TEXAS
Louetta Road

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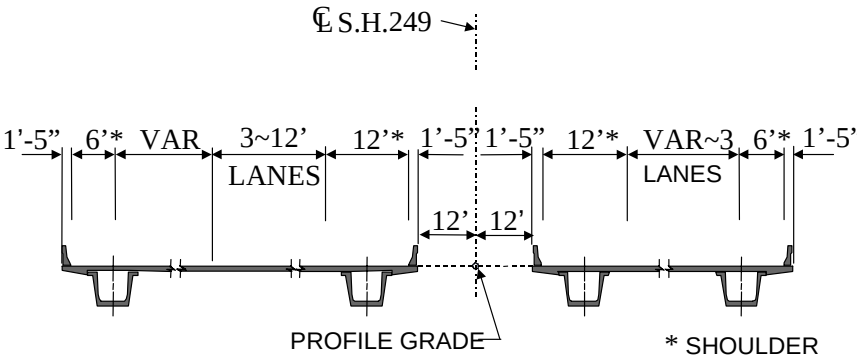
1. DESCRIPTION



Location:	Louetta Road Overpass, State Highway 249, Houston
Open to Traffic:	May 1998
Environment:	Normal over road
HPC Elements:	Precast piers, precast girders, precast deck panels, and cast-in-place deck
Total Length:	391 ft
Skew or Curve:	33 to 39^{o} skew
Girder Type:	Texas U54 beams. See 10. DRAWINGS for details.
Girder Span Lengths:	Varies. See 10. DRAWINGS for details.
Girder Spacing:	Varies. See 10. DRAWINGS for details.
Girder Strand Grade:	270
Girder Strand Dia.:	0.6 in except Span 1 northbound which used 0.5 in for the three interior girders
Max. No. of Bottom Strands:	87

Deck Thickness:	7-1/4-in composite section with 3-3/4-in-thick cast-in-place concrete
Deck Panels	
—Length:	8 ft 0 in
—Thickness:	3-1/2 in
—Strand Grade:	—
—Strand Diameter:	3/8 in

2. BENEFITS OF HPC AND COSTS

A. Benefits of HPC

In order for the 54-in-deep U-beams to span 135.5 ft with simple span construction, which is the preferred method of construction in Texas, higher strength concrete was required. The most critical design was for the exterior beam in the 135.5-ft-long middle span, which required eighty seven 0.6-in-diameter strands. Specified concrete compressive strengths were 8800 psi at release of the strands and 13,100 psi at 56 days. The typical maximum specified strength in Texas is 8000 psi at 28 days.

Based on results obtained from the Louetta Road bridge and the San Angelo bridge, a durability specification for bridge decks has been developed. The emphasis is improved durability at conventional design compressive strengths of 4000 psi for cast-in-place topping and 5000 psi for precast deck panels.

B. Costs

Beams were all bid at the same unit cost of $100/lineal ft compared to $120/lineal ft for a typical 54-in-deep U-beam.

The unit cost for the total structure was $24.09/ft^3 of deck area for the two bridges compared to an average cost of $23.61/ft^3 of deck area for 12 conventional concrete U-beam bridges on the same project.

Total costs of the bridge were $559,220 and $668,853 for the northbound and southbound structures, respectively.

3. STRUCTURAL DESIGN

Design Specifications:	AASHTO Standard Specifications for Highway Bridges, 1992
Design Live Loads:	HS 20-44
Seismic Requirements:	None
Flexural Design Method:	E_c = 6000 ksi
Maximum Compressive Strain:	—
Shear Design Method:	—
Fatigue Design Method:	None
Lateral Stability Considerations:	None
Allowable Tensile Stress	
—Top of Girder at Release:	$10\sqrt{f'_{ci}}$ with bonded reinforcement
—Bottom of Girder after Losses:	$8\sqrt{f'_c}$
Prestress Loss:	55,390 psi
Method Used for Loss:	AASHTO Standard Specifications component equations using TxDOT's PSTRS14 design program
Calculated Camber:	4.06 to 5.64 in at release
Concrete Cover	
—Girder:	1 in
—Top of Deck:	2 in
—Bottom of Deck:	1-3/4 in to 3/8-in-diameter strands in panels
—Other Locations:	—
Properties of Reinforcing Steel	
—Girder:	Grade 60 uncoated
—Deck:	Grade 60 uncoated
Properties of Strand	
—Grade and Type:	270, low relaxation
—Supplier:	Florida Wire and Cable
—Surface Condition:	—
—Pattern:	24 to 34 strands debonded per beam
—Transfer Length:	—
—Development Length:	—

4. SPECIFIED ITEMS

A. Concrete Properties for Precast Girders and Precast Deck Panels

	Precast Girders	Precast Deck Panels
Maximum Cement Content:	752 lb/yd^3	752 lb/yd^3
Max. Water/Cementitious Materials Ratio:	—	—
Min. Percentage of Fly Ash:	—	—
Max. Percentage of Fly Ash:	—	—
Min. Percentage of Silica Fume:	—	—
Max. Percentage of Silica Fume:	—	—
Min. Percentage of GGBFS:	—	—
Max. Percentage of GGBFS:	—	—
Maximum Aggregate Size:		
Coarse Aggregate Factor:	$\geq$ 0.68	$\geq$ 0.68
Slump:	$\leq$ 8 in	$\leq$ 8 in
Air Content:	—	—
Compressive Strength		
—Release of Strands:	6900, 7700, 8800 psi	6000 psi
—Design:	9800, 11,600, 13,100 psi at 56 days See 10. DRAWINGS for details	8000 psi at 28 days
Chloride Permeability: (AASHTO T 277)	—	—
ASR or DEF Prevention:	—	—
Freeze-Thaw Resistance:	—	—
Deicer Scaling:	—	—
Abrasion Resistance:	—	—
Other:		

B. Concrete Properties for Cast-in-Place Concrete Decks

	Northbound	Southbound
Minimum Cementitious Materials Content:	0.44	—
Max. Water/Cementitious Materials Ratio:	—	—
Min. Percentage of Fly Ash:	—	—
Max. Percentage of Fly Ash:	—	—
Min. Percentage of Silica Fume:	—	—
Max. Percentage of Silica Fume:	—	—
Min. Percentage of GGBFS:	—	—
Max. Percentage of GGBFS:	—	—
Maximum Aggregate Size:	—	—
Slump:	3-4 in	3-9 in
Air Content:	5%	0%
Compressive Strength:	4000 psi at 28 days	8000 psi at 28 days
Chloride Permeability: (AASHTO T 277)	—	—
ASR or DEF Prevention:	—	—
Freeze-Thaw Resistance:	—	—
Deicer Scaling:	—	—
Abrasion Resistance:	—	—
Other:	—	—

C. Specified QC Procedures

Precast Girder Production	
Curing:	—
Internal Concrete Temperature:	—
Cylinder Curing:	—
Cylinder Size:	—
Cylinder Capping Procedure:	—
Cylinder Testing Method:	Tex-418-A (Similar to AASHTO T 22)
Frequency of Testing:	Two sets of three cylinders per line of girders
Other QA/QC Requirements:	—
Precast Deck Panel Production	
Curing:	—
Internal Concrete Temperature:	—
Cylinder Curing:	—
Cylinder Size:	—
Cylinder Capping Procedure:	—
Cylinder Testing Method:	—
Frequency of Testing:	—
Other QA/QC Requirements:	—
Cast-in-Place Deck Construction	
Curing:	Wet mat curing for 10 days when fly ash is used or 8 days when fly ash is not used
Cylinder Curing:	—
Cylinder Size:	—
Flexural Strength:	Not specified
Other QA/QC Requirements:	—

