NEW HAMPSHIRE
Route 3A, Bristol

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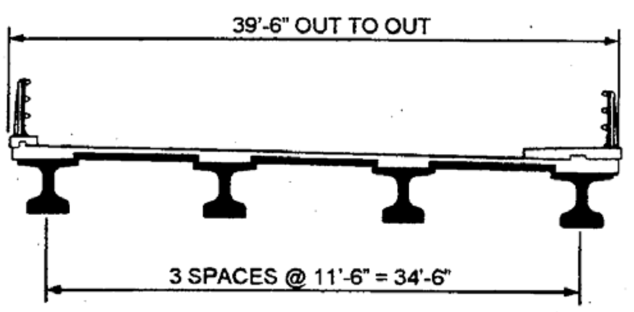
1. DESCRIPTION



The bridge received the 2000 PCI Design Award for the Best Bridge With Spans Less Than 65 Feet.

Location:	Route 3A over Newfound River, Bristol
Open to traffic:	June 1999
Environment:	Normal over water
HPC Elements:	Girders, precast panels, and cast-in-place deck
Total Length:	60 ft
Skew or Curve:	None
Girder Type:	NE 1000 bulb tee
Girder Span Length:	One at 60 ft
Girder Spacing:	11 ft-6 in
Girder Strand Grade:	270
Girder Strand Dia.:	0.6 in
Max. No. of Bottom Strands:	26
Deck Thickness:	9-in composite section with 3.5-in-thick precast deck panels and 5.5-in-thick cast-in-place concrete
Deck Panels	
—Length:	8 ft
—Thickness:	3-1/2-in-thick precast, prestressed
—Strand Grade:	270
—Strand Dia.:	3/8 in

2. BENEFITS OF HPC AND COSTS

A. Benefits of HPC

The use of HPC in the recently developed New England bulb-tee girders allowed the designers to achieve wider girder spacings and to use a shallower girder than if conventional strength concrete had been used. One line of girders was eliminated through the use of higher strength concrete in the girders. The bridge employed precast, prestressed concrete deck panels as stay-in-place deck formwork that became composite with the cast-in-place deck. The use of panels aided the contractor in spanning across the wider girder spacing and minimized construction time. Greater durability with reduced long-term maintenance will be derived by using HPC in both the girders and the deck.

B. Costs

Not available.

3. STRUCTURAL DESIGN

Design Specifications:	AASHTO Standard Specifications for Highway Bridges 1996 with Interims
Design Live Loads:	HS 25-44 as modified for 125% military loading
Seismic Requirements:	AASHTO Seismic Performance Category A
Flexural Design Method:	AASHTO Standard Specifications 9.15
Maximum Compressive Strain:	0.003
Shear Design Method:	AASHTO Standard Specifications 9.20
Fatigue Design Method:	None
Lateral Stability Considerations:	Galvanized intermediate steel diaphragms. Concrete diaphragms at each end
Allowable Tensile Stress	
—Top of Girder at Release:	$7.5\sqrt{f'_{ci}} = 556$ psi
—Bottom of Girder after Losses:	0 psi
Prestress Loss:	48,800 psi
Method Used for Loss:	AASHTO Standard Specifications 9.16.2.1
Calculated Camber:	1-1/8 in at release 2 in at erection 1-1/2 in after casting deck
Concrete Cover	
—Girder:	40 mm
—Top of Deck:	3 in clear before grooves are cut
—Bottom of Precast Panel:	1-3/4 in to center of strand
—Other Locations:	2-1/2 in
Properties of Reinforcing Steel	
—Girder:	AASHTO M 31 (ASTM A 615) Grade 60, epoxy coated
—Precast Panels:	AASHTO M 31 (ASTM A 615) Grade 60, uncoated
—Cast-in-Place Deck:	AASHTO M 31 (ASTM A 615) Grade 60, epoxy coated
Properties of Girder Strand	
—Grade and Type:	Grade 270, low relaxation
—Supplier:	—
—Surface Condition:	Free of nicks, kinks, dirt, rust, oil, and grease
—Pattern:	4 strands debonded
—Transfer Length:	50 diameters = 30 in x 1.2 = 36 in
—Development Length:	1.6 l_d = 155 in

Properties of Panel Strand	
—Grade and Type:	Grade 270, low relaxation
—Supplier:	—
—Surface Condition:	—

4. SPECIFIED ITEMS

A. Concrete Properties

	Girders	Precast Panels	CIP Deck
Minimum Cementitious Materials Content:	—	—	658 lb/yd^3
Max. Water/Cementitious Materials Ratio:	—	—	0.38
Min. Percentage of Fly Ash:	—	—	—
Max. Percentage of Fly Ash:	—	—	—
Min. Percentage of Silica Fume:	—	—	7.5
Max. Percentage of Silica Fume:	—	—	7.5
Min. Percentage of GGBFS:	—	—	—
Max. Percentage of GGBFS:	—	—	—
Maximum Aggregate Size:	—	3/4 in	3/4 in
Slump:	5-7 in	5-7 in	2-3 in
Air Content:	5%, minimum 3.5%	5-8%	5-9%
Compressive Strength			
—Release of Strands:	5500 psi	4000 psi	—
—Design:	8000 psi at 28 days	6000 psi at 28 days	6000 psi at 28 days
Chloride Permeability: (AASHTO T 277)	≤ 1500 coulombs at 56 days	≤ 1500 coulombs at 56 days	≤ 1000 coulombs at 56 days
ASR or DEF Prevention:	—	—	—
Freeze-Thaw Resistance:	—	—	—
Deicer Scaling:	—	—	—
Abrasion Resistance:	—	—	—
Other:	Corrosion inhibitor at 4 gal/yd^3 Type II or III cement		Corrosion inhibitor at 4 gal/yd^3

B. Specified QC Procedures

Girder Production	
Curing:	—
Internal Concrete Temperature:	160 ^{o}F
Cylinder Curing:	Match curing until release followed by storage with the girder
Cylinder Size:	4x8 in
Cylinder Capping Procedure:	Sulfur caps
Cylinder Testing Method:	AASHTO T 22
Frequency of Testing:	Two cylinders/girder at release, 3 days, 7 days, and 28 days
Other QA/QC Requirements:	Test placement of 10-ft long unreinforced girder section
Panel Production	
Curing:	120 – 140 ^{o}F until a concrete strength of 4000 psi obtained
Internal Concrete Temperature:	Maximum of 90 ^{o}F at time of placement
Cylinder Curing:	—
Cylinder Size:	—
Cylinder Capping Procedure:	—
Cylinder Testing Method:	—
Frequency of Testing:	—
Other QA/QC Requirements:	—
Cast-in-Place Deck Construction	
Curing:	Dry cotton mats placed within 10 minutes after concrete is finished. Cotton mats to be kept wet for 7 days by soaker hoses or other approved system.
Cylinder Curing:	—
Cylinder Size:	—
Flexural Strength:	—
Other QA/QC Requirements:	5 cu yd trial placement

5. CONCRETE MATERIALS

A. Approved Concrete Mix Proportions

	Girders	Precast Panels	CIP Deck
Cement Brand:	Blue Circle	Blue Circle	Ciment Quebec
Cement Type:	II	II	Blended (1)
Cement Composition:	See page 40	See page 40	See page 40
Cement Fineness:	—	—	—
Cement Quantity:	550 lb/yd^3	752 lb/yd^3	660 lb/yd^3 (1)
GGBFS Brand:	Newcem	—	—
GGBFS Quantity:	200 lb/yd^3	—	—
Fly Ash Brand:	—	—	—
Fly Ash Type:	—	—	—
Fly Ash Quantity:	—	—	—
Silica Fume Brand:	Rheomax SF100	—	Ciment Quebec
Silica Fume Quantity:	50 lb/yd^3	—	52 lb/yd^3 (1)
Fine Aggregate Type:	Sand	—	—
Fine Aggregate FM:	2.70	2.70	2.80
Fine Aggregate SG:	2.65	2.65	2.69
Fine Aggregate Quantity:	1200 lb/yd^3	1080 lb/yd^3	1190 lb/yd^3
Coarse Aggregate, Max. Size:	3/4 in	3/4 in	3/4 in
Coarse Aggregate Type:	—	—	—
Coarse Aggregate SG:	2.63	2.63	2.69
Coarse Aggregate Quantity:	1750 lb/yd^3	1790 lb/yd^3	1815 lb/yd^3
Water:	242 lb/yd^3	270 lb/yd^3	253 lb/yd^3
Water Reducer Brand:	—	Polyheed 997	Daracem 65
Water Reducer Type:	—	A and F	A
Water Reducer Quantity:	—	70 fl oz/yd^3	19.8 fl oz/yd^3
High-Range Water-Reducer Brand:	Rheobuild 3000 FC	Rheobuild 1000	Daracem 100
High-Range Water-Reducer Type:	A and F	A and F	F and G
High-Range Water-Reducer Quantity:	80 fl oz/yd^3	70 fl oz/yd^3	105.6 fl oz/yd^3
Retarder Brand:	—	—	—
Retarder Type:	—	—	—
Retarder Quantity:	—	—	—
Corrosion Inhibitor Brand:	DCI S	DCI S	DCI S
Corrosion Inhibitor Type:	Calcium nitrite	Calcium nitrite	Calcium nitrite
Corrosion Inhibitor Quantity:	4.0 gal/yd^3	4.0 gal/yd^3	4.0 gal/yd^3
Air Entrainment Brand:	Darex II	Darex II	Daravair 1000
Air Entrainment Type:	Organic acid salts	Organic acid salts	Saponified rosin
Air Entrainment Quantity:	5 fl oz/yd^3	5 fl oz/yd^3	4.5 fl oz/yd^3
Water/Cementitious Materials Ratio:	0.30	0.36	0.38

