate access to the Department to inspect the storage facility at anytime during its use.

4.0 CABLE SUPPORT SYSTEM

4.1 COMPONENTS

A. Cable-supported bridge system components shall meet the requirements as specified and the acceptance testing of the cable-supported bridge system. The cable anchor assembly shall consist of an externally threaded steel socket, anchor head, load bearing nut, and protective cap. It must allow for complete de-tensioning of the cables and subsequent removal of the anchorage components (except the load bearing nut) through the guide sleeve. The assembly shall pass, without failure of any component of the support testing outline elsewhere in these requirements.

B. The anchorage assembly and components shall be protected at all times against corrosion, particularly the wedges and wedge holes. Corrosion protection measures shall be shown on the shop drawings and shall include temporary corrosion protection of areas (if any) where coating is intentionally removed for wedge contact. The permanent protection system shall include a stainless steel cap, adhering to Section 3.3.1 of this Special Provision, to protect the exposed wedge plate and wedges from corrosion. Prior to the installation of the permanent cap, the wedge plate and exposed strand shall be coated with a suitable grease.

C. The threaded portion of the socket shall be of sufficient length for installation of the cable and future force adjustment of ±2.5 percent simultaneously in all cables without the use of shims. The assembly shall have a capacity equal to the guaranteed ultimate strength of the cable. Calculations shall be submitted to the Department showing the service stresses in all load bearing components of the assembly.

D. The anchor assemblies and components shall be protected at all times against corrosion, particularly the wedges and wedge holes. Corrosion protection measures will be shown on the shop drawings and shall include temporary corrosion protection of areas (if any) where coating is intentionally removed for wedge contact. The assembly shall include a transparent cap that covers the ends of the strands.

4.2 CABLE DAMPING REQUIREMENTS

4.2.1 General Requirements

This work shall consist of the design, installation, and testing of a stay cable vibration suppression system

as specified herein. The cable-supported bridge system shall include a vibration suppression system consisting of one or more overlapping systems (dampers (other than neoprene washers), cross ties, and/or cable surface modifications). The vibration suppression system shall provide a minimum damping ratio (percent of critical) calculated as (200 + L) / 1200, where L is the stay cable length in feet, or higher damping as required to meet the performance specifications.

The Design-Builder shall design and construct the stay cable system to prevent excessive vibration of stay cables due to all affects of operating and environmental loadings over the range of temperature associated with steel design in the AASHTO LRFD Code. Excessive vibration is defined at two levels:

1. Vibration which exceeds L/1200 under normal operating conditions, which includes rain-wind excitation and normal wind conditions up to and including 25 mph.
2. Vibration under any service, strength or extreme loading condition that causes damage to or fatigue failure of any strand, cable, appurtenance or bridge component. The acceptable level of vibration and displacement for strength and fatigue limit states shall be established by test.

The design-builder shall establish displacement criteria for service, strength and extreme load vibration levels, in addition to the normal operating criteria noted above, that is based on and consistent with cable testing and detailed analysis of cables and bridge components, and submit criteria to the Owner for approval. The design-builder shall, in all cases, provide at least a mass-damping parameter in conformance with the commentary of Section 5.2.3.2 of the *PTI "Recommendations for Stay Cable Design, Testing and Installation"*.

The design-builder shall warrant construction of the wind design for the stay cable system for a period of two (2) years from date of final acceptance of the bridge. The design-builder will modify damping system(s), cable surface treatment and cable stiffening ropes as required to achieve the performance requirements for cable vibration at no additional cost to the Owner. 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.

The Design-Builder shall have an independent laboratory perform on site testing before and after installation of the dampers to verify that the additional damping provided by the system meets the specified value. The Design-Builder shall also propose a detailed pre-installation qualification plan for the damper devices to demonstrate through physical testing that the installed devices will meet these requirements. The pre-installation qualification plan shall provide detailed methods for remedy of damping value if the post-installation testing indicates that the required additional damping value has not been achieved for each stay cable.

In order to determine the appropriate combination of supplemental dampers and stabilizing cables, it is necessary to estimate the effective damping ratio of the proposed stay cable with the supplemental damping system. The determination of effective damping ratio shall be based upon full-scale test results and shall be subject to review and comment by the Department.

4.2.2 Additional Performance Requirements

Provisions shall be made by the Design-Builder to facilitate rapid introduction of temporary suppression measures for stay cable susceptible to vibrations during construction. The cables shall be monitored for vibrations. Monitoring shall take place during erection at the time of major wind events and under the combined action of wind and rain.

A. Full scale damping measurements of all of the stay cables shall be made to ensure that stay

cable damping estimates used in the design of the vibration suppression system are met. If actual damping differs sufficiently from the values used in design of the vibration suppression system, additional stabilizing cables or damping shall be provided, at no cost to the Department to ensure that the vibration suppression system meets with the intended performance level.

B. Following completion of these tests, the Design-Builder shall submit to the Department a report that demonstrates that the performance of the vibration suppression system meets or exceeds the required performance level.

5.0 CABLE TESTING

The Design-Builder is responsible for delivery of all materials to the laboratory and fabrication of test specimens in a timely fashion. Fabrication of any anchors, components or stay cable strands for permanent installation in the structure shall not begin until all initial phase tests are successfully completed and written approval is given by the Quality Control Manager. The Design-Builder shall also allow for review and comment of materials and test specimens by the Department prior to fabrication. The Design-Builder shall provide an initial proposed schedule for the cable system testing that includes the following milestones:

A. Delivery of materials and conducting the first axial fatigue test on a specimen. Upon completion of this test the leak test shall be performed on the specimen. This specimen will not be tested for ultimate post-fatigue strength and static load testing.

B. Delivery of materials and conducting base strand tests and single strand friction tests.

C. Delivery of materials and conducting the second axial fatigue test. This specimen will be tested for ultimate post-fatigue strength and static load testing.

Dismantling of the previously tested specimen shall occur concurrently with setup/testing of the next specimen.

The Design-Builder shall coordinate the Supplier and Laboratory activities for fabrication, installation and set up of the fixture for the axial fatigue tests with the fabrication of anchorage components along with the testing of base strand material.

5.1 ACCEPTANCE OF PRIOR TESTS OF CABLES

When the cable tests (or similar cable tests) have been conducted for previous projects on specimens identical in material supply, design and details to those proposed for this project, the previous tests may, at the Department's sole discretion, be used as the basis for cable-supported bridge system approval for this project. However the quality control tests outlined in Section 3.2 of the *PTI "Recommendations, Support Cable Design, Testing and Installation"* shall establish that the strand supplied for this project has fatigue characteristics equal or better than the strand used in the acceptance tests of the support cable (or stay cable) specimens in the previous project. Further, the load bearing anchorage and wedge hardware shall be the same as in the previous tests.

5.2 INDIVIDUAL SHEATHING ACCEPTANCE TEST

HDPE, HDPP and corrosion inhibiting material shall meet the requirements of the *PTI "Recommendations, Support Cable Design, Testing and Installation."* The resultant acceptable values of the primary properties for HDPE and HDPP material shall be tested and meet the requirements of the values found in Table 3.2 of *PTI* specifications referenced above.

5.2.1 HDPE Sheathing Requirements

The Design-Builder shall furnish to the Department a certified test report prepared by an independent laboratory documenting compliance of the HDPE with the following requirements:

A. HDPE material shall meet the specific requirements of ASTM D 4976 "Standard Specification of Polyethylene Plastics Molding and Extrusion Materials."

B. The material shall be UV stabilized and suffer no property degradation for a minimum exposure period of 6 months. In applications where the PE sheathed strand may be exposed to UV radiation for periods in excess of 6 months, the requirements of Section 3.5.3.2C of the *PTI "Recommendations for Stay Cable Design, Testing and Installation"* shall apply.

C. HDPE material shall not react with the inert gas (if used), the prestressing steel corrosion inhibiting coating material or any other material, it is permitted to come in contact with, as part of the stay cable sheath and shall be free of water soluble chloride.

D. HDPE material shall be chemically stable without embrittlement or softening over the anticipated exposure temperature and service life of the structure.

5.2.2 HDPP Sheathing Requirements

The Design-Builder shall furnish to the Department a certified test report prepared by an independent laboratory documenting compliance of the HDPP with the following requirements:

A. HDPP material shall meet the requirements of ASTM D 4101 "Standard Specification for Propylene Plastic Injection and Extrusion Materials."

B. The material shall be UV stabilized and suffer no property degradation for a minimum exposure period of 6 months.

C. HDPP material shall not react with the inert gas, the prestressing steel corrosion inhibiting coating material or any other material, it is permitted to come in contact with, as part of the stay cable sheath and shall be free of water soluble chloride.

D. HDPP material shall be chemically stable without embrittlement or softening over the anticipated exposure temperature and service life of the structure.

5.3 EPOXY COATED STRAND ACCEPTANCE TEST

The epoxy coating of each strand shall be with a protective fusion bonded polymer coating applied by the electrostatic deposition method. Epoxy coating and patching materials shall be in accordance with *ASTM A 882*. All coating materials shall be from one supplier to assure uniformity. The Design-Builder shall supply written certification from the supplier that clearly identifies each batch of coating material as to material type, quantity, date of supplier, shelf life (date), and that all supplied coating material meets all requirements specified herein. The epoxy coating supplier and the coating material shall be approved for use by the Department prior to furnishing the material. For plant approval, the plant shall furnish quality control procedures to insure compliance with these requirements. The Design-Builder shall provide at the time of shipment, written certifications from the coating applicator that the coated strands were cleaned, coated and tested in accordance with this requirement. The certification shall include quality control reports indicating all coating thickness measurements, holidays detected, and bend test results.

The surface of the steel strand to be coated shall be cleaned in conformance with the coating requirements of *ASTM A 882*. The coating shall be applied by the electrostatic deposition method, or other methods recognized by *ASTM A 882*, and in conformance with the written recommendations of the supplier of the coating material. Before packing, the coating shall be fully cured in conformance with *ASTM A 882* and the written recommendations of the supplier of the coating material. The coating shall be applied to the cleaned surface as soon as possible after cleaning, and before oxidation of the surface discernible to the unaided eye occurs. However, in no case shall application of the coating be delayed more than 8 hours

after cleaning. The coating shall be applied in a continuous process after drying. No inert particles may be impregnated into the surface of the coating. The uniform film thickness of the coating (exclusive of local surface imperfections discernible to the unaided eye) after curing shall be between 25 mils and 40 mils inclusive. Local surface imperfections shall be defined as holes, cracks, depressions and damaged areas not exceeding 0.5 square inches in area, or 0.5" in maximum dimension. Larger imperfections regardless of origin shall be cause for rejection. Any surface irregularity that results in a local film coating thickness of less than 25 mils shall be cause for rejection.

All local surface imperfections, smaller than that requiring rejection, shall be shop repaired in conformance with this specification. The thickness of the coating shall be measured using a magnetic gauge or other method recognized by *ASTM A 882* and the results furnished to the Department for review and comment prior to the coating process. The gauge, or other approved method, shall be capable of measuring the coating thickness of a coated wire of circular cross section with a diameter in the range of 0.1 to 0.3". The allowable error on a single measurement of the coating thickness on the coated crown of an outer wire of the strand shall be +/- 5 percent.

During the coating process, a continuous holiday detection procedure shall be employed in accordance with Section 3.2.3 of this Special Provision.

The resistance of the strand coating to abrasion shall be determined by the falling sand method of *ASTM D 968* adapted for testing coated strand. The net loss of coating shall not exceed 10 mils per 1,000 liters.

The adhesion and shear strength of the coating shall be evaluated by bending a sample from a finished reel of coated strand 180° around a mandrel diameter equal to 32 times the nominal diameter of the strand. Test specimens shall be at thermal equilibrium between 68° and 86° Fahrenheit (20° and 30° Celsius). No cracking or de-bonding of the coating shall be visible to the unaided eye on the outside radius of the bent strand. Evidence of cracking or de-bonding of the coating shall be considered cause for rejection of all coated strand represented by the bent sample test. Fracture of the steel wire or strand in the bend test shall not be considered as adhesion failure of the coating. Another sample of the same production shall be tested if wire or strand failure occurs. The adhesion of coating shall also be evaluated by a tensile test in accordance with *ASTM A 882*, and the tensile strength shall be recorded. The coated strand shall satisfy the requirements for breaking strength, yield strength (1 percent extension), and ultimate elongation as delineated in *ASTM A 882*. No cracks visible to the unaided eye shall occur in the coating up to an elongation of 1 percent (yield point). The sample that is used for the bend test shall be at least 5' long. Sample length for the tension test shall follow the requirements of *AASHTO T244*. Evidence of cracking or debonding of the coating shall be considered cause for rejection of the coated strand represented by the tensile test sample.

Adhesion tests shall be conducted at the tail end of each manufactured length. If the specimen for coating thickness, continuity, or adhesion of coating fail to meet the specified requirements of *ASTM A 882*, two additional tests shall be made on strand samples adjacent to the first sample from the same reel. If the results of both retests meet the specified requirements, the reels represented by the samples shall be accepted.

The maximum amount of damage repair to any one strand shall not exceed 2 percent of the surface area in any foot of length. Larger amounts of damage are cause for rejection.

Patching shall be done in accordance with the recommendations from the supplier of the patching materials.

5.4 COATING TEST REQUIREMENTS FOR ALL STRAND OPTIONS

The Design-Builder shall furnish to the Department for review and comment, a test report prepared by an independent laboratory documenting compliance with the following tests:

A. Chemical Resistance. The chemical resistance of the coating shall be evaluated in accordance with *ASTM G 20* by immersing coated strands in each of the following: distilled water, a 3 M (Molar) aqueous solution of CaCl2, a 3 M (Molar) aqueous solution of NaOH, and a solution saturated with Ca(OH)2. Tests with specimens without holidays and specimens with intentional 0.25" diameter holes drilled through the coating shall be performed at 75±4° Fahrenheit. Minimum test time shall be 45 days. The coating must not blister, soften, lose bond, nor develop holidays during this period. The intentionally made holes shall exhibit no undercutting during the 45 day period.

B. Chloride Permeability. The chloride permeability characteristics of the films of cured coatings having the minimum thickness as proposed for use shall be measured by the methods outlined in *FHWA RD 74 18*. The test shall be performed at 75±4° Fahrenheit for 45 days. The accumulative concentration of chloride ions permeating through the film shall be less than 0.0039 inches of total penetration.

C. Impact Test. The resistance of a strand coating to mechanical damage shall be determined by the falling weight test. A test apparatus similar to that described in *ASTM G 14* shall be used along with a 4 lb tup. Impact shall occur on the crown areas on the coated strand. The test shall be performed at 70° F. With an impact of 80 in-lbf, no shattering, cracking, or bond loss of the coating shall occur except at the impact area, that is, the area permanently deformed by the tup.

D. Salt Spray Fog Test. Coated strand specimens shall be tensioned to 70% of the maximum ultimate tensile strength and exposed to salt fog for 3,000 hours in accordance with *ASTM B 117*. Care shall be taken to protect the end anchorage used from salt fog or corrosion so as not to influence the test results. Observation for signs of corrosion shall be made and recorded every 250 hours. After 3,000 hours of exposure, no evidence of rust shall be present, and the specimen shall be holiday free. After the salt spray test is completed, the specimen shall undergo a tensile strength test, in accordance with *AASHTO T244* to determine if the ultimate tensile strength of the strand has been affected. The tensile strength of the strand after being exposed to the salt spray shall satisfy the requirements of Section 6, *ASTM A 416*. No cracks visible to the aided eye shall occur in the HDPE or HDPP up to and elongation of 1% (yield point). Results from previous tests for a current project maybe submitted for acceptance provided the testing complied with all of the procedures and requirements mentioned above.

The Design-Builder shall have an independent testing laboratory (not the primary Laboratory contracted by the Design-Builder) perform project specific tests defined in tests A through D above. The Design-Builder shall submit the certified test results from the independent testing laboratory that all aspects of these requirements have been met. All above tests shall be completed prior to completion of the testing of the full size specimens and shall show that all strand requirements are met by the individually plastic coated/sheathed or epoxy coated strand to be supplied. The Laboratory shall perform tests on all material, strands and cable specimen assemblies required for both the acceptance testing phase and the cable component fabrication/production phase as defined by the Strand Acceptance Test and Fatigue Strength Testing of Cables sections of these special provisions. The Design-Builder is responsible for the supply and delivery of all testing materials to the laboratory. Coated strand represented by test samples that do not meet all requirements of the contract shall be rejected.

5.5 STRAND ACCEPTANCE TEST

The following conditions shall be met:

A. One 16' long sample strand shall be taken for every 10 tons of strand produced from each heat of steel. This sample shall be used for both fatigue and ductility testing.

B. All strands and test samples shall be marked in such a manner to ensure traceability during production, transit, storage and testing.

C. The test strands shall be protected from failure in the gripping zone. Should any test strand fail in the gripping zone, the test will be discarded and another test specimen made from the same sample.

D. One test for each manufactured length shall be made for the following:

1) Minimum guaranteed ultimate tensile strength: f's = 270 ksi

2) Minimum yield strength: f'y = 0.90 f's

3) Young's Modulus: E = 28,600 ksi + 5%

5.5.2 Fatigue Testing

A. One tensile fatigue test shall be conducted on an approximately 4' long test specimen from each sample. Minimum length shall be 36" face-to-face of grips.

B. The test strand shall withstand without wire failure 2 million cycles of stress variation from 98.6 ksi to 121.5 ksi.

C. After successful completion of the fatigue testing, each test specimen shall withstand a minimum static load of 95% of the guaranteed ultimate tensile strength of the strand without wire failure.

D. Rejection Criteria: If the first valid test strand from each sample fails, two additional tests shall be made from the same samples. If failure occurs in either of these tests, the strand represented by that sample shall be rejected. Retesting shall not be permitted.

5.5.3 Ductility Testing

A "one-pin" test shall be conducted on each sample. The details and method of the test shall be as defined in Appendix "A" of the *PTI "Recommendations for Support Cable Design and Testing and Installation."*

5.5.4 Acceptance Criteria

For acceptance, the tensile force in the sample during the one-pin test shall equal at least 80% of the tested ultimate strength of the sample.

The above strand acceptance tests shall be performed for materials to be incorporated into the stay cable test specimens and for production materials to be incorporated into the permanent structure.

5.6 FATIGUE STRENGTH TESTING OF CABLES

5.6.1 Test Specimens

Three (3) complete, fully assembled stay cable specimens with multiple strands shall be fabricated for axial load testing in accordance with Section 4.2 of *PTI "Recommendations, Support Cable Design, Testing and Installation"*. The three testing specimens shall represent the largest, the smallest and the average sizes of the proposed production cables. Each specimen shall be fully representative of all materials, details, number of strands, fabrication and assembly procedures proposed for production anchorages. One of the fully assembled stay cable specimens shall be tested in accordance with Section

4.1 of *PTI "Recommendations, Support Cable Design, Testing and Installation"* unless prior testing of the identical stay system is approved by the Department in lieu of project specific testing.

6.0 HANDLING AND INSPECTION

6.1 STRAND

The Department shall have unrestricted access to all manufacturing, fabrication, and testing performed at the supplier's facilities, laboratories and shipping and storage facilities. The Design-Builder shall furnish to the Department for approval, complete test reports and certificates that are prepared by the Supplier for the strand from each production lot number, including stress-strain curves and modulus of elasticity of the coated strand. The strand will be furnished in coils and shall have padded contact areas, wherever possible. Each coil will identify the cable into which it is to be installed and the length of strand on the coil. Each coil shall be protected by a supplier-approved method to ensure a uniformly sheathed and coated strand having no adhering foreign matter or damage to the coating, including that from ultraviolet exposure. The ends of the strand shall be sealed at all times.

At all times, the strand shall be properly stored in a weatherproof enclosure. A weatherproof enclosure shall be considered to be a fully enclosed building complete with floor or a fully enclosed container with wooden or metal roof, sides and floor capable of protecting the strand reels and packing from exposure to rain, wind, snow/ice and sunlight. All strands shall similarly be shipped in closed bed trucks or containers to avoid exposing packing to weather. Each coil shall also be marked with the order number, coil number and heat number. The starting end of each coil shall also be marked. The Design-Builder shall minimize unnecessary bends in the field when uncoiling strands. Handling resulting in sharp kinks or short radius bends less than the spool radius shall be cause for rejection. If, as determined by the Department, the kink or short radius bend was inherent in the coil, it shall be immediately replaced by the Design-Builder.

All systems for handling coated strands shall have added contact areas. All bundling bands shall be padded or suitable banding shall be used to prevent damage to the coating. All reels of coated strand shall be lifted with a strong back, spreader bar, multiple supports, or a platform bridge to prevent abrasion. The reels and strand shall not be dropped or dragged.

All strand ends shall be sealed with approved patching materials by the end of the same day that the strand is cut.

Any damage to the coating shall be repaired by the Design-Builder utilizing project approved materials, procedures and personnel. If the stay cables sheathing is to remain non-grouted along the free length of the stays, it is imperative that the strand coating be undamaged over the full length of cable in order to provide long-term protection to the strands.

6.2 SHEATHING

The Design-Builder shall use padded points of contact during storage, handling, fabrication and erection. Care shall be taken at all stages of the construction process to avoid damage to the finish. The Design-Builder shall immediately repair any damage to the surface finish. The visible grain of the finish shall be uniform in appearance and direction.

These handling/finish requirements shall also apply to exposed portions of any guide pipes.

6.3 ANCHORAGE AND MISCELLANEOUS COMPONENTS

The anchorage components and miscellaneous components shall remain in their original shipping containers as supplied by the Supplier until ready for immediate use unless specified otherwise by the Supplier. These components shall be kept in appropriate weatherproof enclosures. During handling, fabrication, erection and all construction operations, the Design-Builder shall use the utmost in care to protect the components from any damage. Any and all damage shall be repaired by the Design-Builder utilizing previously approved procedures for this project and/or shall replace damaged components.

7.0 FABRICATION OF CABLES

A. Cables shall be fabricated in a manner consistent with the design and testing requirements for the cable-supported bridge system as indicated in these Special Provisions. Appropriate measures shall be taken to ensure that all strands are installed parallel to each other.

B. The Design-Builder shall develop and implement procedures to assure that stay cable components including stainless steel sheathing will not be damaged during handling. All stay cable components shall be protected from corrosives, heat, abrasion and other harmful effects throughout the fabrication and installation.

C. Spreader bars and slings or other appropriate devices shall be used to handle all cable and sheathing components. Slings or similar devices shall be positioned on the cable to carry both the anchor and adjacent cable in a tangent position, preventing bending of the cable at the anchor. Slings and spreader devices shall be padded to prevent damage to the cable sheath.

D. All damage to cables or any components thereof shall be evaluated and remedied by the Design-Builder, to the satisfaction of the Department, prior to installation of the cable. Damaged strand shall be replaced. Damage to non-load carrying components shall be repaired or replaced to the Department's satisfaction prior to the installation of the cables. Any damage occurring after installation shall similarly be evaluated and immediately remedied by the Design-Builder to the satisfaction of the Department.

E. Storage, handling, fabrication, assembly, erection, stressing and completion of all cable-supported bridge system components shall follow without deviation the procedures, details, methods and equipment used as presented in the Design-Builder's approved shop drawings and detailed, step by step erection manual.

F. Guide Sleeve and Bearing Plate. The Design-Builder shall install and align the guide sleeve and bearing plate assemblies during construction. The manual of geometric controls to be developed by the Design-Builder for the Department’s review and comment shall include a detailed survey and alignment procedures for such alignment. The construction manual shall include detailed equipment and procedures used to secure the guide sleeve and bearing plate assemblies during concrete placement and curing.

G. Stay Pipe. All pipe ends shall be prepared for joining with full penetration welds. The welds must be flush with the pipe walls inside and outside. The Design-Builder shall submit to the Department for review and comment recommendations for the welding details and procedures to achieve the weld. The Design-Builder shall submit individually for each welder, a detailed qualifications and experience resume. Each welder proposed for the project must prove substantial experience in welding pipe material using the method proposed by the Design-Builder. In addition, at least 60 days prior to a welder beginning work on production pipe the Design-Builder shall, concurrent with the experience / qualifications resume, supply to the Department a pipe weld sample produced by the proposed welder. The sample shall utilize the same materials and methods to be used for

production welds. The sample shall include at least one (1) full circumferential weld and have a length of sample not less than 2' and not more than 4'. Review of the test weld by the Department shall in no way be interpreted as any acceptance of responsibility by the Department for the quality of the welder's future work on the project.

H. The Design-Builder shall follow the approved welding details and procedures. All stainless steel welding shall conform to *AWS B2.1 98* and *AWS D1.6 99*. One hundred percent of all steel welds shall be tested by ultrasonic methods and/or radiographic (non destructive) testing as specified by *ANSI/AASHTO/AWS D1.5 Bridge Welding Code*. The minimum length section of pipe provided and installed shall not be less than 5' in length.

I. The Design-Builder shall demonstrate that the welding procedures for stainless steel pipe consistently result in a flush inside surface by video inspection of the cable pipe interior. The Department may at any time require, at no additional cost to the project, video inspection of any portion of any cable pipe.

J. No welding of the pipe shall take place with the coated strands inside. Finishing of all welds to the required finish shall principally occur prior to installation of the strands into the pipe. Any remaining finish repair to the weld or other areas shall be conducted in a manner that will not heat the pipe at any point to more than 150° Fahrenheit.

K. Strand Installation. Installation of strands shall follow the fully engineered procedures contained in the Design-Builder's shop drawings and detailed step-by-step erection manual. Deviations from procedures, methods, details or equipment shall not be permitted. The resulting installed strands shall be parallel and damage free.

L. Anchorage and Miscellaneous Components. The anchorage components and miscellaneous components shall be installed following the fully engineered procedures contained in the Design-Builder's shop drawings and detailed step-by-step erection manual. Deviations from procedures, methods, details or equipment shall not be permitted. The installed anchorage and miscellaneous components shall be damage free. Flame cutting of strands is not permitted.

8.0 CABLE STRESSING

A. Accurate calibration of the cable jacks and gauges is critical to the geometry control of the cable-supported structure and the resulting state of stress in the structure. Jacks and gauges for cable installation shall be match calibrated using a load cell or calibrated static load machine by an independent laboratory within one month prior to the beginning of the cable installation, and every 6 months thereafter, for the duration of the cable installation. Calibration shall be accomplished with the jack actively applying load to the machine, not the machine applying load to the jack. Prior to use after each calibration, each field gauge shall be calibrated against the master gauge for reference purposes. Any internal work performed on the jack shall require recalibration.

B. The detailed cable installation procedure, contained as part of the erection manual, shall prescribe force, cable elongation and deck elevations for each jacking operation, and shall establish the priority of force or geometry for control of the jacking operation. This procedure shall stipulate the permissible variance between force and elongation and deck elevation for each cable to be installed.

C. The cable stressing procedures shall include detailed provisions for monitoring the installation of each cable.

D. Permanent records shall be established by the Design-Builder for each cable installation. Such records shall include survey records; date, time and ambient temperatures; cable forces;

cable elongation measurements; ring nut setting; deck loading conditions; and all other special notations necessary and sufficient to establish the conditions under which the cable was installed. This record shall include the as built profile grade elevation of the deck along each web and atop each cable anchor block immediately prior to and immediately after each stressing operation. Copies of this data shall be provided by the Design-Builder to the Department within 24 hours of completing each cable stressing operation.

9.0 COMPLETION OF CABLE-SUPPORTED BRIDGE SYSTEM

After successful closure of the main span superstructure, the Design-Builder shall complete all remaining cable-supported bridge system installation requirements. These include, but are not limited to final restressing (if necessary), final finish of the stay cable pipe, installation of protective end caps, injection of inert gas (optional), installation of permanent cable dampers, boots and miscellaneous hardware.

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605545 - SOIL BORINGS, LAND

General:

Soil Borings are those drillings advanced through unconsolidated or partly consolidated sediments or decomposed rock by use of Hollow Stem Augers (HSA) or Drive Casing and sampling with a split barrel sampling spoon at locations designated on the Plans or as directed by the Engineer. Those soil borings made over "deep" water requiring a barge or other special equipment will be considered Soil Borings, watering all others will be considered Soil Borings, Land.

Standard Penetration Tests (SPT) and Split Barrel Sampling of the soils shall be taken at the ground surface and at 5 foot intervals thereafter in all hollow stem auger and drive casing holes.

Hollow Stem Auger Method:

The Contractor shall use a power-driven, continuous, hollow-stem auger casing to advance and maintain the hole. The clear inside diameter of the hollow stem must be large enough to allow for the insertion of a 3.0 inch OD Shelby Tube soil sampler and attached rods through the in-place auger casing when elevations are reached for securing soil samples.

When using auger casings, the relative resistance to penetration, general feel and performance of the auger operation, and the cuttings obtained from the auger shall be observed and recorded for detection of changes in the materials encountered.

The plug point shall be withdrawn through the hollow stem, the sampler lowered through the full length of the auger, then driven or pressed below the auger bit and withdrawn. After replacing the plug point, the auger shall proceed to the next point of sampling. When the use of hollow stem augers is not feasible because of site conditions, the use of drive casings will be permitted.

All boreholes shall be preserved from collapse and bottom instability during advancement and sampling operations. When drilling below the natural ground water level, water shall be maintained inside the augers at a level above the ground water level at all times. If it is required to prevent bottom instability, water should be added to maintain a positive static water head inside the augers during drilling and withdrawal of the drilling rods. Cleaning out of the augers shall be required if the accumulation of material within the hollow-stem, between sampling intervals, is of a degree that is detrimental to the purpose of the sampling operation. Cleaning out the augers shall be performed with wash rods and a roller or side discharge chopping bit.

Drive Casing Method of Advancing Borings:

All sampling and other procedures referencing the HSA method will also apply where drive casing is employed.

Casings shall be extra-strong steel pipe or flush-coupled casing with nominal inside diameter of 4 inches.

Casings shall be sunk vertically through earth and other materials, including boulders and rock veins, to rock, or if not to rock, to such depth below ground as the Engineer may order. They shall be driven down without washing to the depth at which a sample is to be taken, after which the material shall be cleaned out to the bottom of the casing and the sampler driven or pushed below the bottom of the cleaned casing. After sampling, casing driving shall be resumed.

The use of clean water for cleaning out the casing between sample elevations will be required. Recirculated water shall not be used. The Contractor shall make suitable arrangements for properly procuring and disposing wash water.

The weight of hammer to be used in driving the casing shall be 300 pounds with a 24 inch height of free fall. The hammer shall be raised by means of a rope having one end wrapped (not more than three loops) around a winch head. Wire rope will not be permitted. A continuous record of the blows per foot required for the driving of the casing shall be kept.

Simultaneously washing and driving of the casing will not be permitted except when the Engineer, judges the driving requires the use of water. Where the use of water is permitted, borings shall be advanced by saw tooth, chopping, fishtail, or rollerbits, all having side discharge jets. In advancing the boring, return water circulation, resistance to penetration and general performance of the drill shall be observed for detection of change in material. The casing shall next be advanced, if needed for retaining the hole open, to the point of maximum penetration of the washed pilot hole. The casing shall be cleaned in a manner to result in minimum disturbance of the soil below the casing shoe. All sampling shall be performed in advance of the casing shoe. A record must be kept of the depths between which simultaneous washing and driving occurred.

In some cases where the characteristics of the soil are suitable, the Engineer may permit the Contractor to discontinue driving the casing and accept advancing the boring by means of wash rods with a roller bit or side discharge chopping bit to the elevations at which samples are to be taken. This procedure shall be noted in the boring record. Should there be any indication of the sides of the hole collapsing, thus blocking normal progress of the boring, driving of the casing shall be resumed.

When a boulder or a stratum of ledge rock is encountered before the required depth of boring has been reached, it shall be the Contractor's responsibility to carry the boring through or passed these obstacles but only by methods approved by the Engineer. The Contractor may, in some cases, be permitted to core the boulder or rock stratum to determine its size and characteristics. The required size of sampler to be used below the obstacle shall determine the size of boring to be made. A log of the nature of the obstacle and the method used to carry the boring through the obstacle shall be recorded.

Any method used to carry the boring through the obstacle other than rock core drilling in excess of one (1) foot, shall be considered as Soil Boring and will be measured and paid for at the unit price per linear foot bid in the proposal for that size boring carried through the obstacle.

If the Contractor abandons a boring before adequate information is obtained and starts another boring adjacent to it in preference to carrying the boring through the obstacle, or because of a shattered or misaligned casing, no payment will be made for the work done on the abandoned boring.

Sampling Device:

The sampling device for ordinary, dry samples from Soil Borings shall be a standard split barrel sampler meeting the requirements of the "Standard Method for Penetration Test and Split Barrel Sampler of Soil", ASTM D 1586. The sampler shall be a split barrel tube with an outside diameter of 2 inches, an inside diameter of 1-3/8 inches, a minimum length of 18 inches between the driving shoe and the smaller head, and a minimum total length of 27 inches. The drive shoe shall be hardened steel and shall be replaced or repaired when it becomes dented or distorted. The sampler head shall have a 1/2 inch minimum diameter vent ports and shall contain a reliable ball check valve.

Sampling Procedure:

The HSA shall be drilled to the sampling depth and the loose material within the casing cleaned to its bottom before driving the sampler. Clean out shall be accomplished by roller bit, chipping bit or other method approved by the Engineer.

The sampler shall be driven into the soil below the HSA for a distance of eighteen (18) inches or until further penetration is impossible with a one hundred and forty (140) pound hammer falling freely through a vertical distance of thirty (30) inches. The number of blows of the hammer shall be recorded for each six (6) inches of penetration and if six (6) inches is not penetrated in one hundred (100) blows, the sampler will be considered to have met refusal and the blows shall be recorded as 100/number of inches penetrated. The hammer shall be raised by the use of a manila rope which the driller shall pull by hand with the assistance of a power operated spool or drum about which the rope will freely slip during the drop of the hammer. No more than 3 turns of the rope around the drum shall be allowed as assistance in lifting the hammer. Wire rope will not be permitted to lift the hammer. All sampling devices, including driving mechanisms, used by the Contractor shall be approved by the Engineer.

Samples of the soil retained in the split barrel sampler shall be taken from that portion of the soil column between six (6) and eighteen (18) inches below the bottom of the casing. The sample so obtained shall be representative of the material from which it is taken and shall be in an unwashed condition. Samples recovered from wash water, commonly termed "wash samples" will be unacceptable. If less than nine (9) inches of soil is retained in the sampler, a second sample shall be taken immediately below the deficient sample, after first advancing the boring. If more than one soil type is present in the sampler, a sample shall be taken of each type, and the length of each type of soil in the sampler shall be noted on the boring log.

Preservation and Identification of Samples:

The disturbed samples obtained with the split barrel sampler shall be removed with as little disturbance as possible, and immediately placed in a suitable, tightly capped sample jar. Samples which retain form upon removal form the sampling spoon, shall not be jammed or forced into the jar. These jars shall be clear glass, have a minimum 8 oz. capacity, and be about two (2) inches in diameter and five (5) inches or more in height with a mouth wide enough to accommodate samples from the split barrel sampler and shall be equipped with a screw top and suitable gasket seal. Each sample jar shall be clearly and permanently labeled to show the project and section, boring number, station location, elevation or depth at which the sample was taken, the kind of material and the number of blows of the sampler.

If two or more materials are encountered in a sampler, separate jars shall be used for each material. The letters "A", "B", etc. shall be added to the sample number on each jar to designate the different materials.

The Contractor shall provide the sample containers, keeping a sufficient supply on hand to prevent any delay in the work.

The Contractor shall pack all glass jar samples in containers acceptable to the Engineer, and of sufficient durability to withstand handling without breakage of the sample jars. On the top and one end of each container, the Contractor shall neatly and legibly paint or stencil, using waterproof paint, the following identifying data: title of project and designations of section thereof; location of site by name and/or survey station; boring numbers; and name of Contractor; all as required or directed by the Engineer.

During the period of active work in the field, the Contractor shall provide and be responsible for

storing all soil samples in a warm, dry, locked, temporary storage facility convenient to the work areas. At period determined by the Engineer or in any case at the completion of all field work, the Contractor shall transport all boxed samples to storage location in Dover, Delaware specified by the Engineer except for the C & D Canal samples which shall be transported to Century Engineering, Inc. in Towson, Maryland.

Determination of Running Sand:

In order to determine whether the water pressure on sand, if encountered in a boring is sufficient to cause the sand to run when unconfined, the Engineer may order a test for running sand.

The test shall consist of obtaining a sample of the sand with a split barrel sampler as specified in the sampling procedure. The casing shall then be drilled into the sand to 92 feet below the elevation at which the sand was encountered, and carefully washed out to the bottom. The hole shall then be allowed to stand ten (10) minutes, and the elevation at which the sand then stands in the casing shall be measured. The water in the casing shall then be removed to a point five (5) feet above the bottom of the casing to produce an unbalanced hydrostatic condition and the elevation of the top of the sand shall again be measured.

No more than one such test will be required at each structure when sand is encountered at depths near or above the anticipated elevation of the bottom pier or abutment excavation.

The test for running sand will be considered a normal procedure in the drilling of Soil Borings. No additional compensation will be allowed over and above the unit price per linear foot bid in the proposal for Soil Borings.

Ground Water:

Depth to ground water shall be determined when initially encountered and upon completion. The Contractor shall also take a water level reading 24 hours after the augers are removed. In the event the hole collapses before the ground water is observed the depth tot he collapsed portion shall b recorded. Ground water determination as described in this paragraph will not be paid for separately, but will be considered incidental to the work.

Records and Logs:

The Contractor shall keep a complete and accurate record of all details of the Soil Boring operations in a field book and on suitable boring log forms provided by the Contractor. Upon completion of each boring two copies of the field log, on 8-1/2 x 1 inch paper shall be given to the Engineer. The description of the soil, rock and other material encountered in the boring shall be made by the driller with the assistance of the Engineer. Each boring log shall record the information pertinent to the boring work being accomplished as outlined in the following sections or as deemed necessary by the Engineer. The following general information shall be recorded on each and every boring log:

(a) Title of project and section designation
(b) Location of site by name, and/or survey station, and offset, if any, right or left of survey baseline
(c) Hole number as specified on the Plans or as furnished by the Engineer
(d) Names of the Engineer, Contractor, Inspector, and drilling crew
(e) Date of starting and completing each boring
(f) Ground elevation of the top of the hole as provided by the Engineer
(g) Depth to the top of ground water, if present.

The following information shall be recorded on the boring logs for that portion of the boring penetrating unconsolidated or partly consolidated sediments or decomposed rock by drilling and sampling with a split barrel sampler:

(a) Type of drill rig used
(b) Size, type and length of augers used in each hole
(c) Method used to clean out casing between sampling intervals
(d) Size of split barrel sampler, weight of hammer, height of drop, and number of blows of the hammer for each six (6) inches of penetration of the sampler out of a total minimum penetration of eighteen (18) inches for each sample. Where six (6) inches is not penetrated in one hundred (100) blows of the hammer, the distance penetrated in one hundred (100) blows shall be recorded
(e) Depth to beginning and end of sampling drive, and the length of sample recovered from the sampler
(f) Depth to the top of each change or stratum of material
(g) Description of the material encountered shall be in accordance with standard practice and shall include:

(1) Type - topsoil, sand, silt, clay, gravel, silty clay, sandy silt, etc.
(2) Color - light brown, dark reddish brown, etc.
(3) Moisture - dry, moist, wet, very wet, etc.
(4) Consistency - soft, loose, medium, firm, stiff, etc. as determined by "N" values in Table 1 below.

TABLE 1

DEGREE OF DENSITY OR CONSISTENCY

Non-Cohesive Soils(Sand) Descriptive term	Standard Penetration "N" Blows/Ft.	Cohesive Soils(Clay) -Descriptive Term	Standard Penetration "N" -Blows/ft.
Very loose	0-4	Soft	0-4
Loose	5-10	Firm	5-8
Medium	11-30	Stiff	9-15
Dense	31-50	Very Stiff	16-30
Very Dense	51+	Hard	31+

(h) Unusual occurrences such as running sand, voids, loss of water, etc.
(i) The distance through which a roller bit is used to advance the hole in soft or weathered rock which is too soft to core drill and too hard to advance augers.

False Starts:

The Contractor is to verify the exact location of all known utilities prior to drilling. If the Contractor is unable to drill any boring due to encountering underground pipes, cables, conduits, or other underground utilities or structures, the existence and location of which were not previously know, or because obstacles or obstructions are encountered which the Engineer considers are of an unusual nature and that failure to penetrate them is not the fault of the Contractor's methods or equipment, a false start will be allowed. The length of the false start will be measured as specified and paid for at the applicable Contract unit price, providing, however, that the Contractor shall submit to the Engineer a complete record of all such false starts. If the Contractor abandons a hole prior to approval of the Engineer, no payment will be made for the hole so abandoned. For the new hole, bored to replace the abandoned hole, the Contractor shall conduct his operations as if a completely new hole was bored obtaining soil samples, standard penetrations tests, etc., in the depths reached by the abandoned hole.

~~Basis of Measurement and Payment:~~

~~The quantities for the items of Land Soil Borings for which payment will be made will be the total depth of each boring actually made either by use of driven casing or augered casing and accepted by the Engineer. Measurement will be from the surface of existing ground to the bottom of the hole, or to the depth at which Rock Core Drilling starts. The bottom of the hole shall include the depth of the last ordinary disturbed sample when obtained below the bottom of the drilled hole. When the last sample is an undisturbed sample, the bottom of the hole shall not include the depth of such last undisturbed sample.~~

~~Payment for Land Soil Borings will be made at the same contract unit price per linear foot for Hollow Stem Auger soil borings and 4 inch diameter Drive Casing soil borings, which price and payment shall include the cost of all labor, materials, and plant necessary for furnishing and sinking of casing, as required; the cost of taking, packing, storing, and delivering ordinary dry samples; the cost of determination of running sand; the cost of moving plant and equipment between sites and within sites; the cost of taking and recording ground water observations; the cost of filling holes and surface restoration; and all else in connection with or incidental to the drilling.~~

605589 - BRIDGE EXPANSION JOINT DEVICES

1.0 DESCRIPTION

The Design-Builder shall be responsible for designing, furnishing, fabricating, storing, installing, erecting, adjusting, and completing the assembly of all components of bridge expansion joint devices, including repair and/or replacement of damaged components (if necessary) for the bridge in accordance with the Contract requirements and the criteria established in this Special Provision during all phases of design and construction of the Project. All bridge expansion joint devices shall adequately provide for thermal expansion and contraction, rotation, camber changes, creep and shrinkage of structural members, and movements during all phases of construction and during the service life of the structure. Designing and developing detailed replacement procedures, including equipment, shoring, blocking, and other such procedures and operations for bridge expansion joint devices are the responsibility of the Design-Builder. The Design-Builder shall also be responsible for the satisfactory performance of the bridge expansion joint devices installed on the bridge for the Contract required warranty period.

Complete bridge expansion joint devices include, but are not limited to, sealed finger joints with appropriate elastomeric seals; prefabricated neoprene strip seals; drainage troughs and piping with outfall protection; structural steel and/or other metal and non-metallic components; anchors and/or fixing devices; armor and cover plates; treatment of sliding plates and other similar details to the profiles of curbs and barriers; complete anchorage materials and components including grout, hardware, bolts, connectors, nuts, washers and shims; corrosion protection provisions; temporary corrosion protection provisions during storage and construction; erection devices and equipment; and all permanent and incidental materials and labor to install each bridge expansion joint device in accordance with the Contract requirements.

Any bridge expansion joint device(s) or type of bridge expansion joint device(s), proposed by the Design-Builder for use on the Project, must adhere to the requirements of this Special Provision and must be submitted to the Department for review and comment prior to completion of the Preliminary Design Review.

2.0 STANDARDS

Bridge expansion joint devices are to be provided in accordance with this Special Provision and the "AASHTO LRFD Bridge Design Specifications, U.S. Customary Units," the latest edition with all current Interims as of the issue date of this RFP, unless otherwise noted.

These Special Provisions are intended to complement the "AASHTO LRFD Bridge Design Specifications" and in cases of disagreements, these Special Provisions for bridge expansion joint devices shall govern over the "AASHTO LRFD Bridge Design Specifications." It is the Design-Builder's responsibility to obtain clarification of any and all unresolved ambiguity prior to proceeding with any design or construction.

3.0 ACCEPTABLE BRIDGE EXPANSION JOINT DEVICES

Acceptable bridge expansion joint devices are listed below. The Department shall consider other bridge expansion joint device(s) or other types of bridge expansion joint devices as unacceptable for use for this Project.

A) Sealed Finger Joints with Elastomeric Seals for bridge movements greater than 3 inches; and

B) Strip Seal Expansion Joints with Elastomeric Seals for bridge movements of 3 inches or less.

4.0 MATERIALS

All materials shall be new and unused, with no reclaimed material incorporated in the finished bridge expansion joint devices.

4.1 STEEL

All steel products to be used or supplied in connection with any bridge expansion joint device shall be steel products rolled, formed, shaped, drawn, extruded, forged, cast, fabricated, or other similar process or processed by a combination of two or more such operations, from steel made in the United States by the open hearth, basis oxygen, electric furnace, Bessemer or other steel making process. "United States" means the United States of America and includes all territories, continental or insular, subject to the jurisdiction of the United States.

A) All steel used shall conform to the minimum requirements of ASTM A 709, Grade 36, or Grade 50.

B) Anchor bolts, nuts, and washers shall conform to ASTM A 307.

C) Materials utilized to produce shapes suitable to mechanically lock elastomeric strip seals shall conform to the properties of ASTM A 588.

D) All steel shall be hot-dipped galvanized in accordance with ASTM A 123 after fabrication.

E) The requirements of this section also apply to the sliding plate assemblies on the barriers.

4.2 CONCRETE

Concrete for backfill of expansion joint blockouts and details shall be of the same class and strength as that in the adjacent bridge deck, unless otherwise required by the Design-Builder's design, with the exception that the maximum size of aggregate shall be 3/8 inch.

4.3 LUBRICANT ADHESIVE FOR STRIP SEALS

Elastomeric strip seals shall be installed utilizing a one-part moisture curing polyurethane and aromatic hydrocarbon solvent mixture that complies with ASTM D 4070.

4.4 REINFORCED ELASTOMERIC SHEETS

Elastomeric sheets for troughs or membranes shall be manufactured from 100% virgin chloroprene or EPDM (Ethylene propylene dienemonomer) with good to excellent resistance to weather, oxygen, ozone, radiation and water of the thicknesses, shapes and hardness required by the Design-Builder's bridge expansion joint device design. Neoprene, the sole polymer shall be 100% virgin chloroprene, which shall be not less than 60% by volume of the total compound. Elastomeric sheets shall be internally reinforced with synthetic or natural fabric. The elastomer shall meet the following requirements of ASTM C 864 and as amended below:

Property	Physical Requirements	Procedure as per ASTM Designation
Hardness, Durometer A	50 points minimum	D 2240, Modified
Tensile Strength, psi, min.	1,500	D 412

Property	Physical Requirements	Procedure as per ASTM Designation
Maximum Elongation at Ultimate, Percent	Greater than 30%	D 412
100 ppm ozone in air by volume, 20 percent strain, ± 100° F, 70 hours mounting (Procedure B)	No cracks	D 1149 – samples to be solvent wiped before test to remove any traces of impurities

4.5 ELASTOMERIC STRIP SEALS

The elastomeric strip seal material shall be 100% virgin Polychloroprene (Neoprene) with good to excellent resistance to weather, oxygen, ozone, radiation and water of the thicknesses, shapes and hardness required by the Design-Builder's bridge expansion joint device design. The strip seal shall be an extruded neoprene material meeting the requirements of ASTM D 2628 modified to omit the recovery test. The elastomeric strip seal material shall meet the following requirements determined by applicable ASTM tests and as amended below:

Property	Physical Requirements	Procedure as per ASTM Designation
Hardness, Durometer A, Points	60±7	D 2240, Modified
Tensile Strength, psi, min.	2,000	D 412 (die C)
Ultimate Elongation, Percent, min.	250	D 412 (die C)
Compressive Set, Accelerated Test to Determine Long-term Characteristics Oven-aged – 70 hours at degrees 212° F, Percent, max.	40	D 573
Abrasion Resistance Index	200 or greater permissible	D 1630
Oil Swell, Oil LRM 903, 70 hours at degrees 212° F, Weight Change, Percent, max.	45	D 471
Low Temperature Stiffening, 7 days at degrees 14° F, Durometer A, Points, max.	+15	D 2240
300 ppm ozone in air by volume, 20 percent strain, ± 140° F, 70 hours mounting (Procedure B)	No cracks	D 1149 – samples to be solvent wiped before test to remove any traces of impurities

5.0 REQUIREMENTS

5.1 GENERAL

A) Before the fabrication of any bridge expansion joint device, the Design-Builder shall submit shop drawings to the Department for review and comment. The shop drawings shall be stamped by a professional engineer employed by the Design-Builder's bridge expansion joint device fabricator with a minimum of 5 years of documented history of bridge expansion joint device design experience. The shop drawings, detailed by the Design-Builder's bridge expansion joint device fabricator, shall include, but shall not be limited to, the following for each bridge expansion joint device used for the Project:

1) Detailed drawings showing plan, elevation, and section views;
2) Complete details and sections showing all ASTM, AASHTO, or any other material designations;
3) The size, quantities, and locations of bridge expansion joint devices including the movement capacities of the devices;
4) The Design-Builder's delivery and installation procedures and methods;
5) All appropriate notations and instructions for field installation;
6) Complete details for inspection and construction purposes;
7) Bridge expansion joint device blockouts and all bridge expansion joint device connection details;
8) Coating requirements;
9) Complete and detailed replacement procedures, including equipment, shoring, blocking, and other such procedures and operations; and
10) Complete design calculations, material specifications and certifications, and fabrication procedures verifying the conformance with the provisions of this Special Provision and the Contract requirements.

