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STATE OF CALIFORNIA
DEPARTMENT OF PUBLIC WORKS
DIVISION OF HIGHWAYS

STUDY TO DEVELOP AND EVALUATE AN IMPROVED BRIDGE DECK EXPANSION JOINT

64-38

[redacted]

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State of California
Department of Public Works
Division of Highways
Materials and Research Department

January 1964

Project Work Order R-61264

Mr. J. E. McMahon
Assistant State Highway Engineer
Bridge Department
Sacramento, California

Dear Sir:

Submitted for your consideration is:

REPORT OF

STUDY TO DEVELOP AND EVALUATE

AN IMPROVED BRIDGE DECK EXPANSION JOINT

Study made by . . . . . Structural Materials Section

Under general direction of . . John L. Beaton and E. F. Nordlin

Work supervised by . . . . . H. F. Kuhlman

Report prepared by . H. F. Kuhlman, V. M. Sayers and J. R. Stoker

Very truly yours,

JOHN L. BEATON
Materials and Research Engineer

HFK/VMS/JRS:mw

cc: LRGillis
ALElliott (15)
IOJahlstrom

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INTRODUCTION

Bridge deck expansion joints have given considerable difficulty in that no known type has been found to function efficiently with minimum interference with traffic and at the same time be watertight, prevent dirt and water from going through to the deck or roadway below, and permit easy cleaning and maintenance.

In December of 1961, pursuant to discussions with Mr. Elliott of the Bridge Department, a project was initiated to design, build, and subsequently evaluate a four-foot experimental expansion joint assembly which would meet these criteria.

An expansion joint consisting of two dovetailing metal (cast steel, cast nodular iron, or structural steel) sections with an apron of neoprene bonded to metal to trap dirt and direct water to side drains has been developed. Tests and a trial installation in a roadway adjacent to the Materials and Research Department indicate that this new design will be satisfactory, and a trial installation in a bridge is recommended as the next step.

This report covers the design and fabrication and testing of the expansion joint which has been developed.

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SUMMARY AND RECOMMENDATIONS

Photographs, Figures 3 and 4, and drawings, Figures 7 and 8, show details of the unit finally developed. As shown, it consists of two four-foot dovetailing steel sections, which have been so designed that epoxy concrete can be used in the cantilevered teeth to compensate for any differences in elevation between the pavement and the expansion joint. A neoprene rubber sheet is used as a trough to trap dirt and carry water to side drains. This trough can be readily cleaned by flushing with a hose.

Discussions with industry indicated that it would be practicable either to cast the sections or fabricate them from structural steel; therefore, as shown in Figures 7 and 8, three alternate types are recommended:

1. Welded structural steel.
2. Cast steel.
3. Cast nodular iron.

It would be practicable to cast 4-foot sections which would have an estimated weight of 91 pounds, would cost $20.00 each, and would facilitate maintenance and replacement.

The experimental unit was first designed to be anchored in the concrete with the aid of steel angles (Figure 2). After dynamic testing was performed on this unit, it was concluded that the expansion joint assembly could be installed without these angles. Other changes included in the final design were (1) increasing clearance between fingers to 3/8 inch to prevent wedging of pebbles and (2) use of Expand-O-Flash (or a similar product), consisting of neoprene crimped and cemented to metal for the apron.

Tests which consisted of running a loaded truck over the joint indicated adequate strength and satisfactory distribution of stress. (See "Test Procedures").

Therefore, it is recommended that the alternate designs shown on Figures 7 and 8 be considered for inclusion in future plans and specifications. A trial installation in a bridge deck is suggested as a supplement to the tests already performed.

The following specifications are recommended:

Bridge deck expansion joints shall conform to the provisions in Section 51 of the Standard Specifications, the details shown on the plans, and the following requirements:

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The dovetailed metal sections shall be cast steel conforming to ASTM A27, Grade 65-35, or cast nodular iron conforming to ASTM A339, Grade 60-45, or shall be fabricated of structural steel conforming to ASTM A36.

Fabrication and workmanship of the steel or cast iron members shall conform to Section 55 of the Standard Specifications.

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TEST PROCEDURE

The expansion joint assembly sections used in the tests were fabricated by welding. The finished units were cast into a concrete block so as to simulate a bridge joint. SR-4 strain gages were cemented to the anchor bolts and fingers and also were contained in special supporting bolts. Figure 1 shows the concrete form with the SR-4 gages mounted on the anchor bolts, and Figure 2 shows a finished concrete block representing the deck slab ready for the installation of the expansion joint. Figure 9 shows details of the unit as tested.

The concrete block with the expansion joint installed was placed in the roadway as shown in Figures 3 and 4, ready for test.

The concrete was obtained from a local ready-mix plant and consisted of Class A concrete with Type II cement and Fair Oaks aggregate and with a 2" slump.

The block was moist cured, using burlap covers for 7 days and then dry cured for 21 days. The concrete had an average compressive strength at 28 days of 5300 psi, as determined by standard 6" x 12" test cylinders.

All gages were tested prior to installation and also after installation. The test of the experimental joint consisted of running a loaded truck with dual tired rear axle weights of 18,000 and 19,500 pounds over the installed expansion joint.

