PRACTICAL BRIDGE LOADING LIMITATIONS IN RELATION TO CURRENT COMMERCIAL VEHICLE TYPES AND BRIDGE DESIGN PRACTICE

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Synopsis

This report is an analytical study to determine practical load limits for commercial vehicles which will be based on a uniform bridge stress level. To accomplish this, the bridge moments on a range of bridge spans from 20 to 200 ft are obtained for a short wheelbase and long wheelbase vehicle of each commercial type. These moments are compared with bridge design moments for four design loads, and the axle loads on each vehicle are reduced when necessary for each design to permit no design overstress on the most critical bridge span length. The moments resulting from heavily loaded vehicles permitted to travel by special permit and from earthmoving equipment are also investigated.

Comparisons are also made between the gross vehicle loads for all vehicle types as limited by design stress and as limited by application of the Bridge Formula. With ratios of dead load to live load as determined from Michigan bridge designs, working stresses are compared to design stresses for all vehicle types when legally loaded in order to determine the overstress which would result.

Finally, a simple method for setting legal limits for bridges is presented, based on axle load and gross load limits which, considering its simplicity, is in reasonable agreement with bridge design levels.

The information presented here is one phase of the Research Laboratory Division's Project R-55 F-45, as outlined briefly in material submitted June 12, 1961, by E. A. Finney to W. W. McLaughlin, covering a long-range research program providing for application of AASHO Road Test findings as appropriate for Michigan.

The primary purpose of this study is to develop a simple and practical method of determining highway truck loading limitations that are realistic in terms of bridges now existing and currently being designed. The problem of such limitations is complicated by the basic design differences between pavements and bridges. The urgency of developing a uniform national policy for limiting truck loading is apparent from Table 1, which tabulates lengths, axle loads, and practical maximum gross weights for various types of vehicles, by States. The complexity of the regulations is apparent, and yet the various States are designing bridges with standard vehicle loadings. Thus, the disparity among States is not one of design,

TABLE 1
SUMMARY OF LEGAL MAXIMUM VEHICLE LENGTHS, AXLE LOADS, AND PRACTICAL GROSS WEIGHTS
Bureau of Public Roads, July 1, 1960

State	Length, ft(1)			Axle Load, lb Statutory Limit		Practical Maximum Gross Weight, lb(2)					
	Trucks	Truck Tractor Semitrailer	Other Combinations	Single	Tandem	Truck 2-Axle	Truck 3-Axle	Truck-Tractor Semitrailer 3-Axle	Truck-Tractor Semitrailer 4-Axle	Truck-Tractor Semitrailer 5-Axle	Other Combinations(3)
Region I - North Atlantic States											
Connecticut	50	50	NP	22,400	36,000	30,848	44,720	51,000	61,200	61,200	NP
Delaware	40	50	60	20,000	36,000	28,000	48,000	48,000	56,350	60,000	60,000
Washington, D. C.	35	50	80	22,000	38,000	30,000	46,000	52,000	58,450	61,490	64,650
Maine	50	50	50	22,000	32,000	30,000	40,000	50,000	60,000	60,000	60,000
Maryland	55	55	55	22,400	40,000	30,400	48,000	52,800	65,000	65,000	65,000
Massachusetts	35	50	NP	22,400	36,000	30,400	44,000	52,800	60,000	60,000	NP
New Hampshire	35	50	50	22,400	36,000	30,400	44,000	52,800	66,400	66,400	66,400
New Jersey	35	50	50	22,400	32,000	31,500	41,600	55,040	63,000	63,000	60,000
New York	35	50	50	22,400	36,000	30,400	44,000	52,800	65,000	65,000	65,000
Pennsylvania	35	50	50	22,400	36,000	31,072	45,080	51,500	61,800	61,800	62,000
Rhode Island	40	50	50	22,400	NS	30,400	44,000	50,000	60,000	60,000	88,000
Vermont	50	50	50	NS	NS	30,000	50,000	50,000	60,000	60,000	60,000
Region II - Southeastern States											
Alabama	35	50	NP	18,000	36,000	27,800	47,600	47,600	60,010	64,650	NP
Arkansas	35	50	50	18,000	32,000	26,500	40,500	45,000	59,000	65,000	65,000
Florida	35	50	50	20,000	40,000	30,000	52,000	52,000	65,200	73,095	73,095
Georgia	39	50	50	18,000	36,000	28,340	48,680	48,680	63,280	63,280	63,280
Kentucky	35	50	NP	18,000	32,000	26,900	41,600	45,800	59,640	73,280	NP
Louisiana	35	50	60	18,000	32,000	26,000	40,000	44,000	58,000	72,000	76,000
Mississippi	35	50	50	18,000	28,650	26,000	40,000	44,000	59,000	64,650	64,650
North Carolina	35	50	55	18,000	36,000	27,000	46,000	46,000	65,100	65,100	65,100
South Carolina	35	55	60	20,000	32,000	28,000	40,000	48,000	60,000	66,839	71,115
Tennessee	35	50	50	18,000	32,000	26,000	40,000	44,000	58,000	61,580	61,580
Texas	35	50	50	18,000	32,000	26,900	41,600	45,800	60,500	75,200	75,600
Virginia	35	50	50	18,000	32,000	26,000	40,000	44,000	56,800	56,800	56,800
West Virginia	35	50	50	18,000	32,000	26,900	41,600	45,800	57,844	63,840	63,840
Region III - Midwestern States											
Illinois	42	50	50	18,000	32,000	26,000	40,000	44,000	58,000	72,000	72,000
Indiana	36	50	50	18,000	32,000	27,000	41,000	45,000	59,000	73,000	72,000
Iowa	35	50	NP	18,000	32,000	26,540	40,960	45,080	59,500	73,280	NP
Kansas	35	50	50	18,000	32,000	26,000	40,000	44,000	55,470	63,890	63,890
Michigan	35	55	55	18,000	32,000	26,000	40,000	44,000	58,000	66,000	102,000
Minnesota	40	50	50	18,000	32,000	26,000	40,000	44,000	58,000	68,000	72,500
Missouri	35	50	50	18,000	32,000	26,000	40,000	44,000	55,470	64,650	64,650
Nebraska	40	60	60	18,000	32,000	26,780	41,200	45,320	59,740	73,280	71,146
North Dakota	35	60	60	18,000	32,000	26,000	38,000	44,000	56,000	64,000	64,000
Ohio	35	50	60	19,000	31,500	27,000	39,500	46,000	58,500	71,000	78,000
Oklahoma	35	50	50	18,000	32,000	26,000	40,000	44,000	58,000	72,000	73,280
South Dakota	35	50	60	18,000	32,000	26,000	40,000	44,000	58,000	72,000	73,280
Wisconsin	35	50	50	18,000	30,400	27,500	40,000	47,000	59,500	73,000	73,000
Region IV - Western States											
Alaska	35	60	60	18,000	32,000	26,000	40,000	44,000	58,000	72,000	75,000
Arizona	40	65	65	18,000	32,000	26,000	40,000	44,000	58,000	72,000	76,800
California	35	60	65	18,000	32,000	26,000	40,000	44,000	58,000	72,000	76,000
Colorado	35	60	60	18,000	36,000	26,000	44,000	44,000	62,000	76,000	76,000
Idaho	35	60	65	18,000	32,000	26,000	40,000	44,000	58,000	72,000	76,800
Montana	35	60	60	18,000	32,000	26,000	40,000	44,000	58,000	72,000	76,000
Nevada	NR	NR	NR	18,000	32,000	26,900	41,600	45,800	60,500	75,200	76,800
New Mexico	40	65	65	21,600	34,320	29,600	42,320	51,200	63,920	76,640	86,400
Oregon	35	55	65	18,000	32,000	26,000	40,000	44,000	58,000	72,000	76,000
Utah	45	60	60	18,000	33,000	26,000	41,000	44,000	59,000	74,000	79,900
Washington	35	60	65	18,000	32,000	26,000	36,000	44,000	60,000	68,000	72,000
Wyoming	40	60	60	18,000	32,000	26,000	44,000	44,000	62,000	73,950	73,950

NP - Not permitted. NR - Not restricted. NS - Not specified.

(1) Various exceptions for utility vehicles and loads, house trailers and mobile homes.

(2) Computed under the following conditions to permit comparison on a uniform basis between States with different types of regulation:
- A. Front axle load of 8,000 pounds.
- B. Maximum practical wheelbase within applicable length limits.
  - (1). Minimum front overhang of 3 feet.
  - (2). In the case of a 4-axle truck-tractor semitrailer, rear overhang computed as necessary to distribute the maximum possible uniform load on the maximum permitted length of semitrailer to the single drive-axle of the tractor and to the tandem axles of the semitrailer, within the permitted load limits of each.
  - (3). In the case of a combination having 5 or more axles, minimum possible combined front and rear overhang assumed to be 5 feet, with maximum practical load on maximum permitted length of semitrailer, subject to control of loading on axle groups and on total wheelbase as applicable.
- C. Including statutory enforcement tolerances as applicable.

(3) Legally specified or established by administrative regulation.

but rather of interpretation of what legal loads should be permitted for bridges constructed in a similar manner.

Pavement design based on an elastic plate supported by an elastic foundation naturally leads to axle load limitations, since axle load is the primary factor for such a design situation and total vehicle load is not a design factor. On bridges the problem of simple and practical load limitations becomes much more difficult. The individual axle loads may control the design of floor beams or minor members of a long span bridge, or the main members of very short span bridges. With bridges of longer span, however, the total vehicle load is of more direct concern in the design of major structural members, and the individual axle loads are important only in that they contribute their part to the total load. Because of this design difference between bridges and pavements, a singular load limitation such as axle load or total load cannot be applied to both types of structures.

In addition, the problem becomes much more complicated for bridges, since a formidable array of trucks having numerous combinations of axle types, arrangements, and spacings must be considered, as well as a number of bridge span lengths. A given loaded vehicle may be entirely satisfactory on one span length, but on another span length may cause considerable overstress.

Several approaches are possible in obtaining axle load limits for a given vehicle to prevent overstressing a bridge:

1. In one approach a given vehicle is loaded with arbitrary axle loads and the actual moments are computed for various length bridge spans and compared with the bridge design moments. If overstressing results, the axle loads are reduced in some arbitrary manner and another cycle of computations are made. This is repeated until the maximum axle loads are determined which a vehicle can carry without overstressing various bridge spans.

2. Another approach is to load all vehicles with given load limits for single and tandem axles; compute the actual moments; determine the percent overstress, if any; and then uniformly reduce all load axles to values which will reduce this overstress to zero. Since in almost every case the maximum overstress for practical vehicles occurs with the entire vehicle on the span, this second approach is possible and it has the further advantage of a systematic procedure.

In 1960, at the beginning of this study, other investigators attempting to determine practical national load limits for bridges were making manual computations following the first of these approaches. Therefore, to speed this work and also to verify the results of others, the second approach was teamed up with the first, using an electronic computer. The advantages of the electronic computer are readily apparent in this situation and the problem can hardly be handled adequately without one.

DETERMINATION OF THE MAGNITUDE OF BRIDGE OVERSTRESS

The point of beginning in attempting to set practical load limitations for bridges is the determination of the magnitude of overstress which will result from the application of a typical array of practical vehicles with given axle loads, on bridges with varying span lengths and designed for each of the AASHO design loadings: H20-S16-44, H15-S12-44, H20-44, and H15-44. The AASHO bridge-vehicle design loads are shown in Fig. 1.

Commercial Vehicles

The commercial vehicles analyzed consisted of trucks, truck-trailers, tractor-semitrailers and tractors, semitrailers, trailers--a total of 24 types of truck classification--with the number of axle loads per vehicle varying from two to eleven. For each vehicle type a minimum and a maximum practical extreme axle spacing was selected. Each vehicle was considered under two legal load limits: the first, 18 kips for single axles and 32 kips for tandem axles (Load Limit A), and the second, 22 kips for single axles and 32 kips for tandem axles (Load Limit B). In every case the steering axle load was considered as limited by practical considerations to 10 kips.

The analytical procedure was as follows:

1. The maximum moments for a total of 88 vehicle and load combinations were computed for each of 11 bridge span lengths from 20 to 200 ft, using an electronic computer (968 computations). A complete tabulation of the moments which resulted from these computations is given in Table 2, in which the vehicles are designated by the usual vehicle-type coding. The "minimum" and "maximum" notation in this table (and in Appendices A and B) indicates the practical wheelbase limits for each vehicle type. A complete schematic diagram of each vehicle with its axle loadings and spacings is also given in Appendix B. In the case of certain short bridge spans, the maximum moment values are not shown in Table 2, since the entire vehicle would not be on such short spans. It was readily apparent that these span lengths would not be critical in determining loading limits for certain vehicle types.

2. The moments resulting from the four design bridge loads H20-S16-44, H15-S12-44, H20-44, and H15-44 were tabulated for the eleven span lengths.

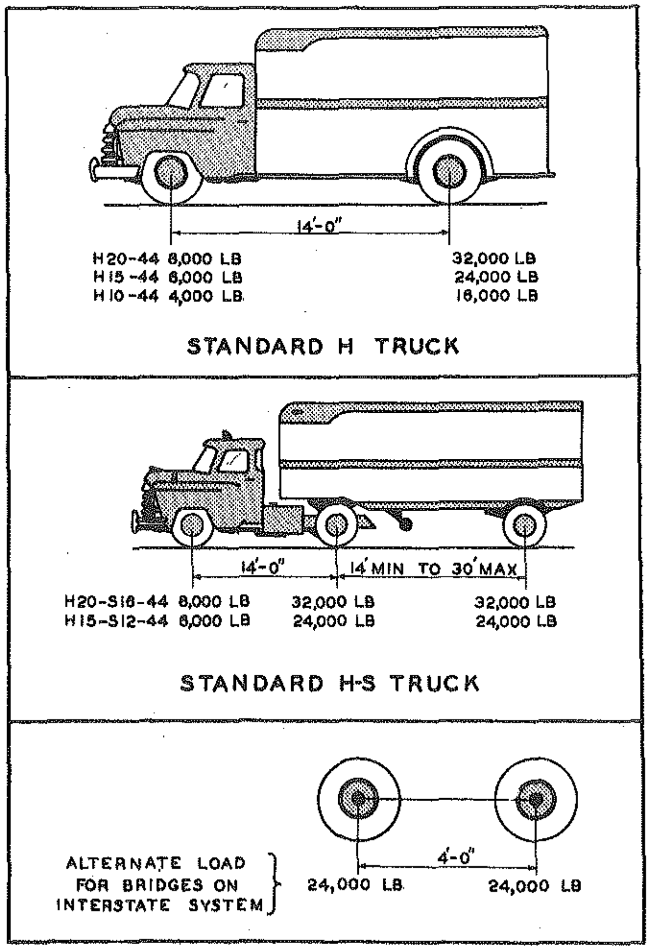

Figure 1. AASHO bridge vehicle design loads, from 1961 AASHO Standard Specifications for Highway Bridges (pp. 11, 13)

3. The maximum moments resulting from the 88 vehicle-load combinations were compared with the moments from the bridge design loadings for each of eleven bridge span lengths. The percents overstress resulting from the practical vehicles were calculated for each span length, as given in Appendix A.

4. The gross vehicle load was reduced until individual vehicle-load combinations did not overstress the bridge for any span length from 20 to 200 ft for bridges designed for the four design loads. The limitation applicable to this vehicle under the so-called "Bridge Formula" was also computed. This formula, one method of limiting vehicle loading on bridges which has been widely discussed during the past ten years, is as follows:

$$W = 500 \left(\frac{N}{N-1} L + 12 N + 32\right) \qquad (1)$$

where

W = allowable load on a group of axles, in pounds
N = number of axles in the axle group under consideration, and
L = length in feet between extreme axles of the axle group under consideration.

