BRIDGE DECK PROTECTION SYSTEM

FINAL

CONSTRUCTION REPORT

by

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Project 1-10-84-562

(DTFH 71-83-3605-TX-10)

TEXAS STATE DEPARTMENT OF HIGHWAYS
AND PUBLIC TRANSPORTATION

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16. Abstract

This report concludes a study of three bridge deck protective systems which were utilized on a bridge deck constructed over the Brazos River on SH 67 south of Graham, Texas. As noted in the *Interim Report* of July, 1986, the protective systems applied were as follows:

(1) *Calcium nitrate* was applied to a single test span as a concrete additive to inhibit steel reinforcement corrosion through pH adjustment of concrete (with non epoxy "plain" reinforcement),

(2) High molecular weight (HMW) *methacrylate* was applied as a surface dressing on two test spans as a means of restricting Cl ion penetration through membrane action (with epoxy coated reinforcement and with plain reinforcement), and

(3) *Linseed oil* surface dressing was also applied for the purpose of restricting Cl ion penetration through membrane action (with epoxy coated reinforcement and with plain reinforcement).

For reasons detailed within this report, current flow readings from corrosometer probes were not attainable, and removal (core drilling) of any test bars was determined to be premature. Also, surface friction with respect to each protective system is addressed. The report summary identifies future work to be conducted and documented in this regard.

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PREFACE

This report was prepared in cooperation with the U.S. Department of Transportation, Federal Highway Administration.

The contents of this report are experimental in nature and reflect the views of the author who is responsible for the facts and the accuracy of the data presented, which is published for informational purposes only.

The contents do not necessarily reflect the official views or policies of the Federal Highway Administration or the State Department of Highways and Public Transportation. Any discrepancies with official views or policies of the Texas State Department of Highways and Public Transportation should be discussed with the appropriate Austin Division prior to implementation of the procedures or results. This report does not constitute a standard, specification, or regulation.

CONTENTS

METRIC CONVERSION FACTORS

Approx. Conversions to Metric Measures			Approx. Conversions from Metric Measures		
Multiply	**By**	**To Obtain**	**Multiply**	**By**	**To Obtain**
			LENGTH		
inches	2.54	centimeters	millimeters	0.04	inches
feet	30.48	centimeters	centimeters	0.39	inches
yards	0.91	meters	meters	3.28	feet
miles	1.61	kilometers	meters	1.09	yards
			kilometers	0.62	miles
			AREA		
sq. in.	6.45	sq. cm.	sq. cm.	0.16	sq. in.
sq. ft.	0.09	sq. m.	sq. m.	1.20	sq. yd.
sq. yd.	0.84	sq. m.	sq. km.	0.39	sq. mi.
sq. mi.	2.59	sq. km.	hectares	2.47	acres
acres	0.4	hectares	(hectares = 10,000 sq. m.)		
			MASS (weight)		
ounces	28.35	gram	grams	0.035	ounces
pounds	0.45	kilograms	kilograms	2.21	pounds
short tons (2000 lbs.)	0.9	tonnes	tonnes (1000 kg)	1.1	short ton
			VOLUME		
teaspoons	5	milliliters	milliliters	0.03	fluid oz.
Tbsp.	15	milliliters	liters	2.11	pints
fluid oz.	29.6	milliliters	liters	1.06	quarts
cups	0.24	liters	liters	0.26	gallons
pints	0.47	liters	cubic meters	35.31	cubic ft.
quarts	0.95	liters	cubic meters	1.31	cubic yd.
gallons	3.79	liters			
cubic ft.	0.03	cubic meters			
cubic yd.	0.76	cubic meters			
			TEMPERATURE (exact)		
Fahrenheit	5/9 (after subtracting 32)	Celsius	Celsius	9/5 (then add 32)	Fahrenheit

ABSTRACT

This report concludes a study of three bridge deck protective systems which were utilized on a bridge deck constructed over the Brazos River on SH 67 south of Graham, Texas. As noted in the *Interim Report* of July, 1986, the protective systems applied were as follows:

(1) *Calcium nitrate* was applied to a single test span as a concrete additive to inhibit steel reinforcement corrosion through pH adjustment of concrete (with non epoxy "plain" reinforcement),

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SECTION 1

INTRODUCTION

1.1 GENERAL

As noted in the *Interim Construction Report*,

> "The utilization of deicing salts on bridges has posed serious problems in long term bridge deck serviceability. Bridge deck steel reinforcement exposed to winter salt applications and which subsequently commences to rust has displayed serious concomitant concrete spalling and delamination distress. Protective systems to restrict chloride contamination have been employed with varying degrees of success. A major concern with protective systems which utilize asphaltic seals and an asphaltic concrete overlay is that any concrete distress which subsequently takes place is hidden from observation. Problems which could have been corrected by timely maintenance when they were minor are likely to be obscured until major distress becomes evident. Further, labor costs, traffic disruptions, and motorist and worker safety are factors which must also be evaluated when considering effective alternate protective systems."

The intent of this project was to address the application, benefits and any shortcomings associated with the utilization of several protective systems, including their potential impact to surface friction.

1.2 PROJECT BACKGROUND

This project was initiated in accordance with a Cooperative Agreement Work Order issued by the U.S. Department of Transportation Federal Highway Administration.

The originating scope of this project (September, 1983) was to evaluate the application, maintenance and effect of linseed oil as a protective system for the Spring Creek Relief Bridge, S.B., 195-1-166 on IH 35, south of Gainesville, Texas. Also, the decks were to be evaluated for potential loss in frictional resistance of the deck surface *after* routine linseed oil applications. Linseed oil, the proposed protective system, was and continues to be extensively used throughout Texas.

In a subsequent modification to the agreement in November, 1984, the scope of work was expanded to include the use of calcium nitrate as an additive to the concrete deck for the Spring Creek Relief Bridge.

The final agreement, in May 1985, further modified the scope of the work to include the use of a high molecular weight (HMW) methacrylate monomer surface dressing as a third bridge deck protective system. This agreement also changed the project location. In this agreement, the systems were scheduled for utilization on a bridge deck to be constructed over the Brazos River on SH 67 south of Graham, Texas. See Figure 1, *Project Location Map*.

To summarize, this project evaluates: (1) calcium nitrate as a concrete additive, (2) HMW methacrylate surface dressing and (3) linseed oil surface dressing as bridge deck protective systems, and potential loss of frictional resistance to the deck after routine applications.

1.3 EXCERPTS FROM INTERIM REPORT

Project Layout

1. The Brazos River Bridge decks were treated with three separate protective systems by District 3 of the Texas SDHPT in cooperation with the W.R. Grace and the Rohm and Haas Companies.

2. The primary construction activity occurred in August and September of 1985.

3. The bridge was open to traffic on December 18, 1985.

4. Control and test spans were set up as noted in Table 1, *Surface Treatments* (sand was also applied to spans 6 & 7).

CONTROL* SPAN	STEEL REINF.	PROTECTIVE TREATMENT	SURFACE TEXTURE
#3	Epoxy	Linseed Oil	Tine
#4	Epoxy	Linseed Oil	Tine
TEST SPAN			
#5	Epoxy	Linseed Oil	Saw Groove
#6	Epoxy	Methacrylate	Saw Groove w/sand
#7	Plain	Methacrylate	Saw Groove w/sand
#8	Plain	Linseed Oil	Saw Groove
#9	Plain	Calcium Nitrate	Saw Groove

* See Figure 2, *Schematic Layout of SH 67 Brazos River Bridge*

TABLE 1 SURFACE TREATMENTS

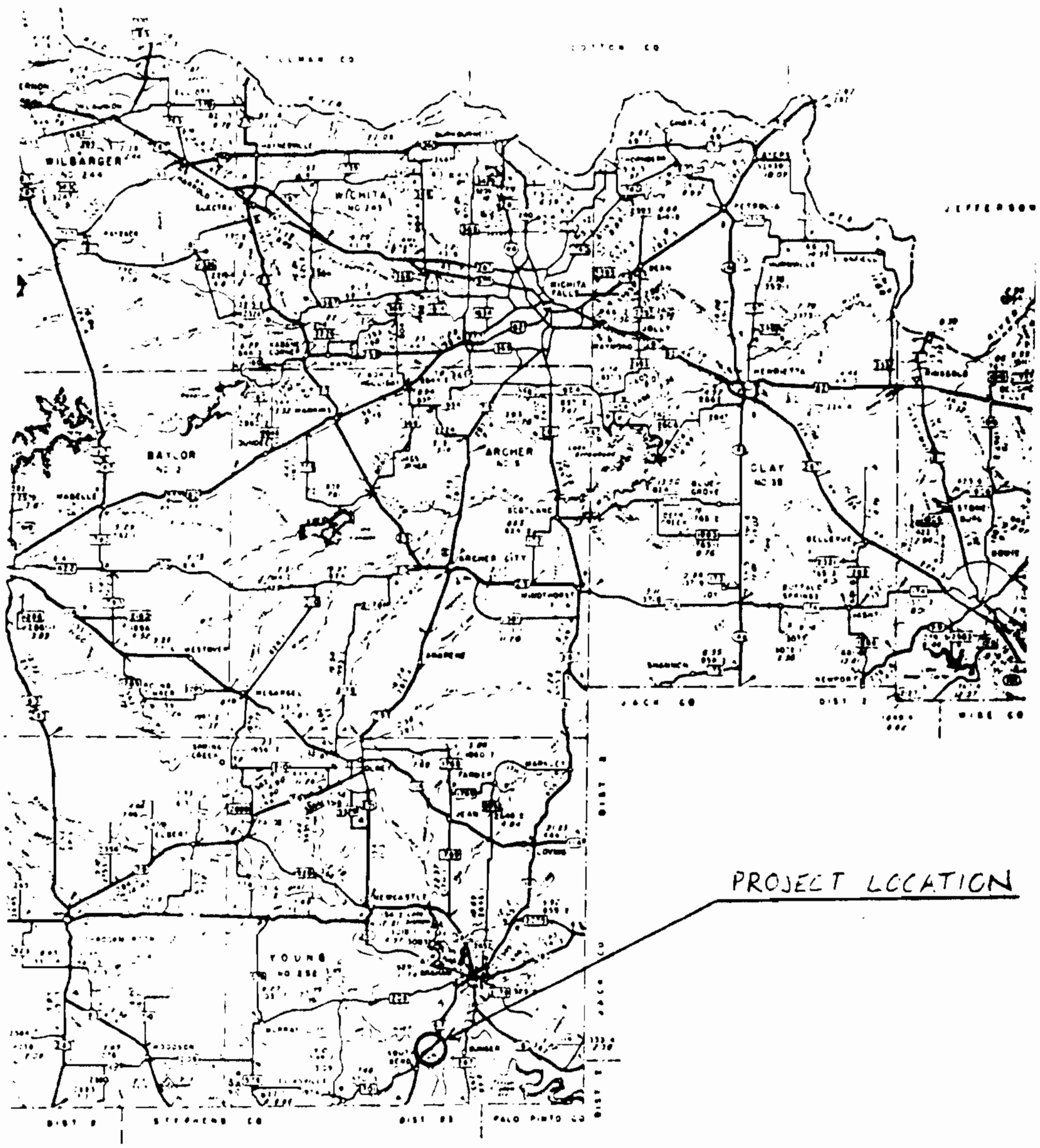


FIGURE 1   PROJECT LOCATION MAP

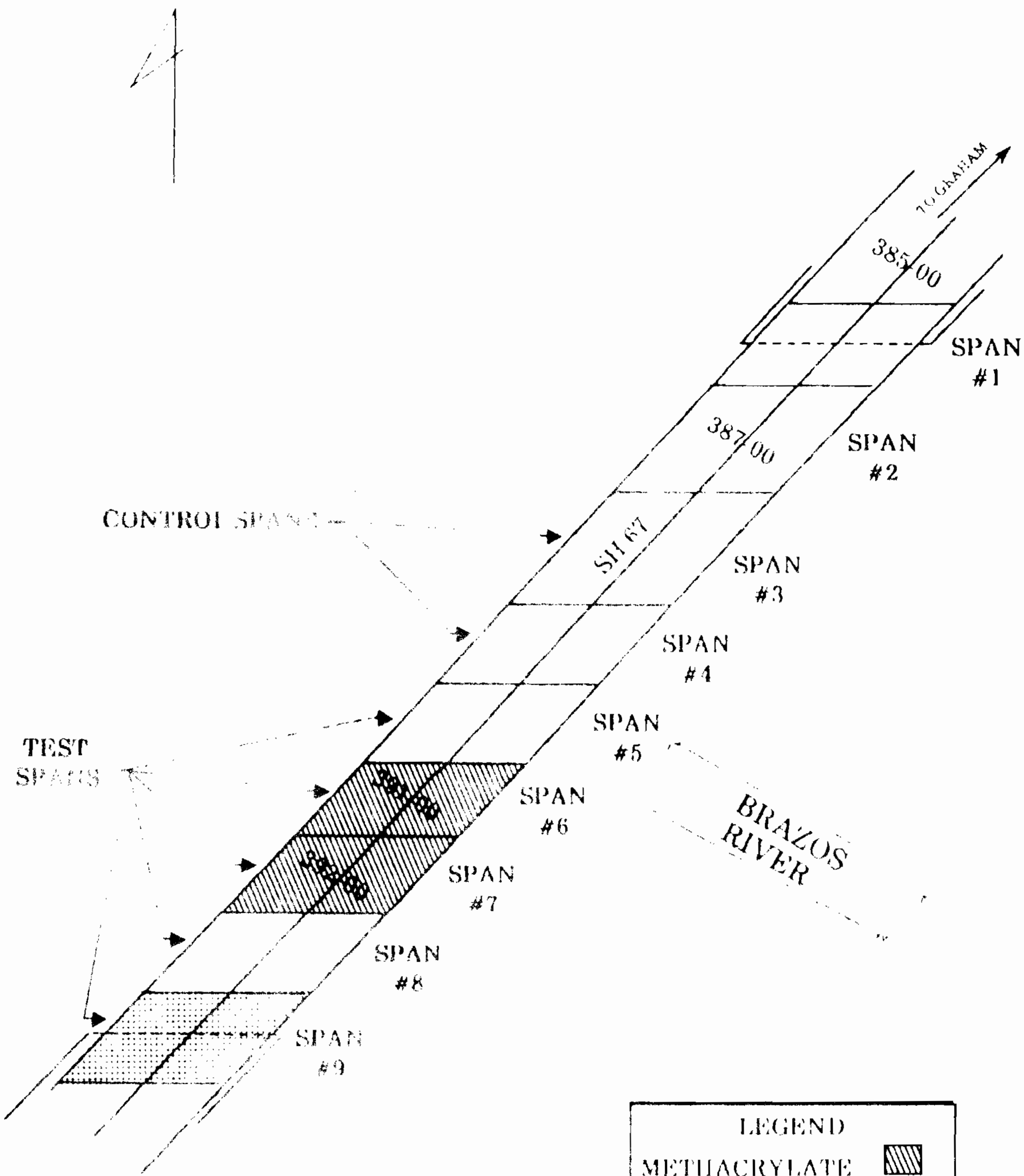


FIGURE 2 SCHEMATIC LAYOUT OF SH 67 BRAZOS RIVER BRIDGE

5. Spans 5 through 9 were saw grooved as part of a field change to compare benefits with tine textured surfaces. Saw grooves for spans 5, 8 and 9 were 3/16 inch in depth, span 6 saw grooves were 7/32 inch in depth and span 7 saw grooves were measured at 1/4 inch.

6. As part of a field change, plain rebars were installed in spans 7, 8, and 9 to compare with epoxy coated bars.

7. The deck is comprised of 4 inches of prestressed panels, with 3 1/2 inch thick reinforced concrete surface overlay.

8. With only a few exceptions, reinforcement steel concrete cover ranges from 2 to 2 3/8 inches.

Instrumentation

1. Current Flow Measurement Devices

    a. Nine corrosometer probes, of plain #5 reinforcing steel bars, six inches in length, were typically installed in each of the experimental spans as noted in Figure 3, *Corrosometer Probe Installation Data*.

    b. Two ground wires were Cadwelded to the deck reinforcing steel in each experimental span.

    c. All leads were fed into locking waterproof junction boxes attached to the outside of the east parapet wall for each span. Figure 4, *Corrosometer Probe Circuit*, illustrates the schematic diagram of the instrumentation contained in each junction box.

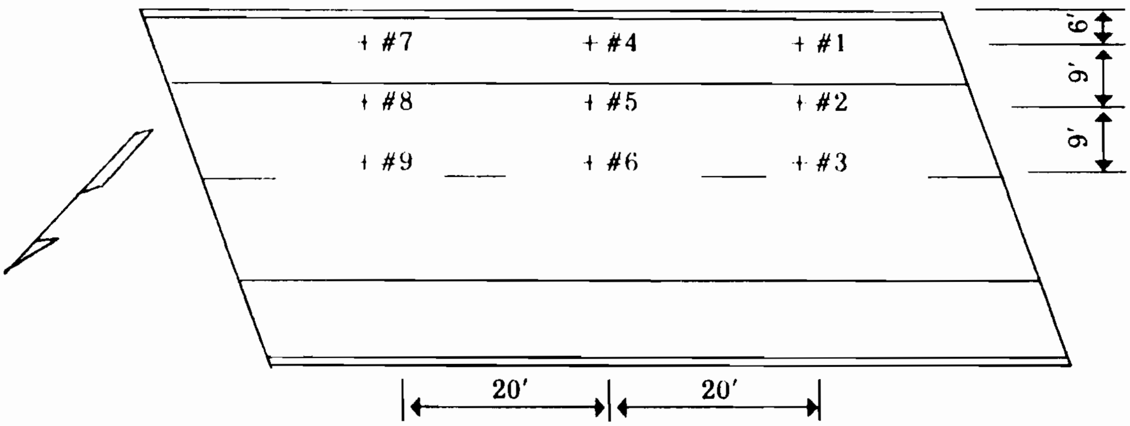
    d. The circuits incorporated an interchangeable precision resistor placed in series with a rotary selector switch.

    e. Eight fifteen-amp breakers were used in each box as switches to compute the rebar circuit as electrical measurements were made.

2. Retrievable Reinforcement Specimens

    a. A set of paired reinforcing steel bars, 7 feet in length of plain and epoxy were installed in each span as noted in Figure 5, *Location Schedule – Retrievable Reinforcing Bars*.

    b. The retrievable bars were placed at steel mat level.



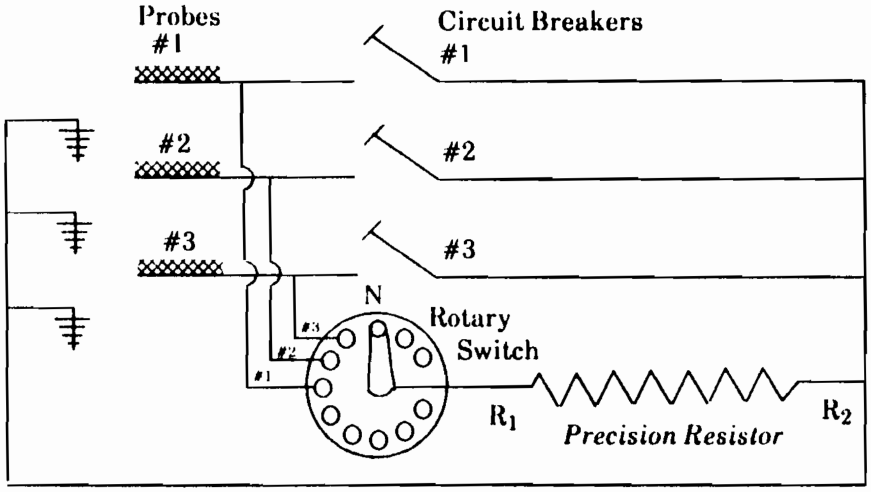
Typical Span *

* Southernmost span is No. 9, northernmost is No. 5

Span	Date Probes Installed 1985	Installed by	Probe Color Code #1	#2	#3	#4	#5	#6	#7	#8	#9	Ground
9	7/31	Canaday & Reed	Red	Blu	Blk	Wht	Org	Pur	Grn	Gry	Brn	Wht (knotted)
8	8/6	Canaday & Reed	Red	Blu	Blk	Wht	Pur (knotted)	Pur	Grn	Gry	Brn	Wht (knotted)
7	8/13	Hustace & Golding	Pur	Red	Brn	Wht	Gry	Blu (knotted)	Blk	Grn	Blu	Wht (knotted)
6	8/16	Reed & Braddock	Red	Blu	Blk	Wht	Grn (tied)	Pur	---	---	---	Wht
5	9/9	Hustace	Gry	Blk	Lav	Wht	Grn	Brn	Red	Blk (knotted)	Blu	Org

SOURCE: PROJECT 562 INTERIM CONSTRUCTION REPORT, 1986

FIGURE 3 CORROSOMETER PROBE INSTALLATION DATA



Corrosometer Voltage Drop Monitoring Procedure

1. Open all circuit breakers.
2. Rotate rotary switch three complete revolutions to clean contact points.
3. Check ground continuity.
4. Set rotary switch to corrosometer probe position and read voltage drop across precision resistor, R1 and R2.
5. Repeat measurement for each probe three times and record the data on the following format and forward it to File D-10R, State Department of Highways and Public Transportation, Austin, Texas 78763-5051.

Corrosometer Probe Measurements

Brazos River Bridge SH 67, Young County
Texas SDH&PT Project 1-10-84-562

Bridge Span No.* 5, 6, 7, 8, 9 (circle one)
Ground continuity check ________

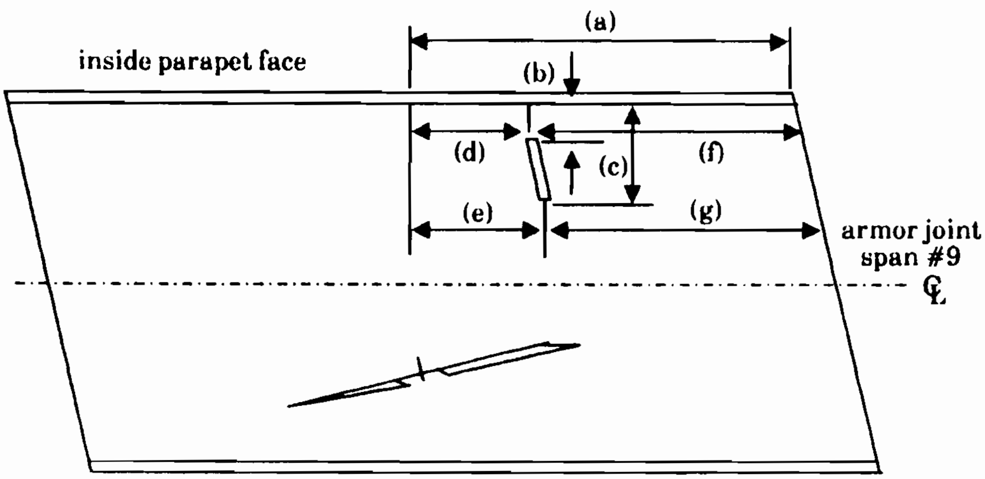
Date	Precision Resistor	Probe Voltages									
Da/Mo/Yr	Value	1	2	3	4	5	6	7	8	9	Recorded by:
Average											

* Span #9 is southernmost span

6. Close all circuit breakers and rotate rotary switch to neutral position (N) until next scheduled reading.

SOURCE: PROJECT 562 INTERIM CONSTRUCTION REPORT, 1986

FIGURE 4 CORROSOMETER PROBE CIRCUIT



Typical Span

Span #	Measurements (feet) (a)	(b)	(c)	(d)	(e)	(f)	(g)
5	40	3.9	10.6	13.1	15.1	--	--
6	45	3.8	10.5	13.6	15.4	--	--
7	40	3.8	10.5	13.5	15.2	--	--
8	40	3.9	10.7	13.5	15.4	--	--
9	40	3.9	10.7	--	--	17.55	27.6

SOURCE: PROJECT 562 INTERIM CONSTRUCTION REPORT, 1986

FIGURE 5 LOCATION SCHEDULE - RETRIEVABLE REINFORCING BARS

SECTION 2

EVALUATION

2.1 INTERIM REPORT FINDINGS

1. Pavement Surface

   a. Construction related problems which might influence expected performance comparisons between test spans were not apparent.

   b. Only two separate deicing salt applications were made to the structure in the first year.

   c. Table 2, *Sand Patch Texture and Saw Groove Depth Measurements Record* and Table 3, *British Pendulum Tester Measurements* reflect surface texture and friction. The results of the Sand Patch tests indicated that the tine texture was rougher than that of saw grooving. The British Pendulum tests also indicate greater frictional qualities with tine texture as opposed to that of saw grooving. While variations existed, the examination of this data indicated that all surfaces had an adequate frictional level when open to traffic and through all subsequent measurements.

2. Current Flow Measurements

   a. Since from the equation, $E = IR$, current is proportional to voltage, a high voltage indicates a high current flow. Control test probes suspended in tap water in the laboratory indicated potential between probes to be *10 to 15 millivolts* with a current flow of 15×10^{6} *amperes*.

   b. Initial voltage measurements of test probes, taken on April 15, 1986, resulted in readings from 1.0 to 37.9 millivolts. These measurements, noted in Table 4, *Corrosometer Probe Voltage Measurements*, did not reflect decisive patterns.

3. Retrievable Reinforcement Bars

   In accordance with the project work order, recoverable reinforcing steel bars were to be examined at periodic intervals to verify comparative corrosion protection.

Location Span #	Protective Treatment	Measurements (inches)				Average (inches)	Texture T	Saw Groove Depth (in.)	Remarks
1	Linseed oil	4.5	4.7	4.8	4.7	4.7	.086	-	
2(a)	" "	5.9	5.8	5.9	5.7	5.8	.057		smoother than typical
2(b)	" "	3.8	3.9	3.7	3.6	3.8	.132	-	rougher than typical
2(c)	" "	4.5	4.8	4.6	4.5	4.6	.090	- -	typical
3	" "	4.9	4.5	4.7	4.8	4.7	.086		
4	" "	4.8	4.8	4.6	5.0	4.8	.083		
5	" "	7.0	6.9	6.9	7.0	6.9	.040	3/16	
6(a)	Methacrylate	6.8	7.0	6.0	6.9	6.7	.043	7/32	before methacrylate
6(b)	"	6.0	5.8	5.8	5.9	5.9	.055	-	after methacrylate
7(a)	"	6.8	6.4	6.0	6.7	6.5	.045	1/4	before methacrylate
7(b)	"	6.3	6.0	6.0	6.1	6.1	.051		after methacrylate
8	Linseed oil	7.0	6.7	6.5	7.1	6.8	.041	3/16	
9	Calcium nitrate	6.7	7.3	6.8	6.8	6.9	.040	3/16	

SOURCE: PROJECT 562 INTERIM CONSTRUCTION REPORT, 1986

TABLE 2 SAND PATCH TEXTURE AND SAW GROOVE DEPTH MEASUREMENTS RECORD

ASTM E303-83

Recorded by Dave Hustace   Date 12 19 85

Outer Wheel Path 9' ℄ Rt

Station	Friction Pad Surface Contact (in.)	Values						Sum	x̄	σ	X̄	Var
Control: Linseed Oil, Tine Texture												
Spans #3 & 4												
388 + 13	5	76	77	79	79	80	81	472	78.7			
388 + 63	4 15/16	80	83	83	85	85	86	502	83.7			
389 + 13	4 15/16	83	84	85	85	85	85	507	84.5			
389 + 53	4 7/8	75	75	76	77	78	77	458	76.3			
										3.9	80.8	15.6
Span #5: Linseed Oil, Saw Groove												
389 + 94	4 7/8	79	81	83	79	80	80	482	80.3			
390 + 19	4 15/16	81	83	82	82	87	84	499	83.2			
390 + 46	4 7/8	75	76	77	78	79	79	464	77.3			
										3.0	80.3	8.7
Span #6: High Molecular Weight Monomer (with Sand), Saw Groove												
390 + 78	4 7/8	73	75	75	73	75	73	444	74			
391 + 04	4 7/8	65	68	69	69	70	70	411	68.5			
391 + 28	4 7/8	70	70	72	71	72	73	428	71.3			
										2.8	71.3	7.6
Span #7: High Molecular Weight Monomer (with Sand), Saw Groove												
391 + 67	5	67	67	68	67	67	68	404	67.3			
391 + 91	4 15/16	73	76	77	77	77	74	454	75.7			
392 + 16	4 15/16	73	73	73	73	72	75	439	73.2			
										4.3	72.1	18.6
Span #8: Linseed Oil, Saw Groove												
392 + 47	4 15/16	67	67	68	69	69	69	409	68.2			
392 + 72	4 15/16	66	67	68	68	68	68	405	67.5			
392 + 94	5	67	68	69	69	70	70	413	68.8			
										0.7	68.2	.4
Span #9: Calcium Nitrate, Saw Groove												
393 + 12	4 7/8	64	67	68	67	68	67	401	66.8			
393 + 54	4 7/8	64	65	65	65	66	67	392	65.3			
393 + 74	5	61	60	61	62	62	64	370	61.7			
										2.6	64.6	6.9

SOURCE: PROJECT 562 INTERIM CONSTRUCTION REPORT, 1986

TABLE 3 BRITISH PENDULUM TESTER MEASUREMENTS

Corrosometer Probe Voltage Measurements
(millivolts)

	Parapet			Wheel Path			℄		
	1	4	7	2	5	8	3	6	9
Span #9 $Ca(NO_3)_2$ (Plain bars)	22.9	19.6	10.9	10.7	13.1	30.2	6.0	6.5	1.0
Span #8 Linseed oil (plain bars)	[illegible]	[illegible]	5.8		8.3	5.2	13.8	14.1	14.9
Span #7 HMWM (plain bars)	[illegible]	[illegible]	[illegible]	18.5	15.8	[illegible]	19.9	26.7	
Span #6 HMWM (epoxy bars)	23.6	[illegible]		11.8	4.8		10.4	3.4	
Span #5 Linseed oil [illegible]	[illegible]	22.4		25.7	20.6	23.2	[illegible]		21.4

Measurements made 4 15 86 by

original signed by David Hustace

Dave Hustace

SOURCE: PROJECT 562 INTERIM CONSTRUCTION REPORT, 1986

TABLE 4 CORROSOMETER PROBE VOLTAGE MEASUREMENTS

2.2 SUBSEQUENT FINDINGS

1. Pavement Surface

Visual observation conducted on January 25, 1989 shortly after a light rainfall revealed numerous, but minor (in appearance) surface cracks. Under dry conditions, these cracks were not apparent. There was also no visible evidence of pavement wear. The methacrylate (with sand) surface especially appeared to be in excellent condition.