B) The Design-Builder shall submit an installation procedure for each specific expansion joint proposed. This plan will be in accordance with the recommendation from the Design-builder's supplier. This plan will include at a minimum:

1) Step by step installation procedures;
2) Method for securing the joint;
3) Method for adjusting the joint for temperature, creep and shrinkage considerations;
4) Method for insuring rideability;
5) Method for placing surrounding concrete, reinforcing and post tensioning; and
6) Method for attaching the barrier rail cover plates.

C) The Design-Builder shall be responsible for coordinating the location of connections to both the superstructure and substructure and to verify that there are no conflicts with post-tensioning or reinforcement with any bridge expansion joint device.

D) The Design-Builder shall be responsible for designing, detailing, furnishing and installing downspouts, scuppers, cleanouts, trench drains, splash blocks, and any other such

materials for the proper conveyance of the colleted discharge from the bridge expansion joint devices. The Design-Builder's drainage system shall provide redundancy and protection of all bridge surfaces shall be robustly designed by the Design-Builder in the event of failure of the seals of the bridge expansion joint devices. The drainage system shall be concealed within the bridge and shall tie-in with the bridge drainage system.

5.2 SEALED FINGER JOINTS WITH ELASTOMERIC SEALS

The sealed finger joints with elastomeric seals system shall accommodate the longitudinal and other movements required by the Design-Builder's design while maintaining a smooth riding surface with minimal space between fingers and shall prevent passage of water through the joint system. The joints shall also be designed to sustain all loads and impacts without damage or fatigue of the joint or the structure to which it is secured and supported. All design loads and movements shall be included in the Design-Builder's design, shop and working drawings. Joints shall be provided such that they can be easily replaced in short sections.

A) For safe operation of motorbikes, when the maximum longitudinal opening in the direction of traffic exceeds 8 inches, the transverse opening shall not exceed 2 inches. For longitudinal openings less than 8 inches, the transverse opening shall not exceed 3 inches. Where narrow bicycle tires are anticipated (outside shoulders and sidewalk) special floor plates or other appropriate details shall provide a continuous path for the tires with minimal transverse steps or irregularities. Floor plates in pedestrian pathway shall also meet the requirements of "The Americans with Disabilities Act of 1990."

B) The minimum joint opening, (maximum design temperature with minimum creep and shrinkage of the superstructure) in the longitudinal direction shall be 0.5 inches.

C) At the maximum joint opening, (minimum design temperature with maximum creep and shrinkage of the superstructure) the minimum tooth overlap shall be no less than 2 inches.

D) Fingers (teeth) shall be aligned parallel to the direction of movement of the adjacent bridge bearing devices (generally the longitudinal direction of the bridge) as shown on the Design-Builder's Plans and Department approved Shop Drawings.

E) The finished elevation of the finger joint and any securing devices shall be a minimum of 1/8 inch and a maximum of 3/16 inch below the adjacent top surface of the deck slab, approach slab or finished roadway riding surface as appropriate. Approved armoring, concrete or synthetic material details shall be provided locally to buttress the exposed top edge of the adjacent riding surfaces at the rear of the finger plate installation on both sides of the joint, as necessary.

F) The fingers of the joint shall be shaped and installed as necessary to ensure that the fingers remain below the level of the riding surface at all times under all anticipated movements and rotations of the superstructure and substructure.

G) Special armoring shall be provided to contain the edge of the structural support surface at the edges of the opening underneath both sides of the finger joint and around all sides of the bridge barriers.

H) Preformed troughs, seals and membranes shall be fabricated as a single piece without splices. Joints in troughs, seals or membranes shall be fabricated according to manufacturer's requirements and shall be waterproof. All material shall be cut cleanly, with a true edge using suitable, sharp tools and methods to provide a straight and accurate installation.

I) Elastomeric drainage troughs, seals or membranes shall be provided to collect all

rainwater run off, de-icing materials and detritus materials from the roadway that flows through the openings of the fingers. The troughs, seals or membranes shall be so attached, weather lapped and sealed to the assembly of the finger joint so that no liquid or debris can leak or escape to run onto the adjacent parts of the structure. Seals shall be turned up and properly detailed at curbs and barriers to prevent leakage.

J) Drainage troughs shall be installed at a slope that is self-cleaning so that debris does not accumulate and shall positively discharge (minimum slope shall be 1 inch per foot), without splash back flow or overflow, into drainage pipes, chutes, or other accommodation for appropriate discharge.

5.3 STRIP SEAL EXPANSION JOINTS WITH ELASTOMERIC SEALS

A) Steel shapes suitable to mechanically lock elastomeric seals shall have a minimum thickness of 1/4 inch as measured from the internal locking mechanism cavity to the top of the steel shape.

B) Steel shapes shall be monolithic with a machined retainer cavity. To assure watertightness, the steel shape sealing cavity shall maintain a tolerance of ±10/1000 (.010) inches. Multiple welded steel shape and rolled steel components that are bent or crimped to achieve the final shape, or seal retainer cavity will not be allowed.

C) Provide 5/8 inch diameter by 6 inch concrete anchor studs factory welded to steel shapes and as detailed on the Design-Builder's fabricator's Shop Drawings for cast-in-place conditions. Material shall meet the requirements of ASTM A 108 with a maximum spacing of 12 inch on center. Any alternate anchorage system shall be submitted by the Design-Builder to the Department for review and comment.

D) Installation of the prefabricated strip seal, and application of adhesives, shall be in accordance with the Design-Builder's supplier's written recommendations and instructions. The Design-Builder's supplier shall provide special tools for insertion of elastomeric strip seals.

E) The strip seal shall be furnished in one piece for the full width of the joint.

6.0 TESTING

An independent testing laboratory (or laboratories) selected by the Design-Builder and approved by the Department shall test all materials and bridge expansion joint device assemblies in accordance of with the testing requirements of this Special Provision for each specific type of bridge expansion joint device proposed by the Design-Builder for the Project. The Design-Builder shall be responsible for all coordination between the Design-Builder's laboratory (or laboratories), Design-Builder's supplier(s), and Department representatives. The Design-Builder shall notify the Department 14 Calendar Days prior to any testing to be performed on bridge expansion joint devices and the Department shall be allowed to witness all testing.

The Design-Builder shall furnish all material and written test procedures, as prepared by the Design-Builder's supplier(s) to the Department for review and comment. Each component of the assembly shall have an AASHTO or ASTM material and test specification. The Design-Builder's supplier(s) and the design-Builder's laboratory (or laboratories) shall prepare separate reports. Each of these reports shall independently describe all the testing data and testing results. All reports shall be submitted by the Design-Builder to the Department within 14 Calendar Days of completing each test as independent records of the testing. The Design-Builder shall be responsible for sub-contracting and coordinating with the Design-Builder's laboratory (or laboratories) and Design-Builder's supplier(s) for all testing laboratory services.

The Design-Builder's supplier(s) shall provide written and detailed recommendations to the Design-Builder regarding storage, handling, transporting, assembly, aligning, and verification of performance of the bridge expansion joint devices. The Design-Builder's supplier(s) shall simultaneously provide copies of all such recommendations directly to the Department for the project files.

7.0 CERTIFICATION

A) A copy of the test certificates documenting the tests performed and mill tests for all materials used in the bridge expansion joint device fabrication shall be submitted by the Design-Builder to the Department's Materials and Research Section for review and comment.

B) The certification package shall include, but not limited to, the following:

1) Material test reports for all steels used except AISI C1018 and AISI C1020 for which a mill certificate of compliance is acceptable;

2) Certificate of Compliance for all non-ferrous metals;

3) Material test reports for any elastomeric components;

4) Certificate of Compliance for any adhesives used;

5) A Certificate of Compliance for the bridge expansion joint devices executed by an officer of the Design-Builder's bridge expansion joint device fabricator's company;

6) Certificate of Compliance for any dowels or bolts supplied; and

7) Test reports for the performance tests.

C) In addition, the Design-Builder must contact the Department's Materials and Research Section to confirm materials are acceptable at least seven (7) Calendar Days before shipping the bridge expansion joint devices to the site.

8.0 FABRICATION, HANDLING AND STORAGE

A) The Design-Builder shall provide the Department with written notification thirty days prior to the start of bridge expansion joint device fabrication. This notification shall include all of the information shown on the shop drawings, which are required by this Special Provision.

B) Bridge expansion joint devices shall have the Design-Builder's fabricator's name, Project Identification Number, Lot Number, and Individual Expansion Joint Device Number stamped with steel impression style stamps on a side that will be visible during inspection after erection.

C) After fabrication and assembly, bridge expansion joint device components and assemblies shall be securely fixed together as units so that they may be shipped to the job site and stored without relative movement of the bridge expansion joint device parts and to prevent disassembly. Steel strapping or other means may be used to prevent relative movement of the bridge expansion joint device parts and disassembly until the time of installation and/or inspection. Packaging shall be adequate to prevent damage from impact and bridge expansion joint devices shall be wrapped in moisture resistant and dust resistant material to prevent contamination during shipping and storage at the jobsite. It is the Design-Builder's responsibility to ensure that all bridge expansion joint devices are properly stored and protected from damage.

D) Bridge expansion joint devices delivered to the Project site shall be stored under cover on a platform above the ground surface until installation. Bridge expansion joint devices shall be protected at all times from damage. When placed, bridge expansion joint devices shall be dry, clean, and free from dirt, oil, grease, or other foreign substances.

9.0 CONSTRUCTION

A) The Design-Builder shall also have a representative from the bridge expansion joint device supplier on site during the installation of at least the first joint of each type and provide written certification that the bridge expansion joint device was installed properly. This written certification shall be submitted to the Department.

B) Field welding of steel or metal alloy components shall comply with approved standards. All deck surface preparation including planing or milling, grinding and blasting, along with satisfaction of the rideability Special Provisions shall occur before installation of the joints. Installation shall not proceed prior to the review and comment of the Department of all material and installation methods.

C) The Design-Builder shall exercise care during installation to avoid damage to the components. Any damage to troughs, seals or membranes shall be removed, replaced and made good, in a manner acceptable to the Department and at the Design-Builder's expense.

D) Anchor bolts, armor and fixing devices shall be accurately located and securely held to correct line and level during placement of blockout concrete. All concrete shall be placed, properly consolidated with no voids, finished and cured to ensure the correct strength. The Design-Builder shall detail his method for aligning, securing, and the timely release of the joint to account for thermal movements of the structure, to protect the closure concrete, and to provide a smooth riding surface within the required tolerances.

E) All materials used to form the secondary pour of the expansion device blockout and to temporarily support the expansion device shall be removed prior to final acceptance.

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605702 - BRIDGE BEARING DEVICES

1.0 DESCRIPTION

The Design-Builder shall be responsible for designing, furnishing, fabricating, testing, storing, installing, erecting, adjusting, and completing the assembly of all components of bridge bearing devices, including repair and/or replacement of damaged components (if necessary) for the bridge in accordance with the Contract requirements and the criteria established in this Special Provision during all phases of design and construction of the Project. All bridge bearing devices shall adequately provide for applied loads, thermal expansion and contraction, rotation, camber changes, creep and shrinkage of structural members, and movements during all phases of construction and during the service life of the structure. Designing and detailing replacement procedures, including jacks, equipment, shoring, blocking, and other such procedures and operations for bridge bearing devices are the responsibility of the Design-Builder. The Design-Builder shall also be responsible for the satisfactory performance of bridge bearing devices installed for the bridge for the Contract required warranty period.

Complete bridge bearing devices include, but are not limited to, bearing assemblies; bearing, masonry, sole and/or distribution plates; bearing, disc, and/or distribution pads; guide bars; permanent and temporary restraint mechanisms (including up-lift restraint mechanisms if required by the Design-Builder's design or erection method); shear pins; elastomer; confining pots, sealing rings, and pistons; machined, faced, and polished sliding surfaces; polytetrafluoroethelene (PTFE) sheets and/or coatings; complete connection hardware; complete anchorage materials and components including grout, hardware, bolts, connectors, nuts, washers and shims; corrosion protection provisions; temporary corrosion protection provisions during storage and construction; erection devices and equipment; and all permanent and incidental materials and labor to install each bridge bearing device in accordance with the Contract requirements.

Any bridge bearing device(s) or type of bridge bearing device(s), proposed by the Design-Builder for use on the Project, shall adhere to the requirements of this Special Provision and shall be submitted to the Department for review and comments prior to completion of the Preliminary Design Review.

2.0 STANDARDS

Bridge bearing devices shall be provided and tested in accordance with this Special Provision and the "AASHTO LRFD Bridge Design Specifications," the latest edition with all current Interims as of the issue date of this RFP unless otherwise noted.

These Special Provisions and the *AASHTO LRFD Bridge Design Specifications* are intended to be complementary. In case of discrepancy between these Special Provisions and the *AASHTO LRFD Bridge Design Specifications,* these Special Provisions shall govern. The Design-Builder shall obtain clarification from the Department of any and all unresolved discrepancies prior to proceeding with design or construction.

3.0 ACCEPTABLE BRIDGE BEARING DEVICES

Acceptable bridge bearing devices are listed in Sections 3.1 through 3.3. The Department shall consider other bridge bearing device(s) or other types of bridge bearing devices as unacceptable for use on this Project.

3.1 ELASTOMERIC BEARING PADS

Elastomeric bearing pads shall be designed, furnished, and constructed in accordance with the Delaware

Department of Transportation, "Standard Specifications for Road and Bridge Construction," Dated 2001 as modified by Delaware Department of Transportation, "Supplemental Specifications, Revisions and Corrections to the August 2001 Standard Specifications," (Part 4 – Appendix A).

3.2 CONFINED ELASTOMERIC BRIDGE BEARING DEVICES (OR "POT" BEARING DEVICES)

Confined elastomeric bearing devices shall be supplied as fixed, guided expansion bearings, and/or non-guided expansion bearings as required by the Design-Builder's design.

3.2.1 Fixed Bearings

A) Fixed bearings shall consist of an elastomeric rotational element, confined and sealed by a piston and steel base pot.

B) Fixed bearings shall allow rotation but horizontal movement shall be restricted in all directions. To restrict movement the bearing shall transmit horizontal forces through contact between the piston and the inside of the pot wall.

C) Fixed bearings shall be designed to resist a horizontal load of not less than 10 percent of the ultimate vertical capacity of the device. Larger values shall be used if required by Design Criteria or the Design-Builder's proposed design.

3.2.2 Guided (uni-directional) Expansion Bearings

A) Guided expansion bearings shall consist of an elastomeric rotational element, confined and sealed by a piston and steel base pot.

B) Guided expansion bearings shall allow rotation and uni-directional movement. To restrict multi-directional movements, either a guide bar or keyway system shall be used.

C) To allow uni-directional movement, the upper surface of the steel piston shall be faced with a PTFE sheet and shall support a sliding steel top bearing plate.

D) The mating surface of the sliding steel bearing plate shall be faced with polished stainless steel.

E) Guided expansion bearings shall be designed to resist a horizontal load of not less than 10 percent of the ultimate vertical capacity of the device. Larger values shall be used if required by the Design-Builder's proposed design.

F) The guide bar or keyway systems and their mating steel surfaces shall be faced with strips of PTFE (may be filled or unfilled as per *AASHTO LRFD Bridge Design Specifications*) and stainless steel.

3.2.3 Non-guided (multi-directional) Expansion Bearings

A) Non-guided expansion bearings shall consist of an elastomeric rotational element, confined and sealed by a steel piston and steel base pot.

B) Non-guided expansion bearings shall allow rotation, longitudinal and transverse movement in the bearing plane.

C) To allow longitudinal and transverse movement, the upper surface of the steel piston shall be faced with PTFE sheet and shall support a sliding steel top bearing plate.

D) The mating surface of the sliding steel bearing plate shall be faced with polished stainless

steel.

3.3 MULTI-ROTATIONAL, HIGH-LOAD DISC BEARING DEVICES

Multi-rotational, high-load disc bearing devices shall be supplied as fixed, guided, and/or non-guided bearings as required by the Design-Builder's design.

3.3.1 Fixed Bearings

A) Fixed disc bearings shall consist of a polyether urethane structural element (disc) confined by upper and lower steel bearing plates. The bearing shall be equipped with a shear restriction mechanism to prevent lateral movement of the disc.

B) Fixed disc bearings shall allow rotation, but horizontal movement shall be restricted in all directions. To restrict horizontal movement the shear resisting mechanism shall be locked between the upper and lower steel bearing plates.

C) Fixed disc bearings shall be designed to resist a horizontal load of not less than 10 percent of the rated capacity of the device. Larger values shall be used if required by the Design-Builder's proposed design.

3.3.2 Guided (uni-directional) Disc Bearings

A) Guided disc bearings shall consist of a polyether urethane structural element (disc) confined by upper and lower steel bearing plates. The bearing shall be equipped with a shear restriction mechanism to prevent lateral movement of the disc.

B) Guided disc bearings shall allow rotation and uni-movement. To restrict multi-directional movements, a guide bar shall be used.

C) To allow uni-directional movement, the upper surface of the upper steel bearing plate shall be faced with a PTFE sheet and shall support a sliding steel sole plate.

D) The mating surface of the sliding steel sole plate shall be faced with polished stainless steel.

E) Guided expansion bearings shall be designed to resist a transverse load of not less than 10 percent of the rated capacity of the device. Larger values shall be used if required by the Design-Builder's proposed design.

F) The guide bars and their mating steel surfaces shall be faced with strips of PTFE (may be filled or unfilled as per *AASHTO LRFD Bridge Design Specifications*) and stainless steel.

3.3.3 Non-guided (multi-directional) Disc Bearings

A) Non-guided disc bearings shall consist of a polyether urethane structural element (disc) confined by upper and lower steel bearing plates. The bearing shall be equipped with a shear restriction mechanism to prevent lateral movement of the disc.

B) Guided disc bearings shall allow rotation, longitudinal movement, and transverse movement in the bearing plane.

C) To allow longitudinal and transverse movement, the upper surface of the upper steel bearing plate shall be faced with PTFE sheet and shall support a sliding steel sole plate.

D) The mating surface of the sliding steel sole plate shall be faced with polished stainless steel.

4.0 MATERIALS

All materials shall be new and unused, with no reclaimed material incorporated in the finished bridge bearing devices.

4.1 STEEL

All steel products to be used or supplied in connection with any bridge bearing device shall be steel products rolled, formed, shaped, drawn, extruded, forged, cast, fabricated, or other similar process or processed by a combination of two or more such operations, from steel made by the open hearth, basis oxygen, electric furnace, Bessemer or other steel making process.

A) All steel used shall conform to the minimum requirements of ASTM A 709, Grade 36, or Grade 50.

B) Stainless steel shall conform to the requirements of ASTM A 240, Type 304. Higher grades of stainless are permissible.

C) Anchor bolts, nuts, and washers shall conform to ASTM A 307 and shall be galvanized in accordance with ASTM A 153.

4.2 LEAD SHEET

A) Lead sheets used under the masonry plate of confined elastomeric bridge bearing devices shall be of the shape and thickness shown in the plans, but not less than 1/8 inch thick, conforming to the requirements of ASTM B 29.

4.3 POLYTETRAFLUOROETHELENE (PTFE)

A) PTFE shall be manufactured from pure virgin (not reprocessed) unfilled PTFE resin.

B) Finished PTFE sheet shall be resistant to all acids, alkalis, and petroleum products, stable at temperatures up to +500° F, non-flammable, and non-absorbing of water.

4.4 ELASTOMERIC DISCS FOR CONFINED ELASTOMERIC BRIDGE BEARING DEVICES

A) The physical properties of neoprene and natural rubber used in these bridge bearing devices shall conform to *AASHTO LRFD Bridge Design Specifications.*

B) Elastomeric discs may be either chloroprene or natural polyisoprene with a 50 ± 5 Shore A durometer hardness and shall be individually molded and monolithic. No layering of elastomers will be allowed.

4.5 ELASTOMERIC DISCS FOR MULTI-ROTATIONAL, HIGH-LOAD DISC BEARING DEVICES

A) The physical properties of the polyether urethane elements shall conform to *AASHTO LRFD Bridge Design Specifications.*

B) Elastomeric rotational element shall be molded as a single piece, separate layers are not allowed.

C) Caution shall be taken to ensure that the steel temperature directly adjacent to the polyether urethane rotational element does not exceed 225° F. The polyether urethane disc shall not be exposed to direct flame or sparks.

5.0 REQUIREMENTS

5.1 GENERAL

A) The Design-Builder and the Design-Builder's bridge bearing device supplier(s) and/or fabricator(s) shall show previous documented experience in the design, fabrication, testing, and installation of bridge bearing devices. Documented experience, showing a minimum of five years of experience and 10 bridge installations shall be submitted to the Department for review and approval.

B) The Design-Builder's bridge bearing device fabricator shall be certified by the American Institute of Steel Construction (AISC) for Conventional Steel Structures Category.

C) Before the fabrication of any bridge bearing device, the Design-Builder shall submit shop drawings to the Department for review and comment. The shop drawings shall be stamped by a Delaware-licensed Professional Engineer employed by the Design-Builder's bridge bearing device fabricator with a minimum of 5 years of documented history of bridge bearing device design experience. The shop drawings, detailed by the Design-Builder's bridge bearing device fabricator, shall include, but shall not be limited to, the following for each bridge bearing device used for the Project:

1) Detailed drawings showing plan, elevation, and section views;
2) Complete details and sections showing all ASTM, AASHTO, or any other material designations;
3) Vertical, horizontal load capacities and rotational and movement capacities;
4) All bridge bearing device offsets if required by the Design-Builder's design;
5) The Design-Builder's alignment plan and installation method;
6) The size, quantities, and locations of bridge bearing devices;
7) Bridge bearing device seats and all bridge bearing device connection details;
8) Complete details for inspection and construction purposes;
9) Shop paint and/or coating requirements;
10) All appropriate notations and instructions for field installation;
11) Complete and detailed replacement procedures, including equipment, shoring, blocking, and other such procedures and operations; and
12) Complete design calculations verifying conformance with the provisions of this Special Provision and the Contract requirements.

D) The Design-Builder shall be responsible for coordinating the location of shear connectors in both the superstructure and substructure and verify there are no conflicts with post-tensioning or reinforcement with any bridge bearing device.

5.2 REQUIREMENTS FOR BOTH CONFINED ELASTOMERIC AND MULTI-ROTATIONAL, HIGH-LOAD DISC BRIDGE BEARING DEVICES

5.2.1 Permanent Corrosion Protection, Metallizing

All steel surfaces exposed to the atmosphere, except stainless steel surfaces and metal surfaces to be welded, shall be metallized.

A) All exposed carbon steel surfaces shall be blasted clean to a near white finish, degreased, and zinc metallized to a minimum uniform thickness of 8 mil.

B) All interior surfaces, including but not limited to, the pot and piston assembly and masonry plate recess, shall receive no less than 1 mil nor more than 3 mil thickness of zinc metallizing.

C) All metallizing shall be performed with good work quality in accordance with American Welding Society Specification AWS C 2.2.

5.2.2 Temporary Corrosion Protection

Metal surfaces to be welded shall be given a coat of clear lacquer, or other protective coating, if the time of exposure before welding takes place is to exceed three months. The coating shall be removed at the time of welding. No metallizing will be done to these surfaces prior to the completion of welding.

5.2.3 PTFE Sliding Surfaces

A) The properties of the PTFE shall conform to the current AASHTO Specifications for the PTFE bearing surfaces.

B) The area of the PTFE shall be designed in accordance with AASHTO LRFD Section 14.7.2. Unfilled PTFE shall meet the following requirements:

1) PTFE shall be bonded and recessed into the surface of the piston for half its thickness. It shall be a minimum of 0.1875 inch thick and not more than 0.25 inch thick.

2) PTFE shall have a minimum ultimate tensile strength of 2,500 psi.

C) Bonding of the PTFE, if required, shall meet the peel test requirements (ASTM D 903) of 25 lb/in at an angle of 180°. Bonding must be complete and without air gaps under the PTFE sheet in order to seal out moisture and provide a smooth, flat sliding surface.

5.2.4 Stainless Steel Sliding Surfaces

A) Stainless steel in contact with the PTFE sheet shall be polished to a finish of less than 20 micro-inches RMS or less.

B) The stainless steel surface shall cover the PTFE surface in all operating positions plus 1 additional inch in every direction of movement.

C) Stainless steel shall be a minimum of 0.07 inch to a maximum of 0.08 inch thick and shall be connected to the sole plate by means of a continuous neat seal weld around the entire perimeter of the plate. Welding slag or other residues on the stainless sliding surfaces is not permitted. Stainless steel used on guide bars or in keyways shall also meet these thickness and other general quality requirements.

D) Welding procedures shall be chosen such that the stainless steel surface is in contact with the sole plate and the surface is smooth and flat.

E) For confined elastomer bridge bearing devices designed with center-guided key, the finished recess in the sole plate shall be a maximum of 1/8 inch wider than the PTFE bonded shear key.

F) Stainless sliding surfaces shall face downward.

5.2.5 Guide Bars

A) Guide bars may be connected to sole plates by means of either welding or recessed high tensile fasteners. High tensile fasteners, if required by design, shall be designed in accordance with the AASHTO LRFD Bridge Design Specifications.

B) Guide bars and all connections to the sole plate shall be designed for the horizontal forces on the bridge bearing device and not less than 10 percent of the ultimate vertical capacity of the bridge bearing device.

C) Unless the space between the guide bars is specified, it shall be a total of 1/8 inch.

D) Guiding arrangements shall be designed so that the guided member is always within the guides at all bridge bearing device translation points.

E) Guiding off the fixed base or any extension of it will not be allowed.

5.3 REQUIREMENTS FOR CONFINED ELASTOMERIC BRIDGE BEARING DEVICES ONLY

5.3.1 Elastomeric Discs

Elastomeric Discs shall conform to the following requirements:

A) Confined elastomeric discs shall have a minimum thickness as determined by the following formula:

$t = ID/C$

Where: t = minimum elastomeric disc thickness

ID = inside diameter of pot cylinder

C = 25 for less than 0.011 radians of rotation

C = 20 for 0.011 thru 0.016 radians of rotation

C = 15 for over 0.016 radians of rotation

B) Areas of elastomeric discs shall be designed for an average working stress of 3,500 psi at the total dead and live loads of the structure.

C) The upper edge of the elastomer shall be recessed to receive the brass rings.

D) The entire top and bottom of the elastomeric disc shall be lubricated with an even film (approximately 1 to 3 mils thick) of silicone grease meeting SAE International Specification SAE-AS8660.

5.3.2 Steel Pots and Masonry Plates

Steel pots and masonry plates shall conform to the following requirements:

A) Pots shall be made from a solid plate by machining.

B) The depth of the pot cavity shall be equal to or greater than the design rotation + 0.02 radians + 0.1 inch + the thickness of the elastomeric disc.

C) Inside diameters shall be the same as the elastomeric disc.

D) The pot shall be seated in a machined recess of 0.000125 inch RMS max. profile (before

metallizing) in the masonry plate, without welding, to a depth required by design, but not less than 0.25 inch.

E) The inside dimension of the finished recess shall be 0.03 inch to 0.05 inch larger than the actual outside dimension of the finished pot base.

F) The juncture formed between the edge of the pot and the top masonry plate surface must be caulked with a durable moisture sealant recommended by the bridge bearing device manufacturer and approved by the Design-Builder's Quality Control Manager.

G) The anchor bolt spacing in the masonry plate and any other considerations shall be incorporated in the design of the bridge bearing devices to allow for future removal, replacement, or repair of the pot cylinder and piston assembly.

H) Concrete bearing stress shall be checked for pots or masonry plates in accordance with the *AASHTO LRFD Bridge Design Specifications*.

5.3.3 Pistons

Pistons shall conform to the following requirements:

A) The piston and/or top plate shall be seated in a machined recess of 0.000125 inch RMS max. profile (before metallizing) in the sole plate, without welding, to a depth required by design, but not less than 0.25 inch.

B) The inside dimension of the finished recess shall be 0.03 inch to 0.05 inch larger than the actual outside dimension of the finished piston or top plate.

C) Pistons shall be designed with outside diameters as follows:

1) Flat brass sealing rings, 0.03 inch to 0.05 inch less than pot inside nominal diameters.

2) Round brass sealing rings, 0.02 inch to 0.1 inch less than pot inside nominal diameters.

D) Piston thickness shall be:

1) POT ID x 0.08 (minimum) for square shape pots.

2) POT ID x 0.06 (minimum) for round shape pots.

E) Pistons for round cross section sealing rings shall have the lower outside edge beveled to accept and retain the ring and allow full design rotation.

F) For laterally restrained confined elastomer bridge bearing devices having a shear key in the piston, the top surface shall have keyway slot and cold finished bar press fit and welded at the ends. Pistons of this design shall be machined from one piece of steel.

5.3.4 Elastomeric Sealing Rings

Elastomeric Sealing Rings shall conform to the following requirements:

A) Flat brass sealing rings shall meet the following requirements:

1) Width shall be 0.375 inch minimum for bridge bearing devices up to 1,000 kips of capacity and 0.5 inch minimum for over 1,000 kips capacity. Rings shall be manufactured to a tolerance of ± 0.005 inch.

2) The thickness shall be 0.05 inch minimum.

3) Up to 1,000 kip capacity, 2 rings shall be used; from 1,000 kips to 3,000 kips, 3 rings; and over 3,000 kips, 4 rings shall be used.

4) Rings shall fit the ID of the pot snugly, and the ends shall be cut at 45°. When installed in the pot, the maximum gap shall be 0.05 inch.

5) Flat brass rings shall conform to the ASTM B 36, half-hard requirements.

6) Round cross section brass rings shall conform to the Federal Specification QQB626, composition half-hard requirements.

7) When 2 seal rings are used, the ring gaps shall be staggered 180° apart. When more than 2 rings are required, the gaps of the successive rings shall be evenly spaced around the perimeter of the pot.

B) Round cross section brass sealing rings shall meet the following design requirements:

1) Rings shall fit the POT ID snugly.

2) Rings shall be made from one piece rolled into a circle and brazed.

6.0 TESTING

An independent testing laboratory (or laboratories) selected by the Design-Builder, acceptable to the Department shall test all materials and bridge bearing device assemblies in accordance with the testing requirements of this Special Provision for each specific type of bridge bearing device proposed by the Design-Builder for the Project. The Design-Builder shall be responsible for all coordination between the Design-Builder's laboratory (or laboratories), Design-Builder's supplier(s), and Department representatives. The Design-Builder shall notify the Department 14 Calendar Days prior to any testing to be performed on bridge bearing devices and the Department shall be allowed to witness all testing.

The Design-Builder shall furnish all material and written test procedures, as prepared by the Design-Builder's supplier(s) to the Department for review and comment. Each component of the assembly shall have an AASHTO or ASTM material and test specification. The Design-Builder's supplier(s) and the design-Builder's laboratory (or laboratories) shall prepare separate reports. Each report shall independently describe all the testing data and testing results. All reports shall be submitted by the Design-Builder to the Department within 14 Calendar Days of completing each test as independent records of the testing. The Design-Builder shall be responsible for sub-contracting and coordinating with the Design-Builder's laboratory (or laboratories) and Design-Builder's supplier(s) for all testing laboratory services.

Materials and components, which comprise the permanent production bridge bearing devices, shall be identical in nature, origin, and composition to those that were the basis of the bridge bearing devices acceptance tests. The Design-Builder's supplier(s) shall provide written and detailed recommendations to the Design-Builder regarding storage, handling, transporting, assembly, aligning, and verification of performance of the bridge bearing devices. The Design-Builder's supplier(s) shall simultaneously provide copies of all such recommendations directly to the Department for their use.

6.1 CERTIFICATION

A) A copy of the test certificates documenting the tests performed and mill tests for all materials used in the bridge bearing device fabrication shall be submitted by the Design-Builder to the DelDOT Office of Materials and Research for review and comment.

B) The certification package shall include, but not limited to, the following:

1) Material test reports for all steels used except AISI C1018 and AISI C1020 for

which a mill conformance certificate is acceptable;

2) Certificate of Compliance for all non-ferrous metals;

3) Material test reports for any elastomeric components;

4) Certificate of Compliance for PTFE and any adhesives used;

5) A Certificate of Compliance for the bridge bearing devices executed by an officer of the Design-Builder's bridge bearing device fabricator's company;

6) Certificate of Compliance for any dowels or bolts supplied; and

7) Test reports for the performance tests.

C) In addition, the Design-Builder shall contact the DelDOT Office of Materials and Research to confirm materials are acceptable at least seven (7) Calendar Days before shipping the bridge bearing devices to the site.

6.2 CONFINED ELASTOMER (POT) BEARING DEVICE TESTING

All confined elastomer (pot) bearing devices tested shall show no signs of failure or any other defects while under load or subsequently upon disassembly and in accordance with the requirements of "*AASHTO LRFD Bridge Design Specifications*." Any resultant defects, such as bond failure, physical destruction or cold flow of PTFE to the point of debonding, shall be cause for rejection. Defects such as cracked steel shall also be cause for rejection.

All confined elastomer (pot) bearing devices from the production lot shall be tested as follows:

A) A proof load test shall be performed on each bridge bearing device of each type (fixed, guided expansion, and/or non-guided expansion). Each bearing device tested shall be loaded to 150 percent of the maximum vertical design load at Service Limit States for a period of one hour. The guided expansion bearings shall also be loaded as follows:

1) 100 percent of the minimum vertical design load in combination with 150 percent of the maximum horizontal load, whether lateral or longitudinal at Service Limit States.

2) These loadings shall be maintained for at least 1 hour.

B) The Department requires the efficacy of any sealing system, regardless of design or material, to be demonstrated and therefore, an elastomer seal test shall be performed on each bridge bearing device. The elastomer seal test shall be performed as follows:

1) A Department approved independent testing laboratory (see Section 6.0) shall perform the test.

2) A Delaware-licensed Professional Engineer, who shall be a staff employee of the testing laboratory, shall witness and certify the elastomer seal test.

3) A bevel plate equal to the design rotation of the bridge bearing device shall be inserted between the test machine and the test bridge bearing device.

4) The load shall be applied to the test bridge bearing device uniformly and smoothly over a period of 5 minutes up to the full test load.

5) The test load shall be 3 times the capacity at Service Limit States of the bridge bearing device and shall be maintained for a period of 6 hours with no change in the load.

6) During the test, the bridge bearing device shall be carefully examined for any

sign of extrusion of the elastomer.

7) After removal of the test load, the bridge bearing device shall be disassembled and examined for any sign of damage or permanent deformation of the sealing system. Bridge bearing devices, which show no sign of extrusion of the elastomer and no deformation of the sealing system, may be considered acceptable.

C) The coefficient of friction shall be determined for all production bridge bearing devices of each type. Specially made or test bridge bearing devices shall not be used for this test.

6.3 MULTI-ROTATIONAL, HIGH-LOAD DISC BEARING DEVICE TESTING

All multi-rotational, high-load disc bearing devices tested shall show no signs of failure or any other defects while under load or subsequently upon disassembly and in accordance with the requirements of *AASHTO LRFD Bridge Design Specifications.* Any resultant defects, such as bond failure, physical destruction or cold flow of PTFE to the point of debonding, shall be cause for rejection. Defects such as extruded or deformed elastomer or cracked steel shall also be cause for rejection.

All multi-rotational, high-load disc bearing devices from the production lot shall be tested as follows:

A) A proof load test shall be performed all bridge bearing devices of each type (fixed, guided, and/or non-guided). Each bearing device tested shall be loaded to 150 percent of the maximum vertical design load at Service Limit States for a period of one hour. The guided expansion bearings shall also be loaded as follows:

1) 100 percent of the minimum vertical design load in combination with 150 percent of the maximum horizontal load, whether lateral or longitudinal at Service Limit States.

2) These loadings shall be maintained for at least 1 hour.

B) The coefficient of friction shall be determined for all production bridge bearing devices of each type. Specially made or test bridge bearing devices shall not be used for this test.

6.4 BRIDGE BEARING DEVICE MOVEMENT TESTING

If a group of 3 or more guided bearings is proposed at any support location, the Design-Builder shall develop and submit to the Department for review and comment a testing procedure for verifying proper bearing movement and function. The test shall confirm the bearing group is capable of moving through the full range of loads without binding. The Design-Builder's testing plan shall be submitted to the Department for review and comment 45 Calendar Days prior to the test being performed. The tests shall not cause damage to any bridge bearing device.

7.0 FABRICATION, HANDLING, AND STORAGE

7.1 GENERAL

A) The Design-Builder shall provide the Department with written notification 30 Calendar Days prior to the start of bridge bearing device fabrication. This notification shall include all of the information shown on the shop drawings, which are required by this Special Provision.

B) Every bridge bearing device shall have the Design-Builder's fabricator's name, Project Identification Number, Lot Number, and Individual Bearing Device Number stamped with steel impression style stamps on a side that will be visible for inspection after

erection.

C) All welding shall conform to, and all welders shall be qualified in accordance with, the requirements of the American Welding Society (AWS).

D) After assembly (including sole plates and masonry plates), bridge bearing device components and assemblies shall be securely fixed together as units so that they may be shipped to the job site and stored without relative movement of the bridge bearing device parts and to prevent disassembly. Steel strapping or other means may be used to prevent relative movement of the bridge bearing device parts and disassembly until the time of installation and/or inspection. Packaging shall be adequate to prevent damage from impact and bridge bearing devices shall be wrapped in moisture resistant and dust resistant material to prevent contamination during shipping and storage at the jobsite. It is the Design-Builder's responsibility to ensure that all bridge bearing devices are properly stored and protected from damage.

E) Bridge bearing device assemblies shall be handled by their bottom surfaces only. Do not lift devices by their tops, sides and/or shipping bands.

F) Bridge bearing devices delivered to the Project site shall be stored under cover on a platform above the ground surface until installation. Bridge bearing devices shall be protected at all times from damage. When installed, bridge bearing devices shall be dry, clean, and free from dirt, oil, grease, or other foreign substances.

G) Multi-rotational, high-load disc bridge bearing devices shall not be disassembled unless otherwise permitted by the Design-Builder's bridge bearing device supplier.

H) Before installation, confined elastomeric bearing devices will be disassembled on the Project site by the Design-Builder under supervision of the Design-Builder's bridge bearing device fabricator for inspection by the Department for conformance with the approved shop drawings and Contract requirements. Following the inspection, the bridge bearing devices shall be repackaged and stored until installation.

I) The edges of all parts shall be rounded by grinding so that there are no sharp edges.

7.2 FABRICATION TOLERANCES

A) Gross bridge bearing device dimensions shall have a tolerance of minus 0, +1/8 inch.

B) The overall height of a bridge bearing device shall not exceed the nominal height by more than 3/16 inch or be less than 1/16 inch under.

C) Except as noted, all bearing surfaces of steel plates shall be finished or machined flat within 0.010 inch per foot. Out of flatness greater than 0.010 inch per foot on any plate shall be cause for rejection. The bottom surfaces of lower bearing plates (masonry plates) designed to rest on bearing pads shall not exceed an out of flatness value of 0.0625 inch per foot.

D) Oxygen cut surfaces shall not exceed a surface roughness value of 1000 micro inches as defined by ANSI B46.1.

E) Flatness tolerances shall be as follows:

1) Class "A": 0.0005 x "Nominal Dimension".

2) Class "B": 0.001 x "Nominal Dimension".

3) Class "C": 0.002 x "Nominal Dimension".

4) "Nominal Dimension" shall be interpreted as the actual dimension of the plate, in inches, under the straightedge where the straightedge is not parallel to any plan dimension of the plate being measured.

5) In determining the flatness, the straightedge may be located in any position on the surface being measured.

F) Elastomeric disc tolerances shall be as follows:

1) Diameters greater than 20": + 3/32 inch.

2) Diameters less than 20": ± 1/16 inch.

3) Thickness shall be 0.0 inch to + 1/8 inch.

G) PTFE and stainless steel sliding surface tolerances shall be as follows:

1) Plan dimensions: total nominal design area 0.0 to +5.0 percent.

2) Flatness: Class "A" tolerance.

H) Masonry and distribution plate tolerances shall be as follows:

1) Plan dimensions over 30": 0.0 inch to + 3/16 inch.

2) Plan dimensions under 30": 0.0 inch to + 1/8 inch.

3) Flatness: Class "B" tolerance.

I) Sole plates shall conform to the following tolerances:

1) Plan dimensions over 30": 0.0 inch to + 3/16 inch.

2) Plan dimensions under 30": 0.0 inch to + 1/8 inch.

3) Thickness: 1/32 inch to + 1/8 inch.

4) Flatness of the upper surface: Class "B" tolerance.

5) No beveled edge shall be less than 5/8 inch thick.

J) Guide bar tolerances shall be as follows:

1) Length: ± 1/8 inch.

2) Section dimensions: ± 1/16 inch.

3) Flatness, where it bears on another plate: Class "A" tolerance.

4) Bar to Bar tolerance: "Nominal Dimension" ± 1/32 inch.

The finished PTFE bonded guide bars shall not be more than 1/32 inch out of parallel, vertically or horizontally.

K) Steel pots for confined elastomeric bridge bearing devices shall meet the following tolerances:

1) The inside diameter shall be machined to a tolerance of ± 0.005 inch up to 20 inch diameter and ± 0.007 inch over 20 inch diameter;

2) Pot undersides shall be machined parallel to the inside to a Class "A" tolerance as defined in this Special Provision; and

3) Internal finish shall be 0.000125 inch RMS or better.

L) Piston tolerances for confined elastomeric bridge bearing devices shall be as follows:

1) Diameters greater than 20": ± 0.007 inch.

2) Diameters less than 20": ± 0.005 inch.

3) Upper side flatness: Class "A" tolerance.

4) Lower side flatness: Class "B" tolerance.

5) Machine finishes shall be 0.000125 inch RMS or better.

M) Confined elastomer bridge bearing devices tolerances for flatness - Flatness of bridge bearing device surfaces shall be determined by the following method:

1) A precision straightedge longer than the nominal dimension to be measured shall be placed in contact with the surface to be measured as parallel to it as possible.

2) An attempt shall be made to insert a feeler gauge, equal to the tolerance allowed and having an accuracy of ± 0.001 inch, under the straightedge.

3) Plates are "acceptable" if the feeler gauge does not pass under the straightedge.

8.0 INSTALLATION

A) Bridge bearing devices shall be installed in accordance with the Design-Builder's bridge design, the Design-Builder's bridge bearing device supplier's recommendations, the requirements of this Special Provision, and the Contract requirements.

B) Removal of the sole, top, bearing, and/or other load distribution plates for separate attachment to the structure is not permitted except under the direct supervision of the Department and the Design-Builder's bridge bearing device fabricator.

C) For bearing groups (*see* Section 6.4 of this Specification), the Design-Builder shall verify the following installation tolerances have been met for each bearing device group. The Design-Builder, in the presence of the bridge bearing device supplier and the Department shall inspect the bridge bearing device components to assure that they are level and parallel to within ± 1/32inch per foot. Any deviations in excess of the allowed tolerances shall be corrected.

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605704 - BRIDGE COATING

Description:

This work shall consist of the preparation of the concrete surfaces, cleaning the surfaces, furnishing and applying the masonry coating as described herein. The masonry coating shall be applied to all concrete surfaces indicated on the plans or as directed. The coating shall be applied only after completion of the surface preparation specified herein. The areas to be coated shall include:

> Exterior of the superstructure (except for the bridge deck surface and pedestrian pathway surface) including tie beam and back span center beam
> Concrete bridge railing
> Abutment walls and retaining walls

Materials:

The masonry coating material shall be a commercial product, one-component ready to use concrete protective coating, designed specifically for coating concrete and must be suitable for application on damp, uncured concrete and/or cured concrete. Only one coating material shall be used on an individual structure. It shall be delivered to the job site in sealed containers bearing the manufacturer's original labels. The brand, color, and type shall be clearly marked on each container. A copy of the manufacturer's printed instructions shall be made available.

The coating material shall be stored in airtight, upright containers. The containers shall be stored in a dry location where the temperature is above 40°F and less than 100°F.

The masonry coating shall have a shelf life of not less than 12 months. After application, the coating shall be dry to the touch within 48 hours and shall achieve a final cure within 2 to 3 weeks under ideal conditions.

The color of the applied masonry coating shall be in accordance with Federal Color Standard No. 33510. A 10' x 20' mock up of the specified color shall be provided for the Engineer's approval of the color before coating any of the surfaces specified in the Plans or as directed.

Surface Preparation

Surface preparation by the general contractor, prior to the application of an applied finish coating shall consist of a general surface finish in accordance with the standard specifications.

Surface to be coated shall be free from efflorescence, flaking coatings, oil, curing compounds, release agents and other deleterious substances prior to the application of the applied coating. Curing compound and release agent must be removed and may require light sandblast or water blast at a minimum 2500 psi or greater.

Application

The application, including equipment used, shall be in accordance with the manufacturer's recommendations. The material shall be applied by qualified personnel experienced in the work.

The material shall be thoroughly mixed in its original container. If skins have formed, they shall

be removed prior to mixing the material. The material shall not be thinned. The masonry coating may be applied over damp, but not wet surface. It shall be applied at a uniform film thickness at a rate of 50±10 square feet per gallon. The application rate shall be sufficient to produce a uniform color and texture. The material shall be applied only when the ambient temperature is between 40°F and rising, and 100°F. It shall not be applied over frozen surfaces or if rain is imminent. In the event of rain during or soon after coating is freshly applied surface, re-coating may be necessary based on any resulting damage.

The Contractor shall schedule the application of the masonry coating as one of the final finishing operations to minimize construction-generated dust. To prevent lap marks, a wet edge shall be maintained at all times. Stopping and starting in midsections shall be avoided. Every attempt shall be made to start or end at natural breaks in the surface such as at a panel edge, corner or joint. When applying the coating with a roller, the material shall be applied in vertical strokes initially, cross rolled for even film and appearance, and then finished with vertical strikes.

The Contractor shall mask all surfaces to prevent overspray on portions of existing structures and other items surrounding the bridge and roadway. The Contractor shall clean all overspray at no additional cost to the Department.

Finished Product

The coating material in the finished state shall be capable of accommodating the thermal and elastic expansion ranges of the substrate without cracking.

The texture of the completed finish coat shall be fine. The completed finished coating shall be tightly bonded to the structure and present a uniform appearance and texture. If necessary, additional coats shall be applied to produce the desired surface texture and uniformity.

Coatings shall be entirely removed from the structure upon their failure to positively adhere without chipping, flaking or peeling, or attaining the desired surface appearance. The finish coating shall be reapplied after proper surface preparation until the desired finish product is achieved. The average thickness of the completed finish coating shall not exceed 1/8 of an inch.

Certification

Before material is applied a certification shall be furnished attesting that the commercial product furnished is in accordance with the same formula as that previously subject to the tests specified below and approved. Copies of the current tests reports shall be attached to certification.