TABLE 2
MAXIMUM MOMENTS CAUSED BY VARIOUS COMMERCIAL VEHICLES ON VARIOUS BRIDGE SPAN LENGTHS*

Vehicle Designation**	Maximum Moments in Ft-Kips for the Following Span Lengths										
	20 ft	30 ft	40 ft	50 ft	60 ft	80 ft	100 ft	125 ft	150 ft	175 ft	200 ft
2D - A Min	90	159	228	297	367	506	646	821	996	1171	1346
2D - B Min	110	188	267	347	427	586	746	946	1146	1346	1546
2D - A Max	90	130	197	266	335	474	613	787	962	1137	1311
2D - B Max	110	165	236	315	394	553	713	912	1112	1311	1511
3 - A Min	143	248	353	458	563	773	983	1246	1508	1771	2033
3 - B Min	143	248	353	458	563	773	983	1246	1508	1771	2033
3 - A Max	132	214	319	424	529	738	948	1211	1473	1736	1998
3 - B Max	132	214	319	424	529	738	948	1211	1473	1736	1998
2S1 - A Min	82	170	265	399	514	744	974	1261	1549	1836	2123
2S1 - B Min	100	206	340	475	609	879	1148	1486	1823	2160	2498
2S1 - A Max	86		223		362	540	765	1049	1335	1620	1907
2S1 - B Max	110		263		422	632	896	1229	1563	1898	2234
2S2 - A Min	124	206	352	500	649	947	1246	1620	1995	2369	2744
2S2 - B Min	124	235	392	550	709	1027	1346	1745	2145	2544	2944
2S2 - A Max	130		289		437	685	974	1341	1710	2081	2453
2S2 - B Max	130		289		437	696	1006	1397	1792	2188	2585
3S1 - A Min	124	249	399	549	699	999	1299	1674	2049	2424	2799
3S1 - B Min	124	257	417	577	737	1057	1377	1777	2177	2577	2977
3S1 - A Max	130		329		538	790	1088	1462	1836	2211	2585
3S1 - B Max	130		329		538	807	1125	1523	1921	2320	2719
3S2 - A Min	138	290	474	659	844	1213	1583	2045	2508	2970	3433
3S2 - B Min	138	290	474	659	844	1213	1583	2045	2508	2970	3433
3S2 - A Max	130		329		522	883	1248	1706	2165	2626	3087
3S2 - B Max	130		329		522	883	1248	1706	2165	2626	3087
2-2 - A Min	108		377	536	696	1015	1335	1734	2134	2534	2934
2-2 - B Min	132		461	650	839	1219	1599	2073	2548	3023	3498
2-2 - A Max	108		284		532	852	1172	1571	1971	2371	2771
2-2 - B Max	132		347		641	1020	1400	1875	2350	2825	3300
2-3 - A Min	148		458	653	848	1238	1628	2116	2603	3091	3578
2-3 - B Min	153		522	737	952	1382	1812	2350	2887	3425	3962
2-3 - A Max	130		299		593	983	1372	1859	2346	2834	3321
2-3 - B Max	130		304		688	1118	1547	2084	2622	3159	3697
3-2 - A Min	148		466	660	855	1244	1634	2121	2608	3096	3583
3-2 - B Min	153		502	715	929	1358	1787	2324	2861	3398	3936
3-2 - A Max	130		265		615	1002	1390	1876	2362	2849	3336
3-2 - B Max	130		307		694	1122	1551	2088	2624	3161	3699
3-3 - A Min	156		540	769	999	1458	1918	2493	3068	3643	4218
3-3 - B Min	163		579	819	1059	1538	2018	2618	3218	3818	4418
3-3 - A Max	130		308		722	1181	1640	2215	2790	3364	3939
3-3 - B Max	130		348		782	1261	1740	2340	2940	3539	4139
2S1-2 - A Min	108		384	573	778	1188	1598	2111	2623	3136	3648
2S1-2 - B Min	132		469	697	942	1432	1922	2535	3147	3760	4372
2S1-2 - A Max	101		299		587	997	1407	1919	2432	2944	3456
2S1-2 - B Max	124		341		717	1206	1696	2308	2920	3532	4145
2S1-3 - A Min	148		468	656	895	1374	1853	2452	3052	3652	4252
2S1-3 - B Min	153		538	769	1038	1577	2117	2791	3466	4141	4815
2S1-3 - A Max	130		330		703	1155	1633	2232	2832	3431	4031
2S1-3 - B Max	130		387		787	1325	1863	2537	3212	3886	4561

* Blank spaces in table indicate no computation was made since it could be observed that values omitted were not critical design values.

** Load Limit A (18K single, 32K tandem), Load Limit B (22K single, 32K tandem). Min = minimum length, Max = maximum length.

TABLE 2 (Cont.)
MAXIMUM MOMENTS CAUSED BY VARIOUS COMMERCIAL VEHICLES ON VARIOUS BRIDGE SPAN LENGTHS*

Vehicle Designation**	Maximum Moments in Ft-Kips for the Following Span Lengths										
	20 ft	30 ft	40 ft	50 ft	60 ft	80 ft	100 ft	125 ft	150 ft	175 ft	200 ft
2S1-4 - A Min	154		562	813	1088	1638	2188	2875	3562	4250	4937
2S1-4 - B Min	154		598	871	1165	1755	2344	3082	3819	4556	5294
2S1-4 - A Max	130		421		856	1380	1929	2616	3303	3990	4678
2S1-4 - B Max	130		428		905	1471	2060	2796	3533	4270	5007
2S2-2 - A Min	148		487	707	947	1427	1906	2506	3106	3706	4306
2S2-2 - B Min	153		532	780	1050	1590	2130	2805	3480	4155	4830
2S2-2 - A Max	130		354		774	1247	1727	2327	2927	3527	4127
2S2-2 - B Max	130		403		848	1379	1919	2594	3269	3944	4619
2S2-3 - A Min	148		508	778	1052	1602	2151	2839	3526	4213	4901
2S2-3 - B Min	153		550	837	1132	1721	2311	3048	3786	4523	5261
2S2-3 - A Max	130		372		817	1365	1914	2601	3288	3975	4662
2S2-3 - B Max	130		412		880	1468	2057	2794	3531	4268	5006
2S2-4 - A Min	165		604	893	1203	1821	2441	3215	3990	4765	5539
2S2-4 - B Min	173		611	911	1230	1869	2508	3307	4106	4906	5706
2S2-4 - A Max	130		466		991	1583	2201	2975	3749	4523	5298
2S2-4 - B Max	130		466		991	1612	2251	3049	3848	4648	5447
3S1-2 - A Min	139		442	671	911	1391	1871	2471	3071	3671	4271
3S1-2 - B Min	143		511	767	1037	1577	2117	2792	3467	4142	4817
3S1-2 - A Max	130		330		700	1180	1659	2259	2859	3459	4059
3S1-2 - B Max	130		387		815	1348	1888	2563	3238	3913	4588
3S1-3 - A Min	148		490	757	1032	1581	2131	2818	3506	4193	4881
3S1-3 - B Min	153		555	841	1136	1725	2315	3052	3790	4527	5265
3S1-3 - A Max	130		353		766	1315	1864	2551	3238	3926	4613
3S1-3 - B Max	130		407		863	1452	2041	2778	3515	4252	4989
3S1-4 - A Min	145		607	896	1205	1824	2444	3218	3993	4768	5542
3S1-4 - B Min	165		635	935	1254	1893	2532	3331	4131	4931	5730
3S1-4 - A Max	131		455		904	1521	2139	2913	3687	4462	5236
3S1-4 - B Max	134		466		963	1601	2239	3038	3837	4637	5436
3S2-2 - A Min	145		528	796	1071	1620	2170	2858	3545	4233	4920
3S2-2 - B Min	145		560	837	1132	1721	2311	3048	3786	4523	5261
3S2-2 - A Max	130		421		859	1409	1958	2646	3333	4021	4708
3S2-2 - B Max	130		428		905	1485	2075	2812	3549	4287	5024
3S2-3 - A Min	165		607	902	1212	1831	2451	3226	4001	4776	5551
3S2-3 - B Min	173		635	939	1259	1899	2539	3339	4139	4939	5739
3S2-3 - A Max	130		461		945	1559	2179	2954	3729	4504	5279
3S2-3 - B Max	130		471		984	1617	2257	3057	3857	4657	5457
3S2-4 - A Min	184		692	1029	1374	2064	2753	3616	4478	5341	6203
3S2-4 - B Min	184		692	1029	1374	2064	2753	3616	4478	5341	6203
3S2-4 - A Max	145		482		1071	1760	2449	3311	4173	5035	5897
3S2-4 - B Max	145		482		1071	1760	2449	3311	4173	5035	5897
3S3-4 - A Min	193		743	1124	1514	2293	3073	4048	5023	5998	6973
3S3-4 - B Min	195		774	1163	1563	2363	3163	4163	5163	6163	7163
3S3-4 - A Max	153		516		1186	1961	2741	3716	4691	5666	6641
3S3-4 - B Max	155		556		1229	2024	2823	3823	4823	5823	6823
3S3-5 - A Min	208		804	1225	1650	2500	3350	4413	5475	6538	7600
3S3-5 - B Min	208		804	1225	1650	2500	3350	4413	5475	6538	7600
3S3-5 - A Max	161		579		1294	2143	2993	4055	5117	6179	7241
3S3-5 - B Max	161		579		1294	2143	2993	4055	5117	6179	7241

* Blank spaces in table indicate no computation was made since it could be observed that values omitted were not critical design values.

** Load Limit A (18K single, 32K tandem), Load Limit B (22K single, 32K tandem). Min = minimum length, Max = maximum length.

The results of this entire four-stage analytical procedure are shown in Appendix B. Before discussing axle load limitations which might be imposed in order to control overstressing, certain interpretations or general statements can be made from this table:

1. For 2-axle vehicles no reduction is required from legal axle Load Limits A or B to prevent overstressing of bridges designed on the basis of three of the four bridge design loadings.

2. Reductions in load are required to prevent overstressing for 3- and 4-axle vehicles of short wheelbase for bridges designed for all except H20-S16-44 loadings.

3. The Bridge Formula gives inconsistent results when compared with the design loads for the maximum length 2S1 truck, since the Bridge Formula would limit total load to 50 kips for this vehicle while even the H15-44 loading would permit 53 kips.

4. Considerable reduction in loading is required from Legal Limit A or B for certain 4-axle trucks of short wheelbase to prevent overstressing of bridges designed for H15-44 loading, and even long wheelbase 4-axle trucks require some reduction in loading.

5. For bridges designed for H20-S16-44 loading the first reduction in load from Legal Limit B occurs for short wheelbase 4-axle vehicles, and from Legal Limit A for 5-axle vehicles.

6. For 4- or 5-axle vehicles the Bridge Formula permits somewhat more than the H15-S12-44 loading and less than the H20-S16-44 loading.

7. In general for vehicles with 6 axles or more the Bridge Formula permits loads considerably greater than would the H15-S12-44 loading.

8. In the case of 9- or 10-axle vehicles the Bridge Formula permits overstress of 24 percent of H20-S16-44 bridges and 66 percent of H15-S12-44 loadings.

9. Increasing the number of axles per vehicle over six axles does very little in increasing total vehicle load permissible without overstressing bridges, for even the heaviest design, H20-S16-44.

In 1951, Stephenson and Cloninger* calculated the maximum moments resulting from the application of six typical vehicles on bridges of various span lengths, and then the percentage of design stress resulting from four conditions of loading:

Case 1: One vehicle in each lane with full allowance for impact
Case 2: One vehicle in one lane only with full allowance for impact
Case 3: One vehicle in each lane with no allowance for impact
Case 4: One vehicle in one lane only with no allowance for impact.

Of the four cases, only Case 1 appears to have significance to the bridge designer, for the following reasons:

1. Reduction in load intensity for the improbable situation of all lanes being fully loaded simultaneously on bridges of two lanes or more has already been considered in the AASHO Design Specifications, and thus loading Cases 2 and 4 are not equitable because the actual load is considered on one basis and the design load on another.

2. Reduction in load intensity by making no allowance for impact (Cases 3 and 4) is equally inequitable, for if the stress from an actual vehicle can be so reduced, so can the stress for the design vehicles H15-S12-44 or H20-S16-44, for again it is completely illogical to say the actual vehicle will have no impact effect while a 25-percent impact effect should be considered for the design vehicle. This disparity makes plausible an increased allowable load for the actual vehicle, supposedly without overstressing the bridge.

As Stephenson and Cloninger show, the greatest overstress occurs for the Type 3-3 vehicle; the magnitude was 23 percent when compared to the H15-44 design load. However, it should be pointed out that wheelbase measurements for some of the six typical vehicles in their analysis were unusually long, leading to a smaller resulting bridge moment than would occur for the same vehicle type with the same load but shorter wheelbase.

In Table 3 the minimum, maximum, and average wheelbase measurements are shown for six types of vehicles as found in 1950 and 1961 Michigan loadometer surveys, along with the wheelbase measurements used by Stephenson and Cloninger for the same vehicle types. It should

* Stephenson, H. K., and Cloninger, K., Jr. "A Review and Discussion of Proposed Revision of Section 5(b) of the AASHO Policy Concerning Maximum Dimensions, Weights and Speeds of Motor Vehicles to be Operated over the Highways of the United States (As Adopted April 1, 1946)." Texas Engineering Experiment Station, College Station, Texas (September 1951).

be noted that the wheelbase measurements for three of their vehicles are longer than the Michigan averages for these vehicle types in either Michigan survey year, and that only one of theirs is shorter than the Michigan average in both Michigan surveys. For a given vehicle type with fixed axle loads the shorter the wheelbase is, the greater is the resulting moment for the bridge span. Therefore, proper design procedure for determining the magnitude of the overstress for a given vehicle type would be to use this vehicle type with a minimum practical wheelbase length. In Fig. 2, the minimum, maximum, and average

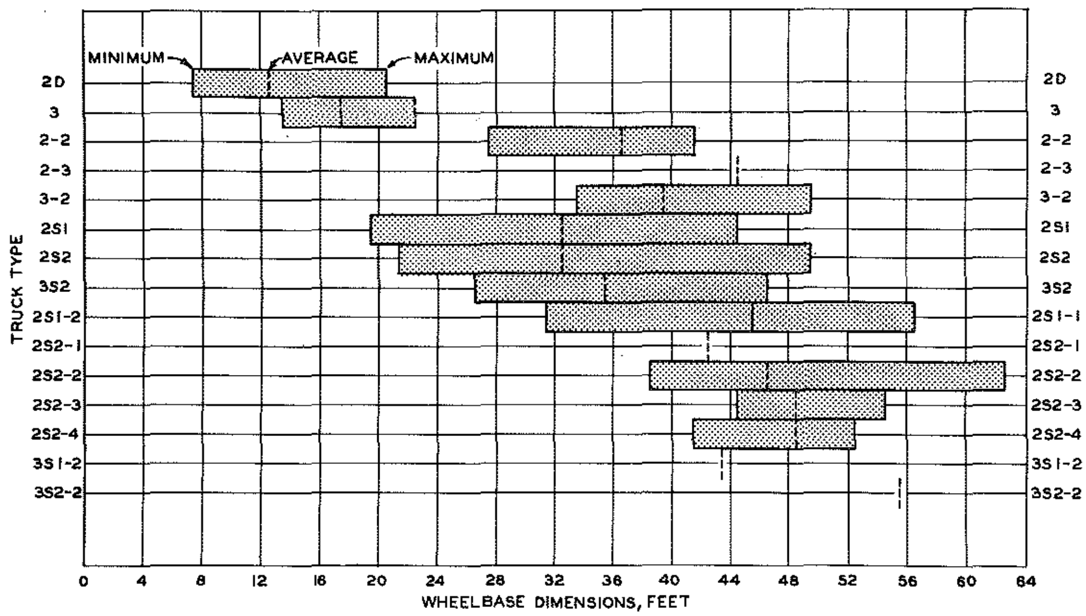

Figure 2. Maximum, minimum, and average wheelbase measurements by truck type from 1950 MSHD loadometer survey.

TABLE 3
WHEELBASE MEASUREMENTS FOR TYPICAL VEHICLES

Vehicle Type	Wheelbase Measurement, ft						
	Michigan 1950 Survey			Michigan 1961 Survey			Stephenson-Cloninger Calculation
	Min	Max	Avg	Min	Max	Avg	
2	7	21	12.5	11	15	12.5	16
3	13	23	17.5	14	21	16.5	20
2S1	19	45	32.5	20	46	35.5	30
2S2	21	50	32.5	22	49	35.5	34
3S2	26	47	36.5	28	50	41.5	44
3-3	- - - - - - - - No Data Available - - - - - - - - - -						54

wheelbase lengths given for various truck types are based on the extensive 1950 Michigan loadometer survey. Maximum moments for the six typical vehicles with short and long wheelbases for spans from 20 to 200 ft are shown in Table 4. In addition, the percent overstress of these vehicles as compared to a H15-44 design loading is also given in this table.