The SH 67 structure experiences traffic volumes of 1700 AADT. Based on the minimal traffic volumes and the visual observations noted, further surface friction tests were not scheduled.

The initial scope of the project (to determine potential loss of frictional resistance "after application") was, however, fully addressed in the interim report. The findings, as stated in Section 2.1.1, indicate that all surfaces had an adequate frictional level when opened to traffic.

2. Current Flow Measurements

Voltage and current measures taken subsequent to the *Interim Report* on September 23, 1986 are included in Tables 5A, 5B, 5C, 5D, and 5E, *Voltage and Current Measurements*. In virtually all instances, the recorded current flows indicated a transient condition where current values dropped over time and as with the initial readings of April 15, 1986, the values did not reflect decisive patterns. To emphasize the inconsistencies and variation in changes with time, a comparison (see Table 6) of the April and September readings is presented.

Based on these findings, there was minimal confidence in obtained values and in the established procedure.

On January 25, 1989, in a subsequent site investigation, it was apparent that the instrument boxes had been disturbed. Several resistors utilized during the initial readings were missing. Based on this finding and with the inconsistencies of previous values obtained, use of the test probes was not pursued in evaluating performance of the bridge deck protective systems.

Voltage and Current Measurements

recorded by Dave Hustace September 23, 1986

Span #5 Linseed oil (epoxy bars)

	Parapet				Wheel Path				℄			
Milliamps	1	4	7	avg.	2	5	8	avg.	3	6	9	avg.
Initial*	6.9	12	15		19	16	23		14	–	17	
@ 30 sec	3.4	5.6	7.3	5.4	10.5	9.6	12.0	10.7	7.7	–	9.2	8.5
Initial*	8	14	16		21	18	24		16	–	19	
@ 30 sec	3.0	6.3	8.0	5.8	11.4	10.5	13.4	11.8	8.6	–	9.3	9.0
Initial*	9	16	17		23	19	27		17	–	20	
@ 1 min.	3.7	5.7	7.1	5.5	11.0	10.1	12.0	11.0	8.1	–	8.9	8.5
Millivolts												
	15.4	26.9	28.0		37.6	30.8	40.3		27.1	-0.2	24.5	
	15.6	27.2	28.7		37.9	31.2	41.6		27.5	-0.2	26.2	
	15.7	27.5	29.3	23.8	38.0	31.5	42.7	41.0	27.7	-0.2	27.2	26.7

*Note: initial current measurements all evidenced a substantial immediate drop from peak values.

srm-39

TABLE 5A VOLTAGE AND CURRENT MEASUREMENTS

Span #6 Methacrylate (epoxy bars)

	Parapet				Wheel Path				℄			
Milliamps	1	4	7	avg.	2	5	8	avg.	3	6	9	avg.
Initial*	26	51	–		17	14	–		29	6.6	–	
@30 sec.	10.2	14.2	–	12.2	6.3	7.1	–	6.7	11.2	2.1	–	6.7
Initial*	22	47	–		16	14	–		29	6.6	–	
@30 sec.	8.6	12.6	–	10.6	5.7	6.7	–	6.2	10.5	2.0	–	6.3
Initial*	23	46	–		15	14	–		29	6.2	–	
@1 min.	6.3	9.6	–	8.0	4.3	5.7	–	5.0	8.5	1.6	–	5.1
Millivolts												
	8.9	20.6	-0.1		6.8	10.5	-0.1		16.5	4.5	-0.1	
	14.6	29.6	-0.1		10.1	12.8	-0.1		22.4	5.7	-0.1	
	18.2	34.7	-0.1		12.0	14.0	-0.1		25.4	6.3	-0.1	
	20.5	38.0	-0.1	23.1	13.3	14.8	-0.1	11.8	27.2	6.7	-0.1	14.3

*Note: initial current measurements all evidenced a substantial immediate drop from peak values.

srm 39A

TABLE 5B VOLTAGE AND CURRENT MEASUREMENTS

Span #7 Methacrylate (plain bars)

	Parapet				Wheel Path				℄			
Milliamps	1	4	7	avg.	2	5	8	avg.	3	6	9	avg.
Initial*	2.7	1.7	3.0		–	7.0	3.3		5.5	14	–	
@30 sec.	1.5	0.5	0.8	2.4	–	2.2	1.1	1.7	1.6	7.1	–	4.4
Initial*	4.5	2.0	3.5		–	8.9	3.4		7.9	14	–	
@30 sec.	2.1	0.5	0.8	1.1	–	2.6	1.1	1.9	1.8	7.8	–	4.8
Initial*	5.4	2.1	5.4		–	9.1	3.9		4.9	16.9	–	
@1 min.	2.1	0.5	0.8	1.1	–	2.1	1.0	1.6	1.6	7.7	–	4.7
Millivolts												
	7.9	3.1	3.5		–0.2	13.9	3.6		8.2	22.7	–0.3	
	8.0	3.2	3.6		–0.2	14.5	4.4		8.6	23.2	–0.3	
	8.2	3.3	3.8	5.0	–0.2	14.9	4.7	9.3	8.7	23.6	–0.3	15.8

*Note: initial current measurements all evidenced a substantial immediate drop from peak values.

srm-39B

TABLE 5C VOLTAGE AND CURRENT MEASUREMENTS

Span #8 Linseed oil (plain bars)

Milliamps	Parapet 1	4	7	avg.	Wheel Path 2	5	8	avg.	℄ 3	6	9	avg.
Initial*	3.4	2.7	6.1		3.1	2.1	1.6		1.5	7.0	5.0	
@ 30 sec.	2.0	1.0	2.7	1.9	1.3	0.6	0.6	0.8	0.5	3.4	2.6	2.2
Initial*	8.9	3.6	7.6		5.0	2.4	2.2		2.1	10.4	6.6	
@ 30 sec.	3.5	1.3	3.1	2.6	1.9	0.7	0.6	1.1	0.6	4.1	2.9	2.5
Initial*	10.0	4.4	8.6		6.1	2.7	2.0		2.4	12.5	7.2	
@ 1 min	3.0	1.2	2.9	2.4	1.8	0.7	0.6	1.0	0.6	3.8	2.7	2.4
Millivolts												
	17.2	6.9	10.9		11.5	5.0	3.4		3.5	16.8	7.4	
	17.6	7.1	11.3		11.8	5.1	3.6		3.6	17.3	8.2	
	17.9	7.3	11.6	12.0	12.1	5.2	3.7	6.8	3.6	17.8	8.7	9.7

*Note: initial current measurements all evidenced a substantial immediate drop from peak values.

srm-39C

TABLE 5D VOLTAGE AND CURRENT MEASUREMENTS

Span #9 Calcium nitrate (plain bars)

	Parapet				Wheel Path				℄			
Milliamps	1	4	7	avg.	2	5	8	avg.	3	6	9	avg.
Initial*	40	56	19		23	58	50		20.5	7.0	6	
@30 sec.	20.9	25.1	5.7	17.2	10.6	28.3	21	20.0	7.1	2.7	2.4	4.1
Inital*	51	54	19		21	44	54		24	6.9	5.5	
@30 sec.	22.3	23.9	5.2	17.1	10.8	27.9	22	20.2	8.0	2.5	2.2	4.2
Initial*	51	51	20		21	56	48		22	7.0	5.0	
@1 min.	19.8	19.4	4.0	20.7	9.6	24.1	16.9	16.9	6.3	2.1	1.7	3.4
Millivolts												
	72.2	74.4	23.8		38.7	75.3	66.2		35.8	9.7	6.4	
	73.1	75.3	24.7		39.0	75.6	68.4		36.4	9.8	7.0	
	73.6	75.7	25.3	81.9	39.3	76.0	69.5	60.9	37.0	9.9	7.2	17.7

*Note: initial current measurements all evidenced a substantial immediate drop from peak values.

srm-39D

TABLE 5E VOLTAGE AND CURRENT MEASUREMENTS

	(5FT FROM PARAPET)			(-RT. WHEEL PATH-)			(DECK CENTER LINE)		
PROBE #	1	4	7	2	5	8	3	6	9
<u>SPAN 5</u>									
4-15-86	17.1	22.4	--	25.7	20.6	23.2	23.2	--	21.4
9-23-86	15.6	27.2	28.7	37.8	31.2	41.6	27.4	-0.2	26.0
CHANGE	-9%	+21%	--	+47%	+52%	+79%	+18%	--	+22%
<u>SPAN 6</u>									
4-15-86	23.6	37.9	--	11.8	4.8	--	10.4	3.4	--
9-23-86	15.6	30.7	-0.1	10.6	13.0	-0.1	22.9	5.8	-0.1
CHANGE	-34%	-19%	--	-10%	+171%	--	+120%	+71%	--
<u>SPAN 7</u>									
4-15-86	7.8	7.0	8.6	18.5	15.8	12.7	19.9	26.7	--
9-23-86	8.0	3.2	3.6	-0.2	14.4	4.2	8.5	23.2	-0.3
CHANGE	+3%	-54%	-58%	-101%	-9%	-67%	-57%	-13%	--
<u>SPAN 8</u>									
4-15-86	24.0	11.8	5.8	--	8.3	5.2	13.8	14.1	14.9
9-23-86	17.6	7.1	11.3	11.8	5.1	3.6	3.6	17.3	8.1
CHANGE	-27%	-40%	+95%	--	-39%	-31%	-74%	+23	-46%
<u>SPAN 9</u>									
4-15-86	22.9	19.6	10.9	10.7	13.1	30.2	6.0	6.5	1.0
9-23-86	73.0	75.1	24.6	39.0	75.6	68.0	36.4	9.8	6.9
CHANGE	+219%	+283%	+126%	+265%	+477%	+125%	+507%	+51%	+690%

TABLE 6 VOLTAGE COMPARISONS

3. Retrievable Reinforcement Specimens

As previously noted, pavement surfaces for all decks appeared to be in satisfactory condition. Also, the interim report noted that only two separate deicing salt applications were made to the structure in the first year. As of January 25, 1989, only two additional applications had been made in the subsequent years. Three consecutive mild winters accounted for the limited deicing applications. Finally, as previously stated, the structure is being subjected to minimal traffic volumes (1700 AADT).

In regard to these findings, it was determined that removal of any of the retrievable reinforcement specimens (core samples) was premature, and therefore not pursued at the time.

SECTION 3

CONCLUSION

3.1 SUMMARY

As great efforts were taken in the planning and placement of numerous corrosometer probes, it is unfortunate that measured current and voltage values appeared to be unreliable.

This study has, however, concluded that proper application of linseed oil and high-molecular-weight methacrylate (with sand) surface dressings will not adversely affect surface friction.

While failure of the various protection treatments in regard to their ability to inhibit steel reinforcement corrosion is not evident at this time, the structures will need to be monitored for several more years, before final conclusions can be reached. It is recommended that core samples of the structure not be obtained for at least three years, unless visual disturbance is noted. These samples and samples taken beyond the three year period can continue to provide structural engineers with useful data in their analysis of steel reinforcement corrosion.

3.2 IMPLEMENTATION

Since additional observation of the structure is essential for deriving conclusive results, recommendations concerning the implementation of the protective systems used in this project cannot be made at this time.

Appendix A

Design Speed: 30MPH

FED. RD. DIV. NO.	STATE	PROJECT NO.		SHEET NO.
6	TEXAS	C 68-8-34		1
STATE DIST. NO.	COUNTY		STATE CONTROL NO.	HIGHWAY NO.
8	HOWARD		68-8-34	US87

STATE OF TEXAS
STATE DEPARTMENT OF HIGHWAYS AND PUBLIC TRANSPORTATION

PLANS OF PROPOSED STATE HIGHWAY IMPROVEMENT

STATE PROJECT. C 68-8-34

SCALES:
PLAN 1 IN. = 100 FT.
PROFILE 1 IN. HOR. = 100 FT., 1 IN. VERT. = 10 FT.
CROSS SECTIONS 1 IN. HOR. AND VERT. = 5 FT.
OTHERS AS NOTED

NET LENGTH OF PROJECT = 1009 FT. = 0.191 MI. ROADWAY = 428 FT. = 0.081 MI.
BRIDGE = 581 FT. = 0.110 MI.

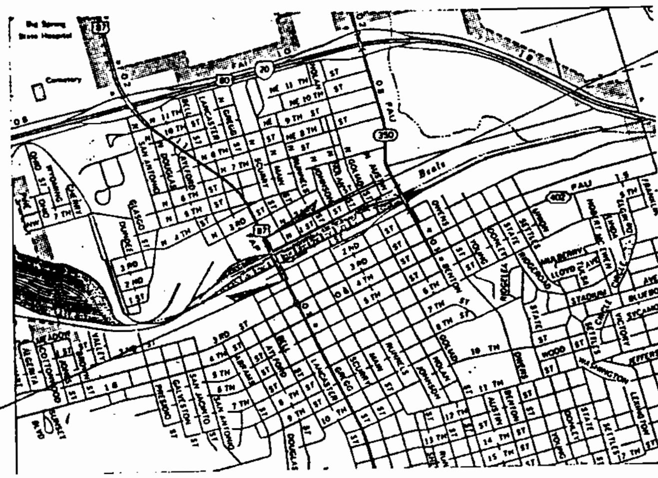
U.S. 87 HOWARD COUNTY

RAILROAD OVERPASS BRIDGE AT UNION PACIFIC RAILROAD IN BIG SPRING
CATHODIC BRIDGE DECK PROTECTION

INDEX OF SHEETS

SHEET NO.	DESCRIPTION
1.	TITLE SHEET
2.	TRAFFIC CONTROL PLAN
3.	TYPICAL SECTION
4	GENERAL NOTES AND SPECIFICATION DATA
6.	SUMMARY SHEET
7.	ESTIMATE AND QUANTITY SHEET
8.	PLAN PROFILE SHEET
9.	SUMMARY OF BRIDG DECK DELAMINATION
10.	LAYOUT OF CATHODIC PROCTECTION SYSTEM
11-12.	SYSTEM "B" DETAILS
13.	CATHODIC PROTECTION SYSTEM MISCELLANEOUS DETAILS
14-15.	BRIDGE DETAILS
16.	IPM(1)
17.	PM(3)
18-24.	BC(1) THRU (7)-82
5	OMITTED

STA. 16+00 END CONTROL 68-8-34
END PROJECT



STA. 5+91 BEGIN CONTROL 68-8-34
BEGIN PROJECT

Barricades Type III(C) with signs G20-1, G20-2, G20-6, & R20-3 at each end of the project. Signs CW20-1D & G20-2 at all city street intersections that are open to traffic during construction.

COUNTY HOWARD PROJ. NO. ___
HWY. NO. US87 LETTING DATE ___
DATE ACCEPTED ___

CONVENTIONAL SIGNS
- STATE OR NATIONAL LINE
- CITY OR VILLAGE LINE
- COUNTY LINE
- BASE OR SURVEY LINE
- RIGHT OF WAY LINE
- RIGHT OF WAY MARKER
- FENCE LINE
- RAILROAD
- TRAVELLED WAY
- CULVERT OR BRIDGE
- POWER LINE
- TELEGRAPH OR TELEPHONE
- CONTROL OF ACCESS

Specifications adopted by the Texas State Department of Highways and Public Transportation, September 1, 1982 and Specification items listed and dated as follows shall govern on this project: Special Labor Provisions for State Projects (000—011).

NO EQUATIONS
NO EXCEPTIONS
NO RAILROAD CROSSINGS

LAYOUT SCALE: 1 IN. = 1,320 FT.

STATE DEPARTMENT OF HIGHWAYS AND PUBLIC TRANSPORTATION

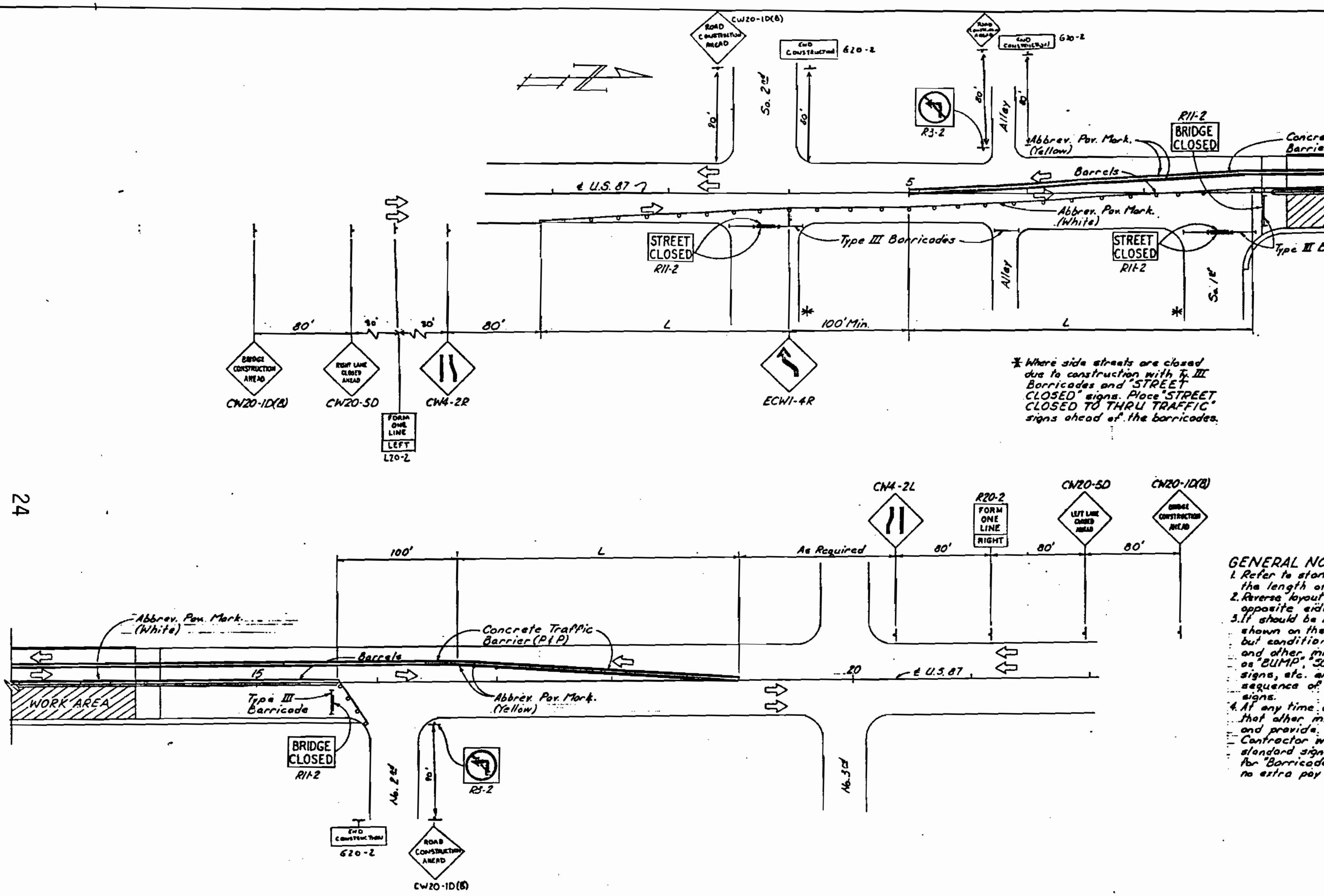
Correct: July 6 1987
Assistant District Engineer

Recommended For Approval: July 6 1987
District Engineer

Approved: ___
Bridge Engineer

Approved For Letting: ___
For Chief Engineer, Highway Design

U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION
APPROVED:
DIVISION ADMINISTRATOR
DATE



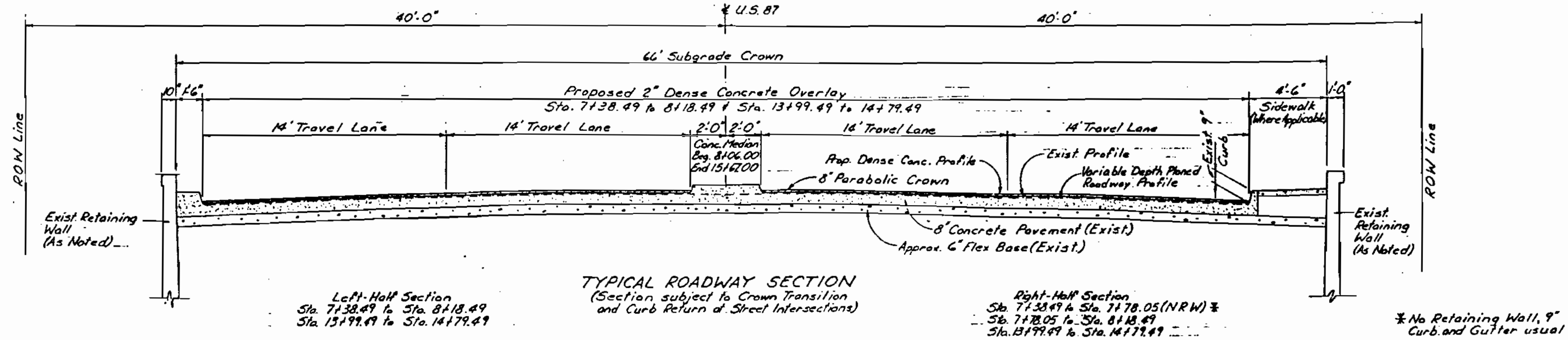
GENERAL NOTES:

1. Refer to standards BC(1)-82 thru BC(7)-82 for the length of tapers and spacing of delineators.
2. Reverse layout when work is moved to the opposite side of the bridge.
3. It should be noted that no other signs than those shown on the Traffic Control Plan, are anticipated; but conditions change as the project progresses and other minor signs may be needed. Signs such as "BUMP", "SOFT SHOULDERS", advisory speed signs, etc. are not shown but the Contractor's sequence of work may warrant the use of these signs.
4. At any time during the prosecution of this project that other minor signs are needed to control traffic and provide safety for the traveling public, the Contractor will provide these signs. Pay for these standard signs will be included in the bid item for "Barricades, Signs, and Traffic Handling" and no extra pay will be allowed.

TRAFFIC CONTROL PLAN

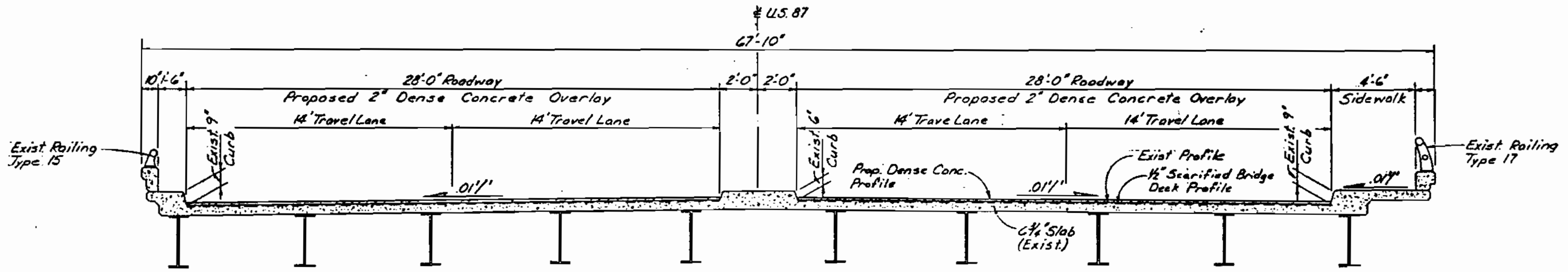
This is a suggested Signing and Barricade Layout and may be altered as approved by the Engineer.

FED RD DIV NO	STATE	FEDERAL PROJECT NO.			SHEET NO.
6	TEXAS	C 68-8-34			2
STATE DIST NO	COUNTY	CONT	SECT	JOB	HIGHWAY NO
8	Howard	68	8	34	US 87



TYPICAL ROADWAY SECTION
(Section subject to Crown Transition and Curb Return at Street Intersections)

* No Retaining Wall, 9" Curb and Gutter usual



TYPICAL BRIDGE SECTION
Sta. 8+18.49 to Sta. 13+99.49

25

TYPICAL SECTIONS
Scale: 1"=3'

DIST.	STATE	PROJECT NO.			SHEET NO.
	TEXAS	C 68-8-34			3
8	Howard	68	8	34	US 87

GENERAL NOTES AND SPECIFICATION DATA--

BEFORE BEGINNING WORK ON THIS PROJECT, THE CONTRACTOR SHALL SUBMIT, FOR APPROVAL BY THE ENGINEER, A PLAN OF CONSTRUCTION OPERATIONS OUTLINING IN DETAIL A SEQUENCE OF WORK TO BE FOLLOWED SETTING OUT THE METHOD HANDLING TRAFFIC. IF AT ANY TIME DURING THE CONSTRUCTION THE CONTRACTOR'S PROPOSED PLAN OF OPERATION FC HANDLING TRAFFIC DOES NOT PROVIDE FOR SAFE, COMFORTABLE MOVEMENT, THE CONTRACTOR SHALL IMMEDIATELY CHANG HIS OPERATIONS TO CORRECT THE UNSATISFACTORY CONDITION.

THE CONTRACTOR'S ATTENTION IS HEREBY DIRECTED TO UTILITIES EXISTING IN OR NEAR THE WORK AREAS OF THIS PROJECT. ANY ACTIVE UTILITIES THAT ARE ENCOUNTERED BY THE CONTRACTOR SHALL IMMEDIATELY BE BROUGHT TO TH ATTENTION OF THE ENGINEER.

ANY WORKSITE OUTSIDE THE RIGHT-OF-WAY AND CLOSE ENOUGH TO THE HIGHWAY FOR ITS CONDITION TO ADVERSELY AFFECT THE VIEW FROM THE HIGHWAY SHALL BE LEFT IN A NEAT AND PRESENTABLE CONDITION ACCEPTABLE TO THE ENGINEER.

