

Loading Spectrum of Bridges Under Current Loading Environment,

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Summary

The Association of American Railroads (AAR) is developing guidelines for assessing and extending the life of steel railroad bridges. As a part of the process, the AAR quantified the current loading environment on five steel bridges by measuring dynamic car, truck, wheel, and axle loads under revenue service freight traffic conditions. The traffic included unit trains of coal, ballast and potash, and mixed freight cars, various intermodal cars, autorack cars, and 4- and 6-axle locomotives. Significant results are:

- A substantial data base of bridge loadings has been established.
- Dynamic loads measured on bridges exceed nominal static car weight in many cases.
- Highest loads were generated by 110-ton coal cars.
- Maximum dynamic loads are approaching the current static design loading.
- High loads affect floor systems and short spans more than main girders or trusses.

Results from these tests are being used in the development of fatigue life models for steel railroad bridges. Results may vary depending on bridge types, traffic, and operating conditions on a particular line.

Suggested Distribution:

- Bridges and Roadway
- Maintenance Planning
- Track Maintenance
- Research & Development



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INTRODUCTION AND CONCLUSIONS

To assess the life of a steel bridge and determine the best method for strengthening requires a thorough knowledge of its load environment. The Association of American Railroads (AAR) measured dynamic loads induced in railroad bridges by typical North American freight traffic. The traffic included mixed freight, high speed intermodal, autorack and unit trains carrying different commodities. Four of the five bridges tested carried mixed freight, four carried intermodal traffic with several configurations, three carried coal, one carried potash, and one carried ballast. The wheel loads described were measured at center span at rail level on five riveted steel railway bridges. Measurements include impact effects due to vehicle/track/bridge dynamics and wheel and rail irregularities. All measurements were taken under normal operations with 4- and 6-axle locomotives. A total of 40,242 cars and locomotives were measured for a total of 4.3 million gross tons (MGT) of traffic.

Two standards serve as comparisons to evaluate the significance of these loads: (1) expected loads produced by an ideal 100-ton car, and (2) the Cooper rating that results from a train containing a car, truck, or axle load corresponding to the largest measured loads. The 100-ton car has a static weight of 263,000 pounds. This produces truck, axle, and wheel loads of 131,500 pounds, 65,750 pounds, and 32,875 pounds, respectively. The current Cooper design load is E 80 with maximum axle loads of 80,000 pounds.

Exhibit 1 summarizes the average and maximum loads recorded by commodity. For each car type, an average and maximum load in kips are given along with truck, axle and wheel loads. The largest loads were produced by 110-ton coal cars with the largest car load measuring 339,000 pounds.

The coal traffic contained both 100- and 110-ton cars. Histograms for the 100- and 110-ton car load groupings are given in Exhibits 2 and 3.

Average measured dynamic loads for the 100- and 110-ton coal cars were 255,000 and 282,000 pounds with maximum loads recorded at 337,000 and 339,000 pounds, respectively. Distribution probability curves were developed from the histograms. One percent of the 100-ton coal cars exceeded 295,000 pounds and 5 percent exceeded 284,000 pounds gross rail load. One percent of the 110-ton cars exceeded 304,000 pounds and 5 percent exceeded 298,000 pounds.

Similar but slightly smaller loads were generated by the ballast and potash cars which produced average loads of 277,000 pounds and 274,000 pounds, respectively. One percent of the loads for ballast cars exceeded 297,000 pounds and 1 percent exceeded 290,000 pounds for potash cars.

The range of dynamic loads for mixed freight was much greater than for unit trains. The maximum mixed freight car dynamic load measured 329,000 pounds. Ten of the largest 30 dynamic loads were generated by mixed freight cars. The intermodal and autorack car loads were generally less than 263,000 pounds.

Based on the results, the following conclusions were drawn:

- In general, the 110-ton coal cars produced larger dynamic loads than any other car type measured in this study. Higher loads are expected to cause increases in shear and moment in girders, stringers, and floor beams.
- Measured strains in riveted bridge girders and truss members are smaller than the calculated strains. The maximum live load bending stresses in girder bridges measured for these loads were only about 4.0 to 5.0



ksi. These are lower than 7.0 ksi, which is the fatigue threshold for a typical detail. One explanation for the lower stresses is that the floor system may be sharing some of the loads which are assumed to be carried entirely by the main girders or trusses.

- The maximum dynamic loads measured under current operating conditions on these bridges are approaching the static E-80 loading, currently used for design. Thus, future increases in allowable car loads should be analyzed carefully. In some cases

increases may result in maximum operating loads that are larger than those currently used for design.

- The effects from maximum loads observed are greatest on floor systems of through-girders and through-trusses, which have relatively short spans. They also may be very significant for reinforced concrete and timber spans that are 30 feet or shorter. However, the results indicate that the effect of an isolated large axle or truck load diminishes as the span length increases, unless multiple large loads are on the span.

