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STATIC LOAD DEFLECTION TESTS ON VARIOUS TYPES OF DEEP BEAM GUARD RAILS

by

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STATIC LOAD DEFLECTION TESTS ON VARIOUS TYPES OF DEEP BEAM GUARD RAILS

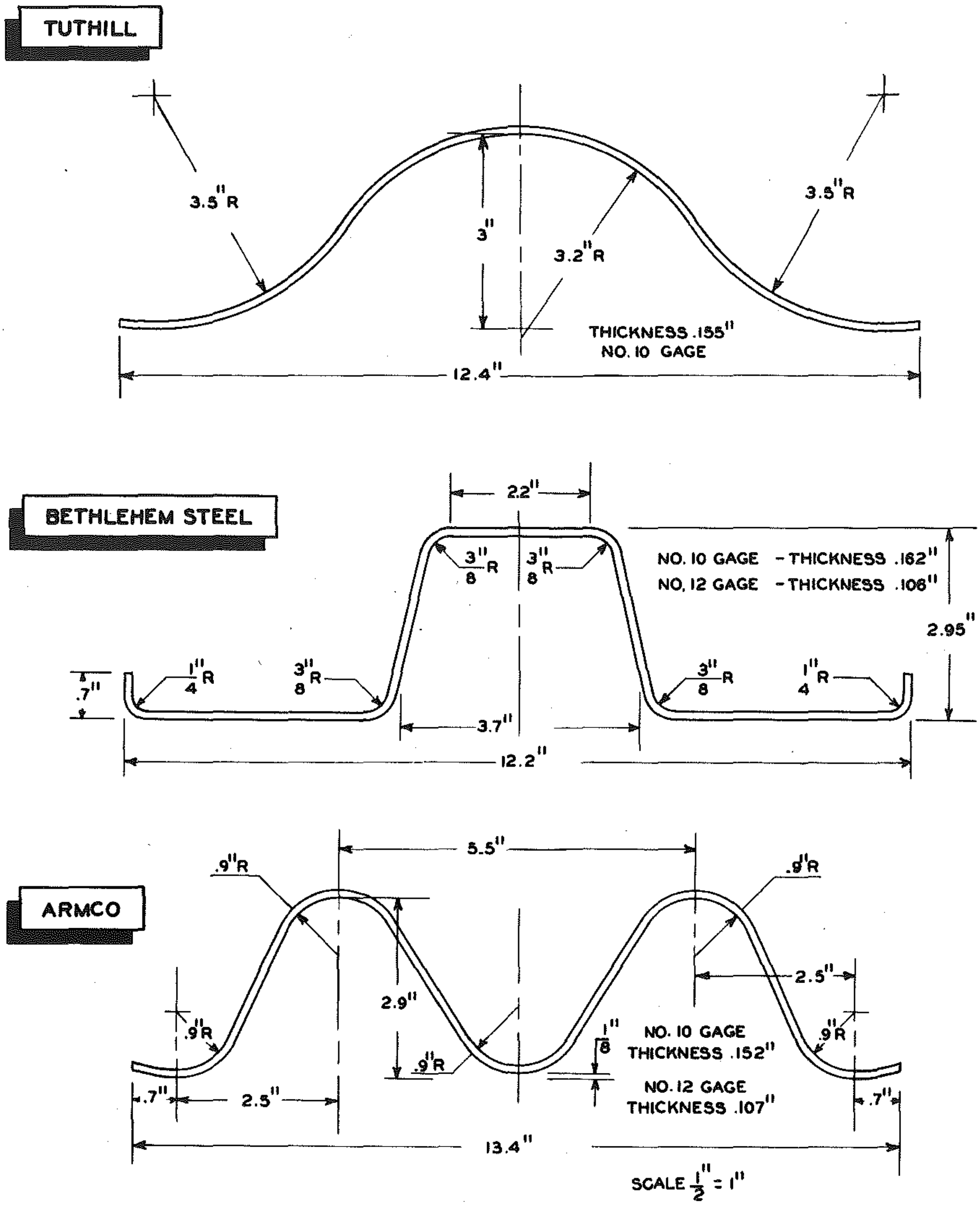
At the request of the Construction Division, static load deflection tests and tensile tests were to be made on samples of deep beam type guard rails and rail joints submitted by the Tuthill Spring Co. Subsequently, this study was expanded to include samples of deep beam guard rails from Armco D. & M. Products Inc. and the Bethlehem Steel Co. In the case of the latter two manufacturers, rail joints for tensile tests were not furnished. The results of the tensile test performed on the Tuthill rail joint appear herein, but for the most part this study was concerned with the determination and evaluation of static load deflection characteristics of the various types of deep beam guard rails.