(1) Cement and silica fume were preblended. Total cementitious materials were 660 lb/yd^3.

B. Measured Properties of Approved Mix

	Girders	Precast Panels	CIP Deck
Slump:	7-1/4 in	—	—
Air Content:	5.7%	—	—
Unit Weight:	144.1 lb/ft^3	—	—
Compressive Strength:	9400 psi at 28 days	—	—
Chloride Permeability: (AASHTO T 277)	1100 coulombs at 56 days	—	—

6. CONCRETE MATERIAL PROPERTIES

A. Measured Properties from QC Tests of Production Concrete for Girders

Cement Composition:	See page 40
Actual Curing Procedure for Girders:	Steam cured at 120 to 130 °F for 22 hours
Average Slump:	7 in
Maximum Girder Temperature:	—
Air Content:	3.5%
Unit Weight:	148.6 lb/ft^3
Average Compressive Strength:	6800 psi at release 11,200 psi at 28 days
Curing Procedure for Cylinders:	Match curing

B. Measured Properties from QC Tests of Production Concrete for Precast Panels

Cement Composition:	See page 40
Actual Curing Procedure for Panels:	Steam cured at 120 °F for 12 hours
Average Slump:	6 in
Average Air Content:	5.7%
Average Unit Weight:	155.6 lb/ft^3
Average Compressive Strength:	4456 psi at 21 hours 6300 psi at 3 days 8335 psi at 28 days
Curing Procedures for Cylinders:	—

C. Measured Properties from QC Tests of Production Concrete for Cast-in-Place Deck

Cement Composition:	See page 40
Actual Curing Procedure for Deck:	Cotton mats placed within 10 minutes of surface finishing followed by 7 days wet curing with soaker hoses
Average Slump:	5.25 in
Average Air Content:	6.0%
Average Unit Weight:	147.4 lb/ft^3
Average Compressive Strength:	5800 psi at 4 days 7100 psi at 7 days 9004 psi at 28 days
Curing Procedure for Cylinders:	—

D. Measured Properties from Research Tests of Production Concrete for Girders

Slump, Air Content, and Unit Weight:

Property	Girder Nos.	
	1 and 2	3 and 4
Slump, in	7	7
Air Content	3.5	3.5
Unit Weight, lb/ft^3	148.4	148.8

Compressive Strength:
(ASTM C 39)

Age, days	Compressive Strength (2), psi	
	Girder Nos. 1 and 2	Girder Nos. 3 and 4
1	6644	7022
3	9493	8334
7	10,660	9824
14	11,674	10,044
28	12,092	10,739
62	12,371	11,337

(2) 4x8-in cylinders match cured and then stored with girders.

Chloride Permeability:
(ASTM C 1202)

Girder Nos.	Chloride Permeability (3), coulombs
1 and 2	237
	428
3 and 4	300
	591

(3) Tests were made at 57 days for girders 1 and 2 and 56 days for girders 3 and 4.

E. Measured Properties from Research Tests of Production Concrete for Precast Panels

Not available.

F. Measured Properties from Research Tests of Production Concrete for Cast-in Place Deck

Slump:	5 in
Air Content:	6.1%
Unit Weight:	142.7 lb/ft^3
Compressive Strength (4):	5759 psi at 4 days
(ASTM C 39)	7001 psi at 7 days
	7822 psi at 14 days
	8506 psi at 28 days
	9120 psi at 56 days

(4) 4x8-in cylinders.

Chloride Permeability: (ASTM C 1202)	1083 and 1036 at 56 days

7. OTHER RESEARCH DATA

Live Load Tests:

Following completion of the bridge, a load test was performed to measure the performance of the HPC deck system by slowly moving a truck across the instrumented section of the deck. The front axle group of truck weighed 16,000 lb and the rear tri-axle group weighed 60,000 lb. Strains in the cast-in-place concrete were measured at five locations along two transverse lines. One line was located above the centerline of a precast panel at midspan of the bridge. The second line was located 4 in away from the edge of a panel near midspan of the bridge. The strain gages were oriented to measure concrete strains caused by transverse bending of the deck slab between two adjacent beams.

Strains measured along the panel centerline had very similar values to strains measured near the edge of the panel. The preliminary conclusion by the investigators was that the deck system was apparently behaving the same in the middle of a deck panel as it was at the joint between deck panels. Since the variation of strain transversely from midspan of the deck to over the centerline of the girders was linear, the investigators concluded that the deck was acting more as a simply supported beam than a continuous beam.

Cracking:

An inspection of the bridge was made approximately one year after the cast-in-place deck was cast. On the underside of the bridge, transverse cracks were observed in two of the 21 deck panels. On the top surface of the deck, five longitudinal cracks were observed. Four of these cracks were located at the ends of the bridge above the abutments. One crack was located towards midspan. Other than numerous small chips observed near the saw-cut grooves in the deck, the bridge deck was reported to be in excellent condition.

8. OTHER RELATED RESEARCH

Not available.

9. SOURCES OF DATA

Sampo, V. and Cook, R. A., "An Evaluation of the High Performance Concrete Deck System on the Route 3a Bridge over the Newfound River in Bristol, New Hampshire," Draft Report, University of New Hampshire, Department of Civil Engineering, October 25, 1999, 28 pp.

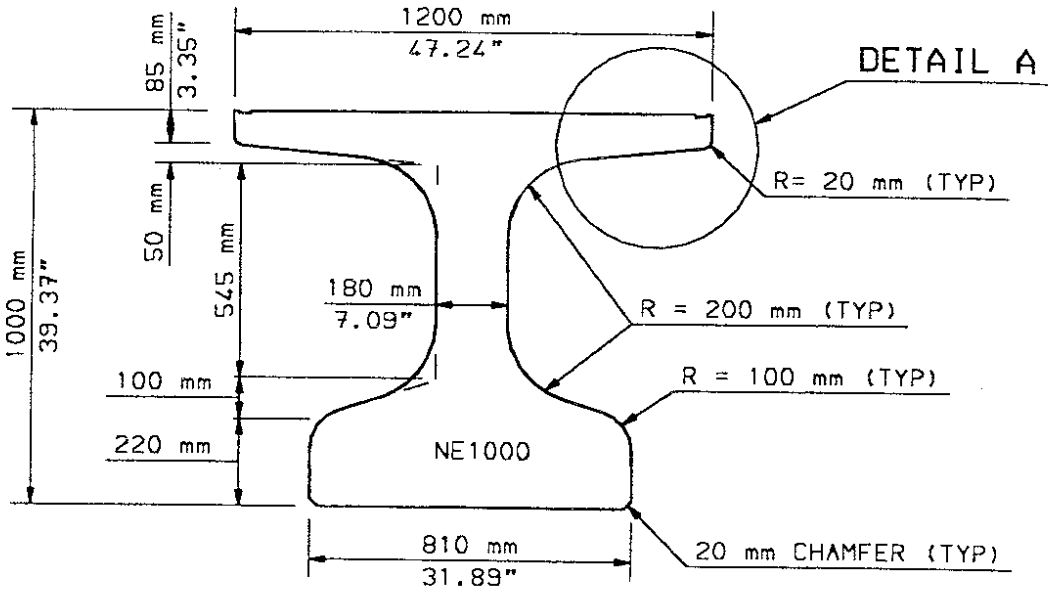
SHRP High Performance Concrete Bridge Showcase Notebook, Waterville Valley, New Hampshire, September 22-23, 1997.