Testing

All testing shall be performed by a qualified commercial testing laboratory acceptable to the Engineer. The Contractor is responsible for the cost of testing necessary to provide material certification. Prior to use of the applied finish coating on any structure, meet the requirements of the test listed below:

Freeze-Thaw Tests

The applied finish coating shall be subjected to freeze-thaw cycle tests as follows:

1. Three concrete specimens, not less than 4" by 6" by 6", of the mix design for the structure shall be cast and cured. Fourteen days moist curing with a drying period at room temperature, 60° to 80°F, for 24 hours will be required before the specimens are coated

with the applied finish. Caution shall be taken that there be no excessive oil on specimen forms. The finish coating shall be applied to the sides of specimens at a spreading rate of 50±10 square feet per gallon. The coating shall be applied by rolling on or mechanically spraying and as approved by the Engineer. Cementitious coatings shall be cured at room temperature and 30 percent relative humidity for 24 hours, at room temperature and 90 percent relative humidity for 48 hours, and at room temperature and 50 percent relative humidity for 4 days for a total curing time of 7 days. Other coatings shall be cured at room temperature for 48 hours after the completion of curing.

2. The specimens shall be immersed in water at room temperature for 3 hours, and then removed.

3. The specimens shall be placed in cold storage at -15°F for 1 hour, and then removed.

4. The specimens shall be thawed at room temperature for one hour.

Steps 3 and 4 shall be repeated for a total of 50 cycles. At the end of 50 cycles, the specimens shall show no visible defects.

Accelerated Weathering

The applied finish coating shall be subjected to 7,500-hour exposure test in a Twin-Carbon-Arc-Weatherometer, ASTM G 152, and Type D, at an operating temperature of 145°F. The test shall be made at 20-minute cycles consisting of 17 minutes of light and 3 minutes of water spray plus light. At the end of the exposure test, the exposed samples shall show no chipping, flaking, or peeling. The panels for this test shall be prepared by applying the coating at a spreading rate of 50±10 square feet per gallon to both sides and edges of panels cut from asbestos cement shingles in accordance with Federal Specification SS-S-346, Type I. Curing time shall be in accordance with Freeze-Thaw Test Section.

Fungus Growth Resistance

The applied finish coating to be used shall pass a fungus resistance test in accordance with Federal Specification TT-P-29g. Fungus growth shall not be indicated after a minimum incubation period of 21 days.

Abrasion Resistance

The applied finish coating to be used shall pass the 2,000-litre sand abrasion test in accordance with Method 6191 Abrasion Resistance-Falling Sand, Federal Test Method Standard 141a, ASTM D 968. The specimens for this test shall be prepared by applying the coating to a cleaned steel panel at a spreading rate of 50±10 square feet per gallon. The specimens shall be cured at room temperature for 21 days.

Impact Resistance

The coating shall be applied to a concrete panel prepared according to Federal Text Method Standard 141a, Method 2051, at a spreading rate of 50±10 square feet per gallon, and allowed to cure for 21 days at room temperature. The test shall then be run using the Gardner Mandrel Impact Tester in accordance with ASTM D 2794 using a ½ of an inch indenter with an impact load of 6 inch-pounds. The coating shall show no chipping under this impact load.

Salt-Spray Resistance Test

A concrete specimen shall be coated at the rate of one gallon per 50 square feet ±10 percent and cured for 21 days at room temperature. The coated specimen shall be exposed to a 5 percent salt solution in accordance with ASTM B 117 for 2,500 hours where the atmospheric temperature is maintained at 90°±2°F. At the end of 2500 hours of exposure, the coating shall show no ill effects, loss of adhesion, or deterioration.

Flexibility Test

A sheet metal specimen shall be coated with the applied finish coating at a rate of one gallon per 45 square feet ± 10 percent and allowed to cure for 48 hours at room temperature. The coated specimen shall be bent 180° over a one-inch round mandrel. After bending, the coating shall show no breaking.

In addition to the certification and test reports required above, a service record shall be supplied showing that the finish coating material has a satisfactory service record on concrete surfaces for a period of not less than 5 years prior to the date of submission of the service record. The finish coating shall also have shown satisfactory service characteristics without peeling, chipping, flaking, and non-uniform change in texture or color. A specific structure for the specific product shall be named for the service record.

In addition to the above requirements, the manufacturer shall submit, for each batch of material used, the following product analysis data:

> Weight per gallon
> Viscosity
> Weight percent pigment.
> Weight percent vehicle solids
> Infrared spectra of vehicle solution.

Chloride Ion Penetration Resistance

This test shall determine the resistance of a concrete specimen to the penetration of chloride ion. The test shall be performed in accordance with AASHTO T259/T260.

Scaling Resistance

ASTM C 672 A rating of "No Scaling" after 100 cycles on the sealed concrete (non-air entrained concrete) as compared to "Severe Scaling" on untreated concrete.

Absorption

ASTM C 642 (non-air entrained concrete). Concrete should be proportioned and mixed in accordance with ASTM C 672. Sealed concrete, under total immersion, will not exceed 1.0% after 48 hours or 2.0% after 50 days.

Cube Test

NCHRP 244, Series II

Weight Gain - not to exceed 25% of untreated cube

Absorbed chloride - not to exceed 25% of untreated cube.

Southern Exposure

NCHRP 244, Series IV

Absorbed Chloride - not to exceed 10% of untreated concrete

~~**Method of Measurement:**~~

~~The quantity to be paid for will be the area of Bridge Coating, in square yards, completed and accepted.~~

~~**Basis Of Payment:**~~

~~Payment will be made for completed and accepted work, including surface preparation, material, labor, application, equipment, pre-qualification testing costs and all incidentals necessary shall be included in the cost of this work.~~

3/11/05

618513 - DYNAMIC PILE TESTING

Description:

The item shall consist of furnishing all equipment and performing dynamic testing and monitoring of driven piles through the use of electronic monitoring equipment in accordance with this Special Provision, the Contract Documents, and as directed by the Design-Builder's Geotechnical Engineer.

Equipment:

The Design-Builder shall furnish a Pile Driving Analyzer (PDA), and all associated equipment including transducers and accelerometers for conducting the dynamic pile testing.

Testing:

The Design-Builder shall employ a firm with a minimum of five (5) years experience in the use of the PDA and related equipment to install or supervise the installation of the necessary equipment and to perform the dynamic monitoring. Documentation of such experience shall be submitted to the Department's Project Manager for approval a minimum of 30 calendar days prior to beginning work.

Dynamic pile testing (monitoring) shall be in accordance with ASTM D 4945 and shall be conducted in the presence of the Design-Builder's inspection staff. PDA monitoring is required at all times during initial driving, re-driving, and pile restrikes. The Design-Builder shall notify the Department's Project Manager of any planned dynamic pile testing a minimum of 24 hours in advance of the work.

The use of pile splices shall be avoided or minimized after initial driving has begun. Should pile splices be required, PDA monitoring shall be performed during the initial drive prior to the splice as well as the re-driving after the splice has been completed. To the extent possible, the delay in the PDA monitoring of the spliced pile should be similar to the anticipated delay for production piles.

All Test Piles shall be dynamically monitored during the full driving length. All Monitoring Piles shall be dynamically monitored for at least the last 25 feet of anticipated driving. Piles shall be driven until the PDA indicates the required nominal resistance, minimum tip elevation, and/or penetration have been obtained or as otherwise directed by the Design-Builder's Geotechnical Engineer.

Pile restrike testing shall be conducted no sooner than 48 hours after the pile, or any pile within a 25' radius, has been driven. Additional restrikes shall be performed for longer set-up periods. All pile restrikes shall be in accordance with the Delaware Department of Transportation "Standard Specifications for Road and Bridge Construction," Dated 2001 as amended by the Delaware Department of Transportation "Supplemental Specifications, Revisions and Corrections to the August 2001 Standard Specifications," (Part 4 – Appendix A) and shall be monitored with PDA. Prior to restriking piles, the hammer shall be warmed up and checked for proper operation by striking another pile or pile cut-off at least 20 blows at full stroke. Piles shall be restruck for at least 20 blows at the stroke height required or as directed by the Design-Builder's Geotechnical Engineer.

Redriving of piles shall be performed with the same hammer and driving system used for the initial drive unless otherwise directed by the Design-Builder's Geotechnical Engineer. Wave Equation Analyses shall be performed and submitted to the Department for review and comment at least 30 calendar days in advance of the use of each proposed hammer and driving system. Wave Equation analyses shall be in accordance with the Delaware Department of Transportation "Standard Specifications for Road and Bridge Construction," Dated 2001 as amended by Delaware Department of Transportation "Supplemental

Specifications, Revisions and Corrections to the August 2001 Standard Specifications," (Part 4 – Appendix A) and the *Geotechnical Requirements* Performance Specification.

The results of PDA results and CAPWAP analyses for each pile monitored shall be submitted to the Department's Project Manager as a PDA Testing Report and shall include the following information for the end of initial drive, the beginning and end of re-driving, all re-strikes, and for any other relevant blows occurring during the driving:

a) Driving logs;
b) Any unusual or noteworthy behavior during or after driving;
c) Any suspected pile damage;
d) Nominal bearing resistance from the Case Goble Method;
e) Input and reflection values of force and velocity;
f) Maximum transferred energy;
g) Maximum compression and tensile stress;
h) Velocity and displacement;
i) Blows per minute (bpm);
j) Values of upward and downward wave velocities; and
k) Ram stroke and corresponding blow sequence.

The PDA Testing Report shall indicate whether the anticipated results were achieved, whether any remedial action is necessary, and what conclusions the Design-Builder's Geotechnical Engineer has made based on the results. This information and findings shall be signed and sealed by a Delaware-licensed Professional Engineer and submitted to the Department's Project Manager within 48 hours of the restrike testing.

All data shall be recorded to CD-ROM media and made available upon the request of the Project Manager.

The Design-Builder shall furnish the Department's Project Manager a Pile Load Test Report (if applicable) and Dynamic Testing Report signed and sealed by a Delaware-licensed Professional Engineer. The reports shall include the following for each pile tested relative to the submission:

a) Its location;
b) Date of testing;
c) Driving log, all data obtained during the test;
d) Any unusual or otherwise noteworthy behavior observed during or after driving or testing;
e) Plot of applied load versus average butt settlement with determination of nominal resistance, as required by the specifications;
f) PDA Testing Report including pile and test information specified above;
g) A summary of nominal bearing resistances from both Static Loading and Dynamic Testing, including an evaluation of the correlation between the two approaches and discussion of any discrepancies; and
h) Recommended driving criteria for production piles.

The results of the Dynamic Testing shall be evaluated by the Design-Builder's Geotechnical Engineer in conjunction with the results of any static load testing to estimate available unit side resistance, end bearing resistance values, production pile lengths, and tip elevations for each pile group. Where bitumen coating and driving collars are required, appropriate driving criteria shall be prepared specifically for such piles.

Production piles shall not be driven until the PDA / CAPWAP test pile results are reviewed by the

Design-Builder's Geotechnical Engineer and driving criteria is provided to the Department's Project Manager for review and comment.

Verification testing and monitoring shall be performed by the Design-Builder through PDA monitoring and CAPWAP analyses on all Monitoring Piles as required in the *Geotechnical Requirements* Performance Specification included in Part 3 of the Contract Documents.

Static load testing shall be performed in accordance with Special Provision 619508 - *Quick Pile Load Test*, as included in Part 4 of the Contract Documents.

If required, bitumen coatings shall be in accordance with Special Provision 619518 – *Bitumen Coating on Piles*, as included in Part 4 of the Contract Documents.

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618517 - STEEL PIPE PILES

Description:

This work consists of manufacturing, furnishing, driving, cutting off, cleaning out, concreting, etc., of steel pipe piles of the sizes shown on the Design-Builder's Plans. This Work includes performing all other incidental work as shown on the Plans and as described herein. Piles shall be furnished and driven as specified.

Site Information:

Prior to submitting a Proposal, the Design-Builder shall visit and examine the work site and all conditions thereon and take into consideration all such conditions that may affect this work, in accordance with Section 102.05 of the Standard Specifications. Subsurface data previously collected from the site has been included in the Reference Documents section of the Scope of Services Package. This data has been furnished to provide general indications regarding the existing sub-surface site conditions but should not be considered by the Design-Builder as a warranty of actual subsurface conditions.

Engineering boring sheets are included in the Indicative Plans in the Contract Documents, Part 6 – Scope of Services Package Plans. These sheets contain information that may be critical to the design and construction of drilled shafts such as soil descriptions and groundwater conditions, including the presence of localized artesian pressures in the vicinity of the likely foundations. Data on subsurface conditions are not intended as representations or warranties of continuity of such conditions. It is expressly understood that the Department will not be responsible for interpretations of and/or conclusions made by the Design-Builder's review of this material. The data is made available for the convenience of the Design-Builder and may be used to satisfy the minimum sub-surface investigation requirements specified in the *Geotechnical Requirements* Performance Specification.

Submittals:

All submittals described in this Special Provision shall be submitted to the Department's Project Manager at least 30 Calendar Days prior to mobilization, unless otherwise specified. The Design-Builder shall perform no test pile or production pile installation until the Department's Project Manager has reviewed and approved all *Qualifying Experience* submittals as described herein. In addition, the Design-Builder will not be permitted to start construction of any steel pipe piles until the complete *Installation Plan* and *Working Drawing* submittals described herein have been received, reviewed and commented on by the Department. The Design-Builder shall allow at least 21 Calendar Days for the Department's review and/or approval of all submittals. 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 with submittals not conforming to the Contract requirements shall be the responsibility of the Design-Builder.

1. *Qualifying Experience.* The Design-Builder shall submit to the Department's Project Manager for approval proof that the proposed superintendent in responsible charge has a minimum of five years of experience (within the last eight years) installing steel pipe piles of dimensions similar to the specified dimensions of the drilled shaft foundation system for this project and under soil conditions similar to the subsurface conditions indicated in the soil boring logs for this project. The Design-Builder may hire Specialty Subcontractors specializing in the installation and/or testing of pile foundation systems, provided the Subcontractors submit proof of qualifying experience satisfying the requirements defined herein.
   a. The Design-Builder shall provide documentation of its proposed superintendent's

qualifications, experience record, and prior project references. All prior project references shall be currently available personnel who can verify the quality of the Design-Builder's previous work and shall include current name, address, and telephone number. This documentation shall reference the experience of the Design-Builder and the Design-Builder's superintendent who is to be in responsible charge of the steel pipe pile installation operations. This documentation shall reference successful installation and load testing of at least 5 similar sized steel pipe piles projects in similar soil conditions.

b. Welder certifications and approved procedures in accordance with Section 826.12(c) of the Standard Specifications.

c. Certifications for all weld inspectors and technicians performing visual inspection, radiographic inspection, ultrasonic inspection, and all other Quality Control on behalf of the Design-Builder.

2. *Installation Plan*. The Design-Builder shall submit to the Department's Project Manager for review and comment an installation plan for the installation of all steel pipe piles as detailed in this Special Provision. The submittal shall include the following:

a. Pile Driving Schedule. The Design-Builder shall provide a tentative pile driving schedule and sequence of driving anticipated for all test, monitor and production piles. The schedule shall identify concurrent activities that are anticipated by the Design-Builder.

b. Equipment List. The Design-Builder's/subcontractor's list of proposed equipment with sufficient capacity to undertake and complete the work within the specified contract time and the tentative pile driving schedule. The list of proposed equipment shall include, but not be limited to cranes, hammer type, lead lengths, drills, augers, and other appurtenances as applicable to the work.

c. Wave Equation Analyses. Wave Equation Analyses shall be prepared and submitted in accordance with Part 4 - Special Provisions, *Dynamic Pile Testing* and Part 3 – Performance Specifications, *Geotechnical Requirements*.

d. Plan for Field Splices. The Design-Builder shall avoid or minimize the need for field splicing where possible; however, provisions shall be made in advance of the work to accommodate field-splicing needs. The Design-Builder shall prepare a plan and details addressing how splicing will be performed, how proper alignment of pile sections will be achieved, how damaged pile ends will be corrected prior to splicing, how the quality of splices will be verified, and what anticipated corrective actions might be taken. Where pipe cutting is required, pipe ends shall be cut using automated guided cutting equipment. Manual flame cutting shall not be used. All welding required for the steel pipe piles shall meet the minimum requirements specified herein.

e. Concreting Methods. Methods of cleaning open-end pipe pile plugs shall be specified and shall include tremie concrete mix designs and methods of placement. Mix designs for concrete core materials shall also be provided as well as methods of placement, curing and protection during curing. Methods of placing, supporting, and maintaining proper clear cover for reinforcing steel shall also be identified.

3. *Working Drawings*. The Design-Builder shall submit to the Department's Project Manager for review and comment Steel Pipe Pile Working Drawings. The Design-Builder shall not be permitted to start installation of steel pipe piles until the proper Working Drawing checks, reviews, and certifications have been performed by the Design-Builder in accordance with Part 2 – DB Section 111-10 of the Contract Documents. Such certifications will not relieve the Design-Builder of responsibility for results obtained by the use of these drawings or any of its other responsibilities under the contract. At a minimum, the Working Drawings shall include the following items:

a. Details and calculations demonstrating how to provide and maintain the specified axial

alignment of the pile to within 1/8" per foot of pile length.

b. Details and calculations demonstrating adequate support and stability for the pile with the full operating weight and dynamic loading of the proposed hammer at the top of the pile.
c. Provisions to provide stability and maintain alignment during placement of the piles and in wind.
d. Provisions to adequately accommodate the forces associated with or prevent the pile from running under its own weight and the weight of the hammer.
e. Provisions for providing adequate workspace for pile welding, cutting and inspection.
f. Provisions for providing adequate alignment and support to prevent movement during field-welding and to ensure that welding tolerances are met if pile extension is directed.
g. Details and equipment used for handling of pile including the use of temporary supporting brackets.
h. Calculation of pile stresses resulting from handing operations.

4. *Construction Reports*. Submittals to the Department during construction shall include record information for each pile and details of any integrity testing performed. The following information shall be furnished to the Department:

a. Details to be included on Record Information reports for each pile.
b. Driving Logs within 24 hours of completion of installation of each pile.
c. Dynamic Pile Testing Reports in accordance with Part 4 - Special Provisions, *Dynamic Pile Testing.*
d. Quick Pile Load Test results in accordance with Part 4 – Special Provisions, *Quick Pile Load Test*.
e. Surveyed location of all piles within a pile group within 5 Calendar Days of completion of all pile driving work within each pile group.
f. Documentation of any corrective measures within 24 hours of such measures being taken.

All submittals and calculations shall be signed and sealed by a Professional Engineer registered in the State of Delaware.

Materials:

Refer to sections 604, 605, 618, 803, and 812 of the Standard Specifications and the following requirements:

Steel Pipe Piles shall conform to the requirements of ASTM A 572, Grade 50.

Construction Methods:

The equipment for driving the steel pipe piles shall conform to these provisions. All equipment shall be in conformance with the approved wave equation analysis.

Steel Pipe Pile Fabrication

Fabrication and inspection of piles shall be in accordance with the Department's standard specifications.

Steel pipe to be used for pipe piling shall conform to the following tolerances:

a. Thickness: The thickness of the pipe piles shall not vary by more than 1/8" from the corresponding thickness specified on the Design-Builder's Plans for thicknesses greater than or equal to 2 inches and no more than 1/16" for thicknesses of less than 2".

b. Diameter: The outside diameter of the steel pipe shall not vary by more than 1%, or more than 1/4" from that corresponding to the diameter shown on the Design-Builder's
c. Out of Round: The pipe shall not be out of round by more than 1 percent of the diameter, nor more than 1/2".
d. Straightness: Maximum deviation in straightness in any 10' section of pipe shall be 1/8". For lengths over 10', use the following formula, not to exceed 3/8" in any 40' length:
   1/8 x (total length in feet/10')
e. Circumference: The outside circumference at any point in a length of pipe shall not vary by more than 1% of the nominal circumference nor more than 1/2".

All welding required for the steel pipe piles shall conform to AWS D1.1 and D1.5. All welding required for splicing of the steel pipe piles shall be full penetration welds and shall be capable of developing the pile in tension or bearing. Welding procedures shall be submitted to the Department for approval at least 30 calendar days prior to the beginning of fabrication.

Welders and welding operators shall be qualified in conformance with the Department's requirements. All welds shall receive 100% visual inspection. All automatic welds shall then receive 10% Radiographic Inspection (RT) or Ultrasonic Inspection (UT), all other welds shall receive either 25% RT or UT in conformance with AWS D1.1 and D1.5. In addition, 10% of all weld intersections shall be inspected as described above for a minimum of 6" in each direction.

Acceptance for RT shall be in accordance with AWS D1.5M Section 9.21.2.2 and UT shall be in accordance with AWS D1.5M Section 9.21.3.1, Table 9.5.

If unacceptable discontinuities are found during these nondestructive tests, an additional 12" of weld on each end beyond the discontinuity shall be tested.

Automatic welding is any welding with equipment that performs the welding operation without manual manipulation of the welding arc by a welding operator. The equipment may or may not load and unload the work pieces.

A certified Welding Inspector (CWI) shall perform all visual inspections. Technicians certified to ASNT-TC-1A Level II in accordance with the requirements of American Society Nondestructive Testing (ASNT), and approved by the Department shall perform all nondestructive testing and inspections.

All unacceptable discontinuities shall be repaired in accordance with AWS D1.1 and D1.5. After repairs of defects have been made, the repair area plus 2" shall be re-inspected (UT or RT) for full 100% in accordance with the above inspection procedures.

Storage and Handling

The piles shall be stored and protected to avoid damage and shall be picked up in a manner that will avoid damage. If the piles are damaged due to improper storage or handling by the Design-Builder, they shall be rejected and replaced by the Design-Builder at no expense to the Department.

Driving Hammers

Steel pipe piles shall be driven with pile hammers and driving systems consistent with those submitted as part of the wave equation analyses in accordance with Part 4 - Special Provisions, *Dynamic Pile Testing* and Part 3 – Performance Specifications, *Geotechnical Requirements*. The pile hammers shall be sized to ensure that stresses associated with hammer impact do not exceed the permissible driving stresses

specified in the "*AASHTO LRFD Bridge Design Specifications*."

The hammer shall be maintained in proper adjustment consistent with manufacturer's recommendations and shall be operated at the manufacturer's rated number of blows per minute and at the rated pressure. The compressor shall be equipped with an accurate pressure gage and automatic read-out of ram velocity and delivered energy to the pile.

The hammer, hammer cushion and pile cushion used to drive the piles shall be the same type and size as those used in the Wave Equations Analysis. No modifications or substitutions will be permitted without resubmission of a revised Wave Equation Analysis unless otherwise authorized by the Department's Project Manager.

Piles damaged because of misalignment of the leads, failure of hammer cushion, failure of splices, malfunctioning of the pile hammer, or for any other reason shall be cause for rejection of the pile if it is determined by the Department or the Design-Builder's QC Manager that the strength of the pile has been compromised. Replacement piles shall be driven at no additional cost to the Department.

Hammer Cushion

Impact pile driving equipment designed to be used with a hammer cushion shall be equipped with a suitable thickness of hammer cushion material to prevent damage to the hammer and to insure uniform driving behavior. Hammer cushions shall be made of durable manufactured materials, proved in accordance with the hammer manufacturer's guidelines. Wood, wire rope and asbestos hammer cushions are specifically disallowed and shall not be used. A striker plate as recommended by the hammer manufacturer shall be placed on the hammer cushion to insure uniform compression of the cushion material. The hammer cushion shall be removed from the helmet and inspected in the presence of the Design-Builder's QC Manager when beginning pile driving at each pile location or after each 100 hours of pile driving, whichever is less. Any reduction of hammer cushion thickness exceeding 50% of the original thickness shall be replaced by the Design-Builder before driving is permitted to continue.

Driving Helmet

A driving helmet shall be used between the top of the pile and the ram to prevent impact damage to the piles. The driving helmet shall be capable of transferring hammer energy uniformly over the top of the pile. The driving helmet shall fit loosely around the top of the pile so that the pile is not restrained by the driving helmets if the pile tends to rotate during driving.

Driving the Piles

Pipe piles shall be driven to the minimum tip elevation and bearing resistance specified by the Design-Builder's Geotechnical Engineer. Pre-augering to aid in the installation of piles may be used within depths expressly permitted by the Design-Builder's Geotechnical Engineer. Piles shall not be installed by water jetting. Any pile damaged by improper driving, or driven out of its proper location of alignment shall be removed, or as an option, a second pile may be driven adjacent thereto. All rejected piles shall be at the expense of the Design-Builder.

Piles shall be visually checked for structural integrity after driving. In addition, the Design-Builder shall monitor the piles by survey for heave during driving of adjacent piles. Piles pushed up more than 1/4" shall be driven back to their original tip elevation at a minimum.

The Design-Builder shall maintain records of pile lengths, hammer speeds, blows per foot, tip

elevations and other relevant data pertinent to all piles driven. The Design-Builder shall also provide assistance to the Department when needed for Quality Assurance inspections, including all required equipment such as lifts, lights, work platform, measuring devices, etc., all in conformance with applicable safety regulations.

All piles shall be driven at locations shown on the Design-Builder's Plans or as directed by the Design-Builder's Geotechnical Engineer. They shall be driven within an allowed variation of 1/8" per foot of pile length from the vertical as shown on the Plans. The piles shall be driven with a variation of not more than 4" in any direction at the cutoff elevation from the positions indicated on the Plans. Any pile driven out of position shall be corrected to the satisfaction of the Department's Project Manager or else withdrawn and replaced. The tops of all piles shall be cut off to a true plane at the elevation shown on the Design-Builder's Plans. Pile driving records shall be completed in accordance with Part 2 – DB Section 112 of the Contract Documents and submitted to the Department upon completion of all pile driving within a pile group.

The Design-Builder shall conduct surveys prior to, during and after pile driving operations to monitor the impact of pile driving vibrations on existing structures. If vibrations caused by pile driving induce settlement of the existing structures, the Design-Builder shall be required to reduce the hammer stroke for driving piles. If the settlement of the existing structures continues, the Design-Builder shall stop pile driving adjacent to the affected area and submit a revised installation procedure for approval before pile driving can resume at these locations. There will be no measurement and payment for stoppage of Design-Builder's work that is a result of Design-Builder pile driving operations.

Where additional piles must be installed to replace unacceptable piles, such additional piles will be located as required to maintain concentric loading on pile caps or footings. Depending upon the location of previously installed piles at any pile cap or footing location where one or more piles is determined to be unacceptable, it may be necessary to install a number of additional piles greater than the number of piles determined to be unacceptable in order to maintain concentric loading on the pile cap or footing. It may also be necessary to revise or enlarge the pile cap dimensions in order to accommodate the additional piles. Submit complete details of proposed installation of piles required to replace unacceptable piles, including the proposed location of replacement piles and any necessary pile cap modifications, for Department's Project Manager's review and comment. Do not install replacement piles prior to receiving the Design QC Manager's approval. Furnish and install all such additional piles, and perform all pile cap redesign and associated construction at no additional cost to the Department.

Pile Cut Off

Piles shall be cut-off to a true plane at the elevations shown on the Design-Builder's Plans. All pile cut-offs will become the property of the Design-Builder and shall be removed from the site and disposed of by the Design-Builder at no additional cost to the owner and in a manner acceptable to the Department's Project Manager.

Concreting Steel Pipe Piles

Soil and debris shall be removed from the portion of the pile in the areas to be filled with reinforced and tremie concrete as shown on the Design-Builder's Plans. The depth of the reinforced concrete inside the pipe pile shall be as shown on the Design-Builder's Plans. The depth of the tremie concrete below the cast-in-place concrete shall be determined by the Design-Builder. After removal of soil and debris, the inside surface of the pile shall be cleaned. Prior to beginning work, the Design-Builder shall submit to the Department's Project Manager for review and comment, a cleanout method for open-ended steel pipe piling as indicated in the "Submittals" section of this Special Provision. Care shall be taken during cleanout of the steel pipe piling to prevent disturbing the material surrounding the pile. Equipment or methods used for

cleanout shall not cause blow-ins, quick soil conditions, scouring, or caving around or below the tip of the steel pipe pile. If the use of water jets for cleaning the insides of the steel pipe and airlifts for cleaning out the steel pile are proposed by the Design-Builder, methods and limits of water jetting shall be clearly identified in the *Installation Plan* submittal.

The soil inside of the steel pipe piles shall not be excavated until the top of the soil elevation inside the pile has been measured and record information submitted to the Department. Soil removed from inside the pipe piles may be used for fill in other portions of the project provided it conforms to the requirements of for fill material defined in Section 209 of the Delaware Department of Transportation "Standard Specifications for Road and Bridge Construction," Dated 2001 as amended by Delaware Department of Transportation "Supplemental Specifications, Revisions and Corrections to the August 2001 Standard Specifications," (Part 4 – Appendix A). Otherwise the soil shall be disposed of at an approved site. No excavated material shall be dumped in the water.

A tremie concrete plug shall be placed and cured prior to dewatering of the pipe pile. The Design-Builder shall design and submit computations signed and sealed by a Delaware-registered Professional Engineer for the tremie plug. If the tremie concrete plug fails prior to filling with concrete, the Design-Builder shall remove the failed plug, re-design, and submit new, signed computations, of a new plug system at no additional cost to the Department. The reinforcement unit shall be placed in the pile prior to filling with concrete. All work shall be in accordance with the Design-Builder's Plans.

After the steel pipe piles have been cleaned out, the water level inside the piles shall be maintained at the inlet level outside the piles. No dewatering shall be permitted until the tremie concrete plugs have been placed and allowed to cure adequately cure. The opening of the pile shall be covered immediately after cleaning. The steel piles shall be free of any soil, rock or other material deleterious to the bond between the steel shell and concrete prior to placing reinforcement and concrete. Reinforcement shall be placed and secured symmetrically about the axis of the pile and shall be securely blocked to clear the sides of the steel shell.

All pipe piles within each individual pile group shall be driven and accepted by the Design-Builder's Construction QC Manager prior to any concrete fill placement.

Immediately prior to concreting, water (deeper than 3") or other foreign substances found in a shell or pipe type pile shall be removed. Any water removed from the pile shall be collected and sediment removed in accordance with the Contract requirements. The concrete shall be deposited in one continuous operation using methods conforming to ACI 336.1 "Specification for the Construction of Drilled Piers", Section 3.5, the latest edition as of the issue date of this RFP.

Inspection of Steel Pipe Piles

Steel pipe piles shall be inspected on the inside by visual methods by the Design-Builder's QC Manager for the entire length of each pile (except for the soil plug) after driving and cleaning and prior to placing reinforcement. No reinforcement or concrete shall be placed until the Design-Builder's QC Manager approves the pile.

The Design-Builder shall provide a means of access to the interior of the pipe piles for use by the Department for inspection. Means of access shall be in accordance with OSHA standards.

Testing of Steel Pipe Piles

Steel Pipe Pile testing shall be performed in accordance with the requirements of the following

Contract Documents:

1. Part 4 - Special Provisions, *Dynamic Pile Testing*;
2. Part 4 – Special Provisions, *Quick Pile Load Test*; and
3. Part 3 – Performance Specifications, *Geotechnical Requirements*.

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618519 - DRILLED SHAFTS

Description:

This work shall consist of all labor, materials, equipment, and services necessary to perform all operations to complete the installation, integrity testing, and load testing of drilled shafts consistent with this special provision, the specifications, and all other applicable contract requirements. Technique shafts and load testing shall be required as specified in Part 3 Performance Specification, *Geotechnical Requirements*. Integrity testing, including crosshole sonic logging, shall be required during construction of all drilled shafts.

The following definitions apply:

1. Drilled Shaft. A cast-in-place foundation element consisting of a shaft section that derives a portion of its compression load capacity through load transfer to the shaft base and the remainder of its load capacity from side friction.

2. Bearing Stratum. A layer of soil that provides bearing support at base of the shaft.

3. Shaft Section in Soil. Length of drilled shaft from ground surface to proposed bearing elevation at the bottom/tip of the drilled shaft.

4. Permanent Casing. Steel pipe, of cylindrical shape, installed by drilling or pushing that, when filled with concrete, becomes a permanent part of the drilled shaft.

5. Obstruction. A natural or man-made object above the bottom of shaft's proposed tip elevation that cannot be removed by drilling with conventional earth augers or under reaming tools, and that requires the use of special rock augers, core barrels, air tools, or hand excavation.

6. Tip Elevation. The bottom elevation of the drilled shaft.

7. Mini-SID. A Miniature Drilled Shaft Inspection Device consisting of a digital video camera and video-control housing unit used for inspection of the bottom of all excavated shafts. The inspection is annotated and recorded on a video recorder for project documentation.

Site Information

Prior to submitting a Proposal, the Design-Builder shall visit and examine the work site and all conditions thereon and take into consideration all such conditions that may affect this work, in accordance with Section 102.05 of the Standard Specifications. Subsurface data previously collected from the site has been included in the Reference Documents section of the Scope of Services Package. This data has been furnished to provide general indications regarding the existing sub-surface site conditions but should not be considered by the Design-Builder as a warranty of actual subsurface conditions.

Engineering boring sheets are included in the Indicative Plans in the Contract Documents, Part 6 – Scope of Services Package Plans. These sheets contain information that may be critical to the design and construction of drilled shafts such as soil descriptions and groundwater conditions, including the presence of localized artesian pressures in the vicinity of the likely foundations. Data on subsurface conditions are not intended as representations or warranties of continuity of such conditions. It is expressly understood that the Department will not be responsible for interpretations of and/or conclusions

made by the Design-Builder's review of this material. The data is made available for the convenience of the Design-Builder and may be used to satisfy the minimum sub-surface investigation requirements specified in the *Geotechnical Requirements* Performance Specification.

Submittals:

All submittals described in this special provision shall be submitted to the Department's Project Manager at least 30 Calendar Days prior to mobilization unless otherwise specified. The Design-Builder shall perform no drilled shaft construction, including test shafts, until the Department's Project Manager has reviewed and approved all *Qualifying Experience* submittals as described herein. In addition, the Design-Builder will not be permitted to start construction of any drilled shafts until the complete *Installation Plan* and *Working Drawing* submittals described herein has been received, reviewed and commented on by the Department. The Design-Builder shall allow at least 21 Calendar Days for the Department's review and approval of all submittals.

1. *Qualifying Experience*. The Design-Builder shall submit proof that proposed superintendent in responsible charge has a minimum of five years of experience (within the last eight years) installing drilled shafts of dimensions similar to the specified dimensions of the drilled shaft foundation system for this project and under soil conditions similar to the subsurface conditions indicated in the soil boring logs for this project using both cased and slurry methods, and a signed statement that the Design-Builder has inspected both the project site and all the subsurface information made available in the Contract Documents. The Design-Builder may hire Specialty Subcontractors specializing in the installation and/or testing of drilled shaft foundation systems, provided the Subcontractors submit proof of qualifying experience satisfying the requirements defined herein.

    a. The Design-Builder shall provide documentation of its proposed superintendent's qualifications, experience record, and prior project references. All prior project references shall be currently available personnel who can verify the quality of the Design-Builder's previous work and shall include current name, address, and telephone number. This documentation shall reference the experience of the Design-Builder and the Design-Builder's superintendent in responsible charge of the drilled shaft operations. This documentation shall reference successful construction of similar sized shafts in the following conditions:
        - > Experience in successfully installing drilled shafts of the size shown on the plans or larger, on schedule, using both cased and slurry methods. The minimum experience shall consist of five (5) similar-sized projects with the work being performed in the past eight (8) years;
        - > Experience in performing the load testing specified herein. The minimum experience shall consist of installing the instrumentation and performing the required O-Cell testing on no less than five (5) similar-sized projects in the past five (5) years;
        - > Experience in crosshole sonic logging (CSL) testing. The crosshole sonic logging subcontractor shall have previous experience in conducting CSL tests on at least five drilled shaft projects of similar size in the past eight years;
        - > Experience in cleaning shaft bottoms when working under wet conditions or with slurry methods; and
        - > Welder certifications and approved procedures in accordance with Section 826.12(c) of the Standard Specifications.

2. *Installation Plan*. The Design-Builder shall submit to the Department's Project Manager for review and comment an installation plan for the construction of drilled shafts as detailed in this

Special Provision. The submittal shall include the following:

a. The Design-Builder's/subcontractor's list of proposed equipment with sufficient capacity to undertake and complete the work within the specified contract time. The list of proposed equipment shall include, but not be limited to cranes, drills, augers, bailing buckets, final cleaning equipment, de-sanding equipment, slurry pumps, sampling equipment, tremie, concrete pumps, casing, and other appurtenances as applicable to the work;

b. The Design-Builder shall prepare a descriptive narrative of the proposed method of access to each drilling location, additional equipment, source and supply of materials, concrete mix design, procedure of drilling, installing reinforcement bars and placing concrete including sample forms for slurry testing, summary of concrete placement, and any tests of completed drilled shafts;

c. Details of overall construction operation sequence and the sequence of shaft construction in bents or groups, including scaled plan and profile showing the location, size and movements of equipment setup and operations. The completion of any required integrity and loading tests shall be noted in the construction operation sequence;

d. Details of shaft excavation and proposed stabilization methods;

e. Data giving the physical and chemical properties of any proposed slurry. Details of the method proposed to mix, circulate, and dispose of slurry shall be provided as part of the slurry management plan. Include method of collecting displaced slurry from the excavation;

f. Method of monitoring and continuously maintaining slurry level in drilled shaft, if applicable, including method of maintaining stability of drilled shafts in the event of sudden slurry loss or loss of slurry stabilization properties;

g. Method of monitoring verticality of the shaft during excavation and details of proposed corrective measures to be implemented as necessary;

h. Specific details of methods to clean the shaft excavation. Details shall include at least three alternative bottom-cleaning methods with descriptions of equipment to be used when installing drilled shafts in accordance with the Design-Builder's proposed methods. Include details of method for identifying type of bearing material for consistency with design assumptions prior to placement of concrete;

i. Details of reinforcement placement including methods for lifting, lowering, support and centralization, and methods for suspending reinforcement cage if required for shaft depth extensions resulting from inadequate bearing at the plan depth;

j. Details of planned load test instrumentation and test procedures including methods for Osterberg Cell (O-Cell) and/or other instrumentation installation. Current equipment calibration certificates shall be completed within three months prior to load tests. Pressure dial gages shall be used for load tests and shall be calibrated within 30 days of use;

k. The concrete mix design, including admixtures to be used. Details of concrete placement, curing, and protection. Concrete mix design should include a slump loss versus time curve for the Design-Builder's proposed mix design. The concrete mix design shall provide for a minimum 4 inch slump during the entire concrete placement period for each drilled shaft;

l. Quality Control methods to be used for confirming field conditions when using high slump concrete or self-compacting concrete;

m. Methods for controlling heat of hydration for mass concrete pours. *See* the *Mass Concrete* Performance Specification in Part 3 for additional requirements;

n. A copy of the proposed report format for planned shaft installation and inspections. Record information for each shaft and details of any required load or integrity tests;

o. Methods to be used maintaining, measuring, and verifying tolerances;

p. Details of proposed crosshole sonic logging tube installation or other proposed non-destructive quality control measures; and
q. Other information requested by the Department's Project Manager.

3. *Working Drawings*. The Design-Builder shall submit to the Department's Project Manager for review and comment Drilled Shaft Working Drawings. The Design-Builder shall not be permitted to start the construction of drilled shafts until the proper Working Drawing checks, reviews, and certifications have been performed by the Design-Builder in accordance with Part 2 – DB Section 111-10 of the Contract Documents. Such certifications will not relieve the Design-Builder of responsibility for results obtained by the use of these drawings or any of its other responsibilities under the contract.

4. *Construction Reports*. Submittals to the Department during construction shall include record information for each shaft and details of any required loading or integrity tests as required. The following information shall be furnished to the Department:

a. Details to be included on Record Information reports for each drilled shaft.
b. Installation logs and Record Information Reports within 24 hours of completion of each shaft.
c. Daily slurry testing records submitted on a weekly basis during drilled shaft construction activities.
d. CSL reports within seven (7) calendar days of the test being performed.
e. Surveyed location of all drilled shafts within a foundation unit upon completion of all drilled shaft work within each foundation unit.
f. Documentation of any corrective measures within 24 hours of such measures being taken.

All submittals and calculations shall be signed and sealed by a Professional Engineer registered in the State of Delaware.

Materials:

Hydraulic Cement Concrete

Hydraulic cement concrete for the drilled shafts shall meet the requirements specified in Section 812 of the Standard Specifications. The hydraulic cement concrete is to provide a Design Minimum Laboratory Compressive Strength at 28 days of 4,500 psi, or greater, if required by the Design-Builder. Water used in mixing concrete or slurry shall conform to Section 803 of the Standard Specifications.

1. Minimum Slump. Concrete mix for slurry displacement method shall have an initial slump of 8″ +/- 1″ and be capable of maintaining a minimum slump of 4″ until completion of concrete placement.

2. Air Content. Do not use air-entrained concrete for drilled shafts.

3. Cementitious Materials. Limit percentage, by weight, of cementitious materials other than Portland cement according to ACI 301 limits.

4. Content Limits. Limit water-soluble, chloride-ion content in hardened concrete to 0.08% by weight of cement.

5. Concrete Mix. Mix design adjustments may be considered if characteristics of materials, project conditions, weather, test results or other circumstances warrant. Resubmit to the

Department for review and written comment any proposed changes to concrete-mix proportions, prior to the placement of concrete.

6. Aggregate Size. The maximum aggregate size for the concrete mix shall be 3/8" diameter.

7. Ready-Mixed Concrete. Measure, batch, mix and deliver concrete according to ASTM C 94, and furnish batch ticket information.
   a. Do not add water to concrete mix after mixing.
   b. Maintain concrete temperature to not exceed 90° F.

8. Admixtures. Admixtures must be certified by manufacturer to contain not more than 0.08% water-soluble chloride ions by weight of cementitious material and to be compatible with other admixtures and cementitious materials. Do not use admixtures containing calcium chloride. If any admixtures are added to the concrete at the site, the admixture shall be added to the concrete by a qualified Design-Builder-furnished technician. Immediately after the addition of the admixture, the drum shall be turned, not less than thirty revolutions, until the concrete is thoroughly mixed. The technician shall then test the slump and consistency of the concrete mixture. Under no circumstances shall the Design-Builder add additional water to the concrete mixture to reach the desired slump. If used, admixtures shall conform to the following specifications:

   a. Water-Reducing Admixture: ASTM C 494, Type A
   b. Water-Reducing and Retarding Admixture: ASTM C 494, Type D
   c. High-Range, Water-Reducing Admixture: ASTM C 494, Type G
   d. Plasticizing and Retarding Admixture: ASTM C 1017, Type II

9. Concrete Cover. Minimum concrete cover for reinforcing steel within drilled shafts shall be as follows:

Diameter (feet)	Minimum Cover (inches)
≤ 6	4"
> 6	6"

Bar Reinforcement

Deformed reinforcing bars shall be in accordance with the sizes, spacing, dimensions, and details shown on the Design-Builder's plans and shall conform to ASTM A 615, Grade 60, and the requirements of Section 603 of the Standard Specifications. Epoxy coating is not required for drilled shaft reinforcing steel.

Threaded mechanical reinforcement coupling device shall meet the requirements of Section 603.07. A wedge or crimp system may be used for spiral reinforcement only. Mechanical bar splices must develop in tension or compression, as required, at least 125% of the specified yield strength of the bars being spliced.

Bar ties shall be provided at a minimum of 50% of the bar reinforcing interfaces and shall be evenly distributed throughout the reinforcing steel cage. Additional ties shall be provided, as needed, to properly stabilize the reinforcing cage.

Slurry

Polymer slurries meeting the following requirements are permitted for use during drilled shaft construction. The Design-Builder may submit alternate polymer or mineral slurry specifications for the Department's review and approval. Blended mineral-polymer slurries shall not be permitted for use.

1. Polymer slurry shall be a stable suspension of polymer in potable water. The Design-Builder shall anticipate encountering brackish groundwater and other agents that may be deleterious to slurry. The Design-Builder is responsible for and shall modify the slurry mix as required so as to maintain a stable suspension at all times.

2. The slurry shall be readily displaced by the hydraulic cement concrete.

3. Additives shall be used in the slurry if needed to maintain the necessary properties.

4. Fluid loss in an open excavation shall be limited to a drop in the slurry level of no greater than 1" per hour per 20' of excavation depth, and no more than 24" total in a twenty-four-hour period.

5. Polymer slurry shall be a suspension of powdered polyacrylamide or vinyl polymer. Polymers shall be mixed with water to provide a stable colloidal suspension; complying with ACI 336.1 with the following density, viscosity, and pH:

Range of Acceptable Values (at 70°F for Polymer Slurry)			
Property(Units)	Time of Slurry Introduction	Time of Concentrating (In Hole)	Test Method
Density (lb/ft^3)	65 to 69	65 to 69	Density Balance
Viscosity (sec/gal)	200 minimum	200 minimum	Marsh Cone
pH	8 to 11	8 to 11	pH paper or meter

Notes:

a. Sand content shall not exceed 1% (by volume) at any point in the shaft excavation as determined by ASTM D 4381 sand content test.
b. Maximum viscosity by Marsh Funnel method shall be in accordance with manufacturer's recommendations.
c. Mixing time shall be a minimum of fifteen minutes for polymer slurry.
d. Storage time to allow hydration shall be a minimum of two hours for polymer slurry.

6. A minimum of four sets of tests to determine density, viscosity and pH shall be made during the first 8 hours of slurry use. When the results show consistent behavior, the testing frequency may be decreased to one set every 4 hours of slurry use.

7. A technical representative from the slurry manufacturer shall be present at the site, as a minimum, during construction of the technique shafts and first drilled shaft at each foundation. If slurry based difficulties are encountered on other shafts, the Design-Builder will be required to have the slurry manufacturer's representative present for any remaining shafts, as required by the Department, at no additional cost to the Department.

8. The Design-Builder shall insure that heavily contaminated slurry suspension, which could impair the free flow of concrete, has not accumulated in the bottom of the shaft. Prior to placing concrete in any shaft excavation, the Design-Builder shall take slurry samples using a sampling tool approved by the Department's Project Manager. Slurry samples shall be extracted from the base of the shaft and at intervals not exceeding 10 feet up the slurry column in the shaft, until two consecutive samples produce acceptable values for density, viscosity, and pH throughout the shaft.

9. When any slurry samples are found to be unacceptable, the Design-Builder shall take whatever action is necessary to bring the slurry within specification requirements. Concrete shall not be poured until the slurry in the hole is re-sampled and test results produce acceptable values.

10. Reports of all tests required above signed by an authorized representative of the Design-Builder, shall be furnished to the Department's Project Manager on completion of each drilled shaft.

11. During construction, the level of mineral slurry in the shaft excavation shall be maintained at a level not less than 4 feet above the highest expected piezometric pressure head along the depth of the shaft, and the level of polymer slurry shall be maintained at a level not less than 6 feet above the highest expected piezometric pressure head along the shaft. If at any time the slurry construction method fails, in the opinion of the Department's Project Manager, to produce the desired final results, then the Design-Builder shall both discontinue this method and propose an alternate method for the approval of the Department's Project Manager.

Welding Material

AWS D1.1 Structural Welding Code shall be used.

Sand-Cement Grout

Sand-cement grout for drilled shafts shall consist of Portland cement, ASTM C 150, Type II; clean natural sand, ASTM C 404; and water to result in grout with a minimum 28-day compressive strength of 1000 psi, and of consistency required for application.

Construction Methods:

Protection of Existing Structures

Precautions shall be taken to prevent damage to all existing structures and utilities. Existing structures shall include, but not be limited to, the approach roadway retaining walls, the existing bridge, adjacent drilled shafts, and other previously constructed new bridge elements. These measures shall include, but are not limited to, selecting construction methods, equipment and procedures that will prevent excessive caving of the shaft excavation, monitoring, and controlling the vibrations from the driving of casing or sheeting, and drilling of the shaft.

All monitoring noted below shall apply to the existing bridge structure regardless of the distance from the drilled shaft construction. All requirements shall apply to technique shafts, load test shafts, and production shafts.

1. The Design-Builder shall verify that there are no subsurface utilities in close proximity of each

shaft before beginning excavation activities.