SPECIMENS:

Samples of deep beam guard rails which were submitted for load deflection tests appear below:

Manufacturer	Quantity	Thickness (Gage)
Tuthill Spring Co.	1	10
Armco D. & M. Products	2	12
Armco D. & M. Products	2	10
Bethlehem Steel Co.	1	12
Bethlehem Steel Co.	1	10

Cross sections of each of the three manufacturers' types of guard rails are depicted in Figure 1.



CROSS SECTIONS OF DEEP BEAM
GUARD RAIL SPECIMENS

FIGURE 1

TEST PROCEDURE:

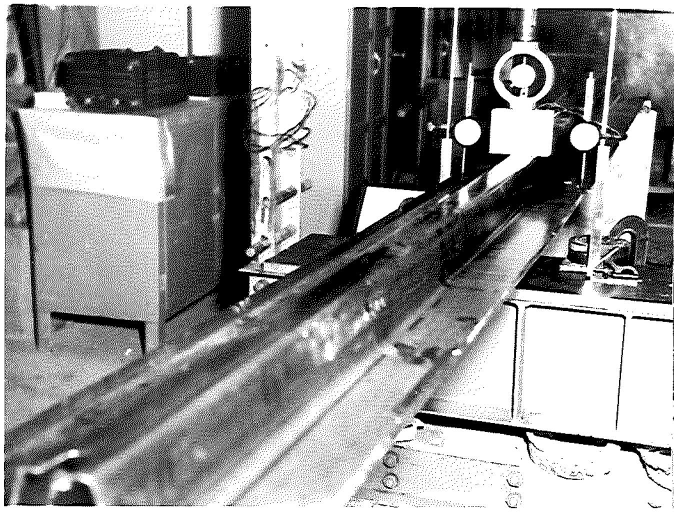
Three of the specimens, an Armco 10 gage, and Armco 12 gage, and a Bethlehem 10 gage were loaded traffic face down. The other four specimens were loaded traffic face up. Each of the seven test specimens was simply supported on inverted angle sections, with a span length center to center of supports of 12' - 0". The load was applied at the center of the span through straight wooden bearing blocks. No attempt was made to provide complete lateral contact between the bearing block and the specimen under test. However, as much of each specimen was loaded laterally as was possible.

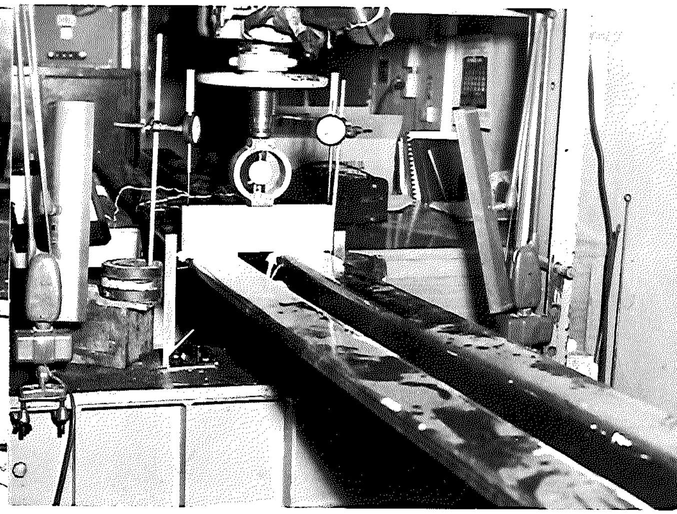
A one-thousandths inch dial and a scale divided in 1/32 inch increments were placed on each side of the specimen at the center of the span.