5. CONCRETE MATERIALS

A. Approved Concrete Mix Proportions for Precast Girders and Precast Deck Panels

	Precast Girders	Precast Deck Panels
Cement Brand:	Capitol	Alamo
Cement Type:	III	III
Cement Composition:	See Page 40	See Page 40
Cement Fineness:	See Page 40	See Page 40
Cement Quantity:	671 lb/yd^3	565 lb/yd^3
GGBFS Brand:	—	—
GGBFS Quantity:	—	—
Fly Ash Brand:	—	—
Fly Ash Type:	C	C
Fly Ash Quantity:	315 lb/yd^3	164 lb/yd^3
Silica Fume Brand:	—	—
Silica Fume Quantity:	—	—
Fine Aggregate Type:	River sand	River sand
Fine Aggregate FM:	2.60	2.60
Fine Aggregate SG:	2.63	—
Fine Aggregate Quantity:	1086 lb/yd^3	1109 lb/yd^3
Coarse Aggregate, Max. Size:	1/2 in	3/4 in
Coarse Aggregate Type:	No. 7 crushed dolomitic limestone	No. 6 crushed river gravel
Coarse Aggregate SG:	2.68	
Coarse Aggregate Quantity:	1919 lb/yd^3	1983 lb/yd^3
Water:	248 lb/yd^3	228 lb/yd^3
Water Reducer Brand:	—	—
Water Reducer Type:	—	—
Water Reducer Quantity:	—	—
High-Range Water-Reducer Brand:	—	—
High-Range Water-Reducer Type:	F	F
High-Range Water-Reducer Quantity:	200 fl oz/yd^3	170 fl oz/yd^3
Retarder Brand:	—	—
Retarder Type:	B and D	B and D
Retarder Quantity:	27 fl oz/yd^3	23 fl oz/yd^3
Corrosion Inhibitor Brand:	—	—
Corrosion Inhibitor Type:	—	—
Corrosion Inhibitor Quantity:	—	—
Air Entrainment Brand:	—	—
Air Entrainment Type:	—	—
Air Entrainment Quantity:	—	—
Water/Cementitious Materials Ratio:	0.25	0.31

B. Measured Properties of Approved Mix for Precast Girders and Precast Deck Panels

	Precast Girders	Precast Deck Panels
Slump:	8-10 in	7-10 in
Air Content:	0.9%	2.0%
Unit Weight:	153.9 lb/ft^3	149.9 lb/ft^3
Compressive Strength:	—	—
Chloride Permeability: (AASHTO T 277)	—	1430 coulombs at 56 days

C. Approved Concrete Mix Proportions for Cast-in Place Concrete Deck

	Northbound Class S(Modified)	Southbound Class K (HPC)
Cement Brand:	Capitol	Capitol
Cement Type:	I	I
Cement Composition:	See Page 40	See Page 40
Cement Fineness:	See Page 40	See Page 40
Cement Quantity:	383 lb/yd^3	474 lb/yd^3
GGBFS Brand:	—	—
GGBFS Quantity:	—	—
Fly Ash Brand:	—	—
Fly Ash Type:	C	C
Fly Ash Quantity:	148 lb/yd^3	221 lb/yd^3
Silica Fume Brand:	—	—
Silica Fume Quantity:	—	—
Fine Aggregate Type:	River sand	River sand
Fine Aggregate FM:	2.54	2.54
Fine Aggregate SG:	—	—
Fine Aggregate Quantity:	1243 lb/yd^3	1303 lb/yd^3
Coarse Aggregate, Max. Size:	1-1/2 in	1 in
Coarse Aggregate Type:	No 4 crushed limestone	No. 5 crushed limestone
Coarse Aggregate SG:	—	—
Coarse Aggregate Quantity:	1856 lb/yd^3	1811 lb/yd^3
Water:	229 lb/yd^3	244 lb/yd^3
Water Reducer Brand:	—	—
Water Reducer Type:	—	—
Water Reducer Quantity:	—	—
High-Range Water-Reducer Brand:	—	—
High-Range Water-Reducer Type:	—	F
High-Range Water-Reducer Quantity:	—	122 fl oz/yd^3
Retarder Brand:	—	—
Retarder Type:	B and D	B and D
Retarder Quantity:	45 fl oz/yd^3	22 fl oz/yd^3
Corrosion Inhibitor Brand:	—	—
Corrosion Inhibitor Type:	—	—
Corrosion Inhibitor Quantity:	—	—
Air Entrainment Brand:	—	—
Air Entrainment Type:	—	—
Air Entrainment Quantity:	2.1 fl oz/yd^3	—
Water/Cementitious Materials Ratio:	0.43	0.35

D. Measured Properties of Approved Mix for Cast-in-Place Concrete Deck

	Northbound	Southbound
Slump:	3 to 4 in	8 to 9-1/2 in
Air Content:	5.0%	0.9 to 1.4%
Unit Weight:	143.2 lb/ft^3	150.2 lb/ft^3
Compressive Strength:	—	—
Chloride Permeability: (AASHTO T 277)	1730 coulombs at 56 days	900 coulombs at 56 days

6. CONCRETE MATERIAL PROPERTIES

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

Cement Composition: —
Actual Curing Procedure for Girders: Self cure
Curing Procedure for Cylinders: —
Air Content: 2%
Unit Weight: 154 lb/ft^3

Slump and Compressive Strength:

Date Cast	Girder Erection No.	Release			Design		
		Slump, in	Age, hours	Comp. Strength, psi	Slump, in	Age, days	Comp. Strength, psi
Northbound							
9/30/94	AA-19 (1) AA-25 (2)	6-1/4	19	8710 (5)	3-3/4	28	14,440 (5)
2/5/96	AA-20 (1) AA-21 (1) AA-22 (1)	4-1/4	21	7000 (4)	7	14	12,170 (4)
9/23/94	AA-23 (1) AA-26 (2) AA-27 (2)	6-3/4	17	8450 (5)	6	28	12,430 (5)
10/28/94	AA-24 (2) AA-28 (2) AA-29 (3)	8-3/4	21	9190 (6)	8-1/4	31	13,990 (6)
2/15/96	AA-30 (3) AA-31 (3) AA-32 (3)	8	20	8550 (5)	7-3/4	28	13,720 (5)
10/7/94	AA-33 (3)	5-1/2	20	8880 (6)	6-1/2	28	14,010 (6)
Average		6-1/2	19.7	8460	6-1/2	—	13,460

(1) Span 1.
(2) Span 2.
(3) Span 3.
(4) Specified strengths of 6900 psi at release and 9800 psi at 56 days.
(5) Specified strengths of 7700 psi at release and 11,600 psi at 56 days.
(6) Specified strengths of 8800 psi at release and 13,100 psi at 56 days.

Date Cast	Girder Erection No.	Release			Design		
		Slump, in	Age, hours	Comp. Strength, psi	Slump, in	Age, days	Comp. Strength, psi
Southbound							
11/10/94	AA-1 (1) AA-10 (2) AA-11 (2)	8-1/2	21	8650 (5)	8-1/2	28	14,550 (5)
3/8/96	AA-2 (1) AA-16 (3) AA-17 (3)	7	19	7730 (5)	6	28	12,720 (5)
2/26/96	AA-3 (1) AA-4 (1) AA-5 (1)	8	20	9240 (5)	5	28	13,160 (5)
9/30/94	AA-6 (1)	6-1/4	19	8710 (5)	3-3/4	28	14,440 (5)
10/7/94	AA-7 (2) AA-12 (2)	5-1/2	20	8880 (6)	6-1/2	28	14,010 (6)
10/21/94	AA-8 (2) AA-9 (2)	9	20	8110 (5)	8-1/2	28	13,790 (5)
11/3/94	AA-13 (3) AA-18 (3)	8-1/2	21	9680 (4)	8-1/2	28	14,320 (4)
3/15/96	AA-14 (3) AA-15 (3)	8	19	8820 (4)	7-1/2	14	12,820 (4)
Average		7-1/2	19.7	8740	6-1/2	—	13,610

(1) Span 1.
(2) Span 2.
(3) Span 3.
(4) Specified strengths of 6900 psi at release and 9800 psi at 56 days.
(5) Specified strengths of 7700 psi at release and 11,600 psi at 56 days.
(6) Specified strengths of 8800 psi at release and 13,100 psi at 56 days.