2. The Design-Builder shall conduct surveys prior to, during, and after the start of drilled shaft installation to monitor the impact of construction on existing structures. The location of the survey points shall be painted with a small spot of fluorescent paint so that future surveys may be taken at the same locations.

3. During drilling of the drilled shafts, surveyed elevations of the adjacent structures shall be obtained daily. After the drilled shaft has been filled with concrete, adjacent structure spot elevations shall be obtained within two hours of concrete placement and on a weekly basis for ten weeks, thereafter.

4. Differentials in surveyed spot elevation greater than 0.2" shall immediately be brought to the Department Project Manager's attention for evaluation and the Design-Builder may be required to cease all or part of the drilling work. Only the Department's Project Manager can give approval to restart drilling activity.

5. After drilling has been halted, the Design-Builder shall propose remedial action for presentation to the Department's Project Manager for review and approval.

6. A report of all surveying of the existing adjacent highway and bridge structures shall be submitted to the Department's Project Manager at the completion of drilling operations. Interim reports as noted above shall be submitted weekly and be included with the final report. Remedial action shall also be included in the final report.

Preparation

1. Drilled shafts shall be excavated to depths and dimensions as required. Bottoms of drilled shafts shall be cleaned of loose or soft material and leveled. Cleaning operations shall be performed in accordance with section "Excavation Inspection" of this special provision prior to concrete placement. The Design-Builder shall inspect each shaft bottom for cleanliness through the use of an inspection device. The cleanliness of each shaft bottom shall be approved by the Construction QC Manager. Excavated material and/or slurry materials shall be disposed of in accordance with Federal, State and Local Regulations. Sediment-laden water and excavated soil from within the drilled shaft shall not be permitted to re-enter the inlet, bay, ocean or other water surface body. Water shall be cleaned in accordance with Section 110.13 of the Standard Specifications prior discharge into a water body.

2. During the drilling of the drilled shafts, the surrounding soil shall be adequately and securely protected against cave-ins, by means of temporary casing and polymer slurry.

3. Water/slurry in the excavation shall be continuously removed, as concrete is being placed. The concrete shall be placed using underwater tremie methods.

4. Each drilled shaft excavation will be inspected and approved by the Design-Builder's Construction QC Manager prior to the placement of concrete. A record of all inspections, including results from the mini-SID, with related construction changes, shall be kept by the Design-Builder. The Design-Builder shall provide the necessary support personnel for inspection and testing procedures.

5. The locations and techniques of the permanent casing method shall be subject to the Department's review and written comment.

6. Blasting shall not be permitted unless otherwise authorized by the Department's Project Manager.

Equipment

The Design-Builder shall furnish all equipment and instrumentation necessary for installation, inspection, and load testing of the drilled shafts.

1. A description of the equipment that is proposed for use shall be submitted as part of the Design-Builder's Installation Plan and will be subject to the Department's review and written comment.

2. The Design-Builder shall furnish all equipment and instrumentation necessary for the installation, shaft bottom inspection (mini-SID), CSL testing, and load testing of the shafts.

3. The excavation and drilling equipment shall have adequate capacity including power, torque, and down thrust (crowd) to excavate a hole of the maximum diameter required to a depth of 15' beyond or 20 percent beyond the anticipated depths required, whichever is greater.

4. The excavation and tools shall be of adequate design, size, and strength to perform the work shown on the Design-Builder's Plans or described herein. When the material encountered cannot be drilled using conventional earth augers with soil or rock teeth, drilling buckets, and/or over-reaming tools, the Design-Builder shall provide special drilling equipment as necessary to construct the shaft excavation to the size and depth required.

5. The Design-Builder shall provide equipment that produces a stable slurry suspension and provides mechanical or hydraulic agitation. Provide a temporary pipeline or other safe method to transport slurry. Provide equipment that removes detrimental quantities of excavated material from the slurry.

6. There shall be a descriptive listing of available equipment provided by the Design-Builder that is fully capable of cleaning shaft bottoms when shafts are excavated under wet or slurry conditions.

Construction Sequence

No construction activity, including drilling, within a radius of three shaft diameters (center-to-center spacing) of a freshly drilled shaft shall take place until the concrete shaft has cured for at least 24 hours and the Construction QC Manager has provided written approval.

1. Excavation. Any disturbance to the footing area caused by shaft installation shall be repaired by the Design-Builder prior to the footing pour.

2. Drilled Shaft Construction. Construction of each drilled shaft shall be performed so that placement of the reinforcing steel cage occurs immediately following the completion of the drilling operation. The concrete placement shall begin immediately thereafter and conclude within 24 hours after final approval of excavation by the Construction QC Manager.

3. Reinforcing Steel Placement. The reinforcing steel cage shall be installed into the open drilled shaft, immediately after approval of the drilled shaft by the Construction QC Manager. The reinforcing steel cage shall be rigid and shall not separate during placement.

4. Reinforcement Steel Cage Tolerances. The top of the reinforcement steel cage shall be within the

limits specified in section "Tolerances".

a. In order to maintain spacing from the sides of the drilled shaft, the reinforcement steel cage shall have sets of spacers attached to the perimeter of the reinforcing steel cage. Each spacer set shall include a minimum of four (4) spacers equally spaced around the perimeter of the cage but no more than 30 inches circumferentially apart. Each spacer sets shall be spaced no more than 10 feet apart vertically. Approved cylindrical concrete feet shall be provided to maintain a minimum of 6″ spacing between the bottom of the rebar cage and bottom of shaft excavation.

b. Additional reinforcing steel (or crossbars) shall be placed across the reinforcing steel cage, as needed, to maintain the regular shape of the reinforcing steel prior to placement. If used, additional crossbars shall be removed as the rebar cage is placed into the hole ensuring that none of the removed cross bars fall into the hole.

5. Concrete Placement. After the reinforcing steel cage has been installed in the drilled shaft and approved by the Construction QC Manager, approval will be given for the concrete placement to begin.

a. Concrete shall be continuously placed by methods that ensure against segregation and dislodging of excavation sidewalls, and shall completely fill the shaft. Concrete shall be placed by tremie or pumping in wet holes. Concrete placement shall be performed in accordance with section "Concrete Placement, Curing, and Protection" of this special provision.

Tolerances

The following construction tolerances shall be maintained in constructing drilled shafts unless more stringent requirements are included on the Design-Builder's plans:

1. Drilled shafts shall be installed with top centerline location deviating not more than 3" from the proposed centerline location in any direction.

2. Drilled shafts shall be installed plumb with a maximum deviation of ½" for the first 10' and 1 ½" for each 10' of additional depth.

3. After all the shaft concrete is placed, the top of the reinforcing steel cage shall be no more than 3" above or below plan position.

4. The minimum diameter of the drilled shaft shall not be more than 1" less than the diameter specified on the Design-Builder's plans.

5. The maximum diameter for any section of drilled shaft shall be no more than 4" greater than the diameter specified on the Design-Builder's plans. If telescoping casing is to be used, no more than two separate diameters shall be permitted within a drilled shaft.

6. The top elevation of the shaft shall be within plus 1" or minus 3" of the plan top of shaft elevation.

7. The drilled shaft tip elevation shall be determined by the Department's Project Manager. The bottom of the shaft excavation shall be normal to the axis of the shaft within ½" per foot of shaft diameter.

8. The reinforcing steel shall be placed and the position maintained so that the outer edges of the reinforcing cage are located uniformly a minimum of 4" inside the perimeter for drilled shafts less than or equal to 6′-0 in diameter and 6″ inside the perimeter for drilled shafts greater than 6’-0” in diameter.

Drilled shaft excavations constructed in such a manner that the concrete shaft cannot be completed within the required tolerances will be considered defective. Correction methods shall be submitted by the Design-Builder for the Department Project Manager's approval. Approval shall be obtained before continuing with the drilled shaft construction. Materials, engineering and work necessary to correct for out-of-tolerance drilled shafts shall be furnished by the Design-Builder at no cost to the Department.

Excavations

Excavations required for shafts shall be performed through whatever materials are encountered, to the dimensions and elevations required. The method used shall be suitable for the intended purpose and materials encountered. The wet or slurry method with temporary and/or permanent casings shall be used as necessary to produce sound, durable concrete foundation shafts that are free of defects.

1. Wet Construction Method. The wet construction method consists of using slurry to maintain stability of the hole perimeter while advancing the excavation to final depth, placing the reinforcing cage, and shaft concrete. Temporary surface casings shall be provided to aid shaft alignment and position, and to prevent sloughing of the top of the shaft excavation.

   Polymer slurries shall be premixed thoroughly with clean fresh water and allowed adequate time for polymerization prior to introduction into the shaft excavation. Adequate slurry tanks will be required. Steps shall be taken as necessary to prevent the slurry from "setting up" in the shaft excavation, such as agitation, circulation, and adjusting the properties of the slurry. The level of the slurry shall be maintained at a height sufficient to prevent caving of the hole, and shall at all times be maintained at a level not less than 6 feet above the highest expected piezometric pressure head along the shaft.

   The Design-Builder shall carry out control tests on slurry to determine density, viscosity, and pH using suitable testing apparatus. Tests to determine density, viscosity, and pH values shall be performed during the shaft excavation to establish a consistent working pattern.

   Prior to placing shaft concrete, the Design-Builder shall collect slurry samples from the bottom and at intervals not exceeding 20' for the full height of slurry until two consecutive sets of samples produce acceptable values for density, viscosity and pH. Heavily contaminated slurry, above the 1% sand limit and not meeting the criteria provided herein, that has accumulated at the bottom of the shaft shall be eliminated. The slurry shall be within specification requirements including sand content immediately before shaft concrete placement. Concrete shall be placed in accordance with section “Concrete Placement, Curing and Protection”.

2. Temporary Casing Construction Method

   The temporary casing construction method consist of installing temporary casing to maintain the stability of the hole while advancing the excavation to final depth, placing

the reinforcing cage and shaft concrete. The casing may be either placed in a predrilled hole or advanced through the ground by twisting, driving, or vibration before being cleaned out. Vibration shall only be permitted a minimum of 24 hours after adjacent drilled shaft concrete pours have been completed.

3. Alternative Construction Methods. The Design-Builder may propose alternative methods to prevent caving and control ground water. Such proposals, accompanied by supporting technical data, shall be submitted in accordance with section "Submittals." Written approval from the Department's Project Manager is required before the use of alternative construction methods.

The bottom elevation of drilled shafts shown on the Design-Builder's plans may be adjusted during construction if the Department or the Construction QC Manager determines that the foundation material encountered during excavation is unsuitable or differs from that anticipated in the design of the drilled shaft. The Design-Builder shall perform exploration borings including Standard Penetration Testing (SPT) and soil sampling in accordance with Part 4 – Special Provisions, *Soil Borings* and in general accordance with ASTM D 1586 prior to excavation of production shafts to determine the character of the material near the proposed shaft tip elevations. The Design-Builder's Geotechnical Engineer shall inspect the samples and determine the final depth of required shaft excavation. Samples shall be available for examination by the Department.

The Design-Builder shall maintain a construction method log during shaft excavation. The log shall contain information such as the description and approximate top and bottom elevation of each soil material strata encountered seepage or groundwater, and remarks, including a description of the tools and drill rigs used and any changes necessitated by changing ground conditions. A sample log indicating the minimum acceptable information is attached to this Special Provision.

The Design-Builder shall provide the necessary equipment to remove and dispose of any materials encountered in forming the drilled shaft excavation to the dimensions shown on the Design-Builder's plans or as directed by the Department's Project Manager.

Obstructions

The Design-Builder shall remove surface and subsurface obstructions at drilled shaft locations. Such obstructions may include man-made and natural materials. Special tools and/or procedures shall be employed by the Design-Builder after the hole cannot be advanced more than 1 foot in thirty minutes using approved equipment operating at maximum power, torque, and crowd. Such special procedures/tools may include but are not limited to: chisels, boulder breakers, core barrels, air tools, hand excavation, temporary casing, and increasing hole diameter. Blasting shall not be permitted unless specifically approved in writing by the Department's Project Manager. If unforeseen obstructions requiring special tools and/or procedures are encountered, notification and payment shall be in accordance with Part 2, DB Section 104-7 of the Contract Documents.

Lost Tools

Drilling tools that are lost in the excavation shall not be considered obstructions and shall be promptly removed by the Design-Builder without compensation. All costs due to lost tool removal shall be borne by the Design-Builder including but not limited to costs associated with hole degradation due to removal operations or the time the hole remains open.

Excavation Inspection

Shaft cleanliness and the bearing surface condition will be evaluated and approved by the Design-Builder's QC Manager prior to concrete placement. After the Design-Builder has prepared the bottom of the shaft excavation, the Design-Builder shall notify the Department's Project Manager. The Design-Builder shall conduct inspection of the drilled shaft including the use of the mini-SID on all shafts. The data from the mini-SID shall be available for review by the Department's Project Manager. The Design-Builder shall coordinate schedules for excavation inspection with the Department's Project Manager.

The bottom elevations may be adjusted by the Design Builder's Geotechnical Engineer to obtain the required design capacity based on the actual bearing material encountered during installation of each drilled shaft or to obtain the minimum length required to meet the design requirements. The Geotechnical Engineer's recommendations shall be subject to review and approval from the Design QC Manager.

Prior to placement of reinforcing steel and concrete, the Design-Builder shall ensure that loose material from the bottom and sides of the excavation have been removed and that shaft is within the specified tolerances. Specified tolerances are listed in section "Tolerances". The shaft excavation shall be cleaned to remove accumulated sediment to allow for a maximum of ½" or less of accumulated sediment over maximum of 50% of the shaft bottom, and no more than 1½" of sediment in any part of the shaft bottom. Final shaft depth shall be measured after final cleaning.

The Construction QC Manager shall determine whether the sidewall of the hole has softened, swelled or otherwise degraded. The Design-Builder shall submit to the Department for review and written comment any proposed corrective measures including over-reaming. The Design-Builder shall bear all costs associated with corrective measures.

1. Design-Builder Supervision. The Design-Builder shall provide appropriate supervision of all phases of drilled shaft construction. Each drilled shaft excavation shall be checked by the Design-Builder for its depth, cleanup, and workmanship and for all tolerance requirements before any concrete is placed. A mini-SID shall be provided and used by the Design-Builder to inspect the full depth of the drilled shaft. The Design-Builder shall have the proper equipment available to check the dimensions and alignment of each shaft excavation when needed. The Design-Builder shall determine the shaft dimensions and alignment under the observation and/or direction of the Department's Project Manager. The Design-Builder shall be responsible for correcting drilled shafts that are not constructed within the specified tolerances. Remedial measures and/or repairs, including engineering analysis and redesign, to correct for out-of-tolerance drilled shaft foundations, shall be performed at no additional cost to the Department.

2. Department Quality Assurance. The Department shall have the option to inspect each drilled shaft excavation immediately after the Design-Builder has checked each drilled shaft using the mini-SID inspection method. The Design-Builder shall furnish the Department all necessary equipment required for proper inspection of drilled shaft excavations and the installed reinforcing steel cage.

<u>Reinforcing Steel Cage Construction and Placement</u>

The reinforcing steel, cage stiffener bars, spacers, centralizers, and other necessary appurtenances shall be completely assembled and placed as a unit immediately after the shaft excavation is inspected and accepted and prior to shaft concrete placement. Prior to installation of the steel cage in the shaft excavation, inspect and clean the reinforcing steel of materials that prevent effective bonding. Clear spacing between bars of the rebar cage shall be at least five times the size of the maximum coarse aggregate. Hooks at the top of the rebar cage shall not be bent outward if temporary casing will be used. Similarly, interior hooks shall be designed to permit adequate clearance for a concrete tremie pipe (i.e., 1'

minimum), if concrete is to be tremied into place. The assembled rebar cage outside diameter shall be as shown on the Design-Builder's plans. Internal stiffeners shall be removed as the cage is placed in the borehole so as not to interfere with the placement of concrete.

The reinforcing steel in the shaft shall be tied at a minimum of 50% of the bar intersections and supported so that the reinforcing steel will remain within allowable tolerances until the concrete supports the reinforcing steel. When concrete is placed by tremie methods, temporary hold-down devices shall be used to prevent uplifting of the steel cage during concrete placement. Concrete spacers or other approved non-corrosive spacing devices shall be used at sufficient intervals (near the bottom and at intervals not exceeding 10′ up the shaft using a minimum of one spacer per 30″ of rebar cage circumference at each level) to ensure concentric spacing for the entire cage length. Spacers shall be constructed of approved material equal in quality and durability to the concrete specified for the shaft. The spacers shall be of adequate dimension to ensure minimum concrete cover is provided between the outside of the reinforcing cage and the side of the excavated hole. Approved cylindrical concrete feet (bottom supports) shall be provided to insure that the bottom of the cage is maintained the proper distance above the base. If an oversize casing or excavation is used, spacer sizes shall be adjusted to ensure concentric spacing.

In the event that any shaft has to be extended due to unacceptable bearing at the plan depth, all reinforcing steel shall be similarly extended and supported once the additional depth exceeds 2'. If the extra depth of shaft is less than 2', the additional depth may be filled with unreinforced concrete.

Installation Requirements for Integrity Testing

Access tubes shall be installed in each shaft to permit access for Integrity Testing or other instrumentation installation. The number of tubes installed shall be as designated on the Design-Builder's plans. The guidelines in the table shall be followed.

Shaft Diameter	Number of CSL Pipes	Tube Spacing
6'	6 minimum	60°
8'	8 minimum	45°

CSL pipes shall be 2" inside diameter schedule 40 steel pipe only. CSL probes may typically be 1.5" or smaller diameter, typically 6 to 10" long. The pipes shall have round, regular internal diameter free of defects or obstructions, including any at pipe joints, in order to permit the free, unobstructed passage of source and receiver probes. The tubes shall be watertight and free from corrosion to ensure a good bond between the concrete and the tubes. The pipes shall each be fitted with a watertight shoe on the bottom and a removable cap on the top. The pipes shall be securely attached to the interior of the reinforcement cage. The Design-Builder shall install the tubes in each shaft in a regular, symmetric pattern. The Design-Builder shall install the tubes such that each tube is spaced the maximum distance possible from each adjacent tube, with spacing in degrees around the perimeter of the cage to correspond to the design drawings or that called out in the table above for the selected number of tubes.

The tubes are typically wire-tied to the reinforcing cage at 3' maximum intervals or otherwise secured such that the tubes stay in position during placement of the reinforcing steel cage and concrete. The Design-Builder shall submit to the Department's Project Manager the selection of tube material and size, along with its proposed method to install the tubes, prior to construction. The tubes shall be as near to vertical as possible. The tubes shall extend from 6" above the shaft bottoms to at least 3' above the shaft tops. Under no circumstance should the tubes be allowed to rest on the bottom of the drilled excavation. If the shaft top is subsurface, the tubes shall extend at least 3' above the ground surface. Any joints required to achieve full-length tubes shall be made watertight. Care shall be taken during reinforcement installation operations in the drilled shaft hole not to damage the tubes.

After placement of the reinforcement cage, the CSL tubes shall be filled with clean water as soon as possible and before concrete placement. The tube tops shall be capped or sealed to keep debris out of the tubes. Care shall be exercised in the removal of caps or plugs from the pipes after concrete placement as to not apply excess torque, hammering, or other stresses, which could break the bond between the tubes and the concrete.

Prior to the beginning of downhole logging, the Design-Builder shall ensure that the test probes can pass through every tube to the bottom. If a tube is obstructed, the Design-Builder shall, at the Design-Builder's expense, remove the obstruction or core an adjacent logging hole positioned such that the coring will not result in any damage to the reinforcing steel in the shaft. All holes shall accommodate the logging equipment for the full depth of the drilled shaft. Downhole testing may commence once all obstructions are removed and/or alternative logging holes are provided, but no sooner than five (5) days after the concrete placement is completed.

Upon completion of the CSL testing of production shafts, all water shall be removed from the access pipes and any other drilled holes. For production shafts, the pipes and holes shall then be completely filled with an approved grout, having strength properties equivalent to or better than those of the drilled shaft concrete.

Concrete Placement, Curing, and Protection

All concrete placement, consolidation and curing activities shall conform to the recommendations of Section 602 of the Standard Specifications.

Concrete placement shall begin immediately after reinforcing steel cage placement. Concrete placement shall be continuous from the bottom to the top cut-off elevation of the shaft. Placement shall continue after the shaft is full until good quality concrete is evident at the top of the shaft.

Concrete to be placed in water or slurry shall be placed by tremie method. The tremie pipe shall be supported so as to permit free movement or permit rapid lowering when necessary to retard or stop the flow of concrete. The discharge end shall be sealed closed at the start of work so as to prevent water or slurry from entering the tube before the tube is filled with concrete. After placement has started, the tremie pipe shall be kept full of concrete to the bottom of the hopper. If water enters the tube after placement is started, the tremie pipe shall be withdrawn, the discharge end resealed, and the placement restarted. The flow of concrete shall be continuous until the work is completed. The discharge end of the tremie shall always be located a minimum of 5' below the level of the already placed concrete. As concrete is placed in the excavation, the slurry shall be collected and properly disposed of as approved by the Department's Project Manager. The Design-Builder shall submit its plan for collection and disposal of slurry to the Department's Project Manager for approval.

The Design-Builder shall prepare and submit a concrete mix design as part of the *Installation Plan* requirements included in this specification. Prior to placement, the Design-Builder shall demonstrate that the mix is capable of maintaining a minimum slump of 4 inches throughout the anticipated concrete placement period. This verification shall include test results of both a trail mix and a slump loss test conducted by an approved testing laboratory using approved methods to demonstrate that the concrete meets this requirement. The trail mixes and slump loss tests shall be conducted using concrete and ambient temperatures appropriate for site conditions. Admixtures such as water reducers, plasticizers, and retarders shall only be used when conditions encountered on the job site during a concrete pour require an adjustment to the concrete mix in order to maintain the concrete in a workable plastic state throughout the entire placement period.

The tremie pipe shall be a minimum of 10" in diameter. Tremie pipes shall not have aluminum parts. Pump hoses shall be a minimum of 4" diameter. All tremie pipe or pump hoses and connections shall be watertight.

The concrete placing rate shall be at least 25 cubic yards of concrete per each one-hour period or greater to meet the required time limit for the mix design. The concrete mix shall be of such design that the concrete remains in workable plastic state throughout the placement of the concrete for the entire drilled shaft.

All concrete within the top 5 feet of the drilled shaft shall be vibrated except where soft soil or slurry remaining in the excavation will possibly mix with the concrete. After placement, any exposed surfaces of the shaft concrete shall be protected to allow proper curing.

Construction Records

The Design-Builder shall provide the following minimum record information. For each drilled shaft foundation installed, record on drilled shaft installation logs the location, alignment, dimensions, elevation of the top and bottom, depth of the bearing stratum penetration, description of the materials encountered at all elevations, elevation of the water table during excavation, condition of the bottom of the excavation, slurry test data, concrete data, verticality and deviation of shaft or reinforcing steel from the plan location, and other data called for on the report form or pertinent to the drilled shaft. Record the theoretical volume of excavation, volume of concrete placed versus depth, and total volume of concrete placed. Report observed irregularities to the Department's Project Manager immediately upon discovery.

The Design-Builder shall develop methods for recording and reporting appropriate record information for each drilled shaft. At a minimum, the record information shall be in accordance with FHWA "Drilled Shafts: Construction Procedures and Design Methods," FHWA-IF-99-025, the latest edition as of the issue date of this RFP or "Drilled Shaft Inspector's Manual, Second Edition, 2004," 2004 Drilled Shaft Committees of DFI: Deep Foundations Institute and ADSC: International Association of Foundation Drilling. A copy of the inspection report planned for use shall be submitted to the Department's Project Manager for review and written comment prior to drilled shaft work commencing. The Design-Builder shall provide the Department's Project Manager with completed shaft installation logs within 24 hours of completion of each shaft. Maintain daily records of slurry testing in accordance with section "Wet Construction Method" of this Special Provision. Submit records on a weekly basis, or more frequently if variation occurs.

Upon completion of all drilled shaft work, the Design-Builder shall provide a record of centerline of the drilled shaft locations based on the survey of the registered surveyor provided by the Design-Builder. In addition, any corrective measures shall be similarly surveyed and recorded as appropriate. A complete tabulation of all records pertaining to approved drilled shafts shall be delivered to the Department's Project Manager at the completion of all drilled shaft installation for this project. Record Drawings for drilled shafts shall be prepared and submitted to the Department in accordance with Part 2, DB Section 111 of the Contract Documents.

Integrity Testing

All completed drilled shaft foundations shall be tested with the nondestructive testing (NDT) method called "Crosshole Sonic Logging" (CSL) after at least five (5) days of curing time has elapsed to allow the concrete to harden sufficiently. The Department's Project Manager may require a longer minimum time if special retarders, mix designs, or other factors result in slower-setting concrete.

All CSL testing shall be completed by the Design-Builder within 45 calendar days of concrete

placement. The CSL tests shall be undertaken by an independent testing organization approved by the Department. The CSL testing organization shall meet the minimum *Qualifying Experience* requirements included in this specification.

The Design-Builder's Geotechnical Engineer shall evaluate and report on the test results. The Design-Builder shall be responsible for submitting to the Department's Project Manager test reports on any given shaft within 7 Calendar Days of the integrity tests performed on that shaft. Each test report shall include a narrative discussing the findings and any additional investigations or additional actions proposed. The report shall be reviewed and approved by the Construction QC Manager prior to submission to the Department. The Department's Project Manager will notify the Design-Builder within 15 Calendar Days of receipt of the test report as to whether any additional investigation for integrity verification is requested by the Department.

1. Description. The CSL test measures the time it takes for an ultrasonic pulse to travel from a signal source in one access pipe to a receiver in another access pipe. In uniform, good quality concrete, the travel time between equidistant pipes will be relatively constant and correspond to a reasonable concrete pulse velocity from the bottom to the top of the foundation. In uniform, good quality concrete, the CSL test will also produce records with good signal amplitude and energy. Longer travel times and lower amplitude/energy signals indicate the presence of irregularities such as poor quality concrete, voids and soil intrusions. The signal will be completely lost by the receiver and CSL recording system for the more severe defects such as voids and soil intrusions.

2. Test Equipment. The CSL equipment consists of the following components:

    a. A microprocessor based CSL system for display of individual CSL records, analog-digital conversion and recording of CSL data, analysis of receiver responses and printing of CSL logs.
    b. Ultrasonic source and receiver probes that shall fit into 2" inside diameter pipe.
    c. An ultrasonic voltage pulsar to excite the source with a synchronized triggering system to start the recording system.
    d. A depth measurement device to determine and record depths.
    e. Appropriate filter/amplification and cable systems for CSL testing.

3. CSL Logging Procedures. Information on the shaft bottom and top elevations and/or length, along with construction dates shall be provided by the Design-Builder to the testing organization before or at the time of the CSL tests. CSL tests shall be conducted between pairs of tubes, with the determination of which pairs will be tested being made by the independent testing agency. Typically, perimeter and/or major diagonal tube pairs are tested. Additional logs may be conducted in the event any anomalies are detected in the specified logs. The full depth of all pipes shall be used for conducting CSL tests unless approved otherwise by the Department's Project Manager. Should an access tube be blocked, the Department's Project Manager will determine what action should be taken in response.

    The CSL tests shall be performed in accordance with ASTM D 6760. Tests shall be carried out with the source and receiver probes in the same horizontal plane unless test results indicate potential anomalies/defects in which case the questionable zone may be further evaluated with angled tests (source and receiver vertically offset in the tubes). CSL measurements shall be made at depth intervals of 2.5" or less, and shall be performed from the bottom to the top of each shaft. The probes shall be pulled simultaneously, starting from the bottoms of the tubes. Any slack shall be removed from

the cables prior to pulling to provide for accurate depth measurements in the CSL records. Any anomalies/defects indicated by longer pulse arrival times and/or significantly lower amplitude/energy signals shall be reported to the Department's Project Manager on site and any further tests carried out as required to evaluate the extent of such anomalies/defects.

4. CSL Results. The CSL results shall be presented in a report. The test results shall be in accordance with ASTM D 6760 and shall include CSL logs with analyses of:

   a. Initial pulse arrival time or compression wave velocity versus depth.
   b. Pulse energy/amplitude versus depth.

   A CSL log shall be presented to the Department's Project Manager for each tube pair tested within 7 days of the test with anomaly/defect zones discussed in the report as appropriate.

5. CSL Test Locations. Non-destructive integrity testing by crosshole sonic logging shall be completed on each technique shaft, each load test shaft and on all production shafts.

6. Other NDT Methods. Other acceptable non-destructive testing (NDT) methods, which could be used in addition to CSL testing but not as a substitute, include Angled Crosshole Sonic Logging, Crosshole Tomography, Singlehole Sonic Logging, Gamma-Gamma Nuclear Density Logging, and/or Sonic Echo and Impulse Response tests.

7. Concrete Coring. If coring is to be used for verification, the proposed coring equipment, hole location and procedures shall be submitted to the Department for review and written comment prior to the coring process beginning. The coring method shall provide for complete core recovery and shall minimize abrasion and erosion of the core. The core hole shall be placed at a position in the shaft that will not produce damage to the reinforcing steel in the shaft. The core hole shall be logged, voids or defects indicated on the log, and the log submitted to the Department's Project Manager. Cores shall be stored on site and available to the Department for inspection.

8. Acceptance of Completed Drilled Shaft Foundations. The acceptance of each drilled shaft shall be at the sole discretion of the Department. At a minimum, the following requirements must be met by the Design-Builder on the construction of a drilled shaft in order for it to be considered acceptable.

   a. All construction and quality control shall be performed by and under the supervision of personnel meeting the qualifying experience requirements included in this Special Provision and approved by the Department prior to the work being performed.
   b. All submittals required by this Special Provision have been made by the Design-Builder at the time specified.
   c. All construction methods and materials used to perform the work are in conformance with this Special Provision and the requirements of the Contract.
   d. All permissible construction tolerances have been met.
   e. Required tip elevations have been achieved.
   f. All required integrity testing has been performed and all remedial repairs have been completed.
   g. The Construction QC manager has approved the completed drilled shaft.

   Rejection of a shaft shall not be solely based on NDT records and reports. The NDT

records are intended to identify areas in need of further investigation and verification of the structural integrity of the shafts by the Design-Builder. Should evidence be found through concrete coring, excavation around the shaft, or other means that conclusively shows a defect in the shaft exists, which will result in inadequate or unsafe performance under service loads, the shaft shall be rejected. The Design-Builder shall then submit to the Department a plan for remedial action including planned repairs to the rejected shaft and alterations to construction methods, if appropriate, to ensure proper construction of additional shafts.

Any modifications to the foundation shafts and load transfer mechanisms caused by the remedial action will require calculations and working drawings to be developed and reviewed in accordance with Part 2, DB Section 111 of the Contract Documents. Any modifications shall account for both geotechnical and structural adequacy of the proposed changes. All labor and materials required to perform remedial shaft action shall be provided at no cost to the Department and with no extension of the contract time.

Site Operations

The Design-Builder shall conduct its operations in a neat and orderly manner. Equipment and materials shall not be placed or stored beyond limits approved by the Department's Project Manager and shall promptly be removed when no longer needed. All materials, water, slurry, and auger cuttings shall be confined to the specified work area so as not to migrate from the specified work area.

Technique Shafts and Load Test Shafts

General Requirements

1. Technique Shaft. A drilled shaft shall be constructed using the same procedure, appropriately sized reinforcing steel cage and approved concrete to an equal depth and diameter of a typical production shaft required for the project. The Technique Shaft may be considered acceptable as a production drilled shaft if all acceptance criteria included in this Special Provision are satisfied. All required Technique Shafts shall be completed prior to the construction of the Load Test Shafts.

2. Load Test Shaft. A sacrificial drilled shaft shall be constructed using the same procedure, shaft diameter, and reinforcing steel as the deepest production shaft it is intended to represent. High early strength concrete may be used for the Load Test Shaft. The proposed concrete mix design for the Load Test Shaft shall be submitted to the Department for review and comment.

3. Locations. At a minimum, two (2) Technique Shafts and two (2) Load Test Shafts shall be constructed and tested (Note: Load testing required for Load Test Shafts only) prior to any production shaft construction. Precise locations shall be designated on the Design-Builder's Plans and shall be in accordance with the requirements of Part 3 – Performance Specifications, *Geotechnical Requirements*.

4. Technique Shaft construction shall be performed under the supervision of the Design-Builder's Geotechnical Engineer.

5. Load testing of Load Test Shafts shall be performed under the supervision of the Design-Builder's Geotechnical Engineer. Prior to the commencement of work, all test

procedures shall be submitted to the Department for review and written comment.

6. The Load Test Shaft shall be loaded as specified in section "Load Testing" but shall not exceed the nominal concrete resistance at the time of loading. The load shall be applied in increments of 5% of the nominal soil resistance specified on the Design-Builder's Plans, or as directed by the Department's Project Manager.

7. Five copies of the load test report shall be submitted directly to the Department's Project Manager.

Technique Shafts

Technique shafts and loading-testing of Load Test Shafts shall be completed before construction of any production drilled shafts. A minimum of two (2) Technique Shafts are required prior to Load Test Shaft construction work commencing. Locations of the Technique Shafts shall be clearly shown on the Design-Builder's Plans. The Technique Shafts shall be constructed to the same construction tolerances as production shafts. The Design-Builder shall include provisions to install longer Technique Shafts to allow for field adjustments during installation, if necessary. In the event the Department's Project Manager determines that the methods of installation of the Technique Shafts are not acceptable due to the presence of defects or the exceedance of construction tolerances, the Design-Builder shall submit to the Department's Project Manager for approval alternate construction methodology to correct installation methods prior to start of production work. Additional Technique Shafts required verifying acceptability of alternate construction methodologies shall be provided at no cost to the Department.

Load Test Shafts

Upon the successful completion of all Technique Shafts, the Design-Builder shall construct a minimum of two (2) sacrificial Load Test Shafts at the locations shown on the Design-Builder's Plans. The Design-Builder shall provide standard and other instrumentation and testing procedures required herein subject to the approval of the Department. The Design-Builder shall provide strain gages, dial gages, telltales, and an appropriate data acquisition system in accordance with the requirements specified in the following sections. Test loads shall be measured with a jack pressure gauge that has been calibrated within three months prior to the date of the load test. In addition, all measuring equipment shall be similarly calibrated. The Design-Builder shall submit to the Department for review and comment a load-testing plan that provides a summary of all instrumentation and techniques to be used for the load-testing. Load Test Shaft construction shall not commence prior to the Department's acceptance of the Technique Shafts and submission of the load-testing plan. The Design-Builder shall allow 15 Calendar Days after submitting results of any load test for the analysis of the load test data by the Department's Project Manager to determine its acceptability.

Loading tests shall include the following:

1. Install Load Test Shafts at non-production locations, as shown on the Design-Builder's plans, to assess installation, equipment, and length requirements.

2. The equipment and construction means and methods used to install the Technique Shafts shall be used for the installation of the Load Test Shafts and all production shafts. At a minimum, this equipment would include the drill rig, slurry mixing, de-sanding equipment and pump. The Design-Builder shall include provisions to install longer Load Test Shafts to allow for field adjustments during installation, if necessary.

3. The Design-Builder shall conduct one exploration borehole at each Technique, Load

Test, and Production Shaft location. Exploration boreholes will be completed in accordance with Part 4 - Special Provisions, *Soil Borings* and shall be in accordance with ASTM D 1586.

4. Exploration boreholes, Load Test Shaft installation, integrity testing and loading tests shall be completed in the presence of the Design-Builder's QC Manager. Complete integrity testing reports shall be provided to the Department's Project Manager at least 24 hours prior to loading tests. Loading tests shall not be performed until the concrete has reached the minimum design compressive strength as determined from concrete cylinders breaks.

5. Complete Osterberg cell (O-Cell) load tests shall be performed by the Design-Builder for each Load Test Shaft in accordance with section "O-Cell Load Test" of this provision.

O-Cell Load Test

This work shall consist of furnishing the required materials and labor necessary for conducting O-Cell load tests for each Load Test Shaft installed by the Design-Builder. The Design-Builder will be responsible for administering and monitoring the load test under the supervision of the Geotechnical Engineer. The drilled shaft(s) used for the load test program shall be instrumented as described herein or as otherwise approved by the Department. Instrumentation shall include strain gages or other appropriate means to distinguish the load transfer in the various bearing materials with no more than a 15' interval between measurement points. At least 30 Calendar Days in advance of the start of the Load Test Shaft installation, the Design-Builder shall submit to the Department's Project Manager for review and written comment a detailed plan prepared by the Specialty Subcontractor showing the intended instrumentation placement.

The Load Test Shafts shall each be installed in accordance with section "Construction Methods" of this Special Provision and reinforced as shown on the Design-Builder's Plans. The shaft shall be extended its full diameter to the test bearing elevation or as directed by the Design-Builder's Geotechnical Engineer.

Quality Assurance

The Design-Builder shall employ a testing firm that has successfully completed no less than five O-Cell load test projects in the past five years to perform the testing and report preparation. The qualifications of the testing firm shall be submitted to the Department's Project Manager for approval.

General Procedures

When the Technique Shaft excavation has been completed, inspected and approved by the Design-Builder's QC Manager, a thin seating layer of fluid concrete shall be placed in the base of the drilled shaft. The mix design for the concrete to be used and the placement methods shall be submitted to the Department as part of the *Installation Plan*. The Design-Builder shall then install the O-Cell assembly at the tip elevation of the Load Test Shaft (while the concrete is still fluid) so that the O-Cell assembly is resting firmly in the concrete. The Design-Builder shall use the utmost care in handling the placement/test equipment assembly so as not to damage the instrumentation during installation. The O-cell shall be mounted from a reinforcing cage that is identical to the reinforcing cage to be used in the production shafts.

After seating the O-Cell assembly, the drilled shaft shall be concreted in the manner specified for production of drilled shafts. The concrete strength for Load Test Shafts shall be the same as that used for

production shafts. At least six concrete compression test cylinders shall be molded from the concrete used in the test drilled shaft. At least one of these cylinders shall be tested prior to the load test and at least two cylinders shall be tested on the day of the load test. The O-Cell test shall not commence until the minimum concrete design compressive strength specified for production shafts on the Design-Builder's plans has been achieved.

If during the period required to perform the load test, the test apparatus shows any signs of negative effects due to construction activities, such construction activities shall cease immediately.

Materials:

The Design-Builder shall supply all materials and personnel required to install the O-Cell and other instrumentation. The Design-Builder shall be responsible for performing the tests, and coordinating with the Specialty Subcontractor who will supply the O-Cell to determine and/or verify all required equipment, materials quantities, procedures and other applicable items necessary to complete the O-Cell load testing are provided.

The O-Cells to be provided shall have a test capacity of at least 150% of the nominal resistance specified on the Design-Builder's Plans and shall be equipped with all necessary hydraulic lines, fittings, pressure source, pressure gauge, strain gauges, telltale devices and other equipment necessary to perform the load testing as specified herein.

Materials supplied by the Design-Builder, which do not become a part of the finished test shafts become the responsibility of the Design-Builder at the conclusion of each load test and shall be removed from the job site.

Materials required include, but are not limited to, the following:

a. Osterberg Load Cells (O-Cells)
b. Piping and Supplies: Requirements for installation of each O-Cell
c. Fresh water from an approved source to mix with a water-soluble oil, to form the hydraulic fluid shall be used to pressure the O-Cell.
d. Materials sufficient to construct a protected work area with a minimum area of 25' by 25' (including provisions such as a tent or shed for protection from inclement weather or direct sunlight for the load test equipment and personnel).
e. Electric power, as required for lights, welding, instruments, etc.
f. Lighting as required.
g. Steel bearing plates, as required.
h. 25' of 2" structural steel angles.
i. Surveyors level and tripod. Level shall be checked for vertical tolerance using the peg method before field measurements are begun.

Instrumentation

The Design-Builder shall provide four to six pairs of vibrating wire strain gages (sister bars) and appropriate lengths of cable. All cable runs from each sister bar to the readout device shall be unspliced. Locate gages in pairs on opposite sides of the reinforcement cage. The actual locations are to be set by the Design-Builder's Geotechnical Engineer after determination of the actual tip elevation of the Load Test Shaft.

The Design-Builder shall supply a suitable strain gauge readout box(es) compatible with the vibrating wire strain gauges and capable of reading and recording at least 48 channels of data.

The Design-Builder shall supply two telltales for each test shaft, or as directed by the Design-Builder's Geotechnical Engineer. Telltale rods shall extend approximately 1' above the elevation of the working surface platform, to be established by the Design-Builder. Telltale casing shall be attached to the inside of test shaft rebar cage. A sufficient length of telltale rods shall be provided for the load tests. Undamaged telltale rods may be reused for other load tests.

Equipment and Personnel

The Design-Builder shall supply equipment and personnel required to assist the Specialty Subcontractor in installing the O-Cell and instrumentation, conducting the load tests, and removing the load test apparatus as required. Equipment/personnel required includes but is not limited to:

a. Furnishing the load test Specialty Subcontractor with personnel to assist with the assembly, welding, and placing of all O-Cell and to assist with the O-Cell load tests.
b. Welding equipment and certified welding personnel, as required, for assembling the test equipment, attaching pipes and fittings to the O-Cell, attaching O-Cell to reinforcement cages, and preparing the work area.
c. An acceptable pressurized gas source consisting of either an approved air compressor (150 cubic feet per minute capacity or greater) or compressed nitrogen (four 230 cubic foot filled cylinders of nitrogen per load test).
d. Equipment and operators for handling the O-Cell and piping, and test shaft reinforcing cages during the installation of the O-Cell and during the performance of the tests, including but not limited to a crane or other lifting device for the O-Cell and piping, manual labor, and hand tools as required by the load test Specialty Subcontractor.
e. Equipment and labor sufficient to erect the protected work area and monitoring reference beam system, to be constructed for each O-Cell load test.
f. Wood reference beams, supports, and dial gauges necessary to measure axial deflections.

Test Equipment Installation Procedure

The O-Cell piping and other instrumentation shall be assembled and made ready for installation under the direction of the Specialty Subcontractor, in a suitable area, adjacent to each test shaft. The following guidelines shall be followed:

a. Steel top and bottom bearing plates, as required, shall be welded to the O-Cell.
b. If steel bearing plates are used, the lower surface of the bottom bearing plate shall be coated with grease prior to installation into the shaft, to prevent concrete bonding with the bottom plate.
c. Attach the O-Cell (s) and plate assembly to the reinforcement cage or carrier bars. Install all instrumentation as indicated on the plans. All hydraulic hoses, telltale casings, slip joints, strain gauges, etc. shall be securely fastened to the rebar cage and/or the O-Cell prior to installation into the shaft. The top of any piping shall be protected to keep dirt, concrete, or other deleterious materials from entering the piping.
d. The Design-Builder shall limit the deflection of the reinforcing cage to 2' between pick points while lifting the cage from the horizontal position to vertical. A minimum of three pick points shall be used. Provide additional support, bracing, strong backs, etc. to maintain the deflection within the specified tolerance.
e. Place approximately 6" of fluid concrete into the bottom of the drilled shaft as a seating bed for the O-Cell immediately prior to placing the rebar cage. After placement of the rebar cage continue with concrete placement as described in section "Concrete Placement, Curing and Protection" of this Special Provision.

f. After the completion of each load test, and at the direction of the Department's Project Manager, the Design-Builder shall remove any equipment, material, waste, etc., that is not a part of the test shaft.

g. After testing is completed on all Load Test Shafts, the shafts shall be abandoned by cutting off the tops of the shafts so that they remain 3' below existing site grades. The abandoned shaft shall be covered with at least 3' of suitable fill and compacted to the satisfaction of the Department's Project Manager.

Load Testing

The Design-Builder shall apply the test loads and record the data from the instrumentation. The Design-Builder shall maintain the test area and support equipment and supply labor assistance as directed by the Specialty Subcontractor.

The load testing shall be performed in general compliance with ASTM D 1143. For each O-Cell load test, the load shall be placed on the shaft in increments equal to approximately five percent of the nominal resistance specified on the Design-Builder's Plans, until the failure criterion as indicated by the instruments is approached. The Geotechnical Engineer may elect to stop the loading increments when it is determined that the failure criterion has been met. Each subsequent load increment shall be applied immediately after a complete set of readings is recorded and verified from all gauges and instruments. Each increment of load shall be applied within the minimum length of time practical and the instrument system readings shall be taken immediately. It is intended that the addition of a load increment and the completion of the instrument system readings shall be completed within 5 to 10 minutes. The Department's Project Manager may elect to have the maximum applied load held for up to one hour.

Direct movement indicator measurements shall be made of the following:

a. Downward drilled shaft end-bearing movement (one indicator is required).

b. Upward top-of-drilled shaft movement (minimum of three indicators required).

c. The strain gauges shall be equally spaced at intervals of no more than 15 feet along the length of the test shaft and at the soil interfaces. The Design-Builder's Geotechnical Engineer shall be responsible for specifying strain gage locations.

d. After each load increment, or decrement, movement indicators shall be read at 1.0, 2.0 and 4.0 minute intervals while the load is held constant. Strain gauge readings shall be concurrent with shaft movement readings. Additional cycles of loading and unloading using similar procedures shall be performed, as required by the Geotechnical Engineer, following the completion of the initial test cycle.

Dial gauges, digital gauges or LVDTs used to measure end bearing, side shear movement and shaft compression shall have a minimum travel of 8" and be capable of being read to the nearest 0.025" division. End bearing movement may be alternately monitored using LVDTs capable of measuring the expansion of the O-Cell. The reference beam selected shall have a minimum length equal to six times the test drilled shaft diameter and shall be monitored for movement during load testing using a surveyor's level.

The load shall be removed in decrements of about 10% of the nominal resistance specified on the plans. Each decrement of load shall be removed within the minimum length of time practical and the instrument system readings shall be taken immediately. It is intended that the removal of a load decrement and the completion of the instrument system readings shall be completed within 5 to 10 minutes. The Department's Project Manager may also require up to two reloading cycles with five loading increments and three unloading decrements. The final recovery of the shaft shall be recorded for a period up to one hour after the last unload interval.

The criteria described herein shall be used to establish the failure load unless otherwise modified by the Design-Builder and approved by the Department's Project Manager prior to the start of the test. The failure load is defined as the sustained load at which continued shaft top or end bearing deflection occurs, or the load that causes a shaft top deflection equal to or greater than the calculated theoretical elastic compression of the test shaft plus 3.33% of the shaft diameter. The shaft top deflection and the associated load used to determine the failure load shall be obtained from the "Equivalent Top Load/Deflection Curves" generated from the O-Cell test data.

Report

The Specialty Subcontractor shall reduce and analyze the data collected during each load test and prepare a written report, which shall be submitted, to the Department's Project Manager within two weeks of the load test. Installation of the production shafts shall not begin until the Department's Project Manager approves the load testing report. The report shall include at least the following items:

a. Drawing showing the location of all instrumentation.
b. Plots of shaft tip movements vs. applied load.
c. Discussion of load distribution in the shaft with appropriate supporting graphs.
d. Equivalent Top Load/ Deflection Curves.
e. Printouts of strain, load, and deflection readout.

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http://www.fhwa.dot.gov/engineering/geotech/pubs/inspectforms/summary.pdf

619501 – PRODUCTION PILE RESTRIKES

Description:

This item shall consist of the Design-Builder furnishing all labor, equipment, and analysis required for production pile restrikes requested by the Department's Project Manager as part of the Department's Quality Assurance Program. The Design-Builder shall perform the Production Pile Restrikes requested by the Department in the same manner as the restrikes required as part of the Design-Builder's Quality Control Plan and monitoring. The Department may, at its sole discretion, choose to waive the Dynamic Pile Testing and monitoring requirements for Department-requested production pile restrikes.

The Design-Builder shall perform production pile restrikes on up to 2 or 5% (whichever is greater) of all production piles within each pile group, including previously designated test piles and/or monitoring piles. The purpose of the Department investigations shall be to further investigate or verify pile integrity, nominal bearing resistances gains/losses as part of the Department's Quality Assurance Program. Accordingly, the Department's Project Manager may require a longer waiting time than that specified by the Design-Builder.

The Department's Project Manager will attempt to promptly schedule any Department-ordered pile restrikes so as to avoid or minimize delays in driving operations.