Mark D. Whittemore, New Hampshire Department of Transportation, Concord, NH.

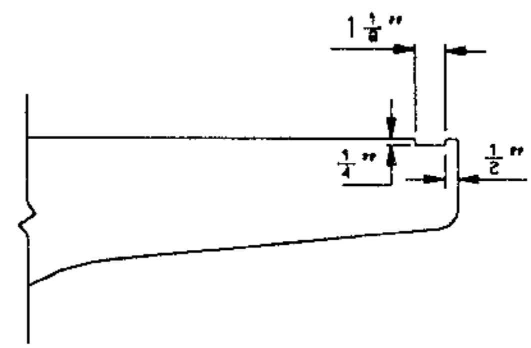
Raymond A. Cook, University of New Hampshire, Durham, NH.

Vincent Sampo, The Louis Berger Group, Inc., Manchester, NH.

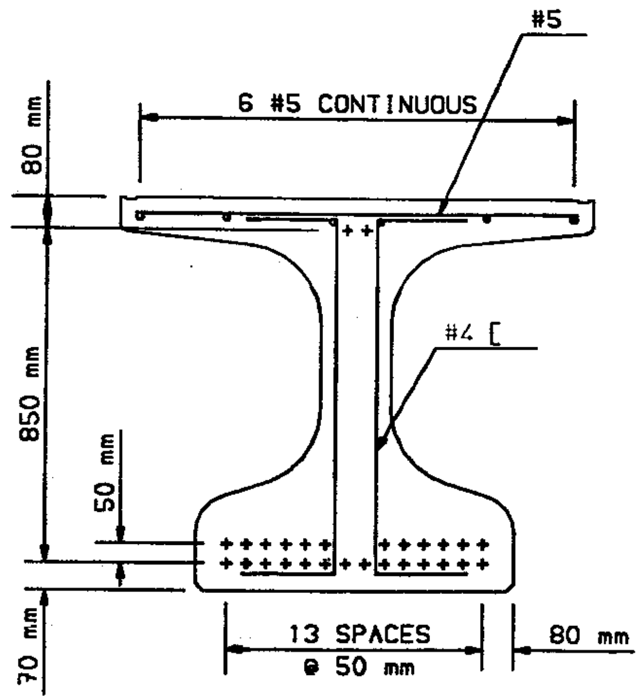
10. DRAWINGS



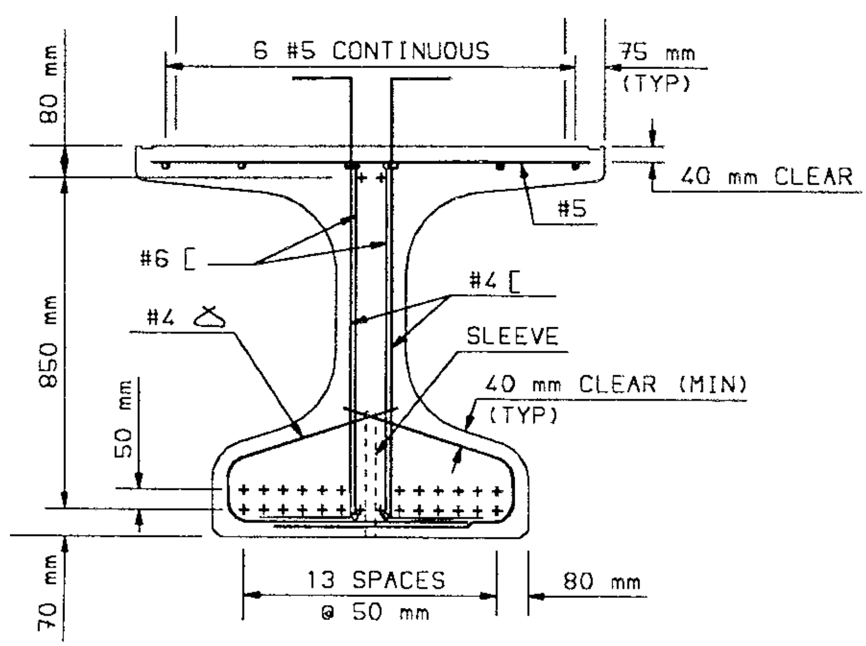
NE 1000 Bulb Tee



Detail A



Midspan Reinforcement



End Reinforcement

11. HPC SPECIFICATIONS

BRISTOL
P-4380

June 26, 1998

SPECIAL PROVISION

AMENDMENT TO SECTION 520 -- PORTLAND CEMENT CONCRETE

Item 520.7003 Concrete Bridge Deck - HPC

Add to 1.1:

1.1.1 The work consists of furnishing, placing, and curing structural portland cement concrete for use in a high performance concrete (HPC) bridge deck.

Add to 1.2:

CLASS	PSI	LBS	PERMEABILITY COULOMBS	MAXIMUM W/C	PERCENT ENTRAINED AIR
AA(6)	7200	658	1000	0.38	5 to 9

(6) 7 1/2% of total cement shall be silica fume.

Add to 2.2:

2.2.5 Silica Fume shall conform to AASHTO M307, Microsilica for use in Concrete and Mortar.

2.2.5.1 Silica Fume supplied in bagged form shall not be used.

Add to 2.6:

2.6.5 Cotton mats shall consist of a filling material of cotton "batting" (minimum 400 grams/square meter); covered with unsized cloth (minimum 200 gram/square meter); tufted or stitched to maintain stability; shall be free from tears; and shall be in good condition.

Amend 2.11.2 to read:

2.11.2 Thirty (30) days prior to the start of work a HPC mix design appropriate for the raw materials, admixtures, and blends of approved aggregates shall be submitted to the Bureau of Materials and Research for approval. No work shall be started on the project until the concrete mix design is approved. The HPC mix design shall contain the following:

Compressive Strength
Amount of Cement (lbs/cy) (bags/cy) (including pozzolan additives)
Fine and Coarse Aggregate Gradation
Air Content
Water/Cement Ratio
Chemical Admixtures (types, Brand names, dosage ranges)
Laboratory test results (Strengths, Air Content, W/C ratios, Slump)

Delete 2.11.3

Amend 3.1.1.7:

3.1.1.7 Corrosion inhibitor admixture shall be added at a rate of 4 gallons per cubic yard.

Amend 3.1.3.2. by deleting the following:

The (*) after (c) Curing box for concrete cylinders, and all the paragraphs following the referenced (*).

Add to 3.1.6:

3.1.6.3 At least two weeks prior to the deck slab placement, a preplacement meeting shall be held to review the specification, outline the deck instrumentation and monitoring plan, and facilitate coordination between all the parties involved. Individuals attending this meeting should include the Project Engineer, Contractor, Concrete Supplier, representatives from the Departments' Bureau of Bridge Design and Materials & Research, and representatives from the University of New Hampshire.

3.1.6.4 A minimum 5 cubic yard trial mixture using the approved mix design shall be placed in a form simulating actual pouring conditions at the project site utilizing the proposed methods of placing, finishing, and curing. This trial pour shall occur at least one week prior to the actual deck placement.

Add to 3.5.1:

3.5.1.2.1 Concrete shall not be placed in the deck forms until researchers have installed the testing probes (thermocouples and wiring) in the deck.

Add to 3.5.2:

3.5.2.6 For placement of the cotton mats, a workbridge completely independent of the finishing machine and capable of riding on the screed rails, shall be used. The workbridge shall have sufficient rigidity to adequately support construction personnel without excessive deflection.

Delete the second sentence of 3.5.3.1

Add to 3.5.3:

3.5.3.7 No concrete shall be placed if the evaporation rate is greater than 0.1 lb./SF/HR as determined by Chart #1 or if the ambient air temperature is above 85°F.

3.5.3.8 No concrete shall be placed if the ambient air temperature is below 50°F. Ambient air temperatures during the cure period shall be 50°F or higher. Should the temperature drop below 45°F during curing, measures shall be taken to insure that the temperature of the concrete is maintained at or above 45°F for the cure period.