---ITEM 421---
THE ENGINEER WILL SAMPLE ALL CONCRETE AND MAKE AND TEST ALL TEST BEAMS AND CYLINDERS IN ACCORDANCE WITH TEST METHODS TEX-418-A AND TEX-420-A. ALL TEST MOLDS WILL BE FURNISHED BY THE ENGINEER AND THE CONTRACT SHALL MAINTAIN THEM IN THE PROPER CONDITION. IN ADDITION, THE CONTRACTOR SHALL BE RESPONSIBLE FOR FURNISHING PERSONNEL TO REMOVE THE TEST SPECIMENS FROM THE MOLDS AND TO TRANSPORT THEM TO THE PROPER CURING LOCATION AT THE SCHEDULE DESIGNATED BY THE ENGINEER AND IN ACCORDANCE WITH THE GOVERNING SPECIFICATION. FOR ALL CONCRETE ITEMS THE CONTRACTOR SHALL HAVE A WHEELBARROW, OR OTHER CONTAINER ACCEPTABLE TO THE ENGINEER, AVAILABLE TO USE IN THE SAMPLING OF CONCRETE. ALL LABOR AND EQUIPMENT FURNISHED BY THE CONTRACTOR WILL BE CONSIDERED SUBSIDIARY TO THE VARIOUS BID ITEMS AND WILL NOT BE PAID FOR DIRECTLY.

---ITEM 437---
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.

---ITEM 446---
PAINT PURCHASED FROM THE DEPARTMENT WILL BE CHARGED AS FOLLOWS:

PROTECTION SYSTEM I PRIME COAT $63.08/5 GAL.
PROTECTION SYSTEM II PRIME COAT $24.39/1 1/4 GAL.

---ITEM 442---
NEW STRUCTURE STEEL ARMOR JOINTS SHALL RECEIVE PROTECTIVE SYSTEM I.

---ITEM 512---
FOR THIS PROJECT THE STATE SHALL FURNISH 1415 FEET OF PORTABLE CONCRETE TRAFFIC BARRIER (PCTB) SECTIONS AND 2 TERMINAL SECTIONS, STOCKPILED ON IH 20 AT EAST HOWARD FIELD ROAD, NEAR THE MITCHELL COUNTY LINE. UPON REMOVAL, THE PCTB AND TERMINAL SECTIONS, SHALL BE RETURNED TO THE STORAGE AREA. THE CONTRACTOR SHAL MAKE ARRANGEMENTS FOR THE LOADING AND UNLOADING OF THE PCTB AT THE STORAGE AREA.

ITEM 618---
ALL CONDUIT RUNS CROSSING THE BRIDGE SHALL BE SECUERLY ATTACHED TO THE SUBSTRUCTURE OF THE BRIDGE. CLAMF EQUIVALENT TO APPLETON CH-50S(1/2- 3/4") AND CH-125S(1") SHALL BE USED. THE NUMBER OF CLAMPS REQUIRED A THEIR SPACING SHALL BE DETERMINED BY THE ENGINEER. THIS WORK SHALL NOT BE PAID FOR DIRECTLY, BUT SHALL E CONSIDERED AS SUBSIDIARY TO ITEM 4642, "CATHODIC BRIDGE DECK PROTECTION SYSTEM".

---ITEM 664---
IF ABBREVIATED PAVEMENT MARKINGS ARE NEEDED FOR TEMPORARY ALIGNMENT ON ON A FINAL SURFACE, THESE MARKINGS SHALL BE APPLIED IN A MANNER THAT WILL ALLOW EASY AND COMPLETE REMOVAL WITH NO UNDUE INJURY TO THE FINAL SURFACE.

YELLOW ABBREVIATED PAVEMENT MARKINGS SHALL BE USED TO SEPARATE TRAFFIC FLOW IN OPPOSITE DIRECTIONS. WHIT ABBREVIATED PAVEMENT MARKINGS SHALL BE USED TO SEPARATE TRAFFIC FLOW IN THE SAME DIRECTION.

---ITEM 676---
BITUMINOUS ADHESIVE SHALL BE USED ON THIS PROJECT.

---ITEM 3003---
SURFACE TEXTURE AND SURFACE TEXTURE TESTS WILL NOT BE REQUIRED.

---GENERAL---
ALL PAVEMENT MARKING SHALL BE IN ACCORDANCE WITH THE M.U.T.C.D..

---ITEM 4685---
A 90 DAY TEST PERIOD IS REQUIRED AFTER INSTALLATION OF THE CATHODIC PROTECTION SYSTEM IS COMPLETED.

ARZA

SPECIFICATION DATA

REV. 9-24-87
REV. 9-17-87

SHEET A

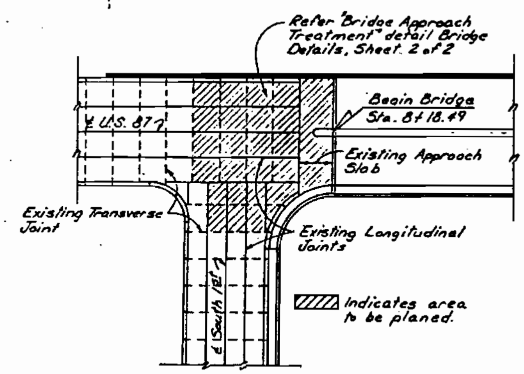
27

BRIDGE SUMMARY

NAME	SHEET NO. Plan Profile	SHEET NO. Layout	STATION Beg.	STATION End	LENGTH	SIZE	DESIGN	DESCRIPTION	Scarify Conc. Br. Slab SY	Dense Concrete Overlay SY	Conc Surf Treat SY	Str Stl (HYC) LB	Str Stl (Armor Jt) LB	Traffic Button (Ty IC) EA	Traffic Button (Ty W) EA	Cathodic Protection System LS		
M.P. RR & Gregg St. Sep.	11	-	8+18.49	13+99.49	581.0'	111.0'-185.0'-115.5' 56.0'-56.0'-56.0'	Special	411.5' Cont. ℄ Girder 168.0' Cont. I-Beam	3615	3615	3615	10204	1545	28	112	1		

ROADWAY SUMMARY

Sta. to Sta.	Planing & Text Pavement SY	Dense Concrete Overlay SY	Conc Surf Treat SY	Conc Traf Bar (Move & Reset) LF	Conc Traf Bar (Remove) LF	Traffic Button (Ty IC) EA	Traffic Button (Ty II AA) EA	Traffic Button (Ty W) EA	Traffic Button (Ty Y) EA					
7+38.49 - 8+18.49	658	658	658	2864	1432	4	6	16	18					
13+99.49 - 14+79.49	498	498	498			4		16						
	1156	1156	1156	2864	1432	8	6	32	18					



PLANED AREA
SOUTH OF BRIDGE

SUMMARY OF ABBREVIATED PAV MARK

Station to Station	4 In Dashed (White) LF	4 In Solid (White) LF	4 In Solid (Yellow) LF	
7+38.49 - 8+18.49	40		160	
8+18.49 - 13+99.49	291			
13+99.49 - 14+79.49	40			
Approx. 2+00 - Approx. 16+00.		1400		
Approx. 5+00 - Approx. 19+32.			2864	
Approx. 6+00 - Approx. 20+00		1400		
Approx. 2+68 - Approx. 17+00			2864	
Totals	371	2800	5888	

SUMMARY SHEET

FED. RD. DIV. NO.	STATE	FEDERAL PROJECT NO.	SHEET NO.
6	TEXAS	C 68-8-34	6

STATE DIST. NO.	COUNTY	CONT.	SECT.	JOB	HWY. NO.
8	Howard	68	8	34	US87

ESTIMATE SUMMARY

PROJECT C 68-8-34

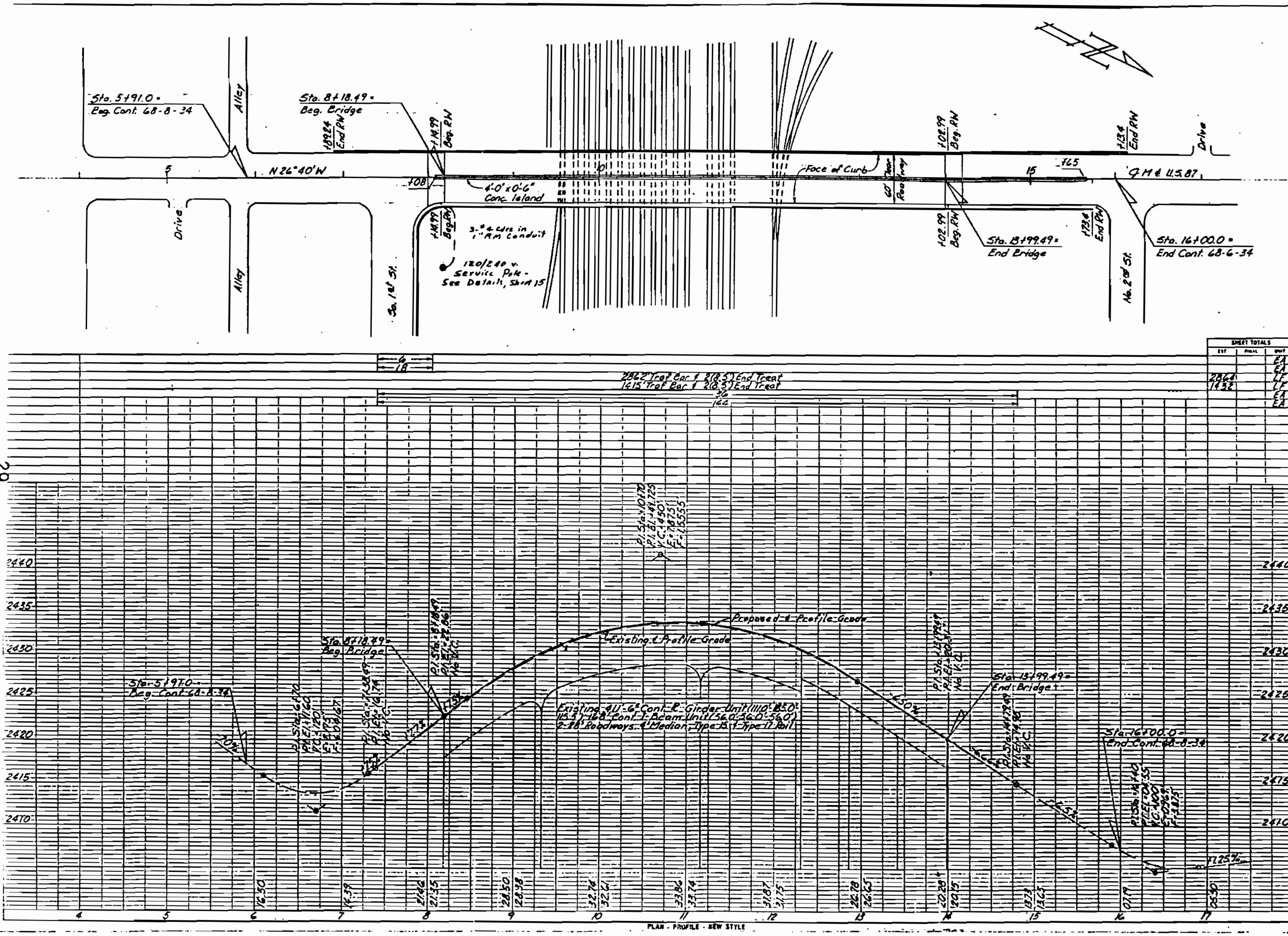
CONTROL 68-08-034

						BRIDGE US 87		ROADWAY US 87		ALT	ITEM-CODE			DESCRIPTION	UNIT	TOTAL	
EST.	FINAL	EST.	FINAL	EST.	FINAL	EST.	FINAL	EST.	FINAL		ITEM NO	DESC CODE	SP NO			EST.	FINAL
						3615.000		1156.000			428	001		CONC SURF TREAT	SY	4771.000	
						3615.000		1156.000			438	002		DENSE CONC OVERLAY (2 IN)	SY	4771.000	
						10204.000					442	001	002	STR STL (HVC)	LB	10204.000	
						1545.000					442	003	002	STR STL (ARMOR JT)	LB	1545.000	
						3615.000					483	001		SCARIFY CONC BRIDGE SLAB (1/2 IN)	SY	3615.000	
								1.000			500	001	001	MOBILIZATION	LS	1.000	
								4.000			502	001		BARCD,SIGN AND TRAF HANDLING	MO	4.000	
								2864.000			512	002		CONC TRAF BAR (MOVE AND RESET)	LF	2864.000	
								1432.000			512	003		CONC TRAF BAR (REMOVE)	LF	1432.000	
						1453.000		1718.000			664	002	002	ABBREVIATED PAV MARK (WHITE)	LF	3171.000	
						2324.000		3564.000			664	003	002	ABBREVIATED PAV MARK (YELLOW)	LF	5888.000	
						28.000		8.000			676	002	011	TRAFFIC BUTTON (TY IC)	EA	36.000	
								6.000			676	004	011	TRAFFIC BUTTON (TY IIAA)	EA	6.000	
						112.000		32.000			676	006	011	TRAFFIC BUTTON (TY W)	EA	144.000	
								18.000			676	007	011	TRAFFIC BUTTON (TY Y)	EA	18.000	
								1156.000			3003	009	001	PLANING CONC PAV CL C(2)(2 IN)	SY	1156.000	
						1.000					4685	001		CATHODIC BR DECK PROTECTION	LS	1.000	
														RAILROAD FORCE ACCOUNT WORK			
														MPRR CO. FORCE ACCOUNT WORK			
														FLAGGING		1.000	

ESTIMATE & QUANTITY SHEET

REV. 9-24-87
REV. 9-17-87

STATE DIST. NO.	COUNTY	PROJECT NO.	SHEET NO.
8	HOWARD	C 68-8-34	7



CROSS SECTION DATA

Station Number	Slope Ratio to 1	Ditch Depth Ft.	Ditch Width Ft.	Slope Ratio to 1	Crown Width (Ft)	Slope Ratio to 1	Ditch Width Ft.	Ditch Depth Ft.	Slope Ratio to 1	Average Ground Slope Per 100'	Typical X Sect. No.

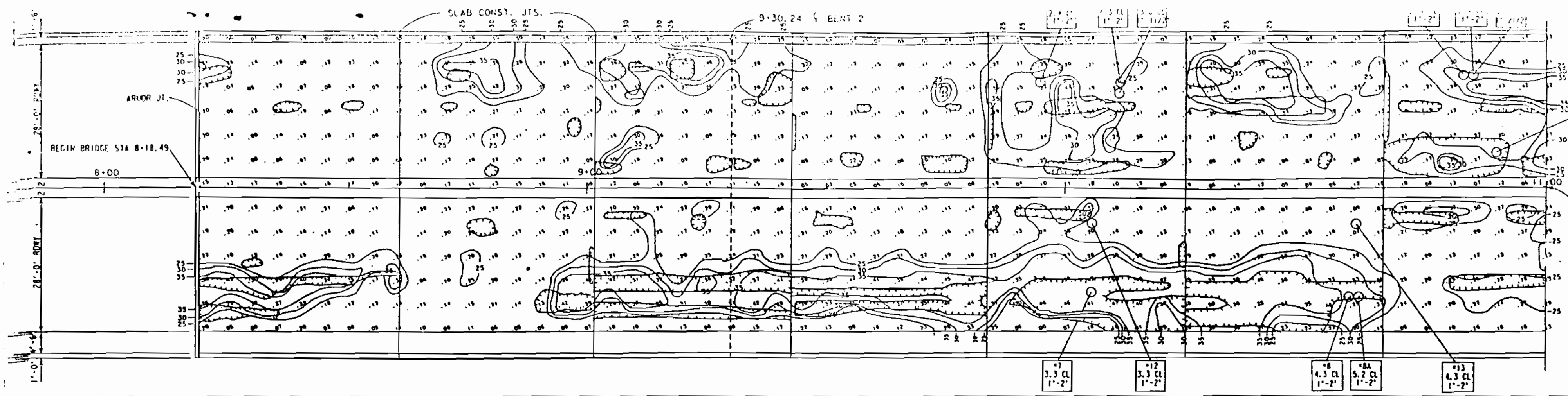
Sheet Totals Est.	Final	Unit	Item
		EA	Traffic Button (Ty II AA)
		EA	Traffic Button (Ty Y)
2864		LF	Conc. Traf Bar (Move and Reset)
1432		LF	Conc. Traf Bar (Remove)
		EA	Traffic Button (T I C)
		EA	Traffic Button (Ty W)

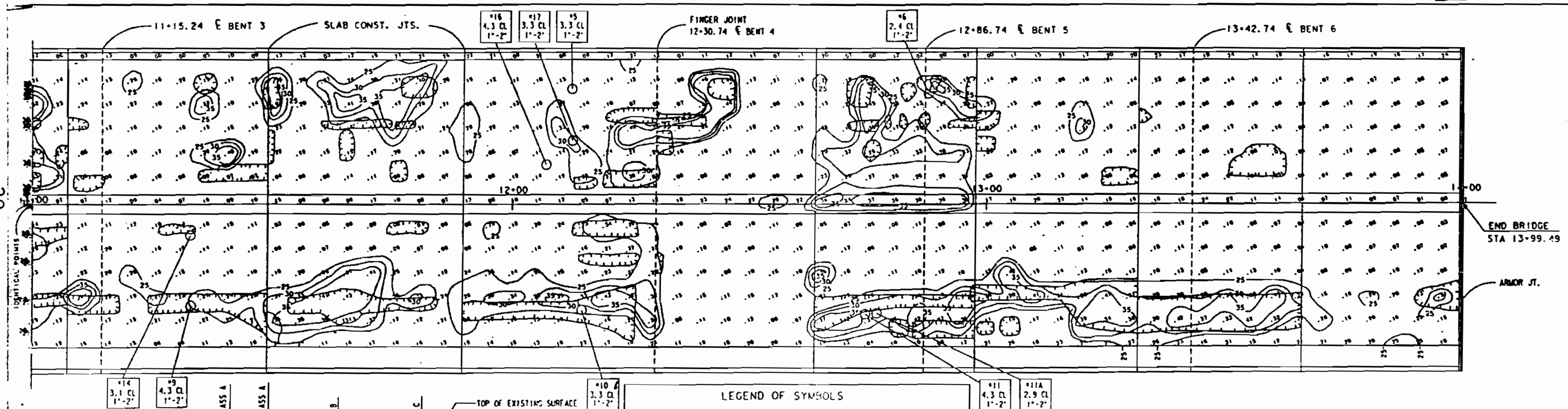
B.M. #1
Northeast corner of north end of bridge El. = 2403.32

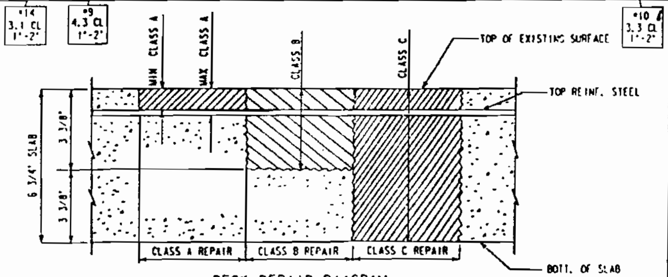
Rev. 7-31-87

Fed. Road Div. No.	State	Federal Aid Project No.	Sheet No.
6	Texas	C 68-8-34	8

Dist.	County	Cont.	Sect.	Job	Highway No.
8	Howard	68	8	34	U.S. 87







DECK REPAIR DIAGRAM

LEGEND OF SYMBOLS

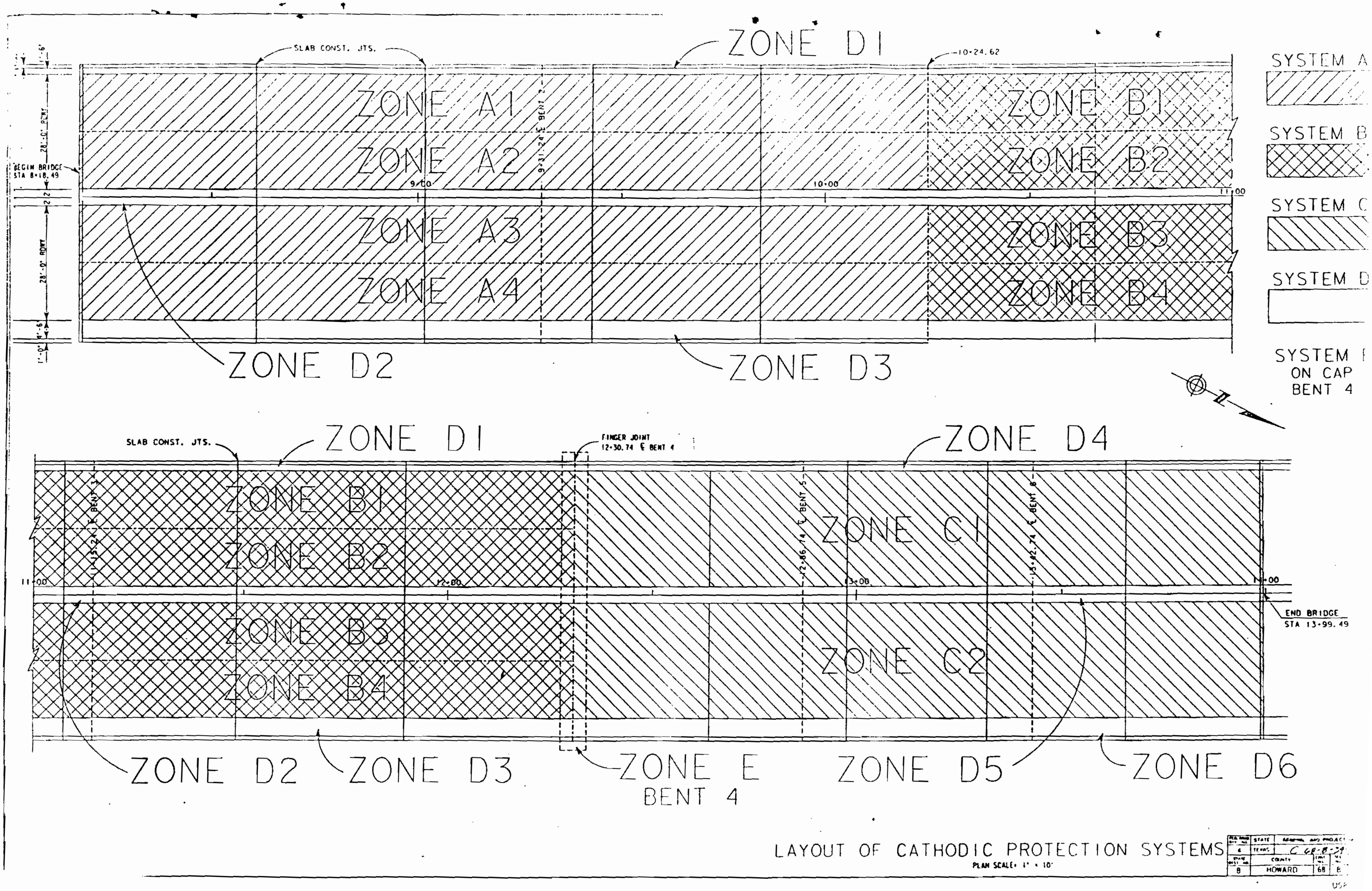
DELAM	-INDICATES "DELAMINATED AREAS"
PATCH	-INDICATES "PATCH AREAS"
.23	-INDICATES "HALFCELL TEST READING"
HOLE NO. / Lbs CL/C.Y. INFO. / Depth	-INDICATES "LOCATIONS OF CHLORIDE SAMPLING HOLES"

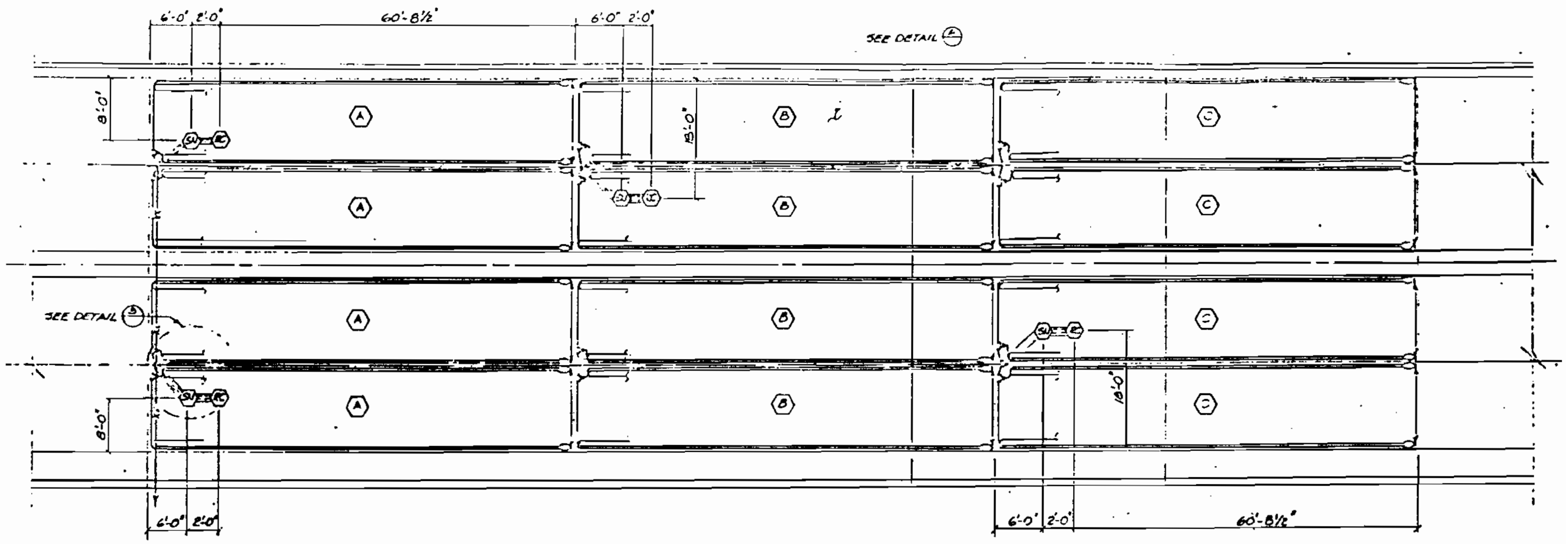
SUMMARY OF BRIDGE DECK DELAMINATION

PLAN SCALE: 1" = 10'

STATE	FEDERAL AID PROJECT NO.	SHEET NO.
TEXAS	C68-8-34	

STATE DIST. NO.	COUNTY	CONT.	SECT.	JOB	HIGHWAY NO.
8	HOWARD	68	6	34	US ...