Two SR-4 type strain gages were mounted on the surface of each specimen at a point four feet from one end support. The testing set up for each type of guard rail is shown in Figure 2.

Each specimen was then loaded in increments of 200 pounds, returning to zero load after each successive increment, that is, 0-200 pounds, 0-400 pounds, 0-600 pounds, etc. until failure occurred.

The center deflection and permanent set were obtained using the average of the two dial readings, and the two scale readings, for each increment of load. Strains were recorded for each increment of load, and by assuming a modulus of elasticity of 29×10^6 psi, and using elastic beam theory, values of moment of inertia, and section modulus for each specimen were determined. The dimensions and physical properties, as obtained experimentally and analytically, of each of the test specimens are shown in Table 1.





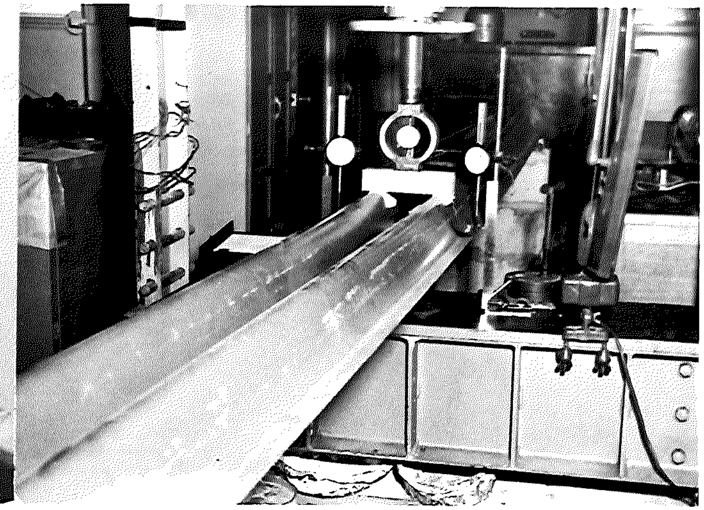


FIGURE 2A. TEST SET UP SHOWING BETHLEHEM DEEP BEAM GUARD RAIL LOADED TRAFFIC - FACE UP.

FIGURE 2B. TEST SET UP SHOWING BETH - LEHEM DEEP BEAM GUARD RAIL LOADED TRAFFIC - FACE DOWN.

FIGURE 2C. TEST SET UP SHOWING ARMCO DEEP BEAD GUARD RAIL LOADED TRAFFIC-FACE UP.

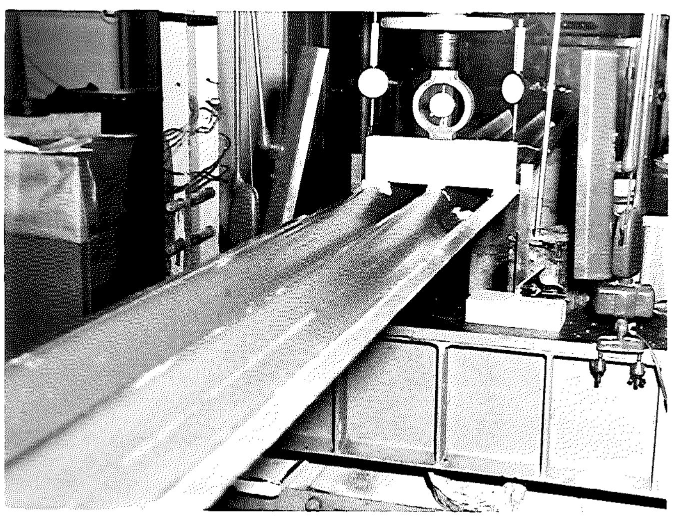


FIGURE 2D. TEST SET UP SHOWING ARMCO DEEP BEAM GUARD RAIL LOADED TRAFFIC-FACE DOWN.