Fig. 3 was prepared for better illustration of the much greater live load overstress possible for the six typical vehicles in the Stephenson-Cloninger report if they had used shorter wheelbase dimensions. The most noteworthy change in overstress occurs for the 3S2 type vehicle, which with a 44-ft wheelbase causes a live load overstress of 39.1 percent. For a 26-ft wheelbase, this overstress increases, very significantly, to 82.4 percent. This illustrates that a practical bridge load limit cannot be prepared on the basis of an investigation involving only a few typical vehicles with average wheelbase measurements.

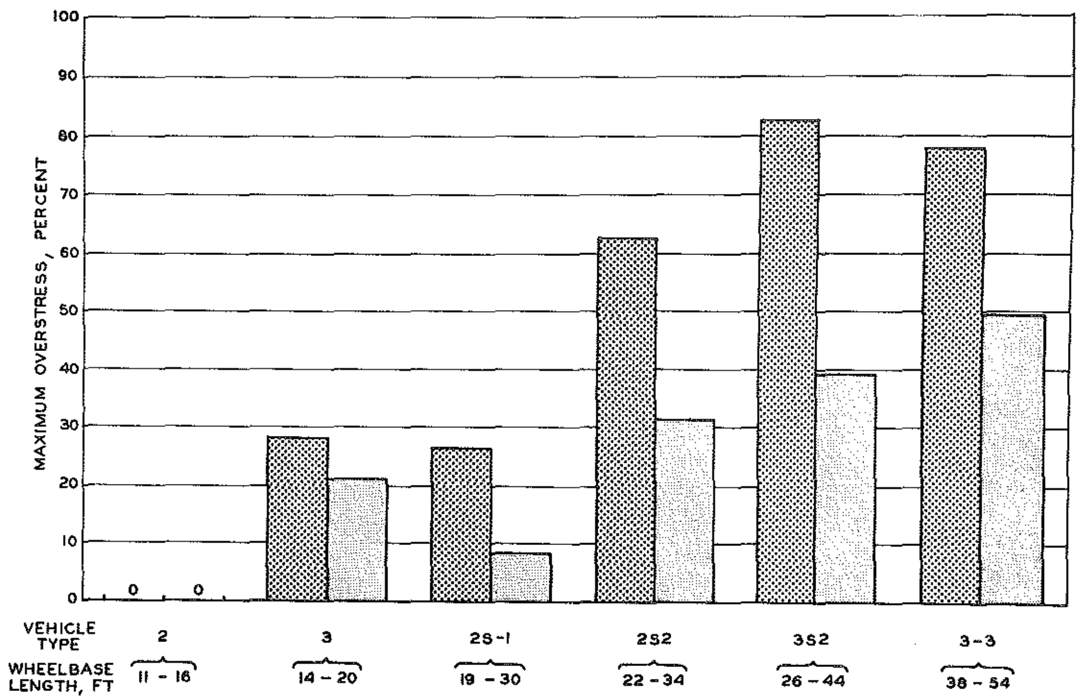

Figure 3. Effect of wheelbase length, for six typical vehicles, on maximum overstress for H15-44 design load (live load only).

Special Permit Vehicles

In addition to regular commercial truck traffic, it is also necessary to consider vehicles operating under special permit. Regulations and limitations concerning these vehicles with axle loads greater than regular

TABLE 4

BRIDGE MOMENTS RESULTING FROM SIX TRUCK TYPES WITH TWO WHEELBASE MEASUREMENTS

Overstress Computed for H15-44 Design Loading

Truck Type	Axle Load and Wheelbase Length	Design Factor	Span Length, ft										
			20	30	40	50	60	80	100	125	150	175	200
2	8K –11'– 18K	Maximum Moment, ft-kips Percent Overstress	90. 0.0	154 0.0	218 0.0	282 0.0	347 0.0	477 0.0	607 0.0	769 0.0	932 0.0	1094 0.0	1256 0.0
	8K –16'– 18K	Maximum Moment, ft-kips Percent Overstress	---- 0.0	136 0.0	200 0.0	264 0.0	329 0.0	458 0.0	588 0.0	750 0.0	912 0.0	1074 0.0	1237 0.0
3	8K –10'– 16K –4'– 16K	Maximum Moment, ft-kips Percent Overstress	128 6.7	228 23.2	328 26.1	428 28.1	528 26.0	728 11.3	928 0.0	1178 0.0	1428 0.0	1678 0.0	1928 0.0
	8K –16'– 16K –4'– 16K	Maximum Moment, ft-kips Percent Overstress	---- ----	----- -----	305 17.1	404 21.1	504 20.3	704 7.7	904 0.0	1154 0.0	1404 0.0	1654 0.0	1904 0.0
2S1	8K –8'– 18K –11'– 18K	Maximum Moment, ft-kips Percent Overstress	94 0.0	202 9.4	312 19.8	421 26.0	531 26.6	750 14.7	970 3.4	1245 0.0	1520 0.0	1795 0.0	2070 0.0
	8K –12'– 18K –18'– 18K	Maximum Moment, ft-kips Percent Overstress	---- ----	----- -----	237 0.0	346 3.5	455 8.5	674 3.0	893 0.0	1167 0.0	1442 0.0	1717 0.0	1992 0.0
2S2	8K –8'– 18K –10'– 16K –4'– 16K	Maximum Moment, ft-kips Percent Overstress	---- ----	----- -----	393 51.2	537 60.7	681 62.5	970 48.2	1259 34.2	1621 19.0	1983 6.8	2345 0.0	2708 0.0
	8K –12'– 18K –18'– 16K –4'– 16K	Maximum Moment, ft-kips Percent Overstress	---- ----	----- -----	----- -----	----- -----	574 29.9	860 31.4	1147 22.2	1507 10.7	1868 0.6	2230 0.0	2592 0.0
3S2	8K –8'– 15K –4'– 15K –10'– 15K –4'– 15K	Maximum Moment, ft-kips Percent Overstress	---- ----	257 38.9	426 63.7	555 78.1	764 82.4	1104 68.7	1444 53.8	1868 37.2	2293 23.5	2718 11.8	3143 2.2
	8K –14'– 15K –4'– 15K –22'– 15K –4'– 15K	Maximum Moment, ft-kips Percent Overstress	---- ----	----- -----	----- -----	408 22.0	574 37.0	910 39.1	1248 33.0	1671 22.7	2094 12.8	2519 3.6	2943 0.0
3-3	8K –8'– 15K –4'– 15K –10'– 16K –12'– 12.5K –4'– 12.5K	Maximum Moment, ft-kips Percent Overstress	---- ----	----- -----	----- -----	547 63.6	744 77.5	1138 74.0	1533 63.4	2027 48.9	2520 35.7	3014 24.0	3508 14.0
	8K –14'– 15K –4'– 15K –12'– 12K –20'– 12.5K –4'– 12.5K	Maximum Moment, ft-kips Percent Overstress	---- ----	----- -----	----- -----	----- -----	581 38.5	976 49.1	1370 46.0	1864 36.9	2358 27.0	2852 17.3	3345 8.7

Dashed lines indicate entire vehicle did not fit on given span length and it was not found necessary to compute moments for parts of the vehicle.

H15-44 Design Loading	Span Length, ft										
	20	30	40	50	60	80	100	125	150	175	200
Maximum Moment, ft-kips	120	185	260	334	419	654	938	1361	1856	2430	3075

legal limits vary greatly among the States. To determine their bridge stress effects, several were selected which have been permitted to operate in Michigan, as shown in Figs. 4 and 5. Maximum moments were calculated for these vehicles on bridge spans from 20 to 200 ft in length, and then compared with those resulting from the H20-S16-44 and H15-44 design vehicles. Vehicle No. 3 with a total load of 138.5 kips caused the least design stress: 171 percent for H20-S16-44 bridges and 266 percent for H15-44 bridges. The greatest design stress occurred for Vehicle No. 1 with a total load of 306 kips: 353 percent for H20-S16-44 bridges and 637 percent for H15-44 bridges.

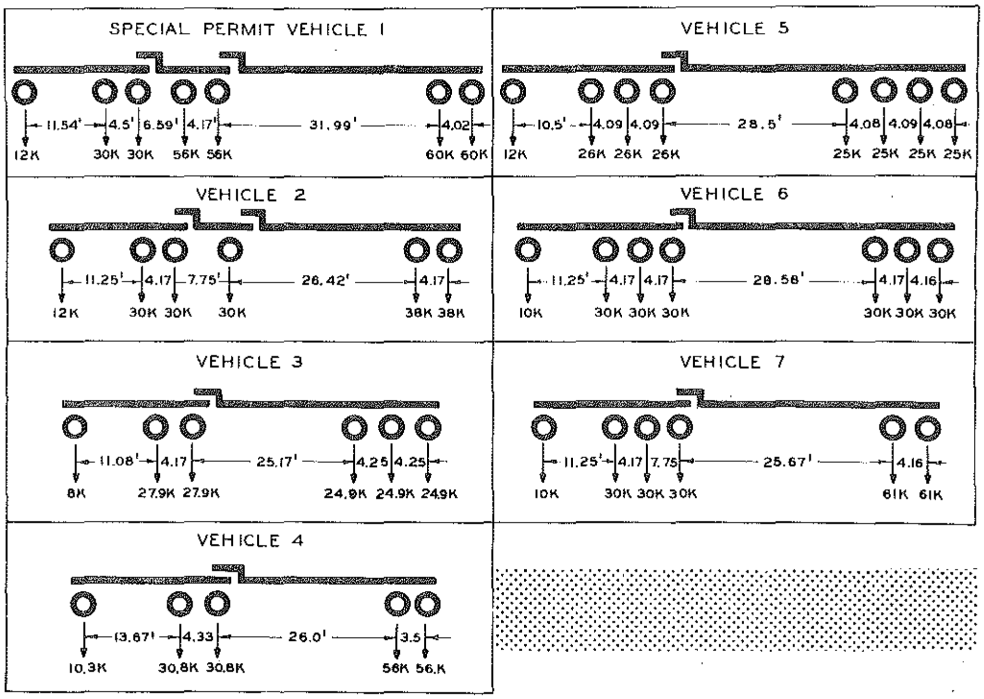

Figure 4. Characteristics of seven selected vehicles operating in Michigan under special permit.

Another type of special equipment traveling over the highway system in an unloaded condition is off-the-road earth-moving equipment. Seven examples of various models of such equipment are presented in Fig. 6. The maximum movements caused by these vehicles on various bridge span lengths are given in Table 5, which also gives the percent live load overstress resulting from these vehicles traveling over H20-S16-44 and H15-44 bridges. Maximum live load overstresses for these vehicles on the two bridge types are illustrated in Fig. 7. Vehicles 1 and 5 (84,000-lb and 69,540-lb gross loads, respectively) caused the greatest overstress:

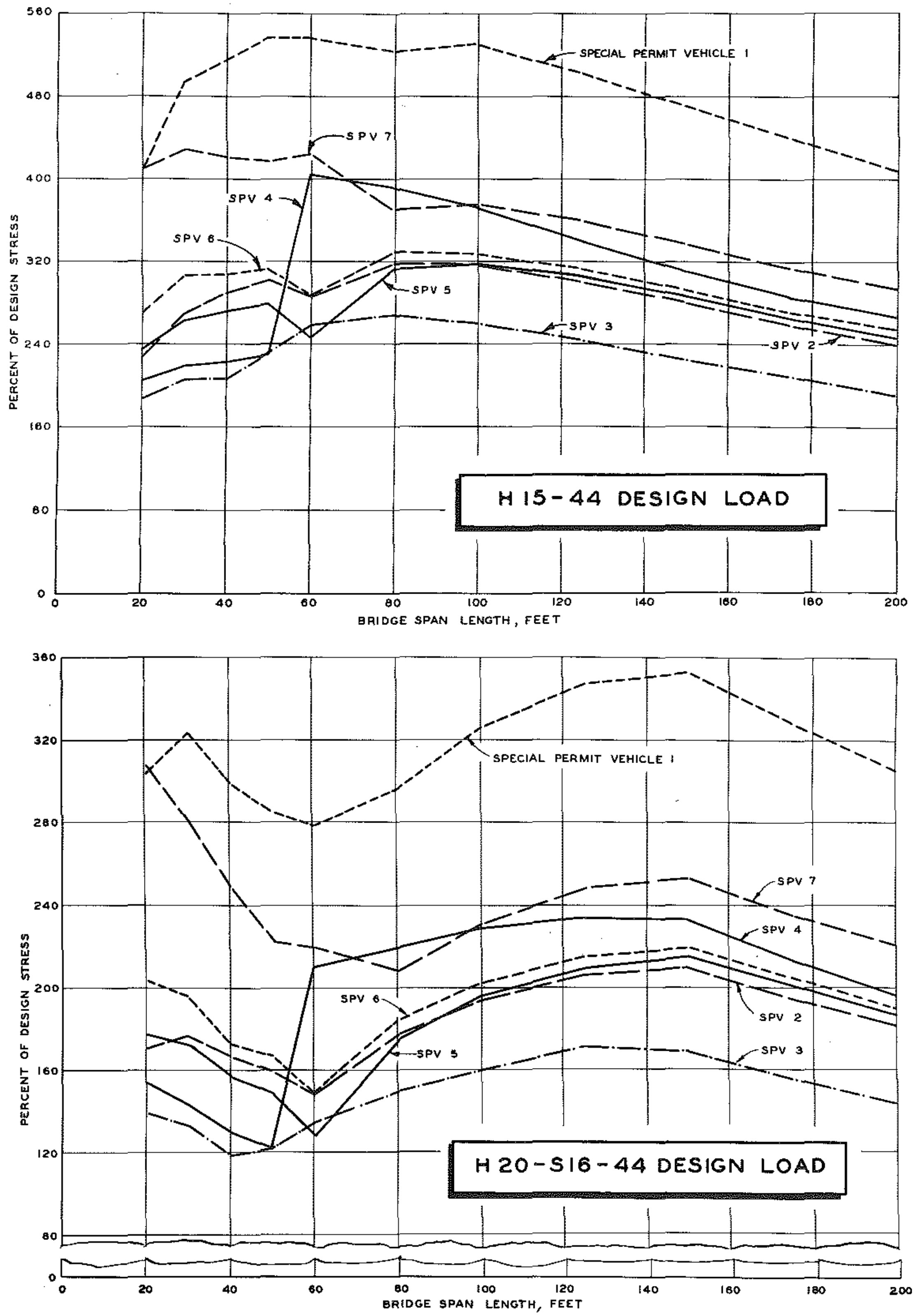

Figure 5. Comparison of live load stress levels for seven vehicles (diagrammed in Fig. 4), operating in Michigan under special permit.