ZONE D1
SLAB CONST. JTS.
10+24.62
SYSTEM A
SYSTEM B
SYSTEM C
SYSTEM D
SYSTEM E ON CAP BENT 4
ZONE A1
ZONE A2
ZONE A3
ZONE A4
ZONE B1
ZONE B2
ZONE B3
ZONE B4
BEGIN BRIDGE STA 8+18.49
9+00
10+00
11+00
28'-0" RDWY
ZONE D2
ZONE D3
ZONE D4
FINGER JOINT 12+30.74 ℄ BENT 4
ZONE C1
ZONE C2
12+00
13+00
14+00
END BRIDGE STA 13+99.49
ZONE E BENT 4
ZONE D5
ZONE D6
LAYOUT OF CATHODIC PROTECTION SYSTEMS
PLAN SCALE: 1" = 10'
TEXAS
HOWARD



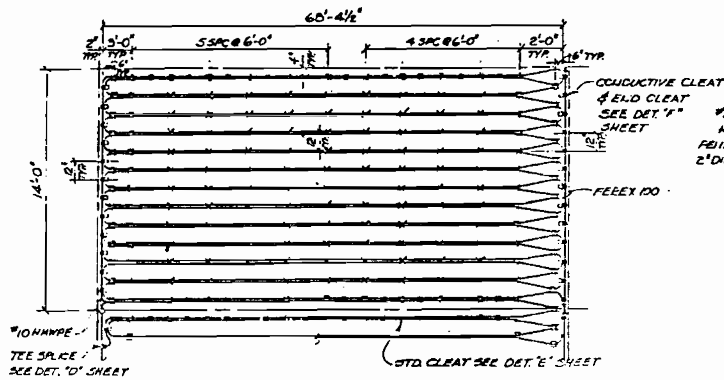
ANODE STRAND PLACEMENT
SCALE: 1" = 10'

LEGEND

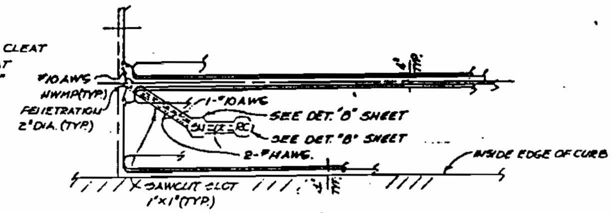
- ◄ – END CAP
- □× – CLEAT WITH PUSHPIN (SEE DETAIL 'E' SHT.
- – CONDUCTIVE END LOOP WITH PUSHPIN (SEE DETAIL 'F' SHT.
- ■ – CONDUCTIVE CLEAT, INSTALL ON OUTSIDE END PAIRS AND ON ENDS OF ANODE RUNS (SEE DETAIL 'J' SHT.
- (RC) – REFERENCE CELL (SEE DETAIL 'A' SHT.
- (SN) – SYSTEM NEGATIVE (SEE DETAIL 'B' SHT.
- ○ – CONCRETE PENETRATION (2" DIA.)
- – FEREX 100 FACTORY PRE-ASSEMBLED TEE SPLICE (SEE DETAIL 'D' SHT.
- (X) – ANODE CIRCUIT X

NOTES

1) INSTRUMENTATION AND SYSTEM NEGATIVE WIRES SHALL BE ROUTED TO CONCRETE PENETRATION IN A SAWCUT SLOT 1" WIDE AND 1" DEEP.



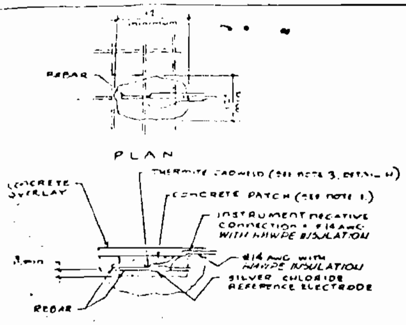
TYPICAL ANODE STRAND PLACEMENT
N.T.S.



PENETRATION AND INSTRUMENTATION PLACEMENT
N.T.S.

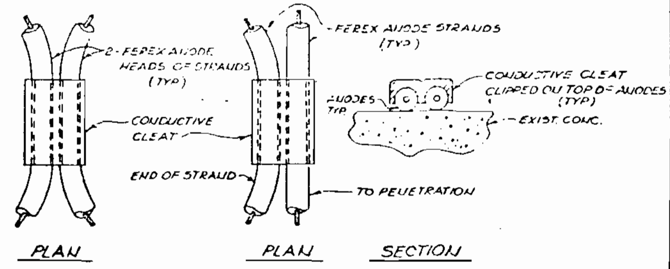
SYSTEM "B" DETAILS
Sheet 1 of 2

STATE	FEDERAL PROJECT NO.	SHEET NO.	TOTAL SHEETS
	C 68-B-34	11	12
COUNTY: Howard	68 8 34	US 87	

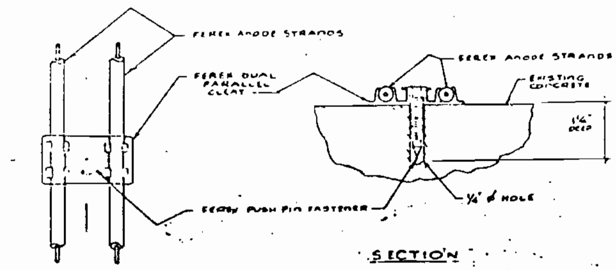


SECTION
HORIZ SURFACE

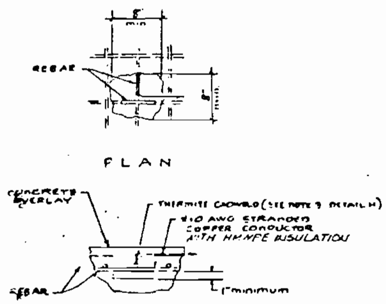
DETAIL A: REFERENCE CELL PLACEMENT (TYP)



DETAIL 'J' ANODE STRAND ATTACHMENT AT END OF PANEL RUNS.
NO SCALE

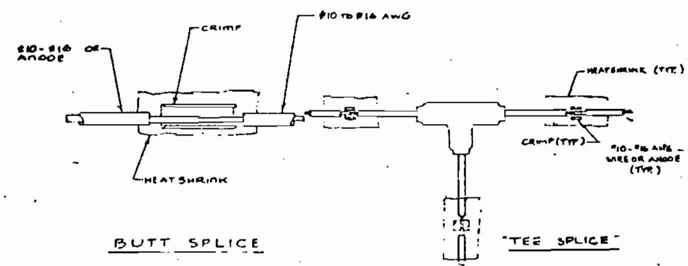


DETAIL E: ANODE STRAND ATTACHMENT AT INTERIOR POINTS (SEE NOTE 5)

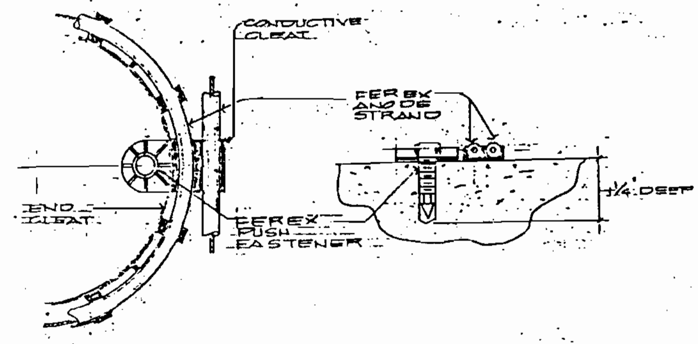


SECTION
HORIZ. SURFACE

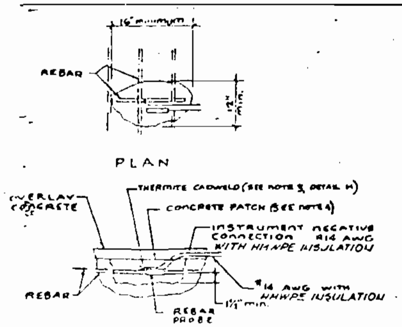
DETAIL B: SYSTEM NEGATIVE CONNECTION (TYPICAL)



DETAIL D: ELECTRICAL SPLICES (TYPICAL)

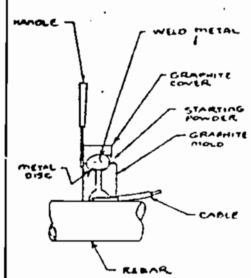


DETAIL F ANODE STRAND ATTACHMENT AT ENDS OF ANODE RUNS



SECTION
HORIZ SURFACE

DETAIL G: REBAR PROBE PLACEMENT (TYPICAL)



STEP 1
FILE REBAR TO BARE SHINY METAL AND CLEAN OVER AREA TO FULLY SEAT TOOL ON REBAR SURFACE.

STEP 2
STRIP INSULATION FROM WIRE SLIP METAL SLEEVE OVER WIRE AND CRIMP.

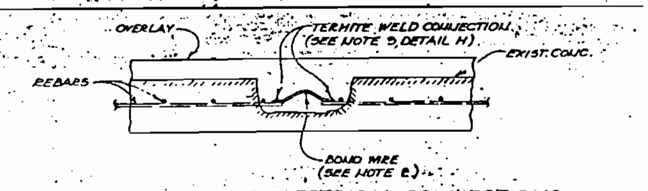
STEP 3
HOLD WIRE SLEEVE IN PLACE WITH MOLD. FILL MOLD WITH POWDER CHARGE.

STEP 4
HOLD MOLD FIRMLY, POSITION THE OPENING IN THE MOLD AWAY FROM DIE OPERATOR. IGNITE POWDER WITH FLINT GUN.

STEP 5
REMOVE SLAG FROM CONNECTION AND TEST WELD FOR SOUNDNESS WITH BRASS HAMMER.

STEP 6
COVER CONNECTION AND EXPOSED REBAR SURFACE WITH A NONCONDUCTIVE EPOXY COMPOUND

DETAIL H THERMITE CADWELD INSTALLATION

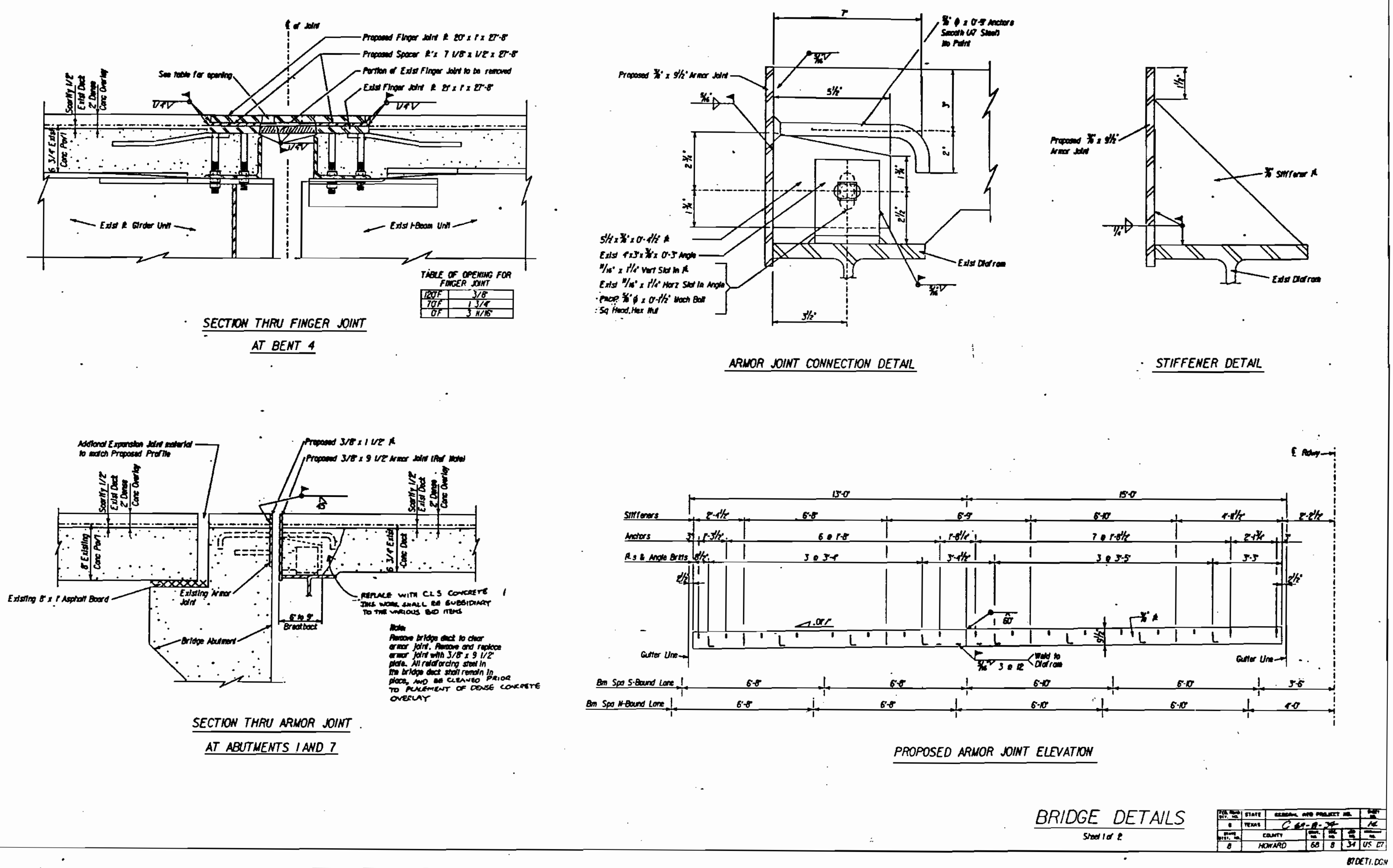


DETAIL C: REBAR TO REBAR ELECTRICAL CONNECTIONS

NOTES:
1) PATCH WITH 7% ± 1% AIR ENTRAINED PORTLAND CEMENT CONC. WITH A 0.50 WATER-CEMENT RATIO AND A CHLORIDE CONTENT OF 15 LBS PER CUBIC YARD OF CONC.
2) AWG. NO. 10 STRANDED COPPER WITH RHW/USE INSULATION.
3) COAT TERMITE CADWELD WITH NON-CONDUCTIVE EPOXY COMPOUND.
4) PATCH WITH 0.50 WATER-CEMENT RATIO, 7% ± 1% AIR ENTRAINED PORTLAND CEMENT WITH A SALT CONTENT OF LESS THAN 0.080 PERCENT BY WEIGHT.
5) ATTACHMENTS TO BE MADE AT 10 FEET SPACINGS OR AS SHOWN ELSEWHERE ON DWGS.

CATHODIC PROTECTION SYSTEM MISCELLANEOUS DETAILS

6	TEXAS	C 68-R-[illegible]				19
8	Howard	68	A	34		115 [illegible]



SECTION THRU FINGER JOINT AT BENT 4

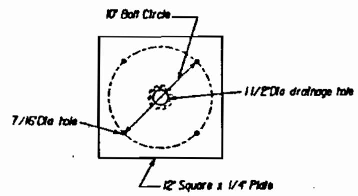
ARMOR JOINT CONNECTION DETAIL

STIFFENER DETAIL

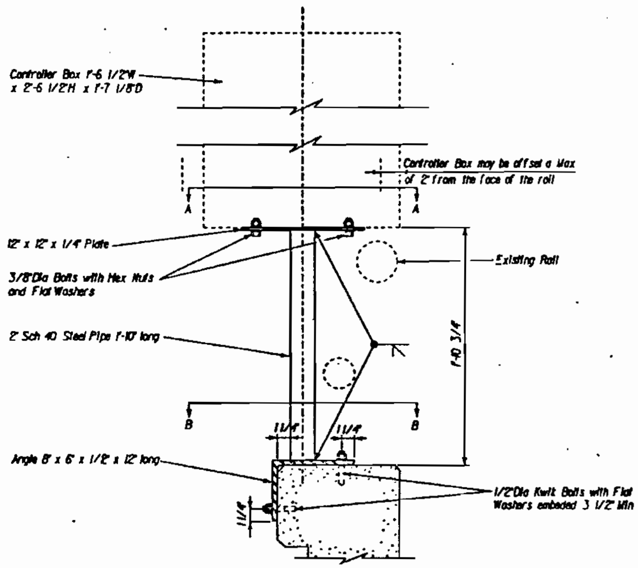
SECTION THRU ARMOR JOINT AT ABUTMENTS 1 AND 7

PROPOSED ARMOR JOINT ELEVATION

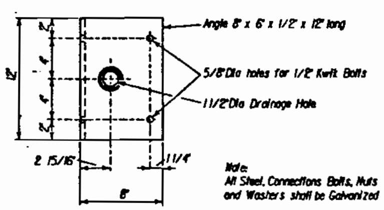
BRIDGE DETAILS



PLAN VIEW AA



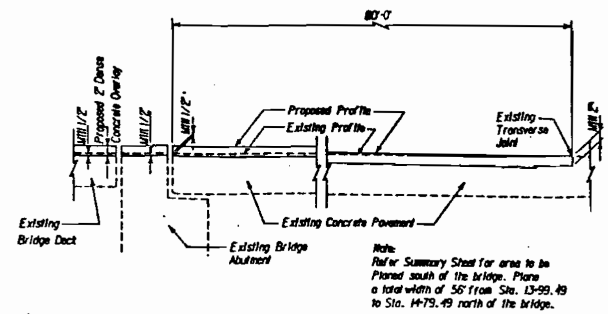
ELEVATION



Note:
All Steel, Connections Bolts, Nuts and Washers shall be Galvanized

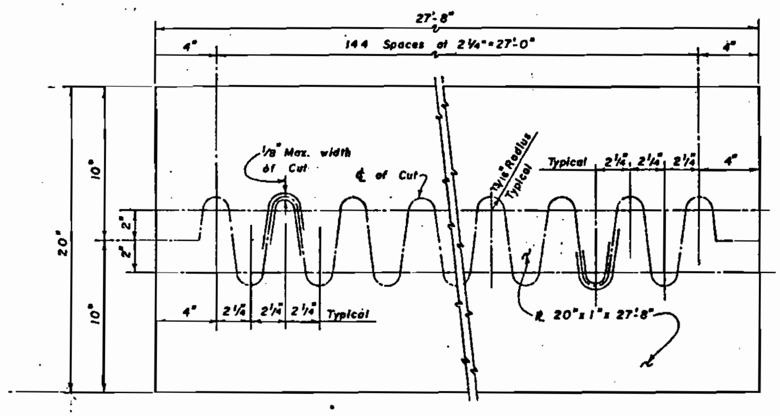
PLAN VIEW BB

CONTROLLER BOX SUPPORT



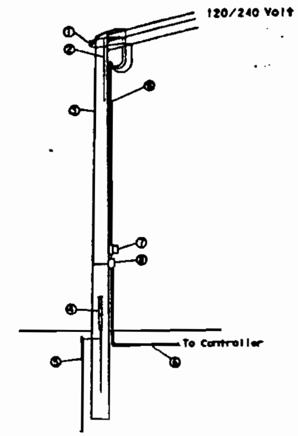
Note:
Refer Summary Sheet for area to be Planed south of the bridge. Plane a total width of 56' from Sta. 13+99.49 to Sta. 14+79.49 north of the bridge.

BRIDGE APPROACH DETAIL



DETAIL OF SCROLL

The scroll shall shall be made by a single cut of a machine guided torch. Spread as required. Grind off burrs.



① - Lightning Arrester
② - No. 6 Bare Ground Wire
* ③ - 30' Class 5 Pole
④ - Ground Wire Moulding - 8' Min.
⑤ - 5/8" x 8' Copper Clad Grnd. Rod
⑥ - 2-#4 XHHW & 1-#4 Bare in 1" RMC
⑦ - Meter
⑧ - 60 AMP Heavy Duty Switch, NEMA 3R

* Or as Required By Utility Company.

All work and materials shall be in accordance with the National Electrical Code. Cathodic Protection Rectifiers shall be set to operate at 240 Volts.

SERVICE POLE AND ELECTRICAL FEEDER

Furnishing and installing service pole and electrical feeder will not be paid for directly but will be subsidiary to the item 'Cathodic Protection System'.

BRIDGE DETAILS

Sheet 2 of 2

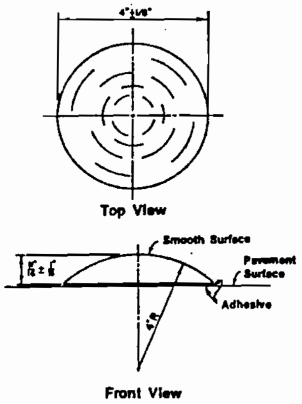
Rev. 9-1-87

FED. RD. DIV. NO.	STATE	FEDERAL AID PROJECT NO.			SHEET NO.
6	TEXAS	C 68-8-34			15
STATE DIST. NO.	COUNTY	CONT. NO.	SEC. NO.	JOB NO.	HIGHWAY NO.
8	HOWARD	68	8	34	US 87

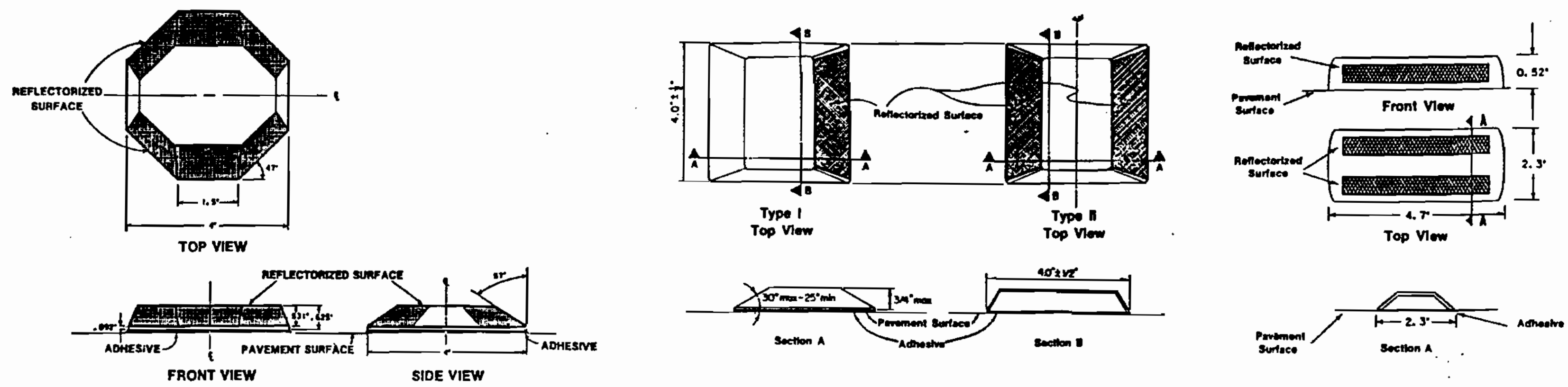
87DET2.DGN

35

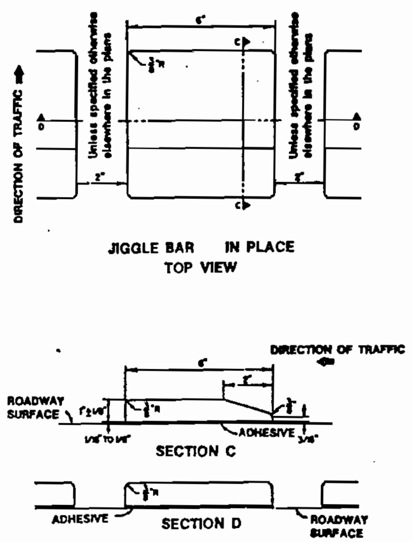
0-76-8



TRAFFIC BUTTONS
(NON-REFLECTORIZED)

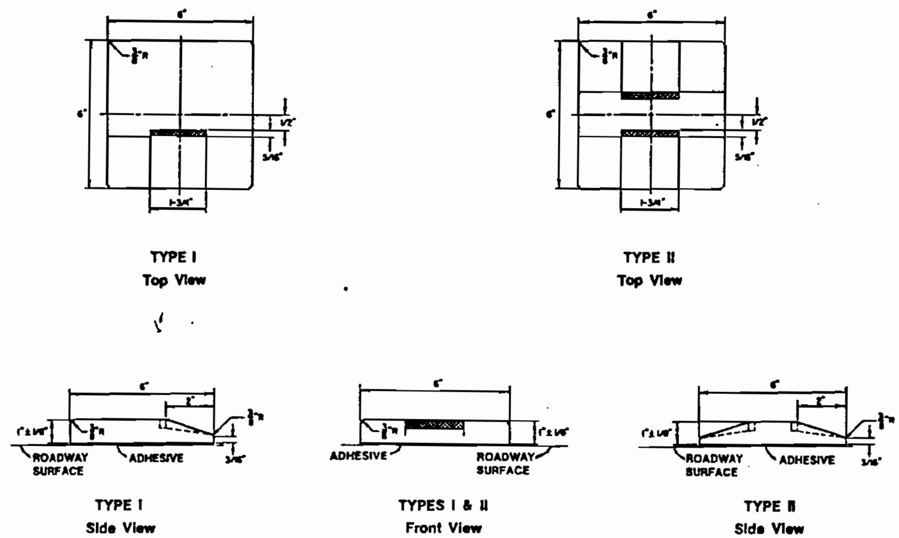


PAVEMENT MARKERS
(REFLECTORIZED)



JIGGLE BAR TILES
(NONREFLECTIVE)

"JIGGLE BARS" CONSIST OF A NUMBER OF JIGGLE BAR TILES PLACED IN A LINEAR CONFIGURATION



JIGGLE BAR TILES
(REFLECTORIZED)

NOTE

ALL DIMENSIONS ARE ± 1/8" UNLESS OTHERWISE SHOWN

GENERAL NOTES:

THE PAVEMENT UPON WHICH THE TRAFFIC BUTTONS, PAVEMENT MARKERS, AND JIGGLE BAR TILE ARE TO BE PLACED SHALL BE PREPARED SUBJECT TO THE APPROVAL OF THE ENGINEER TO INSURE PROPER CLEANING OF THE PAVEMENT SURFACE. RPM'S SHALL BE BONDED TO THE ROADWAY SURFACE WITH ADHESIVE CONFORMING WITH SPECIFICATION.

UNLESS SPECIFIED ELSEWHERE IN THE PLANS, THE USUAL JIGGLE BAR SPACING IS 50' ON MEDIAN PAVED SHOULDERS, 100' ON OUTSIDE PAVED SHOULDERS. JIGGLE BARS SHALL BE ORIENTED PERPENDICULAR TO THE ROADWAY.

JIGGLE BARS SHALL ALSO BE PLACED AT SUCH OTHER LOCATIONS AS SHOWN ON THE PLAN AND PROFILE SHEETS OR WHERE DIRECTED BY THE ENGINEER.

MARKERS SHOWN ARE FOR ILLUSTRATION PURPOSES ONLY. THEY ARE NOT INTENDED TO SPECIFY ANY PARTICULAR PRODUCT.

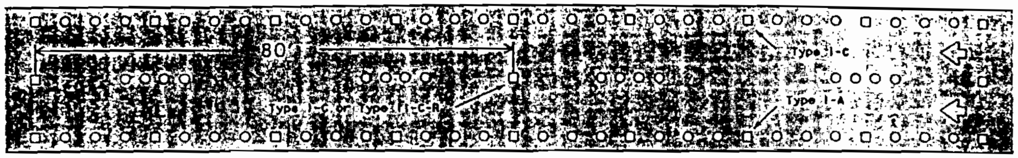
1. TYPE OF PAVEMENT MARKERS (REFLECTORIZED) PROVIDED ON THIS PROJECT WILL BE AT THE CONTRACTOR'S OPTION.
2. ALL PAVEMENT MARKERS PROVIDED SHALL BE OF THE SAME MANUFACTURER.