Exhibit 1. Average and Maximum Dynamic Loads Measured for Commonly Used Equipment

Commodity Cars	Cars		Trucks		Axles		Wheels	
	Avg (kips)	Max (kips)	Avg (kips)	Max (kips)	Avg (kips)	Max (kips)	Avg (kips)	Max (kips)
Coal (100 t)	255	337	127	177	64	109	32	66
Coal (110 t)	282	339	141	180	70	106	35	63
Ballast	277	305	138	162	69	84	35	49
Potash	274	301	136	170	68	95	34	54
Intermodal								
5-Pack	410	846	68	169	34	91	17	56
4-Pack	145	238	72	126	36	68	18	43
2-Pack	74	128	37	68	37	68	18	40
4-Axle Mixed Freight	146	329	73	175	36	95	18	57
Autorack	182	263	91	138	46	71	23	46
6-Axle Loco	413	485	207	247	69	96	34	59
4-Axle Loco	282	362	141	183	71	103	35	52
Intermodals								
10-Pack	700	750	64	95	32	49	16	26
3-Pack	338	357	84	103	42	53	21	29
20-Pack	225	225	75	135	38	68	19	37
6-Pack	159	413	80	207	27	70	13	42
2-Axle	112	175	57	69	57	69	25	36
Empty Coal	56	107	28	71	14	36	7	22
Empty Autorack	116	130	58	68	29	39	15	26

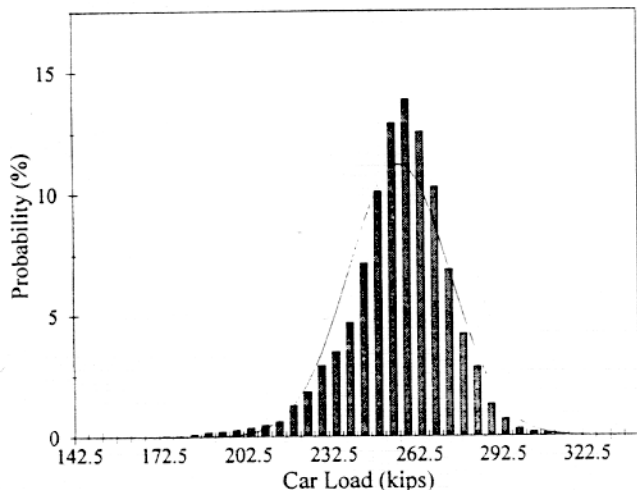


Exhibit 2. Dynamic Car Load Histogram for 100-ton Coal Cars

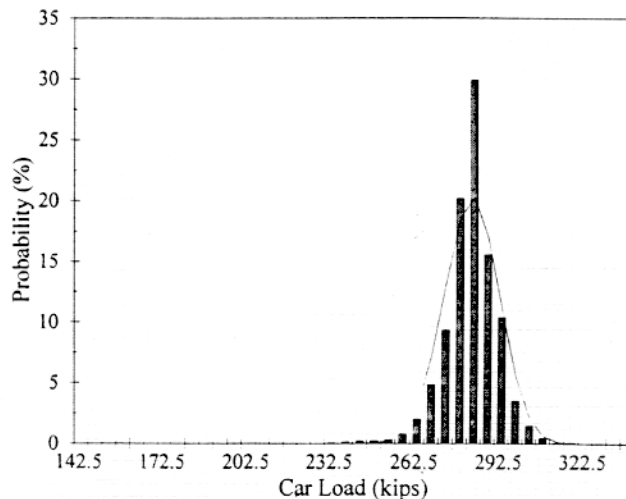


Exhibit 3. Dynamic Car Load Histogram for 110-ton Coal Cars

PROJECT DESCRIPTION

This research began in 1988 as part of a program which focused on evaluation of steel railway bridges.

Research to date is directed toward evaluation of existing bridges, especially bridges of older construction. Most of the existing steel bridges were built before 1940 and many in the late 1890s and early 1900s. Five riveted steel bridges were tested as part of this study. The primary objective was to develop loading spectra for these bridges based on

current operating conditions through field measurements of wheel loads. As a result, wheel, axle, truck, and car loads were measured under revenue traffic on the five bridges tested.

Exhibit 4 lists the type of bridges tested along with the span length, speed limit, and traffic density. Results may vary depending on bridge types, traffic, and operating conditions on a particular line. Data collected from these bridges consisted of loads and bridge response. Information on the response of the structures has been published in previous AAR reports.

Note: Contact Duane Otter at (719) 584-0594 with questions or comments about this document.

Exhibit 4. Bridges where Wheel Loads were Measured and Traffic Type

Bridge Type	Span Length	Speed Limit (mph)	Traffic type & volume (MGT/year)						
			MF	INT	UP	UB	AR	UC	Total
Open Deck Girders	75 & 50	59	17.9	12.6	1.1				31.6
Ballasted Deck Girder	60	59	17.9	12.6	1.1				31.6
Open Deck Girder	80	25	7.1	70					77.1
Through Truss	156	25	5.3	1.3		3.7		8.4	18.7
Through Girder	40	50 Int 60	14.3	3.7			8.5	19.2	45.7

MF - Mixed Freight Int - Intermodal UP- Unit Potash UB - Unit Ballast AR - Auto Rack UC - Unit Coal

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