Add to 3.9.2:

3.9.2.1.1 The self-propelled finishing machine shall be capable of forward and reverse motion and a type approved by the District Construction Engineer. The finishing machine shall be equipped with a vibrating pan to consolidate the concrete, a power driven strike-off auger, a power driven finishing roller, and a pan float. The vibrating pan shall vibrate at a frequency between 2500 and 7000 vpm.

3.9.2.5.1 For concrete deck surfaces specified to be sawn after the concrete achieves the required strength, the Contractor shall provide the concrete with a gritty textured final surface finish. This finish shall be achieved by dragging a multiple-ply damp fabric transversely across the deck surface immediately behind the screed machine.

3.9.2.5.2 The addition of water to the surface of the concrete to assist in the finishing operation will not be permitted.

3.9.2.5.3 Bullfloating will not be allowed except as needed to correct irregularities or close an unacceptably open surface.

Amend 3.9.2.6 to read:

3.9.2.6 The finished surface, before texturing, shall be uniformly smooth, dense, and even. Variations in concrete surface in excess of 1/8 inch, above or below the proper finished elevation, or surface irregularities of more than 1/8 inch in 10 feet, will not be accepted.

3.9.2.6.1 The concrete surface shall be checked at random by the Engineer with an approved straight-edge not less than 10 feet long. The straight-edge shall be furnished by the Contractor and shall be of good, usable condition.

Amend 3.10.1 to read:

3.10.1 Concrete bridge deck exposed surfaces shall be cured by the wet mat curing method. This curing method shall consist of keeping the concrete continuously wet by maintaining wet cotton mats in direct contact with the concrete for a period of 7 days. Dry cotton mats conforming to 2.6.5 shall be placed on the damp concrete surface and wetted down immediately.

3.10.1.1 The cotton mats shall be placed immediately after the concrete surface is dragged. Failure to apply the cotton mats within 10 minutes after the concrete is finished will be cause for rejection of the work as determined by the Engineer.

3.10.1.2 The cotton mats shall be kept continuously wet for a period of 7 days by means of soaker hoses or other approved continuous wetting systems.

Add to 3.12:

3.12.2 All shrinkage cracks shall be treated as directed by the Engineer.

Add to Construction Requirements:

3.13 Instrumentation: Researchers shall have free access for the purposes of installing instrumentation and monitoring deck concrete at all times. These instruments will be used to monitor the internal temperature, and the concrete deck deflection due to creep, shrinkage, and live loads.

3.13.2 Appendix B, attached to the end of the specification, gives detailed information for the deck instrumentation plan. The Contractor shall take the necessary steps to prevent damage to the instrumentation and cooperate with the research team during installation of the sensors and data collection. It is not anticipated that these activities will cause significant delays or work stoppages.

Amend 5.2 to read:

5.2 Concrete bridge deck - HPC will be paid for at the contract lump sum complete in place.

Add to pay items and units:

520.7003	Concrete Bridge Deck - HPC	Unit

EVAPORATION RATE CHART (insert this page)

APPENDIX B

DETAILS FOR DECK INSTRUMENTATION PLAN

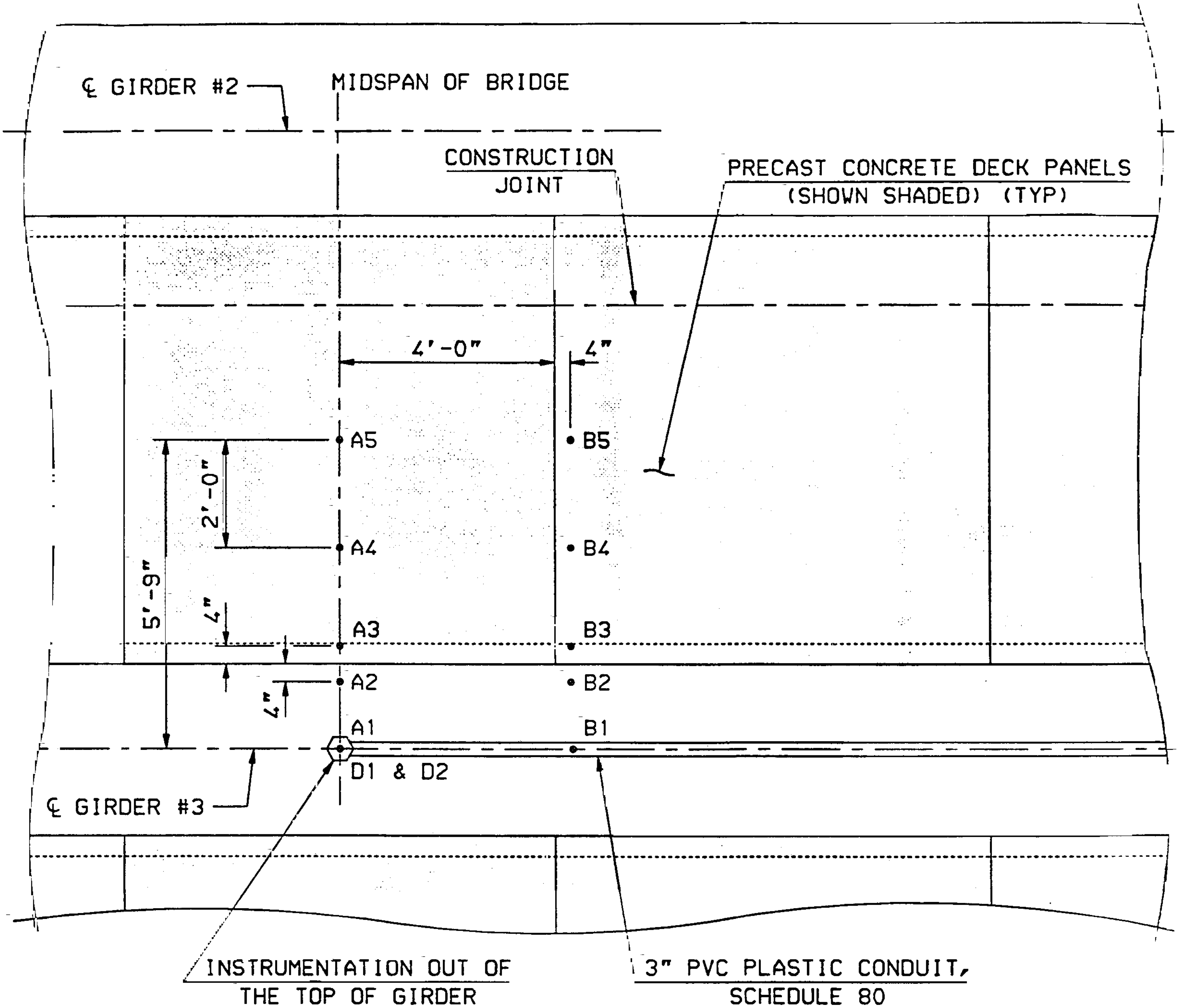
The deck will be instrumented for internal temperature and strain data collection. Embedded sensors will be used to monitor behavior of the deck from the time of concrete placement to several years after construction is completed. Instrumentation will consist of the following:

I. Strain gages to measure the long-term strains within the deck. The gages will be used to determine strains resulting from elastic shortening, creep, and shrinkage and will give an indication of the stresses within the deck due to dead load and live load. The strain gages also come equipped to measure the internal concrete temperature at the gage location. The temperature measurement will be used to determine (1) the level of heat of hydration during the curing process, (2) the temperature gradient in the deck after bridge construction, and (3) the temperature during data compilation.

A. Two gages will be placed at midspan of the bridge directly above the instrumentation within girder #3. One gage will be placed 1" below the top surface of the deck and the second gage will be placed 8" below the top surface. These two gages will be positioned in the longitudinal direction of the bridge.

B. Eight gages will be placed near midspan of the bridge as shown on the accompanying sheet. All these gages will be positioned 1" below the top surface of the deck in the transverse direction of the bridge.

C. Data acquisition will begin as soon as the concrete is placed. Readings will be taken periodically during construction and will continue after the bridge is completed..



INSTRUMENTATION LAYOUT

SCALE: 3/8" = '-0"

A1 THRU A5: STRAIN GAGES POSITIONED 1" BELOW TOP SURFACE DECK
B1 THRU B5: STRAIN GAGES POSITIONED 1" BELOW TOP SURFACE DECK
D1: STRAIN GAGES POSITIONED 1" BELOW TOP SURFACE OF DECK
D2: STRAIN GAGES POSITIONED 8" BELOW TOP SURFACE OF DECK

SPECIAL PROVISION

SECTION 528 -- PRESTRESSED CONCRETE MEMBERS

ITEM 528.11 -- PRESTRESSED CONCRETE MEMBERS - HPC

Description

1.1 This work shall consist of manufacturing, storing, transporting, and erecting precast pretensioned, concrete I-girders and bulb-tee girders, herein referred to as "members", in accordance with the contract plans. The relevant provisions of the AASHTO Standard Specifications for Highway Bridges shall be adhered to unless such provisions are in conflict with this specification.

