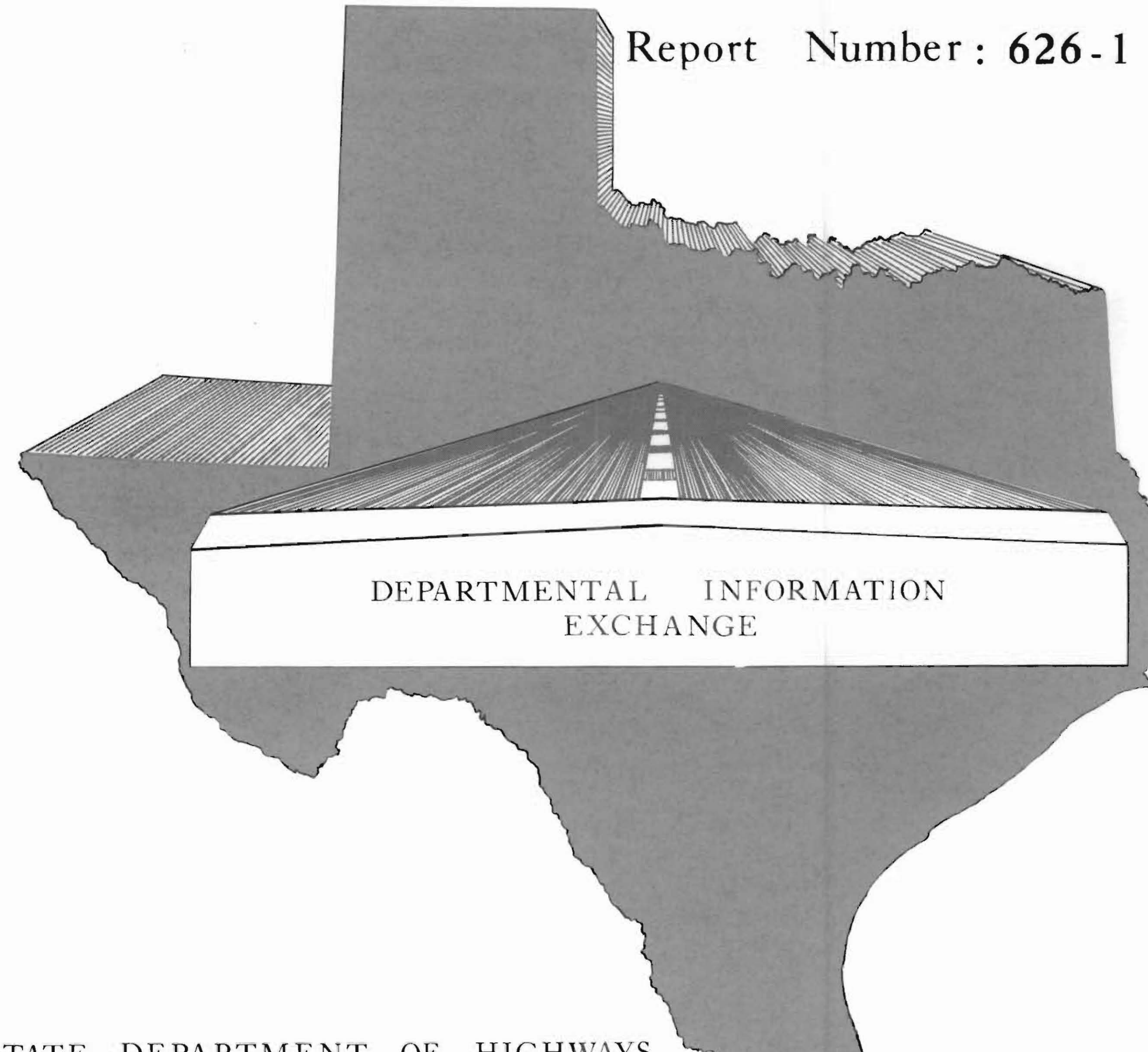
EXPERIMENTAL PROJECTS

EVALUATION OF SHRINKAGE COMPENSATING CEMENT IN A BRIDGE SLAB

Report Number: 626-1



STATE DEPARTMENT OF HIGHWAYS
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FHWA Experimental Project No. 064875009

16. Abstract

The performance of a bridge deck slab made with shrinkage compensating cement (Texas Industries 4-C Type K ChemComp) was evaluated by comparison with a deck slab made with conventional Type II cement. No significant problems were encountered in mixing, placing, or finishing the concrete made with shrinkage compensating cement. Compressive strengths were less than the conventional concrete but were well above the design strength. A few short cracks were found in the control slab but they are not believed to be shrinkage related because they formed between two and three years after construction. Results of this evaluation did not show any engineering advantage gained from the use of shrinkage compensating cement.

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EVALUATION OF SHRINKAGE COMPENSATING CEMENT IN A BRIDGE SLAB

By

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State Department of Highways & Public Transportation

Bridge Division

Austin, Texas

Experimental Projects Report No. 626-1

Work done in Cooperation with
U.S. Department of Transportation
Federal Highway Administration

FHWA Experimental Project
No. 064875009

"Evaluation of Shrinkage Compensating
Cement in a Bridge Slab"

The contents of this report reflect the views of the authors who are responsible for the facts and accuracy of the data presented herein. The contents do not necessarily reflect the views or policies of the Federal Highway Administration. This report does not constitute a standard, specification or regulation.

The material contained in this report is experimental in nature and is published for informational purposes only. Any discrepancies with official views or policies of the State Department of Highways and Public Transportation should be discussed with the appropriate Austin Division prior to implementation of the procedures or results.

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EVALUATION OF SHRINKAGE COMPENSATING CEMENT IN A BRIDGE SLAB

Early in 1974 the Texas State Department of Highways and Public Transportation awarded a contract which included the construction of twin bridges on State Highway 360 over Johnson Creek in Arlington, Texas. At the request of the contractor's cement supplier, a shrinkage compensating cement (Texas Industries 4-C Type K ChemComp) was used in the slab of one of the bridges. Its performance was evaluated by comparison with the other bridge slab made with conventional Type II cement.

Description of Bridges

The Johnson Creek bridges are 175.00 feet long with three prestressed concrete beam simple spans (42.50'-80.00'-52.50'). The prestressed concrete beams are 54 inches deep and the slab thickness is 8.25 inches. The test bridge has an overall width of 60.896 feet and the control bridge has an overall width of 66.896 feet. Slab details for these bridges are shown in Appendix A. The test bridge carries the northbound traffic of State Highway 360 and the control bridge carries the southbound traffic.

Specifications

The slab concrete of the control bridge contained Type II portland cement and was designed and placed in accordance with standard specifications of the Texas State Department of Highways and Public Transportation. Slab concrete in the test bridge contained the ChemComp shrinkage compensating cement and was of the same batch design as the control concrete. All items of the specifications were unchanged except maximum allowable slump for the ChemComp concrete was increased from four to six inches. Placement procedures, equipment, construction joints, placing, finishing, testing, and curing of the two concretes were as nearly identical as possible.

Construction

The Johnson Creek bridge slabs were placed between August 18, 1975, and September 26, 1975. Temperatures were generally warm, ranging from the middle seventies to the high eighties and low nineties. An exception occurred during the placement of slabs B and C of the experimental bridge when temperatures remained generally in the fifties and sixties. During those days of high temperatures, ice was added to the concrete mix to keep the temperature of the concrete at time of placement

85° or less. Ambient air and fresh concrete temperatures for each batch of concrete are shown in Table 1.

Observations

Concrete made with shrinkage compensating cement has a tendency to set up faster than conventional concrete and therefore must be placed as soon after mixing as possible. Travel time between the concrete batch plant and the construction site was approximately thirty minutes and it was determined that the ChemComp concrete would lose approximately one and one-half inches of slump in this time. The slump at the plant was adjusted to give a slump of approximately six inches at the job site.

The final mix design for the ChemComp concrete gave a good plastic mix with no tendency towards segregation and no excessive bleeding with slumps up to six inches. Twenty-eight day strengths were somewhat lower than for the conventional concrete but well above that required. Strengths of the conventional concrete are shown in Table 2 and strengths for the ChemComp concrete are shown in Table 3. The fresh ChemComp concrete had a sticky consistency and would adhere to a wooden float, however this problem was overcome by the use of metal tools. The ChemComp concrete also appeared to set up quicker than conventional concrete and therefore created a problem in obtaining a uniform textured surface.