Procedure:

Within two working days of production pile completion within a pile group designated on the Design-Builder's Plans, the Department's Project Manager may require production pile restrikes be performed within that group after the requested waiting time has elapsed. In no case, shall the Department, request a wait time of greater than 7 Calendar Days unless it can be accommodated without adversely impacting the Design-Builder's scheduled pile driving operations. The following procedures shall be followed by the Design-Builder:

1. The pile hammer used during initial driving must be used for the Restrike.
2. The hammer shall be warmed-up by striking another pile or pile cut-off at least 20 blows at full stroke.
3. The elevation of the top of pile shall be established prior to performing the restrike.
4. The hammer shall be carefully lowered and positioned on the pile. The hammer shall strike the pile 20 blows at the required stroke height.
5. The hammer shall be removed from the pile, and the new top of pile elevation shall be established.
6. After completion of the pile restrike, the Department will review the driving records and dynamic monitoring data, if applicable. The Design-Builder shall be notified immediately of any concerns raised as a result of the Production Pile Restrikes.

Method of Measurement/Basis of Payment:

All costs associated with the Design-Builder's work for this item, shall be borne solely by the Design-Builder, including any perceived mobilization costs, set-up costs, delay costs, etc. or actual labor, materials, and analysis costs. Accordingly, the Design-Builder's Lump Sum Price Proposal shall account for the full number of Department-requested Production Pile Restrikes whether they are used or not during the course of completing the Work.

619508 – QUICK PILE LOAD TEST

Description:

This work consists of furnishing all materials, equipment, tools, and labor necessary to perform a static axial compressive load test at approximate locations as shown on the Design-Builder's Plans in accordance with the applicable requirements of ASTM D 1143 and as modified herein. All Quick Pile Load Tests are to be completed prior to any production piles being driven.

The Design-Builder shall furnish and install the test pile for load testing, all necessary reaction piles, load test reaction frame components, measurement and load application devices. The Design-Builder shall prepare, review and submit drawings and calculations for this item in accordance with Part 2, DB Section 111, of the Contract Documents. The Design-Builder shall allow the Department at least 30 Calendar Days to review and provide written comment on the drawings and calculations. The Design-Builder shall allow additional time to address and/or resolve any issues prior to beginning work. The drawings shall show the method of performing the load tests, including complete details of equipment, reaction frames and measurement systems, etc. The drawings shall also include the load testing schedule to be followed during the test including load hold periods for each load step. The calculations shall include the design of the complete reaction system and calibration plots for all jacks and/or load cells to be used for the test. All drawings and calculations shall be signed and sealed by a Professional Engineer licensed in the State of Delaware.

Construction Methods:

The Design-Builder shall install a sacrificial test pile at each load test location specified on the Design-Builder's Plans. The load test pile shall be of the same type, materials, size (diameter) and length and shall be installed with the same pile driving equipment anticipated for production pile use. The ground elevation around the load test piles shall be prepared to match the proposed bottom of footing elevation for the foundation unit it is intended to represent. Adequate pile length shall be provided above ground to accommodate the static load testing. The installation of the load test pile shall be monitored in accordance with the *Dynamic Pile Testing* Special Provision.

The static load test and analysis of results shall be performed by experienced personnel having performed a minimum of five (5) similar tests within the past five (5) years. The Design-Builder shall submit resumes of the proposed static load testing personnel to the Department's Project Manager for approval at least 30 Calendar Days prior to conducting the static load tests.

The minimum test load shall be 150% of the nominal bearing resistance specified for the pile or as indicated on the Design-Builder's Plans. The test load shall be applied no sooner than 5 full Calendar Days after completion of the last restrike.

The apparatus for measuring movement shall be as described in ASTM D 1143 Section 4 except as modified herein. The test pile shall be monitored with three dial gauges spaced 120° around the pile reading to .0001" and two wire, mirror, and scale systems shall be suitably mounted on opposite sides of the pile as auxiliary monitoring devices. The reaction system shall also be monitored with wire, mirror, and scale systems or with direct reading scales visible to a surveyor's level or laser beam set up outside the immediate test area. All gauges and measuring devices shall be protected from the weather. Such protection shall include shelter from direct sunlight, wind, rain and snow. Alternative systems and methods of measurement may be submitted with the test frame drawings and calculations for review and approval by the Department.

The vertical loading procedure shall be in accordance with the applicable requirements of Section

5.6 of ASTM D 1143. Procedures for obtaining vertical measurements of vertical pile movements shall be as specified in Sections 6.1 and 6.4 of ASTM D 1143.

The Pile Load Test Report shall consist of time, load and displacement data all reduced and presented in appropriate tabular and graphical form. Also, the nominal bearing resistance of the piles shall be estimated using the criteria developed by Davisson (1975) and this information along with the time-settlement curves shall be included in the report. A report shall be prepared for each load test by qualified personnel of the Design-Builder and shall include interpretations of the results. The report shall be signed and sealed by a Delaware-licensed Professional Engineer. Three copies of the report shall be submitted to the Department's Project Manager for review and comment within 10 Calendar Days of the test being performed.

The Pile Load Test Report shall be utilized by the Design-Builder's Geotechnical Engineer in conjunction with the PDA Testing Report results to establish appropriate driving criteria and production pile lengths for the pile groups in accordance with the *Dynamic Pile Testing* Special Provision. The Geotechnical Engineer may revise driving criteria during the course of the Construction based on his evaluation of subsequent information. The Design-Builder shall not implement revised driving criteria until the Department's Project Manager has been properly notified of the proposed revisions at least 48 hours in advance of the implementation of such modifications.

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619518 - BITUMEN COATING ON PILES

Description:

This work shall consist of furnishing and all materials and labor required for applying bituminous coating and primer, and installing oversized steel driving collars to steel pipe pile surfaces as shown on the Plans and as described herein.

Submittals

The Contractor shall submit to the Engineer for review and approval a written Work Plan describing its planned methods for installing oversized steel driving collars and applying primer and bituminous coating to the steel pipe pile surfaces. This Work Plan shall also describe the Contractor's proposed methods of handling, storage, and driving of coated piles. This Work Plan shall be submitted to the Engineer at lease thirty days prior to the start of pile driving operations. No pile driving work shall be performed by the Contractor until the Engineer has approved of its work Plans as described herein.

Materials:

Bituminous Coating on Steel

Bituminous coating shall be a canal liner bitumen conforming to AASHTO M 239 (ASTM D 2521) and shall have a softening point of 190° F to 200° F., a penetration of 56 to 60 at 77° F., and a ductility in excess of 1.4" at 77° F.

Primer

Primer shall conform to the requirements of AASHTO M 116 (ASTM D 41).

Steel Driving Collars

Steel Driving Collars shall conform to the requirements for steel pipe piles as described in Special Provisions 608517 - Steel Pipe Piles, Abutment 4' Diameter.

Construction Requirements:

Install steel driving collars and apply bituminous coating and primer as shown on the Plans and as directed by the Engineer. All fabrication and welding of the steel driving collars required to attached them to the steel pipe piles shall be in accordance with the requirements for steel pipe pile fabrication as described in Special Provision 608517 - Steel Pipe Piles, Abutment 4' Diameter. All surfaces to be coated with bitumen shall be dry and thoroughly cleaned of dust and loose materials. No primer or bitumen shall be applied in wet weather, nor when the temperature and the temperature of the steel pipe pile is below 65° F.

If the Contractor wishes to apply the primer or Bitumen in temperatures below 65° F he shall provide a Work Plan to the engineer for approval to meet the temperature application requirement s as described herein.

Application of the prime coat shall be with a brush or other approved means and in a manner to thoroughly coat the surface of the piling with a continuous film of primer at the rate of one gallon per 100 sq.

ft. of surface. The primer shall be applied to the surfaces and to be dry to the touch before the bituminous coating is applied.

Bitumen coating on steel pipe piles shall be heated to 300° F and applied at a temperature between 200° F and 300° F by one or more mop coats, or other approved means, to apply an average coating depth of 3/16". White-washing of the coating may be required, as directed by the Engineer, to prevent running and sagging of the bituminous coating prior to driving during hot weather.

Bitumen coated steel pipe piles shall be stored immediately after the coating is applied for protection from sunlight and heat. Pile coatings shall not be exposed to damage or contamination during storage, hauling, or handling. The Contractor shall take appropriate measures to preserve and maintain the bitumen coating on the steel pipe piles during storage. Once the bitumen coating has been applied, the Contractor will not be allowed to drag the piles on the ground or to use cable wraps around the pile during handling. Pad eyes, or other suitable devices, shall be attached to the pile to be used for lifting and handling. If necessary, the Contractor shall recoat the piles, at its expense, to comply with these requirements.

The Contractor shall protect the bitumen coating during driving. This includes protection from being scraped off of the pile by the driving leads and protection from being scraped off of the pile by the dense granular soils within the embedded portion of the pile. The bitumen coating may be protected by both proper alignment in the driving leads, pre-augering through the dense granular material of Stratum 1, and the installation of oversized driving collars at regular intervals as shown on the plans.

A nominal length of pile shall be left uncoated where field splices will be required. After completing the field splice, the splice area shall be brush or mop coated with at least one coat of bitumen.

A nominal area of the pile shall be left uncoated where dynamic testing equipment is to be installed on the pile. After dynamic testing of the pile has been completed, including pile restrike testing, the uncoated area shall be brush or mop coated with at least on coat of bitumen.

~~**Method of Measurement:**~~

~~The quantity of Bitumen coating applied and accepted will be measured by the square foot.~~

~~**Basis of Payment:**~~

~~The quantity of Bitumen coating will be paid for at the Contract unit price per square foot. Price and payment will constitute full compensation for furnishing and placing all materials including, installation of the oversized driving collar, applying the bituminous coating and primer, protection of the coating, storage, handling and provisions for applying in temperatures below 65° F and for all labor, equipment, tools and incidentals required to complete the work.~~

623513 - PRESTRESSING

1.0 DESCRIPTION

The Design-Builder shall be responsible for designing, furnishing, fabricating, storing, installing, stressing and grouting of the prestressing system, including repair and/or replacement of damaged components (if necessary), for the bridge in accordance with the Contract requirements and the criteria established in this Special Provision during all phases of design and construction of the Project.

Complete prestressing system shall include any appurtenant items necessary for the particular prestressing system proposed by the Design-Builder, including but not limited to, anchorage assemblies, additional reinforcing bars required to resist stresses caused by anchorage assemblies, ducts, vents, inlets, outlets, grout used for pressure grouting ducts, and all permanent and incidental materials and labor to install the system in accordance with the Contract requirements.

The term "prestressing" globally includes both pre-tensioning and post-tensioning for structural concrete. The requirements of this Special Provision shall apply directly to post-tensioning systems.

2.0 DEFINITIONS

The following terms apply to prestressing:

A) Post-Tensioning: The application of a compressive force to the concrete by stressing tendons or bars after the concrete has been cast and cured. The force in the stressed tendons or bars is transferred to the concrete by means of anchorages.

B) Post-Tensioning Scheme or Layout: The pattern, size and locations of post-tensioning tendons provided by the Design-Builder on the Plans.

C) Post-Tensioning System: A proprietary system where the necessary hardware (anchorages, wedges, strands, bars, couplers, etc.) is supplied by a particular manufacturer or manufacturers of post-tensioning components.

D) Pre-Tensioning: The application of a compressive force to the concrete by stressing tendons before the concrete has been cast and cured. The force in the stressed tendons is transferred to the concrete by means of bond and friction along the length of the tendon. Corrosion protection of the ends of the tendons is accomplished by applying a coating of epoxy to the end of the concrete member.

E) Pre-Tensioning System: A proprietary system where the necessary hardware (anchorages, wedges, strands, etc.) is supplied by a particular manufacturer or manufacturers of pre-tensioning components.

F) Tendon: A single or group of prestressing elements and their anchorage assemblies, which impart prestress to a structural member or the ground. Also included are ducts, grouting attachments and grout. The main prestressing element is usually a high strength steel member made up of a number of strands, wires or bars.

G) Strand: An assembly of several high strength steel wires wound together. Strands usually have six outer wires wound in long pitch helix around a single straight wire of a similar diameter.

H) Wire: A single, small diameter, high strength steel member and, normally, the basic component of strand, although some proprietary post tensioning systems are made up of individual or groups of single wires.

I) Bar: Post-tensioning bars are high strength steel bars, normally available from 5/8 inch to 1-3/4 inch diameter and usually threaded with very coarse thread.

J) Coupler: The means by which the prestressing force may be transmitted from one partial length prestressing bar to another.

K) Anchorage: An assembly of various hardware components that secure a tendon/bar at its ends after it has been stressed and imparts the tendon/bar force into the concrete.

L) Anchor plate: that part of the anchorage hardware that bears directly on the concrete and through which the tendon/bar force is transmitted.

M) Wedge: A small conically shaped steel component placed around a strand to grip and secure it by wedge action in a tapered hole through a wedge plate.

N) Wedge Plate: A circular steel component of the anchorage containing a number of tapered holes through which the strands pass and are secured by conical wedges.

O) Set (Also Anchor Set or Wedge Set): Set is the total movement of a point on the strand just behind the anchoring wedges during load transfer from the jack to the permanent anchorages. Set movement is the sum of slippage of the wedges with respect to the anchorage head and the elastic deformation of the anchor components. For bars, set is the total movement of a point on the bar just behind the anchor nut at transfer and is the sum of slippage of the bar and the elastic deformation of the anchorage components.

P) Anticipated Set: Anticipated set is that set which was assumed to occur in the design calculation of the post-tensioning forces immediately after load transfer.

Q) Bleed: the autogenous flow of mixing water within or its emergence from newly placed grout; caused by the settlement of the solid materials within the mass.

R) Duct: material forming a conduit to accommodate post-tensioned tendon installation.

S) Initial Set of Grout: a degree of stiffening of the grout mixture less than the final set, indicating the time in hours and minutes required for the grout to stiffen sufficiently to resist to an established degree, the penetration of a weighted needle test.

T) Final Set of Grout: a degree of stiffening of the grout mixture greater than the initial set, indicating the time in hours and minutes required for the grout to stiffen sufficiently to resist to an established degree, the penetration of a weighted needle test.

U) Fluidity: A measure of time, expressed in seconds, necessary for a stated quantity of grout to pass through the orifice of the flow cone.

V) Grout: a mixture of cementitious materials and water, with or without mineral additives or admixtures, proportioned to produce a pumpable consistency without segregation of the constituents; injected into the duct to fill the space throughout the prestressing steel, anchorages and ducts.

W) Inlet (also inlet pipe or grout injection port): small diameter tubing or duct used for injection of grout into a duct.

X) Outlet (also ejection pipe or grout outlet vent or vent): a small diameter tubing or duct used to allow the escape of air, water, grout and bleed water.

Y) Thixotropic: the property of a material that enables it to stiffen in a short time while at rest, but to acquire a lower viscosity when mechanically agitated, the process being reversible. Grouts having thixotropic properties can be highly resistant to bleed. Admixtures that may produce thixotropic properties include anti-bleed admixtures and silica fume.

3.0 SHOP DRAWINGS

The Design-Builder shall submit to the Department for review and comment detailed shop drawings that include, but are not limited to:

A) A complete description of, and details covering, each of the prestressing systems (temporary and permanent) to be used for tendons and/or bars. This shall include:

1) Designation of the specific prestressing steel, anchorage devices, bar couplers, duct material and accessory items.
2) Properties of each of the components of the prestressing system.
3) Details covering assembly of each type of prestressing tendon or bar.
4) Equipment to be used in the prestressing sequence.
5) Procedure and sequence of operations for prestressing and securing tendons and/or bars.
6) Procedure for releasing the prestressing steel elements.
7) Parameters to be used to calculate the typical tendon/bar force such as: expected friction coefficients, anchor set and prestress steel relaxation curves.

B) A table detailing the prestressing jacking sequence, jacking forces and initial elongations of each tendon at each stage of erection for all prestressing.

C) Complete details of the anchorage system for prestressing including certified copies of the reports covering tests performed on prestress anchorage devices as required in the Materials Section, and details for any reinforcing steel needed due to stresses imposed in the concrete by anchorage plates.

D) For the operation of grouting prestressing tendons/bars: the materials and proportions for grout, details of equipment for mixing and placing grout and methods of mixing and placing grout; also, locations and details of inlets and outlets for grouting and the direction of grouting.

E) Calculations to substantiate the prestressing system and procedures to be used including stress-strain curves typical of the prestressing steel to be furnished, required jacking forces, elongation of tendons during tensioning, seating losses, short-term prestress losses, long-term prestress losses, temporary overstress, stresses in prestress anchorages including distribution plates and reinforcing steel needed in the concrete to resist stresses imposed by prestress anchorages. These calculations shall show a typical tendon force after applying the expected friction coefficient, anticipated thermal affects and anticipated losses for the stressing system to be used including anchor set losses.

F) Elongation calculations shall be revised when necessary to properly reflect the modulus of elasticity of the wire or strand as determined from in place friction testing in accordance with the Materials Section.

G) Complete details of the apparatus and method to be used by the Design-Builder for the testing required by the Materials Section.

4.0 MATERIALS

All materials to be incorporated into the prestressing system shall be in accordance with the requirements set out herein.

4.1 PRESTRESSING STEEL

A) Strand: Strand shall be uncoated, Grade 270 low relaxation 7 wire strand conforming to requirements of ASTM A 416.

B) Thread Bar: Prestress bars shall be uncoated, Grade 150 high strength deformed thread bars conforming to the requirements of ASTM A 722, Type II.

C) Wires: Wire shall be uncoated, low relaxation wire conforming to the requirements of ASTM A 421.

4.2 THREAD-BAR COUPLERS

Thread bar couplers shall meet the requirements of ASTM A 722. Bar couplers shall be used only at locations approved by the Department. A bar coupler shall develop the required ultimate strength of the bar with a minimum elongation of two percent when tested in the unbonded condition measured in 10 foot gauge lengths, without failure of the coupler or the thread bar.

Testing of couplers shall be performed using samples of the prestressing bar to be used on the Project. The test specimen shall be assembled in an unbonded state and, in testing, the anticipated set shall not be exceeded.

Only threaded type couplers shall be used with post-tensioning thread bars. Post-tensioning thread bars shall be threaded into 1/2 the length of the coupler + 1/4 inch so that when two bars are mated in a coupler, the length of each bar positively engaged in the coupler shall be half the coupler's length within the acceptable tolerances. No coupling or splicing will be permitted with strands.

4.3 PRESTRESS ANCHORAGES

All prestressing steel shall be secured at the ends by means of permanent type anchoring devices. Prestress anchorages shall develop at least 95 percent of the minimum specified ultimate tensile strength of the prestressing steel. Wedges shall be three-part (Two part wedges shall not be used).

Testing of anchorage devices shall be performed using samples representing the type of prestressing steel and concrete strength to be used on the Project. The test specimen shall be assembled in an unbonded state and, in testing, the anticipated anchor set shall not be exceeded. Certified copies of test results for the anchorage system shall be supplied to the Department. The anchorage system shall be so arranged that the prestressing force in the tendon may be verified prior to the removal of the stressing equipment.

For tendon anchorages, the design and furnishing of any local zone reinforcement which is needed to resist bursting and splitting stresses imposed on the concrete by the proposed anchorage system shall be the responsibility of the Design-Builder.

Prestress anchorage devices shall effectively distribute prestressing loads to the concrete and shall conform to the following requirements:

A) The bearing stress in the concrete created by the anchorage plates shall comply with "AASHTO LRFD Bridge Design Specifications."

B) Bending stresses in the plates or assemblies induced by the pull of the prestressing steel shall not exceed the yield point of the material in the anchorage plate when 95 percent of the ultimate strength of the tendon is applied. Nor shall it cause visual distortion of the anchor plate as determined by the Department.

4.4 DUCTS

All duct material shall be sufficiently rigid to withstand loads imposed during placing of concrete and internal pressure during grouting while maintaining its shape, remaining in proper alignment and remaining watertight.

The duct system, including splices and joints shall effectively prevent entrance of cement paste or water

into the system and shall effectively contain pressurized grout during grouting of the tendon. The duct system shall also be capable of withstanding water pressure during flushing of a duct in the event the grouting operation is aborted.

The interior diameter of ducts for single strand, bar or wire tendons shall be at least ¼ inch greater than the nominal diameter of the tendon. The interior diameter of ducts for tendons consisting of more than one strand, bar or wire shall be such that the interior area of the empty duct is not less than 2.25 times the net area of the prestressing steel.

4.4.1 Duct Type Designation

A) Type A: Galvanized Rigid Steel Pipe (Sch 40)

B) Type B: Galvanized Rigid Steel Pipe (Sch 10)

C) Type C: Corrugated Plastic

D) Type D: Smooth Plastic

Specific Duct Applications			
Number of Strands in Tendon		Tendon Radius (R) ft.	Duct Type Material
0.5 inch dia.	0.6 inch dia.		
---	4 (Transverse Flat Duct)	10 or more	C
1 to 13	1 to 8 (Round Duct)	30 or more 10* to 30 2 to 10	A, B, C A A
14 to 18	9 to 13	30 or more 12* to 30 2.5 to 12	A, B, C A A
19 to 32	14 to 37	50 or more 25* to 50 3 to 25	A, B, C A A
* - This radius is the minimum radius allowed for a tendon unless otherwise approved by the Department based upon test data.			

4.4.2 Duct Type Designation Notes:

A) Type D duct material shall only be used for those portions of a tendon not embedded in concrete. External ducts shall be Type D.

B) Type A duct material shall be used throughout the entire length of the particular element where an external tendon is embedded in a deviation block, beam or diaphragm.

C) Type A duct material which is embedded shall be bent to a uniform radius along a curve extending between tangent points located 3 inch inward from the face of the deviation block, beam or diaphragm.

D) Type A or B duct material shall be used in all areas classified as mass concrete. Grout vents and inlets shall consist of galvanized rigid steel pipe (Sch 40) with watertight connections.

E) Type B duct material shall be used for portions of tendons embedded in mass concrete

elements not required to be Type A duct material due to their tendon radius

F) Type C duct material shall be used in environments designated as aggressive exposure.

4.4.3 Specific Material Properties of Ducts and Attachments

A) Type A Galvanized Rigid Steel Pipe (Sch 40). Steel pipe duct shall be galvanized steel pipe conforming to the requirements of ASTM A 53, Type 3, Grade B. The nominal wall thickness of the pipe shall not be less than that of Schedule 40. The pipe shall be bent so as to accurately conform to the alignment of the tendon taking into consideration the minimum bending radius shown in the contract plans or shop drawings.

B) Type B Galvanized Rigid Steel Pipe (Sch 10). Steel pipe duct shall be galvanized steel pipe conforming to the requirements of ASTM A 53, Type 3, Grade B. The nominal wall thickness of the pipe shall not be less than that of Schedule 10. The pipe shall be bent so as to accurately conform to the alignment of the tendon taking into consideration the minimum bending radius shown in the contract plans or shop drawings.

C) Type C Corrugated Plastic (HDPE or HDPP). Plastic duct shall be made of either high-density polyethylene (HDPE) or high-density polypropylene (HDPP). HDPE shall conform to ASTM D 3350 02a, cell classification range 424432C to 335534C. HDPP shall conform to ASTM D 4101, cell classification range PP210B43542 to PP210B65542.

1) Plastic duct shall be corrugated with a pitch not less than 1/10 of the radius of the duct. Material thickness shall be 0.08 inch as manufactured, and 0.06 inch after tensioning.

2) Corrugated plastic duct shall be designed so that a force equal to 40 percent of the ultimate tensile strength of the tendon will be transferred through the duct into the surrounding concrete in a length of 2.5'. Twelve static pull out tests shall be conducted to determine compliance of a duct with the force transfer requirement. If ten (10) of these tests exceed the specified force transfer, the duct is acceptable. The Design-Builder shall provide to the Department certified test reports verifying that the duct meets specification requirements in regard to force transfer.

3) To satisfy the intent of these tests, the results for static pull out tests from previous Projects utilizing identical duct and prestressing steel with similar concrete and grout material may be submitted to the Department in lieu of executing new pull out tests. However, if the previous results are unacceptable or if there is a significant difference in the materials used, then the Design-Builder shall provide results from new tests for this Project.

D) Type D Smooth Plastic for External Tendons. Ducts for external tendons inside box girders shall be black, smooth, high density polyethylene pipe (HDPE) with a minimum wall thickness of Do/18, where Do denotes outside diameter with a minimum Hydrostatic Design Basis (HDB) of 1,250 psi conforming to one of the following designations:

1) ASTM D 2239 or ASTM D 3035, cell classification PE345433C

2) ASTM F 714, cell classification PE 345433C

3) ASTM D 2447, grade P33 or P34

E) Inlets and Outlets (Ports or Vents) for Grout. Inlets (Grout Injection Ports) shall be provided for injecting grout into the duct. Outlets (Grout Exit Vents) shall allow the escape of air, water, grout and bleed water. The inner diameter of inlets and outlets shall be at least 3/4 inch for strand tendons and 3/8 inch for single bar tendons. Inlets and outlets shall be of flexible, HDPE or HDPP pipe (except as noted below for inlets and

outlets in mass concrete). Plastic components, if selected, shall not react with concrete or enhance corrosion of the post-tensioning steel, and shall be free of water soluble chlorides. Inlets and outlets shall be located and attached in accordance with Construction Methods Section "Installation of Ducts, Grout Injection Ports and Outlet Vents" below. Inlets and outlets placed in mass concrete elements shall be Schedule 10 Rigid Steel Pipe (galvanized).

4.4.4 Minimum Radius of Curvature

Tendon ducts shall preferably be installed with a radius of curvature of 20' or more. Ducts with sharper curvature down to a minimum of 10' shall have confinement reinforcement detailed to tie the duct into the concrete. Duct curvature with radii less than 10' may be approved by the Department based on review of test data. The minimum radius for corrugated polyethylene duct shall be 30'. The confinement reinforcement shall be proportioned in accordance with "AASHTO LRFD Bridge Design Specification."

4.5 GROUT

Grout for tendons shall consist of Portland Cement, potable water, mineral admixtures for partial cement replacement and other specified admixtures which impart low water content, flow, fluidity, minimum bleeding, non-shrink and, when necessary, set retarding properties to the grout. Also, when specified, the grout shall have enhanced corrosion resisting properties such as increased resistance to chloride penetration. There shall be no deliberate addition of materials containing chlorides.

Commercial, prepackaged, cement based grout mixtures, meeting the requirements of this Special Provision, may be used subject to approval by the Department.

4.5.1 Classification of Grouts

Two classifications of grouts are used in this specification to reflect different requirements depending on exposure conditions. Exposures conditions shall be determined by the Design-Builder and noted in the Plans for review and comment by the Department.

4.5.1.1 Normal Grout

Normal Grout is to be used only in non-aggressive exposure conditions. The primary constituents of Normal Grout are cement and water. Chemical admixtures may be required, but mineral admixtures such as silica fume and fly ash would not normally be compulsory to meet the performance criteria for Normal Grout. In general, Normal Grout will not have thixotropic properties.

4.5.1.2 Enhanced Grout

Enhanced Grout is to be used in all aggressive exposure conditions or as otherwise required for this Project. Enhanced Grout will normally contain both mineral admixtures for partial cement replacement and chemical admixtures to provide improved corrosion protection and resistance to bleed. Enhanced Grout may or may not have thixotropic properties, depending on the admixtures used.

4.5.2 Grout Ingredients

Both Normal Grout and Enhanced Grout may be in the form of commercial, prepackaged, cement based grout mixtures, meeting the requirements of this Specification, and subject to approval by the Department.

4.5.2.1 Cement

Portland Cement shall conform to requirements of AASHTO M 85 Type I or Type II. The cement shall be fresh and not contain lumps or other indication of hydration or "pack set". The Design-Builder shall furnish the Department, for each shipment of cement, a manufacturer's report stating results of tests made on samples of the material taken during production or transfer and certifying compliance with the applicable requirements of AASHTO M 85.

4.5.2.2 Cement Replacement for Enhanced Grout

The following cementitious materials may be used for cement replacement in order to enhance the corrosion resisting and durability characteristics of grout used for aggressive environments.

A) Silica Fume: 5 to 15% replacement by weight of Portland Cement

B) Fly Ash (Class C): 0 to 35% replacement by weight of Portland Cement.

C) Fly Ash (Class F): 0 to 25% replacement by weight of Portland Cement.

D) Slag: 0 to 55% replacement by weight of Portland Cement.

The water content shall be calculated for the total weight of cementitious material (cement + replacement material) and expressed as water/cementitious ratio.

4.5.2.3 Water

Water shall be potable, clean and free of injurious quantities or substances (chlorides, sulfides, sulfates and nitrates) known to be harmful to Portland Cement or prestressing steel.

Water shall have chloride, sulfide, sulfate, and nitrate contents not greater than 20, 100, 15 and 13 ppm respectively.

Water used for grouting tendons shall be tested for the chemicals noted above at regular intervals not to exceed 120 days. Water shall be tested at the location where the water is placed into containers for the Project. If the water is stored in containers, which might contaminate it (e.g. unlined metal tanks) then the Department can request that tests be performed on water coming from the storage tanks.

4.5.2.4 Admixtures

Admixtures shall consist of chemicals that impart the following properties when incorporated into the grout mixture. These properties are low water content, good flow, fluidity, minimum bleeding (sedimentation of cement), expansion or non-shrink and, when necessary, increase in setting time. Any admixture containing chlorides, sulfites, fluorides or nitrates shall not be used in the grout. The date of manufacture and shelf life shall be clearly stamped on each container. No admixture shall be used for which the shelf life recommended by the manufacturer has expired.

4.5.2.5 Non-Shrink Properties and Expansion Agents

Grout shall have non-shrink properties. However, gas evolving expansion agents and/or additives containing free aluminum, shall not be used.

4.5.2.6 Corrosion Inhibitors

Corrosion inhibiting chemical admixtures shall not be used.

4.5.2.7 Chloride Ion Content

All constituent materials shall be such that the acid soluble chloride ion content of the grout shall not exceed 0.08% by weight of Portland Cement as measured by ASTM C 1152 "Standard Test Method for Acid Soluble Chloride in Mortar and Concrete."

4.5.3 Grout Properties

The Design-Builder shall determine the exact material proportions and admixture requirements to meet the requirements of the Section. Laboratory trial batches of the proposed grout mix shall be prepared using the same materials to be used on the job site. Trial batches shall be subjected to the tests described in this Section at a Laboratory approved by the Department to demonstrate that the proposed grout mix meets the requirements of this Specification. Testing shall be performed by personnel experienced in testing of grouts, and under temperature and humidity conditions expected at the site.

Laboratory testing requirements may be waived at the discretion of the Department if:

A) The Design-Builder proposes to use a commercial prepackaged grout that has previously met the requirements of this Specification as independently certified by a Laboratory approved by the Department; or

B) The results of earlier tests (not exceeding 12 months) on grouts with the same design, same material sources and same procedures are satisfactory and within the requirements of this Specification.

Prior to beginning grouting operations, the Design-Builder shall furnish the Department with a report detailing the results of all laboratory testing, including the types and number of tests performed, test procedures, results and comparison of results with specified values.

In order to qualify, Normal Grout shall have the physical properties listed in Table 1 when mixed, prepared and tested in a Laboratory approved by the Department.

In order to qualify, Enhanced Grout shall have the physical properties listed in Table 1 and Table 2 when mixed, prepared and tested in a Laboratory approved by the Department.

Table 1 – Physical Property Requirements for Normal Grout and Enhanced Grout

Physical Property	Requirement	Test Method
Water-Cementitious Material Ratio	Maximum 0.45	n/a
Setting Time	Minimum 3 hours Maximum 12 hours	ASTM C 953
Grout Cube Strength	Min. 3,000 psi at 7 days Min. 5,000 psi at 28 days	ASTM C 942
Pumpability and Fluidity for Non-Thixotropic Grouts (Flow Cone Efflux Time)	Immediately after mixing: Min. 20 sec., Max. 30 sec. After letting stand for 30 min. and remixing for 30 sec.: Max. 30 sec.	ASTM C 939
Control of Bleed (Wick Induced Bleed Test)	Max. 0% bleed after 3 hours	ASTM C 940, Modified *

* - The modified version of ASTM C 940 is described in the PTI "Guide Specification for Grouting of Post Tensioned Structures."

Table 2 – Additional Physical Property Requirements for Enhanced Grout

Physical Property	Requirement	Test Method
Permeability	2, 500 (max.) Coulombs after 6 hours **	ASTM C 1202 **

Table 2 – Additional Physical Property Requirements for Enhanced Grout		
Physical Property	Requirement	Test Method
Volume Change	Vertical height change of cylinder: 0.0% to 0.1% at 24 hours Less than 0.2% at 28 days	ASTM C 1090
Pumpability and Fluidity for Thixotropic Grouts (Modified Flow Cone Efflux Time for 1 liter discharge***)	Immediately after mixing: Min. 9 sec., Max. 20 sec. After letting stand for 30 min. and remixing for 30 sec.: Max. 30 sec.	ASTM C 939 ***
Control of Bleed	See Table 2A****	Pressure Bleed Test****

** - When evaluating grouts, the ASTM C 1202 procedure shall be modified to perform the test at 30 volts rather than 60 volts. Testing shall be performed on grout samples at 28 days of age. For grouts containing pozzolanic mineral admixtures, testing may be performed on grout samples at 90 days of age.

*** - Grouts containing anti-bleed admixtures or silica fume may have thixotropic characteristics. For Enhanced Grouts with thixotropic properties, the modified flow cone efflux time shall be measured, and the pumpability and fluidity requirements of Table 2 shall supercede those of Table 1. The modified version of C939 involves filling the flow cone to the top instead of the standard level, and the efflux time is measured as the time to fill a 1-liter container placed directly under the flow cone. If an Enhanced Grout does not have thixotropic properties, the pumpability and fluidity requirements of Table 1 shall apply.

**** - The Pressure Bleed Test using Gelman Filter Funnel is described in the PTI Guide Specification, "Grouting of Post-Tensioned Structures," the latest edition with Revisions as of the issue date of this RFP. The pressure to be used during the test is a function of the maximum expected vertical rise in the tendon under consideration, as indicated in Table 2A.

Table 2A – Bleed Under Pressure Limits for Enhanced Grouts		
Maximum. Vertical Rise Along Tendon, x	Gelman Pressure	Bleed After 10 min. (% of sample volume)
0 ft ≤ x ≤ 2 ft	20 psi	4%
2 ft < x ≤ 6 ft	30 psi	2%
6 ft < x < 100 ft	50 psi	0%

5.0 SAMPLING AND TESTING

5.1 PRESTRESSING ELEMENTS

All testing shall be done in accordance with ASTM Specifications. The following samples of materials and devices selected at locations designated by the Department shall be furnished by the Design-Builder at his expense:

A) Three samples of 7' long prestressing wire or bar for each size from each heat number or production lot.

B) Three samples of 5' long prestressing strand for each size from each heat number or production Lot.

C) If bar couplers are to be used, three samples with two specimens each consisting of 4' lengths of the specific prestressing bar coupled with a bar coupler from the materials to be used on the Project.

D) One unit of each prestress anchorage to be used on the Project. For each type of duct material intended for the Project, one sample, 4' long, from each production lot or per 10,000 linear feet, whichever is greater.

Samples shall be furnished at least 90 days in advance of the time they are to be incorporated into the work. The Department reserves the right to reject for use any material or device that is obviously defective or was damaged subsequent to testing.

5.1.1 Manufacturer's Lots (Design-Builder's Quality Control)

The manufacturer of prestressing steel, prestress anchorages and bar couplers shall assign an individual number to each Lot of strand, wire, bar or devices at the time of manufacture. Each reel, coil, bundle or package shipped to the Project shall be identified by tag or other acceptable means as to Manufacturer's Lot number. The Design-Builder shall be responsible for establishing and maintaining a procedure by which all prestressing materials and devices can be continuously identified with the manufacturer's Lot number. Items that at any time cannot be positively identified as to lot number shall not be incorporated into the work.

Low relaxation strand shall be clearly identified as required by ASTM A 416. Any strand not so identified will not be acceptable.

The Design-Builder shall furnish to the Department manufacturer's certified reports covering the tests required by this Specification. A certified test report stating the guaranteed minimum ultimate tensile, yield strength, elongation and composition shall be furnished to the Department for each lot of prestressing steel. When requested, typical stress-strain curves for prestressing steel shall be furnished. A certified test report stating strength when tested using the type prestressing steel to be used in the work shall be furnished to the Department for each Lot of prestress anchorage devices.

5.1.2 Testing of Prestressing Tendons by the Design-Builder

The Design-Builder shall perform certain testing of prestressing tendons as specified herein.

5.1.2.1 In Place Friction Test of Tendons

For the purpose of accurately determining the friction loss in stressing draped or sloped tendons, prior to stressing a draped tendon, the Design-Builder shall test, in place, a draped tendon selected by the Department. If deemed necessary by the Department to accurately establish friction loss, the Design-Builder shall perform tests on additional tendons selected by the Department. The test procedure shall consist of stressing a tendon at an anchor assembly with the dead end anchor incorporating a calibrated load cell. The results of the tests (loss due to friction and modulus of elasticity) shall be submitted to the Department. Apparatus and methods used to perform the tests shall be proposed by the Design-Builder and be subject to the approval of the Department. The Design-Builder shall notify the Department at least two weeks in advance of performing a friction test.

5.1.2.2 Dynamic Testing of Unbonded Tendons

Unbonded tendons are defined as tendons located essentially external to the concrete. For unbonded superstructure tendons, the Design-Builder shall perform two dynamic tests on a representative specimen and the tendon shall withstand, without failure, 500,000 cycles from 60 percent to 66 percent of its minimum specified ultimate strength. In the second test the tendon shall withstand without failure 50

cycles from 40 percent to 80 percent of its minimum specified ultimate strength. The period of each cycle involves the change from the lower to the upper stress level and back to the lower. The specimen used for the second dynamic test need not be the same used for the first dynamic test. Systems utilizing multiple strands, wires, or bars shall be tested utilizing a test tendon of full size. The Design-Builder shall notify the Department at least two weeks in advance of performing a dynamic test. In lieu of the dynamic testing, the Design-Builder may submit data from prior tests. Acceptance of data from prior tests is subject to the approval of the Department.

5.2 GROUT

Acceptance testing for grout physical properties shall conform to *PTI "Guide Specification for Grouting of Post Tensioned Structures"*, latest edition. Recommendations in PTI shall be interpreted as requirements for these specifications.

5.3 GROUT

Acceptance testing for grout physical properties shall be performed during grouting operations as provided below.

In order to qualify, Normal Grout shall have the physical properties listed in Table 3 when mixed, prepared and tested on site during grouting operations.

In order to qualify, Enhanced Grout shall have the physical properties listed in Table 4 when mixed, prepared and tested on site during grouting operations.

In order to qualify, Commercial Prepackaged Grout that has previously met the requirements of this Specification (see Materials Section "Grout Properties") as independently certified by a Laboratory approved by the Department, shall have the physical properties listed in Table 5 when mixed, prepared and tested on site during grouting operations.

For large Projects with extensive grouting requirements, the frequency of testing listed in Tables 3, 4 and 5 may be reduced at the discretion of the Department.

Table 3 – Acceptance Testing Requirements for Normal Grout

Physical Property	Frequency of Testing *	Requirement	Test Method
Grout Cube Strength	One strength test per 2 cubic yards of grout	Min. 3,000 psi at 7 days Min. 5,000 psi at 28 days	ASTM C 942
Pumpability and Fluidity (Flow Cone Efflux Time)	For each 2 cubic yards of grout or every 2 hours of grouting: One (1) test after mixing and before injection, One (1) test on grout collected at duct outlet	Immediately after mixing: Min. 20 sec, Max. 30 sec. After collection at duct outlet: Max. 30 sec.	ASTM C 939

- - Each test shall be performed at least once per grouting operation.

Table 4 – Acceptance Testing Requirements for Enhanced Grout			
Physical Property	Frequency of Testing *	Requirement	Test Method
Grout Cube Strength	One strength test per 2 cubic yards of grout	Min. 3,000 psi at 7 days Min. 5,000 psi at 28 days	ASTM C 942
Pumpability and Fluidity (Flow Cone Efflux Time)	For each 2 cubic yards of grout or every 2 hours of grouting: One (1) test after mixing and before injection, One (1) test on grout collected at duct outlet	Thixotropic Grouts** Modified Flow cone Efflux Time: 1) Immediately after mixing: Min. 9 sec., Max. 20 sec. 2) After collection at duct outlet: Max. 30 sec.	ASTM C 939
Volume Change (Vertical height change of cylinder)	One test per 2 cubic yards of grout	0.0% to 0.1% at 24 hours Less than 0.2% at 28 days	ASTM C 1090
Control of Bleed	One test per 2 cubic yards of grout, sample taken at mixer	See Table 2A***	Pressure Bleed Test ***

* - Each test shall be performed at least once per grouting operation.

** - Grouts containing anti-bleed admixtures or silica fume may have thixotropic characteristics. The modified version of ASTM C 939 involves filling the flow cone to the top instead of the standard level, and the efflux time is measured as the time to fill a 1-liter container placed directly under the flow cone.

*** - The Pressure Bleed Test using Gelman Filter Funnel is described in the PTI Grouting Specification (until the PTI document is published, Appendix B includes requirements for this test). The pressure to be used during the test is a function of the maximum expected vertical rise in the tendon under consideration, as indicated in Table 2A.

Table 5 – Acceptance Testing Requirements for Prepackaged Grout			
Physical Property	Frequency of Testing *	Requirement	Test Method
Pumpability and Fluidity (Flow Cone Efflux Time)	For each 2 cubic yards of grout or every 2 hours of grouting: One (1) test after mixing and before injection, One (1) test on grout collected at duct outlet	Non- Thixotropic Grouts Flow Cone Efflux Time: 1) Immediately after mixing: Min. 20 sec., Max. 30 sec. 2) After collection at duct outlet: Max. 30 sec. Thixotropic Grouts** Modified Flow Cone Efflux Time: 1) Immediately after mixing: Min. 9 sec., Max. 20 sec. 2) After collection at duct outlet: Max. 30 sec.	ASTM C 939 ASTM C 939, Modified

* - Each test shall be performed at least once per grouting operation.

** - Grouts containing anti-bleed admixtures or silica fume may have thixotropic characteristics. The modified version of ASTM C 939 involves filling the flow cone to the top instead of the standard level, and the efflux time is measured as the time to fill a 1-liter container placed directly under the flow cone.

6.0 CONSTRUCTION REQUIREMENTS

6.1 PROTECTION OF PRESTRESSING STEEL PRIOR TO INSTALLATION

Before installation of tendons in ducts, all prestressing steel shall be protected against physical damage at all times from manufacture to grouting or encasing in concrete. Prestressing steel that has sustained physical damage at any time shall be rejected. Any reel that is found to contain broken wires shall be rejected and the reel replaced.

Prestressing steel shall be packaged in containers or shipping forms for protection of the steel against physical damage and corrosion during shipping and storage. A corrosion inhibitor, which prevents rust or other results of corrosion, shall be placed in the package or form, or shall be incorporated in a corrosion inhibitor carrier type packaging material, or when permitted by the Department, a corrosion inhibitor may be applied directly to the steel. The corrosion inhibitor shall have no deleterious effect on the steel or concrete or bond strength of steel to concrete. Inhibitor carrier type packaging material shall conform to the provisions of Military Specifications MIL-P-3420. Packaging or forms damaged from any cause shall be immediately replaced or restored to original condition.

The prestressing steel shall be stored in a manner which will at all times prevent the packing material from becoming saturated with water and allow a free flow of air around the packages. If the useful life of the corrosion inhibitor in the package expires, it shall immediately be rejuvenated or replaced.

At the time the prestressing steel is installed in the work, it shall be free from loose rust, loose mill scale, dirt, paint, oil, grease or other deleterious material. Removal of tightly adhering rust or mill scale will not be required. Prestressing steel that has experienced rusting to the extent it exhibits pits visible to the naked eye shall not be used in the work.

The shipping package or form shall be clearly marked with the heat number and with a statement that the package contains high strength prestressing steel, and care is to be used in handling. The type and amount of corrosion inhibitor used, the date when placed, safety orders and instructions for use shall also be marked on the package or form.

6.2 PROTECTION OF PRESTRESSING STEEL DURING AND AFTER INSTALLATION

The prestressing steel shall be protected from corrosion and the duct system shall be sealed to prevent moisture intrusion from the time of tendon installation to the time of grouting, as provided below.

As discussed in Construction Methods Section 6.3, “Installation of Ducts, Grout Injection Ports and Outlet Vents”, the ends of ducts and anchorages and all duct connections shall be sealed at all times following installation in the forms to prevent entry of moisture and debris. In addition, all grout ports and vents shall be closed or plugged at all times during the period prior to grouting.

Grouting shall proceed as soon as possible after installation and stressing of the tendons. The time from installing the tendons in an unstressed condition to grouting after stressing shall not exceed the following without approval of the Department:

A) Very damp atmosphere (RH > 70%) or over salt water = 7 days

B) Moderate to dry atmosphere (RH < 70%) = 10 days

6.2.1 Tendon Protection Between Installation and Stressing

Measures shall be taken to protect the prestressing steel when there is a period of more than 24 hours

between installation of the tendons in ducts and stressing. Bare strand projecting out of the duct shall be wrapped continuously in plastic sheeting and sealed using waterproof tape. The plastic wrap shall extend to the tendon anchorage, and the anchorage opening shall be sealed with plastic and waterproof tape sufficient to prevent moisture intrusion. All grout ports and vents shall be closed or plugged, and all duct connections shall be sealed.

6.2.2 Tendon Protection During Staged or Segmental Construction

When plans provide for the tendons to be installed in one unit or segment, either longitudinally, transversely or vertically, with a length of bare strand left projecting for purposes of threading into another unit or segment during later erection operations, the provisions described in Construction Methods Section 6.1, "Protection of Prestressing Steel" shall apply. All of the prestressing steel shall be protected immediately after it is first installed in the first unit or segment until the tendon is grouted in the second unit or segment.

6.2.3 Tendon Protection Between Stressing and Grouting

Anchorages should be capped or otherwise sealed again immediately following stressing and cutting of strand tails.

In aggressive exposures where permanent end anchorage protection caps are to be used, the time period between stressing and installation of the permanent end caps shall not exceed 12 hours without approval of the Department.

In non-aggressive exposures, permanent grout caps may or may not be in use. If permanent grout caps are to be used, grout caps shall be installed within 48 hours of stressing. If permanent grout caps are not used, the end anchorage region of the tendon shall be sealed against moisture intrusion using plastic sheeting and waterproof tape within 48 hours of stressing.

In all cases, tendons and ducts shall be thoroughly blown dry with oil free compressed air immediately prior to sealing or capping of the anchorages. In addition, all grout ports and vents shall remain plugged, sealed or otherwise capped, and all duct connections shall be sealed.

6.2.4 Use of Temporary Corrosion Inhibitors

The time between the first installation of the post-tensioning steel in the duct and the completion of the stressing and grouting operations shall not exceed the time specified in Section 6.2 unless the use of a corrosion inhibitor is approved by the Department. The corrosion inhibitor shall not reduce the bond between the post-tensioning steel and the grout or the grout and the ducts, and the removal of the corrosion inhibitor shall not introduce remnant moisture into the ducts or annular spaces between the wires of the post-tensioning strand. Any light surface corrosion forming during this period will not be cause for rejection of the post-tensioning steel.

6.3 INSTALLATION OF DUCTS, GROUT INJECTION PORTS AND OUTLET VENTS

6.3.1 Ducts

Ducts shall be securely tied in position, carefully inspected and repaired before placing of the concrete is started. Care shall be exercised during placement of the concrete to avoid displacing or damaging the ducts. Internal ducts shall be supported at intervals necessary to prevent deflection and or displacement, not to exceed 4'. Any additional mild reinforcing required to support post-tensioning ducts shall be supplied by the Design-Builder. The tolerance on the location of the tendons shall be plus or minus 1/4 inch at any point. After installation in the forms, the ends of ducts shall at all times be sealed to prevent entry of water and debris.

6.3.2 Grout Inlets and Outlets

Pipes, as specified in the Construction Methods Section "Grouting", shall be installed on each duct to serve as injection or vent ports during grouting. These shall be at locations shown on the approved Shop

Drawings and in accordance with the following:

A) Inlets (Grout Injection Ports) shall be provided for injecting grout into the duct.

