TESTING OF ALUMINUM ALLOY DEEP BEAM GUARD RAIL

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The first testing and evaluation of steel deep beam guard rail by the Research Laboratory was conducted at the request of the Construction Division in 1955. This evaluation was made in order to determine the physical properties, static deflection and tensile strength, of four different cross-sections of guard rail produced by four manufacturers. The results of this testing were discussed in Research Laboratory Report No. 232. After the various manufacturers standardized on one type of deep beam guard rail section, the MSHD specifications were revised along with that of other states. Testing was then conducted to determine if all manufacturers' guard rail would meet these specifications. The information on these tests have been distributed in Report No. 265. As a continuation of this project, recent tests have been conducted on several aluminum alloy guard rails to obtain information on their physical properties.

The following is a report of the results of static load-deflection tests and tensile splice tests made on three different aluminum alloy deep beam guard rail elements. Three specimens each of alloy 6061-T6 and alloy 5155-H34 were submitted by the Reynolds Metal Co. through the

Syro Steel Co. as fabricator, and three specimens of alloy 2024-T3 were submitted by the Aluminum Co. of America.

The test procedures were the same as outlined in Report No. 232 "Static Load Deflection Tests on Various Types of Deep Beam Guard Rails."

The general cross sectional shape of the rails is the same as the manufacturer's standard steel deep beam guard rail. Load-deflection curves for rails tested traffic face up and traffic face down are shown in Figure I. Figures 2 and 3 show typical rail splice failures as a result of the tension tests. Table I outlines the results and physical characteristics of the three different alloys tested along with the physical requirements presently specified for steel deep beam guard rails.

Summary

In comparing the aluminum guard rail tested to the tensile and stiffness requirements for steel beam guard rail, the following observations can be made:

1. Aluminum alloy 2024-T3 with 10 gage rail thickness exceeded tensile requirements.
2. Aluminum alloys 6061-T6 and 5155-H34 with 12 gage rail thickness failed to meet tensile requirements. (Test results would indicate that if the rail thicknesses of these alloys were increased to 10 gage they would still have failed to meet tensile requirements.)

3. All aluminum alloys, and of either 10 or 12 gage rail thickness, failed to meet the deflection limitations which are required for steel beam guard rail.

General Considerations

As mentioned in a previous report, static testing of deep beam guard rail cannot establish the optimum flexibility, or stiffness, the proper tensile strength requirements and the proper interaction between guard rail and guard posts. Dynamic testing is required to develop design criteria for these considerations. Thus the appropriateness of comparing static strength and stiffness of aluminum guard rail to the requirements established for steel guard rail, is at least open to question.

On the basis of certain assumptions, however, an analytical comparison can be made of the behavior of a steel and aluminum beam under dynamic loading. The following assumptions were made in this analysis in addition to the normal assumptions for beam analysis:

1. Perfectly elastic impact, all energy absorbed by member in bending without loss in energy due to heat.
2. All energy absorbed by guard rail, guard posts are considered fixed.
3. Stress in guard rail is not beyond proportional limit.
4. Mass of guard rail is negligible in comparison with mass of object causing impact on guard rail.

If a beam be subjected to an impact loading and if the impact is assumed to be perfectly elastic, that is, the beam absorbs all of the energy during impact, it can be shown that the maximum deflection and maximum stress induced in the beam are inversely proportional and directly proportional respectively to the modulus of elasticity. Thus, for a steel and an aluminum beam of the same shape, subjected to the same impact loading, the maximum deflection of the aluminum beam would be approximately 1.7 times as much as the steel beam, while the maximum stress in the aluminum beam would be approximately 0.6 as much as the steel beam stress.