FIGURE 2E. TEST SET SHOWING TUTHILL DEEP BEAM GUARD RAIL LOADED TRAFFIC-FACE UP.

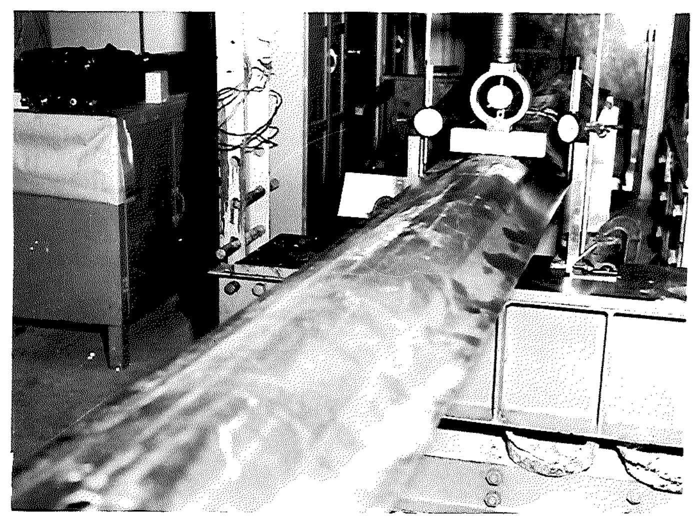


TABLE 1

DIMENSIONS AND PHYSICAL PROPERTIES

MANUFACTURER	Thickness (Gage)	Length (Ft.)	Wt. Per Linear Ft.	Mfgr's. Section Modulus Cu. In.	Experimental		Analytical		Test Position
					Section Modulus Cu. In.	Moment of Inertia	Section Modulus Cu. In.	Moment of Inertia	
Tuthill Spring Co.	10	13	7.2	1.54	1.19	1.90	1.48	2.09	TFU[1]
Armco D & M Products	12	13.5	7.17	1.37	1.40	2.27	1.41	2.29	TFU
Armco D & M Products	10	13.5	9.07	1.64	1.67	2.74	1.72	2.78	TFU
Bethlehem Steel Co.	12	12.5	6.17	*	1.05	1.93	1.16	2.38	TFU
Armco D & M Products	12	13.5	7.17	1.37	1.39	2.27	1.41	2.29	TFD[2]
Armco D & M Products	10	13.5	9.07	1.64	1.62	2.74	1.72	2.78	TFD
Bethlehem Steel Co.	10	12.5	6.17	*	1.00	2.40	1.77	3.64	TFD

* Unavailable

[1] TFU Traffic Face Up

[2] TFD Traffic Face Down

TABLE 2

LOAD DEFLECTION AND PERMANENT SET OF GUARD RAIL
(TRAFFIC FACE DOWN)

LOAD	ARMCO (12 gage)		ARMCO (10 gage)		BETHLEHEM (10 gage)	
	Defl.	Set	Defl.	Set	Defl.	Set
(lb)	(in.)	(in.)	(in.)	(in.)	(in.)	(in.)
0	0	0	0	0	0	0
200	0.19	0	0.16	0	0.20	0
400	0.38	0	0.32	0	0.34	0
600	0.56	0	0.47	0	0.50	0.03
800	0.72	0	0.59	0	0.67	0.06
1000	0.92	0	0.77	0	0.85	0.10
1200	1.11	0	0.91	0	1.12	0.16
1400	1.29	0.01	1.03	0	1.30	0.22
1600	1.50	0.02	1.21	0	1.57	0.32
1800	1.72	0.04	1.36	0	1.82	0.46
2000	1.94	0.06	1.52	0.01	2.16	0.63
2200	2.19	0.12	1.73	0.03	2.53	0.81
2400	2.46	0.22	1.90	0.06	2.70	1.12
2600	3.06	0.47	2.09	0.09	4.16*	2.40*
2800	4.54*	1.14*	2.28	0.13	*For max. load of 2440#	
	*For max. load of 2720#					
3000			2.46	0.17		
3200			2.67	0.21		
3400			2.90	0.34		
3600			3.43	0.55		
3800			4.23*	1.09*		
			*For max. load of 3760#			