B) Outlets (Grout Exit Vents) shall allow the escape of air, water, grout and bleed water. The inner diameter of inlets and outlets shall be at least 3/4 in. for strand tendons and 3/8 in. for single bar tendons.

C) Inlets and Outlets shall be of flexible HDPE or HDPP pipe, except in mass concrete.

D) The length of an inlet port or outlet vent shall extend sufficiently out of the concrete to allow for proper closing. At all high points the outlet shall connect at the uppermost part of the duct profile.

E) Inlets and Outlets shall be placed at locations shown on the Shop Drawings, and on the Grouting Operation Plan (below).

1) At the top of each tendon anchorage and top of grout cap.

2) At each high point of the duct profile when the vertical distance between the highest and lowest point is more than 20 inch.

3) An outlet at each low point of the tendon.

4) An inlet at the lowest point of the tendon. Note judgment should be used in locating the lowest point. For example, if the absolute low point is in a deviation block for an external tendon, then place the inlet close to the block in the accessible portion of the duct.

5) At all low points the inlet/outlet shall be free draining.

6) At major changes in the cross section of the duct, such as couplers and anchorages.

7) At each side of couplers.

8) At a distance of approximately 3 ft. from each high point in the direction of grout flow.

9) For external tendons, provide vents as close to the inside face of the diaphragm as practical, located on the top of the duct.

10) At other locations recommended by the Department.

F) All connections to ducts shall be made with metallic or plastic structural fasteners. Waterproof tape shall also be used at all connections including vent and grouting pipes, except where otherwise specified herein. Vents shall be mortar tight, taped as necessary, and shall provide means for injection of grout through the vents and for sealing the vents by mechanical shut off valves.

G) All inlet and outlets shall be permanently sealed to prevent water infiltration to the grouted tendon. Sealing details are to be submitted for review and comment to the Department.

H) All grout injection and vent pipes shall be fitted with positive mechanical shut off valves. Vents and injection pipes shall be fitted with valves, caps or other devices capable of withstanding the pumping pressures.

I) Inlets and outlets will not be required for the Temporary Post-Tensioning Bars.

6.3.3 Standpipes for Vertical Tendons

For all vertical tendons, which have strands as the prestressing steel, a standpipe shall be provided at the upper end of the tendon to store bleed water and allow it to be reabsorbed by the grout. This device shall

be designed so that the level of the grout can be brought to an elevation which will assure that bleeding or subsidence will at no time cause the level of the grout to drop below the highest point of the upper anchorage device. It will also be designed so that as bleed water migrates to the top, grout is able to migrate downward to replace it. Provision shall be made to assure that bleed water rises into the standpipe, not into the uppermost part of the tendon and anchorage device.

6.3.4 Care and Protection of Ducts, Vents, Anchorages and Blockouts

Care shall be taken to ensure that all ducts, anchorages, blockouts, openings and vents are kept clean and free of debris, fuel, oils, other contaminants and site trash at all times prior to and after installing the tendons. Temporary plugs, seals and covers shall be used. Minor damage to ducts may be repaired by removing the local damage and splicing duct or couplers onto the intact section (prior to the placing of concrete). Repair of major duct damage requires the removal and replacement of the entire duct section.

Connections from grout hose to inlet and ejection ports and to vents shall be kept free from dirt and airtight.

6.3.5 Pre-Grouting Air Pressure Test of Duct System

Following assembly of the complete duct system, including installation of all ducts, grout inlets and outlets, couplers and connections, and immediately prior to placement of the prestressing tendon or after stressing of the tendon, an air pressure test shall be performed on each complete duct system.

The air pressure test shall involve pressurizing the complete duct system with dry, oil free air to 1.5 psi, and monitoring the pressure in the system for a period of 5 minutes. If the pressure loss during this 5 minute period exceeds 10%, all sources of leakage shall be identified, and measures shall be taken to reduce or eliminate the identified leaks, such that upon repeating the pressure test, the pressure loss is limited to less than 10% in 5 minutes.

The operation of each vent shall be tested by blowing dry, oil free air into the duct system and opening and closing each vent in turn.

6.4 POST-TENSIONING OPERATIONS, GENERAL REQUIREMENTS

6.4.1 Concrete Strength

Post-tensioning shall only be applied when the concrete has attained the required compressive strength as determined from test cylinders cured under the same conditions as the structural concrete. The design of the structure is based on the assumed friction and wobble coefficient shown in the plans.

6.4.2 Stressing Tendons

All post tensioning shall be tensioned by means of hydraulic jacks. Monostrand stressing shall not be used for tendons with 5 or more strands.

6.4.3 Maximum Stress at Jacking

The maximum temporary tensile stress at jacking in prestressing steel shall not exceed 80 percent of the specific minimum ultimate tensile strength of the prestressing steel. Tendons shall not be overstressed to achieve elongation.

6.4.4 Initial and Permanent Stress

The prestressing steel shall be anchored at initial stresses in a way that will result in the ultimate retention of permanent forces of not less than those shown on the Plans or the Approved Shop Drawings, but in no case shall the initial stress, after anchor set, exceed 70 percent of the specified minimum ultimate tensile strength of the prestressing steel.

Permanent force and permanent stress are the force and stress remaining in the prestressing steel after all losses, including creep and shrinkage of concrete, elastic shortening of concrete, relaxation of steel, thermal effect, losses in post-tensioned prestressing steel due to sequence of stressing friction and take-up

of anchorages, and all other losses peculiar to the method or system of prestressing have taken place or have been provided for in an approved stressing plan.

6.4.5 Excessive Friction

When friction must be reduced, water-soluble oil or graphite with no corrosive agent may be used as a lubricant subject to the approval of the Department. Lubricants shall be flushed from the duct as soon as possible after stressing is completed by use of water pressure. These ducts shall be flushed again just prior to the grouting operations. Each time the ducts are flushed, they shall be immediately and thoroughly blown dry with oil free air. The waste fluid flushed from the duct system shall be captured and disposed of properly.

6.5 POST-TENSIONING OPERATIONS, STRESSING REQUIREMENTS

6.5.1 Stressing Equipment

Each jack shall be equipped with a pressure gauge having an accurate reading dial at least 6 inch in diameter for determining the jack pressure.

6.5.2 Calibration

Prior to use for stressing on the Project, each jack and its gauge shall be calibrated as a unit. Initial calibration shall be done, using a proven load cell, at an independent testing laboratory, approved by the Department.

Calibration shall be done with the cylinder extension approximately in the position that it will be when applying the final jacking force and with the jacking assembly in an identical configuration to that which will be used at the job site (i.e. same length hydraulic lines). Certified calibration calculations and a calibration chart, both in English units of measure, shall be furnished to the Department for each jack and gauge unit.

Recalibration of each jack shall be done at six month intervals and at other times when requested by the Department. At the option of the Design-Builder, calibrations subsequent to the initial laboratory calibration may be accomplished by the use of a master gauge. The master gauge shall be calibrated at the same time as the initial calibration of the jacks, and shall be part of the unit for each jack. The data recorded during the initial calibrations shall be furnished to the Department for use in the field. The master gauge shall be supplied by the Design-Builder in a protective waterproof container capable of protecting the calibration of the master gauge during shipment. The Design-Builder shall provide a quick attach coupler next to the permanent gauge in the hydraulic lines which enables the quick and easy installation of the master gauge to verify the permanent gauge readings. The master gauge shall remain in the possession of the Department for the duration of the Project.

If a jack is repaired or modified, including replacing the seals or changing the length of the hydraulic lines, the jack shall be recalibrated by the approved testing laboratory.

6.6 STRESSING OF TENDONS

Post-tensioning forces shall not be applied until the concrete has attained the specified compressive strength as evidenced by tests on representative samples of the concrete. These samples shall be stored under the same conditions as the concrete in order to accurately represent the curing condition of the concrete in place.

The tensioning process shall be so conducted that tension being applied and the elongation of the post-tensioning steel may be measured at all times. A permanent record shall be kept of gauge pressures and elongations at all times and shall be submitted to the Department. The post-tensioning force may be verified as deemed necessary by the Department.

For all tendons, excluding post-tensioning bars with lengths less than 20', the tendon force measured by gauge pressure shall agree within seven percent of the theoretical elongation or the entire operation shall

be checked and the source of error determined and remedied to the satisfaction of the Department before proceeding with the work. Elongations shall be measured to the nearest 1/16 inch. In determining why the measured tendon force and the theoretical elongation do not agree within seven percent, the Design-Builder may elect to establish that the apparent modulus of elasticity of the post-tensioning steel varies from the value shown in the general notes to the plans by conducting a bench test on a full size tendon in accordance with a procedure acceptable to the Department. This test may be performed at a site remote from the Project provided that the Design-Builder pays the cost to the Department of sending a representative to witness the test. Equipment for tensioning the tendons must be furnished by the manufacturer of the system. Should agreement between pressure gauge readings and measured elongations fall outside the acceptable tolerances, the Department may require additional in-place friction tests in accordance with the Materials Section 5.1.2 "Testing of Prestressing Tendons by the Design-Builder".

The anchor force for all permanent post-tensioning bars with lengths less than 20' shall be verified with a lift off after initial stressing operations. The resulting lift off shall be within 5% of the expected final anchor force as specified in the plans.

Multi strand post-tensioning tendons having wires that have failed by breaking or slippage during stressing may be accepted providing that:

A) The completed structure must have a final post-tensioning force of at least 98% of the design total post-tensioning force at the affected sections.

B) At any stage of erection, the post-tensioning force across a mating surface must be at least 98% of the force required for that stage.

C) Any single tendon must have no more than 5% reduction in cross sectional area of the post-tensioned steel.

If these conditions cannot be met, then the affected tendon(s) shall be removed and replaced. Previously tensioned strands shall not be re-used. Any of these conditions may be waived by the Department when the Design-Builder is able to propose an acceptable means of restoring the post-tensioning force lost due to wire failure or slippage.

Post-tensioning bars used to apply temporary post-tensioning may be reused as temporary bars if they are undamaged.

Prestressing steel shall be cut by an abrasive saw within 3/4 inch to 1-1/2 inch away from the anchoring device.

6.7 GROUTING

6.7.1 GENERAL

After post-tensioning and anchoring of a tendon has been completed and accepted, the annular space between the prestressing steel and the duct shall be grouted in accordance with this Specification. The interval between post-tensioning and grouting shall be limited as specified in Construction Methods Section 6.2, "Protection of Prestressing Steel". Immediately after post-tensioning, all anchorages and duct connections of each tendon shall be temporarily sealed to prevent entrance of air and water until just prior to tendon grouting.

6.7.2 Grouting Operation Plan

At least six weeks before grouting commences, the Design-Builder shall submit to the Department for review and comment a "Grouting Operation Plan". A written response of this review from the Department is required before grouting occurs. Any adjustments to the plan as a result of trials or mock-ups shall be incorporated. Grouting operations shall be under the supervision of a qualified and experienced person, acceptable to the Department.

A) The Grouting Operation Plan shall address the following:

1) Names and experience of grouting crew and Supervisor.
2) Training to be provided or undertaken prior to operations.
3) Type and brand of equipment to be used, including capacity in relation to demand.
4) Working condition of equipment, back up and spare parts.
5) Types, brands and certifications of materials.
6) Identity of independent testing laboratory for certification of materials.
7) Production of grout fluidity, on site flow testing, adjustments and controls.
8) Estimate of grout required per tendon or group of tendons.
9) Method of controlling rate of flow and filling of ducts.
10) Locations, types and sizes of inlet and outlet vents.
11) Means of sealing and protecting tendons and ducts prior to grouting.
12) Grout mixing and pumping procedures.
13) Tendon or groups of tendons to be grouted in one operation.
14) Direction of grouting and sequence of using inlets and closing vents.
15) Procedures for handling blockages, including flushing of ducts.
16) Procedures for possible re-grouting to detect and fill voids.
17) Procedures for controlling w/c ratio and ensuring that the water used is acceptable.
18) Design-Builder's QC forms that are to be signed daily by Grout Supervisor.
19) Storage of Materials.

B) Before grouting operations commence, a joint meeting shall be held with the Design-Builder, Grouting Crew, the Department, and Engineering Inspection Team to discuss and understand the grouting operation plan, required testing and corrective procedures.

6.7.3 Grouting Personnel Qualifications

All grouting operations shall be carried out by workers trained for the tasks required, and having at least 3 years experience on previously successful Projects of similar type and magnitude.

Grouting shall be performed under the immediate control of a Grouting Supervisor skilled in the various aspects of grouting, and having experience on at least four previous and satisfactorily completed Projects of a similar size and scope. The Grouting Supervisor shall be named and shall furnish proof of certification and experience as required by the Department.

Grouting Supervisors shall have a current ASBI Certified Grouting Technician certificate and previous experience on satisfactorily completed Projects of a similar size and scope.

6.7.4 Equipment

Grouting equipment consists of measuring devices for water and admixtures, a mixer, a storage hopper, and a pump with all the necessary connecting hoses, valve, pressure gauges, and test equipment. Accessory equipment shall provide for accurate solid and liquid measures of all materials to be batched.

The equipment shall have sufficient capacity to ensure that the post-tensioning duct or group of ducts to be grouted can be filled and vented without interruption at the required rate of injection. Under normal conditions, the equipment shall be capable of continuously grouting the longest tendon (or group of tendons) on the Project in 30 minutes.

6.7.4.1 Mixer

The mixer shall be capable of continuous mechanical mixing. It shall produce a homogeneous and stable grout free of lumps and undispersed solids (cement or grout mix) and shall be able to deliver a continuous supply of grout to the pumping equipment. A colloidal mixer is preferred.

There shall be a gravity feed to the pump inlet from the mixer and/or hopper attached to and directly over it. An additional storage hopper may be incorporated between the mixer and the pump. It shall be fitted with an agitator to keep the grout moving continuously before it is pumped into the duct. The storage hopper shall be kept partially full at all times to prevent air from being drawn into the duct.

The grouting equipment shall contain a screen having clear openings of 1/8 inch maximum size to screen incompletely mixed lumps from the grout prior to its introduction into the grout pump or storage hopper. If the grout contains a thixotropic admixture, a screen opening of 3/16 inch will be satisfactory. The screen shall be located between the mixer and the pump, or when a storage hopper is used, between the mixer and the storage hopper. This screen shall be easily accessible for inspection and cleaning.

6.7.4.2 Injection Equipment

Grout pumps shall be capable of pumping the grout in a continuous operation with little variation of pressure and shall include a system for re-circulating grout when injection is not in progress. The equipment shall be capable of maintaining a pressure on completely grouted ducts and shall be fitted with a valve that can be locked off without loss of pressure in the duct. The use of compressed air for pumping grout shall not be allowed.

Grout pumps shall be a positive displacement type capable of producing an outlet pressure of not less than 145 psi and shall have seals adequate to prevent introduction of oil, air or other foreign substance into the grout and to prevent loss of grout or water.

A pressure gauge having a full-scale reading of no greater than 290 psi shall be placed at some point in the grout line between the pumping outlet and the duct inlet.

All piping to the pump shall have a minimum number of bends, valves and changes in diameter and shall incorporate a sampling tee. The diameter and rated pressure capacity of the hoses must be compatible with the pump output, the assumed maximum pressure and the length needed. Grout hoses shall be firmly connected to pump outlets, pipes and inlets of the duct.

6.7.4.3 Stand by Equipment

During grouting operations, provide adequate flushing equipment to facilitate complete removal of the grout in the event of a breakdown of the grouting equipment or other disruption before the grouting operation has been completed. This equipment shall be kept in working order. Where potable water is unavailable, a tank of sufficient water will be required meeting the same requirements for potable water.

6.7.4.4 Equipment for Thixotropic Grout

The following additional equipment shall be used. The grout equipment shall have two identical charging/holding tank units. Each unit alternates between duties either as a blender or holding tank. The tank units shall have a high shear (colloidal) mixer and pump and the placing pump shall have exact pressure control capabilities, and be fed from the holding tank. In addition, a pressure filter type grout test kit is required.

6.7.5 Mixing Grout

The sequence for charging the mixer shall be: first add water, start mixer and add cement. When cement and water are reasonably well mixed, admixtures shall be introduced in accordance with the written instructions of the manufacturer of each admixture. The mixing procedures shall prevent admixture from getting caught on the blades or sides of the drum and from forming gel globules. The mixing procedure may be varied in accordance with the written recommendations of the manufacturer of the admixtures.

The grout shall be mixed until a uniformly blended mixture is obtained and shall be continuously agitated until it is introduced into the grout pump. Batches of grout shall be placed within 30 minutes of mixing. No water shall be added to the grout to modify its consistency after the initial mixing operation is completed.

6.7.6 Cleaning and Flushing Tendons

Tendons shall not be flushed with water except in situations where a water soluble lubricant is applied to the prestressing steel, as described in Construction Methods Section 6.4, "Post-Tensioning Operations", or as otherwise permitted or directed by the Department.

If flushing is to be performed as required in Construction Methods Section 6.4, "Post-Tensioning Operations", the inside of the duct system shall be flushed with water (under pressure) meeting the quality requirements of Section 4.5.2.3 to remove all traces of the lubricant (or other contaminant). Following the flushing operation, water shall be totally drained from within the duct system and it shall be blown out with compressed oil free air to the extent necessary to dry the prestressing steel and inside surfaces of the ducts. The waste fluid flushed from the duct system shall be captured and disposed of properly.

6.7.7 Injecting Grout

Grouting shall start at the lowest injection port with all vent holes open. A continuous one way flow of grout shall be maintained at all times.

The maximum rate of grout injection shall be 16 ft. per minute for vertical ducts and 50 ft. per minute for horizontal ducts.

Grout shall be pumped through the duct and flow continuously at the first vent hole after the injection port until no visible slugs or other evidence of air or water are ejected and the grout being ejected has the same consistency as the grout being injected. At this time, at least one gallon of grout for tendon sizes seven (7)-0.6 inch and smaller and 3 gallons of grout for tendon sizes nine (9)-0.6 inch and larger shall be vented from the first vent hole into a suitable receptacle and discarded properly. The first vent valve shall then be closed. Grout injection shall continue until all vents have been closed one after another in the direction of flow following the same process. At intermediate crests where vents have been provided both at the crest and immediately downstream from the crest, the vent downstream of the crest shall be closed before the associated crest vent.

When the tendon duct is completely filled with grout and after the last outlet vent has been closed, the injection port shall be closed immediately following stoppage of the grout pump.

When a one-way flow of grout cannot be maintained, or when grouting is interrupted, the grout shall be immediately flushed out of the entire length of the duct with water. A water pump shall be available on site for this purpose as part of the standard flushing equipment. The flushing pressure shall not exceed the grouting pressures listed in Construction Methods Section 6.7,"Grouting".

6.7.8 Grouting Pressure

The pumping pressure at the tendon inlet shall not exceed the following:

External tendons of HDPE pipe, 145 psi

Internal PE ducts, 145 psi

Internal flat or oval steel ducts, 145 psi

Internal circular steel ducts, 250 psi

However, normal operations shall be performed at approximately 75 psi.

If the actual grouting pressure exceeds the maximum permitted pumping pressure, the inlet shall be closed and grouting shall continue at any vent hole that has been or is ready to be closed as long as a one way flow of grout is maintained. Grout shall not be injected into a succeeding outlet from which grout has not

yet flowed. Any such outlet used for injection shall be fitted with a positive shut off.

6.7.9 Vertical Grouting

All vertical tendons that have strands as the prestressing steel shall be fitted with a standpipe as specified in the Construction Requirements. As grouting is completed, the standpipe shall be filled with grout to a level, which will assure that, as settlement of grout occurs, the level of grout will not drop below the highest point in the upper anchorage device. If the level of grout drops below the level of the highest point in the anchorage device, additional grout shall immediately be added to the standpipe. After the bleed water is absorbed and the grout has hardened, the standpipe shall be removed.

For long, vertical internal tendons, if the grouting pressure exceeds the maximum permitted pumping pressure specified in Construction Methods Section 6.7, "Grouting", then the grout shall be injected at increasingly higher vents (which become injection locations) which have been or are ready to be closed as long as a one way flow of grout is maintained.

For external vertical tendons, lifts of grout shall not exceed 30' until the lower lift has set without approval of the Department. Two steel band clamps shall be securely fastened around the external duct at the top of the lower lift. Injection shall proceed from a point just above the top of the lower lift. Only grout with no bleed shall be used for external vertical tendons.

6.7.10 Temperature Considerations

When it is anticipated that the air temperature will fall below 32ºF, ducts shall be kept free of water so as to avoid freeze damage to ducts. No grouting shall be done when the temperature of the grout is below 45ºF or when weather reports indicate that the temperature may fall below 45º F for the anticipated duration of the grouting operation. The temperature of the concrete and air surrounding the tendon shall be maintained at 35ºF or above from the time grout is placed until the compressive strength of the grout, as determined from tests on 2 inch grout cubes cured under the same conditions as the in-place grout, exceeds 800 psi.

Under hot weather conditions, grouting shall take place early in the morning when daily temperatures are lowest. No grouting shall be done when the temperature of the grout exceeds 90ºF or when weather reports indicate that the temperature may rise above 90º F for the anticipated duration of the grouting operation. It may be necessary to chill mixing water or take special measures to lower the grout temperature.

6.7.11 Post-Grouting Measures at Injection and Vent Ports

Grouting vents at high points shall be reopened 10 minutes after completion of grouting and any escape of air, water or grout recorded.

Within approximately 30 minutes of grouting and before the grout has hardened, all opened vents shall be checked for voids. At locations where voids are observed, grout shall be topped off through the outlet, or a regrouting operation shall be performed using an injection port and outlet vent.

Not less than 48 hours after the completion of grouting, the level of grout at all injection port and outlet vent locations shall again be inspected and topped up as necessary with freshly mixed grout. This process will continue until the Department is assured that there are no bleed water or subsidence voids. Subsequent spot inspections may be conducted on one or more selected anchorages per span as long as no voids are found. If voids are found then all tendons will be checked for voids until the Department is assured that the voids are not occurring.

6.7.12 Post-Grouting Inspection of Anchorages by Design-Builder

Not less than 48 hours after the completion of grouting, all end anchorages shall be inspected for the presence of voids behind the anchorage.

The grout injection port on the anchorage shall be drilled out or otherwise cleaned of grout to allow the

inspection of potential voids immediately behind the anchorage or within the trumpet region of the tendon. Care shall be taken during the drilling process to ensure that the drilling operation does not come into contact with the strands or bar(s) of the tendon.

Assessment of the potential void space shall involve physical probing through the grout injection port with a suitable wire or probe, or visual inspection using of a flexible fiberscope or videoscope. The presence of a void and an estimation of its extent or length shall be recorded.

6.7.12.1 Void Regrouting Procedures

All voids identified behind anchorages shall be regrouted as follows:

A) Regrouting shall involve insertion of a grout tube through the grout injection port into the void space, and filling of the void with freshly mixed grout meeting the requirements of Materials Section 4.5 "Grout".

B) Grout tube shall be a flexible plastic of sufficient rigidity to allow grouting under pressure without excessive bulging or rupture. The size of the grout tube shall be 0.5 inch maximum O.D.

C) Grout material shall be placed by pumping the material at low pressures (<100 psi). Pressure shall be sufficiently low to prevent segregation and bleeding of the grout.

D) Grout tube shall be inserted into the trumpet as far as possible. Tube shall remain within the trumpet and immersed within the grout at all times during the grouting operation except as specified.

E) The tendon anchorages shall be grouted continuously. No interruptions in grouting will be allowed.

F) Grouting shall continue until all air, water, or other foreign material is completely purged from trumpet and duct. Grouting shall further continue until an uninterrupted stream of sound, uncontaminated grout flows from the port for a minimum of ten (10) seconds. At this time, the grout tube shall be slowly and continuously removed from the port while grout is still flowing out of the tube under pressure.

G) Upon completion of grouting, all ports shall be cleaned and then sealed so as to prevent grout leakage until final set of the grout.

Other regrouting methods, including vacuum grouting, may be used.

6.7.13 Post-Grouting Operations

Except as specified in Construction Methods Section 6.7, "Grouting", shut off valves shall not be opened on injection ports or vent ports, nor shall pipes or caps at port locations be removed until the grout has set.

After the grout has set, pipes used as injection or vent ports shall be cut off as described below.

In non-aggressive exposures, metal pipes shall be cut off 1 inch below the surface of the concrete. Plastic pipes shall be cut off flush with the surface of the concrete.

In aggressive exposures, metal and plastic pipes shall be cut off at least 1 inch below the surface of the concrete. The resulting recess shall be filled with a non-shrink mortar, and an elastomeric waterproof membrane shall be applied over the repair area. Suitable waterproofing membrane materials include urethane, neoprene or silicone based elastomers with the following minimum properties:

A) Tensile Strength (ASTM D 412)

20) at 75º F, 100 psi

21) at 0º F, 500 psi

B) Percent Elongation (ASTM D 412)

22) at 75º F, 500%

23) at 0º F, 250%

All waterproofing materials shall be UV resistant, and shall be reviewed for comment by the Department prior to use.

For vent ports on external tendons, saddles, vent hoses and all other hardware shall be removed and the holes in the ducts shall be sealed using a heat shrink repair sleeve. The heat shrink repair sleeve shall extend a minimum of 6 inch beyond the vent opening in the duct in both directions. All heat shrink repair materials and procedures shall be reviewed for comment by the Department prior to use.

All miscellaneous material (tie wire, waterproof tape, etc.) used for sealing grout inlet or vent connections shall be removed prior to carrying out further work to protect end anchorages. End anchorage protection shall be installed as described in Construction Methods Section 6.7, "Grouting".

6.8 PROTECTION OF PRESTRESS ANCHORAGES

6.8.1 Requirements for Aggressive Environments

For exposures designated as aggressive, a permanent, non-corroding grout cap shall be used. The permanent grout cap shall completely encapsulate the anchorage wedge plate, and shall attach directly to the anchor plate. A suitable gasket shall be used to prevent moisture intrusion behind the grout cap. Any bolts or fixtures used to secure the permanent grout cap to the anchorage shall have a minimum cover of 1 inch and shall be of stainless steel or other rust free material. Grout caps shall be submitted to the Department for review and comment. Additional protection in the form of a block out shall be utilized, consisting of one coat of epoxy bonding compound, approved non-shrink concrete or mortar to fill the block out, and an elastomeric waterproofing membrane.

For external anchorages (not recessed) not located at expansion joints or other location where moisture may directly come in contact with the anchorage, additional protection shall consist of an elastomeric waterproofing membrane.

For recessed anchorages, additional protection shall consist of one coat of epoxy bonding compound, approved non-shrink concrete or mortar to fill the anchorage recess, and an elastomeric waterproofing membrane.

Anchorage recesses or block-outs shall be filled as specified in Construction Methods Section 6.7, "Grouting".

Waterproofing membranes shall be as specified in Construction Methods Section 6.7, "Grouting".

The permanent grout cap shall remain in place at all times following grouting of the tendon.

Anchorage protection for temporary Post-Tensioning Thread Bars will not be required.

6.8.2 Filling of Anchorage Recesses or Block-Outs

For external (not recessed) anchorages to be encapsulated with a block-out, mild steel reinforcement or stainless steel anchors shall be provided to anchor the block-out concrete or mortar to the segment or structural member. A minimum of two (2) hairpin reinforcing ties (bar size #4 or larger) or a minimum of four (4) stainless steel anchors shall be used for each block-out. Minimum concrete or mortar clear cover to all reinforcement or anchors shall be 2 in. Hairpin reinforcement may be installed during segment or member fabrication, or following tendon placement and stressing. In the latter case, all reinforcement shall be dowelled into segment or member concrete a minimum of 4 in. and bonded in place using an appropriate epoxy adhesive that has been submitted to the Department for review and comment. Stainless steel anchors shall be installed in accordance with the manufacturer's recommendations.

Prior to filling of anchorage recesses or block-outs, all exposed end anchorages, strands, grout caps, block out reinforcement and other metal or non-metal accessories or components shall be cleaned of rust, misplaced mortar, grout and other such materials.

Immediately following cleaning operations, the entire surface of the anchorage recess or area to be covered by the block-out (all metal and concrete) shall be thoroughly dried and uniformly coated with an epoxy bonding compound meeting the requirements of AASHTO Specification M 235, Class III. The epoxy shall be applied in a manner and thickness as recommended by the manufacturer.

Immediately following application of the epoxy bonding compound, tight fitting forms shall be installed to encase the entire anchorage system, including reinforcement ties or anchors, where applicable. The anchorage recess or block-out shall be completely filled with pea gravel concrete or non-shrink, cement based mortar. The concrete or mortar filler shall be placed within the time limits specified by the epoxy bonding compound manufacturer. The filler shall exhibit no shrinkage, and shall contain no aluminum powder, iron particles, chlorides, sulfites, fluorides or nitrates.

6.8.3 Waterproof Membrane

An elastomeric waterproofing membrane shall be applied at all anchorage locations following finishing and curing of the pour-back concrete. Suitable waterproofing membrane materials include urethane, neoprene or silicone based elastomers with the following minimum properties:

A) Tensile Strength (ASTM D 412)

24) at 75º F, 100 psi

25) at 0º F, 500 psi

B) Percent Elongation (ASTM D 412)

26) at 75º F, 500%

27) at 0º F, 250%

All waterproofing materials shall be UV resistant, and shall be submitted to the Department for review and comment prior to use.

The waterproofing membrane shall completely cover the pour-back concrete used to fill the anchorage recess, block-out or pour-back and shall extend for a distance of not less than 12 in. beyond the extent of the pour-back concrete. The membrane shall terminate at a groove cut into the concrete not less than 3/8 in. wide by 3/8 in. deep.

6.9 RECORDS

6.9.1 Record of Stressing Operations:

The Design-Builder shall keep a record of all post-tensioning operations for each tendon installed and stressed. This shall include, but shall not necessarily be limited to the following:

A) Project name and number

B) Design-Builder and/or Sub-contractor

C) Tendon location, size and type

D) Date tendon was first installed in ducts

E) Coil/reel number for strands or wires and heat number for bars and wire

F) Assumed and actual cross sectional area

G) Assumed and actual modulus of elasticity

H) Date stressed

I) Jack and gauge numbers per end of tendon

J) Required jacking force

K) Gauge pressures

L) Elongations (anticipated and actual)

M) Anchor sets (anticipated and actual)

N) Stressing sequence (i.e. tendons before and after this)

O) Stressing mode (1 end only, 2 ends in sequence, or 2 ends simultaneous)

P) Witnesses to stressing operation (Design-Builder and Department staff)

Q) Record of any other relevant information

Within 72 hours, the Design-Builder shall provide the Department with a complete copy of each tendon stressing operation.

6.9.2 Record of Grouting Operations:

The Design-Builder shall keep a record of all grouting operations for each tendon installed, stressed and grouted. This shall include, but shall not necessarily be limited to the following:

A) Tendon or group of tendons grouted in one continuous operation

B) Date grouted

C) Number of days from stressing to grouting, per tendon

D) Type of grout mix and additives

E) Fluidity of grout (flow cone) per batch for both newly mixed and 30 minute rested grout

F) Density of grout per batch of fresh mix

G) Location of injection port and direction of grout flow (note: injection port may not necessarily be at an end anchorage)

H) Applied grouting pressure during normal pumping and maximum pressure sustained for one minute after closing all vents grouting

I) Theoretical volume of grout anticipated in order to fill the duct or ducts

J) Actual quantity of grout in place in the duct(s) after grouting (For one grout mixing and injection operation, this is the quantity mixed less the quantity wasted at the vents, less the quantity remaining in the mixer and injection equipment)

K) Summarize any difficulties encountered and corrective action taken

L) Witnesses to grouting operation (Design-Builder and Department staff)

M) Time of commencement and completion of grout pumping

N) Weather conditions at the time of grouting

Within 72 hours, the Design-Builder shall provide the Department with a complete copy of all tendon grouting operations.

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623515 - EPOXY FOR STRUCTURAL BRIDGE APPLICATIONS

1.0 GENERAL REQUIREMENTS

Adhesive bonding material systems for structural applications shall consist of pre-packaged 2-part chemical components. The material systems shall be specifically intended for use in structural applications for the following application classes.

1.1 EPOXY APPLICATION CLASS A

Epoxy bonding system for bonding anchors and dowels to hardened concrete limited to anchors and dowels, installed positions shall range from vertically downward to horizontal only.

1.2 EPOXY APPLICATION CLASS B

Epoxy bonding system for bonding of match cast faces of all joints between precast concrete elements. This Special Provision covers use of normal setting epoxy bonding agents and slow setting epoxy bonding agents. The work covered by this section shall also include temporary post-tensioning across a joint, if required, by provisions contained elsewhere in this Special Provision.

2.0 REQUIREMENTS – EPOXY APPLICATION CLASS A

Material systems for Type V materials may be supplied in two pre-proportioned containers with one container sized to allow the contents of the second container to be added and mechanically mixed. The two components shall be distinctly pigmented so that mixing produces a third color similar to the color of concrete. Do not use material from containers that are damaged or have been previously opened. Use only full packages of components. Combining of epoxy bonding components from bulk supplies is not permitted.

Material systems for Type HV and HSHV shall be pre-packaged to automatically proportion and mix the materials for use. Manual proportioning of the components will not be permitted.

2.1 TYPE V ADHESIVES

Use Type V adhesive bonding materials for constructing doweled pile splices in concrete piles. The dowel holes for these splices shall be oriented in the vertical position. Type V adhesives may not be substituted for Type HV or HSHV adhesives.

2.2 TYPE HV ADHESIVES

Use Type HV adhesive bonding materials for all horizontal installations and vertical installations other than constructing doweled pile splices, except when Type HSHV is required. Type HV adhesives may not be substituted for Type HSHV adhesives.

2.3 TYPE HSHV ADHESIVES

Use higher strength Type HSHV adhesive bonding materials for installation of traffic railing barrier reinforcement and anchor bolts into existing concrete bridge decks and approach slabs. Type HSHV adhesives may be substituted for Type V or Type HV adhesives.

2.4 APPROVED PRODUCTS LIST

The Department does not maintain an “Approved Products List.” Individual adhesive bonding material systems shall be submitted to the Department for review and comment. Submittals shall include certified test reports from an independent testing laboratory that shows the material system meets all the requirements specified herein.

2.5 MINIMUM PERFORMANCE REQUIREMENTS (FM 5-568)

When tested in accordance with Florida Sampling and Testing Methods (FM), FM 5-568, the adhesive bonding material system, for general use, shall meet the following requirements:

Table 2-1 - Uniform Bond Stress

	Type V	Type HV	Type HSHV
Confined Tension	2,290 psi	2,290 psi	3,060 psi
Damp-Hole Installation	1,680 psi	1,680 psi	1,830 psi
Elevated Temperature	2,290 psi	2,290 psi	3,060 psi
Horizontal Orientation	Not Applicable	2,060 psi	2,060 psi
Short-Term Cure	1,710 psi	1,710 psi	1,710 psi
Specified Bond Strength	1,080 psi	1,080 psi	1,830 psi

Maximum Coefficient of Variation for Uniform Bond Stress: 20%

Long-Term Load (Creep):

A) The rate of displacement shall decrease during the 42-day application of load.

B) At 42 days the total displacement due to creep (with load still applied) shall be less than 0.03 inch and during the last 14 days of the 42 day load duration, the total displacement due to creep shall be less than 0.003 inch .

C) After removal of the 42-day load, the uniform bond Stress from a subsequent Confined Tension Test shall not be less than 1,826 psi.

2.6 PRODUCT IDENTIFICATION (FINGERPRINT) PROPERTIES (FM 5-569)

References for comparison including Infrared Absorption, Density or Average Weight, Gel Time or Setting Time and Bond Strength shall be determined in accordance with FM 5-569.

2.7 PACKAGING AND MARKING

The adhesive bonding material system shall be delivered to the Project site in original unopened containers with the manufacturer's label identifying the product. Each package shall be clearly marked with the following information:

A) Manufacturer's name and address;

B) Product Name;

C) Date of Manufacture;

D) Expiration Date;

E) LOT Identification Number; and

F) Storage, Handling, Mixing and Application Requirements.

Each package shall include the manufacturer's instructions for anchor and dowel installation. The instructions shall include the following information:

1) Diameters of drilled holes for applicable anchor and dowel sizes;

2) Cleaning procedure for drilled holes, including a description of permitted and prohibited equipment and techniques;

3) Allowable temperature ranges for storage, installation and curing;

4) Identification of acceptable mixing/dispensing nozzles;

5) Fabrication requirements for anchors and dowels;

6) Description of tools permitted or required for installation;

7) Method of identifying properly proportioned and mixed adhesive materials;

8) Time and temperature schedule for initial set and full-strength cure; and

9) Special requirements for special installation conditions, such as damp holes, or horizontal or near horizontal orientation of the anchor or dowel.

3.0 REQUIREMENTS – EPOXY APPLICATION CLASS B

Epoxy bonding agents for match cast joints between precast elements shall be thermosetting 100 percent solid compositions that do not contain solvent or any non reactive organic ingredient except for required coloring pigments. Epoxy bonding agents shall be of two components, a resin and a hardener. Both components shall be distinctly pigmented, so that mixing produces a third color similar to the concrete in the elements on the exterior of the elements. Samples shall be provided to the Department along with the concrete samples required elsewhere in the Special Provisions for the project.

In its workable state, epoxy bonding agent must provide lubrication along the keys as the precast concrete elements are brought together. In its hardened state, epoxy bonding agent must provide a watertight seal between precast concrete elements. For superstructure precast concrete elements, hardened epoxy bonding agent must provide shear stress transfer across the joint without reliance on shear keys to transfer forces.

Epoxy bonding agents shall be insensitive to damp conditions during application, and after curing, the epoxy shall exhibit high bonding strength to cured concrete, good water resistance, low creep characteristics and tensile strength greater than the concrete.

The components shall be packaged in two parts in sealed containers, pre proportioned in the proper reacting ratio, ready for combining and mixing in accordance with the manufacturer's instructions. Each container shall bear a label designating the manufacturer's name, the type component (resin or hardener), the range of substrate (surface of concrete) temperature over which application is suitable, the date of formulation, the shelf life of the material and the manufacturer's Lot number. Material from containers that are damaged or have been previously opened shall not be used. Combining of epoxy bonding agent components from bulk supplies will not be permitted. Only full buckets of components will be mixed immediately after opening.

Instructions shall be furnished by the manufacturer for the safe storage, handling, mixing and application of the material. The Design-Builder shall furnish to the Department samples of the material for testing, upon request, and certified reports of tests performed by an independent laboratory approved by the Department.

3.1 CLASSIFICATION OF MATERIALS

This Special Provision provides for epoxy bonding agents that remain workable for a short time referred to herein as normal-set epoxy bonding agents and epoxy bonding agents that remain workable over an extended period of time referred to herein as slow-set epoxy bonding agents.

3.2 FORMULATION FOR TEMPERATURE RANGE

An epoxy bonding agent shall be formulated to provide application temperature ranges which are suitable for erection of elements with substrate temperatures between 20°F and 115°F or as recommended by the manufacturer. There shall be a minimum of two, and preferably three, formulations dividing the overall range into equal subsets which overlap by 5°F. Additionally, each of these formulations shall be identified as either normal-set or slow-set epoxies as defined in the following section under Contact Time and Strength.

3.3 PHYSICAL REQUIREMENTS

Epoxy bonding agents proportioned as designated by the manufacturer and mixed in accordance with the manufacturer's recommendations shall meet the physical requirements of ASTM C 881 except as modified below. The components of the epoxy bonding agent shall be conditioned to the temperature at which testing is to be done prior to mixing the test specimen.

3.3.1 Consistency.

This property determines application workability of the epoxy bonding agent. Mixed epoxy bonding shall be tested and conform to the prescribed consistency in accordance with ASTM C 881 at the maximum temperature of the temperature range for the formulation being tested.

3.3.2 Gel Time.

This property is the period of time during which the epoxy bonding agent will remain workable in the mixing container and must be applied to the match cast joint surfaces. The mixed epoxy bonding agent shall be tested and conform to the prescribed gel time in accordance with ASTM C 881 at the maximum temperature of the temperature range for the formulation being tested.

3.3.3 Contact Time and Strength.

This property is the workable period of time allowable between mixing of the epoxy bonding agent components and the application of a minimum 40 psi compression over the cross section of the joining elements. The contact time of the epoxy bonding agent, determined in accordance with the test procedure set out below, shall be as follows:

A)	Normal-Set Epoxy	60 Minutes, Minimum
B)	Slow-Set Epoxy	8 Hours, Minimum

3.3.4 Test Procedure for Determining Contact Time

The test procedure for determining contact time shall be determined in accordance to ASTM C 881 with the following modifications.

A) Soaking of the concrete specimens prior to application of the epoxy bonding agent shall be for 24 hours in water that is at the maximum temperature of the application temperature range for the formulation being tested.

B) Joining of the sloped surfaces shall be delayed for the period of time, measured from the time the epoxy was mixed, set out below:

1)	Normal-Set Epoxy	60 Minutes
2)	Slow-Set Epoxy	8 Hours

C) During the delay period between mixing of the epoxy and joining of the sloped surfaces, the specimens shall be uncovered and maintained at the maximum temperature of the application range for the formulation being tested.

D) The joined specimen shall be cured at the maximum temperature of the application range for the formulation being tested.

E) The formulation of epoxy bonding agent being tested will be acceptable if the specimen when tested sustains the following compressive stress:

1)	Normal-Set Epoxy	1,000 psi at 48 Hours
2)	Slow-Set Epoxy	1,000 psi at 14 Days

For slow-set epoxy, an additional test specimen shall be made and tested to failure at 24 hours. The

formulation being tested is acceptable only if the epoxy bonding agent exhibits a brittle break.

3.3.5 Compressive Yield Strength

This property is the compressive yield strength of the epoxy bonding agent at various ages. Comparison of this property between batches is an indication of the level of quality control achieved in manufacturing the material.

A) The required compressive yield strength of the epoxy bonding agent shall be determined according to ASTM C 881 with the following modifications.

1) Epoxy bonding agent shall be poured into the mold for forming specimens within ten minutes after starting mixing of the components.

2) Normal-Set Epoxy 2,000 psi at 24 Hours and 7,000 psi at 48 Hours

3) Slow-Set Epoxy 1,000 psi at 36 Hours and 2,000 psi at 72 Hours

3.3.6 Bond Strength

This property is the strength of epoxy bonding agent as it bonds with concrete.

This bond strength property shall be determined in accordance with and conform to ASTM C 881 that references ASTM C 882 with the following modifications:

A) The test cylinder of mortar shall have a compressive strength of at least 6,000 psi at seven days age.

B) The specimens shall be conditioned by soaking in water that is at the minimum temperature of the application temperature range for the formulation being tested.

C) The required strength of ASTM C 881 shall be modified as follows:

1) Normal-Set Epoxy 1,000 psi at 48 Hours

2) Slow-Set Epoxy 1,000 psi at 14 Days

3.3.7 Heat Deflection of Epoxy Bonding Agent

This property is the temperature at which an arbitrary deflection occurs under arbitrary testing conditions in the cured epoxy bonding agent. It is a screening test to establish performance of the epoxy bonding agent throughout the temperature range at which a particular formulation may be applied. It shall be tested and satisfy the requirements in accordance with ASTM C 881.

3.3.8 Testing

An independent testing laboratory (or laboratories) selected by the Design-Builder and approved by the Department shall test all materials from each manufactured lot in accordance of with the testing requirements of this Special Provision. The Design-Builder shall be responsible for all coordination between the Design-Builder's laboratory (or laboratories), Design-Builder's supplier(s), and Department representatives. The Design-Builder shall notify the Department 14 days prior to any testing to be performed and the Department shall be allowed to witness all testing.

The Design-Builder shall furnish all material and written test procedures, as prepared by the Design-Builder's supplier(s) to the Department for review and comment. The Design-Builder's supplier(s) and the design-Builder's laboratory (or laboratories) shall prepare separate reports. Each of these reports shall independently describe all the testing data and testing results. All reports shall be submitted by the Design-Builder to the Department within 14 days of completing each test as independent records of the testing. The Design-Builder shall be responsible for sub-contracting and coordinating with the Design-Builder's laboratory (or laboratories) and Design-Builder's supplier(s) for all testing laboratory services.

The Design-Builder's supplier(s) shall provide written and detailed recommendations to the Design-

Builder regarding storage, handling, transporting, mixing, applying and curing of epoxy materials. The Design-Builder's supplier(s) shall simultaneously provide copies of all such recommendations directly to the Department for their use.

The test reports shall document that the epoxy material has passed all tests required in this Special Provision and the Contract requirements.

3.3.9 Application

An epoxy bonding agent meeting the requirements of this Special Provision shall be applied to joining surfaces of all precast concrete elements. The epoxy bonding agent shall be applied only when the substrate temperature of both surfaces to be joined is between 20°F and 115°F or as recommended by the manufacturer.

The formulation of epoxy bonding agent used shall have an application temperature range as previously defined in the Epoxy Material section of this Special Provision, which conforms to the substrate temperature of the surfaces to be joined. If the surfaces have different substrate temperatures, the formulation for the higher temperature shall be used for joining the elements.

The Design-Builder's construction scheme shall provide for a minimum contact pressure of 40 psi compression over the entire joint of precast concrete elements while the epoxy is curing in the joint. The Design-Builder shall plan his erection and post-tensioning operations such that for the particular formulation of epoxy bonding agent being used, the time elapsing between initial mixing of the components for the first batch of epoxy bonding agent and application of the minimum contact pressure of 40 psi compression shall not exceed 70 percent of the contact time.

Prior to beginning erection, the Design-Builder shall submit to the Department for review, details covering how compliance with this 40 psi contact pressure and the time limit will be achieved during erection of elements.

For superstructure elements, the compressive force across a joint (contact pressure) may be accomplished through temporary post-tensioning or permanent post-tensioning. The specified contact pressure shall be continuously maintained across a joint while the epoxy is curing in the joint.

3.3.10 Qualifications of Design-Builder's Personnel

The work of mixing, handling and applying the epoxy bonding agent shall be under the direct supervision of a person who has extensive knowledge of and experience in the use of this material. The Department may require the Design-Builder to arrange for a technical representative of the manufacturer to be at the site as an advisor at the beginning of this operation.

The Design-Builder shall ensure that all personnel who will be working with the epoxy bonding agent are thoroughly familiar with the safety precautions necessary when handling this material.

3.3.11 Cleaning of Surfaces to be Joined

The surfaces to which the epoxy bonding agent are to be applied shall be free from oil, form release agent, laitance, curing compound or any other material that would prevent the epoxy bonding agent from bonding to the concrete surface. Light sandblasting or high-pressure water blasting with a minimum pressure of 5,000 psi shall remove these detrimental materials.

The surfaces shall have no free moisture on them at the time the epoxy bonding agent is applied. Free moisture will be considered to be present if a rag, after being wiped over the surface, becomes damp.

3.3.12 Mixing Epoxy Bonding Agent

Only epoxy bonding agent components from full containers opened immediately prior to being combined and for which the shelf life indicated on the containers has not expired shall be used during erection. Each container of a component shall be thoroughly mixed prior to combining of the components.

The two components of the epoxy bonding agent shall be combined and thoroughly mixed in a mechanical mixer in strict accordance with the manufacturer's recommendations.

Mixing of the epoxy bonding agent shall be scheduled so that the material in a batch is applied to the face of the joint within 20 minutes after the components are combined.

3.3.13 Applying Epoxy Bonding Agent

The epoxy bonding agent shall be uniformly applied to a nominal thickness of 1/16" or in accordance with the manufacturer's recommendations with a spatula or by gloved hand. The material shall be applied to only one of the faces to be joined except that material shall be applied to both faces in the vicinity of post-tensioning ducts. No material shall be placed within 2" of a post-tensioning duct except, regardless of spacing, a bead of epoxy bonding agent shall be applied between all adjacent post-tensioning ducts.

No epoxy bonding agent from a batch shall be used for which the time since combining of components has exceeded 20 minutes.

After concrete elements have been joined and the specified contact pressure applied, a discernable bead line of epoxy bonding agent must appear along the entire exposed edges of a joint. All excess epoxy bonding agent shall be cleaned from exterior surfaces of the concrete element in such a way as to not damage or stain the concrete surface. Excess epoxy squeezed from a joint shall be captured and not allowed to free-fall from the structure onto the ground, river or traffic lanes below.