TABLE 1

PHYSICAL CHARACTERISTICS OF GUARD RAIL SECTIONS

Item	Reynolds Metal - Syro Steel		Alcoa Alloy 2024-T3	MSHD Spec. for Steel Beam Guard Rail
	Alloy 6061-T6	Alloy 5155-H34		
Shape	Mfgr's. Std.	Mfgr's. Std.	Mfgr's. Std.	12 in. Wide Min., 3 in. Deep Min.
Thickness	0.105 in. (12 ga.)	0.105 in. (12 ga.)	0.130 in. (10 ga.)	12 Ga. Min.
Length	13 ft 6 1/2 in.	13 ft 6 1/2 in.	13 ft 6 1/2 in.	
Weight	30.9 lbs	31.2 lbs	40.5 lbs	
Wt. /ft	2.28 lbs	2.31 lbs	2.99 lbs	
Finish	Sq. Edges, no Appreciable Projections	Sq. Edges, no Appreciable Projections	Sq. Edges, no Appreciable Projections	Rolled or Rounded, No Appreciable Projections
Splice Bolts	101-6 HR Steel	101-6 HR Steel	2024-T4 Aluminum	
Ult. Tensile Load of Rail Splice	56,600 lbs	51,700 lbs	98,800 lbs	80,000 lbs
Type of Splice Failure	Bearing	Bearing	Tensile	
Load-Deflection Test (Traffic Face Up)	4.8 in. at 1500 lbs	4.0 in. at Max. Load of 1200 lbs	3.3 in. at 1500 lbs	2 3/4 in. Max. at 1500 lbs
Load-Deflection Test (Traffic Face Down)	3.3 in. at Max. Load of 800 lbs	3.0 in. at Max. Load of 900 lbs	2.4 in. at 1200 lbs	2 3/4 in. Max. at 1200 lbs