Static readings were recorded on all gages. These static readings were so low that serious efforts to accurately record readings imposed by a truck in motion were not attempted. Past experience in measuring loads and deflections on concrete pavements has shown that the loads imposed on a pavement surface by moving vehicles are generally less than for standing vehicles. This appeared true in this case also. The truck was driven across the expansion unit at least 50 times with no observed reading exceeding those recorded for the standing truck.

Figures 5 and 6 show the gage locations and the static readings recorded under axle end loads of 9,000 lb. and 9,750 lb. The "+" figures are tensile stresses and the "-" are compressive.

The gages identified by "A" were attached to anchor bolts welded to the structural steel anchor angles used on the test unit. Gages 1B through 6B were built into special strain gage bolts installed in tapped holes. These supporting bolts secured the dovetailed "finger" components to the anchor angles. Gages 7B through 9B were mounted on the fingers themselves.

As shown, gages Nos. 1A and 4A were defective. The gages on the special strain gage bolts recorded a maximum load of 1260 pounds. Gages 7B through 9B indicated relatively insignificant stresses in the fingers.

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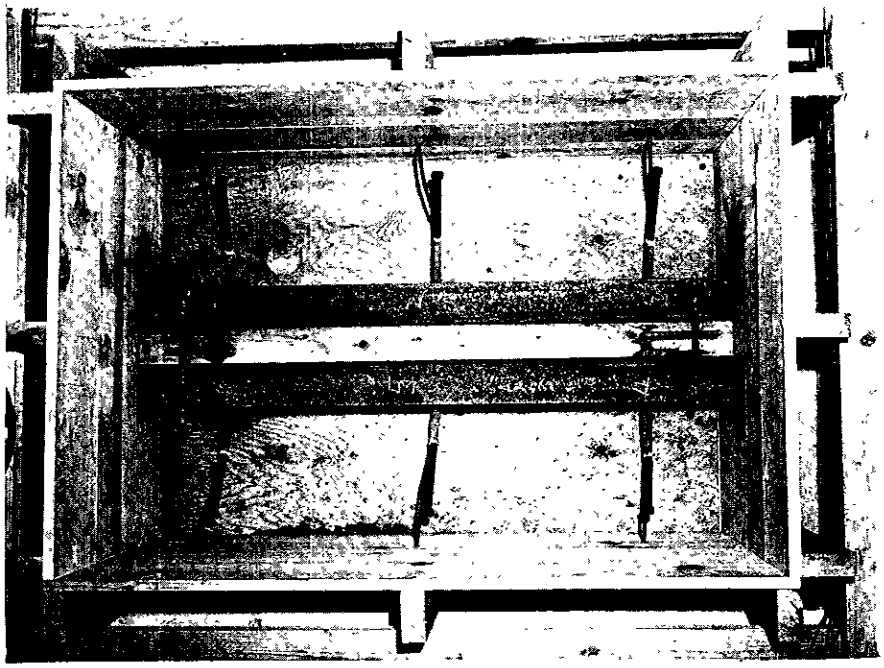