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

Cement Composition: —
Actual Curing Procedure for Deck: Wet for 10 days

Slump, Air Content, Unit Weight, and Compressive Strength:

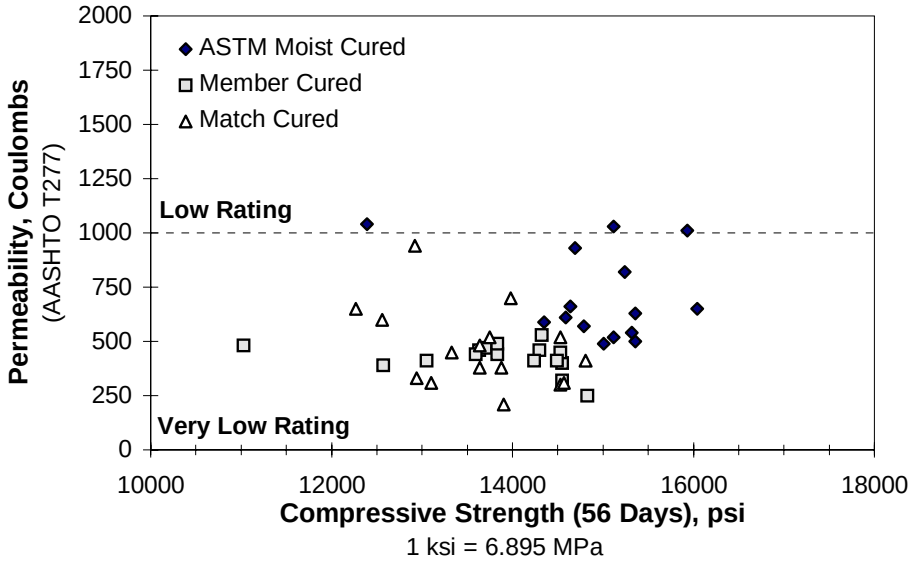
Property	Northbound	Southbound
Slump, in	4	7
Air Content, %	3.8	0
Unit Weight, lb/ft^3	143	150
Compressive Strength, psi	5700 at 28 days	9100 at 28 days

Curing Procedure for Cylinders: —

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

Compressive Strength, Modulus of Elasticity, and Splitting Tensile Strength:	See Excel file for girder data
Coefficient of Thermal Expansion:	Average of 4 cycles between 40 and 120 ^{o}F = 6.1 millionths/^{o}F
Rapid Chloride Permeability:	

The following graph contains data from both San Angelo and Louetta Road Bridges.



See Excel file for girder data.

Creep and Shrinkage:

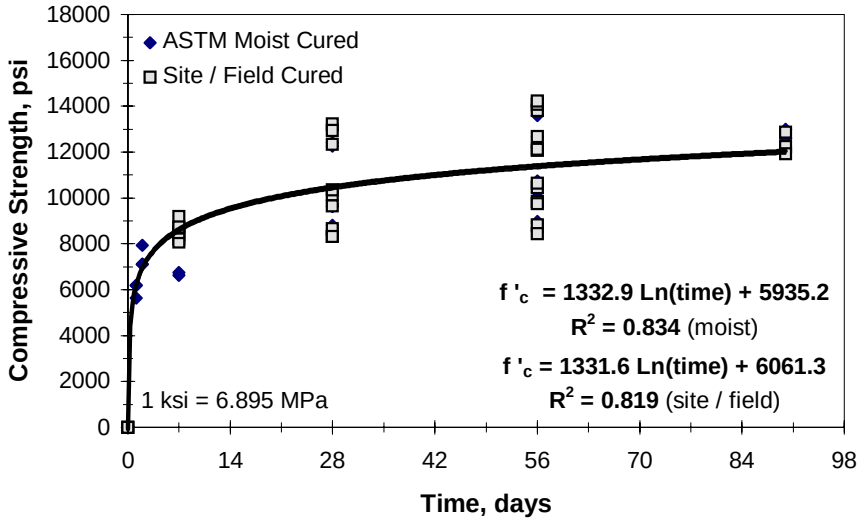
All 4x20-in cylinders stored alongside the beams for 8 to 18 hours, stripped at approximately 24 hours after casting and loaded at age 2 days to 20 and 40 percent of the nominal design compressive strength of the mix. Temperature and humidity were not controlled. Average relative humidity was 55 percent.

Days after Loading	Creep Coefficient (7)	Specific Creep (7), millionths/psi	Shrinkage (8), millionths
7	0.60	0.095	217
28	0.94	0.151	299
56	1.13	0.180	333
180	1.39	0.222	392

(7) Reported creep values are the average values for specimens loaded to 8, 23, and 38 percent of design strength. Nine readings were taken on each specimen.
(8) Shrinkage values included adjustments for one day of drying before initial readings were taken and for length changes caused by variation in concrete temperatures.

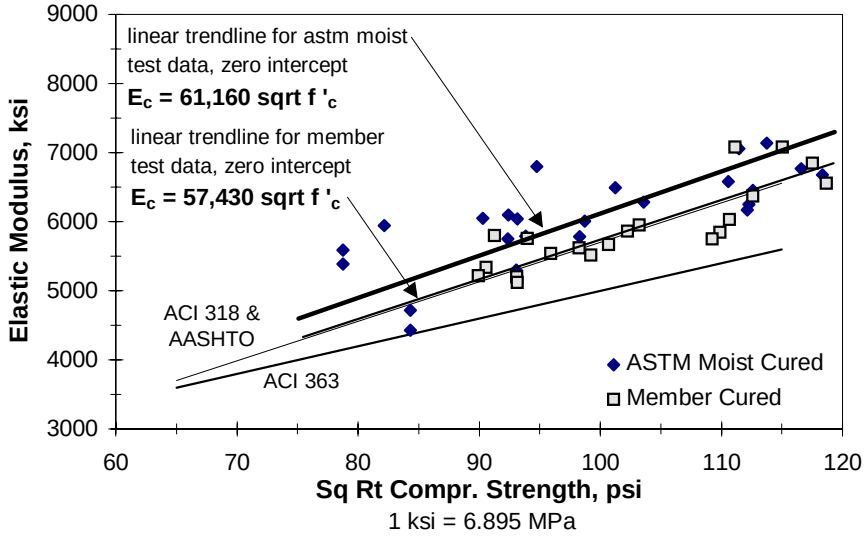
D. Measured Properties from Research Tests of Production Concrete for Precast Deck Panels

Compressive Strength:



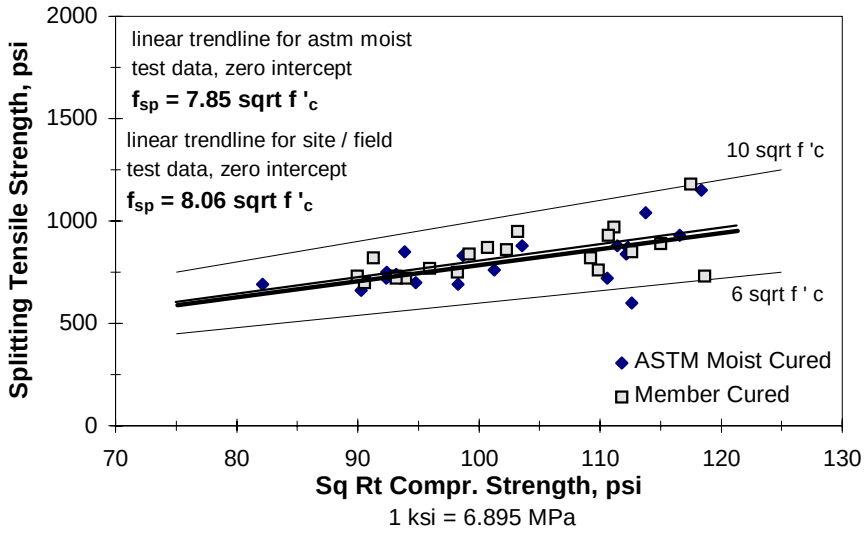
See Excel file for panel data.