The experimental and control bridges were visually inspected at seven months, one year and seven months, and two years and eleven months after construction. There was no discernible difference in the appearance of the two decks and no visible cracks were found until the last inspection was made, nearly three years after construction. During this inspection four short cracks, 12-18 inches long, were found in the control bridge. These bridges have a skew angle of 31°00' and these cracks are located in the acute angle corner of the slabs, an area generally susceptible to the formation of cracks.

Conclusions

Based on the results of this evaluation the following statements are made:

1. The few cracks that formed in the control slab are not believed to be caused by shrinkage since they formed between two and three years after the concrete was placed and in a location generally susceptible to the formation of cracks.
2. There were no significant problems encountered in

mixing, placing, or finishing the ChemComp concrete.

3. Twenty-eight day strength of the ChemComp concrete was less than the conventional concrete but was well above the design strength of 3600 psi.

4. There was no apparent engineering advantage gained from the use of shrinkage compensating cement.

TABLE 1. AMBIENT AIR - FRESH CONCRETE TEMPERATURES FOR EACH BATCH OF CONCRETE

Slab	A	B	C	D	E	F
Date Placed	9-4-75	9-22-75	9-26-75	8-18-75	9-3-75	9-11-75
	80-78	58-78	50-70	78-80	94-79	80-81
	78-78	58-77	50-75	77-78	94-80	80-81
	78-78	60-78	50-76	77-78	78-77	80-82
	80-78	51-72	51-76	80-82	78-78	77-78
	82-80	51-72	51-75	80-81	90-84	78-79
	86-84	51-75	50-75	78-80	76-78	78-80
	86-84	51-75	58-78	78-79	76-78	78-80
	86-82	53-76	56-78	76-?	76-79	76-76
	84-82	54-75	54-78		76-78	76-76
		56-76	51-76		80-80	76-76
		58-77			84-80	76-77
		60-78			84-80	
		64-79			84-81	
		66-78			84-81	
		70-78			86-83	
		58-78			88-85	
					90-85	
					76-?	

Note: Concrete for spans A,B, and C made with shrinkage compensating cement. Concrete for spans D,E, and F made with Type II cement.

TABLE 2. CONCRETE STRENGTHS FOR CONCRETE MADE WITH TYPE II CEMENT

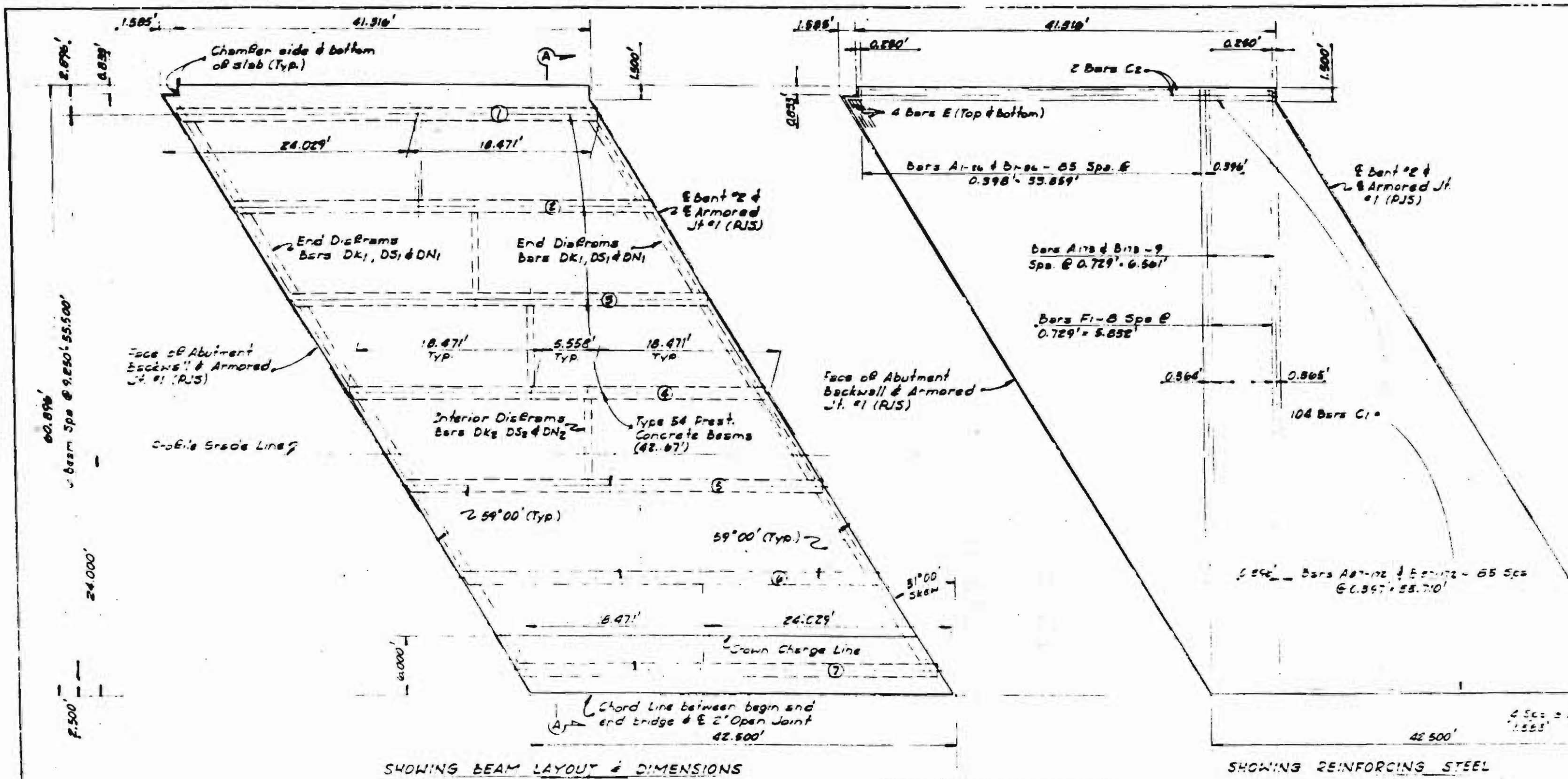
Date	Span	Beam No.	7-Day Flexural	7-Day Compressive	28-Day Compressive
8-18-75	D	C-70	775		
	D	C-71	822		
	D	C-72	846		
	D	C-73	874		
9-3-75	E	C-74	823	4015	5837
	E	C-75	843	4864	6279
	E	C-76	643	3997	5536
9-11-75	F	C-77	690	2812	5023
	F	C-78	663	2848	5447
	F	C-79	634	3449	4828
	F	C-80	686	4156	5200

TABLE 3. CONCRETE STRENGTHS FOR CONCRETE MADE WITH SHRINKAGE COMPENSATING CEMENT

Date	Span	Beam No.	7-Day Flexural	7-Day Compressive	28-Day Compressive
9-4-75	A	4C-1	650	3537	4988
	A	4C-2	671	3661	5306
	A	4C-3	655	3573	5147
9-22-75	B	4C-4A	510	2441	4139
	B	4C-4B	480	2441	3926
	B	4C-5A	580	3537	5359
	B	4C-5B	565	3325	5465
9-26-75	C	4C-6A	594	3608	5394
	C	4C-6B	531	3166	5265
	C	4C-7A	610	2989	5164
	C	4C-7B	622	3467	5394

APPENDIX A

BRIDGE SLAB DETAILS



PLAN - 42.50' END SPAN "A"

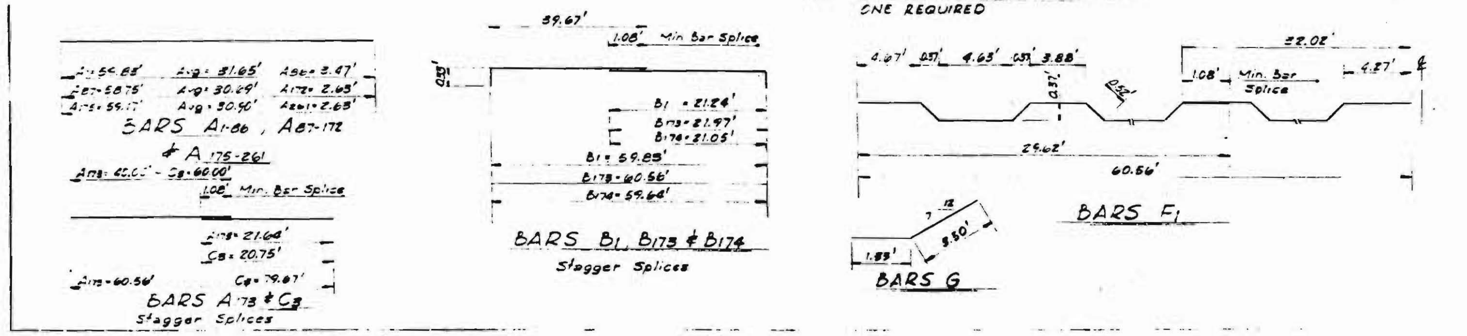
ONE REQUIRED

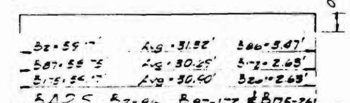
BILL OF REINFORCING STEEL

SPAN "A"