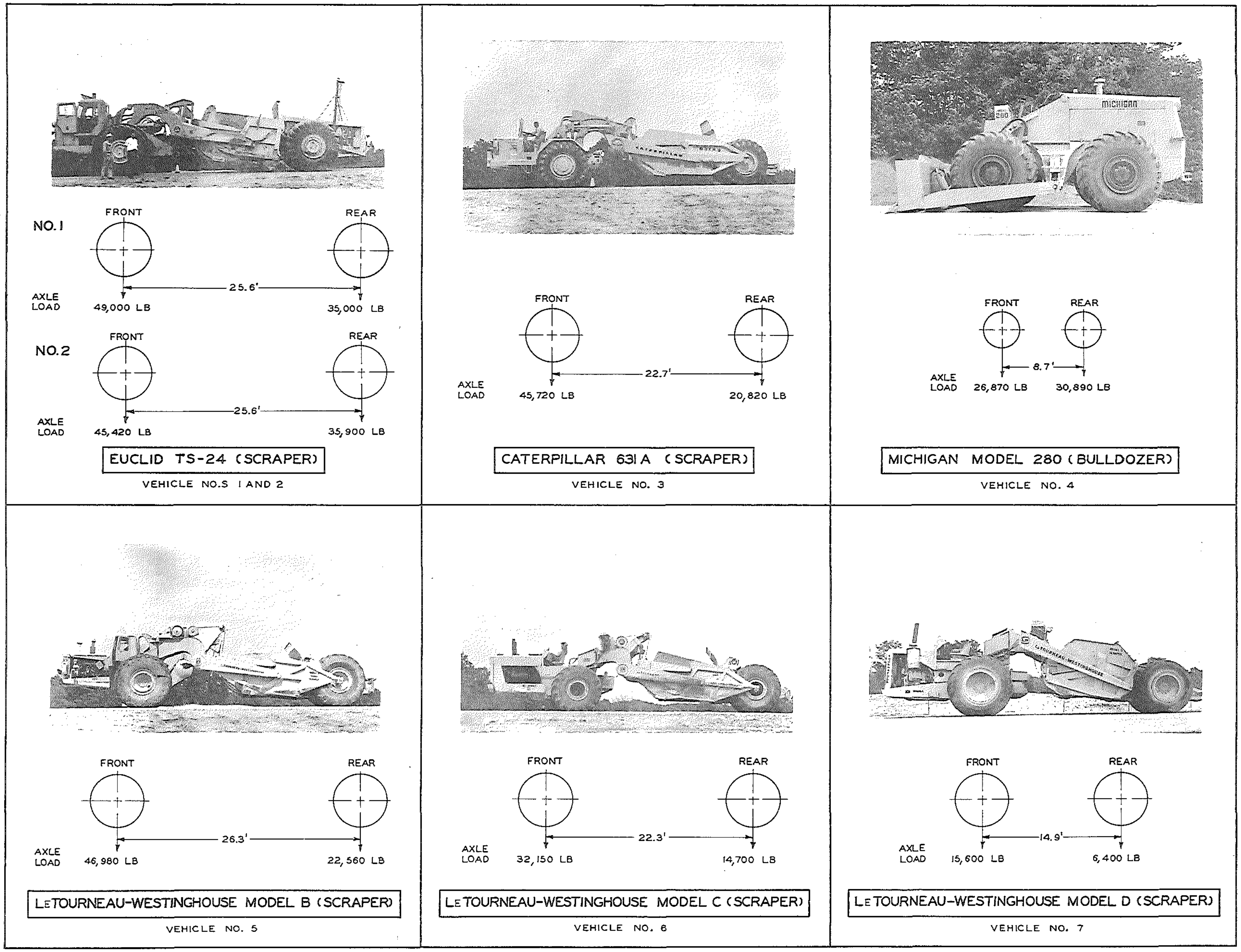

Figure 6. Typical earthmoving equipment (loads shown for unloaded condition).

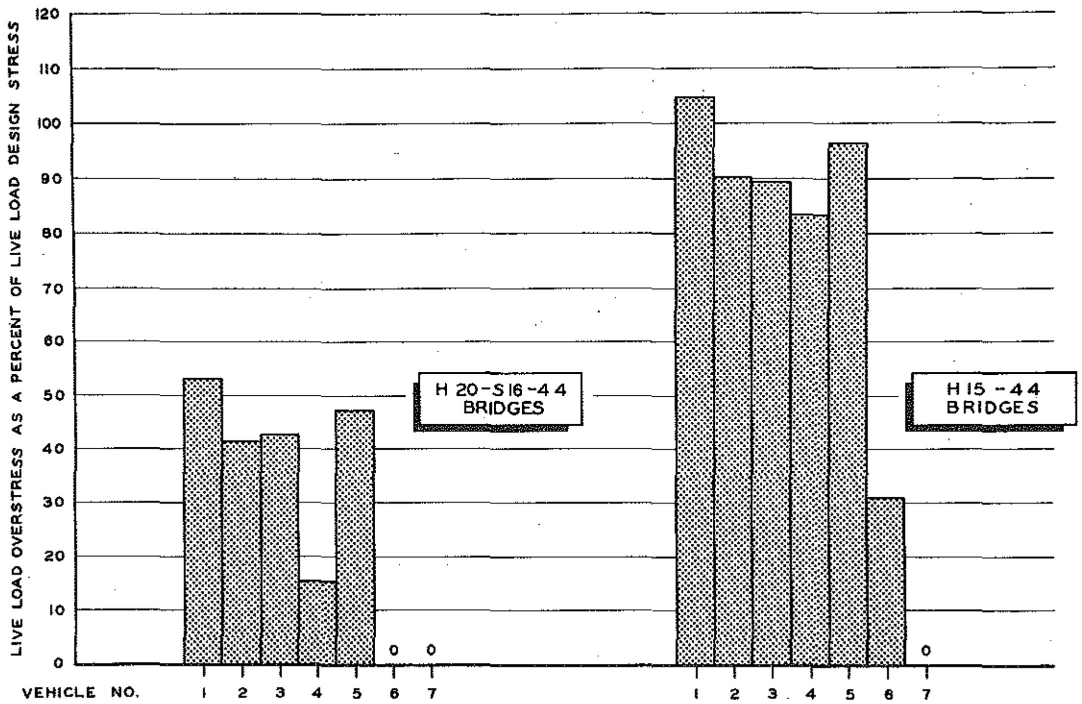

Figure 7. Maximum live load overstress caused by typical earth-moving equipment on H20-S16-44 and H15-44 bridges.

TABLE 5
MAXIMUM MOMENTS AND PERCENT LIVE LOAD OVERSTRESS FOR EARTH-MOVING EQUIPMENT ON H20-S16-44 AND H15-44 BRIDGES
(Dashes indicate no live overstress)

	Vehicle No.	20 ft	30 ft	40 ft	50 ft	60 ft	80 ft	100 ft	125 ft	150 ft	175 ft	200 ft
		Maximum Moments in Ft-Kips for the Following Span Lengths										
Maximum Moments, Ft-Kips	1	245	368	490	650	852	1262	1676	2196	2718	3241	3764
	2	226	340	419	609	804	1199	1599	2102	2607	3113	3620
	3	228	343	454	612	776	1105	1436	1850	2264	2680	3095
	4	184	324	467	610	754	1041	1329	1690	2051	2412	2772
	5	235	352	470	598	768	1110	1454	1887	2320	2753	3187
	6	161	241	322	433	548	780	1013	1305	1597	1889	2186
	7	78	121	175	229	284	394	503	641	778	915	1053
	H 20-S16-44	160	282	450	628	807	1165	1524	1973	2475	3240	4100
	H 15-44	120	185	260	334	419	654	938	1361	1856	2430	3075
Percent Live Load Overstress — H 20-16-44	1	53.1	30.5	8.9	3.5	5.6	8.3	10.0	11.3	9.8	----	----
	2	41.2	20.6	---	---	---	2.9	4.9	6.5	5.3	----	----
	3	42.5	21.6	0.9	---	---	---	----	----	---	----	----
	4	15.0	14.9	3.8	---	---	---	----	----	---	----	----
	5	46.8	24.8	4.4	---	---	---	----	----	---	----	----
Percent Live Load Overstress — H 15-44	1	104.1	99.0	88.5	94.0	103.0	93.0	78.6	61.4	46.5	33.4	22.4
	2	88.4	83.8	61.1	82.3	89.7	83.4	70.6	54.4	40.5	28.1	17.7
	3	89.1	85.5	74.7	83.3	85.5	69.0	53.1	35.8	22.0	10.3	0.7
	4	53.3	75.1	79.6	82.7	80.0	59.3	41.7	24.2	10.5	----	----
	5	95.8	90.3	80.8	79.0	83.4	69.9	55.0	38.7	25.0	13.3	3.6
	6	0.6	30.3	23.8	29.6	30.8	19.3	7.4	----	----	----	----
	7	----	----	----	----	----	----	----	----	----	----	----

53.1 and 46.8 percent on H20-S16-44 bridges, and 104.1 and 95.8 percent on H15-44 bridges, respectively.

In previous computations the bridge overstress which results from passage of a given vehicle-load combination has been based strictly on the live load overstress as a percent of the design live load stress. However, in the design of a bridge (particularly for longer spans) the dead load stress--that is, the weight of the bridge itself--contributes a more important part to the design of the structure. Since the dead load stress does not increase with increased vehicle loads, the actual working stress cannot be obtained for a given bridge without knowing the dead load stress. For a particular bridge, this is readily obtained, but for various types of bridges the dead load varies. For example, in a reinforced concrete T-beam bridge, the dead load is larger in relation to live load for a given span length than for a steel rolled-beam bridge with concrete deck. The steel rolled-beam bridge has the least dead load, and therefore this is the type most critical in considering live load overstressing. To establish the ratio of dead load to total design load for bridge spans of various lengths, data from 72 rolled-beam bridges and 13 plate-girder bridges in Michigan were used to compile the curves in Fig. 8. There is a rather abrupt change in dead load values as shown in Fig. 8 at the transition between rolled-beam and plate girder spans, and therefore the values shown in Table 6 and used in all later analyses have been made more gradual in this area.

Using the percent dead load as established in Table 6, the working stresses have been calculated for all vehicle types with axle loads controlled by Limits A and B. This analysis of working stress has been made for bridges designed for H20-S16-44 and H15-44 loadings and is shown in Fig. 9. For H20-S16-44 bridges the working stress exceeds the design stress by no more than 13 percent for all trucks with 6 axles or less, while the maximum working stress is 151.5 percent of the design stress for the 3S3-5 truck types. On bridges designed for H15-44 loading, the working stresses are much higher, exceeding 150 percent for some vehicle types with 6 axles or less, and reaching a maximum of 203 percent for the 3S3-5 type vehicle.

An additional evaluation of the stresses caused by typical vehicles of various lengths, in terms of percent of allowable working stress, is shown in Fig. 9A. In this case, however, an additional load limit, Load Limit C, has been introduced. Load Limit C is set at 20 kips for single axles, and 34 kips for tandem axles. Axle loads for the typical vehicles used for illustration were limited by Load Limit A, B, or C, for all vehicles with 6 axles or less, without any other gross or bridge formula limitation. The maximum stress as a percent of the allowable working stress for these vehicles with 6 axles or less, is 156 percent for bridges designed for H15-44 loading and 117 percent for bridges designed for H20-S16-44 loading.

For vehicles in Fig. 9A with more than 6 axles, no changes were made in the cases of Load Limits A and B, but for vehicles with Load Limit C, the extreme wheel base length was increased from 56 to 60 ft and the axle loads were further restricted to the load as determined by the modified Bridge Formula.

$$W = 500 \frac{LN}{N-1} + 12N + 36.$$

The results of the anaylsis shown in Fig. 9A indicate that the modified Bridge Formula would require some reduction in axle loads for short wheelbase vehicles with 7 or more axles, and that this reduction would become larger with an increase in the number of axles per vehicle. The modified Bridge Formula, when applied to vehicles with Load Limit C, does reduce the magnitude of the bridge overstress, but it can be noted that it does restrict all vehicles uniformly. With an increase in the number of axles per vehicle, the overstress also increases when applying the formula. Maximum overstress for vehicles with 7 axles or more, with Load Limit C, and with application of the modified Bridge Formula, is 53 percent for bridges designed for H15-44 loading and 17 percent for bridges designed for H20-S16-44 loading.

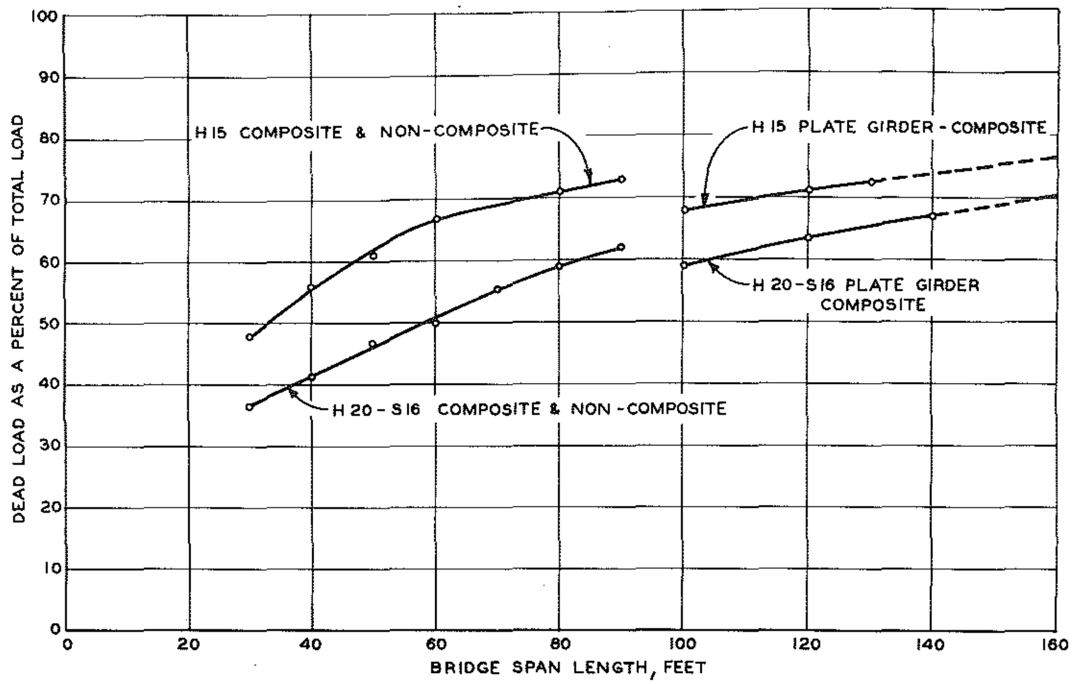

Figure 8. Significance of dead load in relation to total design load for various span lengths.

TABLE 6
DEAD LOAD AS A PERCENT OF TOTAL DESIGN LOAD
H15-44 and H20-S16-44 Bridges

Span Length, ft	H15-44 Bridges		H20-S16-44 Bridges	
	Dead Load as A Percent of Total Load	Live Load As A Percent of Total Load	Dead Load as A Percent of Total Load	Live Load As A Percent of Total Load
20	40	60	32	68
30	48	52	36	64
40	55	45	41	59
50	62	38	46	54
60	65	35	51	49
80	67	33	59	41
100	68	32	59	41
125	71	29	64	36
150	75	25	69	31
175	78	22	72	28
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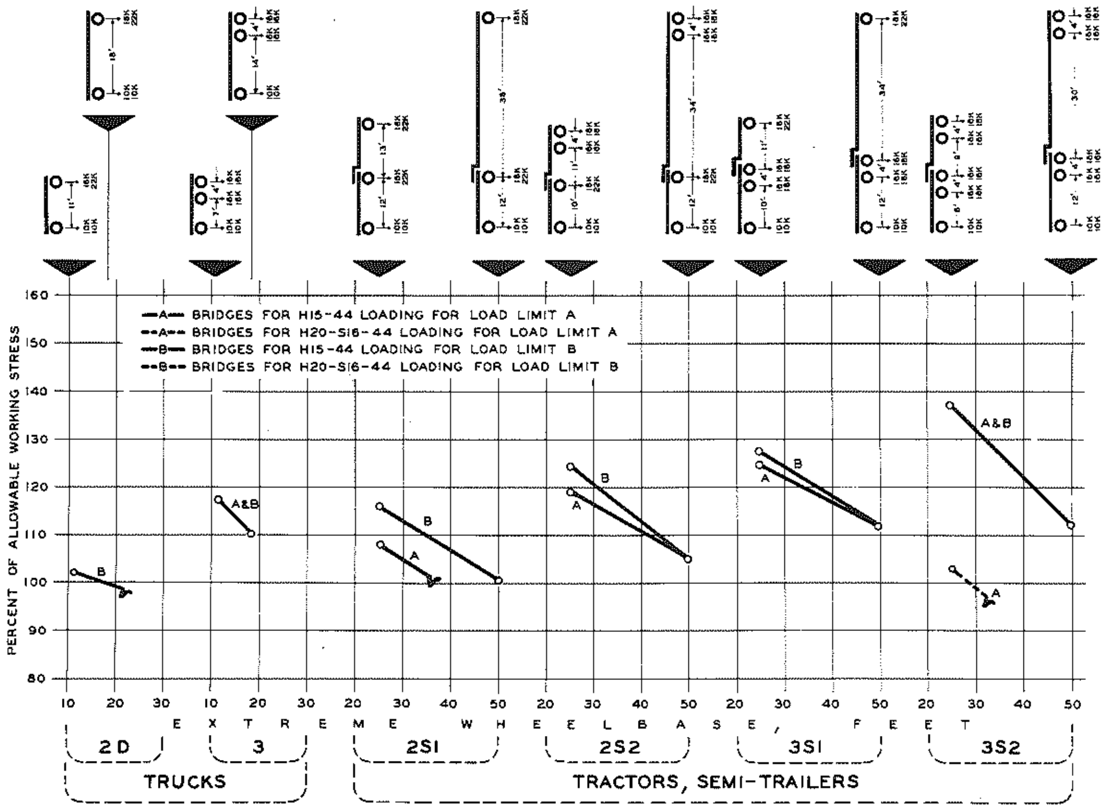


Figure 9. Bridge working stresses for various truck types (Load Limit A: 18-kip single-axle, 32-kip tandem-axle; Load Limit B: 22-kip single-axle, 32-kip tandem axle).