3.3.14 Artificial Heating

If the Design-Builder elects to erect elements in cold weather when the substrate temperature of the joint surfaces of concrete elements is below 20°F (or other minimum temperature as recommended by the manufacturer), they shall provide an artificial environment to increase the substrate temperature subject to the following restrictions.

A) The artificial environment shall be created by an enclosure surrounding the joint through which warm air is circulated.

B) The temperature of the concrete shall be raised to at least 20°F (or other minimum temperature as recommended by the manufacturer) to a depth of approximately 3" beneath the surface to be joined.

C) Localized heating shall be prevented and the temperature of the substrate shall not exceed 105° F at any point on the surface of a joint.

D) The temperature of substrate surfaces shall be maintained between 20° F and 105° F for at least 24 hours after joining of the surfaces for normal-set epoxy and 72 hours for slow-set epoxy.

E) The Design-Builder may propose, for review by the Department, an optional method of raising and maintaining the substrate temperature of the joint surfaces. Any optional method shall meet the restrictions set out above. The Department will base the acceptance of an optional method on it accomplishing an environment suitable for the epoxy bonding agent to perform satisfactorily.

3.3.15 Failure to Comply with Time Limits

If the time limit between mixing of the epoxy bonding agent and application of contact pressure to a joint is exceeded, the concrete elements shall be moved apart and all epoxy bonding agent shall be removed from both faces of the joint. If solvent is used to remove the epoxy bonding agent, reapplication of the epoxy bonding agent to the joint surfaces shall not be done for at least 24 hours.

3.3.16 Cantilever Element Support

A) The Design-Builder shall determine the maximum number of elements that can be

supported in cantilever beyond an epoxy joint, which has not developed a state of substantial cure. For this requirement, substantial cure is defined as that state in which the epoxy will transfer an average shear stress of 250 psi across a joint of two plane surfaces.

B) The Department may require the Design-Builder to submit calculations substantiating the joints ability to safely transfer all applied forces.

3.3.17 Failure to Provide Watertight Seal:

In the event that water seepage through the deck slab at an epoxy precast element joint becomes evident, the Design-Builder shall take measures to seal the joint such as applying a gravity feed low viscosity concrete crack sealer or epoxy pressure injection. Proposed methods for sealing leaking element joints shall be submitted to the Department for review and comment.

3.3.18 Record of Element Joining

The Design-Builder shall record and make available to the Department the following information:

A) General: For the period when precast elements are being erected

1) Weather condition.

2) Air temperature at the site on an hourly basis.

B) For Each Joint: Identified as to Location in the Structure

1) Lot number for the epoxy bonding agent components.

2) Temperature of the concrete on the surface of each concrete element when application of epoxy bonding agent was started.

3) Time of mixing the first batch of epoxy bonding agent and when it was applied to the joint.

4) Time of applying the specified contact pressure to the joint.

5) Date of joining elements with epoxy.

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742500 - FLAGGER REQUIREMENTS

742.01 Description. Flagger shall consist of furnishing personnel and necessary equipment for the controlling of traffic through work areas.

742.02 Flagger Requirements. Flaggers shall be governed by and familiar with the Manual on Uniform Traffic Control Devices (MUTCD) Part VI, latest edition, and updates, and shall conform to the requirements of the latest version of the manual entitled "Delaware Traffic Controls for Street and Highway Construction, Maintenance, Utility and Emergency Operations" (latest edition with all revisions made up to the date of Advertisement of this project and from hereon shall be addressed as the Traffic Manual). Flaggers shall have completed flagger training and testing, within the last 4 years as offered by American Traffic Safety Services Association (ATSSA) or the Delaware Construction Craft Laborers' Apprenticeship Program. The Contractor shall provide appropriate documents showing the flagger certification status throughout the duration of Contract. When additional flagpersons are needed on a project the Contractor shall supply the Engineer with this documentation prior to them beginning work. The Contractor shall also have available a person certified to flag who will relieve the flagperson for any necessary breaks. Flaggers are required to have their approved flagger card, and a photo identification card on their person at all times while flagging. Failure to produce an approved card, when requested to do so by anyone authorized by DelDOT, shall be grounds to have that person removed from the flagger job.

Flagger shall be completely covered (clothed) from neck to feet. The minimum clothing requirements for flagger shall be long pants and a standard T-shirt with sleeves along with appropriate footwear (no open toe shoes). In addition to this, flaggers shall be required to wear high visability clothing in accordance with Section 6E.02 High-Visability Clothing of the MUTCD. When directed by the Engineer, the flagger shall be equipped with a two-way radio or an approved communication device.

Flagging Procedure:

Flagging procedure shall conform to paragraphs E-4 through E-7 of Traffic Manual. Flaggers and operators of construction machinery or trucks shall be made to understand that every reasonable effort must be made to allow the driving public the right-of-way and prevent excessive delays. Whenever flagpersons are relieved or rotated it shall be the Contractor's responsibility to assure that the relief flagperson has been fully orientated about the operation.

Flaggers are required to use DelDOT approved STOP/SLOW (S/S) paddles as hand signaling devices. Flags are generally only allowed for emergencies. S/S paddles are required to meet the requirements of Section E-2 of the Traffic Manual. Any border around the SLOW side shall be black. S/S paddles shall be a minimum of 24 inches x 24 inches (600 mm x 600 mm) with minimum 8 inch (200 mm) high, "C" series letters on the STOP side of the paddle and 8 inch (200 mm) high, "B" series letters on the SLOW side of the paddle and are required to have high intensity retroreflective sheeting for the orange, red and white colors (both day and night). A rigid handle shall be provided such that the bottom of the sign paddle shall be 6 feet (1.8 m) above the ground. Flagger stations shall be sufficiently illuminated at night in accordance with Section E-5 of the Traffic Manual. Care shall be taken to assure that traffic is not blinded from any direction of travel by illumination of the flaggers' station. The flagger must be positioned so as to be clearly visible to traffic.

Any Flagger not performing duties in accordance with Delaware Traffic Controls for Street and Highway Construction, Maintenance, Utility and Emergency Operations Manual or non compliance to the specifications shall be justification for the Engineer to suspend work in conformance with Subsection 104.07 of the Standard Specifications. The flaggers shall be replaced and when the flaggers are in

compliance with the policies outlined in this specification, the work may resume.

Flagger Cards may be confiscated from personnel flagging improperly. The Engineer shall contact the Contractor's supervisor. The supervisor shall confiscate the card from the flagger. The card shall be turned over to the Engineer and forwarded to DelDOT's Safety Section. The Safety Section shall forward the card, or if the person refuses to give up the card, a letter to ATSSA's main office for the purpose of removing the individual's name from the certified list. Any flagger whose card has been confiscated shall be retrained and retested prior to consideration for reinstatement. Retraining and retesting shall not occur until at least one month after the infraction.

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743514 - FURNISH AND MAINTAIN MESSAGE BOARD

Description:

The item shall consist of furnishing, placing, operating and maintaining trailer mounted message board during the construction of the project. When no longer required for use on the project as decided by the Engineer, the message board with trailer and related hardware shall become the property of the Contractor.

The message board must be approved by the Department prior to use. For a list of approved message boards and approval process, contact the Department's Chief Safety Officer.

Operation and Maintenance:

The message board shall be placed and relocated on the job site at location(s) as determined by the Engineer. The Contractor shall have qualified and trained message board programmer(s) to program desired messages, and mechanic(s) to perform required service on the message board unit, available on a 24 hour basis. The Contractor shall maintain and service the message board unit throughout the period of its operation on the job.

~~**Basis of Payment**:~~

~~The payment for the item shall be made for at the Contract unit price per Each-Day bid for the item "743514 - Furnish and Maintain Message Board", which price and payment shall constitute full compensation for furnishing the message board with trailer, placing, relocating, operating programming, final removal when no longer required, and for all labor, tools, equipment, and necessary incidentals to complete the work.~~

~~Should an operational problem be reported to the Contractor at any time during use of the unit, the Contractor shall have two hours after receipt of notification to rectify the problem to the Engineer's satisfaction. If such repair is not made satisfactorily, no payment will be made for the six-hour quarter day in which the failure occurred. Also, a second failure within any 6-hour quarter day period will void payment for that period.~~

~~It is the Department's intent to provide a continuously operating Message Board whenever the unit is in service. The Contractor is required to make all necessary arrangements to assure continuous operation of the unit. To this end, the Contractor shall designate an on-site representative, other than the Project Superintendent, who shall be the Department's contact on all project issues related to the Message Board. The Contractor shall also designate a Manufacturer's Representative to be on call for technical assistance or as otherwise necessary.~~

NE - 1/24/01

746574 - BRIDGE ELECTRICAL SYSTEM

Description:

The work specified in this item consists of providing the design, construction, and installation of complete conduit, wiring, and power distribution equipment and controls for all lighting and power circuits associated with the Design-Builder's Proposal and all minimum requirements specified herein. The work to be performed includes the following items and all incidental items necessary to complete the work:

A. Providing all necessary electric service and distribution to serve the power and lighting requirements of the contract. It includes all work related to the connection to the Power Company.

B. Providing interior and exterior lighting and associated controls in and on the bridge, including nautical and aerial navigational lights on the bridge; maintenance lights inside the bridge; path lights on the pedestrian walkway on the bridge; and aesthetic lighting to accent the bridge.

C. Providing receptacles throughout the bridge to be used for maintenance activities.

D Providing multi-duct conduit and junction boxes for weather sensor pucks and future ITMS communications.

All electrical systems and associated work required in accordance with the *University of Delaware Bridge Monitoring Program* Performance Specification included in Part 3 of the Contract Documents shall be considered extra work and will be negotiated between the Design-Builder and the Department upon award of the Contract.

General:

RELATED DOCUMENTS:

A. The Indicative Plans from Contract #25-073-02 included in Scope of Services Package – Contract Documents Part 6 – Directive and Indicative Plans.

B. Delaware Department of Transportation, "Standard Specifications for Road and Bridge Construction," Dated 2001 as modified by Delaware Department of Transportation, "Supplemental Specifications, Revisions and Corrections to the August 2001 Standard Specifications," (Part 4 – Appendix A);

1. Section 745: Conduits (non-metallic or galvanized)

2. Section 747: Cabinet Bases

3. Section 603: Bar Reinforcement

4. Section 812: Portland Cement Concrete

C. Delaware Department of Transportation, "Standard Construction Details," the latest edition as of the issue date of this RFP.

D. American Society for Testing Materials (ANSI)

E. National Electrical Manufacturers Association (NEMA):

1. ICS 4: Standards for Terminal Blocks

2. KS 1: Standards for Disconnect Switches

3. PB 1.1: Standards for Panel Boards

F. National Fire Protection Association (NFPA):

1. NFPA, "NFPA-70: National Electric Code," (NEC) the latest edition as of the issue date of this RFP.

ACRONYMS:

A. PVC: Polyvinyl Chloride

B. UL: Underwriter Laboratories, Inc.

C. NEC: National Electric Code

D. GFCI: Ground Fault Circuit Interrupt

J. LED: Light Emitting Diode

K. ITMS: Intelligent Transportation Management Systems

L. RGS: Rigid Galvanized Steel

M DP: Delmarva Power

N RLM: Reflector and Lighting Equipment Manufacturers

DEFINITIONS:

Luminaire (Light Fixture): A complete lighting device consisting of lamp(s) and ballast(s), when applicable, together with parts designed to distribute light, to position and protect lamps, and to connect lamps to power supply.

SUBMITTALS:

A. All working drawings and/or shop drawings pertaining to work completed under this item shall be prepared and submitted to the Department's Project Manager for review and comment a minimum of 30 Calendar Days prior to beginning the associated work. Drawings shall be submitted, reviewed, and approved by the Design QC Manager in accordance with Part 2 – DB Section 111 of the Contract Documents. Work completed without previously submitting all relevant drawings shall be subject to removal and reinstallation at the discretion of the Department's Project Manager.

B. Shop drawings shall include, but not be limited to:

1. Shop drawings shall show materials, finishes, metal gauges, overall and detail dimensions, electrical and mechanical connections, fastener, fittings, welds, provisions for work of others, and similar information.

2. All Electrical Equipment

3. Luminaires

   A. Shop drawings shall indicate complete details of the luminaire, not limited to but including manufacturer's catalog numbers for sockets, ballasts, diffusers, lenses, switches and type of wiring. Adjustable luminaires shall indicate focusing and locking devices. A note confirming specific UL listing shall be included.

   B. Catalog sheets, brochures and similar material shall not be accepted in lieu of shop drawings unless specifically authorized by the Department's Project Manager.

   C. Prior to the installation of any luminaire, a full size sample of the fixture shall be submitted to the Department's Project Manager for approval. Luminaires shall not be installed without the Department Project Manager's approval of the sample, unless otherwise directed.

4. Locations of ground rods, connectors, cables, etc., and details of connections, terminations and access points.

5. Procedures and equipment for testing resistance and electrical continuity.

6. Utility hanger system for mounting of all electrical equipment and conduits.

7. Complete conduit and sleeve layout, verifying that conduit and sleeve locations do not conflict with proposed bridge components.

8. Details for installation of the aesthetic lighting and path lighting.

C. Photometric data, developed by an independent laboratory, shall be provided by the Design-Builder at no additional cost to the Department.

E. Submit a detailed plan of the proposed methods of and scheduling of the overall systems and equipment-testing program at least 30 calendar days prior to initiating the testing program.

F. Provide National Electric Code Inspection and certification of the jurisdictional authorities.

G. Certifications

1. Certified test reports verifying that ground resistance of each ground grid when installed and each ground bus where connected to the ground grid does not exceed specifications.

QUALITY ASSURANCE:

A. All electrical work shall be performed and all materials provided shall be in accordance with the NEC. The NEC shall be the minimum requirements for the electrical work and if there is a conflict between the requirements specified in the Contract Documents and the code, the more stringent requirement will apply as determined and approved by the Department's Project Manager.

B. Unless otherwise indicated, provide electrical materials and equipment that are the standard product of manufacturers regularly engaged in the production of such materials and equipment. Provide the manufacturer's design. When two or more units of the same class of material and equipment are required, these units shall be the product of the same manufacturer.

C. Workmanship and materials shall be guaranteed for a minimum period of two (2) years from the date of Final Acceptance of the Work. Installation shall be in strict accordance with manufacturer's specifications and instructions. All items shall be in satisfactory operating conditions before acceptance by Owner.

D. Materials are to be stored and handled such that their quality and acceptability for work is preserved.

COORDINATION:

A. Coordinate with other sections of the Specifications to ensure proper scheduling for delivery and installation of the work specified herein. Coordinate with other sections to ensure that proper provisions are made for the installation of the work specified herein.

B. Sequence, coordinate, and integrate installation of electrical materials and equipment for efficient flow of the Work.

C. Coordinate construction of all electrical components with all authorities having jurisdiction within project limits and adjacent development.

D. Coordinate electrical service connections to components furnished by utility companies.

E. Coordinate slots, inserts, sleeves, and openings with general construction work and arrange in bridge structure during progress of construction to facilitate the electrical installations that follow. Set inserts and sleeves in poured-in-place concrete and other structural components as they are constructed. Drilling of concrete shall be avoided.

F. The Design-Builder shall coordinate installation of large electrical equipment requiring positioning during bridge construction.

G. The Design-Builder shall provide and secure all electrical inspections as required and pay for the same. The Design-Builder shall obtain at his expense all necessary permits and certificates as required.

H. The Design-Builder shall make all necessary provisions throughout the site to receive the work as construction progresses and shall furnish and install adequate backing, supports, inserts, and anchor bolts for the hanging and support of all electrical fixtures, conduit, panelboards and switches.

REGULATORY REQUIREMENTS:

A. Conform to all applicable UL and electrical codes.

B. All city, state, and national standards shall apply.

DELIVERY, STORAGE, AND HANDLING

A. Deliver to site and properly store, protect, and handle products at site.

B. Deliver products to site in sealed and labeled packages; Design-Builder's QC Manager to inspect to verify acceptability.

C. All products delivered to the site shall be made available to the Department for Quality Assurance inspections prior to installation.

OPERATING AND MAINTENANCE INSTRUCTIONS:

A. Upon completion of all work and tests, prepare a Maintenance Manual for all Bridge Electrical Systems in accordance with the *Inspection, Maintenance and Construction Requirements* Performance Specification. The Design-Builder shall instruct the Owner's representative(s) in the operation, adjustment, and maintenance of all electrical systems and equipment.

B. Instruction shall be provided as requested by the Department's Project Manager, and divided into multiple sessions (minimum of two). Sessions shall be held at a time and length specified by the Department's Project Manager.

C. The Design-Builder's instructor shall be thoroughly familiar with all parts of the system or equipment on which he is to give instruction.

Materials:

GENERAL:

A. All electrical materials and equipment shall be new, shall carry a UL label when such material, equipment and/or system are of a type or class listed by the Underwriters Laboratories, Inc., and shall be suitable for the conditions and duties imposed on them. If a UL label is not available from the manufacturer, when requested or required by the local authority having jurisdiction, an approved electrical testing company in accordance with NEC shall test the equipment. The Design-Builder shall submit to the Department's Project Manager data indicating compliance with standards prior to installation. The description, characteristics, and requirements of materials to be used shall be in accordance with qualifying conditions established in the following sections.

B. All component parts of each item of equipment or device shall bear the manufacturer's nameplate, giving the name of manufacturer, description, size, type, serial or model number, electrical characteristics, etc., in order to facilitate maintenance or replacement. The nameplate of a subcontractor or distributor will not be acceptable.

C. Any deviations from size and/or type of material specified herein shall be submitted to the

Department's Project Manager for approval.

ELECTRICAL CONDUIT AND FITTINGS:

A. Materials shall conform to the requirements of Delaware Standard Specifications, Section 745.02.

B. Conduit shall be sized in accordance with the requirements of the NEC. Minimum size shall be 3/4 inch.

C. All conduit shall be UL approved and shall be suitable for marine environment use.

D. All conduit and fittings shall be water-tight.

E. Conduit installed for Delmarva Power from the switchgear to the transformer(s) shall be PVC schedule 40 and be gray in color. It shall be installed as per Delmarva Power requirements.

F. PVC schedule 40 shall meet the requirements of UL-651.

G. Flexible conduits shall be UL listed, liquid-tight, PVC covered hot dip galvanized steel.

H. Multi Duct conduit shall consist of outer duct and inner duct conduit. The outer duct conduit shall be 4" high density polyethylene (HDPE) schedule 40 or SDR-13.5 smooth wall conduit with permanently pre-lubricated lining, meeting ASTM D 2447, ASTM D 3035 and NEMA TC7 specifications. Inner duct conduit shall be 1" HDPE ribbed duct.

I. Fittings shall be of the same material and finish as the raceways and shall meet requirements of UL-514 and ANSI C80.4. Threaded connectors shall be used for all rigid metal conduits.

J. Conduit Expansion Fittings

1. Conduit expansion fittings shall be installed where conduits cross expansion joints in the structure or where otherwise required by the NEC. All fittings shall be of the same material as conduit raceway.

2. Conduit couplings shall be capable of accommodating a minimum of 125% of the anticipated design movements at all joints resulting from expansion, contraction, creep, shrinkage, and/or deflection.

3. Expansion fittings shall provide for be grounding continuity as required by NEC. Bonding straps shall be of sufficient length to allow for full expansion.

4. Expansion joints shall be rated UL 514.

K. Sleeves

1. Provide sleeves wherever electrical and communications conduit is required to penetrate bridge members.

2. Inside diameter of sleeves shall be at least ½ inch larger than the outside diameter of conduit. Sleeves shall be installed to provide at least ¼ inch space all around the conduit.

3. The Design-Builder shall provide shop drawing detailing the size and location of sleeves in each bridge segment.

BOXES, ENCLOSURES, AND CABINETS:

A. Each box shall have sufficient volume to accommodate the number of conductors in the box, or sufficient dimensions to accommodate the size of conduit entry, in accordance with the NEC.

B. Junction boxes inside the bridge shall be of the non-metallic type and be rated NEMA 4X. Drill and tap boxes for conduit openings.

C. ITMS junction boxes shall be 24” x 12” x 6” deep and shall be accessible from the northbound and southbound outside roadway shoulders.

D. Hinged or screw cover enclosures inside the bridge shall have continuous or separate hinge covers held closed by screws or flush latch.

E. Panel board enclosures inside the bridge shall be stainless steel boxes with removable interior panel and removable front. Panel board enclosures shall have a hinged door in front cover with flush latch and concealed hinge and a key latch to match panel boards.

F. Panels for mounting electrical components shall be minimum 14-gauge steel.

G. Enclosures outside the bridge including, but not limited to, the junction boxes for ITMS conduit installed in traffic barriers and the main bridge distribution panel board enclosure shall be NEMA 4X, stainless steel.

ELECTRICAL CABLE, WIRE AND CONNECTORS:

A. Conductors shall be copper, 98 percent conductivity, soft annealed copper meeting requirements of ASTM B 33.

B. Conductors No. 8 AWG and larger shall be stranded.

C. Wire and cable shall be delivered to the job site in full coils or reels, each bearing a tag containing the UL approval stamp, name of manufacturer, trade name, code, type of wire, and month and year of manufacture.

D. All wire(s) to be used in this contract shall be manufactured in conformance with the National Electric Code, insulated for 600 volts, and be of the type THHN/THWN.

E. Wires and cables for maximum 600 VAC power circuits and control circuits shall be THHN/THWN. The insulating tape shall be of the self-bonding type.

F. The jacket type shall be of the waterproof type.

G. The Design-Builder shall use soapstone powder, or approved substitute, as lubricant for wire pulling.

H. The Design-Builder shall provide a sealing type of waterproof compound for painting of rubber tape.

I. Splices shall be mechanically secured by means of a standard tinned copper pressure type connector. Splice connectors for No. 10 AWG and smaller gauge solid conductors shall be insulated pressure twist-on nut type. Splice connectors for No. 8 AWG and larger gauge conductors shall be split bolt or compression type for making parallel or butt splices. Provide companion performed plastic insulating covers or tape equivalent to conductor insulation.

J. Provide solderless terminal lugs for stranded and multiple solid conductors at connection to terminals or use UL listed crimp tool compression style lugs.

K. Wire and cable shall have the following information surface printed at regular intervals throughout their entire length:

1. Manufacturer or trade name

2. Size of conductor

3. Type of insulation

4. Voltage classification

5. Color coding

6. Color coding shall be provided throughout the entire network for service, feeder, branch, control and low energy signal circuit conductors. Conductors shall have factory impregnated color throughout their entire length. Phase taping is not permitted. Color shall be green for grounding conductors, and white or gray for neutrals. The color of conductors shall be as follows or as otherwise directed by the Department:

480Y/277V Three Phase System: (If used)
PHASE A – brown
PHASE B – orange
PHASE C – yellow
NEUTRAL – gray
GROUND – green

208Y/120V Three Phase System:
PHASE A - black;
PHASE B - red;
PHASE C - blue;
NEUTRAL - white;
GROUND - green.

240/120V Single Phase System:
PHASE A - black;
PHASE B - red;
PHASE C - n/a;
NEUTRAL - white;
GROUND - green.

GROUNDING:

A. Conductors shall be copper, 98 percent conductivity, soft annealed copper meeting requirements of ASTM B 33.

B. Ground rods shall be sectional; segments shall be 0.75 inches in diameter and 10 feet in length with a steel core and copper jacket. Ground rods shall be of sufficient length to obtain a resistance to ground not to exceed 10 ohms. Ground rods shall be UL approved and supplied with clamps for connecting the grounding conductor to the rod. Quantity of ground rods shall be as required to obtain the specified ground resistance. Ground wire shall be exothermically welded to ground rods.

C. Grounding electrode conductors shall be insulated copper conductor. Size shall be in accordance with NEC Table 250-66.

D. Equipment grounding conductor shall be sized in accordance with NEC article 250-122.

E. Furnish an equipment grounding conductor to provide a continuous and effective grounding of all equipment throughout the entire electrical system. Extend ground conductor runs individually to the ground bus of the panel board.

CONCRETE FOUNDATIONS:

A. Concrete for foundations shall have a minimum compressive strength at 28 days of 3000 psi.

B. Anchor bolts for cabinet bases shall be cast into concrete foundations. Drilling and grouting of anchor bolts into concrete foundations shall not be permitted.

LUMINAIRES, LAMPS AND LIGHTING STRUCTURES:

A. Luminaire Construction

1. All luminaires shall be constructed, wired, and installed in compliance with all applicable National, State and Local Codes. Unless otherwise specified, each luminaire shall be listed by the Underwriters' Laboratories as suitable for application and location shown and shall conform to any additional regulations necessary to obtain approval for use in locations shown. If Underwriters' Laboratories listing of luminaire is waived, all electrical components shall be UL recognized.

2. Internal wiring of luminaires shall contain a minimum number of splices and all splices shall be made with approved connectors. Wiring and connectors shall be suitable for the current, voltage and temperature to which they will be subjected.

3. Luminaires shall be constructed with the minimum possible number of joints. Joints shall be made only by means of approved welded, brazed, screwed, or bolted construction methods. Soldered joints shall not be acceptable. No self tapping screws, bled metal tapping methods, or rivets shall be employed for fastening any parts which must be removed to gain access to electrical components requiring service or replacement, or for fastening any electrical component or support for same.

4. Ferrous metal parts, and supports of luminaires other than parts manufactured out of stainless steel, shall be completely rust-proofed after fabrication and before finishing coatings are applied. Mounting frames and all screws, bolts, nuts, and other fastening or latching hardware shall be zinc, cadmium, or equivalent plated unless otherwise specified.

5. Non-ferrous metal, cast or extruded parts of luminaires shall be close grained, sound and free from imperfections or discolorations. Cast or extruded parts shall be rigid, true to pattern, and of ample weight and thickness. Parts to be visible after installation on job shall be properly fitted, filed, ground, buffed, and chased to provide finished surfaces and joints free of imperfections. Finished thickness of all cast parts shall not be less than 1/8 inch.

6. Where anodized aluminum finishes are required, the aluminum shall be surface treated before anodizing. The final finish shall be uniform and even in appearance and free from surface imperfections. Color of all visible parts shall match.

7. Prior to painting, all parts shall receive proper cleaning and etched surface preparation to assure paint adherence and durability. Finish shall be uniform, even in appearance and free from runs and surface imperfections.

8. Luminaires shall be suitably sealed and/or gasketed to prevent access of moisture into electrical components or enclosing diffusers, lenses, or globes.

9. Unpainted aluminum parts of luminaires shall be anodized to protect against corrosion.

10. Where luminaires require porcelain enameled finish, such finish shall be free of crazing, cracking, and orange peeling and shall meet or exceed RLM standards in all respects. Porcelain coating shall be not less than 7.5 mils thick. Reflective surfaces shall be white, non yellowing, and with minimum reflectance of 85 percent.

11. Where stainless steel or non ferrous metal surfaces (other than reflectors) are to remain unpainted, or where steel surfaces are to be electroplated, unless otherwise specified, they shall be coated with a baked on clear lacquer. Where aluminum surfaces are anodized, the clear lacquer coating may be omitted.

12. Reflectors shall be free of ripples, tool marks and other surface imperfections.

13. Sockets for all luminaires shall be suitable for the specified lamps and shall be set so that lamps are positioned in an optically correct relationship to lenses, reflectors, baffles, etc.

14. Face trims fabricated in pieces for rectangular or square luminaires shall have mitered corners, continuously welded and smoothed before finishing. Lapping of trim metal shall not be acceptable.

15. Glass used for lenses, refractors, or diffusers shall be high impact and high heat resistant. Prisms or other optical configurations shall be formed sharp and true.

16. High intensity discharge lamp luminaires shall conform to the following:

    a. Screw base sockets shall have porcelain body with nickel plated bronze screw shell suitably attached and adequately reinforced to prevent tearing or distorting the shell when inserting or removing lamp. Sockets shall be rated minimum 660 watt, 250 volt or 600 volt (as required) for medium base and 1500 watt, 600 volt for mogul base.

    b. Ballasts and matched capacitors shall be supplied suitable for the electrical

characteristics of the supply circuits to which they are connected and for operating the specified lamps. Minimum power factor shall be 90 percent. They shall be UL recognized and rated suitable for installed operating temperatures.

c. Ballasts and capacitors mounted remote from luminaires shall be located and wired in accordance with the specific ballast manufacturer's recommendation.

d. Ballasts for outdoor use shall be equipped with weatherproof leads and capable of starting and sustaining the lamp arc down to the lowest outdoor temperatures encountered.

E. LED Navigation Lights:

1. Navigation lights shall be furnished and installed by the Design-Builder in accordance with Section 4.6.3 of the *Inspection, Maintenance and Construction Requirements* Performance Specification included in Part 3 of the Contract Documents.

2. Navigation lights shall be wired for LED lamps (green or red as specified) capable of operating at 120V. Lamps shall be vibration resistant and have a life of 100,000 hours.

3. Lamp housing shall be cast bronze.

4. All joints shall be sealed with weatherproof gaskets and non-hardening silicon sealer.

5. Lamp hardware shall be stainless steel.

6. Access shall be provided for service equipment inside the fixture head.

7. The lens shall be of permanent, rigid, heat-resistant glass, 8-inch diameter (177 mm I.D.) standard marine Fresnel type.

8. The lens shall be cushioned with shock absorbing gaskets to absorb direct impact and reduce damage to the lens.

9. Navigation lights to mark the edge of channel shall have a 180 degree red lens (channel margin light). Navigation lights to mark the center of the channel shall have a 360 degree green lens (channel center light). Each set of three (3) navigational lights shall be supplied with a backup power supply system.

10. Navigational lights shall meet all requirements of the U.S. Coast Guard and other regulatory bodies.

11. Manufacturer of the navigation lights shall have a minimum of five (5) years experience in the manufacture of navigation lights and shall make available replacement parts for ten (10) years. The Design-Builder shall submit to the Department for approval documentation of the manufacturer’s experience.

12. All navigation lights shall be individually inspected at time of final assembly and test.

13. Each navigation light shall be tagged "ACCEPTED" upon completion of inspection and a final inspection check list shall be included in the navigation light for validation of meeting internal Quality Assurance standards.

F. LED Navigation Lights Back-up Power Supply

1. Provide efficient, heavy duty, voltage and frequency controlled, auto-switching, emergency power source for navigation lights with an integrated heavy duty battery charger/regulator.

2. Electrical enclosure for power supply and battery shall be compression molded, flame-retardant, fiberglass reinforced polyester. Enclosure shall be chemically resistant to corrosive atmospheres.

3. The cover shall be removable from the enclosure and be padlockable with quarter turn door latches.

4. Enclosure shall be vented to provide adequate cooling in the power supply enclosure and ventilation of excess gasses in the battery enclosure.

5. Switching power supply shall be capable of a maximum sustained output of 2000 watts with a regulated output of 120 VAC with hardwire outlets. Upon failure of commercial power, the unit shall automatically switch over to an external battery source, and continue to supply voltage and frequency controlled 120 VAC, 60 Hz power to the navigation lights for as long as battery power is available.

6. Power supply shall sense low voltages on commercial power and switch over to the battery supply when needed. A built-in five second delay shall protect connected equipment when utility AC power returns by waiting five seconds for rolling over voltages to subside before reconnecting to utility power.

7. DC fuses shall be supplied to protect against overload during battery operation and accidentally reverse polarity during battery connection.

8. A remote module connector shall be standard on all power supplies; it shall allow for remote "ON/OFF" control as well as indicator light monitoring from a point distant from the power supply.

9. Battery and a weather-proof enclosure shall be supplied providing a minimum of 6 hours of continued operation of the navigational light system. The batteries shall be 12V, 115 amp-hour valve regulated lead acid batteries.

10. Luminaries shall have integral surge suppressors.

G. Aerial Beacon and Controller:

1. Aerial beacons shall be furnished and installed by the Design-Builder in accordance with Section 4.6.3 of the *Inspection, Maintenance and Construction Requirements* Performance

Specification included in Part 3 of the Contract Documents.

2. The aerial beacon shall be a dual white/red flashing medium intensity strobe that meets all requirements of the Federal Aviation Administration's (FAA) Advisory Circular 150/5345-43.

3. A power supply control cabinet, photocell, and strobe cable shall be provided with the aerial beacon.

4. Horizontal Coverage: 360°

5. Vertical Beam: 3° Min.

6. Fresnel Optics: 320 mm Lense

7. Lamp Description: 1 - Xenon flashtube and an array of LED's

8. Effective Candelas: 20,000 +/- 25% (day); 2,000 +/- 25% (night)

9. No. of flashes/minute: 40 (day) / 22 (night) +/- 2 FPM

10. Flashhead Dimensions: 28 in. x 17 ½ in. (approx.)

11. Flashhead Material: Acrylic

12. Flashhead Base Material: Aluminum/Blue Powder Coat

13. Operating Voltage: 120V

H. Maintenance Lights

1. Maintenance lights shall be furnished and installed by the Design-Builder in accordance with Section 4.7.1 of the *Inspection, Maintenance and Construction Requirements* Performance Specification included in Part 3 of the Contract Documents.

I. Aesthetic Lighting

1. Aesthetic lighting shall be designed, furnished, and installed by the Design-Builder in accordance with Section 4.8 of the *Inspection, Maintenance and Construction Requirements* Performance Specification included in Part 3 of the Contract Documents and shall be fully suited for use in a marine environment.

2. The aesthetic lighting mounting system shall include a mechanism for adjusting, aiming and locking the tilt and direction of the luminaire.

3. The luminaire system shall include a vibration dampening system to ensure the safe, continuous operation of the lighting.

4. The primary lens shall be impact and heat resistant. A water-tight system shall be provided

to eliminate condensation and prevent the intrusion of dirt and moisture within the light module and lens.

5. All exposed hardware shall be marine-grade stainless steel or corrosion-free composite materials.

6. The lighting system shall be capable of fully functioning when temperatures are between -20° F and 160° F.

7. Luminaire shall be IP-66 U.L. listed for protection against water. All hardware such as, but not limited to, hinges, latches, springs, nuts, screws, washers, pins and other similar parts shall be made of marine grade stainless steel which is inherently corrosion-proof in this application. All hinges and latches shall be made to withstand the vibrations and winds encountered in this application. All joints shall be gasketed to be watertight.

8. The luminaire and ballast enclosures shall each bear a nameplate or other type of indelible and aesthetically acceptable marking that shall identify it as to type, catalog number, manufacturer, wattage and voltage.

J. Path Lights

1. Pedestrian pathway luminaire suitable for use in a marine environment shall be furnished and installed by the Design-Builder. Luminaires shall be impact and heat resistant and safe for use near pedestrians.

2. The lamp cover shall be sealed, but still allow for easy re-lamping.

3. The luminaire and ballast enclosures shall each bear a nameplate or other type of indelible and aesthetically acceptable marking that shall identify it as to type, catalog number, manufacturer, wattage and voltage.

K. Replacement Units

1. Additional lighting units and/or replacement bulbs shall be furnished to the Department in accordance with Section 2.5 of the *Warranty Requirements* Performance Specification included in Part 3 of the Contract Documents. The Design-Builder shall coordinate with the Department's Project Manager for delivery of the lighting units to the Department, which will maintain the lighting units for storage. Lighting units shall be packaged or bundled appropriately in order to protect the units during storage.

ELECTRICAL CONTROL DEVICES

A. Timer for Aesthetic Lighting and Path Lights

1. Control for aesthetic lighting and path lights shall be digital 365-day astronomical timers with holiday and seasonal scheduling. Operating voltage shall be 120V. Timers shall be programmed to turn on at dusk and off at dawn unless otherwise directed by the Department.

2. The controller shall program in AM/PM format with one-minute resolution. The display shall be of LCD type. The controller shall be capable of 99 set points and separate scheduling for each day of the week. The controller shall have 365-day holiday capabilities with 24 single dates and 4 seasons of unlimited duration. Different daily schedules shall be programmable within each season. The controller shall have Daylight Savings time and automatic Leap Year correction. The controller shall be astronomic with 1 to 99 minutes +/- offset from Sunrise or Sunset. The unit shall have a NEMA Type 3R indoor/outdoor enclosure. The controller shall have permanent schedule retention for up to 40 years and a 30-day backup for real time using field replaceable 9V lithium battery. The controller shall be capable of manual override ON or OFF to the next scheduled event using one button.

C. Photoelectric Controls

1. A photocell shall be provided and installed with the aerial beacon and controller.

2. The photocell shall be in a sealed unit.

3. All necessary mounting hardware shall be furnished by the Design-Builder.

D. Switches

1. Electric switches shall have three terminals used to control a circuit from two different locations or four terminals used to control a circuit from two or more locations.

2. Switches shall be specification grade and have a non-metallic enclosure.

3. All switches shall be labeled with a name plate as to identify the lighting areas that the switch controls.

4. Switches shall be provided at all entry points to voided structure elements, at a minimum.

ELECTRICAL DISTRIBUTION EQUIPMENT

A. Contactors

1. Contactors shall be of the current ratings and number of poles specified in the Design-Builder's Electrical Plans. Contactors shall be held by permanent magnets.

2. Contactors shall be fully rated for all classes of load to 600 volts AC and shall have an interrupting rating of 600 percent of rated current.

3. Contactors shall be rated for ballast lighting loads.

4. A switch or astronomic timer shall actuate the control coil. Contactors actuated by an astronomic timer shall be electrically held.

B. Circuit Breakers

1. Circuit breakers shall be molded case type having a minimum rating of 10,000 amp interrupting capacity (AIC) and be quick make, quick break, thermal magnetic, trip

indicating, and have common trip on all multiple breakers with internal tie mechanism.

2. For circuit breaker frame sizes 125-amp and smaller, bolt-on circuit breakers shall be used.

3. The circuit breakers shall have the current and voltage ratings and number of poles as specified in the Design-Builder's Electrical Plans, and shall be treated to resist fungus and be ambiently compensated for the enclosure and proximity to adjacent breakers.

4. Circuit breakers in panel boards shall conform to Federal Specification W-C-375 and shall be bolted to copper busses.

C. Panel Boards

1. Panel boards shall conform to Federal Specification W-P-115 and shall be suitable for operation on the voltage and type service specified in the Design-Builder's Electrical Plans. They shall be UL listed and labeled.

2. Panel boards shall be equipped with the number and size of circuit breakers specified by the Design-Builder.

3. Bus ratings shall be as specified by the Design-Builder.

4. Lugs shall be compression style, suitable for number, size, trip ratings, and conductor materials.

5. Panel boards in the bridge electrical control room shall be NEMA 4X, capacity and voltage as required by the load and as specified by the Design-Builder. Panel to be 3-phase, 4-wire, 42 circuit. Panel boards shall have a copper bus, lockable door and shall be surface mount type. A minimum of 25% spare capacity and 20% spare breakers are to be provided.

6. Bridge Service Panel

   a. The main bridge distribution panel shall be suitable for use as service equipment. The size and amperage shall be as specified by the Design-Builder. The branch circuit breakers shall be the size and amperage as specified by the Design-Builder and be suitable to service the distribution panels located within the bridge.

   b. The main bridge service panel shall be mounted in a NEMA 4X pad mounted double door padlockable enclosure. Size shall be as specified by the Design-Builder.

   c. Panel boards shall have a copper bus, lockable door and shall be surface mount type.

7. Terminal Blocks shall be NEMA ICS 4, UL listed.

D. Receptacles

1. Receptacles for use by bridge maintenance personnel shall be GFCI duplex receptacles, rated 125 Volts, 20 amp, 3-wire with integral ground fault current interrupter and

weatherproof while-in-use cover.

2. GFCI receptacles shall detect and trip at a current leakage of 6 milli-amperes and shall have front mounted test and reset buttons. GFCI receptacles shall conform to UL Standards 943, Class A and NEC requirements for ground fault protection.

3. Receptacles shall be mounted in a rugged, die-cast aluminum NEMA 3R box rated suitable for wet locations. Box shall have a powder coated, corrosion-resistant finish.

E. Transformers

1. The Design-Builder shall coordinate with Delmarva Power and determine the number, size, and location of transformers to be provided. Transformers and pads shall be supplied and installed by Delmarva Power.

2. The Design-Builder shall contact the Delmarva Power representative specified in the Utility Statement included in Part 5 of the Contract Documents to coordinate the installation of the transformer and conduits.

3. The Design-Builder shall furnish and install 5 inch Schedule 40 PVC Conduit (gray in color) for the primary electric service.

4. Delmarva Power shall supply and install primary electric cable.

5. The Design-Builder shall furnish and install all conduit and cable for secondary electric services.

6. The Design-Builder shall furnish all required secondary conductor termination hardware.

F. Meter Socket

1. Meter pan shall be furnished and installed by the Design-Builder and shall be approved by the Utility Company.

2. Electric meter shall be mounted to the exterior of the bridge main service panel enclosure.

UTILITY HANGERS

A. The Design-Builder shall use a utility hanger system, as needed, to support conduits, boxes, luminaires, and all other electrical equipment. The utility hanger system shall consist of cast-in-place concrete inserts, metal framing members and accessories as required for mounting/supporting equipment.

B. The load and spacing on each hanger and/or insert shall not exceed the nominal resistance for any component of the support system, including the concrete and inserts that hold the support system. The Design-Builder shall submit structural calculations with the Working Drawings for the utility hanger system. The calculations may include, but are not limited to, a description of the design criteria, stress and deflection analysis, selection of framing members. The Design-Builder shall submit all shop/assembly drawings necessary to completely install the utility hanger system in

compliance with the Contract Documents. The Design-Builder shall submit all pertinent manufacturers published data, including, but not limited to, types, materials, finishes, gauge thickness, and hole patterns.

C. Concrete Inserts

1. Concrete inserts shall provide the minimum nominal resistances indicated on the Working Drawings. To inhibit concrete seepage, all inserts shall be provided with closure strips and end caps or foam filler. Anchors shall be spaced according to manufacturer's recommendations based on factored loads.

2. Manufacturer's standard brackets, inserts, and accessories designed for use with continuous concrete inserts may be used. Insert length and spacing shall accommodate all conduit sizes and equipment in the area as required by the NEC.

D. Supplementary Structural Supports

1. The Design-Builder shall provide supplementary structural supports and accessories as required, including, but not limited to, metal framing members, clamps, brackets, hanger rods, nuts and fittings.

2. Hangers and supports shall be sized to fit the outside diameter of conduit.

E. Material and Finish

1. Utility hangers shall be protected against corrosion and shall have all sharp burrs removed

F. Quality Assurance

1. The Design-Builder shall submit to the Department for approval proof that manufacturer has a minimum of 5 years experience in manufacturing metal framing systems of the types required. The manufacturer must certify in writing all components supplied have been produced in accordance with an established quality assurance program.

WEATHER SENSOR PUCKS

A. The Design-Builder shall provide all 4” multi-duct ITMS conduit as shown on Contract #25-073-02 Plan Sheet B-601 Plans to service the weather sensor pucks. Multi-duct conduit shall be provided over the entire bridge length on both the east and west sides.

B. Weather Sensor Pucks and wiring shall be furnished and installed by others.

Construction:

GENERAL

A. All equipment installations shall conform to NEC, local utility company requirements, and State and local laws and ordinances governing the work. All electrical work shall be accomplished under the direct supervision of a master electrician. All work performed shall be performed under the supervision of a master electrician. The Design-Builder shall obtain and pay for all permits, licenses

and inspection fees.

B. The Design-Builder shall furnish all labor, material, instruments, fuel, and power required to perform all necessary tests. All tests shall be to the complete satisfaction of the Department's Project Manager. All defective materials and/or workmanship discovered as a result of these tests shall be removed and replaced at the Design-Builder's expense and the test repeated.

C. Install raceways, fittings, boxes, and cabinets free from direct contact with reinforcing steel.

D. Provide fasteners, anchor bolts, anchorage items and supports as required to insure proper and rigid alignment. Attach equipment with stainless steel fasteners sized according to size and weight of equipment and thickness of supporting surfaces.

E. Make metallic conduit electrically and mechanically continuous and ground as required. Conduits shall be continuous between outlets, boxes, cabinets, and panels and shall enter and be secured to each box. Provide ground conductors in each conduit run.

F. Stored materials, even though approved before storage, may again be inspected by the Department prior to their use in work. Stored materials shall be located so as to facilitate their prompt inspection.

ELECTRICAL CONDUIT AND FITTINGS

A. Construction methods shall conform to the following Delaware Standard Specifications Subsections:

Under existing pavement, PVC	745.03 (b)
Under new pavement, galvanized and PVC	745.03 (c)

B. For underground installations, when multiple conduits are required, the Design-Builder shall install all conduits at the same time as the initial installation. Additional conduits may be stacked one on top of the other, side by side or in a matrix. The orientation shall be at the Design-Builder's discretion, but conduits shall not twist around one another. Conduits installed in the same slot, trench, or bore shall remain oriented the same in relation to one another throughout the conduit run.

C. Bends

1. Make changes in direction with bends and fittings. Field-made bend and offsets shall be made with a hand bender or conduit-bending machine.

2. Bending of conduits with a pipe tree or vise is prohibited. Flattened, dented, or deformed conduits are not permitted. Remove and replace the damaged conduits with new undamaged material.

3. Conduit runs shall have no more than the equivalent of three 90-degree bends or total 270 degrees of bend. Pull boxes shall be provided where shown on the Design-Builder's Electrical Plans and as required to meet the above requirement.

D. Connections

1. Conduit runs shall be made with as few couplings as standard length will permit.

2. Rigid steel conduit connections shall be threaded. Field cut threads of galvanized conduit shall be painted with an approved galvanizing repair paint prior to assembly.

3. Nonmetallic conduit shall be connected by a solvent welding process.

E. Conduit Terminations

1. Pull boxes or conduit bodies shall be used at conduit terminations.

2. Conduits terminating in cast iron junction boxes shall be threaded into hubs with bonding screws furnished and installed on the interior of the box.

3. Conduits terminating in junction boxes without hubs shall be secured with two lock nuts with an insulated grounding bushing furnished and installed.

4. Conduits terminating at concrete foundations and junction wells shall be secured as specified by the Design-Builder.

5. All ends of unused conduit shall be capped.

F. Cleaning and Capping

1. Prior to installation of conductors in any run, the conduit shall be checked for cleanliness and all obstructions removed. Each conduit run and all fittings shall be cleaned of all debris by a pull through mandrel type device inserted in the presence of the Design-Builder's Construction QC Manager.

2. All ends of conduits shall be capped by use of a manufactured cap or plug. Prior to the installation of wiring, manufactured caps or plug shall be removed and an insulated bonding bushing for galvanized rigid conduit or bell end fitting for PVC conduit installed.

3. Repair cuts, nicks and abrasions or replace damaged conduits as directed by the Design-Builder's Construction QC Manager.

G. Pull Wire

1. After installation, all conduits shall have a pull wire or cord installed. Pull wire or cord shall be made of corrosion resistant material with a minimum breaking strength of 200 lb.

H. Exposed Conduit

1. Exposed conduit runs shall be parallel to, or at right angles to, walls, slabs, etc.

2. Conduit shall be located to minimize accumulation of dirt.

3. Conduit shall be attached to steel, concrete, masonry, or timber by straps, clamps or hangers of an approved type made of stainless steel or galvanized malleable iron. Conduit shall be attached to utility hangers inside the bridge.

4. Spacing of attachments shall be per NEC conduit support requirements or as specified in the

Design-Builder's Plans.

5. Conduit shall be installed in such a manner as to avoid all obstructions and to preserve head room and keep openings and passageways clear.

I. Expansion Joints

1. Where conduits cross expansion joints in the structure, or where otherwise specified, expansion joint fittings shall be of the type that assures electrical continuity across the joint.

2. Expansion joints shall be installed in such a manner as to allow equalized movement for both expansion in hot weather and contraction in cold weather. Therefore the temperature at the time of installation shall be considered in the nominal positioning of the joint in the conduit and allowance for movement shall favor the opposite season.

3. Fittings and strap clamps shall be securely tightened and sufficient length shall be allowed for temperature movement.

4. Two or more expansion fitting may be placed in series with one another where required.

J. Multi-Duct Conduit

1. If a pull line is not already pre-installed in the conduit, Design-Builder shall jet in a pull line in new conduit prior to pulling inner duct. Design-Builder shall rod existing conduit to ensure that it is free of any obstructions before installing a pull line and pulling inner duct.