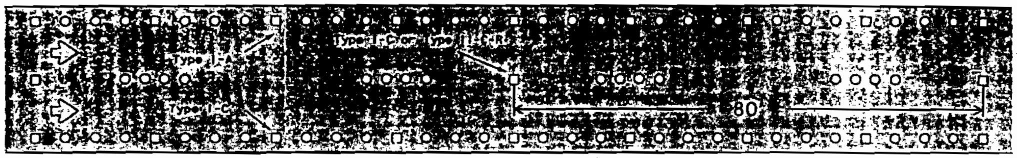
STATE DEPARTMENT OF HIGHWAYS AND PUBLIC TRANSPORTATION

INDIVIDUAL UNIT PAVEMENT MARKINGS REFLECTIVE PAVEMENT MARKERS, TRAFFIC BUTTONS & JIGGLE BAR TILE

IPM(1)

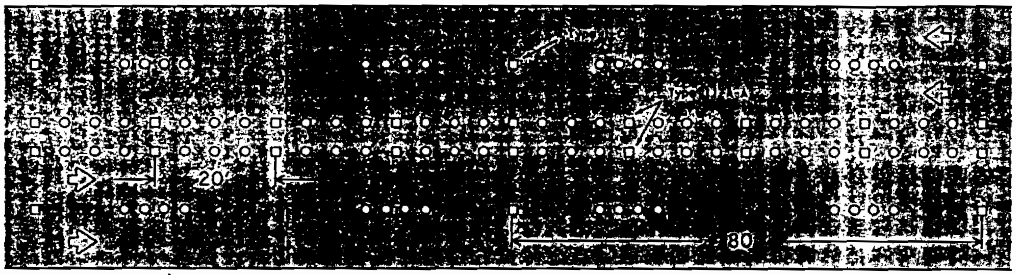
1-81	8	6	C 61-8-24	16
2-82 7-86	Howard	68	8 34	25.77
7-85 10-86				21A
11-85				





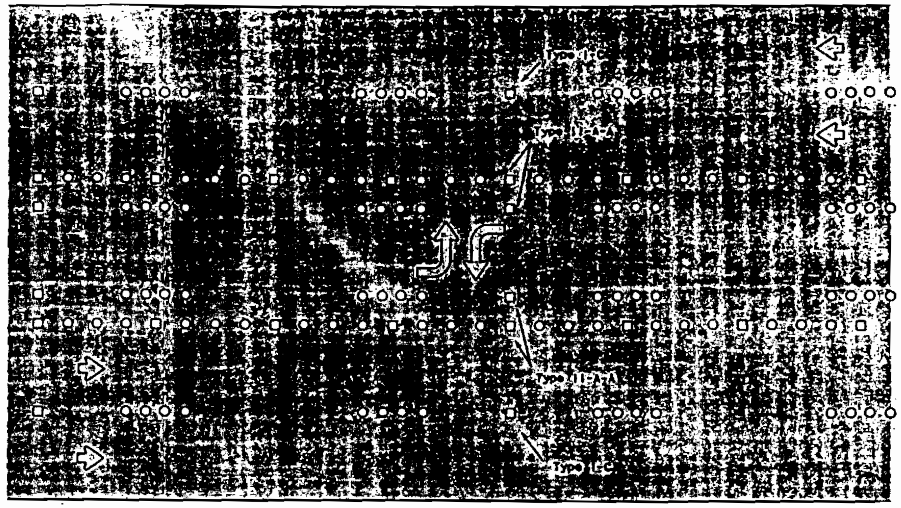
EDGE LINES AND LANE LINES
FOR DIVIDED HIGHWAYS

INDIVIDUAL UNIT MARKER TYPE II-C-R, CRYSTAL FACE TOWARD NORMAL TRAFFIC AND RED FACE TOWARD WRONG-WAY TRAFFIC, SHALL BE SPACED ON 80-FOOT CENTERS EXCEPT ON VERTICAL CURVES, GRADES OVER 2 PER CENT, LESS THAN 1000 FEET LONG, HORIZONTAL CURVES, AND ON CONTINUOUSLY ILLUMINATED SECTIONS OF HIGHWAY WHERE THEY MAY BE PLACED ON 40-FOOT CENTERS IF DEEMED NECESSARY BY THE ENGINEER.



LANE LINES & CENTER LINES
FOR MULTI-LANE UNDIVIDED HIGHWAYS

INDIVIDUAL UNIT MARKER TYPE I-C, CLEAR FACE TOWARD NORMAL TRAFFIC, SHALL BE PLACED ON 80-FOOT CENTERS.



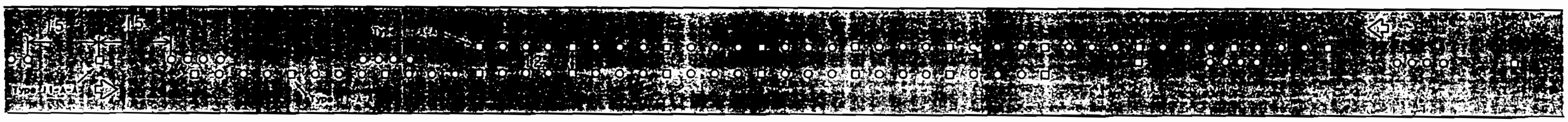
PAVEMENT MARKINGS FOR
TWO-WAY LEFT TURN LANE

GENERAL NOTES:

ALL INDIVIDUAL UNIT MARKERS PLACED IN DASHED LINES SHALL BE PLACED IN LINE WITH AND MIDWAY BETWEEN THE STRIPES.

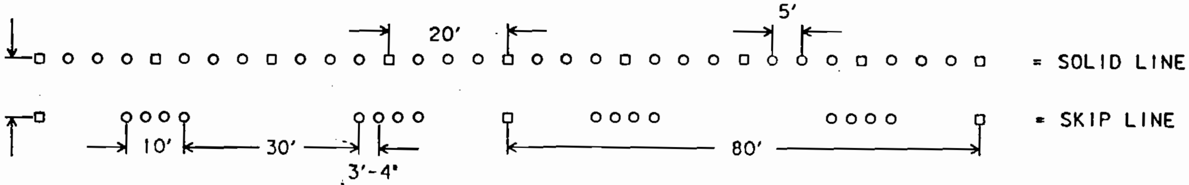
FIRST AND LAST INDIVIDUAL UNIT MARKERS IN A NO-PASSING ZONE BARRIER LINE ARE TO BE LOCATED ADJACENT TO EITHER THE MIDPOINT OF THE GAP OF THE CENTERLINE MARKING OR TO THE MIDPOINT OF THE STRIPE OF THE CENTERLINE MARKING.

BUTTON SPACING FOR CENTER LINES AND LANE LINES MAY BE 5 FEET IF DIRECTED BY THE ENGINEER.



CENTER LINE & NO PASSING ZONE BARRIER LINES
FOR TWO-LANE TWO-WAY HIGHWAYS

INDIVIDUAL UNIT PAVEMENT MARKINGS
○ = TRAFFIC BUTTON (NONREFLECTORIZED)
□ = TRAFFIC MARKER (REFLECTORIZED)



PATTERN DETAIL

STATE DEPARTMENT OF HIGHWAYS
AND PUBLIC TRANSPORTATION

INDIVIDUAL UNIT PAVEMENT
MARKINGS USED TO SIMULATE
STANDARD PAVEMENT MARKINGS FOR
CENTER LINES AND LANE LINES
PM(3)

2-82	8	6	C 68-8-34	17
7-86	Howard	68	8	34
10-86				US 87
				220

CONSTRUCTION PAVEMENT MARKINGS

When required elsewhere in the plans, the Contractor will be responsible for maintaining pavement markings on all roadways that are open to traffic within the limits of the project. On projects involving roadway surfacing which will require pavement marking for control of traffic during construction, the markings may include both standard and abbreviated markings as defined below:

1. Standard Pavement Markings - Standard markings placed in conformance with the requirements of the Texas MUTCD. Such markings should be placed on all roadways open to traffic during construction, including new pavement, resurfacing, detours or other roadways where construction activities may have covered or obliterated existing markings. Standard markings should be placed as soon as possible and practical. When it is not practical or possible to place standard markings at the end of each day's work, abbreviated markings may be utilized for short periods until standard markings can be placed.

2. Abbreviated Pavement Markings - Abbreviated pavement markings are shorter in length than standard markings. The length and spacing of these markings shall be as specified elsewhere in the plans or specifications. Abbreviated pavement markings may be used to delineate lane continuity only until such time as standard markings can be placed. They are not intended to substitute for standard markings for periods greater than two (2) weeks. To separate traffic flows in opposing directions, the pavement markings shall be yellow. White pavement markings shall be used to delineate the separation of traffic flows in the same direction.

When abbreviated pavement markings are used, a DO NOT PASS sign shall be used to mark the beginning of the section where passing is to be prohibited and a PASS WITH CARE sign shall be used to mark the beginning of a section where passing is permitted.

REMOVAL OF PAVEMENT MARKINGS

Removal of Pavement Markings - includes centerline, barrier lines, lane lines, edge lines, and raised pavement markings.

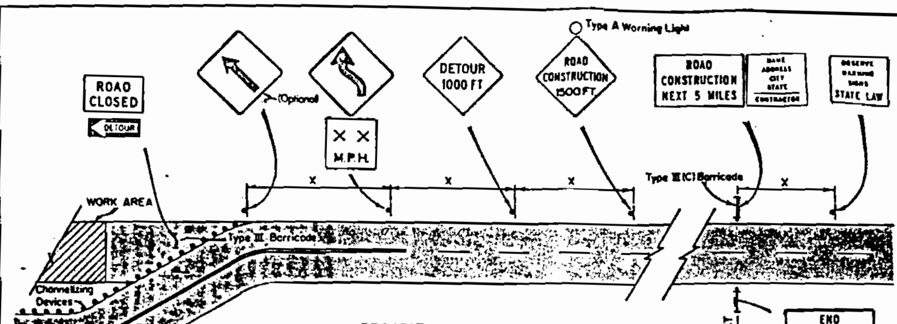
Immediately upon opening a detour to traffic, any pavement markings on the existing original roadway in the detour transition area that are no longer applicable and which may create confusion or direct a motorist toward or into the closed portion of the roadway, shall be removed or obliterated. In addition, when a detour is to be discontinued any pavement markings used to transition traffic into the detour which may create confusion or direct a motorist into the discontinued detour shall likewise be removed or obliterated. The above shall not apply to detours of a short time duration of a few hours where flagmen or sufficient channelizing devices are used to outline the detour route and the detour is not to be maintained overnight.

The removal of pavement markings shall be an integral part of establishing the detour. Detours shall be planned and scheduled well enough in advance to allow adequate time to complete all phases of the operation prior to darkness. If inclement weather or darkness becomes a factor, it will be the contractors decision to continue with the detour operation or retain the existing travelway open to traffic when any or all of the requirements of the detour cannot be accomplished.

Pavement markings shall be removed to the fullest extent possible, so as not to leave a discernible marking, by any method that does not materially damage the surface or texture of the pavement. Subject to the approval of the Engineer, any method that proves to be successful on a particular type pavement may be used. Sandblasting may be used but will not be required unless specifically shown in the plans. Over-painting of the marking will not be permitted. Removal of raised pavement markings shall be as directed by the Engineer.

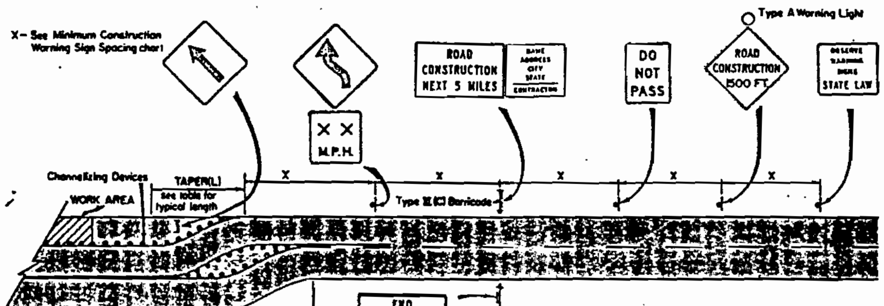
Where mechanical means of marking removal have been employed to completely remove the marking and its reflectivity, paint of a color matching the pavement surface or used crankcase oil may be employed if necessary as a means of covering contrasting pavement texture. Nighttime inspections are needed to verify the continued effectiveness of the change.

Pavement markings to be removed shall be as shown in the plans or as directed by the Engineer. Removal of pavement markings will be considered subsidiary to the item BARRICADES, SIGNS AND TRAFFIC HANDLING. Any sandblasting required by the plans for marking removal shall be measured and paid for as a bid item in the contract.



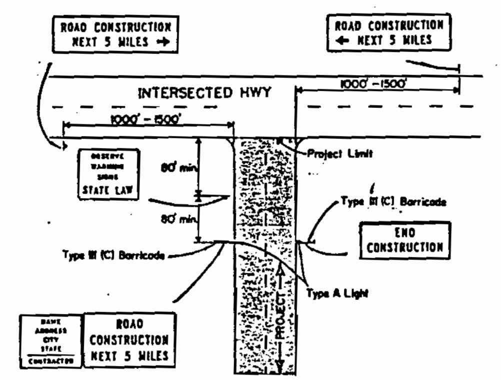
PROJECT LIMITS AWAY FROM WORK AREA

(Greater than 2000ft. between project limits and work area)



PROJECT LIMITS ADJACENT TO WORK AREA

(Less than 2000ft. between project limits and work area)



PROJECT LIMITS AT T-INTERSECTION

SPECIAL NOTES

1. The ROAD CONSTRUCTION NEXT X MILES (← OR →) sign should be erected on the intersected highway as detailed above.

2. On the intersected highway, additional traffic control devices, such as a flagman and accompanying signs or other signs, should be used when work is being performed at or near the intersection.

Project Limit Traffic Control Devices

GENERAL NOTES

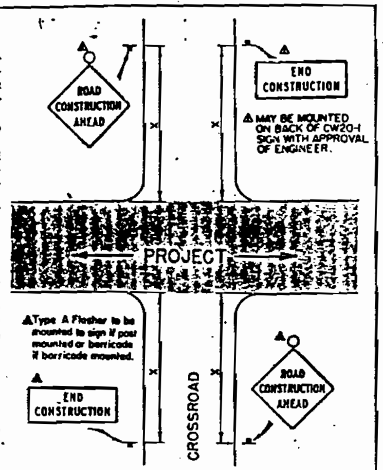
1. As detailed above and on sheet BC(2), the ROAD CONSTRUCTION NEXT X MILES, CONTRACTOR NAME and END CONSTRUCTION signs shall be erected on Type III(C) Barricades at or near the project limits and the OBSERVE WARNING SIGNS STATE LAW sign shall be erected in advance of the Type III(C) Barricades.
2. Appropriate standard traffic control devices shall be used within the project limits to adequately warn, advise, control and guide traffic around and/or through all areas of work activity, detours and other such hazardous locations.
3. As a general rule, additional traffic control devices in advance of the project limits should only be used in those cases where a work area, a detour, or a hazardous location is less than 2,000 feet inside of the project limits.
4. Duplicate construction warning signs should be erected on the median side of divided highways where median width will permit and traffic density justifies the signing.
5. Except for devices required by Note 1, traffic control devices should be in place only while work is actually in progress or a definite need exists such as for detours and hazards, otherwise, they should be removed or covered.
6. The traffic control devices used in the above illustrations are examples only. Field conditions should dictate the most appropriate traffic control devices to be used within a construction project.

CROSSROAD SIGNING AND BARRICADING

Except as noted below or elsewhere in the plans, the minimum signing on a crossroad approach should be one CW20-1 ROAD CONSTRUCTION AHEAD sign with a Type A Warning Light when work is actually in progress or a hazard exists in the vicinity of the intersection. Where speeds and volumes are relatively low the MCW 20 may be used, provided that a minimum letter size of 5 inches can be accommodated on this size with the appropriate legend. Additional signs such as FLAGMAN AHEAD, LOOSE GRAVEL, or other appropriate signs may be required; and when required, such signs will be considered part of the minimum requirements. When Type III Barricades are used on the project roadway, where practical, it is desirable that they be placed 30 feet or more from the crossroad.

EXCEPTIONS - TO BE NOTED ELSEWHERE IN THE PLANS

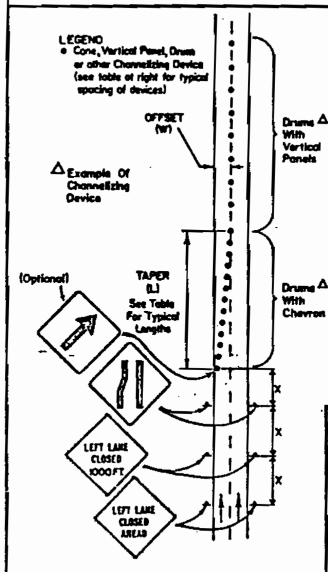
1. On higher volume crossroads or where major construction in the intersection area may require more than normal warning, more signing and barricading than the minimum specified above may be required. In some cases the Type III (C) Barricade plan along with the advance signing may be required during all or certain sequences of the work. However, unless the need for additional signs and/or barricades is noted elsewhere in the plans, the minimum requirements specified above will prevail.
2. On low volume crossroads the minimum signing required above may be omitted or modified if exceptions are noted elsewhere in the plans.
3. The G20-1c may be required on major crossroads to advise motorists of the length of construction in either direction from the intersection.



MINIMUM CONSTRUCTION WARNING SIGN SPACING*

POSTED SPEED OR 85% SPEED	30 or less	35	40	45	50	55
X MINIMUM DISTANCE (FT.)	80	120	160	240	320	500

For roads with a 55 MPH posted speed limit, advance warning signs should be placed approximately 1,500 feet in advance of the condition to which they are calling attention. Where a series of advance warning signs are used, the warning sign nearest the work site should be placed approximately 500 feet from the point of restriction with the additional signs at approximately 500-1000 foot intervals.



TYPICAL TRANSITION FOR SHORT DURATION LANE CLOSURE

For Long Duration Lane Closure, Pavement Markings In The Transition Area Shall Be Removed.

TYPICAL TRANSITION LENGTHS AND SUGGESTED MAXIMUM SPACING OF CHANNELIZING DEVICES

Posted Speed*	Formula	Minimum Desirable Taper Lengths ** 10' Offset	11' Offset	12' Offset	Suggested Maximum Spacing of Device On a Taper	On a Tangent
30	$L = \frac{WS^2}{60}$	150'	165'	180'	30'	60'-75'
35		205'	225'	245'	35'	70'-90'
40		265'	295'	320'	40'	80'-100'
45	L=WS	450'	495'	540'	45'	90'-110'
50		500'	550'	600'	50'	100'-125'
55		550'	605'	660'	55'	110'-140'
60		600'	660'	720'	60'	120'-150'

*85th Percentile Speed may be used on roads where traffic speeds normally exceed the posted speed limit.

**Taper lengths have been rounded off.

L=Length of Taper (FT.) W=Width of Offset (FT.) S=Posted Speed (MPH)

STATE DEPARTMENT OF HIGHWAYS AND PUBLIC TRANSPORTATION

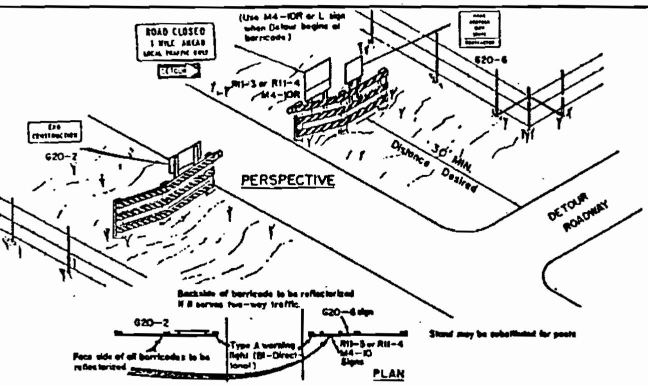
BARRICADE AND CONSTRUCTION STANDARDS

ADVANCE SIGNING
CROSSROAD SIGNING
PAVEMENT MARKINGS

BC(1)-82

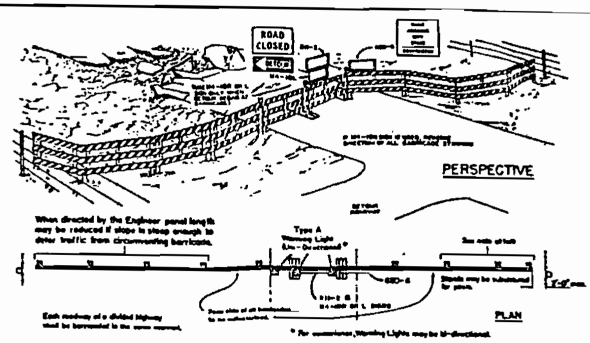
2-82

6



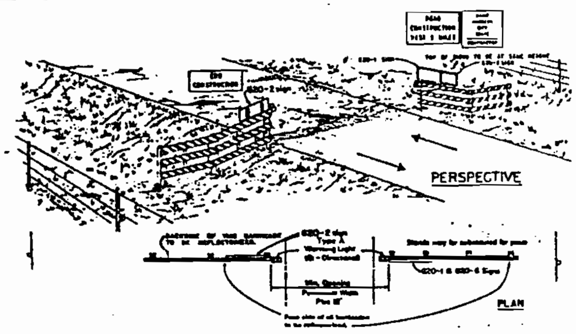
TYPE III (A) BARRICADE

1. The plan shown above is to be used when local traffic is permitted inside project or permitted to use the road beyond the intersection with the temporary route. Other signs and barricades (Type I, II or III) may be required inside the project limits based upon the contractor's sequence of work and other conditions.
2. Where conditions will permit, minimum length of barricade on each side of roadway should be 12 feet.
3. First barricade panel on each side of roadway should be approximately level. Additional panels, if needed, may follow contour of right-of-way.
4. Advance signing, including construction warning signs, and detour signing shall be as specified elsewhere in the plans.



TYPE III(B) BARRICADE

1. The plan shown above is to be used when no local traffic is permitted inside the project. Contractor may locate his access gate anywhere in barricade except at center of roadway where R11-2 and M4-10 signs must be mounted on fixed barricade section.
2. Advance signing, including construction warning signs, and detour signing shall be as specified elsewhere in the plans.



TYPE III(C) BARRICADE FOR TWO WAY UNDIVIDED ROADWAY

GENERAL NOTES FOR TYPES I, II & III BARRICADES

Type I or II Barricades (see Sheet BC(3)) are for temporary use to control traffic within the limits of a project whenever it is necessary to confine traffic to a specific area because of some particular construction operation. Type I Barricades would normally be used on conventional roads or urban streets and arterials. As Type II Barricades have more reflective area, they are intended for use on expressway and freeways or other high speed roadways.

Type III(A) Barricades and accompanying signs are to be used at each end of construction projects closed to all but local traffic.

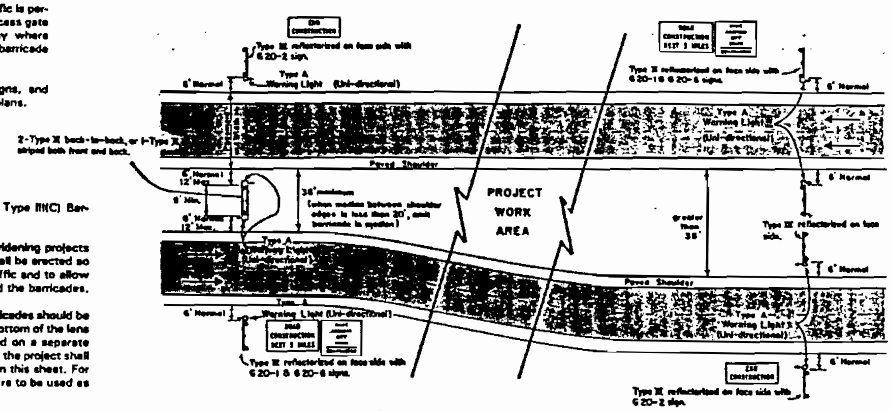
Type III(B) Barricades and accompanying signs are to be used at each end of construction projects closed to all traffic.

Type III(C) Barricades and accompanying signs are to be used at each end of construction projects where traffic is maintained through the project. Type III(C) Barricades may also be used where traffic from other highways, county roads or city streets is permitted to enter the project area. Typical signing for Type III(C) Barricades in shown on Sheet BC(1).

Type III(D) Barricades are to be used on culvert widening projects where traffic is routed over the structure. They shall be erected so as to provide the maximum roadway width for traffic and to allow sufficient space for construction operations behind the barricades.

Warning Lights placed on Type III(A), (B) or (C) barricades should be mounted at a minimum height of 36 inches to the bottom of the lens and may be attached to the barricade or mounted on a separate channelizing device. Barricades used at each end of the project shall be supplemented with warning lights as detailed on this sheet. For all other barricades, used at night, warning lights are to be used as detailed on Sheet BC(3).

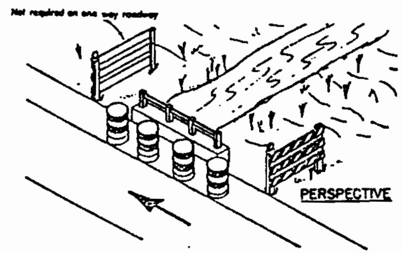
For dimensions of barricade panels see Sheet BC(3).

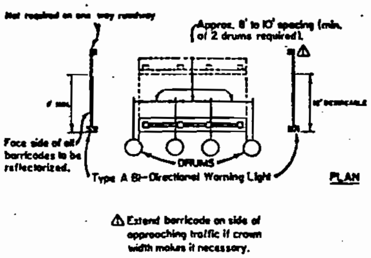


TYPE III(C) BARRICADE FOR DIVIDED HIGHWAYS

NOTES FOR TYPE III (C) BARRICADES

1. The plans shown above are to be used when all traffic is maintained through the project. The signs shown apply to the first and last barricades of a project. Other signs and barricades (Types I, II or III) will be required inside the project limits based upon the contractor's sequence of work and other conditions.
2. Where conditions will permit, minimum length of barricade on each side of roadway should be 12 feet except as noted.
3. First barricade panel on each side of roadway should be approximate level. Additional panels, if needed, may follow contour of right-of-way.





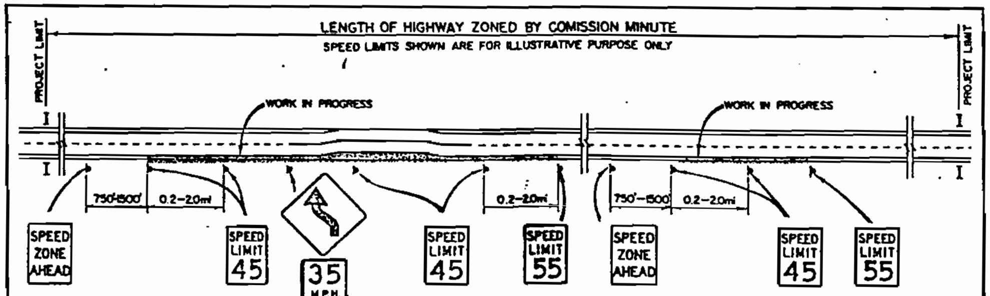
Extend barricade on side of approaching traffic if crown width makes it necessary.

TYPE III (D) BARRICADE

FOR CULVERT WIDENING SITE WITHIN THE PROJECT LIMITS

NOTES:

1. Where positive redirectional capability is provided, drums and barricades may be omitted.
2. On streets or roads with posted speeds of 35 MPH or less, Type III Barricades may be used in lieu of barrels where necessary for pedestrian safety.



TYPICAL APPLICATION OF SPEED ZONE SIGNS

NOTES

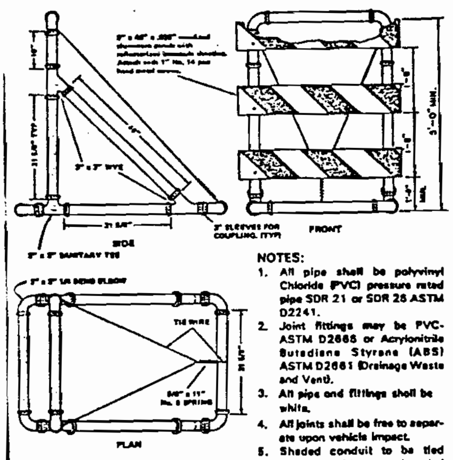
- Frequency of speed limit signs should be every 0.2 to 2.0 miles for speeds 40 MPH and above and 0.2 to 1.0 miles for speeds 35 MPH and below.
- Reduce speeds when required should only be posted in the vicinity of work being performed or other areas when needed rather than throughout the entire project.
- SPEED ZONE SIGNS ARE ILLUSTRATED FOR ONE DIRECTION OF TRAVEL ONLY AND ARE NORMALLY POSTED FOR EACH DIRECTION OF TRAVEL
- REGULATORY CLASS SPEED ZONE SIGNS SHALL HAVE BLACK LEGEND ON A WHITE REFLECTIVE BACKGROUND

STATE DEPARTMENT OF HIGHWAYS AND PUBLIC TRANSPORTATION

BARRICADE AND CONSTRUCTION STANDARDS

BARRICADES
SPEED ZONING

BC(2)-82



NOTES:

1. All pipe shall be polyvinyl Chloride (PVC) pressure rated pipe SDR 21 or SDR 26 ASTM D2241.
2. Joint fittings may be PVC-ASTM D2666 or Acrylonitrile Butadiene Styrene (ABS) ASTM D2661 (Drainage Waste and Vent).
3. All pipe and fittings shall be white.
4. All joints shall be free to separate upon vehicle impact.
5. Shaded conduit to be tied together with rope threaded into pipe interior. Use 3/16" No. 8 solid braided nylon or equivalent.
6. A fixed frangible pavement connection is preferred. Sand Bags may be substituted.