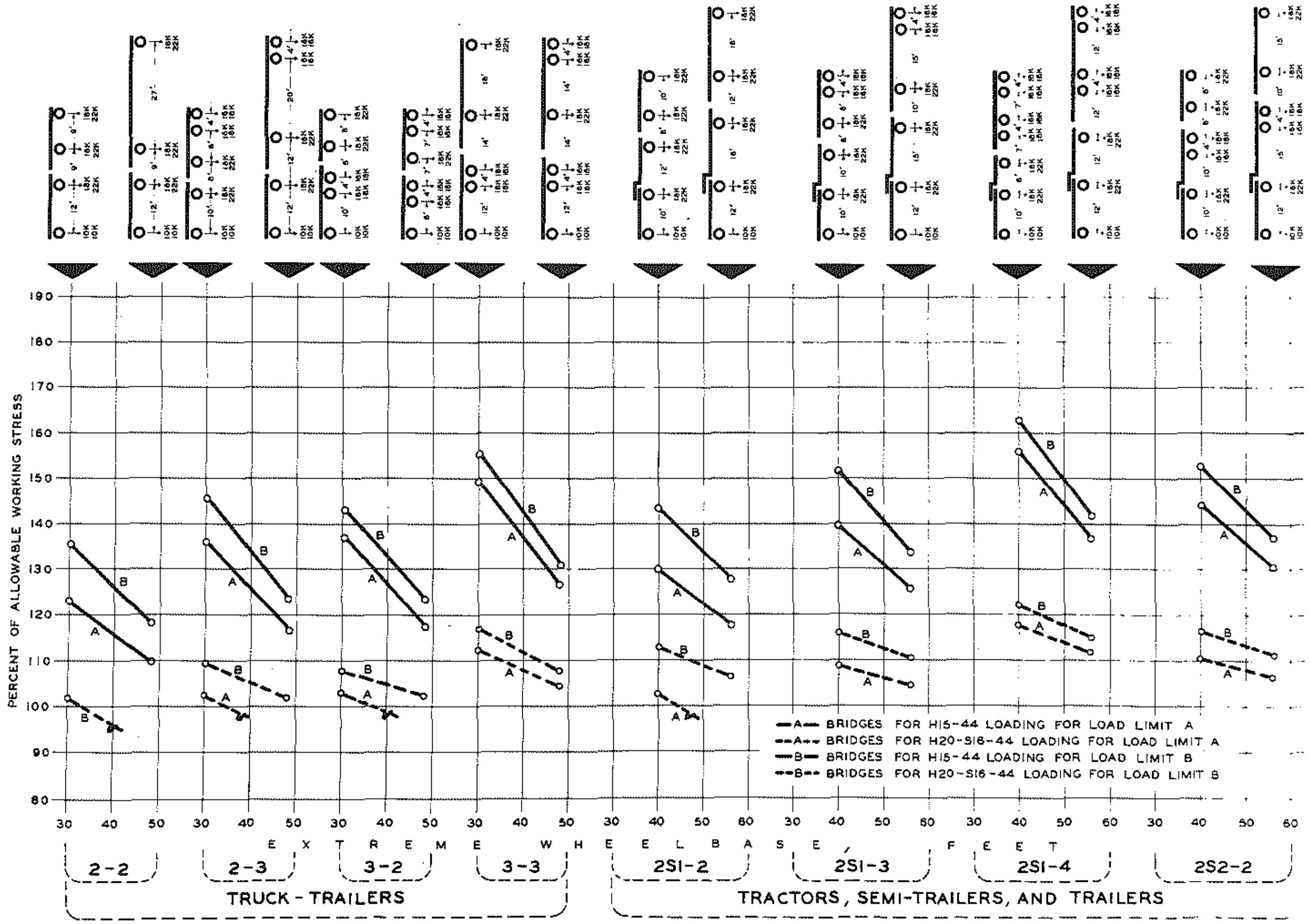


Figure 9 (cont.). Bridge working stresses for various truck types (Load Limit A: 18-kip single-axle, 32-kip tandem-axle; Load Limit B: 22-kip single-axle, 32-kip tandem axle).

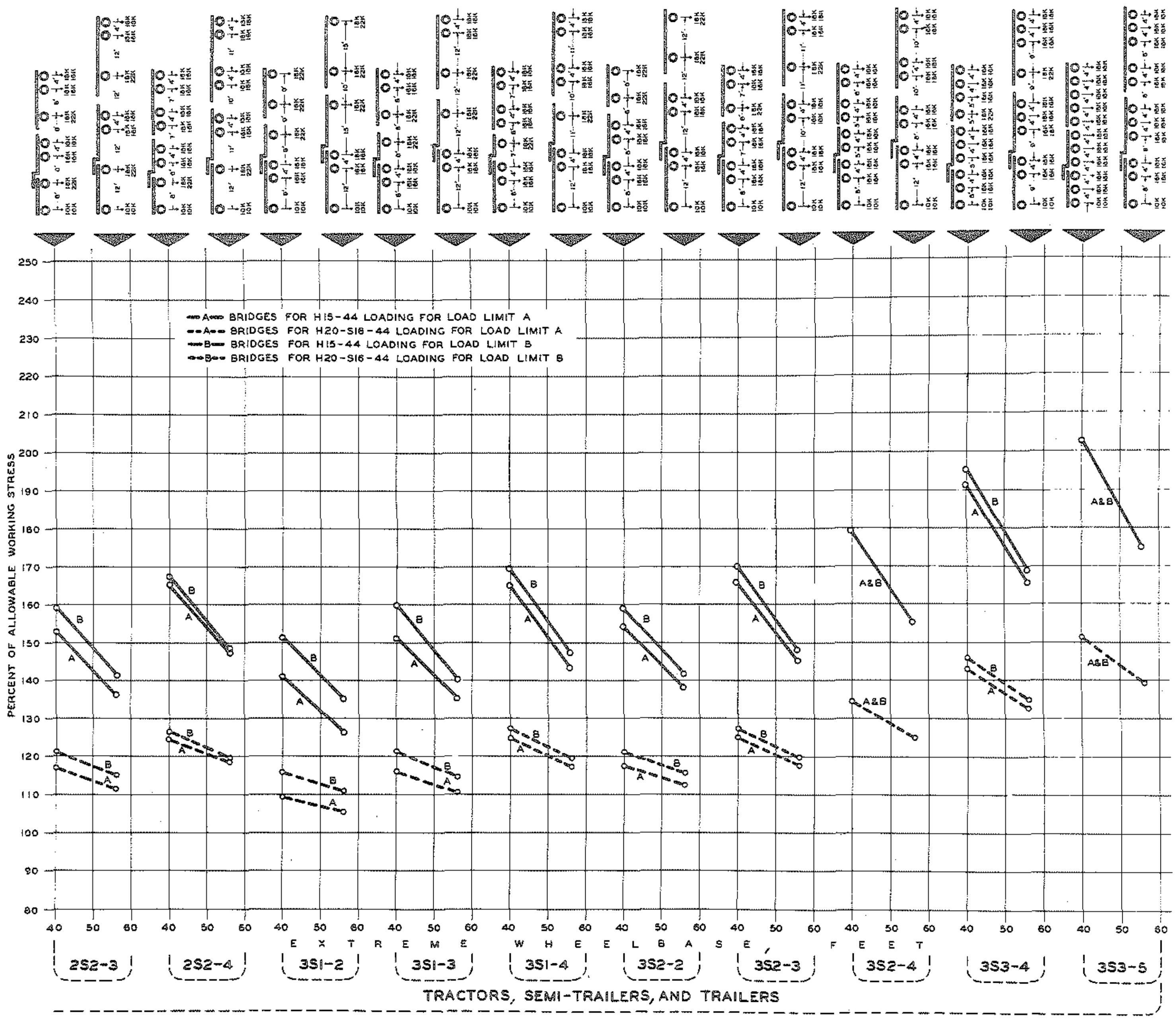


Figure 9 (cont.). Bridge working stresses for various truck types (Load Limit A: 18-kip single-axle, 32-kip tandem-axle; Load Limit B: 22-kip single-axle, 32-kip tandem axle).

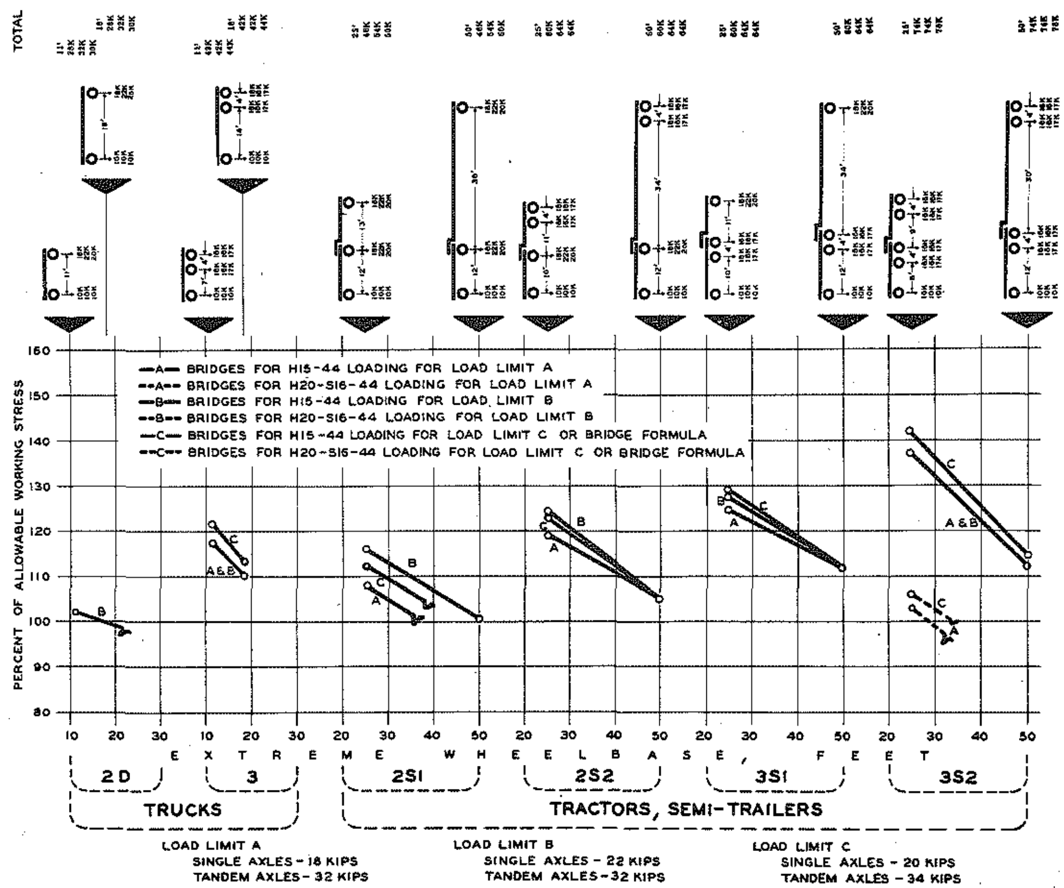


Figure 9A. Bridge working stresses for various truck types.

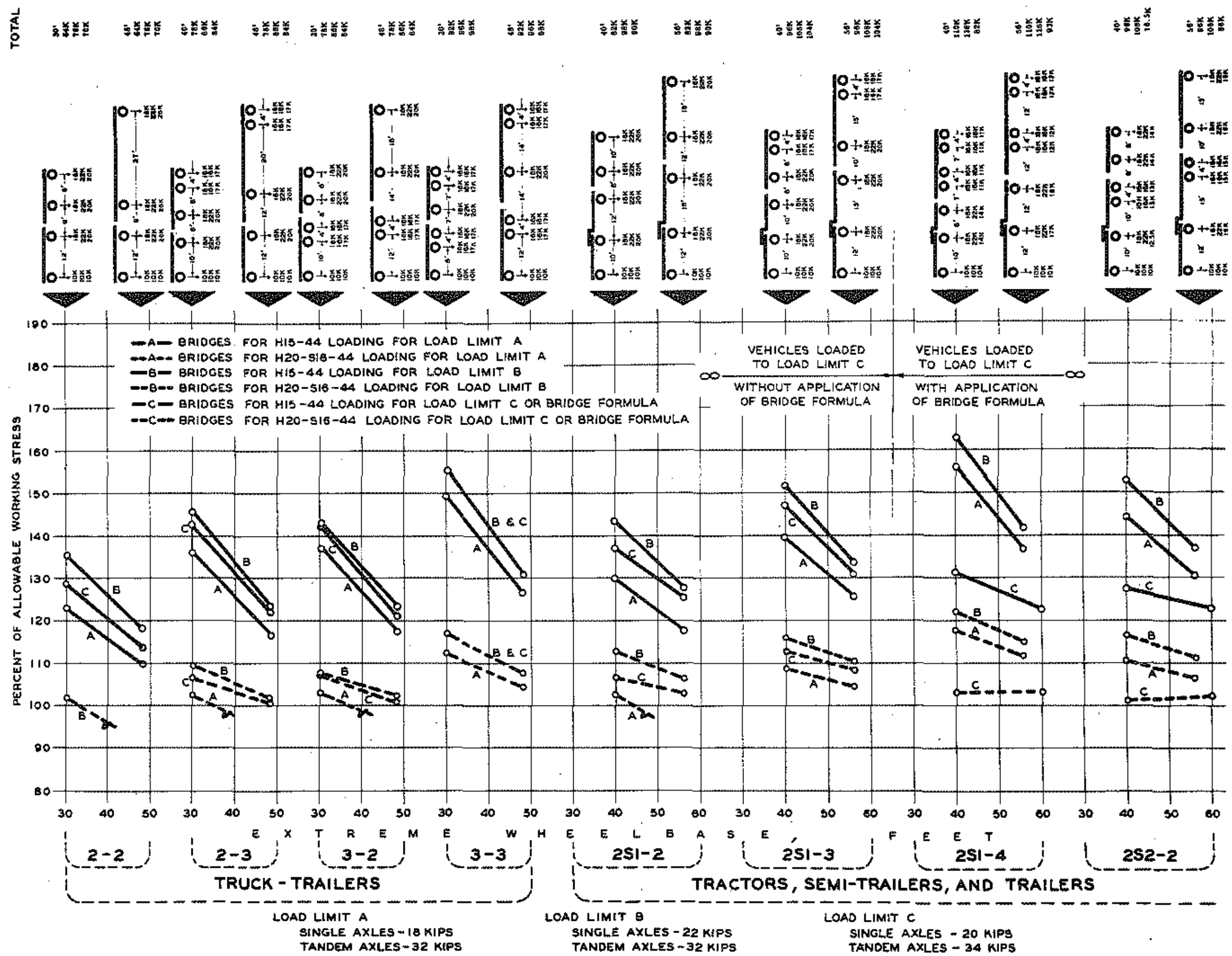


Figure 9A (cont.). Bridge working stresses for various truck types.