Bar	No.	Size	Length	Weight
• A1-86	1ea.	#5	31.65' Avg.	2839
• A87-172	1ea.	#5	30.69' Avg.	2753
• A173	10	#5	‡61.64'	643
B2-86	1ea.	#5	31.48' Avg.	2835
B87-172	1ea.	#5	31.35' Avg.	2812
B173	10	#5	‡62.50'	650
• C1	104	#5	42.17'	4574
• C2	2	#5	40.98'	85
• E	16	#5	3.50'	58
• DK1	48	#5	9.14'	458
• DK2	36	#5	7.83'	294
• DN1	2	#8	65.82'	352
• DN2	6	#8	10.17'	163
DS1	108	#4	4.83'	348
DS2	48	#4	6.83'	219
B1	1	#5	‡61.57'	64
F1	9	#5	‡63.44'	596
Total Pounds				19763

• Indicates straight bars
D Indicates Diafram Steel
‡ Includes Bar Splice (See Detail)





TEXAS HIGHWAY DEPARTMENT

175.00' PRESTRESSED CONCRETE BEAM UNIT

(42.50' - 80.00' - 52.50' SPANS)

JOHNSON CREEK BRIDGE

STA 328+75.00 TO STA 330+50.00

191

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Dn. JML	Drawing Date	U 1128 (3)	191
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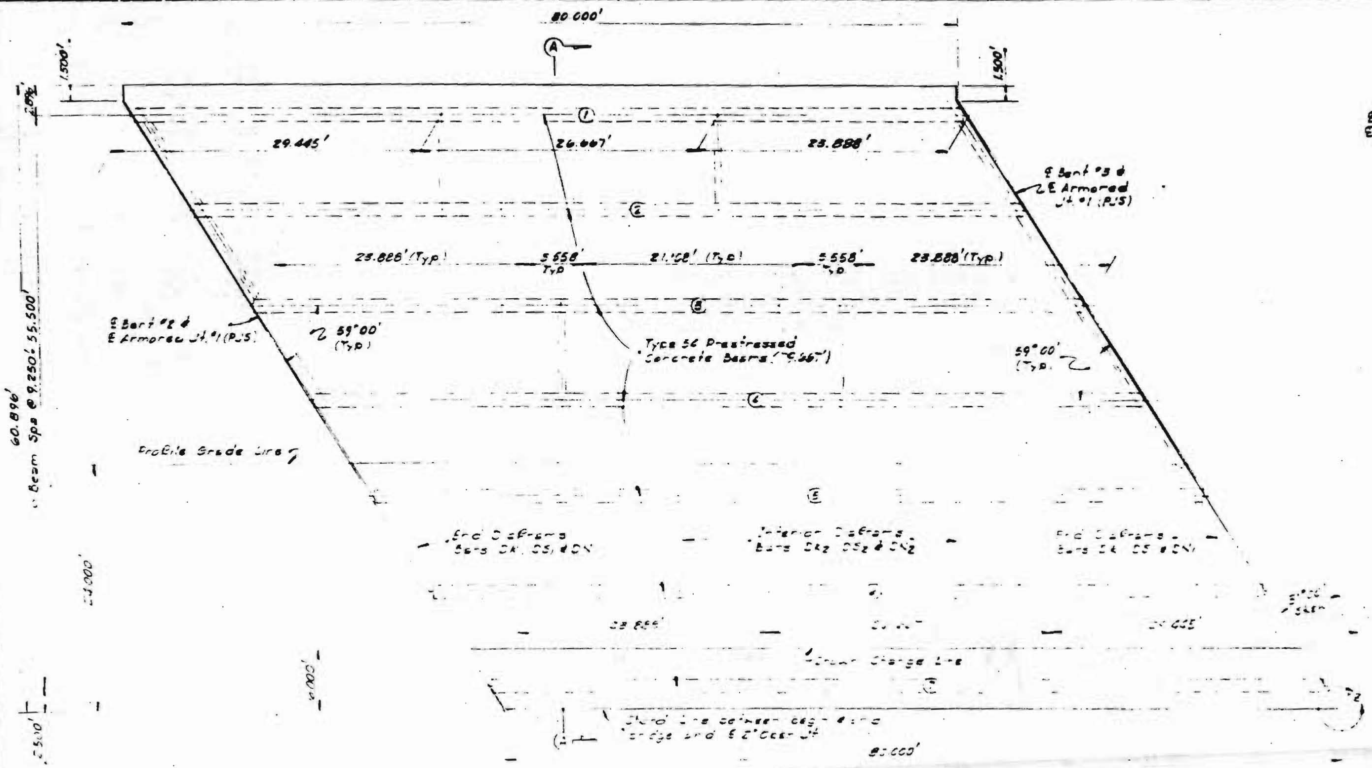
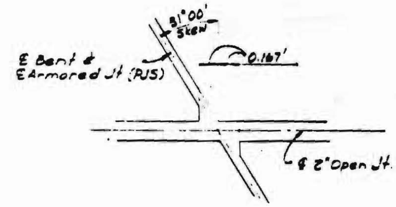


SHOWING BEAM LAYOUT & DIMENSIONS

PLAN - 80.00' INTERIOR SPAN "B"

ONE REQUIRED



CORNER DETAIL "Z"

ESTIMATED QUANTITIES

ITEM	UNIT	SPAN "A"	SPAN "B"	SPAN "C"	SPAN "D"	SPAN "E"	SPAN "F"
Class "C" Concrete Slab	CY	75.3	138.4	91.1	83.0	152.2	100.3
Reinforcing Steel	LB	[illegible]	[illegible]	[illegible]	22493	38002	263.8
Structural Steel Shoe & Armor Jt.*	LB	† 3290	2350	† 3390	† 3635	2350	† 3656
Type 54 Prestressed Conc. Beams	LF	295.2	557.7	565.2	337.3	657.3	417.3
Traffic Rail Type PH-T2	LF	41.3	80.0	49.9	39.9	80.0	51.3

* Includes quantities for armored joints & shoulder drains
† Includes approach slab and backwall armored plates