Materials

2.1 Concrete

2.1.1 Concrete shall be controlled, mixed, and handled as specified in the pertinent portions of 520 unless otherwise specified herein.

2.1.2 HPC Mix Design. The Contractor shall design and submit for approval the proportions and test results for a concrete mix which has attained the following: a minimum average compressive strength of 9400 psi at 28 days for 3 test cylinders when sampled in accordance with the requirements of AASHTO T 141, molded and cured in accordance with the requirements of AASHTO T 23, and tested in accordance with the requirements of AASHTO T 22; a rapid chloride ion permeability of 1500 Coulombs or less measured at 56 days using AASHTO T 277.

2.1.2.1 Sixty (60) days prior to the start of girder fabrication, the HPC mix design shall be submitted to the Bureau of Materials and Research for approval. No concrete shall be placed within the girders until the concrete mix design is approved. The HPC mix design shall contain the following:

Compressive Strength (as specified in 2.1.2)
Amount of Cement (lbs/cy) (bags/cy) (including pozzolan additives)
Fine and Coarse Aggregate Gradation
Air Content (target value as specified in 2.1.3 or higher)
Water/Cement Ratio
Chemical Admixtures (types, Brand names, dosage ranges)
Laboratory test results (Strengths, Air Content, W/C ratios, Slump)

The Contractor shall submit three 4" dia. x 8" high cylinders to the Bureau of Materials & Research at least fifty (50) days prior to girder fabrication to use for permeability testing. Cylinders shall be submitted between the ages of 5 to 11 days to be tested at 14 days.

2.1.2.2 Should a change in sources of material be made, a new mix design shall be established and approved prior to incorporating the new material. When unsatisfactory results or other conditions make it necessary, the Engineer will require a new mix design.

2.1.3 The slump of the concrete shall be between 5 and 7 inches with high range water-reducing admixture. Air entrainment shall be targeted at a value of 5 percent with an absolute minimum of 3.5 percent required. Testing shall be in accordance with AASHTO T 119 and T 152.

2.2 Cement shall be standard portland cement, AASHTO M 85, Type II or III. Unless otherwise approved in writing, all cement used in the manufacture of the members in any one structure shall be from the same mill and of the same type.

2.3 Aggregate. The maximum size of course aggregate used shall be as specified for Concrete Class AA in 520.

2.4 Admixtures.

2.4.1 W. R. Grace, DCI, DCI-S, or approved equal, corrosion inhibitor (calcium nitrite) admixture shall be used at a rate of 4 gallons per cubic yard, <u>if specified on the plans</u>.

2.4.2 All other admixtures shall meet the requirements of 520.

2.5 Water. Water for use in the concrete shall meet the requirements of 520.

2.6 Prestressing Steel.

2.6.1 Prestressing steel shall be uncoated, seven-wire, stress-relieved strand, as called for on the plans and as specified herein, conforming to the requirements of AASHTO M 203 (ASTM A 416) Grade 270 low-relaxation.

2.6.2 The Contractor shall furnish without charge certified copies of a representative load-elongation curve test report for each size and grade of strand, for lots of 10 tons or fraction thereof.

2.6.3 The Contractor shall furnish a certified mill test report for each heat and coil of wire used in the production of the strand.

2.6.4 Each manufactured reel of prestressing steel strand to be shipped shall be assigned an individual lot number and clearly tagged for accurate identification. Such identification shall not be removed from the reel or strand until the reel is entirely used or until end-use fabrication has been completed.

2.7 Reinforcing steel shall conform to the requirements of 544.

2.8 Welded deformed steel wire fabric shall conform to the requirements of AASHTO M 221 (ASTM A 497).

Construction Requirements

3.1 General.

3.1.1 Design stresses are closely controlled, however, the behavior in service depends upon the specified concrete being properly placed in forms of the correct dimensions around accurately positioned prestressed strand.

3.1.2 Specifications. Fabrication, transportation and erection of prestressed concrete members shall conform to the requirements of the AASHTO Standard Specifications for Highway Bridges, Division II, Section 8-Concrete Structures and Section 10-Prestressing, and PCI MNL-116, Manual for Quality Control for Plants and Production of Precast and Prestressed Concrete Products, except as modified by this special provision, whichever is the most stringent.

3.1.3 Approval. Prior to performing any work under 528, the Contractor must have received approval for all shop drawings and any special contract requirements. The Contractor shall bear full responsibility and costs for all materials ordered or work performed, prior to approval of the shop drawings or written authorization from the Engineer.

3.1.4 Special Contract Requirements.

3.1.4.1 Pre-Placement Meeting. At least forty-five (45) days prior to girder fabrication, a pre-placement meeting shall be held to review the specification, outline the girder instrumentation and monitoring plan, and facilitate coordination between all the parties involved. Individuals attending this meeting should include the Project Engineer, Contractor, Fabricator, representatives from the Departments' Bureau of Bridge Design and Materials & Research, and representatives from the University of New Hampshire.

3.1.4.2 Sure Cure System. The Contractor shall utilize the Sure Cure Cylinder Mould System, or approved equivalent system, to temperature match cure test cylinders sampled in accordance with AASHTO T 141, molded in accordance with AASHTO T 23 and tested in accordance with AASHTO T 22 for use to determine successful test placement section and for use as a basis for acceptance of girder concrete.

3.1.4.2.1 Match cured cylinders (4" dia. x 8" high) shall be produced using the sure cure system. The cylinders shall be connected to the system's temperature matching controller for the initial curing period. Once the girders are stripped and detensioned or the test section stripped, the cylinders shall be subsequently stripped from their molds and stored alongside the girder or the test section until they are scheduled to be tested.

3.1.4.2.2 The system's reference thermocouple shall be located in the center of the bottom bulb of the girder section, or as otherwise directed by the Engineer. The thermocouple extension wire shall protrude up out of the top of the top flange and shall be connected to the system's temperature matching controller.

3.1.4.3 Test Section. At least thirty (30) days prior to girder fabrication, a test placement (10 feet in length) of the actual girder section (unreinforced) shall be poured utilizing the proposed methods of concrete placement and curing. The air entrainment target value of 5 percent shall be held as an absolute minimum value for the test section.. Concrete not meeting the air content target value shall not be incorporated into the test placement. Slump as required per 2.1.3 shall be maintained

3.1.4.3.1 The Contractor shall submit to the Bureau of Materials & Research results of temperature match cured cylinders (a set of two, averaged to comprise one strength test) tested for strength at the following intervals (15 hours, 24 hours, 3 days, 7 days, and 28 days) for determination of a strength versus time plot for the test placement section.

3.1.4.3.2 The Contractor shall obtain two cores in accordance with AASHTO T 24 from the web of the test section and test them for strength at 28 days to verify the in place concrete strength of the test section. The cores shall be taken no earlier than two days prior to conducting the actual test. Results of the core strength tests shall be submitted to the Bureau of Materials & Research.

3.1.4.3.3 Rapid Chloride Permeability testing will be completed by the Bureau of Materials & Research in accordance with AASHTO T 277 at an age of 56 days or later. The Contractor shall obtain two additional cores from the web of the test section and submit the cores to the Bureau of Materials & Research for permeability testing. The Contractor shall also submit two additional match cured cylinders from the test placement to the Bureau of Materials & Research for permeability testing.

3.1.4.3.4 Approval to proceed to girder fabrication will be provided by the Bureau of Materials & Research and shall be contingent on successfully achieving a minimum of 8000 psi in each of the match cured cylinders and cores tested at 28 days. If unsatisfactory results occur or conditions arise to hinder the outcome of the tests, the Engineer will require a new test section placement, with modifications as deemed necessary, to be poured and successfully tested.

3.1.5 Girder Concrete Strength Testing.

3.1.5.1 The Contractor shall submit to the Bureau of Materials & Research results of temperature match cured cylinders (a set of two, averaged to comprise one strength test) tested for strength at the following intervals (at release, 3 days, 7 days, and 28 days) for determination of a strength versus time plot for each girder cast.