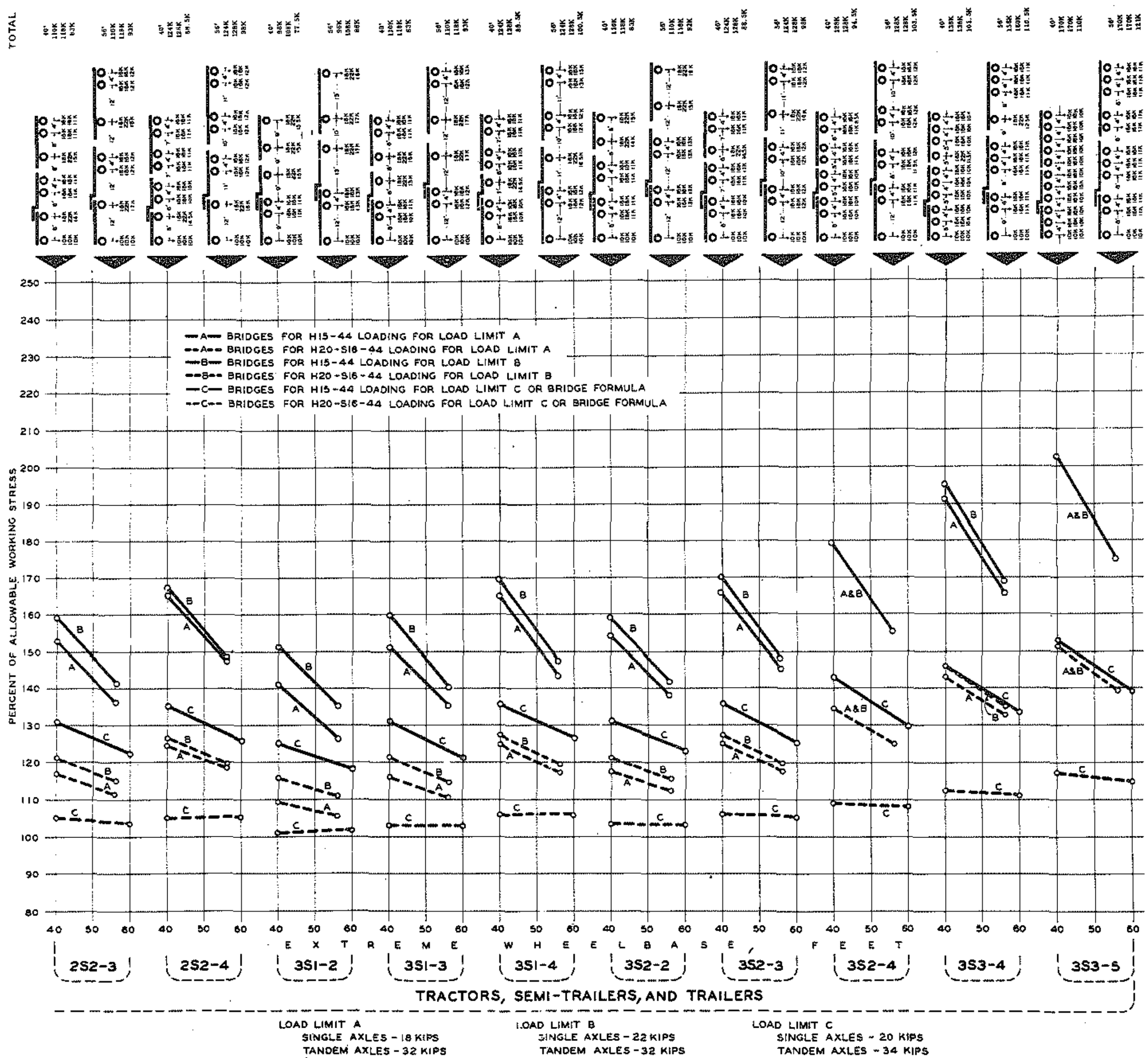


Figure 9A (cont.). Bridge working stresses for various truck types.

LOAD LIMIT ANALYSIS

With the preceding background on the effects of a great number of actual commercial vehicles on bridge stresses, the effect of certain special permit vehicles on bridge stresses, and the effect of vehicle wheelbase measurements on stresses, it is possible to set realistic load limitations in line with the design of existing bridges.

Applying the Bridge Formula, given previously as Equation 1, to vehicles with 2 to 9 axles and varying in extreme wheelbase dimensions, results in load limits as shown in Table 7. The load limitations resulting from the use of the Bridge Formula may also be studied for the 88 typical vehicle-load combinations in Appendix B, where the total loads for the vehicles under Load Limits A and B have been reduced in order to comply with the Bridge Formula.

In an attempt to simplify the practical aspects of load enforcement, Table 8 has been prepared in format similar to the Bridge Formula table (Table 7), but with the following differences:

1. Using the Bridge Formula (as in Table 7) the load limit for the vehicle as a whole is obtained by determining the load limit for all combinations of two-axle groups, three-axle groups, four-axle groups, etc., to the limit of axles for that vehicle. However, in Table 8, the entire vehicle load is determined only on the basis of the number of axles and the wheelbase length of the vehicle, provided individual axle loads do not exceed the legal limit.

2. The limiting loads shown in Table 8 are for a vehicle live load moment that will not cause a greater moment than caused by the design vehicle.

Using the simplified analytical procedure for obtaining limits as given in Table 8, there remains the possibility of bridge overstress as a result of interior axle groups loaded to the legal individual axle load limits. This will occur when a vehicle is loaded correctly to a total load limit, but the magnitudes of the individual axle loads are distributed very unevenly along the vehicle. For bridges designed for H20-S16-44 loading this could result in a maximum overstress of 4.6, 3.3, 8.2,

TABLE 7
PERMISSIBLE GROSS LOADS
BASED ON THE BRIDGE FORMULA
FOR VEHICLES IN REGULAR OPERATION

$$\text{Weight Formula: } W = 500 \left(\frac{LN}{N-1} + 12N + 32 \right) \text{, Modified*}$$

Distance in feet between the extremes of any group of two or more consecutive axles	Maximum load in pounds carried on any group of two or more consecutive axles							
	2 axles	3 axles	4 axles	5 axles	6 axles	7 axles	8 axles	9 axles
4	32,000							
5	32,000							
6	32,000							
7	32,000							
8	32,000	40,000						
9	36,000	40,750						
10		41,500						
11		42,250						
12		43,000	48,000					
13		43,750	48,667					
14		44,500	49,333					
15		45,250	50,000					
16		46,000	50,667	56,000				
17		46,750	51,333	56,625				
18		47,500	52,000	57,250				
19		48,250	52,667	57,875				
20		49,000	53,333	58,500	64,000			
21		49,750	54,000	59,125	64,600			
22		50,500	54,667	59,750	65,200			
23		51,250	55,333	60,375	65,800			
24		52,000	56,000	61,000	66,400	72,000		
25		52,750	56,667	61,625	67,000	72,583		
26		53,500	57,333	62,250	67,600	73,167		
27		54,000	58,000	62,875	68,200	73,750		
28		55,000	58,667	63,500	68,800	74,333	80,000	
29			59,333	64,125	69,400	74,917	80,571	
30			60,000	64,750	70,000	75,500	81,143	
31			60,667	65,375	70,600	76,083	81,714	
32			61,333	66,000	71,200	76,667	82,286	88,000
33			62,000	66,625	71,800	77,250	82,857	88,563
34			62,667	67,250	72,400	77,833	83,429	89,125
35			63,333	67,875	73,000	78,417	84,000	89,688
36			64,000	68,500	73,600	79,000	84,571	90,250
37			64,667	69,125	74,200	79,583	85,143	90,813
38			65,333	69,750	74,800	80,167	85,714	91,375
39			66,000	70,375	75,400	80,750	86,286	91,938
40			66,667	71,000	76,000	81,333	86,857	92,500
41			67,330	71,625	76,600	81,917	87,429	93,063
42			68,000	72,250	77,200	82,500	88,000	93,625
43			68,667	72,875	77,800	83,083	88,571	94,188
44			69,333	73,500	78,400	83,667	89,143	94,750
45			70,000	74,125	79,000	84,250	89,714	95,313
46			70,667	74,750	79,600	84,833	90,286	95,875
47			71,333	75,375	80,200	85,417	90,857	96,438
48			72,000	76,000	80,800	86,000	91,429	97,000
49			72,665	76,625	81,400	86,583	92,000	97,563
50				77,250	82,000	87,167	92,571	98,125
51				77,875	82,600	87,750	93,143	98,688
52				78,500	83,200	88,333	93,714	99,250
53				79,125	83,800	88,917	94,286	99,813
54				79,750	84,400	89,500	94,857	100,375
55				80,375	85,000	90,083	95,429	100,938
56				81,000	85,600	90,667	96,000	101,500
57				81,625	86,200	91,250	96,571	102,063
58				82,250	86,800	91,833	97,143	102,625
59				82,875	87,400	92,417	97,714	103,188
60				83,500	88,000	93,000	98,286	103,750

* The modification consists in limiting the maximum load on any single axle to 18,000 lb.

TABLE 8
PERMISSIBLE GROSS VEHICLE LOADS
Based on Legal Limit A (18-kip single axle, 32-kip tandem axles)
Steering axle load assumed as 10 kips

	Distance in Feet Between Extreme Axles	Maximum Load in Kips for Vehicle with Following Number of Axles							
		2	3	4	5	6	7	8	9 or more
H20-S16-44 Bridge Loading	4	28							
	7	28							
	10	28							
	13	28	42						
	16	28	43						
	19	28	44						
	22		45						
	25		46						
	28		46	64	70				
	31		46	64	73	73			
	34		46	64	74	74			
	37		46	64	75	75			
	40		46	64	76	76			
	43		46	64	77	77	77	77	77
	46		46	64	78	80	80	80	80
	49		46	64	78	82	82	82	82
	52		46	64	78	82	82	82	82
	55		46		80	82	82	82	82
	58		46		82	82	83	83	83
	Maximum Overstress(a)	0	0	0	0	4.6	3.3	8.2	8.7
H15-S12-44 Bridge Loading	4	28							
	7	48							
	10	28							
	13	28	35						
	16	28	37						
	19	28	39						
	22		44						
	25		54						
	28		54	54	54				
	31		54	54	54	55			
	34		54	54	54	55			
	37		54	56	56	56			
	40		54	57	57	57			
	43		54	58	58	58	58	58	58
	46		54	59	59	59	59	59	59
	49		54	60	61	61	61	61	61
	52		54	62	63	63	63	63	63
	55				63	63	63	63	63
	58				63	63	63	63	63
	Maximum Overstress(a)	0	0	8.3	8.3	12.1	11.2	10.9	10.4

(a) Overstress due to arrangement of loads between extreme axles, but with same total vehicle load.

and 8.7 percent, for vehicles with 6, 7, 8, and 9 axles or more, respectively. For H15-S12-44 bridges the maximum overstress would be 12.1 percent and would occur for a 6-axle vehicle.

In Table 9 a direct comparison is made between the Bridge Formula limitations and two bridge design loadings (H20-S16-44 and H15-S12-44). In addition to the bridge design loadings, individual legal axle load limitations are also applied--22-kip single axles and 32-kip tandem axles for H20-S16-44 loading, and 18-kip single axle and 32-kip tandem axle loads for H15-S12-44 loading. Table 9 indicates that:

1. For vehicles with 5 axles or less, the Bridge Formula generally gives a slightly lower load limit than the H20-S16-44 design loading limit.

2. One exception to this is that the Bridge Formula limitation appears to increase slightly faster with increased vehicle wheelbase length than the H20-S16-44 loading and, therefore, for vehicles with wheelbase lengths over 52 ft the Bridge Formula gives a slightly greater load limit than the H20-S16-44 loading.

3. For vehicles with 6 axles or less, the Bridge Formula limitation gives greater loads than the H15-S12-44 loading, but this varies considerably from a small percentage for 3-axle vehicles and shorter wheelbase measurements, to a maximum of 38 percent for 6-axle vehicles with 58-ft wheelbases.

4. For vehicles with 7 axles or more, the Bridge Formula gives a higher limit than the H20-S16-44 loading and a much higher limit than the H15-S12-44 loading.

5. For vehicles with 6 axles or more, the Bridge Formula limit tends to increase more rapidly with increased numbers of axles than does the H20-S16-44 design loading. This leads to an average overstress for an H20-S16-44 bridge, loaded on the basis of the Bridge Formula, of 7 percent for a 7-axle vehicle, and of 20 percent for a vehicle with 9 axles or more. The largest overstress is 22.2 percent.

6. For vehicles with 6 axles or more, the Bridge Formula limit leads to an average overstress for an H15-S12-44 bridge of 44 percent for a 7-axle vehicle and of 61 percent for a vehicle with 9 axles or more. The largest overstress is 62.8 percent.

TABLE 9
COMPARISON OF BRIDGE FORMULA WITH PERMISSIBLE GROSS LOADS FOR PRACTICAL VEHICLES BASED ON H20-S16-44 AND H15-S12-44 BRIDGE DESIGN LOADINGS

Distance in Feet Between Extreme Axles	Maximum Load in Kips*							
	2 Axles	3 Axles	4 Axles	5 Axles	6 Axles	7 Axles	8 Axles	9 or More Axles
4	32 32.0 28							
7	32 32 28							
10	32 38.0 28	41.5						
13	32 40.0 28	42 43.8 35	48.7					
16	32 40.0 28	42 46.0 37	50.7	56.0				
19	32 40.0 28	42 48.2 39	52.7	57.9				
22		46 50.5 44	54.7	59.8	65.2			
25		54 52.8 54	56.7	61.6	67.0	72.6		
28		54 55.0 54	70 58.7 54	70 63.5 54	68.8	74.3	80.0	
31		54 57.2 54	72 60.7 54	73 65.4 54	73 70.6 55	76.1	81.7	
34		54 59.5 54	73 62.7 54	74 67.2 54	74 72.4 55	77.8	83.4	89.1
37		54 61.8 54	73 64.7 56	75 69.1 56	75 74.2 56	79.6	85.1	90.8
40		54 64.0 54	74 66.7 57	76 71.0 57	76 76.0 57	81.3	86.9	92.5
43		54 66.2 54	74 68.7 58	77 72.9 58	77 77.8 58	77 83.1 58	77 88.6 58	77 94.2 58
46			75 70.7 59	79 74.8 59	80 79.6 59	80 84.8 59	80 90.3 59	80 95.9 59
49			76 72.7 60	81 79.6 61	82 81.4 61	82 86.6 61	82 92.0 61	82 97.6 61
52			77 74.7 62	81 78.5 63	83 83.2 63	83 88.3 63	83 93.7 63	83 99.2 63
55			76.7	82 80.4 63	84 85.0 63	84 90.1 63	84 95.4 63	84 100.9 63
58			78.7	82 82.3 63	84 86.8 63	84 91.8 63	84 97.1 63	84 102.6 63

* In each 3-figure group of values in the respective axle columns shown, individual figures represent the following values:

1 (top). Permissible total vehicle load based on H20-S16-44 loading and Legal Limit B (22 kip single, 32 kip tandem). Steering axles assumed as 10 kips.

2 (center). Permissible total vehicle load based on Bridge Formula and use of extreme axle spacing limitation only.

3 (bottom). Permissible total vehicle load based on H15-S12-44 loading and Legal Limit A (18 kip single, 32 kip tandem). Steering axles assumed as 10 kips.

Setting Practical Load Limits

In order to illustrate a method of setting practical load limitations for bridges that are based on an equitable design stress level for all vehicles, the following two load-stress criteria will be used:

1. For commercial truck traffic on H15-44 bridges a 33-percent overstress based on a combination of live and dead load is permitted.

2. For commercial truck traffic on H20-S16-44 bridges no overstress is permitted.

Any other load-stress criteria could be used equally well for determining practical load limits, but these appear to be reasonable and a median of the general opinion of bridge design engineers.

Since overstresses are permitted by the first load-stress criterion above, and since these overstresses will be based on the combined live and dead load, it is necessary to establish a live load-dead load ratio for bridge spans of various lengths. This has been done on the basis of Michigan bridge design as shown in Fig. 8. Seventy-two rolled span bridges and thirteen plate girder bridges were used to compile these curves. In Table 6 a dead load as a percent of total load was selected from Fig. 8 for each span length category and computations were made as indicated in this table to determine the percentage that live load stress increased for a 33-percent overall stress increase.

Considering the two stated load-stress criteria, the allowable load limits for the 88 commercial vehicle-load combinations (Appendix B) are presented in Table 10. It should be noted that the second criterion controls in every case, i.e., the limit for zero overstress under the H20-S16-44 loading is more restrictive than a 33-percent overstress for H15-44 loading. Thus, the allowable total loads would be those given by Table 8 if individual axle loads are restricted to 18-kip single axle loads and 32-kip tandem axle loads. This would be slightly higher for trucks with 2, 3, or 4 axles if the single axle load limit were 22 kips instead of 18.