FIGURE 1

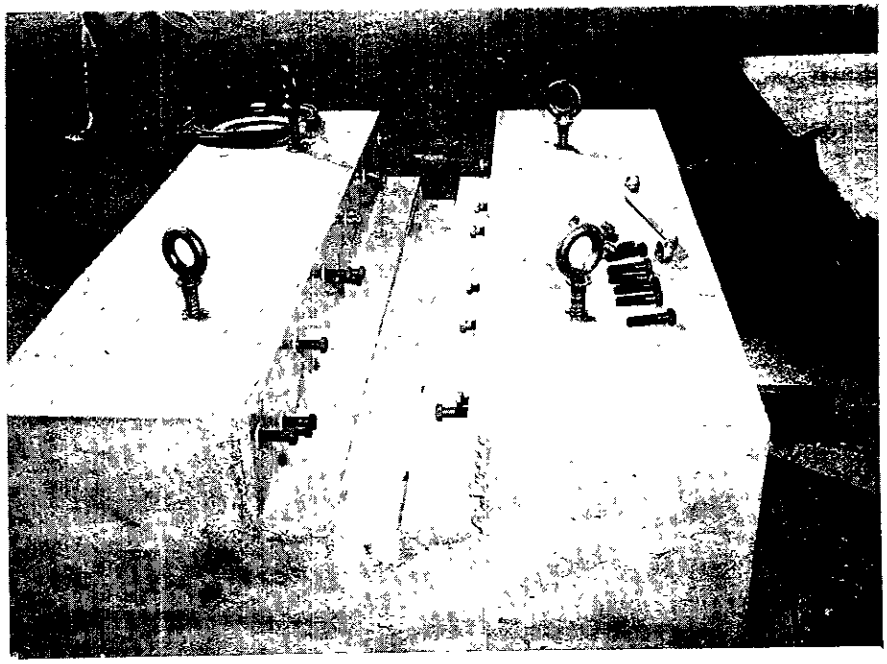

FIGURE 2

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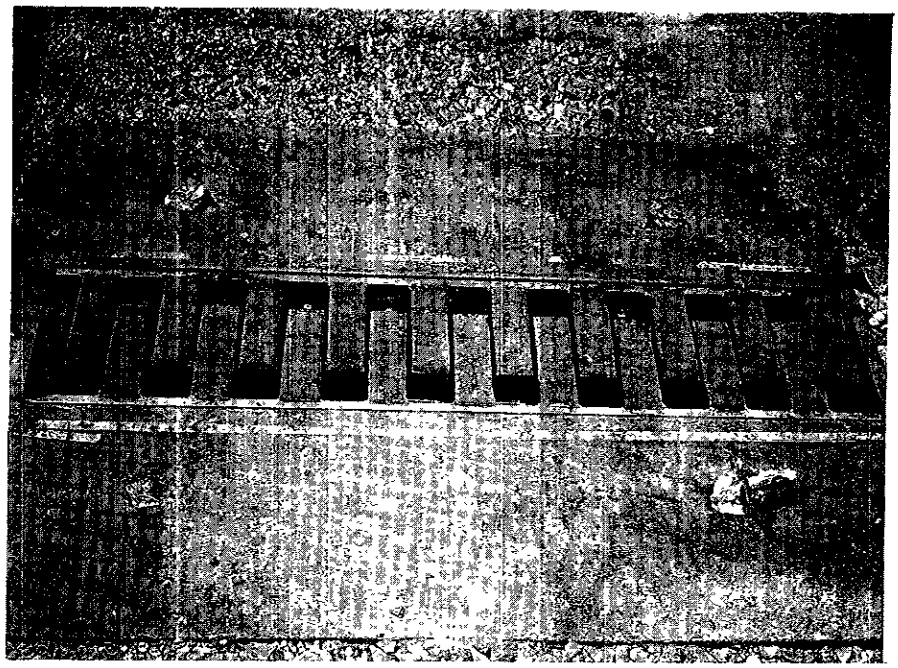

FIGURE 3

FIGURE 4

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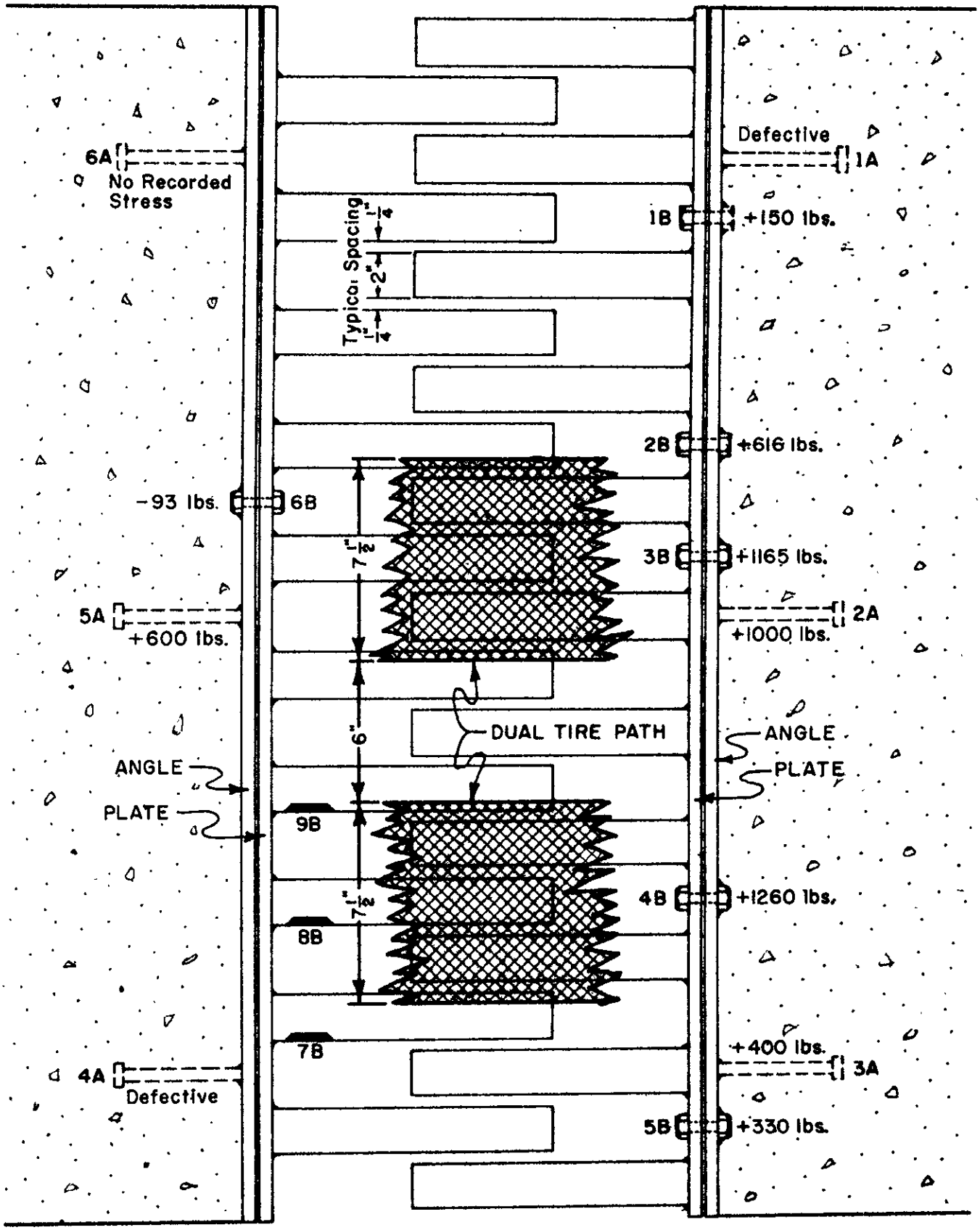