TABLE 3

LOAD DEFLECTION AND PERMANENT SET OF GUARD RAIL
(TRAFFIC FACE UP)

LOAD	TUTHILL (10 gage)		ARMCO (12 gage)		ARMCO (10 gage)		BETHLEHEM (12 gage)	
	Defl.	Set	Defl.	Set	Defl.	Set	Defl.	Set
(lb)	(in.)	(in.)	(in.)	(in.)	(in.)	(in.)	(in.)	(in.)
0	0	0	0	0	0	0	0	0
200	0.30	0	0.22	0	0.19	0	0.23	0
400	0.47	0	0.41	0	0.37	0	0.47	0
600	0.72	0	0.59	0	0.51	0	0.69	0
800	1.01	0	0.76	0	0.65	0	0.87	0
1000	1.28	0	0.95	0	0.85	0	1.11	0.02
1200	1.47	0.01	1.12	0	0.98	0	1.32	0.05
1400	1.67	0.04	1.29	0	1.11	0	1.52	0.09
1600	2.03	0.10	1.50	0.01	1.29	0.01	1.80	0.16
1800	2.40	0.20	1.69	0.02	1.46	0.03	2.00	0.25
2000	2.80	0.45	1.86	0.04	1.59	0.04	2.23	0.41
2200	3.39*	0.84*	2.15	0.08	1.76	0.06	2.80	0.81
2400	*For max. load of 2060#		2.30	0.12	1.90	0.08	3.00*	1.27*
2600			2.55	0.19	2.06	0.10	*For max. load of 2280#	
2800			2.86	0.30	2.23	0.11		
3000			3.20	0.46	2.33	0.16		
3200			3.95	0.93	2.56	0.21		
3400			4.58*	1.44*	2.71	0.27		
3600			*For max. load of 3260#		2.83	0.32		
3800					2.99	0.41		
4000					3.33	0.55		
4200					3.55	0.70		
4400					4.03	1.06		
4500					4.39	1.40		

TABLE 4

MAXIMUM LOAD OF GUARD RAIL

MANUFACTURER	THICKNESS (GAGE)	TESTED	MAXIMUM LOAD
Tuthill Spring Co.	10	Traffic face up	2060#
Armco D. & M. Products	12	Traffic face up	3260#
Armco D. & M. Products	10	Traffic face up	4500#
Bethlehem Steel Co.	12	Traffic face up	2280#
Armco D. & M. Products	12	Traffic face down	2720#
Armco D. & M. Products	10	Traffic face down	3760#
Bethlehem Steel Co.	10	Traffic face down	2440#

TABLE 5

RELATIVE MAXIMUM LOAD CAPACITY OF GUARD RAIL

MANUFACTURER	THICKNESS (GAGE)	STIFFNESS	MAX. LOAD CAPACITY
Tuthill Spring Co.	10	1.0	1.0
Armco D. & M. Products	10	1.55	2.18
Armco D. & M. Products	12	1.33	1.58
Bethlehem Steel Co.	12	1.12	1.11

RESULTS:

Pictures of some of the specimens after failure are shown in Figure 3. These pictures show the permanent set and buckled condition of the compression flange of those specimens loaded traffic face down.

All of the load deflection and permanent set data for each of the specimens loaded traffic face up and traffic face down have been prepared in graphical and tabular form in Figures 4A, 4B, and Tables 2 and 3.

The maximum load attained by each of the seven specimens is shown in Table 4.

For those specimens loaded traffic face up, Table 5 shows the relative stiffness and relative maximum load capacity of each. In this table the stiffness and load capacity of the Tuthill specimen is taken as unity.