In weighing the various factors which influence setting a practical load limit for commercial vehicles, the two types of restrictions should be kept in mind. Individual axle load limits are necessary chiefly in connection with pavements but also for short span bridges, and limits for axle load groups are most important for bridges, particularly for long spans. Higher individual axle load limits will permit greater total loads for vehicles with 2, 3, or possibly 4 axles, but are of no value for vehicles with 5 axles or more, since within practical wheelbase lengths the total load will be limited by the load on an axle group. Generally, this critical axle group consists of the axles for the entire vehicle and thus higher load limits do no practical good. This is shown by comparing the two portions of Table 8 for the case of 5 axles or more; the values are identical whether 18- or 22-kip single axle loads are used as the limit. Similarly, it follows that increasing the load limit for tandem axle loads from 32 to 36 kips, for example, would benefit Type 3, Type 2S2, or Type 3S1 vehicles only, and not Type 3S2 with two tandem axle groups since for this vehicle the total load rather than individual axle loads controls.

Simple rules or limits can be devised which will prevent stressing all bridges beyond a fixed limit, but the simpler these rules are the more inflexible they will necessarily be, and they may unnecessarily restrict certain vehicle types or certain axle load arrangements. The more complex the load limiting system, the more flexible and less arbitrary it can be. The Bridge Formula is one of these more complex systems of controlling vehicle loads; however, from this analysis it appears that it has the following limitations:

1. It does not maintain a uniform stress level. When compared to the H20-S16-44 design loading it generally gives too low a limit for vehicles with 5 axles or less and too high a limit for vehicles with 7 axles or more.

2. Its wheelbase length provision grants too high a load limit as length increases, as compared to the H20-S16-44 design loading.

3. It is more complex than is necessary since its fundamental accuracy when compared to bridge design loads is not sufficiently close to warrant this detail.

TABLE 10
PRACTICAL LIMITS FOR COMMERCIAL VEHICLES

Vehicle Type	Wheelbase Length, ft.	Load Limit in Kips	
		H15-44 Loading with 33% Overstress	H20-S16-44 with Design Stress
2D	11	32*	32*
	18	32*	32*
3	11	42*	42*
	18	42*	42*
2S1	25	54*	54*
	50	54*	54*
2S2	25	64*	64
	50	64*	64*
3S1	25	64*	64*
	50	64*	64*
3S2	25	70	70
	50	74*	74*
2-2	30	73	72
	48	76*	76*
2-3	30	74	73
	48	86*	81
3-2	30	75	73
	48	86*	86*
3-3	30	75	73
	48	96*	96*
2S1-2	40	85	77
	56	98*	82
2S1-3	40	86	77
	56	107	84

* Load limited by axle loads: 22-kip single, 32-kip tandem

TABLE 10 (cont.)
PRACTICAL LIMITS FOR COMMERCIAL VEHICLES

Vehicle Type	Wheelbase Length, ft.	Load Limit in Kips	
		H15-44 Loading with 33% Overstress	H20-S16-44 with Design Stress
2S1-4	40	83	76
	56	104	82
2S2-2	40	83	76
	56	102	82
2S2-3	40	85	76
	56	105	83
2S2-4	40	84	76
	56	102	82
3S1-2	40	86	76
	56	105	83
3S1-3	40	87	77
	56	109	83
3S1-4	40	84	76
	56	107	83
3S2-2	40	84	76
	56	102	82
3S2-3	40	84	77
	56	104	82
3S2-4	40	82	75
	56	103	82
3S3-4	40	84	76
	56	104	82
3S3-5	40	84	76
	56	104	82

CONCLUSIONS

In place of the Bridge Formula with its complexities of application, requiring the examining of each axle group from two axles to the total for the group and the respective distances between extreme axles for each load group, it is possible to devise a simple table such as Table 10 to control truck loading by individual axle loads and total vehicle loads. By doing this, the amount of bridge overstress on practical vehicles due to irregular placement of loads but complying with the total load limit would be restricted to less than 10 percent. This method is much simpler in application than the Bridge Formula and yet the real error or difference between design condition and load limit would be smaller than by the Bridge Formula.

With only a limited amount of overstressing, however, it is possible to simplify these limitations still further as follows:

1. For vehicles with 4 axles or less, axle load limits of 18 kips for single and 32 kips for tandem are all that are required.

2. For vehicles with 5 or 6 axles, limit gross vehicle load to 75 kips.

3. For vehicles with 6 axles or more, limit gross vehicle load to 80 kips.

These limits would cause a maximum overstress of less than 7 percent for trucks with extremely short axle spacings and uniformly loaded axles, and approximately 15 percent for the same type trucks with very non-uniformly loaded axles, but within the axle load limits. Table 8 also shows that these three limits would not unnecessarily restrict the loading for even the longest trucks by more than 10 percent.

APPENDICES

APPENDIX A

PERCENT LIVE LOAD OVERSTRESS RESULTING FROM DESIGNATED VEHICLES ON BRIDGES WITH FOUR DESIGN LOADINGS

Bridge Span Length

Vehicle Designation	Gross Weight, kips	20 Feet — Percent Overstress for				30 Feet — Percent Overstress for				40 Feet — Percent Overstress for				50 Feet — Percent Overstress for				60 Feet — Percent Overstress for			
		H20-S16	H15-S12	H-20	H-15	H20-S16	H15-S12	H-20	H-15	H20-S16	H15-S12	H-20	H-15	H20-S16	H15-S12	H-20	H-15	H20-S16	H15-S12	H-20	H-15
2D-A Min.	28	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
2D-B Min.	32	----	----	----	----	----	----	----	1.6	----	----	----	2.7	----	----	----	3.9	----	----	----	1.9
2D-A Max.	28	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
2D-B Max.	32	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
3-A Min.	42	----	19.2	----	19.2	----	17.0	0.4	34.1	----	4.7	2.0	35.8	----	----	2.7	46.1	----	----	0.9	34.4
3-B Min.	42	----	19.2	----	19.2	----	17.0	0.4	34.1	----	4.7	2.0	35.8	----	----	2.7	46.1	----	----	0.9	34.4
3-A Max.	42	----	10.0	----	10.0	----	0.9	----	----	----	----	----	22.7	----	----	----	26.9	----	----	----	26.3
3-B Max.	42	----	10.0	----	10.0	----	0.9	----	----	----	----	----	22.7	----	----	----	26.9	----	----	----	26.3
2S1-A Min.	46	----	----	----	----	----	----	----	----	----	----	----	1.9	----	----	----	19.5	----	----	----	22.7
2S1-B Min.	54	----	----	----	----	----	----	----	11.4	----	0.9	----	30.8	----	0.8	6.5	42.2	----	0.7	9.1	45.3
2S1-A Max.	46	----	----	----	----					----	----	----	----					----	----	----	----
2S1-B Max.	54	----	----	----	----					----	----	----	1.2					----	----	----	0.7
2S2-A Min.	60	----	3.3	----	3.3	----	----	----	11.4	----	4.5	1.7	35.4	----	6.2	12.1	49.7	----	7.3	16.3	54.9
2S2-B Min.	64	----	3.3	----	3.3	----	10.8	----	27.0	----	16.3	14.2	50.8	----	16.8	23.3	34.7	----	17.2	27.1	69:2
2S2-A Max.	60	----	8.3	----	8.3					----	----	----	11.2					----	----	----	4.3
2S2-B Max.	64	----	8.3	----	8.3					----	----	----	11.2					----	----	----	4.3
3S1-A Min.	60	----	3.3	----	3.3	----	17.5	0.8	34.6	----	18.4	15.3	53.5	----	16.6	23.1	64.4	----	15.5	25.3	66.8
3S1-B Min.	64	----	3.3	----	3.3	----	21.2	4.0	38.9	----	23.7	20.5	60.4	----	22.5	29.4	72.8	----	21.8	32.1	75.9
3S1-A Max.	60	----	8.3	----	8.3					----	----	----	26.5					----	----	----	28.4
3S1-B Max.	64	----	8.3	----	8.3					----	----	----	26.5					----	----	----	28.4
3S2-A Min.	74	----	15.0	----	15.0	2.8	38.7	17.4	36.2	5.3	40.5	37.0	82.3	4.9	40.0	47.8	97.3	4.6	39.5	51.3	101.4
3S2-B Min.	74	----	15.0	----	15.0	2.8	38.7	17.4	36.2	5.3	40.5	37.0	82.3	4.9	40.0	47.8	97.3	4.6	39.5	51.3	101.4
3S2-A Max.	74	----	8.3	----	8.3	----	----	----	----	----	----	----	26.5	----	----	----	----	----	----	----	24.6
3S2-B Max.	74	----	8.3	----	8.3	----	----	----	----	----	----	----	26.5	----	----	----	----	----	----	----	24.6
2-2-A Min.	64	----	----	----	----					----	11.9	9.0	45.0	----	13.8	20.2	60.5	----	15.0	24.7	66.1
2-2-B Min.	76	----	10.0	----	10.0					2.4	36.8	33.2	77.3	3.5	38.0	45.7	94.6	4.0	38.7	50.4	100.2
2-2-A Max.	64	----	----	----	----					----	----	----	9.2					----	----	----	27.0
2-2-B Max.	76	----	10.0	----	10.0					----	3.0	0.3	33.5					----	6.0	14.9	53.0
2-3-A Min.	78	----	23.3	----	23.3					1.8	35.9	32.4	76.2	4.0	38.6	46.4	95.5	5.1	40.2	52.0	102.4
2-3-B Min.	86	----	27.5	----	27.5					16.0	54.9	50.9	100.8	17.4	56.5	65.2	120.7	18.0	57.4	70.6	127.2
2-3-A Max.	78	----	8.3	----	8.3					----	----	----	15.0					----	----	5.9	41.5
2-3-B Max.	86	----	8.3	----	8.3					----	----	----	16.9					----	13.7	23.3	65.3
3-2-A Min.	78	----	23.3	----	23.3					3.6	38.3	34.7	79.2	5.1	40.1	48.0	97.6	5.9	41.3	53.2	104.1
3-2-B Min.	86	----	27.5	----	27.5					11.6	49.0	45.1	93.1	13.9	51.8	60.3	114.1	15.1	53.6	66.5	121.7
3-2-A Max.	78	----	8.3	----	8.3					----	----	----	1.9					----	1.7	10.2	46.8
3-2-B Max.	86	----	8.3	----	8.3					----	----	----	18.1					----	14.7	24.4	65.6
3-3-A Min.	92	----	30.0	----	30.0					20.0	60.2	59.0	107.7	22.5	63.3	72.4	130.2	23.8	65.1	79.0	138.4
3-3-B Min.	96	1.9	35.8	1.9	35.8					28.7	71.8	67.3	122.7	29.1	73.9	83.6	145.2	31.2	75.0	89.8	152.7
3-3-A Max.	92	----	8.3	----	8.3					----	----	----	18.5					----	19.3	29.4	72.3
3-3-B Max.	96	----	8.3	----	8.3					----	3.3	0.6	33.8					----	29.3	40.1	86.6
2S1-2-A Min.	82	----	----	----	----					----	13.9	11.0	47.7	----	21.7	28.5	71.6	----	28.6	39.4	85.7
2S1-2-B Min.	98	----	10.0	----	10.0					4.2	39.2	35.5	80.4	11.0	48.0	56.3	106.7	16.7	55.7	68.8	124.8
2S1-2-A Max.	82	----	----	----	----					----	----	----	15.0					----	----	5.2	40.1
2S1-2-B Max.	98	----	3.3	----	3.3					----	1.2	----	31.2					----	18.5	28.5	71.1
2S1-3-A Min.	96	----	23.3	----	23.3					4.0	38.9	35.3	80.0	4.5	39.3	47.1	96.4	10.9	47.9	60.5	113.6
2S1-3-B Min.	108	----	27.5	----	27.5					19.6	59.6	55.5	106.9	22.5	63.3	72.4	130.2	28.6	71.6	86.0	147.7
2S1-3-A Max.	96	----	8.3	----	8.3					----	----	----	26.9					----	16.2	26.0	67.8
2S1-3-B Max.	108	----	8.3	----	8.3					----	14.8	11.8	48.8					----	30.1	41.0	87.8