2. If a pull line is not already pre-installed in the inner duct, Design-Builder shall jet in a pull line in each inner duct after installing the inner duct. When installing more than one, inner ducts shall all be pulled in together and kept parallel with no twisting or tangling.

3. The pulling procedure and lubricant shall be as recommended by the manufacturer.

4. No splicing of inner duct shall be permitted between junction wells.

5. All runs must be continuous and unbroken

K. Sleeves

1. Set sleeves in cast-in-place concrete components as they are constructed, prior to concrete pour.

BOXES, ENCLOSURES, AND CABINETS

A. Install enclosures at indicated or approved locations in accordance with manufacturer's instructions and at convenient operating height such that unless shown otherwise, no manually operable device will be within 18 inches of the floor or higher than 6 ½ feet above the floor.

B. Adjust straight and plumb and fasten enclosures securely in place. Align securely and independently fasten each section of multi-section enclosures. Inside the bridge, install all enclosures, boxes, and cabinets on structural channel systems, such as strut.

C. Junction boxes for the multi-duct ITMS conduit shall be provided at a maximum spacing of 400 feet. ITMS junction boxes shall be accessible from the outside roadway shoulder in both the northbound and southbound directions on the bridge.

D. ITMS junction boxes shall be provided at mid-span of the main span of the bridge in both the east and west traffic barriers.

ELECTRICAL CABLE, WIRE, AND CONNECTORS

A. The Design-Builder shall provide adequate equipment satisfactory to the Department's Project Manager for installation of wire; and shall pull all wire through conduits in a manner which will not overstress, or stretch any wire, and shall use precautions so as not to score, cut, twist, or damage the insulation and/or the jacket.

B. In pulling the wire into conduits, where the strain on the wires is likely to be excessive, the Design-Builder shall use soapstone powder as lubricant.

C. Without exception, all wires in junction or fuse boxes, transformer bases, and service panels shall be provided with a sufficient slack; and shall be arranged in a neat and orderly manner.

D. After wires have been installed, and pending permanent connection or splicing, the end of each wire shall be carefully sealed using rubber tape, and painted with a sealing type of waterproof compound.

E. All wiring shall be furnished to give a neat and orderly appearance. Wires shall be supported on cable rack assemblies in all junction wells and junction well foundations. Wires in distribution cabinets shall be neatly arranged and laced with cable ties.

F. Where two or more wires occupy the same conduit, they shall be drawn in together and be kept parallel to each other by means of a pulling head. Phase legs shall be arranged circumferentially and in sequence around neutral wires.

G. Wires shall be spliced in junction wells or junction boxes as previously described. Splices shall then be wrapped with half-lapped layers of insulating tape installed in opposite directions. Several layers of half-lapped jacket tape shall be applied over the insulating tape. Two coats of waterproofing sealant shall be applied over the complete splice.

H. The Design-Builder shall install complete raceway system and clear debris and moisture before conductor installation. Provide sufficient slack in conductors. Conductors shall be identified by circuit number at all pull and junction boxes. Conductors terminating at terminal blocks shall be identified with numbers and/or letters identical to the circuit or control identification.

I. Conductor Identification

1. Power conductors terminating in the NEMA enclosure shall be identified at each end and in intervening junction and pull boxes. Where feeder conductors pass through a common box, tag the feeder to indicate the electrical characteristics and circuit number for terminals and on exposed portions of conductors within pull and junction boxes.

2. Wire markers shall be clop sleeve or sleeve type, made of PVC, nylon, or delrin, white in color, with black letters impressed in the material. On wire too large for the standard sleeve sizes, sleeve type markers shall be used, inserted on a cable tie and the tie then installed around the wire.

J. Check all wires for continuity and identification by beans of a D.C. test device with bell or buzzer or by means of battery operated phones before terminal connections are made.

K. Perform all insulation resistance tests on wiring after splices have been made but prior to making final terminations. Perform the tests with disconnecting devices in the open position to include only the circuits to be tested.

L. Perform insulation resistance tests on all feeders and subfeeders. This includes all cables to the final points of distribution (panel boards, and other incidental items). Measure and record the insulation resistance for each phase conductor to ground.

M. Perform the tests by utilizing a megger insulation tester with a full range scale from 0 to 200 megohms and using 1000 volts D.C. The minimum acceptable reading on any feeder is 20 megohms.

ELECTRICAL IDENTIFICATION

A. Identify and label each piece of equipment and conductor. Develop a schedule for labels showing the text of each as shown on the Drawings, schedules and by the nature of the system. In the absence of specific data, the Design-Builder shall develop text from the nature of the service or system and submit for approval by the Department's Project Manager. The text shall be arranged to produce a legible comprehensive identification system.

B. Path lights shall be labeled with the bridge segment identification inside the pedestrian railing post as well as at the junction box inside the bridge.

C. Switches shall be labeled with a name plate identifying the section of bridge lighting that the switch operates.

GROUNDING

A. Unless otherwise specified, ground all non-current carrying metallic parts of electrical equipment and the neutral of all wiring systems in accordance with the NEC and other applicable codes. Where equipment contains a ground bus, extend and connect grounding conductors to that bus. Run ground conductors inside conduits enclosing the power conductors.

B. Metallic Enclosures

1. Bond the grounding conductors to metallic enclosures at each end and to all intermediate metallic enclosures.

2. Make connections of grounding conductors to circuits 20 amps or above by a solderless terminal and a 5/16" bolt tapped to the equipment housing.

3. Ground connections to smaller equipment grounding system with groundings clips mounted

directly on the box or with 3/8" machine screws.

4. Remove all paint, dirt or other surface covering at grounding conductor connection points so that good metal-to-metal contact is made.

5. Test metallic conduit and raceways, equipment enclosures, metallic cable troughs, fences, handrailings, metallic structures and light standards for continuity to grounding system.

C. Non-Metallic Enclosures

1. One or more equipment grounding conductors brought into a non-metallic box shall be arranged so that a connection can be made to any fitting, device, switch, etc.

2. Grounding terminals shall be of the solderless type and approved as pressure-terminal connectors recognized for the wire size used.

D. Ground Rods

1. Test each ground rod to measure the earth resistance and report results to the Department's Project Manager. Tests must be conducted before the ground wire is permanently attached. Follow manufacturer's recommendations for measuring earth's resistance to ground.

2. The resistance must be less than 10 ohms. If the resistance is greater, then an additional ground rod(s) must be driven, temporarily connected to the first and retested.

3. Ground rods shall be joined to grounding wire by an exothermic weld after successful testing. The weld and exposed cable shall be painted with two coats of insulating varnish.

CONCRETE FOUNDATIONS

A. Non-standard bases shall be designed by the Design-Builder and depicted on the Electrical Plans. The actual bases shall conform to the dimensions shown on the Electrical Plans.

B. Provide fasteners, anchor bolts, anchorage items and supports as required to ensure proper and rigid alignment. Attach equipment with fasteners sized according to size and weight of equipment and thickness of supporting surfaces.

C. Anchor bolts shall be plumb. Suitable templates for setting anchor bolts shall be accurately placed and left in place until the concrete has attained its initial set.

D. All concrete shall be mixed, handled, placed, cured, and tested in accordance with all applicable requirements.

E. It is the intent that all foundations be poured against existing, undisturbed earth. Where the existing ground, however, will not retain its shape during excavating operations, or if the excavation should show any tendency to cave-in before pouring the foundation, a sleeve or form shall be provided to retain the earth and receive the concrete. Sleeves or forms shall be of the required size and shall be carefully placed.

F. Exercise care during concrete pour operations to avoid movement or displacement of reinforcing

cage or template-set anchor bolt template.

G. Precast concrete caps will not be permitted. The entire case shall be placed as a unit, forming a one-piece monolithic concrete structure.

H. No portion of the form or sleeve shall be left above the finished grade after concrete has cured.

I. Conduits entering the base must enter only in the designated area. A minimum distance of 1 inch shall be maintained between conduits and a minimum distance of 2 inches between conduits and the ground rods. A minimum of 10 feet of the ground rod shall be driven into undisturbed soil. The grounding conductor shall run in a 3/4 inch RGS sleeve into the enclosure.

UTILITY HANGERS

A. Utility hangers and concrete inserts shall be installed in accordance with manufacturer's recommendations and with recognized industry practices.

B. The Design-Builder shall inspect the work area prior to installation. If work area conditions are unsatisfactory, installation shall not proceed until satisfactory corrections are completed.

C. Installation shall be accomplished by a fully trained manufacturer authorized installer. During installation, it shall be the responsibility of the Design-Builder to protect this work from damage. Upon completion of installation, the Design-Builder is responsible for protecting the work from damage during the remainder of construction on the project.

D. Inserts shall be of a type which will not interfere with reinforcing or post-tensioning devices as shown on the Plans and which will not displace excessive amounts of structural concrete.

E. Plan, layout, and coordinate setting of inserts prior to concrete pour. Conduit support locations shall be as required by the NEC and as detailed in Shop Drawings.

F. Suitable concrete inserts for conduit and equipment hangers shall be set and properly located for all conduit and equipment to be suspended from concrete construction.

LUMINAIRES, LAMPS, AND LIGHTING STRUCTURES

A. General

1. Luminaires shall be installed complete with all equipment, materials, parts, attachments, devices hardware, hangers, cables, supports, channels, frames, and brackets necessary to make a safe, complete and fully operative installation. Manufacturer of each luminaire shall supply complete installation instructions including diagrams, illustrations, etc. The Design-Builder shall install in strict conformance with such instructions.

2. Luminaires, when installed, shall be set true and be free of light leaks, warps, dents or other irregularities.

3. Supports for luminaires shall be adequate for the weight of the luminaires. Where necessary, the Design-Builder shall provide extra supports from the structure at no additional cost.

4. The Design-Builder shall provide manpower and tools for final focusing, at no additional cost to the Owner, of all adjustable luminaires, including such focusing as may be necessary after regular working hours. This includes, but is not limited to, the focusing of all adjustable luminaires in the tie beam. Such focusing must be completed to the satisfaction of the Department's Project Manager.

5. Blemished, damaged, or unsatisfactory luminaires shall be replaced in manner satisfactory to the Department's Project Manager.

B. After installation has been completed and prior to the performance test, refractors and reflectors shall be cleaned with a product approved by the manufacturer.

C. Navigation lights sets shall be installed on the east and west sides of the bridge and in accordance with the manufacturer's recommendations and instructions. A back-up power supply shall be installed for each navigational light.

D. The aerial beacon and controller shall be installed at the apex of the bridge or the top of pylons and in accordance with the manufacturer's recommendations and instructions and FAA requirements.

E. The maintenance lights shall be installed throughout the bridge according to the Design-Builder's Plans and in accordance with the manufacturer's recommendations and instructions.

F. Aesthetic lighting shall be installed according to the Design-Builder's Plans and in accordance with manufacturer's recommendations and instructions.

G. Path lights shall be installed along the length of the bridge such that the lighting fixtures do not in any way interfere with the intended function of the pathway or railing. Path lights shall be installed according to the Design-Builder's Plans and in accordance with manufacturer's recommendations and instructions.

H. Check all lighting circuits for proper operation. Check lighting controls for proper operation.

I. Whenever practicable, test lighting systems at the same time that the distribution panel board or switchboard is tested.

ELECTRICAL CONTROL DEVICES

A. Timers

1. Timers for bridge lighting shall be installed in the electrical room in the bridge.

2. Timers shall be mounted to a metal framing system as indicated on the Design-Builder's Plans.

3. All timers shall be installed in accordance with manufacturer's recommendations and instructions.

B. The aerial beacon photocell shall be installed in accordance with manufacturer's recommendations and instructions.

ELECTRICAL DISTRIBUTION EQUIPMENT

A. Panel Boards

1. Install panel boards and accessories according to NEMA PB 1.1.

2. Comply with mounting and anchoring requirements specified by the Design-Builder in the Electrical Plans.

3. Mount plumb and rigid without distortion of box.

4. Install overcurrent protective devices and controllers.

5. Set field-adjustable switches and circuit breaker trip ranges.

6. Install filler plates in unused spaces.

7. Arrange conductors in gutters into groups and bundle with wire ties after completing load balancing.

B. Receptacles

1. Receptacles inside the bridge shall be mounted as shown by the Design-Builder in the Electrical Plans.

2. Connect receptacles to branch circuits using pigtails that are not less than 6 inches in length.

3. When conductors larger than No. 12 AWG are installed on 20 Amp circuits, splice No. 12 AWG pigtails for device connections. Where required, use a terminal block to tap down to a No. 12 AWG.

C. Transformers

1. Delmarva Power shall install the transformer and transformer pad at the location indicated.

2. The Design-Builder shall stub conduit at the transformer and at the switchgear (service location).

3. The Design-Builder shall furnish and install sufficient slack in the secondary conductors at the transformer for termination.

4. The Design-Builder shall furnish all required secondary conductor termination hardware for Delmarva Power.

6. Delmarva Power shall install the conductor terminators and terminate all conductors in the transformer.

7. Delmarva Power shall furnish and install primary electric.

D. Temporary Power

1. Should the Design-Builder deem temporary power necessary to aid in ease of construction, he shall be responsible for all coordination and costs associated with temporary power connections from the utility.

WEATHER SENSOR PUCKS

A. The Design-Builder shall install all ITMS multi-duct conduit as detailed on Contract #25-073-02 Plan Sheet B-601 for the weather sensor pucks.

B. Weather sensor pucks and associated wiring will be provided and installed by others.

TRENCHING AND BACKFILLING

A. Trenches shall be excavated in accordance with the DelDOT Standard Specifications and in accordance with the NEC.

B. In areas where conduit is trenched, a detector tape shall be placed in the trench at a depth of 6" below finished grade. The color of the tape shall be red. The tape shall be imprinted with a continuous warning message that reads "CAUTION: ELECTRICAL LINE BURIED BELOW" repeated every 36". The tape shall be inductively and conductively traceable using a standard pipe and cable-locating device.

C. The trench shall be backfilled and compacted. Material used for backfill shall be free of topsoil, organic, frozen or other undesirable material. Spaces to be backfilled shall be kept free of trash and shall be cleaned before backfill is placed. All backfill shall be compacted in layers not exceeding 6" loose thickness. Compaction shall be done with mechanical or vibratory compaction equipment to obtain at least 92% of maximum density and moisture content within 2% of optimum.

D. For work outside of the new construction area, restore grass, sidewalk and road to existing conditions upon completion of conduit installation.

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763503 - TRAINEE

Description:

The item shall consist of providing training in the construction crafts in accordance with the requirements stated in the General Notices of this proposal under the Standard Federal Equal Employment Opportunity Construction Contract Specifications (Executive Order 11246). The Design-Builder shall submit the training program(s) for review and approval prior to start of field work.

The Department will supplement the cost to the Design-Builder at a fixed rate of $.80 per hour toward the hourly rate of the trainee. Payment will be made based on the hours reflected in the Certified Payroll Reports for the hours the employee is engaged in the activities covered by the Department approved training program.

NE - 8/25/06

763508 Project Control System Development Plan (CPM Schedule)
763509 CPM Schedule Updates and/or Revised Updates

Progress schedules will be required for this contract. Progress schedules shall utilize the Critical Path Method (CPM). Attention is directed to the requirements of DB Section 105 as related to cooperation by the Design-Builder. Nothing in these special provisions shall be construed as relieving the Design-Builder from the responsibilities specified in DB Section 107, "Legal Relations and responsibility to the Public". All schedules are required to reflect a reasonable plan to execute the contract scope of work (both the design and the construction). The Design-Builder shall be solely responsible for the content of the schedule and the execution of all contract requirements.

The provisions in DB Section 108-2.1, "Progress Schedules" shall not apply.

DEFINITIONS

The following definitions apply to this section "Progress Schedule (Critical Path Method):"

A. Activity: Any task or portion of a project, which takes time to complete.
B. Baseline Schedule: The initial CPM schedule representing the Design-Builder's original work plan, as accepted by the Department.
C. Controlling Operation: The activity considered at the time by the Department, within that series of activities defined as the critical path, which if delayed or prolonged, will delay the time of completion of the contract.
D. Critical Path: The series of activities, which determines the earliest completion of the contract (Forecast Completion Date). This is the longest path of activities having the least amount of float.
E. Critical Path Method: A mathematical calculation to determine the earliest completion of the contract represented by a graphic representation of the sequence of activities that shows the interrelationships and interdependencies of the elements composing a project.
F. Contract Completion Date: The current extended date for completion of the contract shown on the most recent CPM update reviewed and accepted by the Department.
G. Early Completion Time: The difference in time between the current contract completion date and the Design-Builder's scheduled early forecast completion date as shown on the accepted baseline schedule, or schedule updates and revisions.
H. Float: The amount of time between the early start date and the late start date, or the early finish date and the late finish date, of any activity or group of activities in the network.
I. Scheduled Completion Date: The completion date of the last scheduled work activity identified on the critical path.
J. Free Float: The amount of time an activity can be delayed before affecting a subsequent activity.
K. Hammock Activity: An activity added to the network to span an existing group of activities for summarizing purposes.
L. Milestone: A marker in a network, which is typically used to mark a point in time or denote the beginning or end of a sequence of activities. A milestone has zero duration, but will otherwise function in the network as if it were an activity.
M. Revision: A change in the future portion of the schedule that modifies logic, adds or deletes activities, or alters activities, sequences, or durations.
N. Tabular Listing: A report showing schedule activities, their relationships, durations, scheduled and actual dates, and float.
O. Total Float: The amount of time that an activity may be delayed without affecting the total project duration of the critical path.

P. Update Schedule: The modification of the CPM progress schedule through a regular review to incorporate actual progress to date by activity and to reflect the current plan to complete the project.

Q. Time Scaled Logic Diagram: A schematic display of the logical relationships of project activities, drawn from left to right to reflect project chronology with the positioning and length of the activity representing its duration.

R. Bar Chart (Gantt Chart): A graphic display of scheduled-related information, activities or other project elements are listed down the left side of the chart, dates are shown across the top, and activity durations are shown as date-placed horizontal bars.

S. Near Critical Path: A path having 30 days or less of total float.

T. Delay: The time period during which some part of the construction project has been extended beyond what was originally planned due to unanticipated circumstances. A delay occurs when the respective activity or group of activities, requiring additional time, impacts the completion of the successor construction activity and also extend the scheduled contract completion date.

U. Data Date: The day after the date through which a schedule is current. Everything occurring earlier than the data date is "as-built" and everything on or after the data date is "planned."

V. Narrative Report: .A document submitted with each schedule that discusses topics related to project progress and scheduling.

W. Department Owned Float Activity: The activity documenting time saved on the critical path by actions of the Department. It is the last activity prior to the scheduled completion date.

X. Time Impact Analysis: A schedule and narrative report developed specifically to demonstrate what effect a proposed change or delay has on the current scheduled completion date.

The Department will schedule and conduct a Preconstruction Scheduling Conference with the Design-Builder's Project Manager and Construction Scheduler within seven days after the proposer has received the contract for execution. At this meeting, the requirements of this section of the special provision will be reviewed with the Design-Builder. The Design-Builder shall be prepared to discuss its schedule methodology, proposed sequence of operations, the activity identification system for labeling all work activities, the schedule file numbering system, calendars, etc.. The Department will submit a scheduling shell project on electronic medium, displaying an activity code dictionary consisting of fields populated with Department's scheduling codes, filters, layouts, report formats, contract milestones, and a resource dictionary. The Design-Builder shall utilize these codes, filters, layouts, etc. and may add other codes as necessary to group and organize the work activities. Periodically the Department may request the Design-Builder to utilize additional filters, layouts or activity codes to be able to further group or summarize work activities.

Also, the Department and the Design-Builder shall review the requirements for all design and construction submittals applicable to the contract and discuss their respective preparation and review durations. All submittals and reviews are to be reflected on the Interim Baseline Schedule and the Baseline Schedule.

GENERAL SCHEDULE ITEMS

The following items are applicable to all schedules:

A. Activity identification numbers for deleted activities are not to be reused. Added activities shall be assigned a new and unique activity identification number.

B. Activity descriptions are not to be revised when the scope of the activity is changed. The existing activity shall be deleted and a new activity shall be added.

C. When forecasting new durations for activities that have not started, the original duration field shall be revised.
D. All Resource requirements shall be included for all new design and construction activities.
E. All activities shall have durations of not more than 20 days and not less than one day unless permitted otherwise by the Department.
F. All activities in the schedule, with the exception of the first and last activities, shall have a minimum of one predecessor and a minimum of one successor.
G. Negative lags shall not be assigned for any activity relationships.
H. All out of sequence activities identified on the scheduling and leveling report shall be reviewed and their relationships either verified or changed.
I. The Design-Builder shall not add job inefficiencies or weather days to a project calendar without prior approval by the Department.
J. Offsite fabrication and material/equipment delivery activities shall be sufficiently detailed to allow monitoring of schedule progress.
K. The Design-Builder shall provide to the Department two copies of all schedules on electronic medium, together with printed copies of the network diagrams or bar charts and tabular reports described under "Project Schedule Reports", and the Schedule Narrative Report.

The Department's review and acceptance of schedules shall not waive any contract requirements, shall not imply that the schedules are reasonable in all aspects or that if followed they will result in timely completion of the project, and shall not relieve the Design-Builder of any obligation hereunder or responsibility for submitting complete and accurate information. Schedules that are rejected shall be corrected by the Design-Builder and resubmitted to the Department within 5 days of notification by the Department, at which time a new review will begin.

Errors or omissions on schedules shall not relieve the Design-Builder from finishing all work within the time limit specified for completion of the contract. If, after a schedule has been reviewed and accepted by the Department, either the Design-Builder or the Department discover that any aspect of the schedule has an error or omission, it shall be corrected by the Design-Builder on the next update schedule.

INTERIM BASELINE SCHEDULE

Within I5 days after approval of the contract, the Design-Builder shall submit to the Department an Interim Baseline Project Schedule which will serve as the progress schedule for the first 120 days of the project, or until the Baseline Schedule is accepted, whichever is sooner. The Interim Baseline Schedule shall utilize the critical path method of scheduling. The Interim Baseline Schedule shall depict how the Design-Builder plans to perform the work for the first I20 days of the contract. Additionally, the interim Baseline Schedule shall show all required submittals, working drawings, and review periods, and shall provide for all permits, and other non-work activities necessary to begin the work. The Design-Builder shall also submit a Summary Schedule, reflecting the duration of the contract, grouped by major areas of the project identified by the scheduling codes provided in the DelDOT scheduling codes or as defined by the Department. This summary schedule is for information purposes only and is to be used as a reference until the Baseline Schedule is accepted. It is understood that as the design of this project will not have been completed at the time of the submission of the Interim Baseline Schedule, a detailed construction schedule can not be provided. For the early schedule submittals the Design-Builder shall show construction activities in general categories of work. Then, as the design is completed, the Design-Builder shall provide the required schedule details for the specific construction activities.

The interim Baseline Schedule shall include the data files used to generate the schedule on electronic medium.

The Department shall be allowed 10 days to review the schedule and to provide comments, including the Design-Builder's application of the supplied activity codes. All comments are to be implemented into the Baseline Schedule. Re-submittal of the Interim Baseline Schedule is not required. Late review of the interim Baseline Schedule shall not restrain the submittal of the Baseline Schedule. No contract payments shall be made to the Design-Builder until an interim Baseline Schedule is submitted in accordance with the above requirements.

BASELINE SCHEDULE

Within 90 days, after execution of the contract, the Design-Builder shall submit to the Department a Baseline Project Schedule including the incorporation of all comments provided to the Interim Baseline Schedule. The Baseline Schedule shall have a data date of the day prior to the first day of work day of the contract. The schedule shall not include any actual start dates, actual finish dates, or constraint dates (except for Contract Milestone dates) and activities scheduled to start or finish between the data date and the run date shall reflect dates that can be attained. The Baseline Schedule shall meet interim milestone dates, contract milestone dates, stage construction requirements, internal time constraints, show logical sequence of activities, and must not extend beyond the number of days or the completion date originally provided for in the contract.

All task activities shall be assigned to a project calendar. Each calendar shall identify a workweek, and holidays. Different calendars shall be used for work activities that occur on different work schedules. Activities for the preparation and the review of submittals: offsite fabrication, and material/equipment deliveries are to be assigned to the same calendar unless approved by the Department. All non-activity periods for Environmental work restrictions shall he identified with the appropriate calendars. A minimum of seven (7) calendars shall be used and the first seven (7) shall be ordered and entitled as follows: 1) Full Schedule, 2) Winter Condition, 3) Concrete Paving, 4) Asphalt Base, 5) Asphalt Surface, 6) Asphalt Superpave, 7) Environmental.

The Baseline CPM Schedule submitted by the Design-Builder shall have a sufficient number of activities to assure adequate planning of the project and to permit monitoring and evaluation of progress and the analysis of time impacts. The Baseline Schedule shall depict how the Design-Builder plans to complete all design and construction work involved, and shall show all activities that define the critical path. Multiple critical paths and near-critical paths shall be kept to a minimum, as determined by the Department.

Department-owned float shall be considered a resource for the exclusive use of the State. The Department may accrue Department owned float by the early completion of review of any type of required submittal when it saves time on the critical path. The Department will document Department-owned float by directing the Design-Builder to update the Department-owned float activity on the next schedule update. The Design-Builder shall include a log of the action on the Department-owned float activity and include a discussion of the actions in the narrative report. The Department may use Department-owned float to mitigate past or future State delays by offsetting potential time extensions.

The Design-Builder shall be responsible for assuring that all work sequences are logical and the network shows a coordinated plan for complete performance of all design and construction work. Failure of the Design-Builder to include any element of work required for the performance of the contract in the network shall not relieve the Design-Builder from completing all work within the time limit specified for completion of the contract. If the Design-Builder fails to define any element of work, activity or logic, the Design-Builder in the next monthly update or revision of the schedule shall correct it.

The Baseline Schedule shall be supplemented with resource allocations for every task activity to a level of

detail that facilitates report generation based on labor craft and equipment class for the Design-Builder and subcontractors.

The Design-Builder shall optimize labor to reflect a reasonable plan for accomplishing the work of the contract and to assure that resources are not over committed in concurrent activities. The Design-Builder shall not create hammock activities for the purpose of resources loading. The Baseline Schedule shall not attribute negative float to any activity.

Along with the baseline progress schedule, the Design-Builder shall also submit to the Department time-scaled resource histograms of the labor crafts and equipment to be utilized on the contract.

Each schedule submitted to the Department will comply with all limits imposed by the contract, with all specified intermediate milestone and contract completion dates, and with all constraints, restraints or sequences included in the contract. The degree of detail shall include factors including but not limited to:

A. Physical breakdown of the project:
B. Contract milestones and completion dates, substantial completion dates, constraints, restraints, sequences of work shown in the contract, the planned substantial completion date, and the final completion date:
C. Type of work to be performed, the sequences, and the major subconsultants and subcontractors involved:
D. All purchases, submittals, submittal reviews, manufacture, fabrication, tests, delivery, and installation activities for all major materials and equipment:
E. Preparation, submittal and approval of shop and working drawings and material samples, showing time, as specified elsewhere, for the Department's review:
F. Identification of interfaces and dependencies with preceding, concurrent and follow-on contractors, railroads, and utilities as shown on the plans or specified in the specifications:
G. Identification of each and every utility relocation and interface as a separate activity, including activity description and responsibility coding that identifies the type of utility and the name of the utility company involved:
H. Actual tests, submission of test reports, and approval of test results:
I. All start-up, testing, training, and assistance required under the contract:
J. Punchlist and final clean-up:
K. Identification of any manpower, material, or equipment restrictions, as well as any activity requiring unusual shift work such as double shifts, 6-day weeks, specified overtime, or work times other than regular days or hours:
L. Identification of each and every ramp closing and opening event as a separate one day activity, including designation by activity coding and description that it is a north-bound, south-bound, east-bound, west-bound, and entry or exit ramp activity:
M. Separate resources graphs for the Design-Builder's labor, equipment and critical path labor with an accompanying analysis of each and explanation for any variances:
N. Equipment and labor shall be differentiated by a cost account code within the resource dictionary.
O. State owned float as the last activity in the schedule, at the end of which is the Scheduled Completion Date.

The Department will be allowed 30 days to review and accept or reject the baseline project schedule submitted. Rejected schedules shall be resubmitted to the Department within 5 days, at which time a new 15-day review period by the Department will begin.

PROJECT SCHEDULE REPORTS

Schedules submitted to the Department including Interim Baseline, Baseline, and update schedules shall include time scaled network diagrams or bar charts in a layout format requested by the Department. The network diagrams or bar charts submitted to the Department shall also be accompanied by four computer-generated mathematical analysis tabular reports for each activity included in the project schedule. The reports (8.5" x 11" size) shall include a network diagram report showing the activity columns only, a predecessor and successor report, a resource report (Interim Baseline and Baseline Schedules), and a scheduling and leveling calculation report. The network diagram reports shall include, at a minimum, the following for each activity:

A. Activity number and description:
B. Activity codes:
C. Original, actual and remaining durations;
D. Early start date (by calendar date):
E. Early finish date (by calendar date);
F. Actual start date (by calendar date);
G. Actual finish date (by calendar date):
H. Late start date (by calendar date);
I. Late finish date (by calendar date):
J. Identify activity calendar ID:
K. Total Float and Free Float, in work days: and
L. Percentage complete.

Network diagrams or bar charts shall be sorted and grouped in a format requested by the Department reflecting the project breakdown per the Department activity codes. They shall show a continuous flow of information from left to right per the project sorting and grouping codes; e.g., project milestones, submittals sub-grouped by description, and the construction activities sub-grouped by the scope breakdown structure. The primary paths of criticality shall be clearly and graphically identified on the diagrams or charts. The network diagram or bar chart shall be prepared on E-size sheets (36" x 48"), shall have a title block in the lower right-hand corner, and a timeline on each page. Exceptions to the size of the network sheets and the use of computer graphics to generate the network or bar charts shall be subject to the approval of the Department.

Schedule network diagrams the tabular reports shall be submitted to the Department for acceptance in the following quantities:

A. 2 sets of the Network Diagrams or Bar Charts:
B. 2 copies of the tabular reports (8.5" x 11" size): and
C. 2 copies on electronic medium, each with a backup of the current schedule file.

WEEKLY SCHEDULE MEETINGS

The Department and the Design-Builder shall hold weekly, or as determined by the Department, scheduling meetings to address any long-term schedule issues, and to discuss any relevant technical issues. The Design-Builder shall develop a rolling 4-week schedule identifying the previous week worked and a 3-week look ahead. It shall provide sufficient detail to include the actual and planned activities of the Design-Builder and all the subcontractors for offsite and construction activities, addressing all activities to be performed and to identify issues requiring engineering action or input.

Each activity in the 4-week rolling schedule should be identified by an associated CPM schedule activity ID numbering system. This schedule should not be hand written. The Design-Builder shall utilize a schedule layout as acceptable to the Department. The schedule shall be electronically submitted to the Department one day prior to the scheduled meeting date.

MONTHLY CASH FLOW REPORTS

The Design-Builder shall allocate a portion of the lump sum cost to the appropriate schedule activities. The total of all activity costs shall equal the total contract price. This information shall be sufficient to generate a monthly cash flow report showing the anticipated monthly contract progress payments. The format for the report shall be acceptable to the Department. Actual Progress Payments shall be made in accordance with DB Section 109, "Lump Sum Price, Progress and Payment".

MONHLY UPDATE SCHEDULES

The Design-Builder shall submit a monthly update Schedule to the Department once in each month within 5 days of the data date. The proposed update schedule prepared by the Design-Builder shall include all information available as of the 20th day of the month, or other data date as established by the Department. A detailed list of all proposed schedule changes such as logic, duration, lead/lag, forecast completion date, additions and deletions shall be submitted with the update.

The Monthly Update Schedule submitted to the Department will be accompanied by a Schedule Narrative Report. The report shall describe the physical progress during the report period, plans for continuing the work during the forthcoming report period, actions planned to correct any negative float, and an explanation of potential delays or problems and their estimated impact on performance, milestone completion dates, forecast completion date, and the overall project completion date. In addition, alternatives for possible schedule recovery, to mitigate any potential delay or cost increases shall be included for consideration by the Department. The report shall follow the outline set forth below:

Design-Builder's Schedule Narrative Report Outline:

A. Design-Builder's Transmittal Letter:
B. Work completed during the period:
C. Description of the current critical path:
D. Description of current problem areas:
E. Current and anticipated delays:
   1. Cause of the delay:
   2. Corrective action and schedule adjustments to correct the delay: and
   3. Impact of the delay on other activities, milestones, and completion dates:
F. Changes in design or construction sequences:
G. Pending items and status thereof:
   1. Permits;
   2. Change Orders:
   3. Time Extensions: and
   4. Non-Compliance Notices:
   5. Notice of Potential Claims:
H. Contract completion date(s) status:
   1. Ahead of schedule and number of days: and
   2. Behind schedule and number of days: and
I. Include updated Network Diagram and Reports.
J. Response to Previous Schedule Comments

Portions of the network diagram on which all activities are complete need not he reprinted and submitted in subsequent updates. However, the submitted schedule and the related reports shall constitute a clear record of progress of the work from award of contract to final completion.

On a date determined by the Department, the Design-Builder shall meet with the Department to review

the monthly schedule update. At the monthly progress meeting, the Design-Builder and the Department shall review the updated schedule and shall discuss the contents of the Narrative Report. The Department will be allowed 10 days after the meeting to review and accept or reject the update schedule submitted. Rejected schedules shall be resubmitted to the Department within 5 days, at which time a new 5-day review period by the Department will begin. All efforts shall be made between the Department and the Design-Builder to complete the review and the acceptance process prior to the next update schedule data date. To expedite the process, a second meeting between the Department and the Design-Builder may be held.

SCHEDULE REVISIONS

If the Design-Builder desires to make a change to the accepted schedule, the Design-Builder shall request permission from the Department in writing, stating the reasons for the change, and proposed revisions to activities, logic and duration. The Design-Builder shall submit for acceptance an analysis showing the effect of the revisions on the entire project. The analysis shall include:

A. An updated schedule not including the revisions. The schedule shall have a data date just prior to implementing the proposed revisions and includes a project completion date:
B. A revised schedule that includes the proposed revisions. The schedule will have the same data date as the updated schedule and include a project completion date:
C. The Design-Builder should add resources for all new activities, also adjust resources for those activities that their remaining duration were changed:
D. A narrative explanation of the revisions and their impact to the schedule:
E. Computer files of the updated schedule and the revised schedule sequentially numbered or renamed fur archive (record) purposes.

The Department will provide a response within 10 days to Design-Builder's proposed schedule revisions.

Within I5 days, the Design-Builder shall submit a revised CPM network for approval when requested by the Department, or when any of the following occurs:

A. There is a significant change in the Design-Builder's operations that will affect the critical path:
B. The current updated schedule indicates that the contract progress is 2 weeks or more behind the planned schedule, as determined by the Department: or
C. The Department determines that a previously accepted or anticipated change will impact the critical path, milestone or completion dates, contract progress, or work by other contractors.

The Department shall be allowed 10 days to review and accept or reject a schedule revision. Rejected schedule revisions shall be revised and resubmitted to the Department within 10 days, at which time a new 10-day review period by the Department will begin. Only upon acceptance of a change by the Department shall it be reflected in the next schedule update submitted by the Design-Builder. 'The revised schedule shall also include a narrative explanation of the revisions and their impact to the schedule.

TIME IMPACT ANALYSIS

When the Design-Builder requests a time adjustment due to contract change orders or delayed activities or if the Design-Builder or the Department considers that a previously accepted or anticipated change will impact the critical path or contract progress, the Design-Builder shall submit to the Department a written Time Impact Analysis illustrating the impact of each change or delay to the current contract completion date or milestone completion date, utilizing the current accepted schedule. Each Time impact Analysis

shall include a schedule update (an accepted schedule with a data date within the previous month of the event) reflecting the "before conditions", and schedule revision reflecting the "after condition", both with the same data dates, demonstrating how the Design-Builder proposes to incorporate the change order or delay into the current schedule. The schedule revision shall include the sequence of activities and any revisions to the existing activities to demonstrate the impact of the delay, or change into the schedule. The Time Impact Analysis shall also include proposed mitigation measures or work arounds including but not limited to alternate work calendars, re-sequencing of other activities, or performing work activities out-of-sequence to minimize the impact of the change order or the delayed activities.

Each Time Impact Analysis shall demonstrate the estimated or actual time impact based on the events of delay, the estimated or actual date of the contract change order work performance, the status of the design and/or construction at that point in time, and the event time computation of all activities affected by the change or delay. The event times used in the analysis shall be those included in the latest update of the current schedule in effect at the time the change or delay was encountered.

Time extensions will be granted only to the extent that equitable time adjustments for the activity or activities affected exceed the total or remaining float along the critical path of activities from the time of actual delay, or from the time the contract change order work is performed. Mitigation measures shall be included in the analysis. The Time Impact Analysis shall also consider the use of Department-owned float as a mitigation measure. Time extensions will not be granted nor will delay damages be paid unless:

A. The delay is beyond the control and without the fault or negligence of the Design-Builder and its subconsultants, subcontractors or suppliers, at any tier; and
B. The delays extend the actual performance of the work beyond the current established contract completion date.
C. The delay impacts a fabrication or construction activity – delays to the Design-Builder's submittal or shop drawing process must impact a successor fabrication or construction activities. The Time Impact Analysis shall be based on the impact to fabrication or construction activities.

The Design-Builder shall designate the number of adverse weather days in the chart as "non-work" days in their baseline schedule. Time extensions for extreme weather conditions, if appropriate, shall be based on the following chart:

Table 1: Monthly anticipated adverse weather delay based on a seven (7) calendar day week:

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
12	10	5	5	4	2	4	3	4	3	2	6

The above table is developed based on the daily weather report log as maintained by the Material and Research Section. Severe/adverse weather is defined as daily precipitation equal to or exceeding 0.25 inches and/or maximum daily temperature not exceeding 32 degrees F as recorded at the weather station located on site. Allowances for unsuitable wind condition will be made on a case-by-case basis. The Design-Builder shall submit justification to the Department for the maximum sustained wind speed he can work in based on his means and methods for a particular activity. Once approved, this will become the threshold that time extensions are measured against. It is expected that the Design-Builder's wind threshold will vary with construction activity; therefore, more than one submission may be required.

The Design-Builder shall make immediate written notification to the Department's Project Manager for each occurrence of any day that is unsuitable for prosecuting those items of work shown on the current CPM schedule. Time extensions will be granted only if the activity(s) representing the scheduled construction operations is on the critical path or becomes the critical path. When a scheduled activity(s) becomes the critical path, the allowable days for time extension will be reduced by days the activity(s) was not on the critical path. Inability to prosecute work not shown as activities in progress on the most

recent CPM schedule will not be considered when determining time extensions. The Department's Project Manager will have the final decision as to the number of calendar days the Design-Builder's work was limited to because of adverse weather.

Time Impact Analysis shall be submitted within 15 days after the delay occurs or after initiation of the contract change order. The schedule files will be submitted on electronic medium along with the Time Impact Analysis, which shall include a narrative description of the delay, its impact on contract completion or milestone dates and proposed mitigation measures. Mitigation measures utilized to minimize the impact of the change order or delay shall include but are not limited to work arounds, re-sequencing of work, alternate work calendars, increased resources, expedited procurement and use of State owned float.

A response to each Time Impact Analysis by the Department will be made within 15 days after receipt of the Time Impact Analysis. The Department's review shall utilize actual data unless it is appropriate to use estimated data. Resolution of each Time impact Analysis by the Department shall be completed after all effects of the disruption are documented, which may include mitigation measures. A copy of the Time impact Analysis accepted by the Department shall be returned to the Design-Builder and the accepted schedule revisions illustrating the impact of the contract change orders or delays shall be incorporated into the project schedule during the first update after acceptance. Until such time that the Design-Builder provides the analysis, the Department may, at their option, construct and utilize the project as-built schedule or other method to determine adjustments in contract time.

FINAL SCHEDULE UPDATE

Within 15 days after the acceptance of the contract by the Department, the Design-Builder shall submit a final update of the schedule with actual start and actual finish dates for all activities. This schedule submission shall be accompanied by a certification, signed by an officer of the company and the Design-Builder's Project Manager stating "To the best of my knowledge, the enclosed final update of the project schedule reflects the actual start and completion dates of the activities contained herein."

SOFTWARE

CPM software shall be Primavera Project Planner, version 3.1 or later and schedule analysis software should be Claim Digger or equivalent.

The computer software furnished shall he compatible with that used by the Design-Builder for the production of the CPM progress schedule required by the Contract, and shall include original instruction manuals and other documentation normally provided with the software.

The Design-Builder shall furnish, install, set up, maintain and repair the computer software ready for use at a location determined by the Department. The software shall be installed and ready for use within 30 days of the contract award. The Design-Builder shall provide 24 hours of formal training for up to four (4) people selected by the Department, in the use of the hardware and software to include schedule analysis, reporting, and resource and cost allocations. An authorized vendor of Primavera Project Planner shall perform the training.

All software furnished shall remain the property of the Design-Builder and shall be removed by the Design-Builder upon acceptance of the contract when no claims involving contract progress are pending. When claims involving contract progress are pending, computer software shall not be removed until the final estimate has been submitted to the Design-Builder.

PAYMENT

Progress schedule (critical path) will be paid for as part of the lump sum price per the requirements of DB Section 109, "Lump Sum Price, Progress and Payment". The Design-Builder shall establish a Project Component (PC) for the progress schedule (critical path) which shall include full compensation for all labor, materials (including computer hardware and software), tools, equipment, and incidentals: and for doing all the work involved in preparing, furnishing, updating and revising CPM progress schedules.
Payments for progress schedule (critical path) PC will be made as follows:

A. Interim baseline schedule accepted, then 10 percent payment for progress schedule (critical path) PC will be made.
B. Baseline schedule accepted, then 10 percent payment for progress schedule (critical path) PC will be made.
C. Monthly update schedules accepted, then an equal payment for each month will be made not to exceed a cumulative total of *75* percent payment for progress schedule (critical path) PC.
D. Final schedule update accepted, then *5* percent payment for progress schedule (critical path) PC will be made.

The Department will retain an amount equal to $50,000 for each estimate period in which the Design-Builder fails to conform to the provisions of this section, including failure to submit an interim baseline, baseline, revised or updated CPM schedule conforming to the requirements of this section, as determined by the Department. Retentions for failure to submit acceptable CPM schedules shall be in additional to all other retentions provided for in the contract. The retention for failure to submit acceptable CPM schedules will be released for payment on the next monthly estimate for partial payment following the date that acceptable CPM schedules are submitted to the Department.

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763588 - MAINTENANCE OF TRAFFIC

Description:

This item shall be used for construction activities that require traffic control, but will be performed outside the physical limits or time frames of the maintenance of traffic plans provided for the roadway contract.

All requirements of the traffic manual "Delaware Traffic Controls for Streets & Highways Construction, Maintenance, Utility & Emergency Operations (latest edition with all revisions made up to the date of Advertisement of this project and from hereon shall be addressed as the Traffic Manual) shall apply for all traffic control devices. Any, and all, control, direction, management and maintenance of traffic shall be performed in accordance with the requirements of the Traffic Manual, and notes on the Plans.

Materials and Construction Methods:

The Contractor and all of the Contractor's subcontractors working on this project shall submit to the Construction Engineer a traffic control Plan for the Department's approval before the start of work. The time restrictions as listed in the "Notice to Contractors" shall be applicable.

The Contractor shall be responsible for all traffic control devices except as specifically noted above, and shall perform all work in a manner that will insure the least practicable obstruction to traffic consistent with safety. Advanced coordination with the Department and other Contractors working in the area is required so there is no conflict or overlap with other maintenance of traffic set-ups in the area of work.

The Contractor shall provide and maintain ingress and egress for each property abutting the construction area and each property located between the diversion points of any detour and the actual construction site. Construction activities which may temporarily or otherwise interfere with property access shall be coordinated in advance with the affected property owners.

The Contractor shall conduct construction operations in a manner which will minimize delays to traffic, and shall meet the following requirements:

1. The flagger(s) shall direct the flow of traffic in concert with the traffic signals in construction areas to avoid queuing, unless active work prohibits such action.

2. When a lane adjacent to an open lane is closed to travel, the traffic control devices shall be set 2 feet (0.61 m) into the closed lane from the edge of the open lane, unless an uncured patch exists or actual work is being performed closer to the open lane.

3. Lanes shall not be closed unless construction activity requiring lane closure is taking place, or will take place within an hour; lanes shall be reopened immediately upon completion of the work. The Contractor shall conduct construction operations in a manner so as to minimize disruption to traffic during peak hours and periods of heavy flow. The Department reserves the right to stop or change the Contractor's operations, if in the opinion of the Engineer, such operations are unnecessary at that time or if they can be conducted in a manner with less impact on traffic.

4. Work in the vicinity of traffic signals, shall be scheduled to minimize the time during which the signal is operated without detectors, and approval of the Engineer shall be required for such schedule.

It is required that all traffic control work and related items shall either be performed entirely by the Contractor's own organization, or totally subcontracted. Maintenance of equipment shall not be subject to this requirement.

At the end of each work day, the Contractor shall correct all pavement edge drop-offs within 10 feet (3 m) of a travel lane to result in a drop-off of no more than 2 inches (50 mm). This corrective work shall be accomplished with Temporary Roadway Material (TRM) unless an alternate method is specified in the Plans. All ruts and potholes shall be filled with TRM by the end of each work day. If temporary elimination of a drop-off hazard cannot be accomplished, then the area should be properly marked and protected with traffic control devices such as temporary barricades, warning signs, flashing lights, etc. as required; the payment for TRM materials and the traffic control devices shall be made under the respective items of the Contract.

All the operations shall be properly signed with notice of "Pavement Drop-Off" and/or "Uneven Pavement".

All construction signs and barricades shall meet the applicable standards for reflectorization as required in the Traffic Manual.

When specified on the Plans, the Contractor shall be required to have an American Traffic Safety Services Association (ATSSA) certified traffic control supervisor on the project. The ATSSA certified traffic control supervisor's sole responsibility will be the maintenance of traffic on the project. This responsibility shall include the installation, operation, maintenance and service of traffic control devices. Also included is the keeping of a daily log to record maintenance of traffic activities i.e. number and location of traffic control devices; and times of installation, changes, and repairs to traffic control devices. He/she shall also serve as the liaison with the Department concerning the Contractor's maintenance of traffic.

All cost for providing the services of an ATSSA certified traffic control supervisor shall be included in this item.

Certification:

Temporary traffic control devices used on all highways open to the public in this State shall be crashworthy in accordance with the National Cooperative Highway Research Program (NCHRP) Report 350 and the memorandum issued August 28, 1998 by The USDOT Federal Highway Administration **Information:** Crash Tested Work Zone Traffic Control Devices. It is the requirement of the Department that such certification be submitted for traffic control devices used on **all** projects, not just those involving the National Highway System.

In brief, certification of compliance with NCHRP report 350 is required for the following categories of traffic control devices:

Category I contains small and lightweight channelizing and delineating control devices which includes cones, tubular markers, flexible delineator post and drums, all without any accessories or attachments.

Category II includes traffic control devices that are not expected to produce significant vehicular velocity changes to impacting vehicles. These devices which shall weigh 45 kg or less, include Type I, II and III barricades, portable sign supports with signs, and intrusion alarms. Also included are drums, cones, and vertical panels with accessories or attachments.

Category III includes traffic control devices that are expected to cause significant vehicular velocity changes to impacting vehicles. These devices which weigh more than 45 kg include temporary barrier, temporary impact attenuators, and truck-mounted attenuators.

Category IV includes portable or trailer-mounted devices such as arrow panels, variable message signs, temporary traffic signals and temporary area lighting.

The requirements for certification are as follows:

Category I - All devices shall be certified as conforming to NCHRP Report 350 criteria.

Category II - All new devices shall be certified as conforming to NCHRP Report 350 criteria.

Category III - All new temporary barrier devices shall be certified as conforming to NCHRP Report 350 criteria.

Category IV - Certification of compliance to NCHRP Report 350 criteria is not required.

For DelDOT administered projects the certification shall be submitted to the Engineer prior to installation or use of traffic control devices. For Category I devices, the manufacturer or contractor may self-certify that the devices meet NCHRP-350 criteria. For Category II and Category III devices, the Contractor shall supply the Federal Highway Administration's NCHRP-350 acceptance letter for each type of device.

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