TEXAS HIGHWAY DEPARTMENT

175.00' PRESTRESSED CONCRETE BEAM UNIT

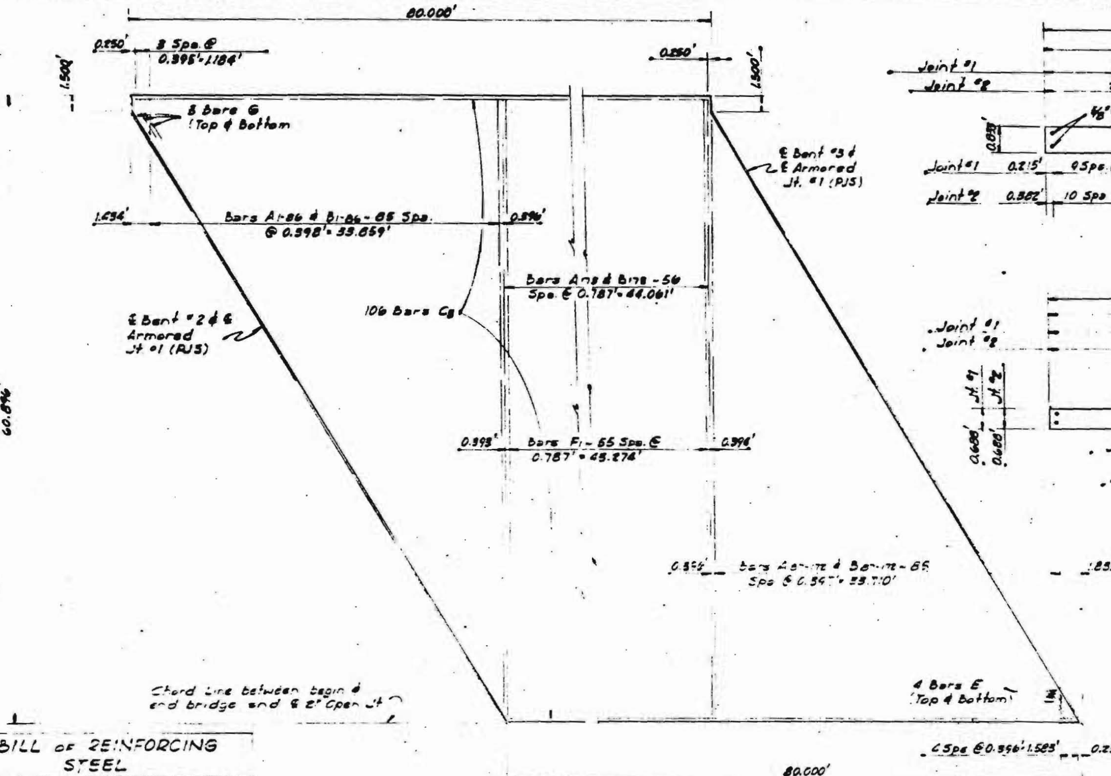
42.50 - 80.00 - 52.50 SPANS

JOHNSON CREEK BRIDGE

STA 5284+75.00 TO STA 5286+50.00

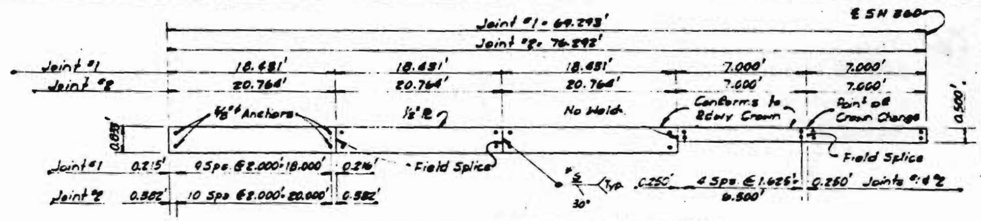
192

Sheet 2 of 6 Sheets

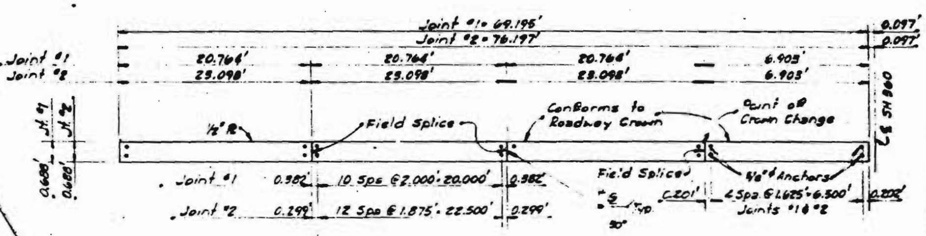


SHOWING REINFORCING STEEL

PLAN - 80.00' INTERIOR SPAN "B"



ELEVATION APPROACH SLAB PLATES



ELEVATION BRIDGE SLAB PLATES

ESTIMATED WEIGHTS:
Joint #1 - Approach Slab ℄ (1℄ = 1161 Lb (2 Required)
Joint #1 - Bridge Slab ℄ (1℄) = 1051 Lb (6 Required)
Joint #2 - Approach Slab ℄ (1℄ = 1287 Lb (2 Required)
Joint #2 - Bridge Slab ℄ (1℄) = 1163 Lb (6 Required)

#NOTE: Portions of welded splices to come in contact with PJS to be ground smooth.

ARMORED JOINT DETAILS

Chord Line between begin & end bridge and ℄ 2" Open Jt.

BILL OF REINFORCING STEEL

SPAN "B"

Bar	No.	Size	Length	Weight
*A1-86	86	#5	31.65' Avg.	2839
*A87-172	86	#5	30.69' Avg.	2753
*A178	57	#5	# 61.64'	3665
B1	1	#5	# 61.57'	64
B2-86	86	#5	31.98' Avg.	2856
B87-172	86	#5	31.35' Avg.	2812
B178	57	#5	# 62.50'	3704
*C3	106	#5	# 80.75'	8928
*E	8	#5	3.50'	29
F1	56	#5	# 63.44'	3705
G	6	#5	4.85'	30
*DK1	68	#5	9.14'	458
*DK2	72	#5	7.85'	588
*DN1	2	#8	65.85'	352
*DN2	12	#8	10.17'	326
DS1	108	#4	4.83'	348
DS2	96	#4	6.83	438
Total Pounds				33874

* Indicates straight bars
# Includes bar splice (See Detail)
D Indicates Diaphragm Steel

TEXAS HIGHWAY DEPARTMENT

175.00' PRESTRESSED CONCRETE BEAM UNIT

(42.50' - 80.00' - 52.50' SPANS)

JOHNSON CREEK BRIDGE

STA 328+75.00 TO STA 330+50.00

193

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Dn. ML	Drawing	Date	
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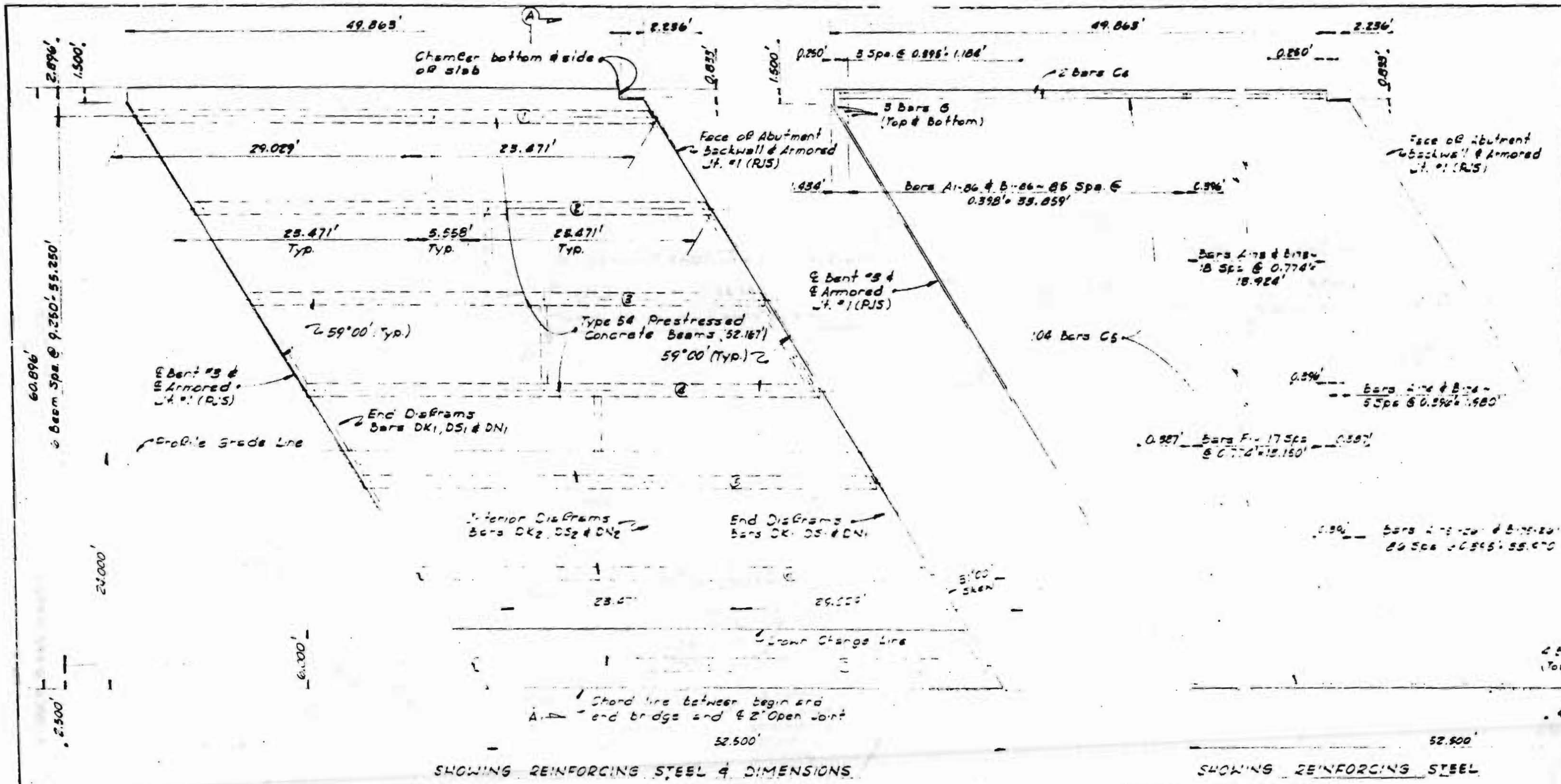