LOADED WITH DUAL REAR WHEELS
19,500 lb. AXLE LOAD

Figure 5

April 19, 1962

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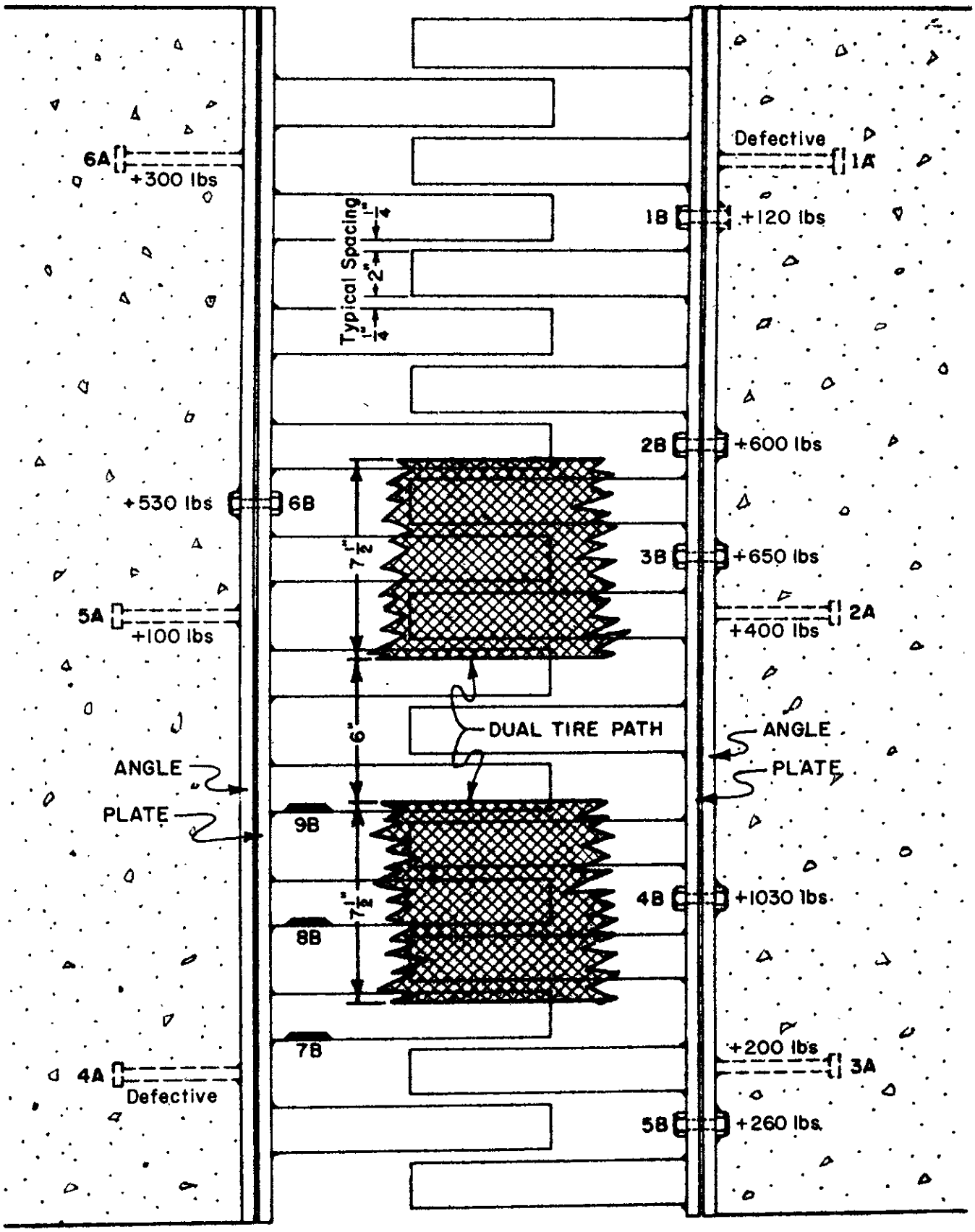