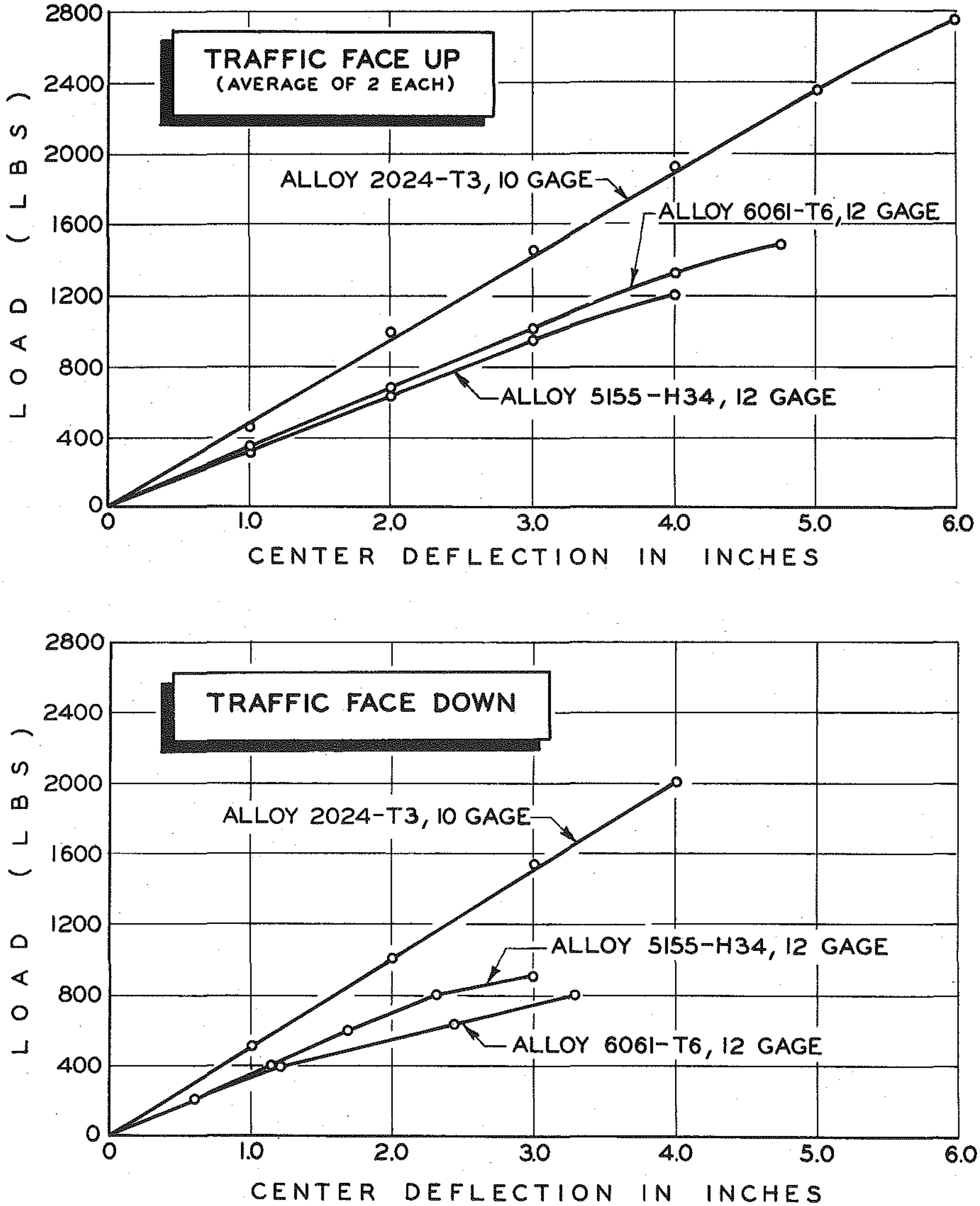

Figure I. Load deflection curves.