SHOWING REINFORCING STEEL & DIMENSIONS — SHOWING REINFORCING STEEL

PLAN - 52.50' END SPAN "C"

ONE REQUIRED

BILL OF REINFORCING STEEL

SPAN "C"

Bar	No.	Size	Length	Weight
* A1-86	168	#5	31.65' Avg.	2896
* A1-3	5	#5	* 61.64'	1822
* A174	6	#5	58.64'	373
* A175-201	162	#5	30.90' Avg.	2804
B1	1	#5	* 61.87'	66
B2-86	168	#5	31.98' Avg.	2885
B178	19	#5	* 62.50'	1235
B174	7	#5	* 61.58'	364
B175-201	162	#5	31.56' Avg.	2864
* C4	2	#5	49.50'	705
* C6	104	#5	52.17'	5659
* E	8	#5	3.50'	29
F1	18	#5	* 63.44'	1191
G	6	#5	4.85'	30
* DK1	48	#5	9.16'	456
* DK2	36	#5	7.83'	294
* DN1	2	#8	65.83'	352
* DN2	6	#8	10.17'	163
DS1	108	#4	4.83'	348
DS2	48	#6	6.83'	219
Total Pounds				28460

* Indicates straight bars
• Includes bar splice (See Detail)
D Indicates Diafram Steel

TEXAS HIGHWAY DEPARTMENT

175.00' PRESTRESSED CONCRETE BEAM UNIT

(62.50 - 60.00 - 52.50' SPANS)

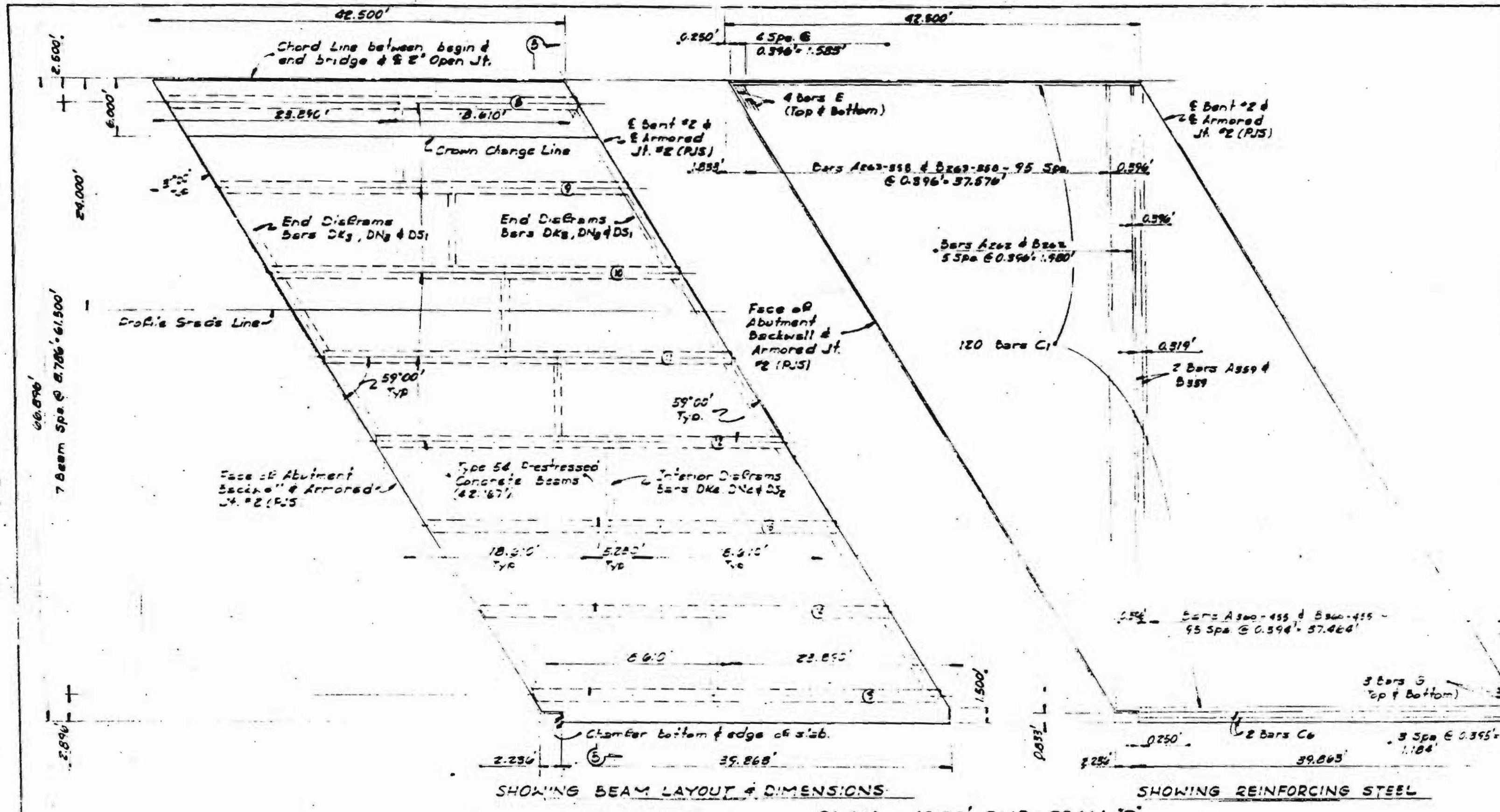
JOHNSON CREEK BRIDGE

STA 323+75.00 TO STA 330+50.00

194

Sheet #4 of 9 Sheets

Drawing	Date		
Engineer	Feb 73	U 1128 (3)	
		E TARRANT	



PLAN ~ 42.50' END SPAN 'D'

ONE REQUIRED

BILL OF REINFORCING STEEL

SPAN 'D'

Bar	Nº	Size	Length	Weight
*A262	6	#5	*66.64'	417
*A263-271	1 ea	#5	*63.61' Avg.	597
*A272-358	1 ea	#5	30.93' Avg.	2807
*A359	2	#5	* 67.56'	141
*A360-369	1 ea.	#5	*63.93' Avg.	667
*A370-455	1 ea.	#5	31.86' Avg.	2818
B262	6	#5	*67.50'	421
B263-271	1 ea	#5	*64.27' Avg.	603
B272-358	1 ea	#5	31.59' Avg.	2867
B359	2	#5	* 68.22'	142
B360-369	1 ea.	#5	*64.59' Avg.	674
B370-455	1 ea	#5	32.01' Avg.	2871
*C1	120	#5	42.17'	5278
*C6	2	#5	39.50'	82
*E	8	#5	3.50'	29
G	6	#5	4.85'	30
*DK3	56	#5	8.56'	501
*DK4	42	#5	7.33'	321
*DN3	2	#8	72.83'	389
*DN4	7	#8	9.75'	182
DS1	126	#4	4.83'	407
DS2	56	#4	6.83'	255
Total Pounds				22495

*Indicates straight bars
‡Includes bar splice (See Detail)
D Indicates Diafram Steel

TEXAS HIGHWAY DEPARTMENT

175.00' PRESTRESSED CONCRETE BEAM UNIT

(42.50' - 80.00' - 52.50' SPANS)