The effect of having the outstanding flange of the specimens in compression reduces their maximum load carrying capacity. In the case of the Armco 10 gage and the Armco 12 gage, this reduction amounted to 16.5 percent.

Tensile Test of Tuthill Bolted Joint Connection

This joint attained a maximum load of 81,500 pounds with some yielding of the connection occurring at loads of 12,200 and 17,700 pounds. The permanent separation of the joint was 1.28 inches after the ultimate load was applied.

DISCUSSION OF RESULTS:

Present Michigan State Highway Department specifications concerning deep beam type guard rails would allow the use of the Tuthill Spring Co. product. The Bethlehem Steel Co. product has a cross section that is not covered in these specifications. From data submitted by Armco, their rail joint splice would not meet the ultimate tensile strength specified. However, the specimens submitted by Bethlehem and Armco in both

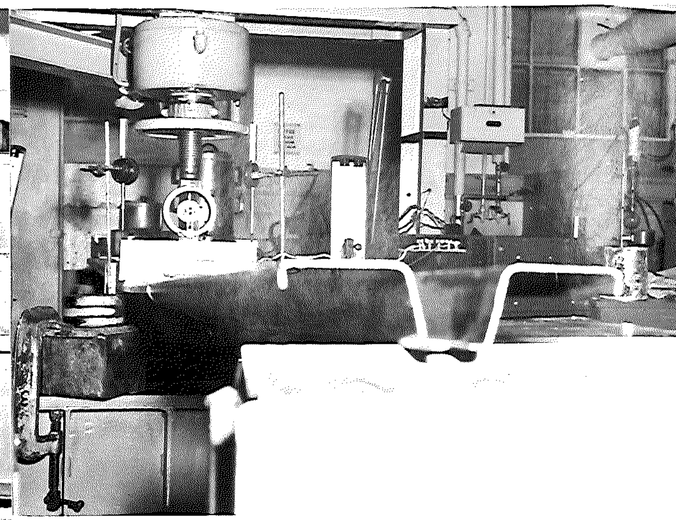


FIGURE 3B. BETHLEHEM DEEP BEAM GUARD RAIL, LOADED TRAFFIC-FACE DOWN, SHOWING BUCKLED COMPRESSION FLANGE AT FAILURE.