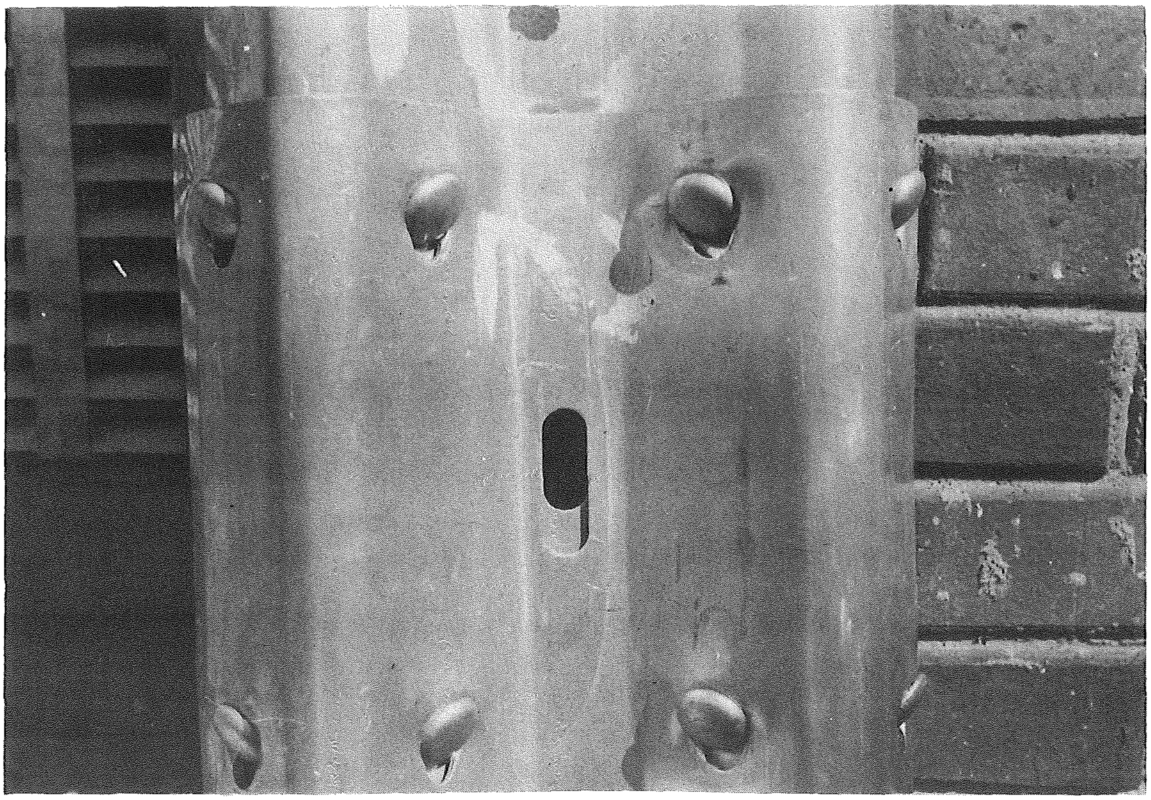

Figure 2 - Typical rail splice failure.
Aluminum alloys - 6061-T6 and 5155-H34 with 12 gage thickness.

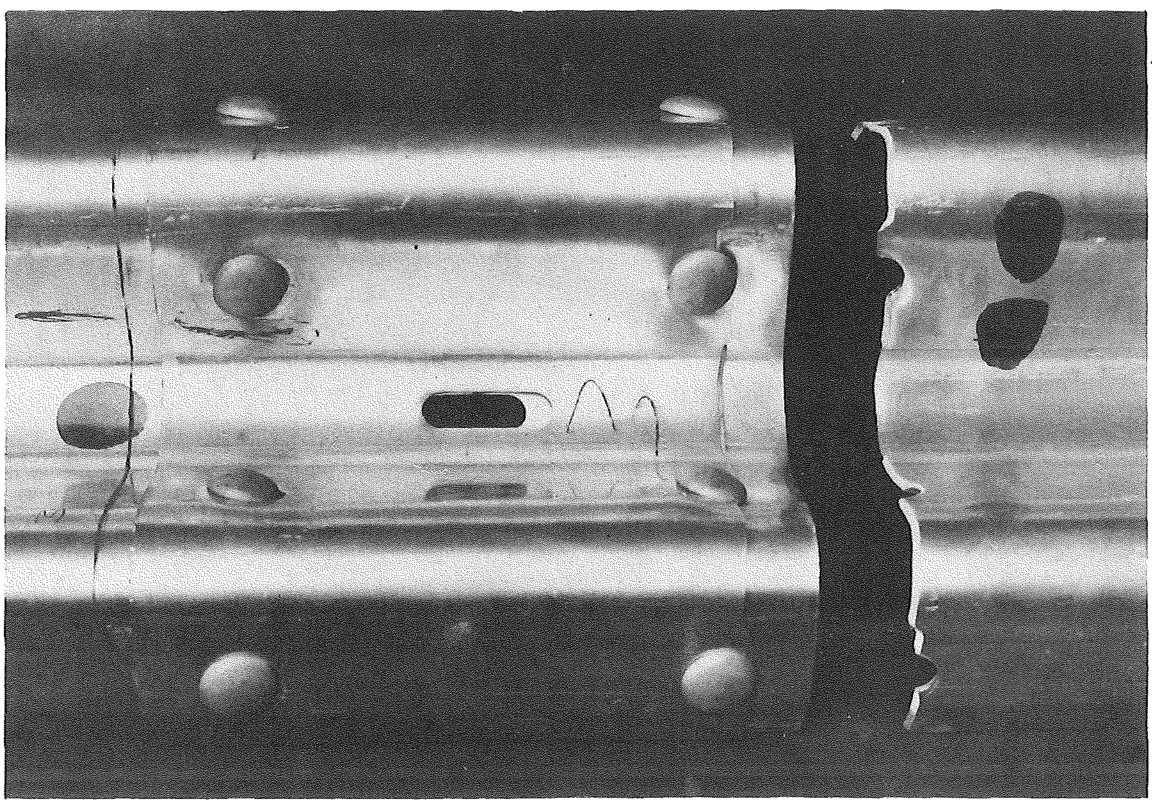

Figure 3 - Typical rail splice failure.
Aluminum alloy 2024-T3 with 10 gage thickness.