Modulus of Elasticity**:**



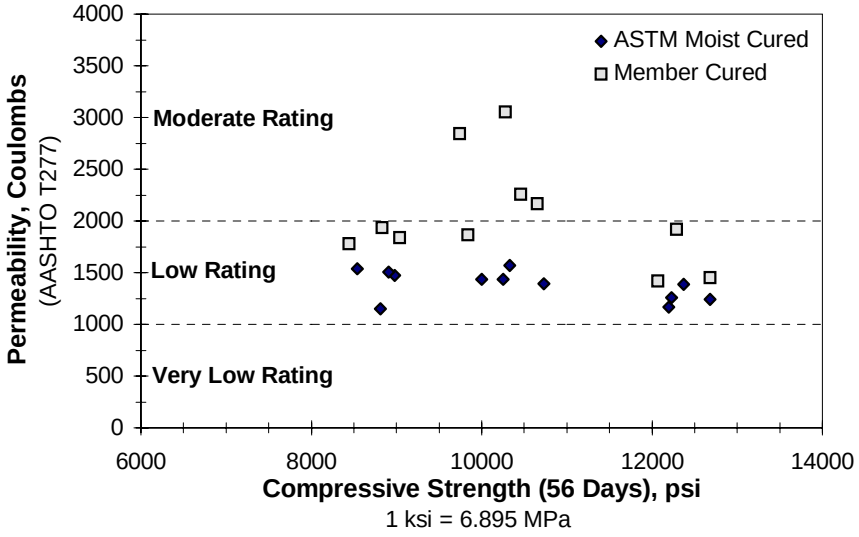
See Excel file for panel data.

Splitting Tensile Strength:



See Excel file for panel data.

Rapid Chloride Permeability:



See Excel file for panel data.

Coefficient of Thermal Expansion: Average of 4 cycles between 40 and 120 ^{o}F = 7.3 millionths/^{o}F

Creep and Shrinkage:

All 4x20-in cylinders stored alongside the panels for 8 to 18 hours, stripped at approximately 24 hours after casting and loaded at age 2 days to 20 and 40 percent of the nominal design compressive strength of the mix. Temperature and humidity were not controlled. Average relative humidity was 55 percent.

Days after Loading	Creep Coefficient (9)	Specific Creep (9), millionths/psi	Shrinkage (10), millionths
7	0.54	0.085	80
28	0.77	0.120	198
56	0.92	0.143	233
180	1.16	0.180	268

(9) Reported creep values are the average values for specimens loaded to the 20 and 40 percent levels. Nine readings were taken on each specimen.
(10) Shrinkage values included adjustments for one day of drying before initial readings were taken and for length changes caused by variation in concrete temperatures.

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

Compressive Strength, Modulus of Elasticity, Splitting Tensile Strength, and Chloride Permeability:

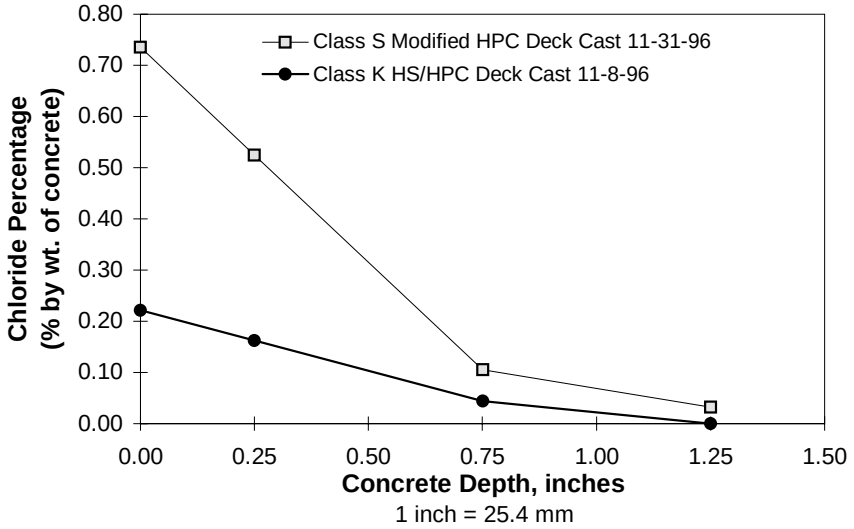
Property	Age, days	Northbound (11) Class S Modified		Southbound (12) Class K (HPC)	
		ASTM Cured	Site Cured	ASTM Cured	Site Cured
Compressive Strength, psi	28	5600	4890	9630	9220
	56	5700	5090	9740	9100
Modulus of Elasticity, ksi	28	4520	4460	5170	4730
	56	4870	4010	5750	4990
Splitting Tensile Strength, psi	28	460	465	740	725
	56	540	550	820	730
Chloride Permeability, coulombs	56	1730	2120	900	1300

All tests made using 4x8-in cylinders.
(11) Cast 10/31/96.
(12) Cast 11/8/96

Coefficient of Thermal Expansion: Average of 4 cycles between 40 and 120 ^{o}F =
4.0 millionths/^{o}F for northbound
4.2 millionths/^{o}F for southbound

Chloride Ion Penetration:
(AASHTO T 259)

Chloride percentages are the average of six samples.



Creep and Shrinkage:

All 4x20-in cylinders stored alongside the deck for 8 to 18 hours, stripped at approximately 24 hours after casting and loaded at age 2 days to 20 and 40 percent of the nominal design compressive strength of the mix. Temperature and humidity were not controlled. Average relative humidity was 55 percent.

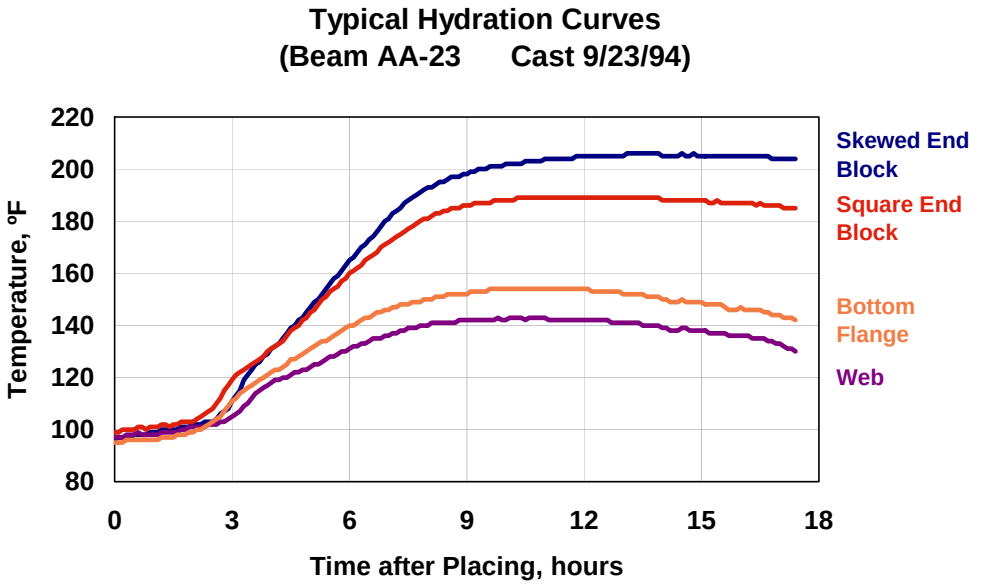
Days after Loading	Creep Coefficient (13)		Specific Creep (13), millionths/psi		Shrinkage (14), millionths	
	Northbound	Southbound	Northbound	Southbound	Northbound	Southbound
7	0.39	0.46	0.084	0.087	66	91
28	0.74	0.80	0.160	0.152	178	238
56	0.98	1.09	0.213	0.206	240	279
180	1.47	1.69	0.317	0.320	296	344