OPTIONAL
TYPE III PVC BARRICADES
TYPICAL DESIGN DETAILS

May be used at the option of the Contractor

STRIPING FOR BARRICADE

Where a barricade extends entirely across a roadway, it is desirable that the stripes slope downward in the direction toward which traffic must turn in detouring. When both right and left turns are provided for, the chevron striping may slope downward in both directions from the center of the barricade.

Striping should cover the full width of the rail. Striping of rails, panels and gates for the right side of the roadway is shown above. For the left side of the roadway, striping should slope downward to the right.

For all types of barricades with rails less than 3'-0" long, stripes 4" wide shall be used.

The 8" rail width is a nominal dimension for rails made of lumber.

Identification markings may be shown only on back side of barricade rails.

BARRICADE DETAILS

All lumber sizes are nominal dimensions
Fabrication Details - ± 1/2"

BARRICADE NOTES

Channelizing devices other than barricades should normally be used for channelization purposes.

Barricades should normally be placed perpendicular to the traffic flow. Other channelizing devices, such as drums, vertical panels or portable barriers, should be used where needed to separate traffic from the work area. In all cases, the barricades should be so located as to most advantageously warn and direct traffic.

Barricades may be designed and constructed from wood, PVC pipe or any other suitable material in a manner approved by the Engineer. The construction details shown hereon are typical and are suggested details for wood and PVC pipe support systems for barricades. The details of rail width and striping, number and spacing of rails, minimum length and height (above pavement) of rails must be adhered to when alternate designs are used.

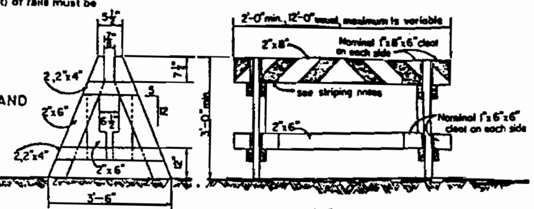
When signs are placed on barricades, a maximum number of 2 signs should be visable to the motorist.

Barricades are to be constructed in a first-class workmanship manner of clean sound material. All surfaces above ground, which are not striped, shall be white except the unpainted galvanized metal or aluminum components may be used. Components made of lumber shall be painted with a minimum of two coats of an approved brand of white paint to secure thorough coverage and a uniform white color.

The Contractor shall maintain each barricade in a clean and good condition.

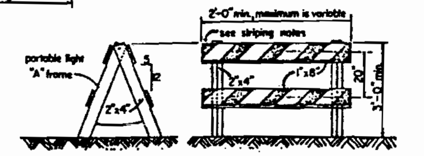
Barricades shall be removed upon completion of the work and/or the elimination of the hazard on any section.

TYPE I BARRICADE



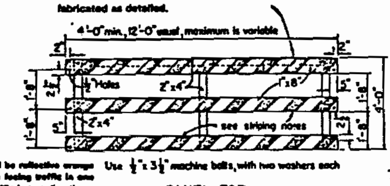
For Type I Barricades, both sides of the top rail shall have reflective orange and reflective white striping.

TYPE II BARRICADE



For Type II Barricades, all four (4) rail faces shall have reflective orange and reflective white striping.

When Wood Barricades are used and when orange and white stripes are required on the backside, a 2" x 8" rail may be used in lieu of the 1" x 8" rail and 2" x 4" stiffener. Otherwise the rail should be fabricated as detailed.

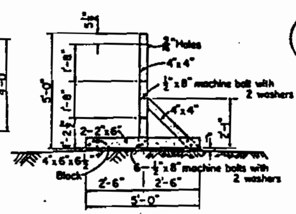


TYPE III BARRICADE

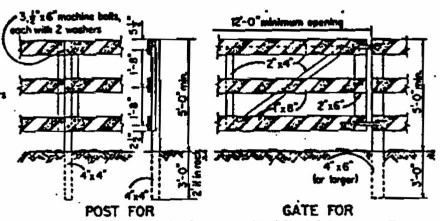
For Type III Barricades, the three (3) rails shall be reflective orange and reflective white stripes on one side if it is facing traffic in one direction only, and on both sides if it serves traffic in two directions. See Barricade Layouts on Sheet BC (2).

Use $\frac{1}{2}$"x$3\frac{1}{2}$" machine bolts, with two washers each

PANEL FOR
TYPE III BARRICADE

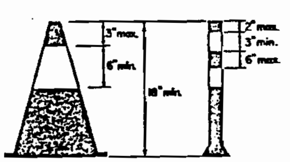


STAND FOR TYPE III BARRICADE



POST FOR
TYPE III BARRICADE

GATE FOR
TYPE III BARRICADE



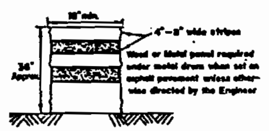
CONES

Traffic cones and tubular markers shall be a minimum of 18 inches in height with a broadened base and may be made of various materials to withstand impact without damage to themselves or to vehicles. Larger sizes should be used on freeways and other roadways where speeds are relatively high or wherever more conspicuous guidance is needed. Orange shall be the predominant color on cones and tubular markers. They should be kept clean and bright for maximum target value. For nighttime use they shall be reflectorized or equipped with lighting devices for maximum visibility. Reflectorized material shall have a smooth, sealed outer surface which will display the same approximate color day and night.

Reflectorization of tubular markers shall be a minimum of two three-inch bands placed a maximum of 2" from the top with a maximum of 6" between the bands. Reflectorization of cones shall be provided by a minimum 6" band placed a maximum of 3" from the top.

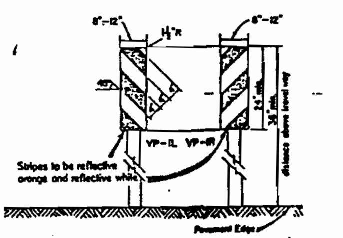
Cones or tubular markers are generally only suitable for temporary usage (up to 6 hours) with other channelization devices such as vertical panels or barricades preferred for longer term usage. Care should be taken to insure that they remain in their proper location and in an upright position.

DRUMS



Drums, set on end, and used for traffic warning or channelization shall be approximately 36" in height and minimum of 18" in diameter. The contractor, at his option, may use drums made from steel barrels or black polyethylene plastic drum liners weighing approximately eight pounds each. The markings on drums shall be horizontal, circumferential, reflectorized orange and reflectorized white stripes, 4 to 8 inches wide. The first reflectorized stripe should start within two (2) inches of the top of the drum. There shall be at least two orange and two white stripes on each drum. If there are non-reflectorized spaces between the horizontal orange and white stripes, they shall be no more than 2 inches wide. Metal drums shall be painted black or orange before reflectorized stripes are added. All drums on a project will be the same color. When drums are placed in the roadway, appropriate warning signs should be used. During hours of darkness, a flashing warning light should be placed on drums used singly as a warning device. Steady burn electric lights or delineators should be placed on drums used in series for traffic channelization. Drums should not be weighted with sand, water or other material to the extent that it would make the drums dangerous to motorists.

CW1-8 CHEVRON signs, CW1-8A ARROW signs or VP-1 Vertical Panels mounted above drums may be used as supplements to drum delineation.

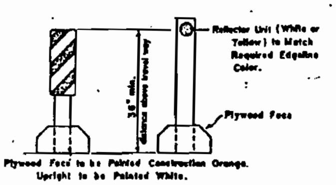


VERTICAL PANELS (VP)

Vertical Panels are normally used as channelizing devices to indicate tangent or nearly tangent roadway alignment where good target value of a device is needed in daytime as well as the nighttime. In addition, vertical panels should be used at the edge of shoulder drop-offs and other areas such as lane transitions where positive day and night delineation may be required. Vertical panels should be mounted back to back if used at the edge of cuts adjacent to two-way two lane roadways. Stripes should always slope downward toward the traveled way.

CHANNELIZING DEVICES

The Type or Types of Channelizing Devices used are to be as specified by the Engineer.



TYPICAL PORTABLE VERTICAL PANEL OR DELINEATOR

Other similar supports may be used when approved or directed by the Engineer.

GENERAL NOTES

REFLECTORIZATION

The reflectorized white and reflectorized orange stripes for barricades, drums and vertical panels shall be constructed of retroreflective sheeting in conformance with project specifications and shall be maintained to meet the appearance, color, and reflectivity requirements of those specifications.

WARNING LIGHTS

Warning lights are portable lens directed, enclosed lights. The color of the light emitted shall be yellow. The lights should be mounted at a minimum height of 36 inches to the bottom of the lens.

Type A-Low Intensity Flashing Warning Lights are commonly mounted on barricades, other channelization devices or advance warning signs and are intended to warn the driver that he is approaching a hazardous area. Their use shall be as specified elsewhere in the plans, on Sheets BC(1) and BC(2), or as directed by the Engineer.

Type B High Intensity Flashing Warning Lights are normally used near approaching extremely hazardous site conditions within the construction area. They may be mounted on barricades, signs or other supports. As these lights are effective in daylight as well as dark, they are designed to operate 24 hours per day. Their use should be specified else-where in the plans or as directed by the Engineer. Flashing warning lights shall not be used in a series.

Type C Steady Burn Lights are intended to be used in a series for delineation to supplement other traffic control devices used to delineate the edge of the traveled way on detour curves, lane changes, lane closures, shoulder drop-offs and other similar conditions or hazards. The series of Steady Burn Lights should have a Type B High Intensity Flashing Warning Light at the beginning and end of the series to mark the hazard. Where Steady Burn Lights are to be used for delineation, the contractor may at his option, utilize delineators.

Contractors shall furnish a copy of a certification from the manufacturer of the lights that the warning lights meet the requirements of the ITE Standard For Flashing and Steady Burn Warning Lights as contained in the latest edition of the "Texas Manual on Uniform Traffic Control Devices for Streets and Highways."

DELINEATORS

Delineators are normally used to indicate roadway alignment where improved nighttime visibility is needed but other roadway features are sufficient for daytime alignment. They should generally be used on high fills and horizontal and vertical curves where only nighttime delineation is needed. Delineators, when required for temporary use to control traffic through construction areas, will be considered subsidiary to the Item BARRICADES, SIGNS AND TRAFFIC HANDLING. Delineators shall meet the material requirements of the project specifications. When used, delineators on the right side of the roadway facing traffic shall be white. The color of delineators used along the left edge of divided streets and highways and one-way roadways shall be yellow.

SPACING OF DELINEATORS

Spacing of Delineators on curves should be according to the Table below. Spacing of delineators on tangent sections should normally be between 100 and 200 feet with the closer spacing for lower speeds and greater spacing for higher speeds.

RADIUS OF CURVE (FEET)	50	150	200	250	300	400	500	600	700	800	900	1000
APPROX. SPACING ON CURVE (FEET)	20	30	35	40	50	55	65	70	75	80	85	90

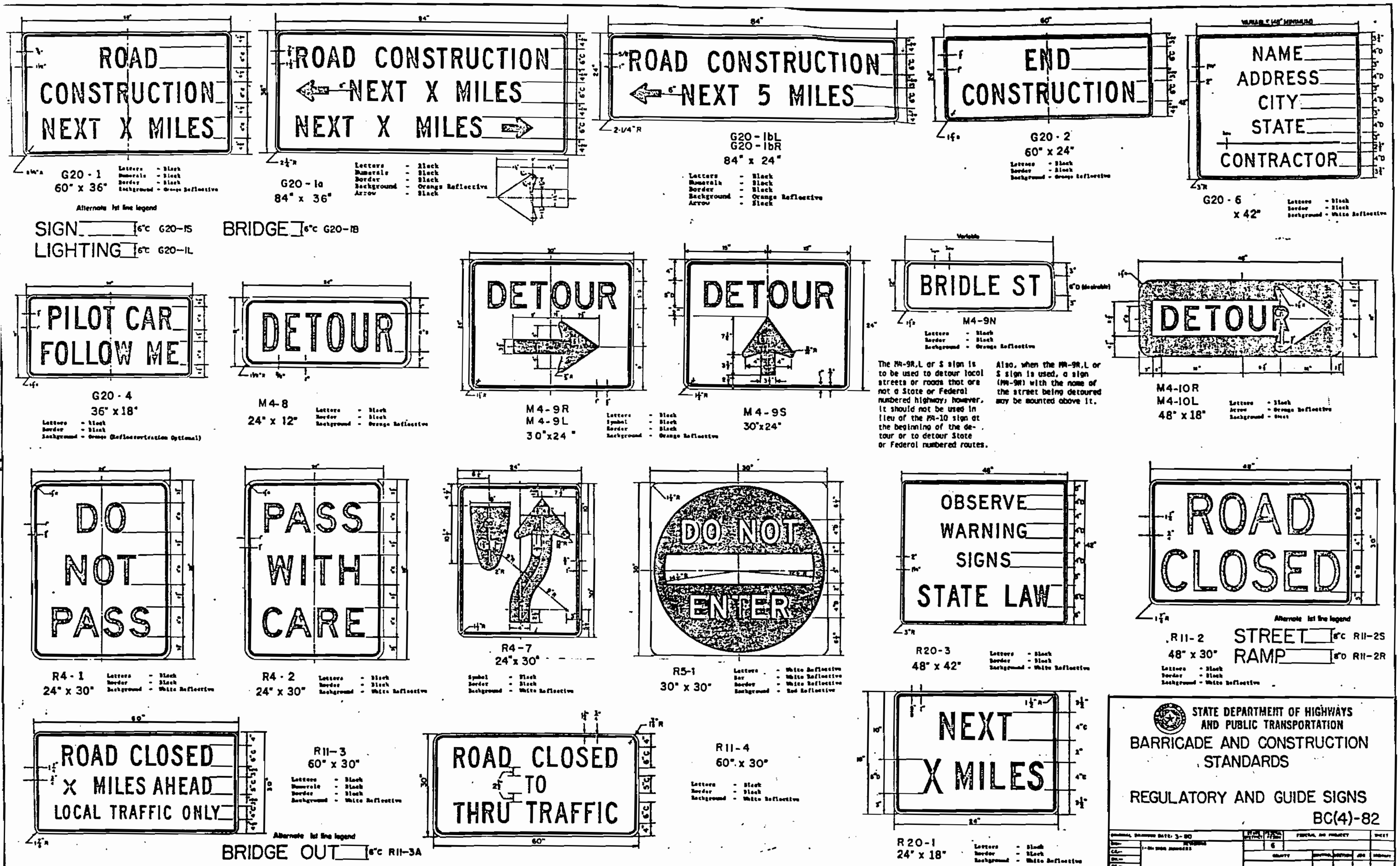
STATE DEPARTMENT OF HIGHWAYS
AND PUBLIC TRANSPORTATION

BARRICADE AND CONSTRUCTION STANDARDS

BARRICADE DETAILS
DELINEATORS & VERTICAL PANELS
DRUMS & CONES
REFLECTORIZATION
WARNING LIGHTS

BC(3)-82

ORIGINAL DRAWING DATE: 3-80	REVISED	STATE DISTRICT	FEDERAL REGION	FEDERAL AID PROJECT	SHEET
	2-82	6			



STATE DEPARTMENT OF HIGHWAYS AND PUBLIC TRANSPORTATION

BARRICADE AND CONSTRUCTION STANDARDS

REGULATORY AND GUIDE SIGNS

BC(4)-82

CONSTRUCTION SIGN NOTES

Construction signs shall be made from wood or metal. The designation of metal and wood as primary materials for signs shall not be interpreted to exclude other suitable rigid materials now or hereafter available.

Wood for signs shall be waterproof resinbonded exterior grade plywood, Douglas Fir Plywood Association, or equal, of minimum 1/2 inch thickness. All wood signs made up of 2 or more pieces shall have one or more cleats, 1/2 inch by 8 inch plywood fastened to the back of the sign and extending fully across the sign. On plywood signs cleats shall be used as splice plates running the length of the joints. In localities where untreated wood rots rapidly, it is recommended that wood used for signs be treated either with chromated zinc chloride, Wolman salts, or pentachlorophenol.

Aluminum sign blanks shall have a minimum thickness of 0.080". Steel sign blanks shall have a minimum thickness of 14 gauge.

On secondary roads or city streets where speeds are low, smaller size construction warning signs may be used with the approval of the Engineer and if the sign size is in accordance with the "Typical Construction Warning Sign Size and Spacing Chart" shown on page 6B-2.2 of the Texas MUTCD.

Reflectorized signs shall be constructed of retro-reflective sheeting and shall be maintained to meet the requirements for appearance, color and retro-reflectivity of the project specifications. Signs shall comply with the general requirements specified in the "Standard Specifications for Construction of Highways, Streets and Bridges" in effect at the time of contract award.

All sign lettering shall be clear, open rounded type capital letters as approved by the National Committee on Uniform Traffic Control Devices and its sponsoring agencies, and as published by the Federal Highway Administration. Signs and lettering shall be of first class workmanship equivalent to that of the Department's standard signs.

Standard signs shall be used as required by Sheets BC(1) thru BC(7), the plans, or as directed by the Engineer to regulate, warn, and guide traffic. All sign erection and usage shall be in strict accordance with the "Texas Manual on Uniform Traffic Control Devices for Streets and Highways." The Contractor shall maintain each sign in a clean and good condition.

Signs shall be removed upon completion of the work.

Signs may be erected on portable, temporary, or fixed supports, for use on construction projects to warn or guide the traffic through and/or around the actual construction area. However, at the end of the workday if the signs do not warn or regulate traffic relative to night time roadway conditions or whenever the specific danger of which the particular sign warns has ceased to exist, the signs shall be either removed, turned away from the view of any traffic or covered. When signs are turned away from the view of any traffic the sign shall not be turned 90° to the direction of traffic and on two-way roadways or expressways or freeways with medians less than 12' (when the sign is installed in the median area) the sign shall not be turned 180° to the direction of traffic. When signs are covered the material used shall be opaque such as heavy mill black plastic. Burlap shall not be used to cover signs.

Signs erected on portable supports for use on construction projects normally mean signs which are used during the day to warn or guide traffic through and/or around the actual construction area, but at the end of the workday such signs are either removed or turned away from the view of traffic. Portable supports shall be as shown on this sheet or as approved by the Engineer. The bottom of the sign shall be a minimum of one (1) foot above the pavement edge. Signs required for nighttime usage should not normally be mounted on portable supports, except when approved by the Engineer.

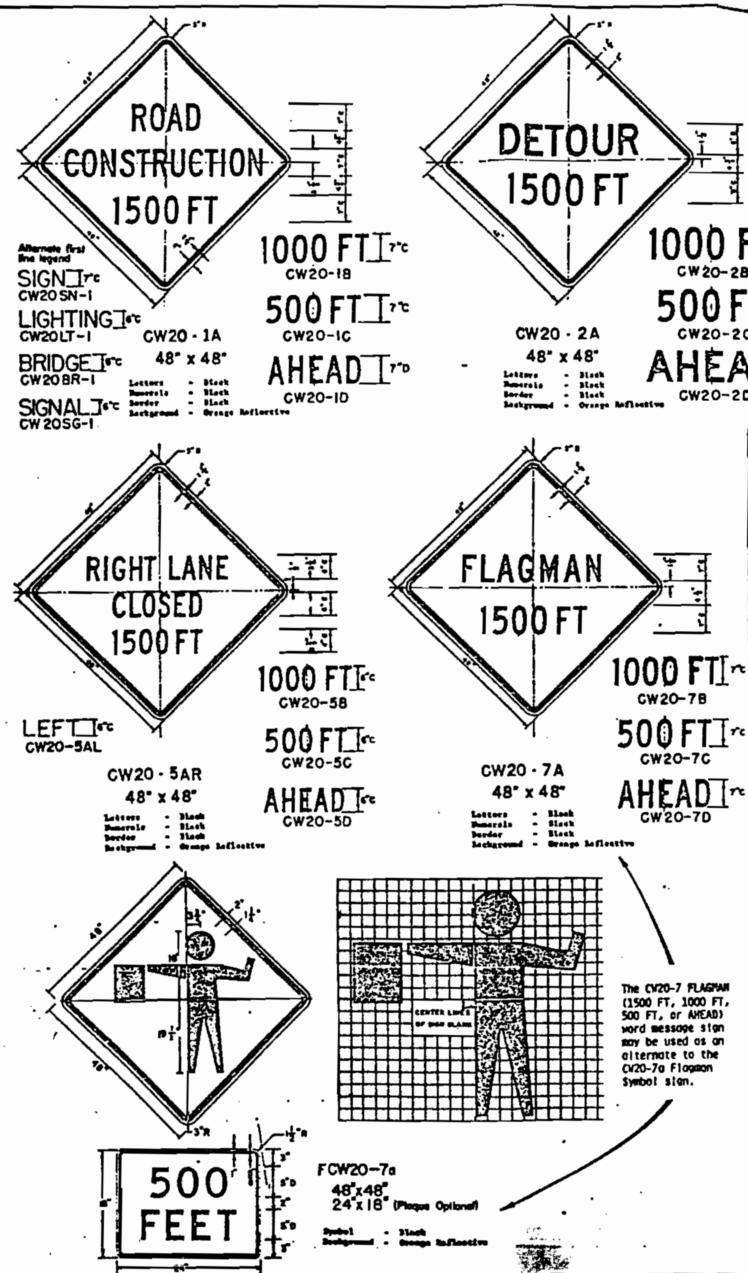
Signs erected on fixed supports for use on construction projects normally mean signs that are to remain in place for both day and night usage to regulate, warn and guide traffic in advance of and within the limits of the project including the crossroad approaches. However, under certain conditions, such as where a sign may be required for a few days duration and then is no longer needed or where a sign is moved from location to location every few days or where it is not practical or desirable to provide a fixed mounting, such signs may be erected on a temporary type of support. Temporary supports shall be as shown on this sheet or as approved by the Engineer. Signs erected on temporary supports should be at a minimum height of 3 feet. Signs erected on fixed supports should be at a minimum height of five (5) feet in rural areas and seven (7) feet in urban areas and other rural locations where sight distance obstructions are present. Regardless of the type of support used, regulatory signs should not be erected at height less than the 5 or 7 foot minimum specified above unless a lower height is approved by the Engineer. Posts for fixed supports should be set in the ground without concrete footings.

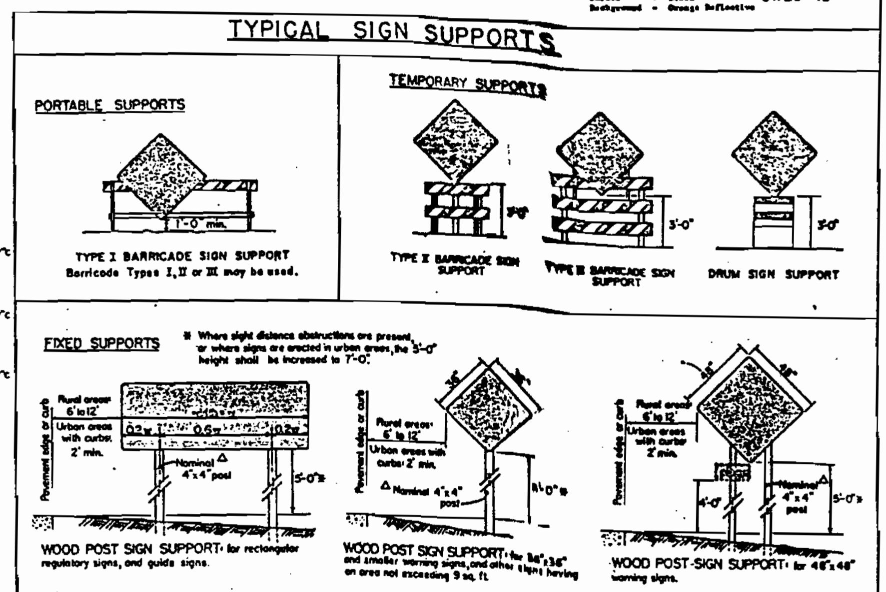
Wood sign post supports shall be painted white.

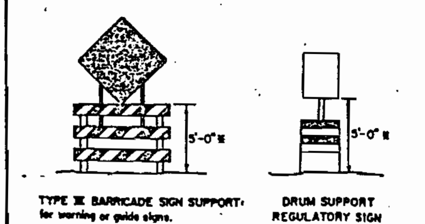
Where portable or temporary supports require the use of weights to keep a sign or barricade from turning over, the use of some type of sandbag is recommended. The use of pieces of concrete, rocks, iron, steel or other solid objects will not be permitted.

All traffic control devices shall conform with the "Texas Manual on Uniform Traffic Control Devices for Streets and Highways."

Contractors may use either the sign designs shown on sheets BC-(4), BC-(5), BC-(6) and BC-(7) or those sign designs shown in the U.S. Department of Transportation's latest edition of "Standard Highway Signs" when the required sign is illustrated in the "Standard Highway Signs" book. All construction type signs provided for in "PART VI" of the Texas MUTCD, but not detailed in the plans, may be used when so directed by the Engineer.







Δ other types of sign supports may be used with approval of the Engineer.

STATE DEPARTMENT OF HIGHWAYS AND PUBLIC TRANSPORTATION

BARRICADE AND CONSTRUCTION STANDARDS

APPROACH WARNING SIGNS
TYPICAL SIGN SUPPORTS

BC(5)-82

STATE DISTRICT	FEDERAL REGION	FEDERAL AID PROJECT	SHEET
	6		

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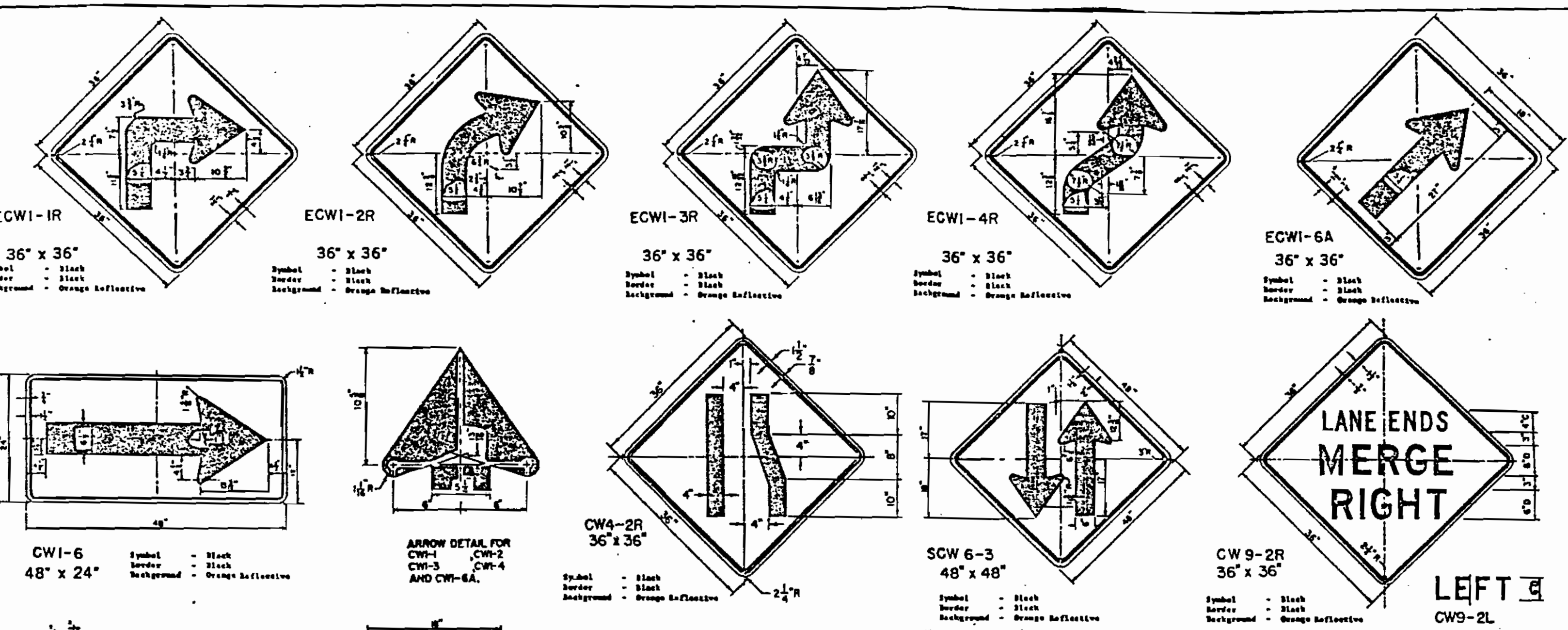
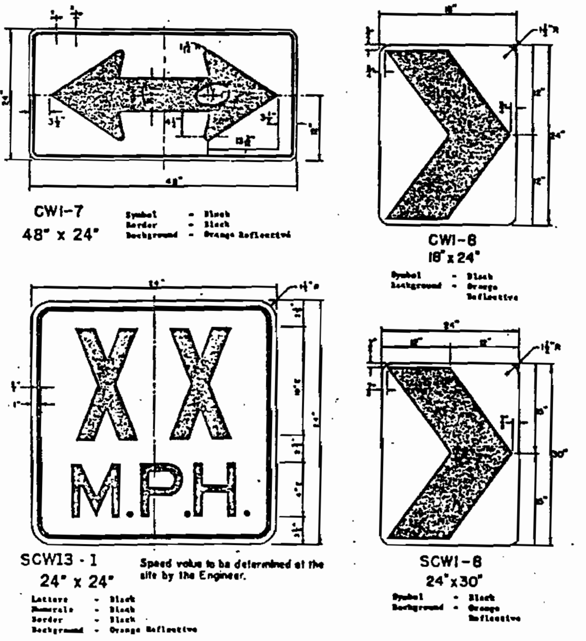
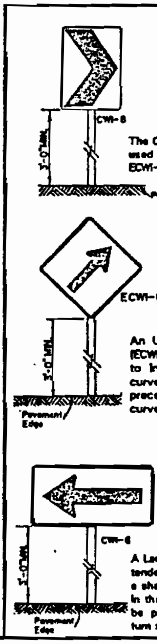


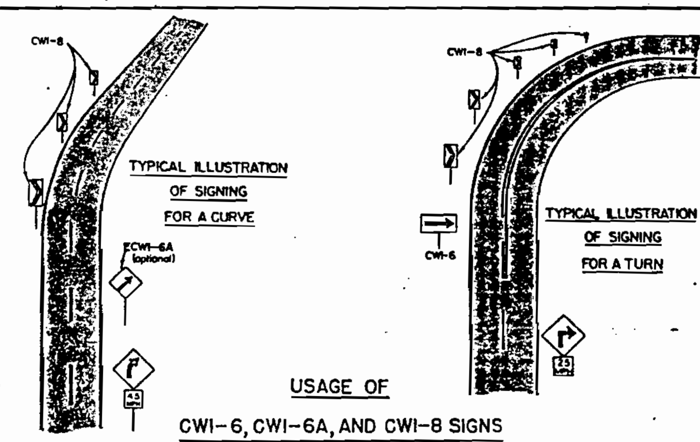




The Chevron sign (CW1-8) may be used to supplement the CW1-6 or ECW1-6A sign.