3.1.5.2 Acceptance of the concrete within each girder will be based on successfully achieving a minimum average compressive strength of 8000 psi at 28 days for the two match cured test cylinders.

3.1.6 Girder Concrete Permeability Testing.

3.1.6.1 Rapid Chloride Permeability testing will be completed on each girder by the Bureau of Materials & Research in accordance with AASHTO T 277 at an age of 56 days or later. The Contractor shall submit one match cured cylinder from each girder to the Bureau of Materials & Research for permeability testing.

3.1.6.2 The average rapid chloride permeability of the girder concrete shall be 1500 Coulombs or less. Average rapid chloride permeability values above 3500 Coulombs will deem the girder concrete unacceptable and the girder will be rejected. A positive pay adjustment will be made for permeability results below 1500 Coulombs and a negative pay adjustment will be made for permeability results between 1500 and 3500 Coulombs.

3.2 Qualification of the Fabricator.

3.2.1 Certification. The precast concrete manufacturing plant shall be certified by the Prestressed Concrete Institute Plant Certification Program. The Contractor shall submit proof of certification prior to the start of production. For straight strand members certification shall be, as a minimum, in category B3. For draped strand members certification shall be in category B4.

3.2.2 Minimum Requirements. All plants/shops fabricating material for the Department shall have the personnel, equipment, and resources capable of producing a product equal to a PCI certified plant and shall satisfy the following minimum requirements:

3.2.2.1 Engineering/drafting. The Fabricator shall have trained, knowledgeable, and experienced drafting personnel available who can produce and check legible, complete, and accurate shop detail drawings.

3.2.2.2 Specifications. The Fabricator shall have available in the shop all pertinent specifications governing the work.

3.2.2.3 Technician. The Contractor shall provide a technician having at least 5 years continuous experience in the manufacture of prestressed members, who shall supervise the work.

3.2.3 Quality Control. The Fabricator shall perform quality control functions to insure that the product is fabricated in accordance with contract documents and specifications.

3.3 Shop Drawings.

3.3.1 The Contractor shall prepare and submit for approval, shop detail, erection, and all other necessary working drawings in accordance with the requirements of 105.02.

3.3.2 The shop drawings shall be furnished sufficiently in advance of fabrication to allow for review, resubmission, and approval by the Engineer.

3.3.3 Fabrication shall not begin until written approval of the submitted shop drawings has been received from the Engineer.

3.3.4 Deviation from the approved shop drawings will not be permitted without written order or consent of the Engineer.

3.3.5 Tracings. Original tracings of all shop drawings, corrected, shall be delivered to the Engineer before final payment will be made.

3.4 Shop Inspection.

3.4.1 Quality assurance inspection. The Department will inspect the test section placement and fabrication of the members. This quality assurance inspection will include the observation of required testing and the examination of materials, work procedures, and the final fabricated product.

3.4.1.1 Fabrication and required testing stated herein shall only be done in the presence of an authorized inspector representing the Department. The Department's authorized quality assurance inspector is herein referred to as the "Inspector".

3.4.1.2 The Inspector shall have free entry for the purpose of the required inspection at all times.

3.4.2 Notice. At least sixty (60) days prior to the first casting, the Contractor shall submit a schedule showing the dates on which the test placement and the members will be cast. Submit schedule to the Department's Bureau of Materials and Research.

3.4.3 Authority. The Inspector shall have the authority to reject any material or workmanship that does not meet the requirements of the contract documents.

3.4.3.1 Inspection at the shop is intended as a means of facilitating the work and avoiding errors, and it is expressly understood that it will not relieve the Contractor from any responsibility in regard to imperfect material or workmanship and the necessity for replacing the same.

3.4.4 Acceptance. The Inspector shall affix the acceptance stamp to the members when they are ready for shipment and have been properly loaded. This acceptance mark shall be made by paint or ink stamp.

3.4.4.1 The Fabricator shall present the Inspector with a copy of the shipping invoice to be stamped for verification of inspection and approval of prestressed members prior to shipment.

3.4.4.2 The Inspector's acceptance implies that at the time of shipment from the shop, it was the opinion of the Inspector that the members were fabricated from accepted materials by approved processes and loaded for shipment in accordance with the contract requirements.

3.4.5 Cooperation. The Fabricator shall fully cooperate with the Inspector in the inspection of the work in progress. This shall include the storage of members completed during the Inspector's absence, in such a manner, that the finished work can be completely and safely inspected.

3.4.5.1 The Fabricator shall allow the Inspector unrestricted access to the necessary parts of the shop during work hours. Work done while the Inspector has been refused access shall be automatically rejected.

3.5 Stressing Equipment.

3.5.1 Prestressing shall be done with approved hydraulic jacking equipment.

3.5.2 Hydraulic jacks shall be equipped with accurately reading pressure gauges. The combination of jack and gauge shall be calibrated and a certified graph or table showing the calibration shall be submitted to the Engineer. The calibration date shall be within a 12-month period immediately prior to the start of work.

3.6 Placement and Stressing of Strands.

3.6.1 Prestressing strands shall be accurately placed to achieve the center of gravity of the strand as shown on the approved shop drawings. Strands shall be protected against corrosion and free of nicks, kinks, dirt, rust, oil, grease, and other deleterious substances.

3.6.2 Layers of strands shall be separated by steel supports in accordance with the Concrete Reinforcing Steel Institute Manual of Standard Practice and shall be of approved shape and dimension. Suitable horizontal and vertical spacers shall be provided, if required, to keep the strands in true position in the forms. Hold-down devices used at all points of change in slope of the strands shall be of approved low-friction type.

3.6.3 Prior to stressing, the Contractor shall submit for approval the computations of the proposed gauge pressure, elongation of the prestressing strands (allowing for losses), and the sequence of operations. A record shall be kept of the gauge pressure and the elongation produced thereby for each strand. Complete and accurate records of each stressing operation shall be submitted to the Engineer.

3.6.4 Except for normal reinforcing in the bottom, the reinforcing shall be placed in position after the stressing is performed.

3.6.5 Each strand shall be stretched initially to a minimum gauge pull of 1000 pounds to eliminate all slack and equalize the stresses in the strands before starting elongation measurements. All strands shall be in position before the stressing operation is begun.

3.6.6 Stressing shall be performed by either simultaneous or individual application of tension to the strands. The amount of stress to be applied to each strand and the sequence of stressing shall be as shown on the approved shop drawings. Stressing shall be performed only in the presence of the Inspector.

3.6.7 Safety Measures. Safety measures must be taken by the Contractor to prevent accidents due to possible breaking of the prestressing strand or the slipping of the grips during the prestressing process.

3.6.8 Several members may be cast in a continuous line and stressed at one time. Sufficient space shall be maintained between ends of members to permit access for cutting strands after the concrete has attained the required strength.

3.7 Debonding. Debonding of the prestressing strands , if required, shall be accomplished by the use of sheathing. Sheaths shall be of an approved material which is watertight, has sufficient strength to withstand concrete placement and does not react with concrete or steel. Sheaths shall be properly sealed to prevent intrusion of cement paste during concrete placement.

3.8 Forms.

3.8.1 Forms shall be subject to the approval of the Engineer.

3.8.2 Forms shall be made and maintained true to the shapes and dimensions shown on the plans.

3.8.3 The surface of forms shall be smooth, and if necessary, joints shall be treated so that a minimum of joint marks are evident in the finished member.

3.8.4 Forms shall be constructed and end bearing plates placed so as to allow for any shortening of the member due to compressive stresses resulting from transfer of stress and from shrinkage.

3.8.5 Side forms shall be of steel and shall be supported without resort to ties or spreaders within the body of the member. They shall be braced and stiffened so that no deflection or curvature occurs during concrete placement.

3.8.6 Forms shall be adequately cleaned before each use.

3.9 Placement of Concrete.

3.9.1 Concrete shall not be placed in the forms until the Inspector has given approval of the placement of the reinforcing and prestressing strands. Concrete shall be placed only in the presence of the Inspector and in accordance with 520.

3.9.1.1 Concrete shall not be placed in the forms of the instrumented girder (girder #3 as noted on the contract plans) until researchers have installed testing probes (thermisters, strain gages, and wiring) within the member.

3.9.2 All reinforcing and strands shall be free of dirt, rust, oil, grease, and other deleterious substances.

3.9.3 All items encased in the concrete shall be accurately placed in the position shown on the plans and firmly held during the placing and setting of the concrete. Clearance from the forms shall be maintained by supports, spacers, or hangers in accordance with 544.3.4 and shall be of approved shape and dimension.