JOHNSON CREEK BRIDGE

STA 328+75.00 TO STA 330+50.00

Sheet # 5 of 9 Sheets

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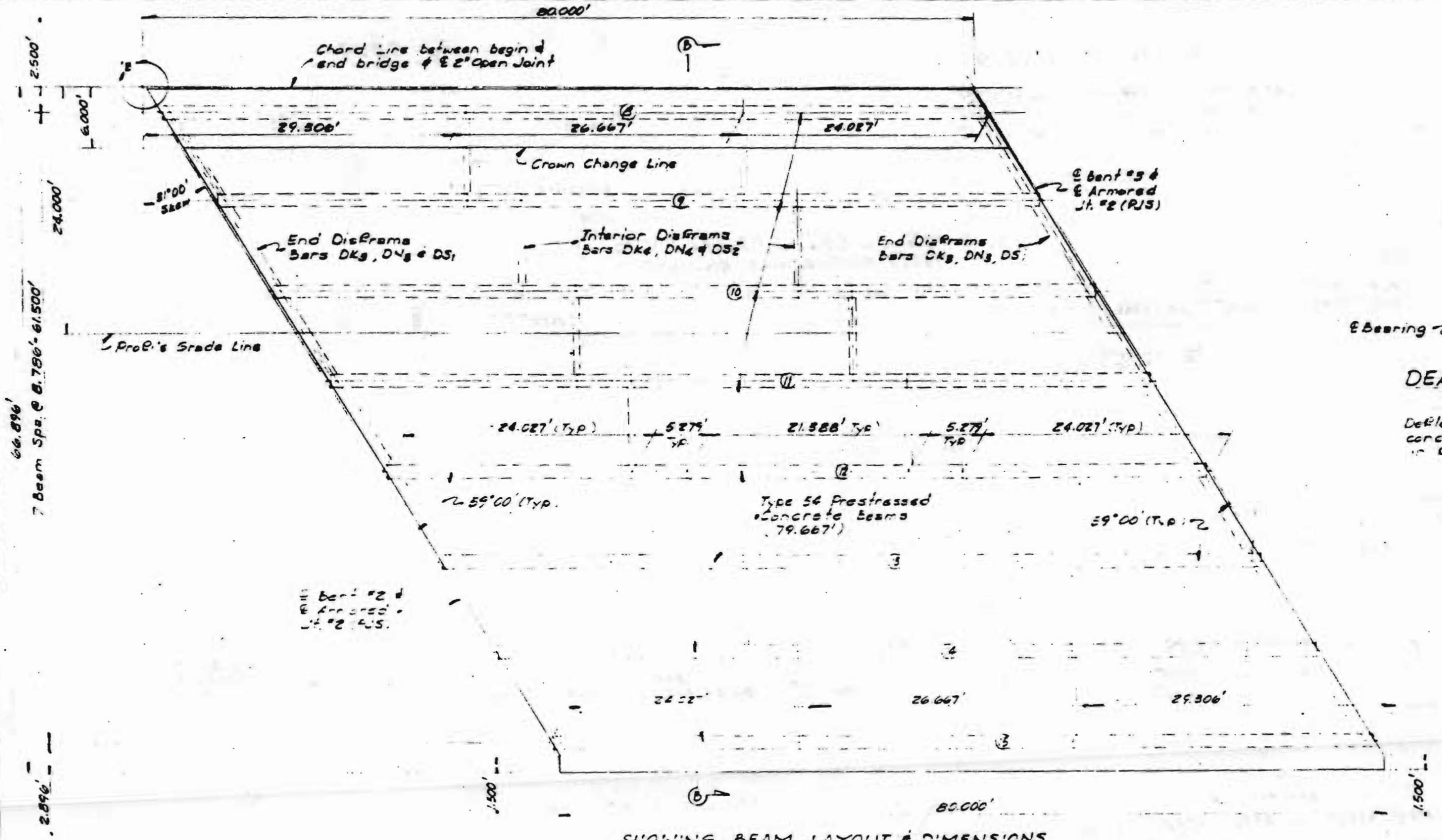

SHOWING BEAM LAYOUT & DIMENSIONS

PLAN ~ 80.00' INTERIOR SPAN "E"

SPAN "A"	0.000	0.002	0.003	0.004	0.005	0.005
SPAN "B"	0.000	0.022	0.041	0.057	0.066	0.070
SPAN "C"	0.000	0.004	0.007	0.010	0.012	0.013
SPAN "D"	0.000	0.002	0.003	0.004	0.005	0.005
SPAN "E"	0.000	0.021	0.039	0.054	0.063	0.066
SPAN "F"	0.000	0.004	0.007	0.010	0.011	0.012

℄ Bearing — 5 Eq. Spa. — Symm. about ℄ Span

DEAD LOAD DEFLECTION DIAGRAM

Deflections shown are for cast-in-place concrete only. Deflections are shown in feet. Based on E = 6,000,000

TEXAS HIGHWAY DEPARTMENT

175.00' PRESTRESSED CONCRETE BEAM UNIT

(42.50' - 80.00' - 52.50' SPANS)

JOHNSON CREEK BRIDGE

STA 328+75.00 TO STA 330+50.00

196

Sheet #6 of 9 Sheets

Design: Drawn: Date: Feb

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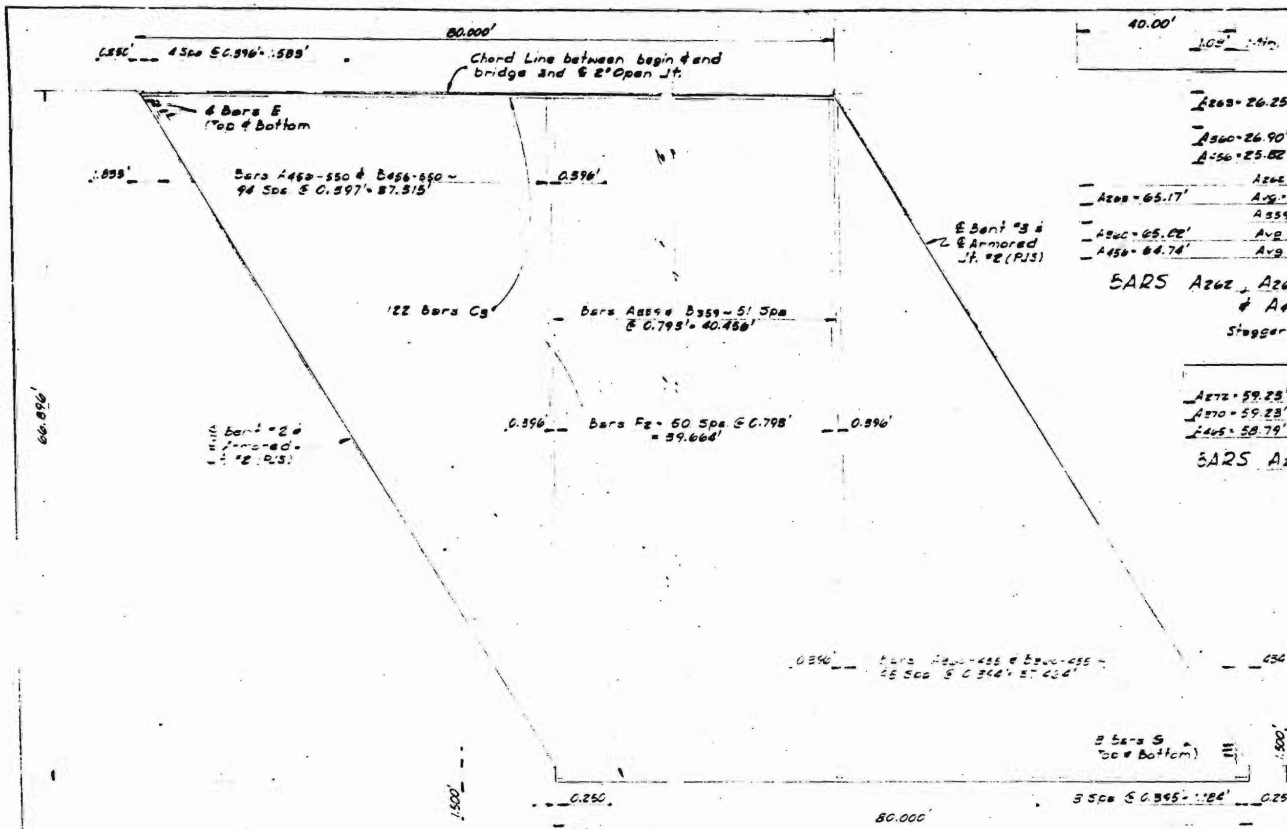
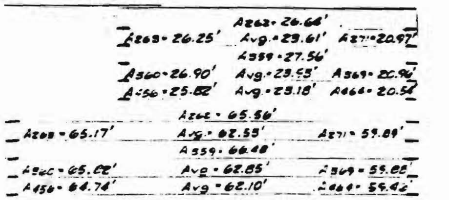


SHOWING REINFORCING STEEL
PLAN - 80.00' INTERIOR SPAN "E"