An Upward Sloping Arrow sign (ECW1-6A) is intended to be used to indicate the beginning of a curve or transition. It should be preceded with an appropriate curve sign when needed.

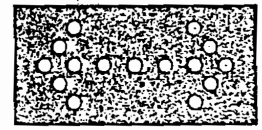
A Large Arrow sign (CW1-8) is intended to be used to give notice of a sharp change in alignment (turn) in the direction of travel. It should be preceded with an appropriate turn sign.



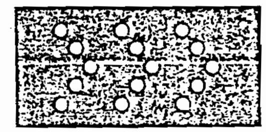
USAGE OF
CW1-6, CW1-6A, AND CW1-8 SIGNS

NOTES:

- CW1-6, ECW1-6A & CW1-8 Signs may be mounted on temporary supports.
- Chavron Alignment signs, when used, are erected on the outside of a curve, sharp turn or on the far side of an intersection, in line with and at right angles to approaching traffic. Spacing of the signs should be such that two are visible throughout the change in horizontal alignment.
- For two-way traffic, use same arrangement of signs on outside of curve for each direction of travel.
- Appropriate Advance Warning Turn or Curve sign with Advisory Speed plaque should be used when needed.



FLASHING ARROW PANEL



SEQUENCING ARROW PANEL

ADVANCE WARNING FLASHING OR SEQUENCING ARROW PANELS

The Advance Warning Flashing Arrow and Sequencing Arrow Panels are intended to supplement existing traffic control devices. They provide additional advance warning and directional information to assist in diverting and controlling traffic around construction or maintenance activities being conducted on or adjacent to the traveled way.

The Advance Warning Arrow Panel may be used for day or night closures, slow moving maintenance or construction activities on the traveled way, or extremely hazardous high density and speed conditions.

Necessary signs, barricades or other traffic control devices should be used in conjunction with the Advance Warning Arrow Panel.

Arrow panels should have the capability of the following mode selections: Left Arrow, Right Arrow, Left and Right Arrow and caution. The caution mode consists of four or more lamps, arranged in a pattern which will not indicate a direction.

Arrow panels shall be capable of minimum 50 percent dimming from rated lamp voltage. The flashing rate of the lamps shall not be less than 25 times per minute.

REQUIREMENTS

TYPE	MINIMUM SIZE	MINIMUM NUMBER OF PANEL LAMPS	MINIMUM VISIBILITY DISTANCE
B	30" x 54"	13	3/4 mile
C	48" x 96"	15	1 mile

The panels shall be mounted on a vehicle, trailer or other suitable support.

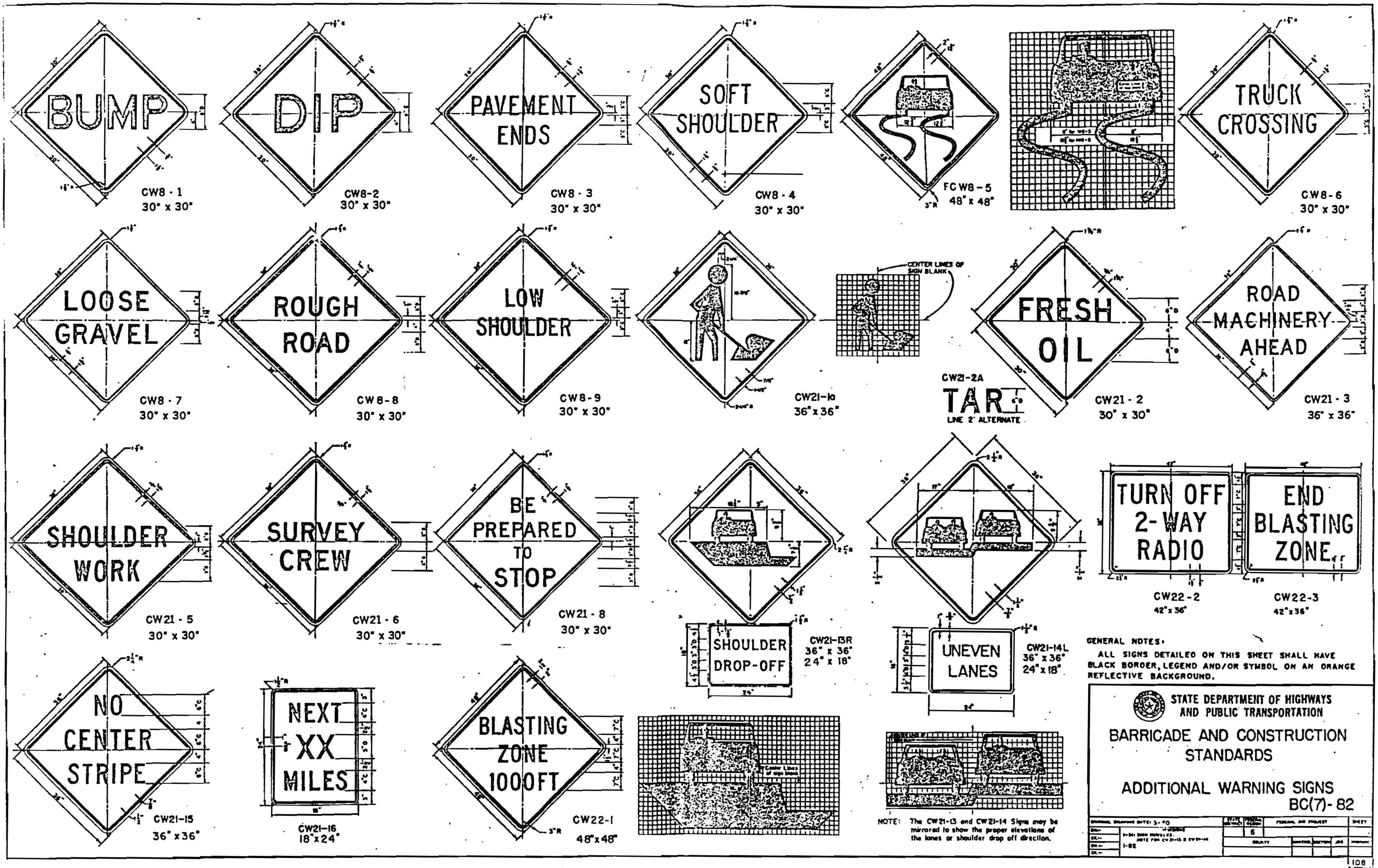
STATE DEPARTMENT OF HIGHWAYS
AND PUBLIC TRANSPORTATION

BARRICADE AND CONSTRUCTION STANDARDS

CONSTRUCTION WARNING SIGNS
ADVANCE WARNING ARROW PANELS

BC(6)-82

ORIGINAL DRAWING DATE: 3-80 | REVISIONS: 1-82 | STATE DISTRICT: 6 | FEDERAL AID PROJECT | SHEET | COUNTY | CONTROL | SECTION | JOB | HIGHWAY


BUMP
CW8 - 1
30" x 30"
DIP
CW8-2
30" x 30"
PAVEMENT ENDS
CW8 - 3
30" x 30"
SOFT SHOULDER
CW8 - 4
30" x 30"
FCW8 - 5
48" x 48"
TRUCK CROSSING
CW8 - 6
30" x 30"
LOOSE GRAVEL
CW8 - 7
30" x 30"
ROUGH ROAD
CW8-8
30" x 30"
LOW SHOULDER
CW8-9
30" x 30"
CW21-1a
36"x36"
CENTER LINES OF SIGN BLANK
CW21-2A
TAR
LINE 2' ALTERNATE
FRESH OIL
CW21 - 2
30" x 30"
ROAD MACHINERY AHEAD
CW21 - 3
36" x 36"
SHOULDER WORK
CW21 - 5
30" x 30"
SURVEY CREW
CW21 - 6
30" x 30"
BE PREPARED TO STOP
CW21 - 8
30" x 30"
TURN OFF 2-WAY RADIO
CW22-2
42"x36"
END BLASTING ZONE
CW22-3
42"x36"
SHOULDER DROP-OFF
CW21-13R
36" x 36"
24" x 18"
UNEVEN LANES
CW21-14L
36" x 36"
24" x 18"
NO CENTER STRIPE
CW21-15
36" x 36"
NEXT XX MILES
CW21-16
18"x24"
BLASTING ZONE 1000FT
CW22-1
48"x48"
NOTE: The CW21-13 and CW21-14 Signs may be mirrored to show the proper elevations of the lanes or shoulder drop off direction.
GENERAL NOTES:
ALL SIGNS DETAILED ON THIS SHEET SHALL HAVE BLACK BORDER, LEGEND AND/OR SYMBOL ON AN ORANGE REFLECTIVE BACKGROUND.
STATE DEPARTMENT OF HIGHWAYS AND PUBLIC TRANSPORTATION
BARRICADE AND CONSTRUCTION STANDARDS
ADDITIONAL WARNING SIGNS
BC(7)-82
6
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Appendix B

SPECIAL SPECIFICATION

ITEM 4685

CATHODIC BRIDGE DECK PROTECTION SYSTEM

I. JOB DESCRIPTION: Five impressed current cathodic protection systems will be installed on the U.S. 87 overpass in Big Spring, Texas in Howard County. There shall be 5 separate systems. Each system will utilize a different type of anode material. These five systems shall be further sub-divided into zones. Each zone shall be separately energized from an enclosed rectifier assembly.

A. Terms and definitions

Resident Engineer: The representative of the state who shall have the final decision in all matters concerning this job.

Contractor: The company or business that this job is awarded to.

Cathodic Protection Engineer: A professional Engineer supplied by the contractor who shall be licensed and fully accredited in the area of bridge deck cathodic protection systems. (The Cathodic Protection Engineer shall assist the Resident Engineer in all aspects of the complete cathodic protection installation).

Manufacturer: The company that manufactures the anode material used in each system.

Technical Representative: A representative chosen by each anode material manufacturer to assist in the installation of the represented material.

B. General Information

1. Material suppliers should attend the pre-letting conference at the Resident Engineer's office in Big Spring on September 16, 1987 at 10:00 a.m.

2. The contractor shall furnish, install, and put into operation five complete impressed current cathodic protection systems as described in these plans and specifications. The contractor shall have a technical representative qualified in the field of Cathodic Protection of bridge decks to supervise the installation, energizing and adjusting of the complete systems.

3. The contractor shall have a technical representative from each manufacturer of the anode materials used in traffic lanes to advise in the installation of the represented material.

4. The contractor shall coordinate installation of the cathodic protection systems with all other construction operations. Special caution and scheduling may be required to prevent damage to installed components by subsequent operations.

5. The contractor shall contact the Resident Engineer prior to installing each system.

6. The contractor shall hold a preconstruction conference with the subcontractors installing the cathodic protection systems at least seven days before the installations. The Resident Engineer, Cathodic Protection Engineer, and the cathodic protection system manufacturer's representative(s) shall be present at the conference.

7. The cathodic protection systems shall include all the materials identified in these plans and specifications. Substitutions may be made only with the written permission of the Resident Engineer.

7. The cathodic protection systems shall be of the impressed current type and shall consist of the following:

a. Direct current power supply (rectifier) with at least seventeen (17) separate voltage and current regulated outputs meeting the requirements of the plans and specifications.

b. Seventeen (17) zones of cathodic protection consisting of five different types of anode material meeting the requirements of the plans and specifications.

c. A negative ground return (cathode) wiring system connected to the reinforcing bars as described in these plans.

d. Bonding of the following to the reinforcing bars:

(1) armor joints (2) guard rail supports (3) dowel bars used to connect adjacent deck slabs (4) steel diaphrams and girder supports under or contacting a cathodically protected member (5) illumination poles, clamps, conduit, electrical enclosures, supports or metallic members in contact with a cathodically protected member.

e. Reference cells in each zone with continuous lead wires terminating at rectifier enclosure.

9. The electrical installation shall in all applicable ways conform with the National Electrical Code and all local codes.

10. The contractor shall arrange for power service and the connection to the system. The contractor shall arrange for all inspections and obtain all necessary permits.

11. The contractor shall furnish all material to the Resident Engineer for inspection and samples for testing when specified or requested. The Resident Engineer may accept material on the basis of the manufacturer's certification when testing is performed by a qualified independent laboratory. A copy of the independent laboratory report documenting the test results and testing procedures shall accompany the certification. The Engineer may accept or reject these materials on the basis of these certifications or other tests performed by or for the Department.

12. SPECIAL NOTE:

THE RESIDENT ENGINEER SHALL BE INFORMED OF ANY FUTURE SLAB WORK OR EQUIPMENT MOUNTING ON THE NEW OVERLAY SURFACE. CONCRETE CHIPPINGS, HOLE DRILLING OR CORING, DETECTOR LOOP SAWCUTTING AND OTHER SUCH OPERATIONS MUST NOT BE PERFORMED UNTIL THE ENGINEER HAS BEEN CONSULTED.

13. The Contractor shall purchase the following instruments for use by State personnel for taking measurements of the performance of the various cathodic bridge deck protection systems being installed on the bridge structures:

Portable "Three Electrode Linear Polarization Rate of Corrosion Device", complete package with single portable probe and twenty (20) permanent probes.

The device purchased shall include training for at least three personnel into the operation and use of the device and any related computer programs.

Currently the only known portable device of this type is a "3LP" unit made by Ken Clear, Inc. The permanent probes to be used with this unit are "3LP" permanent probes and must be installed according to the manufacturer's specifications. Complete package by Ken Clear, Inc. is as follows:
(1) Three Electrode Linear Polarization Device (Portable)
(2) PC-8 Pocket Computer with Printer
(3) "Corrate II" Program for use on IBM PC
(4) Single Portable Probe
(5) Permanent Probes as Required
(6) Training for Personnel

Two permanent probes shall be provided by the Contractor in each zone on the bridge deck traffic lanes. A total of twenty (20) permanent probes will be provided by the Contractor for the complete cathodic protection installation.

Two areas per zone will be provided for portable rate of corrosion measurements in zones not in the traffic lanes. These measurement areas consist of locations on the sidewalks, median and on a bent below the bridge deck.

II. Structural Integrity of Bridge

A. After scarification of the deck surface, the contractor shall verify that the concrete surface is sound. The contractor shall correct unsatisfactory conditions before continuing with the installation of the cathodic protection systems. The Resident Engineer will determine that the structure is sound and has been prepared according to specification.

B. Removal of concrete will be necessary to:

1. Expose the top and bottom (or outer and inner) rebar mats for continuity testing

2. Install reference electrodes

3. Install instrument and system negatives

4. Install rebar bonds

5. Install rebar probes

6. Install "3-LP" probes

C. The contractor shall be responsible for the physical concrete removal and bar exposure. The contractor shall ensure all exposed steel is cleaned to bare gray metal and all debris is removed from the cavities.

D. The reference electrodes, rebar probes, instrument negative and system negative installation cavity shall be located within ten (10) feet of the location marked on the drawings, or as determined by the Cathodic Protection Engineer and approved by the Resident Engineer. An existing cavity from delamination removal may be used if approved by the Cathodic Protection Engineer and Resident Engineer.

E. The contractor shall be responsible for proper repair of all concrete of the bridge structure. An anode system will not be installed until repairs have been completed on the area of installation.

III. Rebar Preparation and Connections

A. The contractor shall have the responsibility of making sure that the entire bridge structure has been made electrically continuous.

B. Following the continuity survey and before any anode materials are installed, it is the responsibility of the contractor to ensure that all conduits, signs, markings, drains, and other embedded or surface mounted metallic fixtures within the area of protection are electrically continuous with the reinforcing steel.

1. Rebar bond wiring is not shown in the plans. Rebar bond wiring shall be installed as directed by the Cathodic Protection Engineer and approved by the Resident Engineer.

2. REBAR BOND WIRES SHALL BE COPPER WIRE WITH WHITE INSULATION. WHITE INSULATED WIRE MAY NOT BE USED FOR ANY OTHER CONNECTIONS. (Except where local electrical codes specify otherwise.)

3. Wherever possible the bond wires shall be thermite brazed to the rebar or metallic fixtures. Where this is not possible the bond shall be established as directed by the Cathodic Protection Engineer and approved by the Resident Engineer.

4. Rebar bonds shall be made to reinforcing bars having no more than 5% section loss at the connection location.

5. Rebar bond wires do not have to be labeled except for the wires within the rectifier enclosure.

6. The length of the bond wire shall be kept to a minimum.

7. Bond wiring shall be well secured to the structure using cable ties.

8. Bond wires shall be anchored within six (6) inches of their termination (thermite braze).

9. Bond wires may not be spliced.

10. All reinforcing steel lead wire and other metal to metal permanent lead wire connections, except those in the junction boxes and rectifier enclosure shall be made using the thermite welding process in accordance with the manufacturer's instructions.

11. The discontinuous objects must be connected (bonded) to a rebar which is electrically continuous with the rest of the structure using copper wire with white insulation.

12. All mats not electrically connected shall be connected together using copper wire and thermite bonding.

13. A discontinuous rebar or metallic fixture shall be bonded to a nearby continuous rebar.

14. Bonding shall be provided for all of the following to the reinforcing bars:

a. Armor joints
b. Guard rail supports
c. Dowel bars used to connect adjacent deck slabs
d. Steel diaphrams and girder supports under the deck or other structures contacting a cathodically protected member

8. Each reference cell lead wire and corresponding instrument negative lead wire shall be brought through a 1/2 inch diameter hole drilled in the deck. The hole shall be filled with a non- conductive epoxy approved by the Engineer.

9. The reference cells shall be positioned as determined by the Cathodic Protection Engineer and approved by the Resident Engineer. The reference cells shall be located within one (1) inch, but not in direct contact with top-mat reinforcing steel.

10. Each reference cell shall be cast in an air- entrained portland cement concrete patch with a chloride content about equal to that of the surrounding concrete and a water-cement ratio of about 0.50.

11. Rebar probes shall be installed by the contractor as necessary.

V. Wiring

A. The contractor shall be responsible for installation of all wiring concerning the five cathodic protection systems, system negatives and related instrumentation.

B. The Cathodic Protection Engineer shall consult each of the anode material manufacturers and prepare a complete wiring diagram subject to the Resident Engineer's approval. All wiring changes made during the project shall be documented and subject to the Resident Engineer's approval.

1. Wiring shall run according to plans prepared by the Cathodic Protection Engineer and approved by the Resident Engineer.

2. All wires shall be properly labeled. Labels used shall have a long life expectancy and be resistant to destruction by insects local to the region. Each label used shall not easily separate from the wire that it has been attached to.

3. Wiring shall be run in conduit or saw cuts as determined by the Cathodic Protection Engineer and approved by the Resident Engineer.

4. Wiring run in saw cuts shall be fastened down every twenty (20) feet.

5. Wiring connected to reinforcing steel shall be securely anchored to the rebar with a cable tie within six (6) inches of the thermite braze.

6. Care shall be taken during cathodic protection system installation and concrete overlay installation to avoid damaging the wiring.

7. Any damaged wiring shall be repaired or replaced as directed by the Cathodic Protection Engineer prior to placing the concrete overlay. All repaired or replaced wiring shall be documented and approved by the Resident Engineer.

e. Illumination poles, clamps, conduit, electrical enclosures, supports or metallic members in contact with a cathodically protected member.

C. All wire to rebar connections shall be made using thermite brazing techniques unless otherwise directed by the Cathodic Protection Engineer and approved by the Resident Engineer.

1. Specific attention shall be directed to the processes of connecting lead wires to reinforcing steel and other metallic components.

2. Each project thermite weld shall be made to the satisfaction of the Resident Engineer and may be hammer impact tested.

3. Slag from the thermite weld operation shall be removed and the weld approved by the Resident Engineer before a coating is applied.

4. All thermite brazing connections shall be coated with a non-conductive epoxy as directed by the Cathodic Protection Engineer and approved by the Resident Engineer.

IV. Reference Cells

A. The contractor shall install reference cells in each zone. Locations for reference cells are to be determined by the Cathodic Protection Engineer and approved by the Resident Engineer.

1. At least one reference cell shall be installed in each zone in an area of high chloride content.

2. Reference cells shall be silver-silver chloride furnished in an ion trapping, chloride rich backfill or equal approved by the Resident Engineer.

3. The reference cell assembly shall be approximately five (5) inches long and one (1) inch in diameter.

4. The reference cells shall not be placed in direct contact with reinforcing steel or other metallic embedments.

5. The reference cell lead wires shall be No. RG-58U coax-cable or approved equal. The lead wires shall be continuous from the reference cell to the rectifier enclosure.

6. An instrument negative lead wire will be attached to the reinforcing steel by a thermite weld not more than twelve (12) inches from the cell location, coated with non-conductive epoxy. No splices shall be allowed in the instrument negative lead wire.

7. Instrument negative lead wire shall be made only to reinforcing bars having no more than 5% section loss at the connection location.

8. Wiring shall be spliced only at locations determined by the Cathodic Protection Engineer and approved by the Resident Engineer.

9. All direct current and instrumentation conduit shall be PVC. PVC conduit size shall be 1.5 inch inside in diameter for all runs except as otherwise designated in the plans.

10. All PVC used on the project shall be Polyvinyl- chloride (PVC) conduit conforming to NEMA TC-2, Schedule 40.

11. PVC conduit expansion and contraction sections shall be placed at all appropriate locations and not to exceed 75 feet apart. These sections shall provide at least 4 inch of movement.

12. Rectifier power supply (AC) shall be run in Galvanized Rigid Steel conduit (RSC) which conforms to ANSI C 80.1 and bears the U.L. Label. RSC conduit size shall be 1 inch diameter with RSC fittings unless otherwisedetemined by the Cathodic Protection Engineer and approved by the Resident Engineer.

13. All components of conduit hangers and clamps shall be made of stainless steel or galvanized steel approved by the Engineer. Conduit clamps for PVC conduit shall permit movement of the conduit and shall be placed at 4 foot maximum spacing.

14. CARE SHALL BE TAKEN TO MAKE SURE THAT CONDUIT HANGERS AND CLAMPS DO NOT CAUSE SHORT CIRCUITS WITHIN THE CATHODIC PROTECTION ZONES.

15. All connections and splices shall be made in junction boxes approved by the Resident Engineer.

16. All wires within junction boxes shall be properly labeled.

17. Junction boxes shall be constructed of the same material as joining conduit, of sufficient size to house wiring and splices and shall be sealed against entry by nest building insects and have provisions to prevent water retention.

18. All wires within the rectifierinclosure shall be properly and thoroughly labeled.

19. All conduit shall enter the rectifier inclosure from the bottom with provisions for drainage of conduit water at a level beneath the rectifier. The drainage site shall be sealed against entry by nest building insects.

B. Size of wire to be used will be determined by the Cathodic Protection Engineer and approved by the Resident Engineer.

C. All wiring shall conform to the following specifications for color, mimimum size and insulation type.

1. White = Cathode leads for System negative and Rebar bond wiring

a. Minimum 8 AWG stranded copper
b. Type HMWPE on the deck or within structures
c. Type XHHW or approved equal below deck to the rectifier inclosure

2. Red = Anode leads

a. Minimum 8 AWG stranded copper
b. Type HMWPE on the deck or within structures
c. Type XHHW or approved equal below deck to the rectifier inclosure

3. Brown = Reference cell rebar grounds

a. Minimum 14 AWG stranded copper
b. Type HMWPE on the deck or within structures
c. Type XHHW or approved equal below deck to the rectifier inclosure

4. Black = Reference cell lead wires and rebar probe lead wires

a. RG-58U or equivalent

5. Green = Rectifier cabinet ground

a. Minimum 4 AWG
b. Type XHHW or approved equal

D. Color code for AC line power shall be per all applicable National and local codes.

VI. Rectifier Specifications

A. The contractor shall locate the rectifier enclosure in an area accessible to maintenance personnel.

B. The rectifier enclosure shall be attached to a controller box support as shown in the plans.

C. The contractor shall take care to avoid damaging the rectifier. Any damage caused by the contractor's operations shall be repaired at the contractor's expense.

D. The contractor shall connect the rectifier as determined by the Cathodic Protection Engineer and approved by the Resident Engineer.

1. All wiring shall be fully documented. A copy of the final wiring diagram with all corrections noted shall be stored in the rectifier enclosure for future reference by maintenance personnel.

E. The rectifier shall conform to the following specifications:

1. The rectifier shall be suitable for cathodic protection of a bridge. It shall operate from 120/240 VAC single phase 60 Hz mains and provide seventeen (17) independent and individually controlled outputs for connection to seventeen (17) independent anode zones.

2. The unit shall be designed for a 20 year minimum working life under continuous operation. The unit shall be convection cooled with no fans or moving parts and shall operate at full capacity in ambient temperatures from 0 degrees F to 110 degrees F.

3. Each zone shall be controlled independently using modular DC controllers.

A. Output DC controllers shall be of modular plug in construction for simple field replacement.

B. Each module shall be removed and replaced from the front of the rectifier enclosure.

C. Each module shall have a method of current limiting which does not require manual resetting.

D. Each module shall be independently controlled.

E. Output adjustment of one circuit must not effect the output of any other module and must be continuous over the entire rated range of output current.

F. Each module shall be capable of supplying continuous full-rated output at temperatures from 10 F to 140 F.

G. Each module shall be air cooled by natural convection.

H. Each module shall be provide with lightning protection separate from AC power lightning protection.

I. The rectifying elements shall be silicon diodes. The diodes shall be protected against high voltage surges with metal oxide varistors.