3.9.4 The details of all inserts, anchors, and any other items required to be cast into the members (whether detailed on the contract drawings or provided for the Contractor's convenience) shall be shown on the shop drawings. Members shall not be fired or drilled into for attachment purposes. All hardware shall be galvanized except as otherwise noted.

3.9.5 The temperature of the concrete shall not exceed 90°F when placed in the forms.

3.10 Consolidation of Concrete.

3.10.1 Consolidation of concrete shall conform to 520.3.5.4 or as ordered.

3.10.2 The vibrating shall be done with care and in such manner as to avoid displacement of reinforcement, strands, shoes, or other inserts.

3.10.3 The size of the vibrator spud shall be proper for the size of the openings available.

3.10.4 External vibration will be permitted.

3.11 Roughness of Top Surface of Member

3.11.1 The top surface of all members shall be finished reasonable true by striking off at the top of the forms.

3.11.2 As soon as conditions permit before the concrete has fully hardened, all dirt, laitance, and loose aggregate shall be removed from the top surface. The top surface shall be finished as shown on the plans.

3.12 Curing.

3.12.1 Curing of the concrete shall conform to 520.3.10 or as ordered.

3.12.2 Steam curing when used shall conform to the following:

(a) The Contractor shall furnish sufficient canvas and framework or other type of housing to completely enclose the member so that the curing temperatures can be controlled.

(b) Live steam shall be introduced into the enclosure through a series of steam jets which shall be evenly spaced within the enclosure.

(c) The initial set of the concrete shall take place before steam for curing is applied.

(d) The steam enclosure shall be maintained at 100% relative humidity to prevent loss of moisture and to provide excess moisture for proper hydration of the cement.

(e) During the application of the steam, the internal concrete temperature of the girder shall be continuously monitored through the use of the sure cure system. At no time shall the internal concrete temperature exceed 160°F. The ambient air temperature may increase at a rate not to exceed 40°F per hour until a maximum temperature of 120°F to 140°F is reached. Curing at this temperature shall continue until concrete test cylinders, prepared from the fresh concrete at the time of the placing, and cured under the same temperature and moisture conditions as the member, have attained 5500 psi compressive strength.

(f) Necessary equipment for testing the cylinders shall be available at the Fabricator's plant unless permitted otherwise.

(g) When discontinuing steam, the ambient air temperature shall not decrease at a rate to exceed 40°F per hour until the temperature has reached 20°F above the temperature of the air to which the concrete will be exposed.

3.12.3 The concrete shall not be exposed to temperatures below 32°F for 6 days after casting.

3.13 Release of Prestress.

3.13.1 Detensioning shall not commence until the concrete has attained a compressive strength of at least 5500 psi (or the release strength indicated on the plans) as shown by test cylinders cured by methods identical with the curing of the member. Detensioning shall be done at approximately equal concrete strengths for all members.

3.13.2 Detensioning shall be accomplished by a gradual release of jack pressure, or by cutting individual strands in an approved sequence. If detensioning is accomplished by single strand release, each strand shall be cut by gradually heating the strand at both ends of the member simultaneously. A minimum length of 5 inches of strand shall be heated to prevent any shock or snap when the strand is finally severed. Each strand shall also be cut at all spaces between members when cast continuously before starting detensioning on the following strand in the sequence. All detensioning shall be performed in the presence of the Inspector.

3.13.3 If the concrete has been heat-cured, detensioning shall be performed immediately following the curing period while the concrete is still warm and moist.

3.13.4 Detensioning shall be kept symmetrical about the axes of the member and in the sequence shown on the approved shop drawings.

3.13.5 Forms or any device which restrict either horizontal or vertical movement of the member shall be stripped or loosened, prior to detensioning.

3.14 Stripping Forms and Finish of Member.

3.14.1 No forms shall be removed without approval. Proper care and precautions shall be exercised in removing forms so that no damage results to finished surfaces.

3.14.2 The member shall be finished in accordance with 520.3.9.

3.14.3 Finish of Strands. At the ends of members strands shall be recessed. Each recess shall be 1 1/2 inches square and 3/4 inches deep. Projecting strands shall be burned out and the recess cleaned prior to patching with an approved material. The entire end cross-section of the member shall then be coated with an approved bitumastic material.

3.15 Patching.

3.15.1 Patching of any surface irregularities, especially those resulting from honey-combing, shall be done only after inspection for determination as to whether or not the work is acceptable.

3.15.2 When patching is allowed, it shall be done within 24 hours after stripping, and the patching shall be damp-cured for not less than a 3-day period and kept from freezing for the following 3 days.

3.15.3 Patching of damaged members in lieu of required replacement will not be permitted

3.16 Dimensional Tolerances.

3.16.1 All tolerances shall be in accordance with PCI MNL -116 "Manual for Quality Control for Plants and Production of Precast and Prestressed Concrete Products".

3.16.2 Camber shall be measured at consistent times within 24 hours after transfer of prestress.

3.17 Handling and Storing.

3.17.1 Special care shall be taken in handling and storing the members to prevent any damage to the members.

3.17.2 Members shall be lifted at the designated points by approved lifting devices embedded in the concrete and proper hoisting procedures so that only a vertical pull will be applied to the lifting devices.

3.17.3 The points of support and the direction of the reactions with respect to the member during handling and storage shall be approximately the same as when the member is in its final position. Members shall be stored plumb.

3.17.4 Storage areas shall be smooth and well compacted to prevent damage due to differential settlement.

3.17.5 Members may be loaded on a trailer as described above. Shock-absorbing cushioning material shall be used at all bearing points during transportation of the members. Tie-down straps shall be located at the lines of blocking only.

3.17.6 The members shall not be subject to damaging torsional or impact stresses.

3.17.7 Members damaged by improper storing or handling shall be replaced by the Contractor at no cost to the Department.

3.18 Shipping. Members shall not be transported from the casting yard until the design 28-day compressive strength has been attained as shown by test cylinders cured by methods identical with the curing of the members.

3.19 Erection.

3.19.1 Delivery and Field Inspection. Material, workmanship and condition after shipment will be inspected after delivery to the construction site, with this and any previous inspections constituting only partial acceptance.

3.19.1.2 All work of handling, assembling and erecting the members shall be subject to the inspection and approval of the Engineer, who shall be furnished with necessary facilities, including approved scaffolding and supports, to provide access to the structure to allow for inspection of workmanship.

3.19.2 Methods and Equipment. Before starting the work of erecting the members the Contractor shall fully inform the Engineer as to the proposed method of erection and the amount and character of the equipment, which shall be subject to the approval of the Engineer.

3.19.3 Erection Plans. Three copies of the erection plans shall be submitted to the Engineer, sufficiently in advance of the work, to allow for review and approval of the plans, and if necessary, arrange for discussions with the Contractor. No work shall be done until such approval by the Engineer has been obtained.

3.19.3.1 Responsibility. The approval of the erection plans by the Engineer shall not be considered as relieving the Contractor of the responsibility for the safety of the method or equipment or from carrying out the work in full accordance with the plans and specifications under the terms of the contract. See 105.02.

3.19.4 Temporary bracing. After a member has been erected, temporary braces shall be provided as necessary to resist wind and other loads. Details of temporary bracing shall be provided as part of the erection plans.

3.19.5 Bearings. Bearings shall be installed in accordance with 548.

3.20 Instrumentation. Researchers shall have free access for the purpose of installing instrumentation and monitoring the instrumented girder (girder #3 as noted on the contract plans) at all times. The instruments will be used to monitor internal concrete temperature and strain in the beam prior to, during, and after construction.

3.20.1 Appendix A, attached to the end of this specification, gives detailed information for the instrumentation plan. The Fabricator and Contractor shall take the necessary steps to prevent damage to the instrumentation and cooperate with the research team during installation of the sensors and data collection. It is anticipated that these activities will <u>not</u> cause significant delays or work stoppages.

3.20.2 Instrumentation wires will protrude through the top of the girder contained within 1½" diameter flexible plastic tubing. Wires shall be stored in bubble wrap and adequately taped to the side of the girder for protection during shipping, erection, and construction operations.

3.20.3 Researchers shall have access to survey the top of the girder prior to and after the release of the prestressing strands.