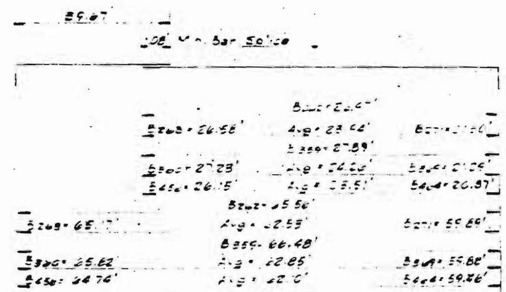


BARS A262, A263-271, A359, A360-369 & A456-464
Stagger Splices

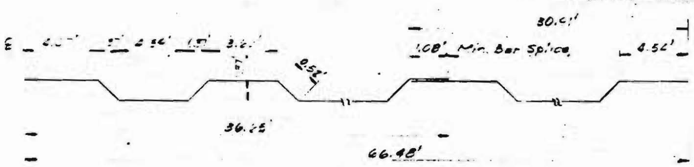
BARS A272-358, A370-455 & A465-550

Bar	No	Size	Length	Weight
* A359	52	#5	° 67.56'	3664
* A360-369	102	#5	° 63.93' Avg	667
* A370-455	102	#5	31.35' Avg	2812
* A456-464	102	#5	° 63.18' Avg	593
* A465-550	102	#5	30.71' Avg	2765
B359	52	#5	° 68.22'	3700
B360-369	102	#5	° 64.59' Avg	674
B370-455	102	#5	32.01' Avg	2871
B456-464	102	#5	° 63.84' Avg	599
B465-550	102	#5	31.37' Avg	2814
* C8	122	#5	° 80.75'	10275
* E	8	#5	3.50'	29
F2	51	#5	° 69.66'	3705
G	6	#5	4.83'	30
* DK3	56	#5	8.58'	501
* DK4	84	#5	7.33'	642
* DN3	2	#8	72.83'	389
* DN4	14	#8	9.75'	364
DS1	126	#4	4.93'	407
DS2	112	#4	6.83'	511
Total Pounds				39002

* Indicates straight bars
° Includes bar splice (See detail)
D Indicates straight bars



BARS B262, B263-271, B359, B360-369 & B456-464
Stagger Splices



BARS F2

BARS B272-358, B370-455 & B465-550

TEXAS HIGHWAY DEPARTMENT

175.00' PRESTRESSED CONCRETE BEAM UNIT

(62.50' - 80.00' - 32.50' SPANS)

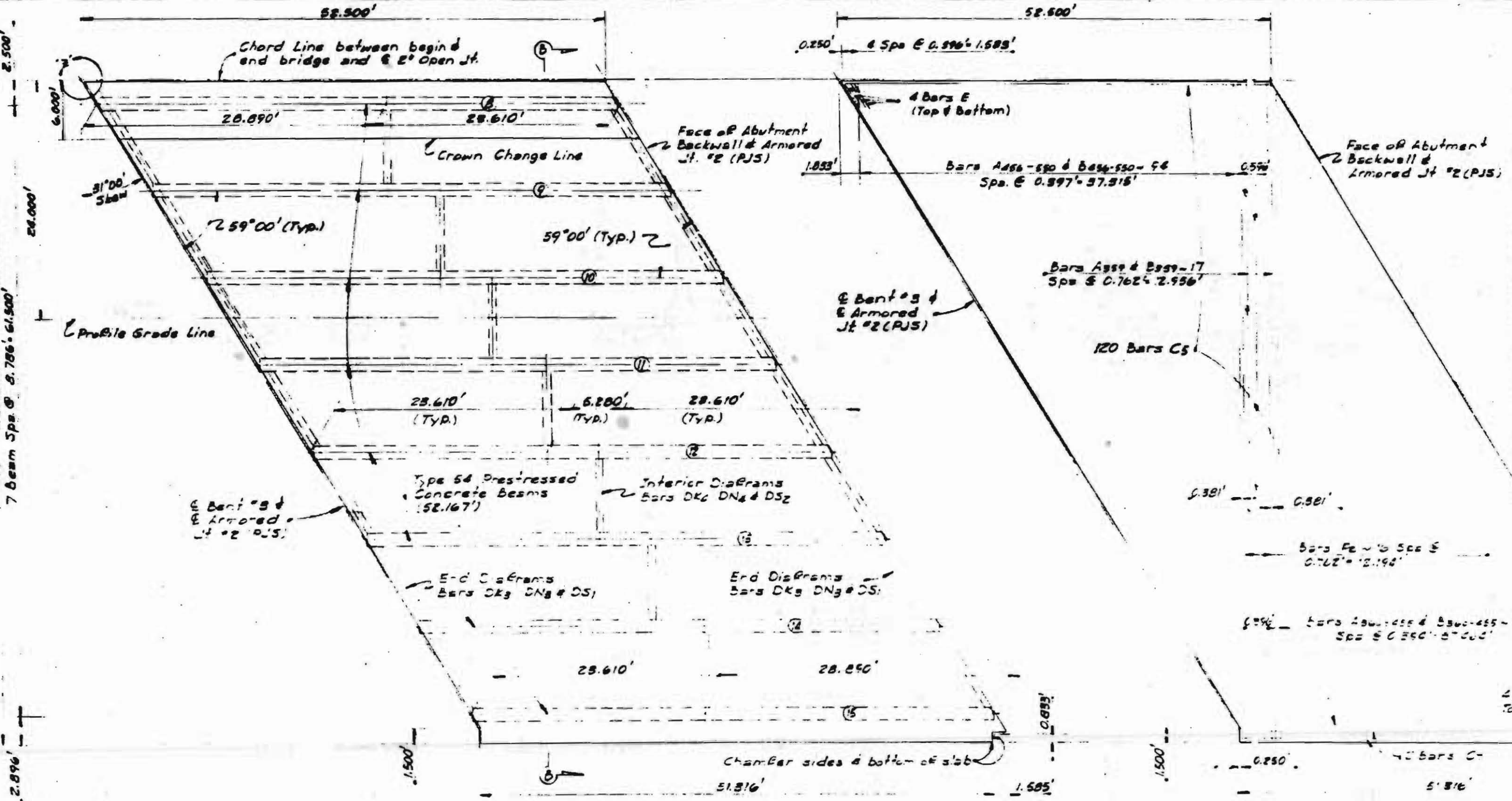
JOHNSON CREEK BRIDGE

STA 328+75.00 TO STA 330+50.00

197

Sheet #7 of 9 Sheets

Dn. JML Drawing Date
Ck. WPD Original Feb73
Dn. JML
Ck. WPD
2 TARRANT



SHOWING BEAM LAYOUT & DIMENSIONS

SHOWING REINFORCING STEEL

PLAN ~ 52.50' END SPAN "F"

BILL OF REINFORCING STEEL

SPAN "F"

Bar	No	Size	Length	Weight
* A389	18	#5	# 67.56'	1268
* A360-369	1 ea.	#5	# 65.95' Avg.	667
* A370-455	1 ea.	#5	51.55' Avg.	2812
* A456-464	1 ea.	#5	# 63.18' Avg.	593
* A465-550	1 ea.	#5	30.71' Avg.	2755
B389	8	#5	# 68.22'	1281
B360-369	1 ea.	#5	# 64.59' Avg.	676
B370-455	1 ea.	#5	52.01' Avg.	2871
B456-464	1 ea.	#5	# 63.84' Avg.	599
B465-550	1 ea.	#5	51.57' Avg.	2814
* C6	120	#5	52.17'	6530
* C7	2	#5	51.00'	106
* E	16	#5	3.50'	58
F2	17	#5	# 69.66'	1235
* DK3	56	#5	8.58'	501
* DK4	42	#5	7.33'	321
* DN3	2	#8	72.85'	389
* DN4	7	#8	9.75'	182
DS1	126	#4	4.85'	407
DS2	56	#4	6.83'	255
Total Pounds				26318

* Indicates straight bars
\# Includes bar splice (See Detail)
D Indicates Diafram Steel

TEXAS HIGHWAY DEPARTMENT

175.00' PRESTRESSED CONCRETE BEAM UNIT

(52.50 ~ 80.00 ~ 52.50 SPANS)

JOHNSON CREEK BRIDGE

STA 328+75.00 TO STA 330+50.00

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Sheet # 8 of 9 Sheets

Dn. JMC	Drawing	Date		
Ck. WPS	Original	Feb 73	U 1128 (3)	
Dn. JMC				
Ck. WPD			2 WARRANT	