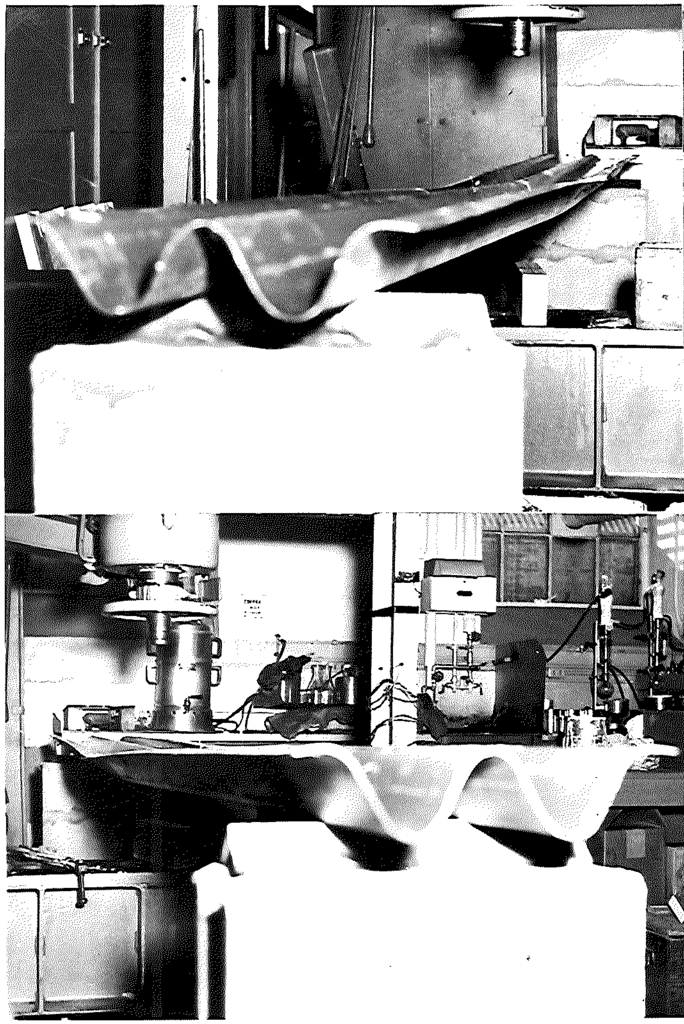


FIGURE 3A. ARMCO DEEP BEAM GUARD RAIL, LOADED TRAFFIC-FACE DOWN, SHOWING BUCKLED COMPRESSION FLANGE AT FAILURE.

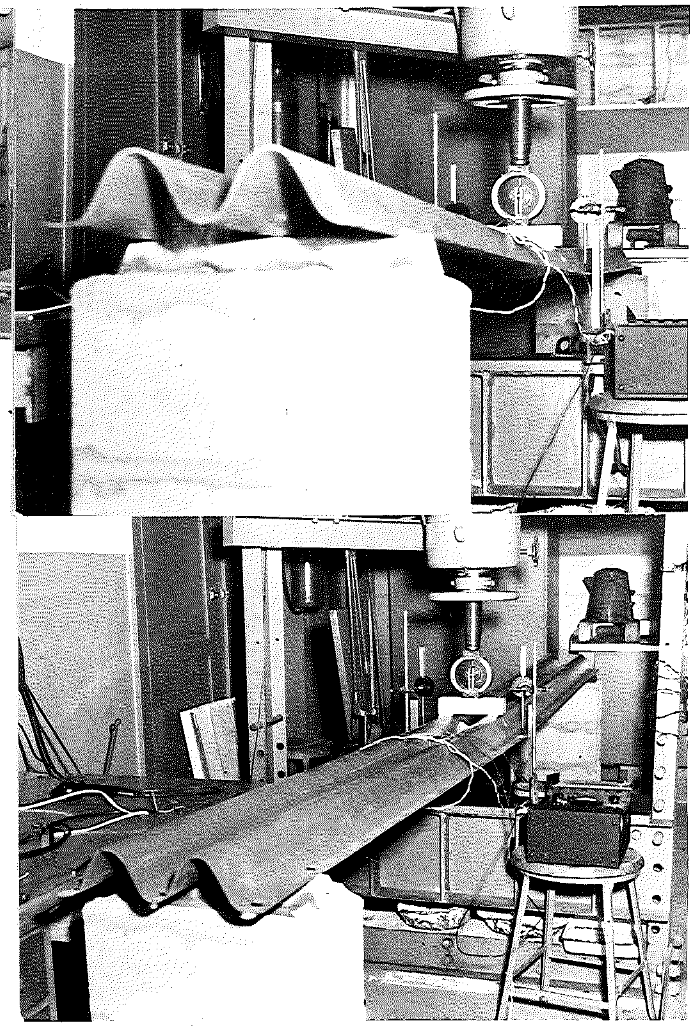


FIGURE 3C. ARMCO DEEP BEAM GUARD RAIL, LOADED TRAFFIC-FACE UP SHOWING PERMAMENT SET AT FAILURE.

the 10 gage and the 12 gage are stiffer than the Tuthill product, due to the shape of these cross sections which develop a greater moment of inertia.

In order to ascertain the most desirable flexibility or stiffness of guard rail that should be utilized, a comprehensive dynamic series of testing should be carried out. Such things as angle of impact, the degree of continuity afforded by the rail splices, and the stability of the posts are factors that would not be readily determined by analytical means or static testing procedures.

It appears that the present specifications concerning deep beam type guard rails should be revised, but a change based on this study is not warranted.