3.20.3.1 A flattened area of sufficient size (4"± by 4"±) shall be provided at the centerline of bearing and tenth points on tops of all the girders to facilitate taking elevations for measuring camber and deflection. These areas shall be steel trowel finished with a maximum difference in elevation between the high to low spots being less than 1/16".

Method of Measurement

4.1 Prestressed concrete members will be measured as a unit. When more than one unit is specified in the contract, separate item numbers will appear for each separate and complete unit.

Basis of Payment

5.1 The accepted quantity of prestressed concrete members will be paid for at the contract lump sum price complete in place.

5.1.1 No extra payment will be made for the test section placement or for the testing required as stated herein.

5.2 Pay adjustments will be paid based on Unit Price (UP) and pay adjustment factors as specified below. The UP will be the contract unit price divided by the number of girders as required per contract plans.

5.2.1 When the average rapid chloride permeability of the girder concrete is greater than 3500 Coulombs (C), the concrete will be deemed unacceptable. When the average rapid chloride permeability of the girder concrete falls below 1500 Coulombs, a positive pay adjustment for rapid chloride permeability for each girder will be made in accordance with the formula on the next page. When the average rapid chloride permeability of the girder concrete falls between 1500 and 3500 Coulombs, a negative pay adjustment for each girder will be made in accordance with the formula on the next page.

Pay Adjustment Factor = 0.00006(1500-C)+1.
Pay Adjustment for each Girder = UP × (Pay Adjustment Factor-1)

Pay items and unit:

528.11	Prestressed Concrete Members - HPC	Unit
Item 51.528	Pay Adjustment, HPC	$

[1] Not a bid item.

APPENDIX A

DETAILS FOR GIRDER INSTRUMENTATION PLAN

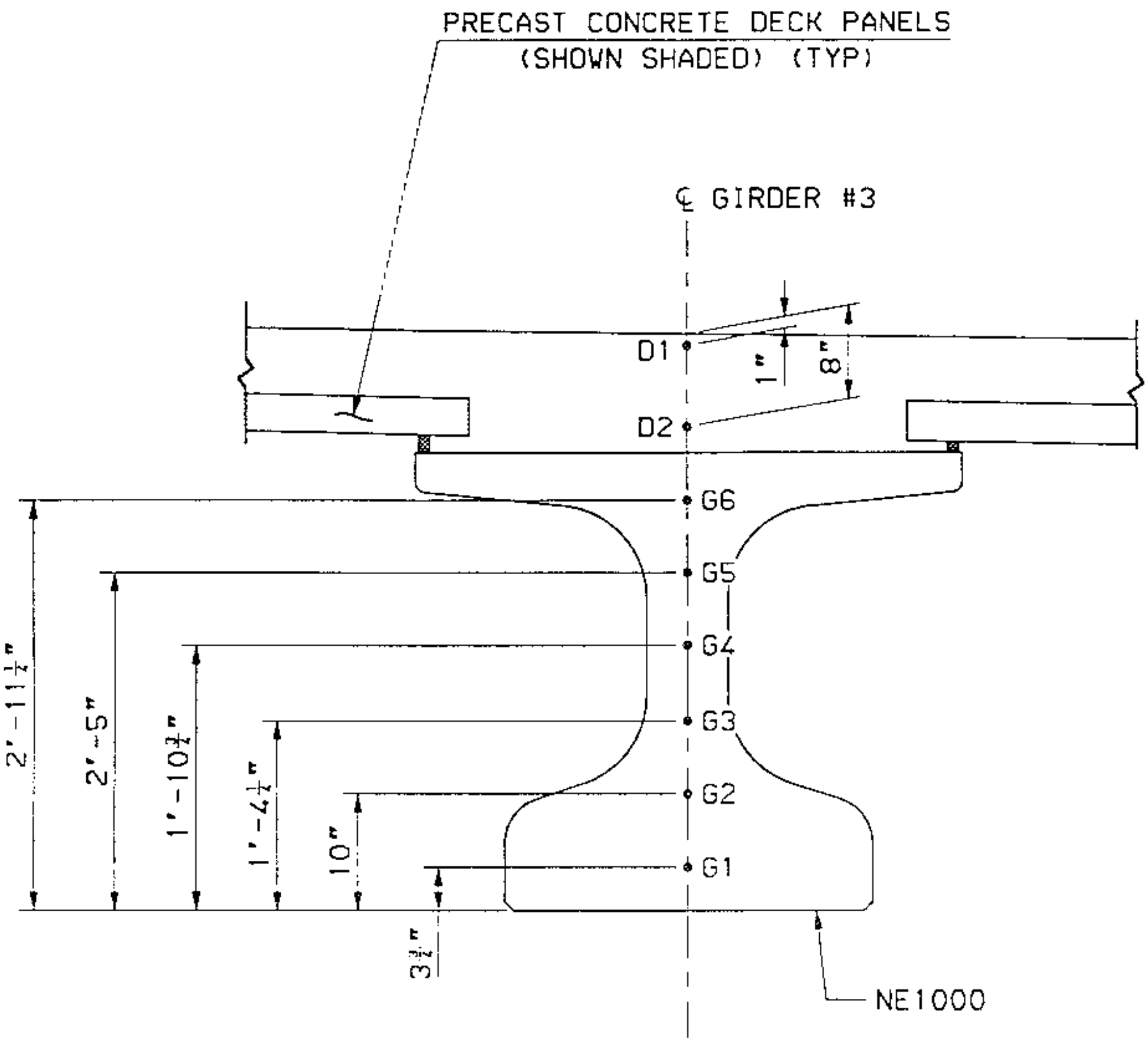
One girder (girder #3 as noted on the contract plans) will be instrumented for internal temperature and strain data collection. Embedded sensors will be used to monitor behavior of the girder from the time of casting to several years after construction is completed. Instrumentation will consist of the following:

I. Strain gages to measure the long-term strains within the girder. The strains will be used to determine prestress losses from elastic shortening, creep, and shrinkage and will give an indication of the stresses within the girder due to dead load and live load. The strain gages also come equipped to measure the internal concrete temperature at the gage location. The temperature measurement will be used to determine (1) the level of heat of hydration during the curing process, (2) the temperature gradient in the girder after bridge construction, and (3) the temperature during data compilation.

A. Six gages will be placed at midspan of the girder at a depth of 3 ¾", 10", 16 ¼", 22 ¾", 29" and 35 ¼" as measured from the bottom of the beam.

B. Data acquisition will begin as soon as the concrete is placed. Readings will be taken prior to and after every significant event that affects the stress in the girder (i.e. form stripping, transfer of prestressing force, erection of beams, etc.). After completion of the structure, readings will be taken periodically.

Stainless steel inserts shall be cast in to the bottom flange of all the girders as specified on the contract plans. Stainless Steel Hemispherical bolts or low profile acorn nuts with threaded lugs shall be installed in the inserts after erection of the girders is completed. These inserts and bolts will be used as part of a deflection survey to measure girder deflection due to creep, shrinkage, dead loads, and live loads. Elevations of the beam points will be determined initially once the girders are erected but prior to the installation of the precast deck panels and subsequently after the bridge construction is completed. Deflection surveys will continue periodically for several years after construction is completed.



Instrumentation Layout
Scale: 3/4" = 1'-0"

G1 thru G6: Strain gages positioned in girder @ midspan
D1 thru D2: Strain gages positioned in deck in line with gages G1 thru G5

NH ROUTE 3A BRIDGE
Cementitious Materials Composition

Component	Weight %			
	Girders and Panels		CIP Deck	
	Cement	GGBFS	Cement	Cement and Silica Fume
SiO_2	20.7	20.1	21.5	27.18
Al_2O_3	5.1	5.5	4.9	4.40
Fe_2O_3	3.1	2.3	3.1	2.67
CaO, Total	62.7	63.2	63.7	59.18
CaO, Free	1.2	1.2	0.7	—
SO_3	3.0	3.5	2.9	2.96
MgO	3.4	2.6	2.4	2.18
Na_2O	0.63	0.76	0.8	—
Loss on Ignition	1.2	1.2	0.7	0.84
Insoluble Residue	0.3	0.3	0.3	3.44
C_3A	8	11	7.6	7.15
C_4AF	—	7	9.6	—
C_3S	51	54	50.9	—
C_2S	—	17	23.1	—
K_2O	—	—	—	0.98
SrO	—	—	—	0.18
Mn_2O_3	—	—	—	0.04
ZnO	—	—	—	0.05
Cr_2O_3	—	—	—	0.02