LOADED WITH DUAL REAR WHEELS
18,000 lb. AXLE LOAD

Figure 6

April 4, 1962

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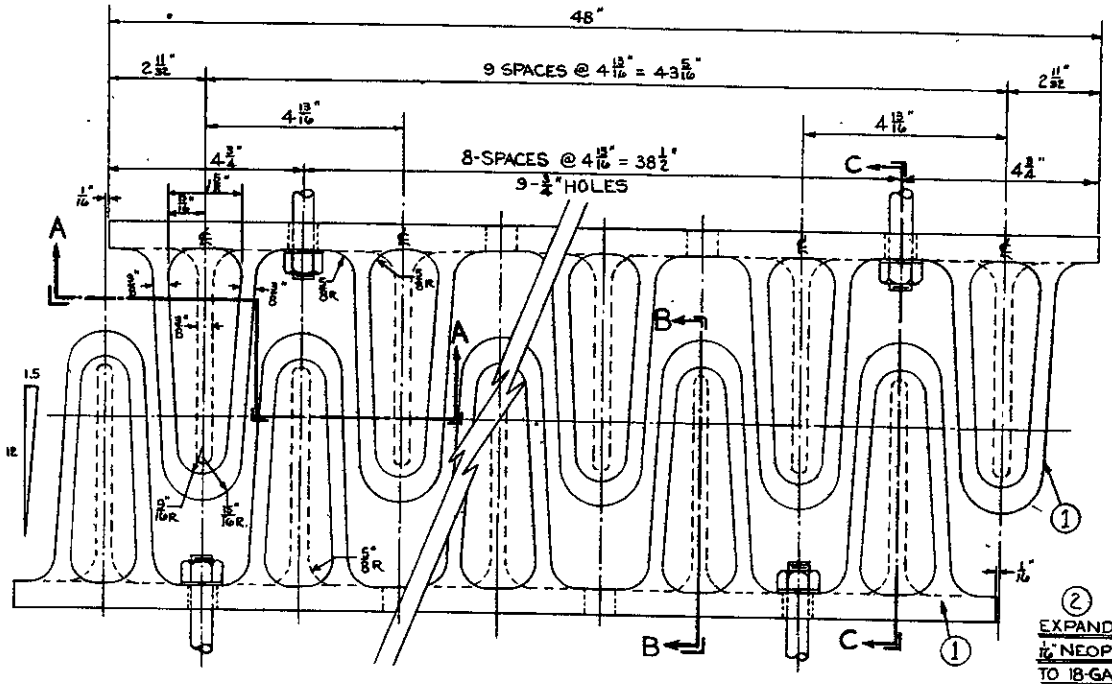
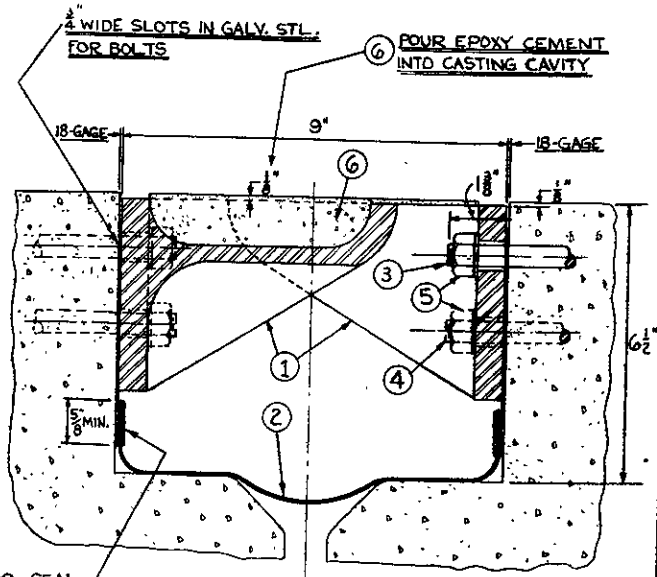
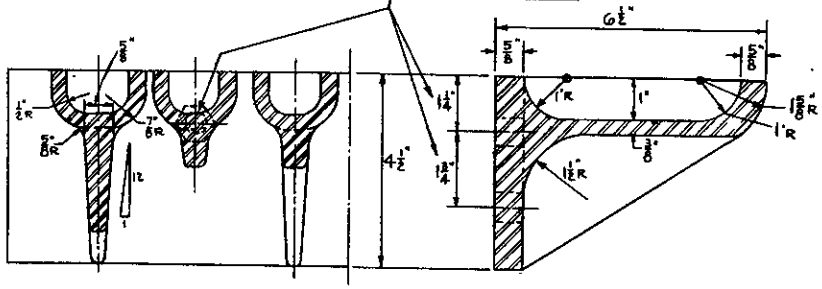


PLAN VIEW



SIDE ELEVATION
EXPANSION JOINT
SECTION C.C.

9-3/4" HOLES
ALTERNATE HOLES 1 1/4" & 3" FROM TOP.
THE END HOLES TO BE 1 1/4" FROM TOP.



SECTION A A

SECTION B B.

NOTE:

1. MATERIAL TO BE CAST STEEL A-27 GRADE 65-35 OR NODULAR IRON A-339 GRADE 60-45
2. CASTING TO BE TRUE WITHIN ± 1/8"
3. THE EXPANSION JOINT SHALL CONFORM TO THE PROVISIONS IN STD. SPECS. SECTION 51
4. EXPANDO-SEAL TO BE BONDED TOGETHER BY VENDER.

MATERIAL REQ'D FOR 12' LENGTH.