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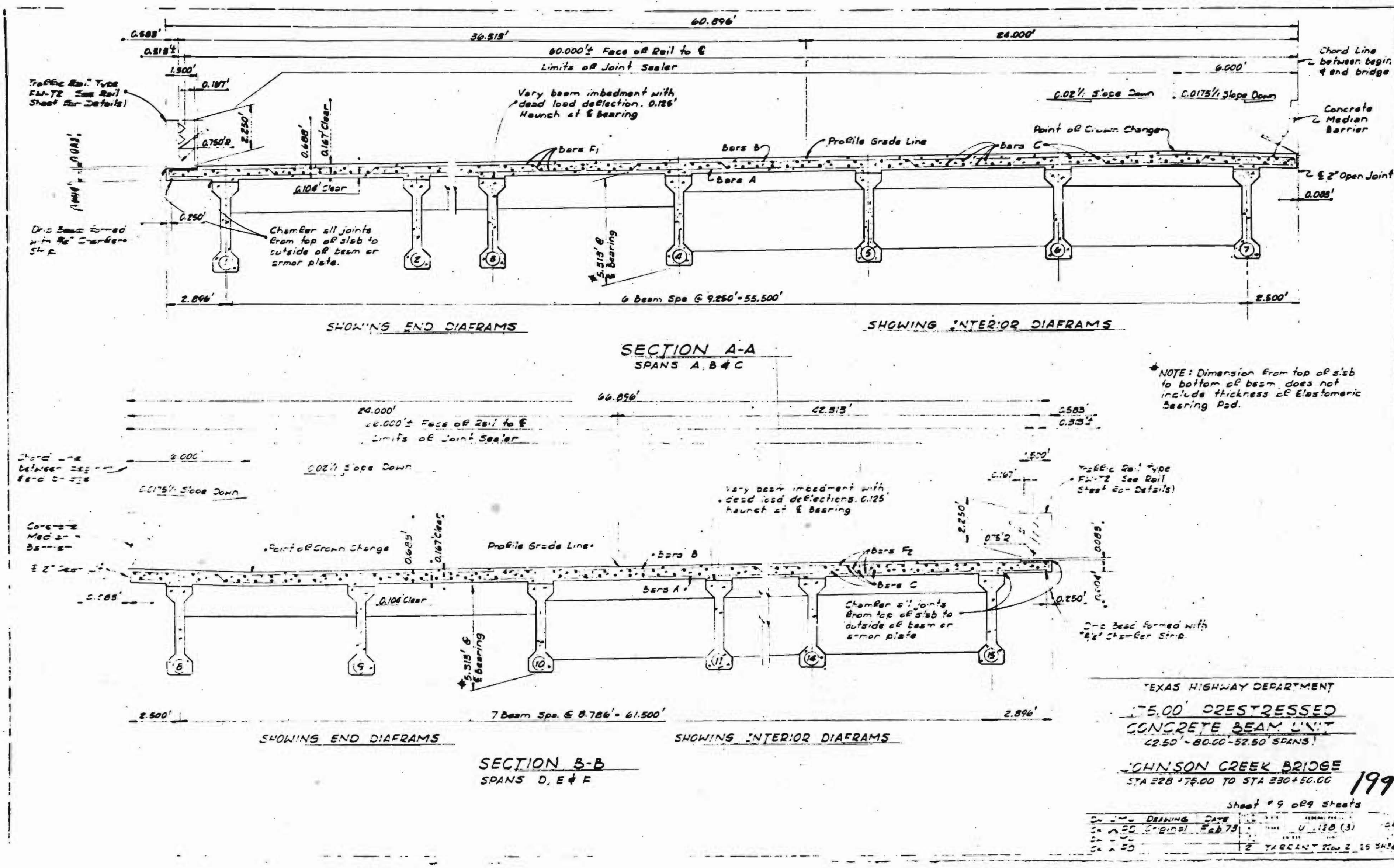

60.896'
0.583'
36.513'
24.000'
0.313'±
60.000'± Face of Rail to ℄
Chord Line ℄ between begin & end bridge
1.500'
Limits of Joint Sealer
6.000'
0.187'
Traffic Rail Type FW-T2 See Rail Sheet for Details)
Vary beam imbedment with dead load deflection. 0.125' Haunch at ℄ Bearing
0.02'/' Slope Down
0.0175'/' Slope Down
Concrete ℄ Median Barrier
2.250'
0.686'
0.167' Clear
0.750'R
Point of Crown Change
Bars F1
Bars B
Profile Grade Line
Bars C
Bars A
℄ 2" Open Joint
0.104' Clear
0.083'
0.250'
Drip Bead formed with ¾" Chamfer Strip
Chamfer all joints from top of slab to outside of beam or armor plate.
5.515' @ ℄ Bearing
2.896'
6 Beam Spa @ 9.250' = 55.500'
2.500'
SHOWING END DIAFRAMS
SHOWING INTERIOR DIAFRAMS
SECTION A-A
SPANS A, B & C
*NOTE: Dimension from top of slab to bottom of beam does not include thickness of Elastomeric Bearing Pad.
66.896'
24.000'
42.313'
0.583'
60.000'± Face of Rail to ℄
0.313'±
Limits of Joint Sealer
Chord Line ℄ between begin & end bridge
6.000'
1.500'
0.02'/' Slope Down
0.167'
Traffic Rail Type FW-T2 See Rail Sheet for Details)
0.0175'/' Slope Down
Vary beam imbedment with dead load deflections. 0.125' haunch at ℄ Bearing
2.250'
Concrete Median Barrier
Point of Crown Change
0.686'
0.167' Clear
Profile Grade Line
Bars B
Bars F2
0.75'R
0.083'
℄ 2" Open Joint
0.583'
Bars A
Bars C
0.104' Clear
0.250'
Chamfer all joints from top of slab to outside of beam or armor plate
Drip Bead formed with ¾" Chamfer Strip.
5.515' @ ℄ Bearing
2.500'
7 Beam Spa. @ 8.786' = 61.500'
2.896'
SHOWING END DIAFRAMS
SHOWING INTERIOR DIAFRAMS
SECTION B-B
SPANS D, E & F
TEXAS HIGHWAY DEPARTMENT
175.00' PRESTRESSED CONCRETE BEAM UNIT
(62.50' - 80.00' - 52.50' SPANS)
JOHNSON CREEK BRIDGE
STA 328+75.00 TO STA 330+50.00
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Sheet 9 of 9 Sheets
Original Feb 75
TARRANT

APPENDIX B
CONCRETE BATCH DESIGNS

CONCRETE BATCH DESIGN
SHRINKAGE COMPENSATING CEMENT

Aggregate Characteristics

	Sp. Gr.	SSD Unit Wt. Lbs./Ft.^{3}	% Solids
Fine Aggregate (FA)	2.63	102.80	62.50
Coarse Aggregate (CA)	2.64	96.70	58.60

Design Factors

Cement Factor (CF) 6.0 Sacks per C.Y. of Concrete
Coarse Aggregate Factor (CAF) 0.73
Water Factor (WF) 5.50 Gal./Sack
Air Factor (AF) 4.00%

Batch Design (One Sack)		1 Sk. Wts.	1 C.Y. Batch
Concrete Yield	= 4.500		
Volume CA	= 1.925	317.63	1905.76
Volume Mortor	= 2.575		
Volume Water	= 0.733	45.83	275.00
Volume One Sk. Cement	= 0.485	94.00	564.00
Volume Entrained Air	= 0.180		
Volume Paste	= 1.398		
Volume FA	= 1.177	193.41	1160.48
Yield	= 4.500		
Fine Agg. Factor	= 0.73		

CONCRETE BATCH DESIGN
TYPE II CEMENT

Aggregate Characteristics

	Sp. Gr.	SSD Unit Wt. Lbs./Ft.^{3}	% Solids
Fine Aggregate (FA)	2.66	103.00	62.00
Coarse Aggregate (CA)	2.62	94.70	57.80

Design Factors

Cement Factor (CF) 6.0 Sacks per. C.Y. of Concrete
Coarse Aggregate Factor (CAF) 0.77
Water Factor (WF) 4.90 Gal/Sack
Air Factor (AF) 4.00%

Batch Design (One Sack)		1 Sk. Wts.	1 C.Y. Batch
Concrete Yield	= 4.500		
Volume CA	= 2.003	327.95	1967.72
Volume Mortar	= 2.497		
Volume Water	= 0.653	40.83	245.00
Volume One Sk. Cement	= 0.485	94.00	564.00
Volume Entrained Air	= 0.180		
Volume Paste	= 1.318		
Volume FA	= 1.179	195.99	1175.95
Yield	= 4.500		
Fine Agg. Factor	= 0.76		