J. The peak inverse voltage rating of the SCR's shall be no less than 600 volts. Protection.

K. Following assembly of the modules, each module shall have been individually tested over the full range of its rated current to insure proper operation. The card shall then be coated with a heavy coating of Dow Corning 2577 or equivalent conformal coating.

4. An LCD meter coupled with suitable switching arrangement shall be provided to monitor DC voltage, current, structure to electrolyte and rebar to probe potentials. A power on/off switch shall be provided to remove AC power from the meter when it is not in use. Meter jacks shall be provided which enable all readings to be taken using a portable hand held meter.

5. An AC circuit breaker shall be provided. It shall be of the manually reset type.

6. THE STATE OF THE AC CIRCUIT BREAKER SHALL BE INDICATED BY A LIGHT VISIBLE FROM OUTSIDE THE INCLOSURE THAT CAN BE SEEN FROM TRAFFIC LANES ON THE BRIDGE.

7. Protection against lightning surges shall be provided to protect against 1) AC line to ground overvoltage, 2) ground to structure overvoltage, and 3) structure to anode overvoltage.

9. A service manual shall be provided with each unit which explains operation, operating principles, maintenance, installation, and schematics.

10. The rectifier shall be equipped with compression type connectors for all positive and negative output cables and be sized for up to No. 6 AWG wire.

11. Acceptable line input voltage shall be 120 VAC or 240 VAC +10% - -5%, 60 HZ, single phase.

12. The instrument panel shall be clearly labeled as to the functions it performs.

13. All switches and instruments shall be clearly labeled as to their functions.

14. A light shall be provided which is easily visible from the traffic lanes. This light shall indicate the status of the AC circuit breaker within the rectifier assembly. The light shall be armor encased for protection from vandalism.

F. Rectifier Enclosure

1. The enclosure shall meet all the requirements of NEMA STANDARD MR-20-1958, "CATHODIC PROTECTION RECTIFIER UNITS".

2. The enclosure shall be NEMA 4 water tight and dust tight with conduit access in the bottom to accommodate AC and DC wiring.

3. The enclosure shall have a front opening door.

4. Provisions for padlocking shall be provided.

5. The rectifier cabinet shall be constructed of one of the following materials or equal approved by the Resident Engineer:

A. One-eighth inch aluminum sheet (5052-H32) and one-quarter inch aluminum back panel or

b. Minimum 11 gauge galvanized steel and coated with white baked on enamel.

6. A grounding lug for connecting No. 4 AWG wire to earth ground shall be provided on the enclosure exterior.

7. All components shall be mounted on the back panel easily removable through the front opening door.

8. Mounting bolt holes shall allow for 3/8" diameter bolts.

9. A hinged door with over-center latches and locking hasp shall be provided. A neoprene gasket 1/5" thick and 1" wide shall seal the door opening against moisture and dust. When closed, the door shall form a dust tight, water tight closure and shall be equipped with lift off type hinges providing easy removal of the door for access to internal components.

10. Each rectifer shall have provisions for permanent storage of the manual, schematic, and system wiring diagram in the door of the rectifier.

11. The cabinet and door shall be essentially "square and true" such the the door does not sage when opened and does not require force when opening or closing.

12. The cabinet shall be equipped with panel support a brackets with hinges and panel stops which are of sufficient strength to support the instrument panel in both the closed and open positions.

13. All welds and sharp edges shall be completely deburred and rounded.

G. Transformers

1. Power transformers shall provided rated output over the full range of input voltages, be of E-I laminated construction to provide isolated secondary voltages appropiate for circuit operation, and have independent primary and secondary windings. Adjustment of output by tap bars is not acceptable. Varnish impregnation and Farraday shield between primary and secondary must be provided. Transformer efficiency shall be at least 95% and the regulation shall not exceed 3% when measured from 1/4 to full load.

2. Control transformers for module power shall be of E-I lamination construction and shall have primary power supplied from the power transfomer secondary for line surge isolation.

H. Filter Chokes

1. Filter chokes of E-I lamination or other suitable core construction shall be used in each rectifier output circuit to:

a) Improve efficiency

b) Provide some surge protection from transients externally generated

c) Provide full outtput current capability at low output voltage

d) To reduce R.F.I. In the load circuit.

I. Circuit Breaker

1. A two (2) pole fully magnetic circuit breaker shall be provided as an input power switch and for protection to the line against rectifier fault.

2. The breaker shall be rated for 240 volt AC.

3. The breaker must hold 101% rated current and must trip at 125% of rated current.

J. Meter

1. Metering shall be provided for monitoring the operating current, operation voltage, and reference electrode potentials.

2. A 3 1/2 digit L.C.D. (Liquid crystal display) meter with 200 MV 2000 count sensitivity shall be provided to take readings.

2. The meter shall have input impedance sufficiently high to cause no appreciable (1 micro amp max) loading of circuits connected to it such as sensitive half cell.

3. Appropiate scaling and switching circuits shall be provided to give direct meter displays in amperes and volts.

4. Structure potentials shall be displayed in volts up to 1.999 either positive or negative with respect to the half cell.

5. The meter shall have the capability of being removed from the circuit when readings are not being taken.

6. The meter shall have the capability of monitoring reference electrodes when the rectifier is shut off.

K. Wiring inside the enclosure

1. Wiring shall be sized for a minimum of 500 CM/ampere for power circuits and No. 28 AWG minimum for signal circuits.

2. Power wires shall have 600 volt insulation and be stranded copper wire such as MTW or similar.

3. Wires shall be neatly bundled, tied and clamped as necessary to provide a clean neat appearance.

4. Signal wires shall be stranded copper and routed separately from power leads wherever possible.

5. All wiring shall be of sufficient length to avoid tension at terminal connections.

6. All connections either electrical or mechanical shall be tightly secured with lock washers.

7. Any electrical connection through the instrument panel shall not rely on pressure to the panel to maintain good connection.

L. Cable Entry

1. All wiring shall enter through the bottom of the cabinet.

2. AC INPUT AND DC OUTPUT BE KEPT SEPARATE.

3. Reference cell leads shall be kept separate from all other anode and cathode wiring.

M. Complete Rectifier Dialectric Test

The insulation and spacings of a rectifier unit shall be capable of with-standing without breakdowm, for a period of one minute, the application of a 60 cycle alternating-current rms voltage of 1000 volts plus twice the rated primary voltage between current-carrying parts of the primary circuit and (1) non-conductive-carrying metal parts which may be grounded and (2) current- carrying metal parts of an insulated secondary circuit. When operating below 60 volts, an insulated secondary circuit shall be capable of withstanding an alternating-current rms test voltage of 600 volts to any non-current-carrying metal parts which may be grounded; when operating within the range of 60 to 90 volts, the alternating-current rms test voltage shall be 900 volts.

If the rectifier unit includes devices which normally fall within the scope of other recognized standards requiring dielectric test voltages lower than the foregoing, such devices shall be disconnected before the remainder of the equipment is subjected to the test. The disconnected devices shall be tested separately for dielectric strength in accordance with the applicable standards.

N. Circuit Operation Test

Each circuit shall be tested to insure that all of its components are properly interconnected and function normally at 5% low and 10% high AC input line voltage. The unit shall then be tested with all circuits energized and operating at rated output current to insure normal operation at 5% low and 10% high input line voltages. If the rectifier is designed for more than one input line voltage, the test shall be run at each.

With all circuits energized, an adjustment of one or more of the circuits' output current shall not effect any of the other circuits' output amps. Any circuit must be able to be adjusted over its full range without changing the output of any other circuit.

O. Current Regulation

The current regulation of each circuit shall be checked and shall not exceed +- 1 when the load resistance is varied between 0 and rated load resistance. The current regulation of the entire unit with all circuits energized shall not exceed +- 1% when the total load resistance is varied between 0 and total rated load resistance.

VII. Post Installation Tests.

The contractor shall be responsible for performing the following tests as detailed in this specification and will be required to document results, procedures and train at at least three State employees to conduct subsequent required tests as directed by the Resident Engineer.

A. E log I tests shall be performed prior to system energizing at each of the reference locations in each zone. The data shall be plotted and explanations of the data shall be provided to State personnel. The system will be adjusted based on this data.

B. Two sets of polarization tests ,shall be performed by the contractor and adjustments made if the system is not within a minimum of 100 millivolts to a maximum of 150 millivolts range.

1. The first set of tests shall be performed after 45 days of continuous system operations. Adjustments to the system shall be made as necessary by the contractor and explanation of the adjustments shall accompany the data.

2. The second set of tests shall be performed after 90 days of continuous system operations. Adjustments to the system shall be made as necessary by the contractor and explanation of the adjustments shall accompany the data.

C. Rate of corrosion tests shall be performed by the contractor prior to system energizing and upon each depolarization test. The rate of corrosion test shall be performed for each of the two areas per zone. The data from these tests shall be documented and analyzed using the Corrate II computer program.

VIII. System "A"

A. This system shall utilize an anode of expanded titanium metal mesh anode as manufactured by Eltech or equivalent. The installation will be on the bridge deck main lanes between Station 8+18.49 and Station 10+24.62.

B. Zones

There shall be four separately energized zones in this system. The areas of coverage for these zones shall be determined by the anode manufacturer's representative and approved by the Resident Engineer.

C. General Information

1. Traffic on the Deck

After installation of the anode strands, traffic on the deck shall be limited to vehicles required for delivery and installation of the overlay. Recesses or grade changes of greater depth that one (1) inch must be temporarily bridged for vehicles with gross vehicle weight greater than two (2) tons.

2. Gasoline and Oil on the Deck

When cathodic protection material are exposed, the contractor shall ensure that gasoline and oil do not drip onto the cathodic protection materials from equipment being used. Refueling and servicing of the equipment shall be performed off any deck covered with exposed anode materials.

3. Installation

a. Anode material installation shall not begin until all concrete surface preparation is complete and installation of all the cathodic protection instruments is complete.

b. The Resident Engineer shall determine that the concrete surface is sound and has been prepared according to specification. The contractor responsible for concrete work shall correct unsatisfactory conditions before installation of the anode material.

C. Prior to installing the anode material, the contractor shall verify that all conduits, signs, markings, drains, and other embedded or surface mounted metallic fixtures within the area of protection are electrically continuous with the reinforcing steel.

d. Where concrete cover over the steel reinforcement is one-quarter (1/4) inch or less, one of the following procedures must be followed:
(1) Epoxy coat the exposed rebar surface.
(2) Add one-quarter (1/4) inch maximum layer of cementitious material.
(3) Insert insulating spacers.
(4) Route the anode material to avoid the area with shallow cover.

The appropriate procedure shall be specified by the Cathodic Protection Engineer and approved by the Resident Engineer. The Cathodic Protection Engineer shall ensure that the minimum anode to cathode separation is one-quarter (1/4) inch.

e. Anodes shall be fastened to the deck with insulating fasteners supplied with the anode material and approved by the Resident Engineer, to not more than one-half (1/2) inch (may be more or less depending on the thickness of the overlay) from the surface of the deck. At least one fastener shall be used for every five (5) square feet of deck surface.

f. As directed by the Resident Engineer, fasteners may need to be attached to the concrete to ensure the anode mesh lies flat during concrete overlay placement.

g. The contractor shall take care to prevent damage to the anode mesh during anode installation and concrete overlay placement. Damaged anode mesh shall be repaired or replaced as directed by the Resident Engineer.

h. Anode fasteners and installation aids shall be supplied by the anode material manufacturer.

i. Anodes shall be terminated within two (2) inches of the expansion joint, fixed joint or other integral steel members at the surface of the deck. Layout of anodes and anode zones shall be determined by the anode manufacturer's representative after scarification of the bridge deck and approved by the Resident Engineer.

j. Current shall be distributed to the anodes via titanium current distributor bars or equal approved by the Resident Engineer.

k. Current distributors shall be attached to the anode mesh by resistance welded metallurgical bonds. There shall be at least one weld for every three linear inches of distributor bar.

l. Current distributors shall be at locations determined by the anode manufacturer's representative and approved by the Resident Engineer.

M. Current distributors shall be bent to extend through a one inch diameter hole to junction boxes located beneath the deck as shown by the plans. Current distributors shall be covered within this hole by an insulating heat-shrinkable sleeve approved by the Resident Engineer. Holes shall then be filled with a non-conductive epoxy approved by the Resident Engineer.

n. Insulated anode lead wires shall be AWG No. 10 stranded copper wire with THHN insulation or approved equal. Anode lead wires shall be attached to current distributors external to the concrete using spade lug connectors, and connections shall be coated with an epoxy approved by the Resident Engineer. Wires shall be tagged to indicate their position. No splices shall be allowed.

IX. System "B"

A. This system shall utilize Ferex 100 anode strand as manufactured by Raychem Corporation or equivalent. The installation will be on the bridge deck main lanes between Station 10+24.62 and Station 12+30.74.

B. Zones

There shall be four separately energized zones in this system. The areas of coverage for these zones shall be determined by the anode manufacturer's representative and approved by the Resident Engineer.

C. General Information

1. Traffic on the Deck

After installation of the anode strands, traffic on the deck shall be limited to vehicles required for delivery and installation of the overlay. Recesses or grade changes of greater depth that one (1) inch must be temporarily bridged for vehicles with gross vehicle weight greater than two (2) tons.

2. Gasoline and Oil on the Deck:

When cathodic protection material are exposed, the contractor shall ensure that gasoline and oil do not drip onto the cathodic protection materials from equipment being used. Refueling and servicing of the equipment shall be performed off any deck covered with exposed anode materials.

3. Installation

a. Anode strand installation shall not begin until all concrete surface preparation is complete and installation of all the cathodic protection instruments is complete.

b. The Resident Engineer shall determine that the concrete surface is sound and has been prepared according to specification. The contractor responsible for concrete work shall correct unsatisfactory conditions before installation of the anode material.

C. Prior to installing the anode strand, the contractor shall verify that all conduits, signs, markings, drains, and other embedded or surface mounted metallic fixtures within the area of protection are electrically continuous with the reinforcing steel.

d. Where concrete cover over the steel reinforcement is one-quarter (1/4) inch or less, one of the following procedures must be followed:

(1) Epoxy coat the exposed rebar surface.
(2) Add one-quarter (1/4) inch maximum layer of cementitious material.
(3) Insert plastic cleats or rebar clips as spacers.
(4) Route the anode material to avoid the area with shallow cover.

The appropriate procedure shall be specified by the Cathodic Protection Engineer and approved by the Resident Engineer. The Cathodic Protection Engineer shall ensure that the minimum anode to cathode separation is one-quarter (1/4) inch.

e. The contractor shall fasten each anode strand end loop to the concrete. The anode strand shall be fastened to the concrete a minimum of every five (5) feet at cleat locations between end loops.

f. As directed by the Resident Engineer, additional cleats may need to be fastened to the concrete to ensure the anode strand lies flat during concrete overlay placement.

g. The contractor shall take care to prevent damage to the anode strands during anode installation and concrete overlay placement. Anode strands shall not be bent through a radius smaller than two (2) inches. Damaged anode strands shall be repaired or replaced directed by the Resident Engineer.

h. Anode splicing shall be done in accordance with the anode manufacturer's representative and shall be subject to the Resident Engineer's approval. Anode splicing material shall be supplied by the anode manufacturer.

i. Anode to anode or anode to insulated wire splices shall be covered with a heavy wall heat shrinkable tubing internally coated with a specialized meltable sealant as supplied by the manufacturer. Substitutions shall be made only with the anode manufacturer representative's recommendation and the Resident Engineer's approval. Only the appropriate heat shrinkable splice seal shall be used.

j. Anode strand fasteners and installation aids shall be supplied by the anode material manufacturer.

k. Anodes shall be terminated within two (2) inches of the expansion joint, fixed joint or other integral steel members at the surface of the deck. Layout of anodes and anode zones shall be determined by the anode manufacturer's representative after scarification of the bridge deck and approved by the Resident Engineer.

L. Insulated anode lead wires shall be AWG No. 10 stranded copper wire with THHN insulation or approved equal. Anode lead wires shall be attached to current distributors external to the concrete using connectors supplied by the anode manufacturer and approved by the Engineer. Connections shall have non- conductive coatings approved by the Engineer. Wires shall be tagged to indicate their position. No splices shall be allowed in the anode lead wires.

X. Bu System "C"

A. This system shall utilize an anode of platinized primary wire, carbon filament secondary strands and anodecrete backfill. The installation will be on the bridge deck main lanes between Station 12+30.74 and Station 13+99.49.

B. Zones

There shall be two separately energized zones in this system. The areas of coverage for these zones shall be determined by the Cathodic Protection Engineer and approved by the Resident Engineer.

C. General Information

1. Traffic on the Deck

After installation of the platinized wire and anode strands, traffic on the deck shall be limited to vehicles required for delivery and installation of the overlay. Recesses or grade changes of greater depth that one (1) inch must be temporarily bridged for vehicles with gross vehicle weight greater than two (2) tons.

2. Gasoline and Oil on the Deck:

When cathodic protection material are exposed, the contractor shall ensure that gasoline and oil do not drip onto the cathodic protection materials from equipment being used. Refueling and servicing of the equipment shall be performed off any deck covered with exposed anode materials.

4. Anode Materials and Backfill

a. Compostion of Primary Anode Wire

Each primary anode wire shall be a continuous length of 0.062 inch diameter platinized niobium copper core wire. The wire shall have a minimum coating of 25 micro-inches of platinum. At least 35% of the wire cross sectional area shall be niobium (outside the copper core). Electrical resistance of the wire shall not exceed 4.0 milliohms per foot.

B. Composition Secondary Anode Strands

Secondary anode strand shall be a 20,000 filament high purity carbon strand (99% minimum carbon) with a tensile strength of at least 250,000 P.S.I., a cross sectional area of 240 x 10 exp -5 inches squared, a resistivity of .00075 ohm-cm and a maximum electrical linear resistance of 2.0 ohms per foot. The strand shall be wrapped with Dacron or equivalent thread, to prevent fraying during handling.

C. Anode Backfill

(1) The anode backfill material shall be extremely resistant to degradation by acid, chlorine, freezing, thawing, and thermal cycling while bonded to concrete, and shall have the following properties:

(A) compressive strength, more than 4,000 psi (4 hrs. @ 70 F)

(b) electrical resistivity, less than 10 ohm-cm

(c) water absorption (24 hrs.), less than 0.5%

(2) Composition

The composition of the anode backfill shall be as follows unless otherwise approved by the Engineer.

% by wt.	
35.	Resin - Vinyl Ester Resin D-1115 Hetron as manufactured by Ashland Chemical Co., Columbus, Ohio.
0.35	Silane Coupling Agent - A-174
0.35	Wetting Agent - S-440
0.35	Cobalt Naphthemate (Con)
0.70	Titanium Dioxide (TiO_2) RHD 6x
65.	Coke Breeze DW1
0.70	Methyl Ethyl Ketone Peroxide (MEXP)

4. Installation of the Anodes

a. The deck surface shall be cleaned immediately prior to placing the anodes. The deck surface shall be free of moisture, dirt, grease, oil, asphalt, or other foreign matter when laying out anode materials. Anodes shall be held in place by a method approved by the Resident Engineer until placement of the anodecrete backfill.

B. All exposed reinforcing bars and other metallic material shall be covered with a non-conductive epoxy, approved by the Engineer.

c. Testing to prevent shorts in the anode system shall be conducted by the contractor to insure that no reinforcing steel or other material continuous with the reinforcing steel is within 1/2 inch of the primary or secondary anode materials. Areas found to be in such condition shall be covered with non- conductive expoxy prior to placing the anode system.

d. Primary anodes, secondary anodes and anodecrete shall be terminated within two (2) inches of the expansion joint, fixed joint or other integral steel members at the surface of the deck. Layout of anodes and anode zones shall be determined by the Cathodic Protection Engineer after scarification of the bridge deck. Layouts shall be approved by the Resident Engineer.

e. The primary anode wire shall not be kinked or scored. Damage to the anode wire shall be grounds for rejection.

f. Current shall be distributed to the anodes via platinized wire approved by the Resident Engineer. The current distributors shall be laid perpendicular to the carbon strands. At the end opposite the current distributor for the carbon strands, another platinized wire shall be placed. The platinized wire shall be attached at each end of the carbon filaments.

g. Current distributors shall be at locations determined by the Cathodic Protection Engineer and approved by the Resident Engineer.

h. Current distributors shall be bent to extend through a 1 inch diameter hole to junction boxes located beneath the deck as shown by the plans. Current distributors shall be covered within this hole by an insulating heat-shrinkable sleeve approved by the Resident Engineer. Holes shall then be filled with a non-conductive epoxy approved by the Resident Engineer.

i. Insulated anode lead wires shall be AWG No. 10 stranded copper wire with THHN insulation or approved equal. Anode lead wires shall be attached to current distributors external to the concrete using methods specified by the Cathodic Protection Engineer and approved by the Resident Engineer. Connections shall have non-conductive coatings approved by the Resident Engineer. Wires shall be tagged to indicate their position. No splices shall be allowed in the anode lead wires nor in the primary anodes.

5. Installation of the Backfill Material

a. The anodecrete backfill shall be packaged in kits sized for the project.

B. The quantity of backfill material mixed at any time shall not be in excess of the amount that can be used within 30 minutes.

c. The backfill material shall be installed only when the deck temperature is expected to be about 40 degrees fahreheit for at least four (4) hours following the installation.

d. The manufacturer's instructions, including likely safety and handling measures, must be followed explicitly.

e. The deck surface shall be free of moisture, dirt, grease, oil, asphalt, or other foreign matter when covering the anodes with anodecrete backfill.

f. The anodecrete backfill shall be mounded over the primary and secondary anodes immediately after the anodes have been placed and any drill holes are completely sealed.

g. The backfill material must not come in contact with the reinforcing rods or any other metallic object of the bridge.

h. The anodecrete backfill mounded over the anodes shall be approximately one (1) inch wide and three-eights (3/8) inch high.

i. The mounded anodecrete backfill shall have dry, fine silica sand broadcast to excess over them within 15 minutes of pouring. The excess sand shall be broomed from the surface after the material has set.

6. Laboratory Tests

a. Prior to contract approval the contractor must submit independent laboratory tests certifying that the material proposed for use on this project meets the requirements as specified.

b. A sample shall be obtained from every fourth batch of material produced in the field. The sample shall be evaluated by an independent engineering laboratory to assure compliance with the resistivity and water absorption requirements. The test results shall be submitted to the Resident Engineer for approval.

c. The independent laboratory shall not be owned or connected in any way with the contractor, material supplier or Cathodic Protection Engineer.

XI. System "D"

A. This system shall utilize an anode of hot sprayed zinc, 20 mils plus or minus 3 mils thick. The installation will be on the bridge sidewalks and median between Station 8+18.49 and Station 12+30.74.

B. Zones

There shall be six separately energized zones in this system. The areas of coverage for these zones shall be determined by the Cathodic Protection Engineer and approved by the Resident Engineer.

C. General Information

1. Gasoline and Oil on the Sidewalks and/or Median

2. When cathodic protection material are exposed, the contractor shall ensure that gasoline and oil do not drip onto the cathodic protection materials from equipment being used. Refueling and servicing equipment shall be performed away from the area of coverage by the anode material.

3. Installation

a. Anode material installation shall not begin until all concrete surface preparation is complete and installation of all the cathodic protection instruments is complete.

b. The Resident Engineer shall determine that the concrete surface is sound and has been prepared according to specification. The contractor responsible for concrete work shall correct unsatisfactory conditions before installation of the anode material.

c. Prior to installing the anode material, the contractor shall verify that all conduits, signs, markings, drains, and other embedded or surface mounted metallic fixtures within the area of protection are electrically continuous with the reinforcing steel.

d. Where concrete cover over the steel reinforcement is one-quarter (1/4) inch or less, one of the following procedures must be followed:

(1) Epoxy coat the exposed rebar surface.
(2) Add one-quarter (1/4) inch maximum layer of cementitious material.
(3) Use approved masking to avoid the area with shallow cover.

The appropriate procedure shall be specified by the Cathodic Protection Engineer and approved by the Resident Engineer.

e. The contractor shall take care to prevent damage to the anode material during the installation. Damaged anode areas shall be repaired or resprayed as directed by the Resident Engineer.

f. Areas not to be sprayed shall be masked off with an appropriate masking material. Anode material application shall be terminated within two (2) inches of the expansion joint, fixed joint or other integral steel members at the surface of application area. Layout of masking for anode zones shall be determined by the Cathodic Protection Engineer after any repairs have been made. Layout approval by the Resident Engineer must be obtained.

G. Current distributors shall as determined by the Cathodic Protection Engineer and approved by the Resident Engineer.

h. Insulated anode lead wires shall be AWG No. 10 stranded copper wire with THHN insulation or approved equal. Wires shall be tagged to indicate their position. No splices shall be allowed in the anode distributor lead wires.

i. The Cathodic Protection Engineer shall be responsible for determining what type of coating (if any) is required to alleviate any hazards to pedestrian traffic as a result of the installation of the cathodic protection material.

j. The contractor is required to take all necessary precautions to protect contractor personnel and pedestrians.

XII. System "E"

A. This system shall utilize an anode of Porter DAC-85 Conductive coating or equivalent. The installation will be on bent 4 located at Station 12+30.74 of the bridge.

B. Zones

There shall be one zone in this system. The areas of coverage for this zones shall be all surfaces of the bent.

C. General Information

1. Gasoline and Oil on the Bent

2. When cathodic protection material are exposed, the contractor shall ensure that gasoline and oil do not drip onto the cathodic protection materials from equipment being used. Refueling and servicing of the equipment shall be performed away from the area of coverage by the anode material.

3. Installation

a. Anode material installation shall not begin until all concrete surface preparation is complete and installation of all the cathodic protection instruments is complete.

b. The Resident Engineer shall determine that the concrete surface is sound and has been prepared according to specification. The contractor responsible for concrete work shall correct unsatisfactory conditions before installation of the anode material.

c. Prior to installing the anode material, the contractor shall verify that all conduits, signs, markings, drains, and other embedded or surface mounted metallic fixtures within the area of protection are electrically continuous with the reinforcing steel.

d. Where concrete cover over the steel reinforcement is one-quarter (1/4) inch or less, one of the following procedures must be followed:

(1) Epoxy coat the exposed rebar surface.
(2) Add one-quarter (1/4) inch maximum layer of cementitious material.
(3) Use approved masking to avoid the area with shallow cover.

The appropriate procedure shall be specified by the Cathodic Protection Engineer and approved by the Resident Engineer.

E. The contractor shall take care to prevent damage to the anode material during the installation. Damaged anode areas shall be repaired or re-applied as directed by the Resident Engineer.

F. Areas not to be coated shall be masked off with an appropriate masking material. Anode material application shall be terminated within two (2) inches of the expansion joint, fixed joint or other integral steel members at the surface of the bent. Layout of masking for anode zones shall be determined by the Cathodic Protection Engineer after any repairs have been made. Approval of layouts by the Resident Engineer must be obtained.

G. Current distributors shall as determined by the Cathodic Protection Engineer and approved by the Resident Engineer.

H. Insulated anode lead wires shall be AWG No. 10 stranded copper wire with THHN insulation or approved equal. Wires shall be tagged to indicate their position. No splices shall be allowed in the anode distributor lead wires.

I. The Cathodic Protection Engineer shall be responsible for determining what type of coating (if any) may be required to alleviate possible shorting of the system due to small debris falling onto the bent. (Note: The current configuration of the finger joint immediately above the bent allowed a significant amount of trash to collect on the top surface of the bent - ie. Cans, bottle tops

4. The conductive coating system shall employ platinum wire primary anodes layed on the surface and covered with fiberglass screen adhesive tape.

5. The conductive coating shall be graphite/acrylic consisting of 42% solids.

6. The conductive coating shall have a resistivity of 1 ohm-cm. or less after curing.

7. The applied dry film thickness shall not be less than 16 mils.

XIII. <u>MEASUREMENT</u>. The complete Cathodic Protection System as indicated on the plans and as described herein when completely installed will be measured by the complete Cathodic Protection System.

XIV. <u>PAYMENT</u>. Payment shall be made at the contract lump sum bid for "Cathodic Protection System", which price shall be full compensation for all tools, labor, equipment, and incidentals necessary to complete the work.