ASSEM	No. REQ'D	PART No	DESCRIPTION	STOCK SIZE	MATERIAL	HEAT TREAT
		-6	EPOXY (ADD SAND TILL STIFF)	THIOKOL LP3-82% CATALYST DMP-30 10% 2-PARTS	TEXPON B-20 100% - 1-PART	SAND-GO WASH-80% 30 MESH - 80% 1½ OZ CARBON BLACK 18 TUBE
	54	-5	NUT	5/8" DIA HEX HD - 13 N.C.	STEEL (No REQ'D FOR 12' LANE)	LOCK WASHER
	24	-4	LOWER BOLT	5/8" DIA x 10" LG	STEEL	No REQ'D FOR 12' LANE
	30	-3	UPPER BOLT	5/8" DIA x 12" LG	STEEL	No REQ'D FOR 12' LANE
	1	-2	EXPANDO-SEAL	8" WIDE x 12 FT LONG 12" WIDE x 12 FT LONG	18-GAGE - GALV STL 1/16 THK - NEOPRENE	HOBART BROS. No. 1 14 TH ST. SAN FRANCISCO
	6	-1	CASTING	48" LG (6-REQ'D PER 12-FT LANE)	SEE NOTE 1	

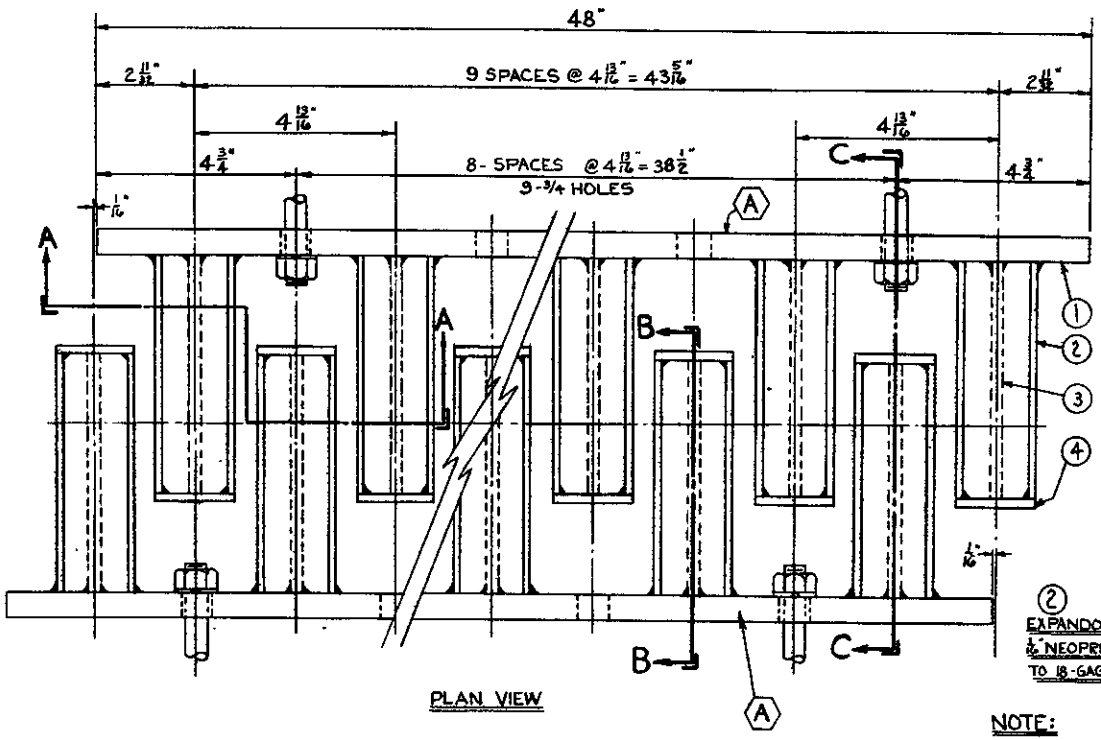
LIST OF MATERIAL

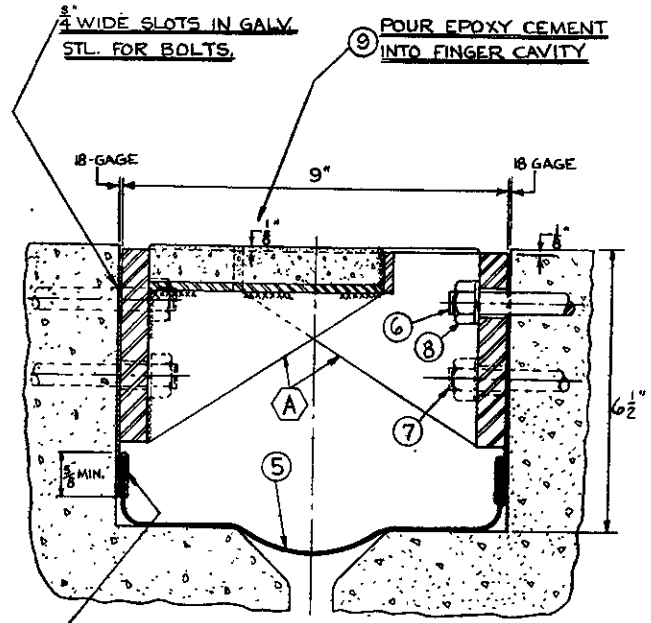
DO NOT SCALE DWG	SCALE HALF	DATE	BRIDGE DECK EXPANSION JOINT CAST TYPE
DIMENSION LIMITS UNLESS OTHERWISE SPECIFIED ARE 0.0 Equals ± .125; 0.00 Equals ± .015; 0.000 Equals ± .005	DRAWN	12-7-62	STATE OF CALIFORNIA DIVISION OF HIGHWAYS MATERIALS AND RESEARCH DEPT.
	CHECKED		
	CH DRFTS.	12-11-62	
	SUBMITTED		
NEXT ASSEMBLY—DWG. No	APPROVED	12-17-62	SHEET 1 OF 2 SHEETS
REVISED BY / DATE	APPROVED J. H. McHenry MATERIALS AND RESEARCH ENGINEER		C-515