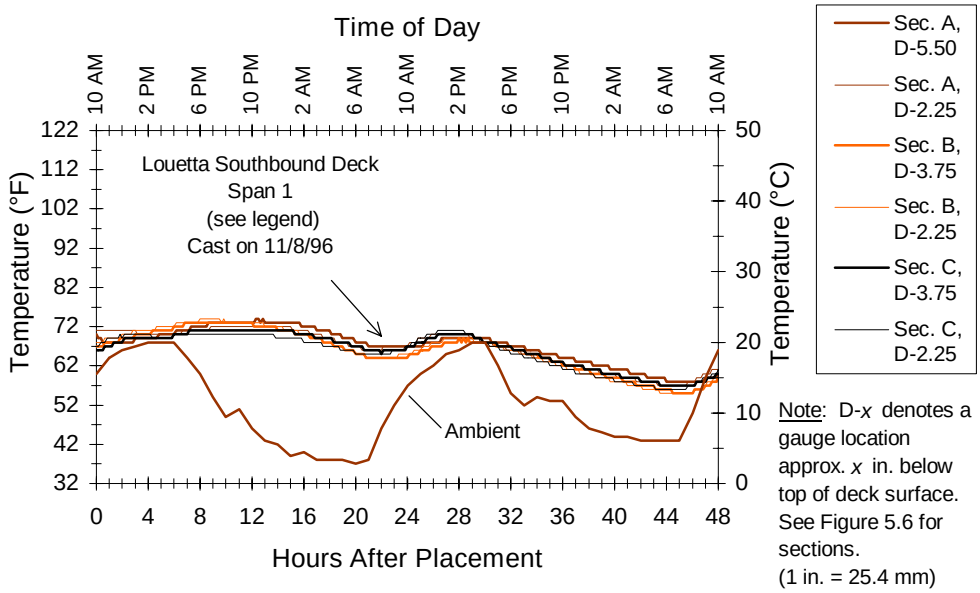
(13) Reported creep values are the average values for specimens loaded to the 20 and 40 percent levels. Nine readings were taken on each specimen.
(14) Shrinkage values included adjustments for one day of drying before initial readings were taken and for length changes caused by variation in concrete temperatures.

7. OTHER RESEARCH DATA

A significant amount of research was conducted in connection with the construction of the San Angelo bridge. Data were collected on concrete curing temperatures, thermal gradients, and temperatures in the bridge; concrete strains, prestress losses, camber, and deflection; and responses during static live load tests. The following sections report key data. For more detailed results, consult the project final reports.

Concrete Curing Temperatures:





Member	Concrete Temperature, °F			
	Placement (15)	Peak (16)	Max. Rise (16)	Max. Gradient (17)
Southbound Beams				
S16	91	140	50	14
S25 (18)	77	131	50	10
Precast Panels				
LP2	95	130	30	2
Southbound Deck				
LS1-A	74	74	5	2
LS1-B	72	74	3	1
LS1-C	73	71	2	2
LS2-A	74	68	0	5

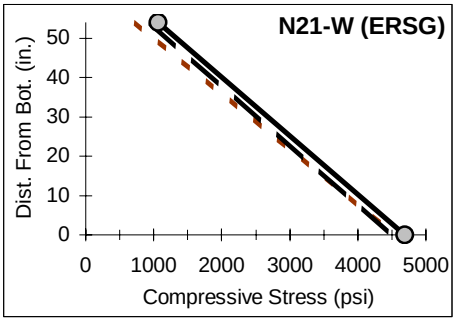
(15) Average temperature for all gages in a beam, and average of two locations in panels and decks.
(16) At a single gage location.
(17) Between two gage locations.
(18) Steam cured to maintain a favorable temperature under the tarpaulin.

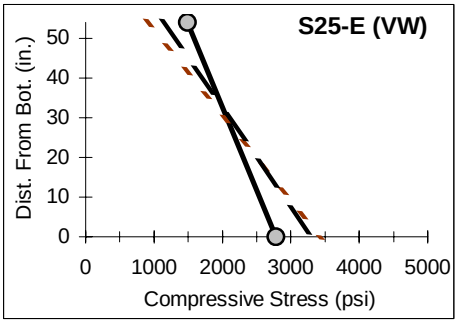
Thermal Gradients:

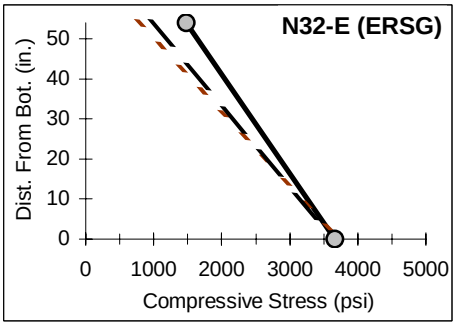
	Northbound (19)	Southbound (19)
Measured Thermal Gradient (20), °F		
Positive Gradient	30	31
Negative Gradient	13	11
Highest Average Measured Gradient for a Calendar Month, °F		
Positive Gradient	24 (21)	25 (21)
Negative Gradient	7 (22)	6 (22)

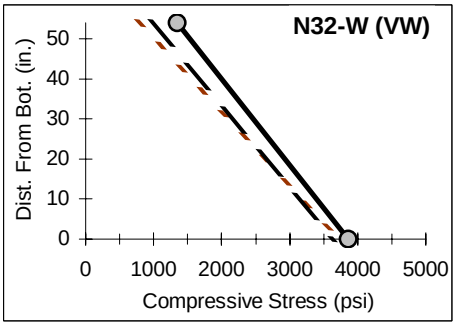
(19) Data collected for the full 1997 calendar year.
(20) Temperature difference between the beam and the location of the top deck gage. This ranged from 2.00 to 2.25 in below the deck surface.
(21) Average for July 1997.
(22) Average occurred in many months.

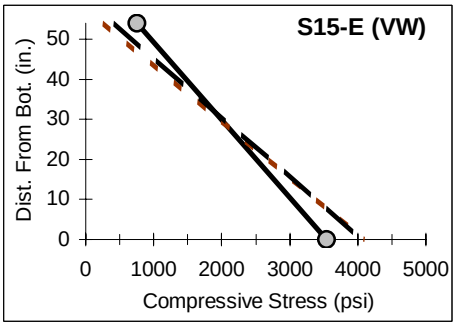
Concrete Stresses at Release of Pretensioning:

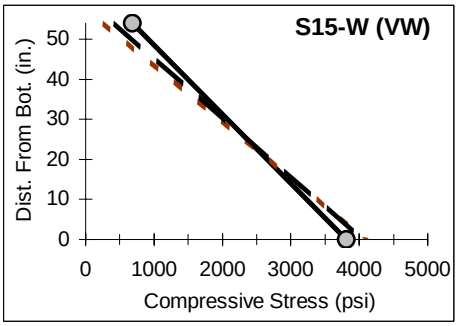


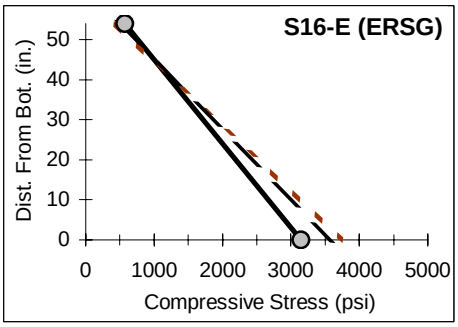










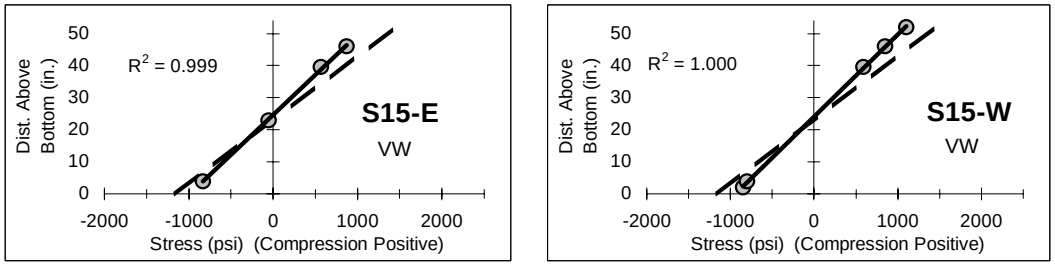


Note: Solid lines represent "measured" stresses determined by multiplying measured strains by modulus of elasticity from tests on companion specimens. Dotted lines represent "design" prediction. Dashed lines represent "measured" prediction. (See Table 6.2 for assumptions.)