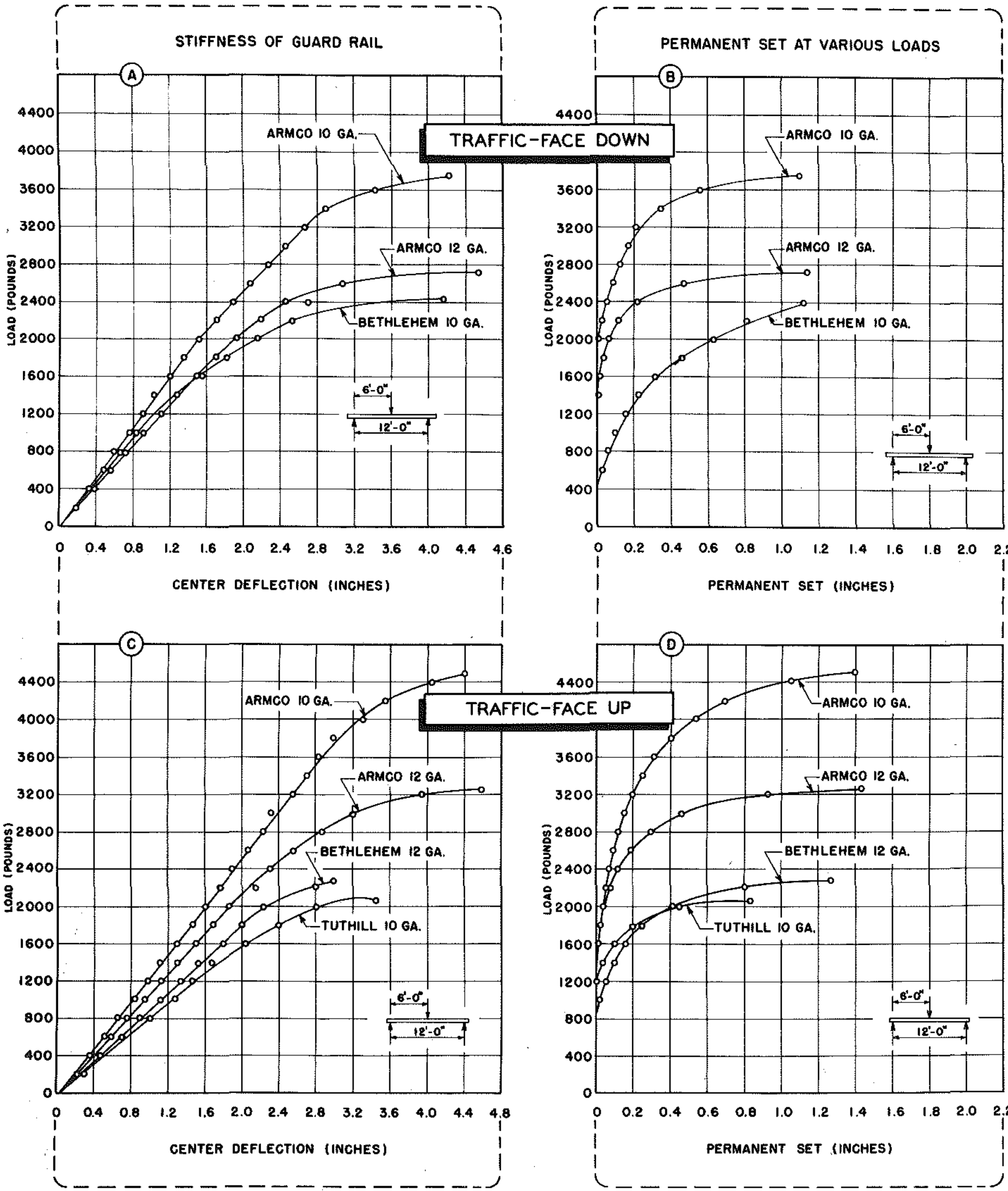


FIGURE 4. STIFFNESS AND PERMANENT SET
OF GUARD RAIL FOR VARIOUS LOADS