6264 56 R

REFERENCE DWG. D-4-58

Figure 7

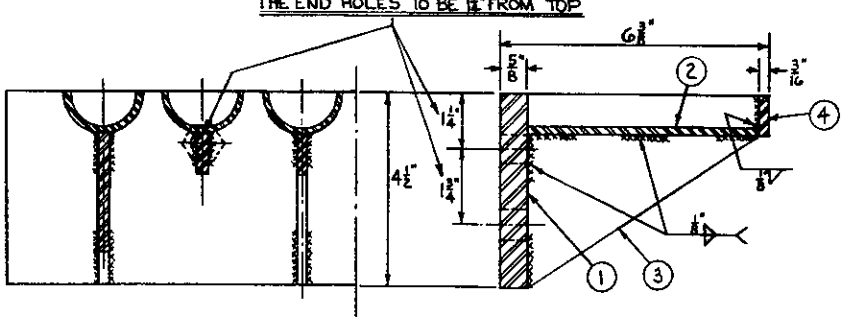




NOTE:

1. WELDMENT TO BE SQUARE WITHIN ± 1/8"
2. THE EXPANSION JOINT SHALL CONFORM TO THE PROVISIONS IN STD. SPECS. SECTION 51.
3. EXPANDO-SEAL TO BE BONDED TOGETHER BY VENDER.
4. MATERIAL TO BE STRUCTURAL STEEL A-36 ——— UNLESS OTHERWISE SPECIFIED

9-3/4 HOLES
ALTERNATE HOLES 1 1/4" ℄ 3" FROM TOP
THE END HOLES TO BE 1 1/4" FROM TOP



MATERIAL REQ'D. FOR 12' LENGTH.

ASSEM.	No. REQ.	PART No	DESCRIPTION	STOCK SIZE	MATERIAL	HEAT TREAT
		-9	EPOXY (ADD SAND TILL STIFF)	TWO PARTS: CIBA 6-24 RESIN & CATALYST DMP-30 - 85%	2 PARTS: 1 PART 96 SC CARBON BLACK, 1 PART TIDE	
	54	-8	NUT	5/8" DIA. HEX HD 13 NC	STEEL (No. REQ'D FOR 12' LANE)	LOCK WASHER
	24	-7	LOWER BOLT	5/8" DIA x 10" LG	STEEL	No. REQ'D FOR 12' LANE
	30	-6	UPPER BOLT	5/8" DIA. x 12" LG.	STEEL	No. REQ'D FOR 12 LANE
	1	-5	EXPANDO-SEAL	8" WIDE x 12 FT LONG 12" WIDE x 12 FT LONG	18-GAGE - GALV. STL. VIB. THK. - NEOPRENE	ROBERT DEED No 1 METEF. BONTEMPELLIER
	10	-4	END	3/16" x 1" x 2"	STEEL	
	10	-3	GUSSET	1/4" x 3 1/2" x 5 1/2"	STEEL	
	10	-2	PIPE (1.900 O.D. x 1.610 I.D.)	1 1/2" DIA STD. PIPE (CUT IN TWO)	SEAMLESS STL. BLACK PIPE	ASTM A-53 GRADE B
	1	-1	PLATE	5/8" x 4 1/2" x 48"	STEEL	
A	6		WELDMENT	48" LG (6 REQ'D FOR 12' LANE)		

LIST OF MATERIAL

DO NOT SCALE DWG.	SCALE HALF	DATE	BRIDGE DECK EXPANSION JOINT STRUCTURAL TYPE.
DIMENSION LIMITS UNLESS OTHERWISE SPECIFIED ARE 0.0 Equals ± .125; 0.00 Equals ± .015; 0.000 Equals ± .005	DRAWN C. Eunkenter	12-7-62	
	CHECKED		
	CH. DRFTS.		
	SUBMITTED		
NEXT ASSEMBLY—DWG. No.	APPROVED	12-17-62	STATE OF CALIFORNIA DIVISION OF HIGHWAYS MATERIALS AND RESEARCH DEPT.
REVISED BY / DATE	APPROVED (MATERIALS AND RESEARCH ENGINEER)		SHEET 2 OF 2 SHEETS C-515