Table 6.2 follows.

Parameters	Design Analysis	Measured Analysis
Sectional Properties	Gross section	Transformed section
Prestress Force/Loss	No loss assumed before release. Elastic shortening loss calculated by approximate method given in *AASHTO LRFD Specifications*	3.5 to 4.5% loss assumed before release
Beam Self-Weight	Gross beam area at 150 lb/ft^3 (3.29 kg/m^3)	Gross beam area and measured unit weight, with approximate weight of steel included.
Modulus of Elasticity	$33w^{1.5}\sqrt{f_c'}$ for Westbound $40{,}000\sqrt{f_c'}+1{,}000{,}000$ for Eastbound	Based on tests of companion specimens

Concrete Stresses from Placement of Cast-in-Place Deck:



Note: Points represent measured stresses (strains multiplied by measured modulus of elasticity). Solid lines represent regression lines fit to measured data (coefficient of determination given on each chart). Dashed lines represent predicted stresses based on analysis using measured modulus of elasticity, measured deck thickness, and transformed section properties.

Prestress Losses:

Beam	Days after Release	Loss Components, ksi				
		PR (23)	ES at Release	CR + SH (24)	RE	TOTAL
N32	761	8.10	17.75	14.47	2.78	43.11
S15	748	8.10	16.38	10.61	2.77	37.85
S16	1262	8.10	17.10	11.93	3.06	40.26
S25	1221	8.10	12.96	9.70	3.04	33.81

ES = Elastic shortening component measured using a combination of vibrating wire strain gages and electrical resistance strain gages.
CR+SH = Creep and shrinkage component determined as the difference between total shortening and elastic shortening measured with vibrating wire strain gages.
RE = Relaxation component after release calculated for low relaxation strand.
(23) PR = Pre-release component calculated as 4.0 percent of the nominal jacking stress.
(24) Includes compensation for measured elastic change in stress from superimposed dead load.

Camber and Deflection:

All camber and deflection values in inches. Negative values indicate downward deflection.

Beam No.	Camber at Release		Camber Growth (25)		CIP Deck (26)	Total Deck (27)	Long Term (28)	
	Actual	Corrected (29)	Days of Data	Camber			Days of Data	Camber
N21	3.12	3.17	632	2.13	-1.16	-2.32	961	2.87
N22	2.11	1.83	660	1.62	-1.50	-2.84	989	0.38
N23	1.77	—	667	1.48	-1.39	-2.77	996	0.21
N31	3.03	3.08	632	2.20	-1.09	-2.10	961	2.78
N32	2.20	2.51	159	1.65	-1.43	-2.73	486	1.15
N33	2.28	2.60	159	1.33	-1.33	-2.60	486	0.92
S14	2.50	2.44	146	1.44	-1.09	-2.18	475	1.24
S15	2.50	2.46	146	1.33	-1.23	-2.34	475	1.15
S16	2.18	1.94	660	1.80	-0.80	-1.76	989	1.80
S24	2.21	2.00	619	1.42	-1.79	-3.11	948	-0.08
S25	1.95	1.74	619	1.61	-1.76	-3.16	948	-0.14
S26	3.33	—	646	1.61	-1.42	-2.60	976	2.13

(25) Growth in camber during storage at the plant.
(26) Deflection caused by placing the cast-in-place deck.
(27) Deflection taken as the difference between readings before placement of precast panels and after placement of the cast-in-place deck.
(28) Total measured long-term camber.
(29) Actual values corrected for thermal gradient in the beam. All other data are also corrected.

Live Load Tests

Loadings:

LS-A1 LS-A2	One truck pair centered over Beam S15 near midspan of SB Span 1 (at Beam S15). Loading repeated twice at different times during testing.
LS-B	Two truck pairs placed near midspan of SB Span 1 (at Beam S15). Outer edge of wheel lines for each truck pair at 2.0 ft. from centerline of Beam S15. Intended to produce approximately maximum stress in Beam S15.
LS-C	One truck pair near midspan of SB Span 1 (at Beam S15). One wheel line centered halfway between Beams S14 and S15, other wheel line above Beam S15.
LS-D	One truck pair with resultant of loads at quarter-point of Beam S15 and one truck pair with resultant of loads at midspan of Beam S25. For investigation of possible continuity across Bent 2. If continuity exists, this loading should produce negative moment at Bent 2 and positive moment at midspan of Span 2.

Test Results:

Beam (30)	Deflection (31), in	Curvature (32), millionths/in	Beam (30)	Deflection (31), in	Curvature (32), millionths/in
Loading LS-A1					
S11	0.02	—	S21	-0.03	—
S12	0.10	—	S22	0.07	—
S13	0.04	—	S23	0.06	—
S14	-0.02	—	S24	—	—
S15	-0.10	0.91	S25	—	-0.13
S16	-0.14	—	S26	—	—
Loading LS-A2					
S11	0.05	—	S21	0.03	—
S12	0.07	—	S22	0.03	—
S13	0.02	—	S23	0.04	—
S14	-0.06	—	S24	0.08	—
S15	-0.12	—	S25	0.08	—
S16	-0.12	—	S26	0.07	—
Loading LS-B					
S11	-0.07	—	S21	0.04	—
S12	-0.08	—	S22	0.04	—
S13	0.01	—	S23	0.07	—
S14	-0.17	—	S24	0.01	—
S15	-0.31	1.75	S25	0.05	-0.04
S16	-0.21	—	S26	0.04	—
Loading LS-C					
S11	-0.02	—	S21	0.05	—
S12	-0.02	—	S22	0.01	—
S13	-0.05	—	S23	0.03	—
S14	-0.10	—	S24	0.00	—
S15	-0.14	1.14	S25	0.06	-0.04
S16	-0.07	—	S26	0.02	—
Loading LS-D					
S11	0.09	—	S21	0.06	—
S12	0.08	—	S22	0.05	—
S13	0.08	—	S23	0.04	—
S14	-0.07	—	S24	-0.05	—
S15	-0.13	0.50	S25	-0.11	0.58
S16	-0.05	—	S26	-0.08	—

(30) S is southbound. First number is span. Second number is beam line.
(31) Midspan deflection measured using precise surveying. Negative values are downward deflection. Reported values are the average from each web of the U-beam.
(32) Midspan curvature determined by fitting a regression line through the measured concrete strains at several depths. Positive values indicate a downward deflection. For S15, reported curvatures are the average values from each web of the U-beam. For S25, reported curvatures are based on the east web only.

8. OTHER RELATED RESEARCH

Prior to construction of the bridge, five full-scale test specimens were made using concrete with specified compressive strengths in the range of 10,000 to 13,000 psi. Three test specimens were 40-ft long, 3 ft-7-5/8-in-wide and 8-1/4-in thick and represented the bottom flange of the U-beams. A 24-in-tall by 18-in-wide concrete section was included at each end to represent the end blocks. The specimens contained a concentric arrangement of prestressing strands. The specimens were made so that the effects of using 0.6-in-diameter strands at 50-mm spacing could be observed. The variables in the specimens were debonding pattern, confinement steel reinforcement, and concrete strength.

The other test specimens consisted of two 53-ft-6-in-long full-scale U-beams including an 18-in-thick end block section. The primary variable was strand pattern at the end of the beam.

Concrete strains measured on the surface of the test specimens indicated that the transfer length of 0.6-in-diameter-slightly-rusted strands was between 18 and 24 in. No cracking was observed in any of the test beam end regions as a result of transfer of the prestressing force.