6264-56R

REFERENCE DWG D-458

Figure 8

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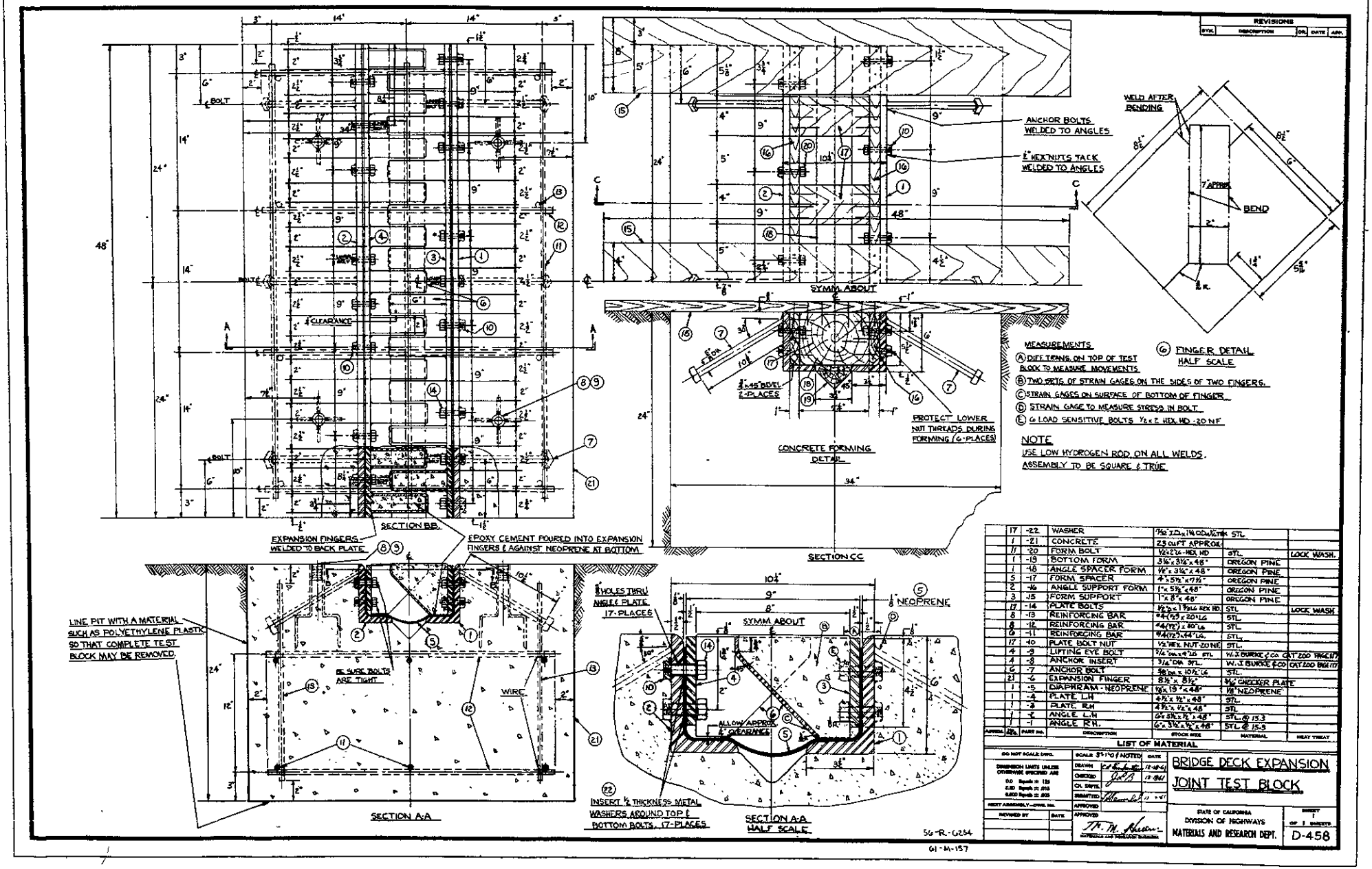
SECTION BB
EXPANSION FINGERS WELDED TO BACK PLATE
EPOXY CEMENT POURED INTO EXPANSION FINGERS & AGAINST NEOPRENE AT BOTTOM
LINE PIT WITH A MATERIAL SUCH AS POLYETHYLENE PLASTIC SO THAT COMPLETE TEST BLOCK MAY BE REMOVED.
BE SURE BOLTS ARE TIGHT
WIRE
SECTION A-A
SYMM ABOUT
ANCHOR BOLTS WELDED TO ANGLES
1" HEX NUTS TACK WELDED TO ANGLES
CONCRETE FORMING DETAIL
PROTECT LOWER NUT THREADS DURING FORMING (6-PLACES)
SECTION CC
WELD AFTER BENDING
BEND
FINGER DETAIL HALF SCALE
MEASUREMENTS
(A) DIFF. TRANS. ON TOP OF TEST BLOCK TO MEASURE MOVEMENTS
(B) TWO SETS OF STRAIN GAGES ON THE SIDES OF TWO FINGERS.
(C) STRAIN GAGES ON SURFACE OF BOTTOM OF FINGER.
(D) STRAIN GAGE TO MEASURE STRESS IN BOLT.
(E) 6 LOAD SENSITIVE BOLTS 1/2 x 2 HEX. HD. -20 NF
NOTE
USE LOW HYDROGEN ROD ON ALL WELDS.
ASSEMBLY TO BE SQUARE & TRUE
1/8" HOLES THRU ANGLE & PLATE 17-PLACES
1/8" NEOPRENE
ALLOW APPROX. 1/8" CLEARANCE
INSERT 1/8 THICKNESS METAL WASHERS AROUND TOP & BOTTOM BOLTS, 17-PLACES
SECTION A-A HALF SCALE
REVISIONS
LIST OF MATERIAL
BRIDGE DECK EXPANSION JOINT TEST BLOCK
STATE OF CALIFORNIA DIVISION OF HIGHWAYS MATERIALS AND RESEARCH DEPT.
D-458
56-R-6254
61-M-157

Figure 9