9. SOURCES OF DATA

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Barrios, A. O., Burns, N. H., and Carrasquillo, R. L., "Behavior of High Strength Concrete Pretensioned Girders During Transfer of Prestress," Center for Transportation Research, The University of Texas at Austin, Preliminary Research Report 9-580-1, 1994, 146 pp.

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Shawn P. Gross, Villanova University, Villanova, PA.

John J. Myers, University of Missouri-Rolla, Rolla, MO.

10. DRAWINGS

Beam Span Lengths, Beam Spacings, and Specified Compressive Strengths
Northbound:

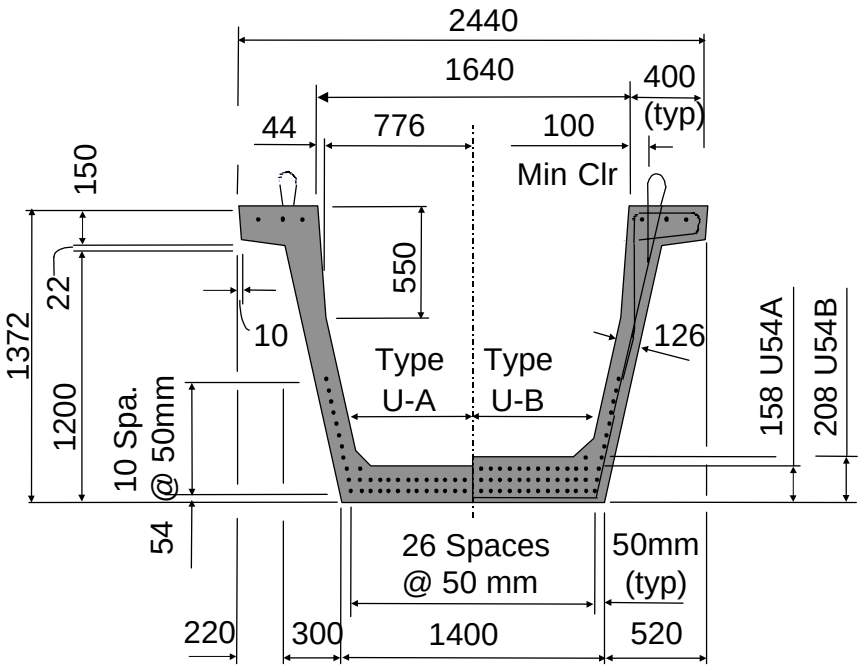
Beam (33)	Beam Type	Span Length (34), ft	Beam Spacing (35), ft	Specified Compressive Strength, psi	
				Release	56 days
N11	U54B	119.86	13.97	7700	11,600
N12	U54B	120.42	12.94	6900	9800
N13	U54B	120.98	12.88	6900	9800
N14	U54B	121.54	12.82	6900	9800
N15	U54B	122.11	13.91	7700	11,600
N21	U54B	134.17	13.66	8800	13,100
N22	U54B	134.74	12.33	7700	11,600
N23	U54B	135.32	12.28	7700	11,600
N24	U54B	135.89	12.22	7700	11,600
N25	U54B	136.48	13.61	8800	13,100
N31	U54B	132.38	13.30	8800	13,100
N32	U54A	132.89	11.61	7700	11,600
N33	U54A	133.40	11.56	7700	11,600
N34	U54A	133.92	11.52	7700	11,600
N35	U54B	134.43	13.26	8800	13,100

(33) In beam designation xyz, x = bridge, y = span number, and z = beam number.
(34) Distance between center line of bearings.
(35) Average perpendicular distance between adjacent beams at midspan.

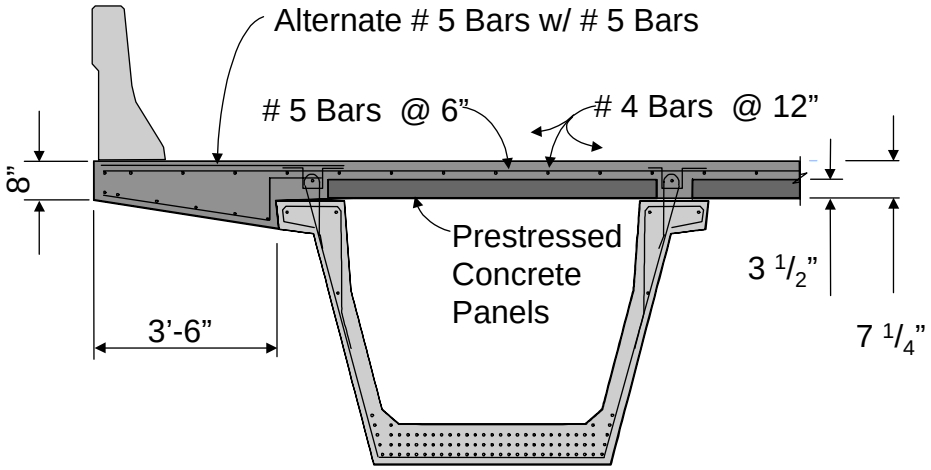
Southbound:

Beam (33)	Beam Type	Span Length (34), ft	Beam Spacing (35), ft	Specified Compressive Strength, psi	
				Release	56 days
S11	U54B	112.27	15.81	7700	11,600
S12	U54A	113.68	16.62	7700	11,600
S13	U54A	115.13	16.41	7700	11,600
S14	U54A	116.62	16.20	7700	11,600
S15	U54A	118.15	16.00	7700	11,600
S16	U54B	119.71	15.50	7700	11,600
S21	U54B	125.95	14.72	8800	13,100
S22	U54B	127.48	14.45	7700	11,600
S23	U54B	129.05	14.27	7700	11,600
S24	U54B	130.66	14.10	7700	11,600
S25	U54B	132.31	13.92	7700	11,600
S26	U54B	134.00	14.46	8800	13,100
S31	U54B	125.06	13.62	7700	11,600
S32	U54A	126.43	12.25	6900	9800
S33	U54A	127.83	12.11	6900	9800
S34	U54A	129.26	11.98	6900	9800
S35	U54A	130.72	11.84	6900	9800
S36	U54B	132.22	13.42	7700	11,600

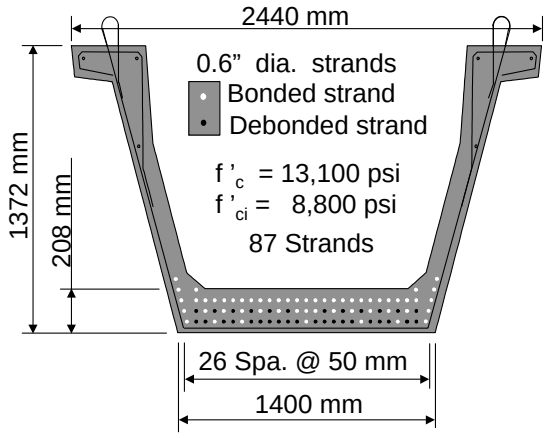
(33) In beam designation xyz, x = bridge, y = span number, and z = beam number.
(34) Distance between center line of bearings.
(35) Average perpendicular distance between adjacent beams at midspan.



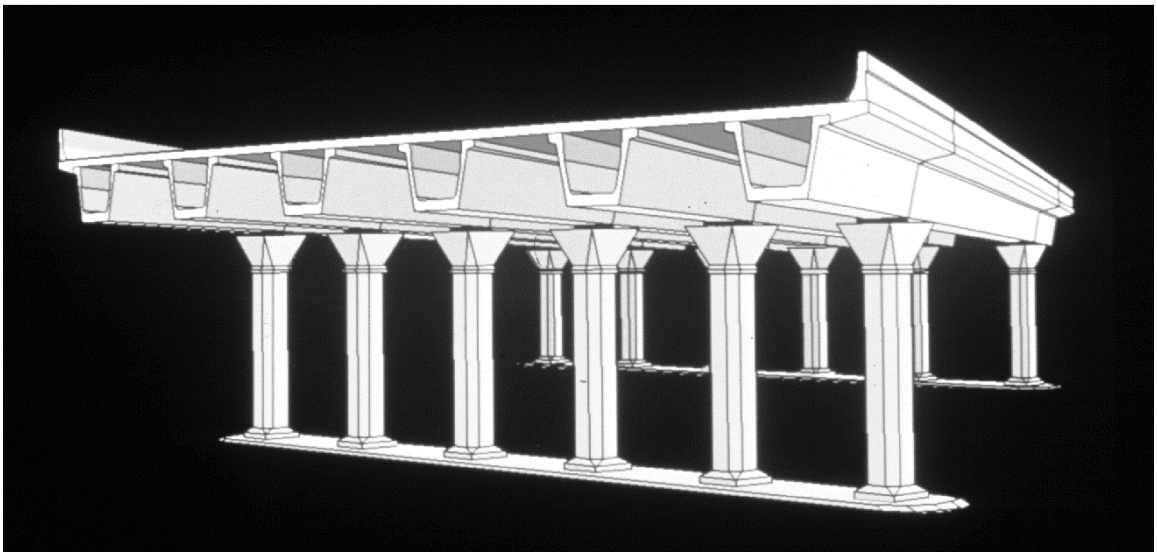
Texas U54A and U54B Beam Cross Sections.



Cross Section of Edge Beam showing Precast Deck Panels and Cast-in-Place Deck.



Texas U54B Beam Cross Section Showing Debonded Strands.



11. HPC SPECIFICATIONS

The Louetta Road project was let under the 1982 Texas specifications with modifications to the sections dealing with concrete structures, portland cement concrete, and prestressed concrete structural members. The following text was extracted from the General Notes and Specification Data.

STRUCTURE MONITORING

THE RESEARCHERS WILL DEVELOP A FIELD MEASURING PROGRAM IN ORDER TO MONITOR THE STRUCTURAL PERFORMANCE OF THE BRIDGE AND ITS COMPONENTS. THE CONTRACTOR WILL NEED TO MAKE AVAILABLE SELECTED COMPONENTS FOR ATTACHMENT OF EXTERNALLY MOUNTED MEASUREMENT DEVICES. IT IS NOT ANTICIPATED THAT THE INSTALLATION OF EQUIPMENT OR THE COLLECTION OF DATA WILL CAUSE ANY SIGNIFICANT DELAYS OR WORK STOPPAGES FOR THE CONTRACTOR.

ITEMS 426, 421, 425 AND 6734.
USE OF EXTRA-HIGH-STRENGTH CONCRETE FOR BRIDGE STRUCTURES. THIS STUDY IS CO-SPONSORED BY THE FEDERAL HIGHWAY ADMINISTRATION AND THE TEXAS DEPARTMENT OF TRANSPORTATION. THE INVESTIGATION TEAM IS FROM THE CENTER FOR TRANSPORTATION RESEARCH OF THE UNIVERSITY OF TEXAS. THE SUCCESS OF BOTH THE RESEARCH AND THE CONSTRUCTION PROJECT REQUIRES THAT THE INVESTIGATING TEAM [RESEARCHERS) PLAY AN INTEGRAL PART IN THE CONSTRUCTION PROCESS AND THAT THE CONTRACTOR AND SUBCONTRACTOR COOPERATE FULLY WITH THE RESEARCHERS. THE FOLLOWING SECTION DESCRIBES SPECIAL CONSIDERATION REQUIRED OF THE CONTRACTOR AND OUTLINES THE ROLE OF THE RESEARCHERS IN VARIOUS ASPECTS OF THE CONSTRUCTION PROCESS.

COORDINATION OF WORK WITH THE CONTRACTOR

ALL ASPECTS OF THE INVESTIGATING TEAM'S WORK WILL BE COORDINATED WITH THE CONTRACTOR. AFTER LETTING, A PRECONSTRUCTION MEETING WILL BE SCHEDULED BETWEEN THE RESEARCHERS, SPONSORS, AND THE CONTRACTOR, INCLUDING PERTINENT SUBCONTRACTORS. DURING CONSTRUCTION, COORDINATION BETWEEN THE INVESTIGATING TEAM AND THE CONTRACTOR'S REPRESENTATIVES WILL BE REQUIRED TO ENSURE IMPLEMENTATION OF THE NECESSARY MEASURES FOR DESIGN AND CONTROL OF HIGH STRENGTH CONCRETE.

CONCRETE MIX DEVELOPMENT

THE RESEARCHERS WILL PROVIDE TECHNICAL EXPERTISE TO TO THE CONTRACTOR IN DEVELOPING AND EVALUATION THE HIGH STRENGTH CONCRETE (f'c GREATER THAN OR EQUAL TO 8000 PSI) MIX DESIGNS USED FOR THE LOUETTA RD. OVERPASS STRUCTURES. THE DESIGN AND CONTROL OF THE HIGH STRENGTH CONCRETE SHALL BE IN ACCORDANCE WITH THE STANDARD SPECIFICATIONS, SPECIAL PROVISIONS AND CONTRACT PLANS. EMPHASIS WILL BE GIVEN T0 USING THE LOCAL MATERIALS AVAILABLE AS PROPOSED BY THE CONTRACTOR. HOWEVER, HIGHER QUALITY MATERIALS THAN ARE AVAILABLE LOCALLY MAY BE REQUIRED TO MEET MINIMUM STRENGTH AND MODULUS CRITERIA.

LABORATORY AND FIELD TESTING

DURING THE TRIAL MIX PHASE OF THE HIGH STRENGTH CONCRETE MIX DESIGN, AND FOR CONTROL OF THE CONCRETE DURING CONSTRUCTION/FABRICATION, CONCRETE SPECIMENS IN ADDITION TO THOSE REQUIRED BY THE SPECIFICATIONS/CONTRACT PLANS WILL BE MADE BY THE RESEARCHERS AND/OR TxDOT PERSONNEL. THE CONTRACTOR SHALL MAKE THE NECESSARY PROVISIONS TO ALLOW ADEQUATE SAMPLING OF THE CONCRETE.

ITEM 437: CONCRETE ADMIXTURES

HIGH RANGE WATER REDUCERS WILL BE USED ONLY TO MEET SPECIAL REQUIREMENTS AND WILL REQUIRE THE WRITTEN APPROVAL OF THE ENGINEER ON EACH SPECIFIC PROJECT. A SATISFACTORY WORK PLAN FOR CONTROL SHALL BE SUBMITTED BY THE CONTRACTOR FOR APPROVAL AND AN EVALUATION OF THE CONCRETE CONTAINING THE ADMIXTURE WILL BE PERFORMED BY THE ENGINEER. WHEN DIRECTED BY THE ENGINEER, AN APPROVED RETARDER AT THE DOSAGE SPECIFIED BY THE ENGINEER SHALL BE USED.

Louetta Road Bridge
Properties of Cement used in Girders, Deck Panels, and Cast-in-Place Deck

Property		Girders	Panels	CIP Deck
Chemical, %				
SiO_2		19.66	18.95	20.24
Al_2O_2		5.38	6.50	5.66
Fe_2O_3		2.06	2.97	2.11
CaO		64.05	64.57	64.63
MgO		1.26	0.71	1.27
SO_3		4.09	3.79	3.16
Loss of Ignition		2.64	1.57	2.06
Insoluble Residue		0.27	0.24	0.19
Free Lime		N/A	1.70	N/A
C_3S		60.58	61.10	59.23
C_3A		10.77	1.80	11.43
Total Alkali		0.60	0.71	0.60
Specific Surface, cm^2/gm				
Blaine		5730	6360	3430
Wagner		2926	2933	1823
% Passing No. 325 Sieve		98.6	99.7	93.7
Compressive Strength, psi				
1 Day		4545	4230	N/A
3 Day		5910	5076	4085
7 Day		6750	5930	5115
28 Day		N/A	N/A	N/A
Setting Time, min				
Vicat	Initial	75	N/A	115
	Final	120	N/A	180
Gilmore	Initial	135	62	185
	Final	255	118	350

N/A = Not available