Vehicle Designation	Gross Weight, kips	80 Feet — Percent Overstress for				100 Feet — Percent Overstress for				125 Feet — Percent Overstress for				150 Feet — Percent Overstress for				175 Feet — Percent Overstress for				200 Feet — Percent Overstress for			
		H20-S16	H15-S12	H-20	H-15	H20-S16	H15-S12	H-20	H-15	H20-S16	H15-S12	H-20	H-15	H20-S16	H15-S12	H-20	H-15	H20-S16	H15-S12	H-20	H-15	H20-S16	H15-S12	H-20	H-15
2D-A Min.	28	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
2D-B Min.	32	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
2D-A Max.	28	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
2D-B Max.	32	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
3-A Min.	42	----	----	----	18.2	----	----	----	4.8	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
3-B Min.	42	----	----	----	18.2	----	----	----	4.8	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
3-A Max.	42	----	----	----	12.8	----	----	----	1.1	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
3-B Max.	42	----	----	----	12.8	----	----	----	1.1	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
2S1-A Min.	46	----	----	----	13.8	----	----	----	3.8	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
2S1-B Min.	54	----	0.6	0.8	34.4	----	0.4	----	22.4	----	0.4	----	9.2	----	----	----	----	----	----	----	----	----	----	----	----
2S1-A Max.	46	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
2S1-B Max.	54	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
2S2-A Min.	60	----	8.4	8.6	44.8	----	9.0	----	32.8	----	9.5	----	19.0	----	7.5	----	7.5	----	----	----	----	----	----	----	----
2S2-B Min.	64	----	17.5	17.8	57.0	----	17.8	7.7	43.5	----	17.9	----	28.2	----	15.6	----	15.6	----	4.7	----	4.7	----	----	----	----
2S2-A Max.	60	----	----	----	4.7	----	----	----	3.8	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
2S2-B Max.	64	----	----	----	6.0	----	----	----	7.2	----	----	----	2.6	----	----	----	----	----	----	----	----	----	----	----	----
3S1-A Min.	60	----	14.3	14.6	52.8	----	13.6	3.9	38.5	----	13.1	----	23.0	----	10.4	----	10.4	----	----	----	----	----	----	----	----
3S1-B Min.	64	----	20.9	21.2	61.6	----	20.5	10.2	46.8	----	20.1	----	30.6	----	17.3	----	17.3	----	6.0	----	6.0	----	----	----	----
3S1-A Max.	60	----	----	----	20.8	----	----	----	16.0	----	----	----	7.4	----	----	----	----	----	----	----	----	----	----	----	----
3S1-B Max.	64	----	----	----	23.4	----	----	----	19.9	----	2.9	----	11.9	----	3.5	----	3.5	----	----	----	----	----	----	----	----
3S2-A Min.	74	4.1	38.8	39.1	85.5	3.9	38.5	26.6	68.8	3.6	38.2	12.7	50.3	1.3	36.1	1.3	35.1	----	22.2	----	22.2	----	11.6	----	11.6
3S2-B Min.	74	4.1	38.8	39.1	85.5	3.9	38.5	26.6	68.8	3.6	38.2	12.7	50.3	1.3	36.1	1.3	35.1	----	22.2	----	22.2	----	11.6	----	11.6
3S2-A Max.	74	----	1.0	1.3	35.0	----	9.2	----	33.0	----	15.3	----	25.3	----	16.6	----	16.6	----	8.1	----	8.1	----	0.4	----	0.4
3S2-B Max.	74	----	1.0	1.3	35.0	----	9.2	----	33.0	----	15.3	----	25.3	----	16.6	----	16.6	----	8.1	----	8.1	----	0.4	----	0.4
2-2-A Min.	64	----	16.1	16.4	55.2	----	16.8	6.8	42.3	----	17.2	----	27.4	----	15.0	----	15.0	----	4.3	----	4.3	----	----	----	----
2-2-B Min.	76	4.6	39.5	39.8	86.4	4.9	39.9	27.9	70.5	5.1	40.1	14.2	52.3	2.9	37.3	2.9	35.1	----	24.4	----	24.4	----	13.8	----	13.8
2-2-A Max.	64	----	----	----	30.3	----	2.5	----	24.9	----	6.1	----	15.4	----	6.2	----	6.2	----	----	----	----	----	----	----	----
2-2-B Max.	76	----	16.7	17.0	56.0	----	22.5	12.0	49.3	----	26.7	3.3	37.8	----	26.6	----	26.6	----	16.3	----	16.3	----	7.3	----	7.3
2-3-A Min.	78	6.3	41.6	42.0	89.3	6.8	42.4	30.2	73.6	7.2	43.0	16.6	55.5	5.2	40.2	5.2	40.2	----	27.2	----	27.2	----	16.4	----	16.4
2-3-B Min.	86	18.6	58.1	58.5	111.3	18.9	58.5	45.0	93.2	19.1	58.8	29.5	72.7	16.6	55.5	16.6	55.5	5.7	40.9	5.7	40.9	----	28.8	----	28.8
2-3-A Max.	78	----	12.5	12.7	50.3	----	20.0	9.8	46.3	----	25.6	2.4	36.6	----	26.4	----	26.4	----	16.6	----	16.6	----	8.0	----	8.0
2-3-B Max.	86	----	27.9	28.2	70.9	1.5	35.3	23.8	64.9	5.6	40.8	14.8	53.1	5.9	41.3	5.9	41.3	----	30.0	----	30.0	----	20.2	----	20.2
3-2-A Min.	78	6.8	42.3	42.7	90.2	7.2	43.0	30.7	74.2	7.5	43.3	16.9	55.8	5.4	40.5	5.4	40.5	----	27.4	----	27.4	----	14.2	----	14.2
3-2-B Min.	86	16.6	55.4	55.7	107.6	10.7	56.3	43.0	90.5	17.8	57.0	28.0	70.8	15.6	54.1	15.6	54.1	4.9	39.8	4.9	39.8	----	28.0	----	28.0
3-2-A Max.	78	----	14.6	14.9	53.2	----	21.6	11.2	48.2	----	26.8	3.4	37.8	----	27.3	----	27.3	----	17.2	----	17.2	----	8.5	----	8.5
3-2-B Max.	86	----	28.4	28.7	71.6	1.8	35.7	24.1	65.4	5.8	41.1	15.0	53.4	6.0	41.4	6.0	41.4	----	30.1	----	30.1	----	20.3	----	20.3
3-3-A Min.	92	25.2	66.8	67.2	122.9	25.9	67.8	53.4	104.5	26.4	68.4	37.4	83.2	24.0	65.3	24.0	65.3	12.4	49.9	12.4	49.9	2.9	37.2	2.9	37.2
3-3-B Min.	96	32.0	76.0	76.4	135.2	32.4	76.6	61.0	115.1	32.7	76.9	44.2	92.4	30.0	73.4	30.0	73.4	17.8	57.1	17.8	57.1	7.8	43.7	7.8	43.7
3-3-A Max.	92	1.4	35.1	35.4	80.6	7.6	43.5	31.2	74.8	12.3	49.7	22.0	38.6	12.7	50.3	12.7	50.3	3.8	38.4	3.8	38.4	----	28.1	----	28.1
3-3-B Max.	96	8.2	44.3	44.6	92.8	18.6	52.2	39.2	85.5	18.6	58.1	28.9	71.9	18.8	58.4	18.8	58.4	9.2	45.6	9.2	45.6	1.0	34.6	1.0	34.6
2S1-2-A Min.	82	2.0	35.9	36.2	81.7	4.9	39.8	27.8	70.4	7.0	42.6	16.3	55.1	6.0	41.3	6.0	41.3	----	29.1	----	29.1	----	18.6	----	18.6
2S1-2-B Min.	98	22.9	63.8	64.2	119.0	26.1	68.2	53.8	104.9	28.5	71.3	39.7	86.3	27.2	69.6	27.2	69.6	16.1	54.7	16.1	54.7	6.6	42.2	6.6	42.2
2S1-2-A Max.	82	----	14.1	14.3	53.4	----	23.1	12.6	50.0	----	29.7	5.7	41.0	----	31.0	----	31.0	----	21.2	----	21.2	----	12.4	----	12.4
2S1-2-B Max.	98	3.5	38.0	38.3	84.4	11.3	48.4	35.7	80.8	17.0	55.9	27.2	69.6	18.0	57.3	18.0	57.3	9.0	45.3	9.0	45.3	1.1	34.8	1.1	34.8
2S1-3-A Min.	96	17.9	57.2	57.6	110.1	21.6	62.1	48.2	98.1	24.3	65.7	35.1	80.2	23.3	64.4	23.3	64.4	12.7	50.3	12.7	50.3	3.7	38.3	3.7	38.3
2S1-3-B Min.	108	35.4	80.4	80.8	141.1	38.9	85.2	69.4	125.7	41.5	88.6	53.8	105.1	40.0	86.7	40.0	86.7	27.8	70.4	27.8	70.4	17.4	56.6	17.4	56.6
2S1-3-A Max.	96	----	32.2	32.5	76.6	7.2	42.9	30.6	74.1	13.1	50.8	23.0	64.0	14.4	52.6	14.4	52.6	5.9	41.2	5.9	41.2	----	31.1	----	31.1
2S1-3-B Max.	108	13.7	51.6	51.9	102.6	22.2	63.0	49.0	98.6	28.6	71.4	39.8	86.4	29.8	73.1	29.8	73.1	19.9	59.9	19.9	59.9	11.2	48.3	11.2	48.3

Note: Dashes are used in blanks to indicate no overstress exists. When no symbol is used it indicates that no calculation was made for this blank.

APPENDIX A (cont.)

PERCENT LIVE LOAD OVERSTRESS RESULTING FROM DESIGNATED VEHICLES ON BRIDGES WITH FOUR DESIGN LOADINGS

Bridge Span Length

Vehicle Designation	Gross Weight, kips	20 Feet, Percent Overstress for H20-S16	20 Feet H15-S12	20 Feet H-20	20 Feet H-15	30 Feet, Percent Overstress for H20-S16	30 Feet H15-S12	30 Feet H-20	30 Feet H-15	40 Feet, Percent Overstress for H20-S16	40 Feet H15-S12	40 Feet H-20	40 Feet H-15
2S1-4-A Min.	110	----	28.3	----	28.3					24.9	66.8	62.4	116.2
2S1-4-B Min.	118	----	28.3	----	28.3					32.9	77.4	72.8	130.0
2S1-4-A Max.	110	----	8.3	----	8.3					----	24.9	21.7	61.9
2S1-4-B Max.	118	----	8.3	----	8.3					----	27.0	23.7	64.6
2S2-2-A Min.	96	----	23.3	----	23.3					7.6	44.5	40.1	87.3
2S2-2-B Min.	108	----	27.5	----	27.5					18.2	57.9	53.8	104.6
2S2-2-A Max.	96	----	8.3	----	8.3					----	5.0	3.3	36.2
2S2-2-B Max.	108	----	8.3	----	8.3					----	19.6	16.5	55.0
2S2-3-A Min.	110	----	23.3	----	23.3					12.9	50.7	46.8	95.4
2S2-3-B Min.	118	----	27.5	----	27.5					22.2	63.2	59.0	111.5
2S2-3-A Max.	110	----	8.3	----	8.3					----	10.4	7.5	43.1
2S2-3-B Max.	118	----	8.3	----	8.3					----	22.2	19.1	58.5
2S2-4-A Min.	124	3.1	37.5	3.1	37.5					34.2	79.2	74.6	132.3
2S2-4-B Min.	128	8.1	44.2	8.1	44.2					35.8	81.3	76.6	135.0
2S2-4-A Max.	124	----	8.3	----	8.3					3.6	38.3	34.7	79.2
2S2-4-B Max.	128	----	8.3	----	8.3					3.6	38.3	34.7	79.2
3S1-2-A Min.	96	----	15.8	----	15.8					----	31.2	27.7	70.0
3S1-2-B Min.	108	----	19.2	----	19.2					13.6	51.6	47.7	96.5
3S1-2-A Max.	96	----	8.3	----	8.3					----	----	----	26.9
3S1-2-B Max.	108	----	8.3	----	8.3					----	14.8	11.8	48.8
3S1-3-A Min.	110	----	23.3	----	23.3					8.9	45.4	41.6	88.5
3S1-3-B Min.	118	----	27.5	----	27.5					23.3	64.7	60.4	113.5
3S1-3-A Max.	110	----	8.3	----	8.3					----	4.7	2.0	35.8
3S1-3-B Max.	118	----	8.3	----	8.3					----	20.7	17.6	56.5
3S1-4-A Min.	124	----	20.8	----	20.8					34.9	80.1	75.4	133.5
3S1-4-B Min.	128	3.1	37.5	3.1	37.5					41.1	88.4	83.5	144.2
3S1-4-A Max.	124	----	9.2	----	9.2					1.1	35.0	31.5	75.0
3S1-4-B Max.	128	----	11.7	----	11.7					3.6	38.3	34.7	79.2
3S2-2-A Min.	110	----	20.8	----	20.8					17.3	56.7	52.6	103.1
3S2-2-B Min.	118	----	20.8	----	20.8					24.4	66.2	61.9	115.4
3S2-2-A Max.	110	----	8.3	----	8.3					----	24.9	21.7	61.9
3S2-2-B Max.	118	----	8.3	----	8.3					----	27.0	23.7	64.6
3S2-3-A Min.	124	3.1	37.5	3.1	37.5					34.9	80.1	75.4	133.5
3S2-3-B Min.	128	8.1	44.2	8.1	44.2					41.1	88.4	83.5	144.2
3S2-3-A Max.	124	----	8.3	----	8.3					2.4	36.8	33.2	77.3
3S2-3-B Max.	128	----	8.3	----	8.3					4.7	39.8	36.1	81.2
3S2-4-A Min.	138	15.0	53.3	15.0	53.3					53.8	105.3	100.0	166.2
3S2-4-B Min.	138	15.0	53.3	15.0	53.3					53.8	105.3	100.0	166.2
3S2-4-A Max.	138	----	20.8	----	20.8					7.1	43.0	39.3	85.4
3S2-4-B Max.	138	----	20.8	----	20.8					7.1	43.0	39.3	85.4
3S3-4-A Min.	156	20.6	60.8	20.6	60.8					65.1	120.5	114.7	185.8
3S3-4-B Min.	160	21.9	62.5	21.9	62.5					72.0	129.7	123.7	197.7
3S3-4-A Max.	156	----	27.5	----	27.5					14.7	53.1	49.1	98.5
3S3-4-B Max.	160	----	29.2	----	29.2					23.6	65.0	60.7	113.8
3S3-5-A Min.	170	30.0	73.3	30.0	73.3					78.7	138.6	132.4	209.2
3S3-5-B Min.	170	30.0	73.3	30.0	73.3					78.7	138.6	132.4	209.2
3S3-5-A Max.	170	6.3	34.2	6.3	34.2					28.7	71.8	67.3	122.7
3S3-5-B Max.	170	6.3	34.2	6.3	34.2					28.7	71.8	67.3	122.7

Vehicle Designation	Gross Weight, kips	50 Feet, Percent Overstress for H20-S16	50 Feet H15-S12	50 Feet H-20	50 Feet H-15	60 Feet, Percent Overstress for H20-S16	60 Feet H15-S12	60 Feet H-20	60 Feet H-15	80 Feet, Percent Overstress for H20-S16	80 Feet H15-S12	80 Feet H-20	80 Feet H-15
2S1-4-A Min.	110	27.9	72.6	82.3	143.4	34.8	79.8	95.0	159.7	40.6	87.4	87.8	150.5
2S1-4-B Min.	118	38.7	84.9	95.3	160.8	44.4	92.6	108.8	178.0	50.6	100.8	101.3	168.3
2S1-4-A Max.	110					6.1	41.5	53.4	104.3	18.5	57.9	58.3	111.0
2S1-4-B Max.	118					12.1	49.6	62.2	116.0	26.3	68.3	68.7	124.9
2S2-2-A Min.	96	12.6	50.1	58.5	111.7	17.3	56.5	69.7	126.0	22.5	63.3	63.6	118.2
2S2-2-B Min.	108	24.2	65.6	74.9	133.5	30.1	73.6	88.2	150.6	36.5	81.9	82.3	143.1
2S2-2-A Max.	96					----	27.9	38.7	84.7	7.0	42.7	43.0	90.7
2S2-2-B Max.	108					5.1	28.7	52.0	102.4	18.4	57.8	58.1	110.9
2S2-3-A Min.	110	23.9	65.2	74.4	132.9	30.4	73.9	88.5	151.1	37.5	83.3	83.7	145.0
2S2-3-B Min.	118	33.3	77.7	87.7	150.6	40.3	87.1	102.9	170.2	47.7	96.9	97.4	163.1
2S2-3-A Max.	110					1.2	35.0	46.4	95.0	17.2	56.2	56.5	108.7
2S2-3-B Max.	118					9.0	45.5	57.7	110.0	26.0	68.0	68.3	124.5
2S2-4-A Min.	124	42.2	89.6	100.2	167.4	49.1	98.8	115.6	187.1	56.3	108.4	108.8	178.4
2S2-4-B Min.	128	45.1	93.4	104.3	172.8	52.4	103.3	120.4	193.6	60.4	113.8	114.3	185.8
2S2-4-A Max.	124					22.8	63.8	77.6	136.5	35.9	81.1	81.5	142.0
2S2-4-B Max.	128					22.8	63.8	77.6	136.4	38.4	84.4	84.9	146.5
3S1-2-A Min.	96	6.8	42.5	50.4	100.9	12.9	50.6	63.3	117.4	19.4	59.2	59.5	112.7
3S1-2-B Min.	108	22.1	62.8	72.0	129.6	28.5	71.4	85.8	147.5	35.4	80.4	80.8	141.1
3S1-2-A Max.	96					----	15.7	25.4	67.1	1.3	35.0	35.3	80.4
3S1-2-B Max.	108					1.0	34.7	46.1	94.5	15.7	54.2	54.6	106.1
3S1-3-A Min.	110	20.5	60.7	69.7	126.6	27.9	70.6	84.9	146.3	35.7	80.9	81.3	141.7
3S1-3-B Min.	118	33.9	78.6	88.6	151.8	40.8	87.8	103.6	171.1	48.1	97.4	97.8	163.8
3S1-3-A Max.	110					----	26.6	37.3	82.8	12.9	50.5	50.8	101.1
3S1-3-B Max.	118					6.9	42.6	54.7	106.0	24.6	66.1	66.5	122.0
3S1-4-A Min.	124	42.7	90.2	100.9	168.3	49.3	99.2	115.9	187.6	56.6	108.7	109.2	178.8
3S1-4-B Min.	128	48.9	98.5	109.6	179.9	55.4	107.3	124.7	199.3	62.5	116.6	117.1	189.4
3S1-4-A Max.	124					12.0	49.4	62.0	115.8	30.6	74.0	74.4	132.6
3S1-4-B Max.	128					19.3	59.2	72.6	129.8	37.4	83.2	83.6	144.8
3S2-2-A Min.	110	26.8	69.0	78.5	138.3	32.7	77.0	91.9	155.6	39.1	85.5	85.9	147.9
3S2-2-B Min.	118	33.3	77.7	87.7	150.6	40.3	87.1	102.9	170.2	47.7	96.9	97.4	163.1
3S2-2-A Max.	110					6.4	42.0	53.9	105.0	20.9	61.2	61.6	115.4
3S2-2-B Max.	118					12.1	49.6	62.2	116.0	27.5	69.9	70.3	127.1
3S2-3-A Min.	124	43.6	91.5	102.2	170.1	50.2	100.3	117.2	189.3	57.2	109.5	110.0	180.0
3S2-3-B Min.	128	49.5	99.4	110.5	181.1	56.0	108.1	125.6	200.5	63.0	117.3	117.8	190.4
3S2-3-A Max.	124					17.1	56.2	69.4	125.5	33.8	78.4	78.8	138.4
3S2-3-B Max.	128					21.9	62.6	76.3	134.8	38.8	85.0	85.4	147.2
3S2-4-A Min.	138	63.9	118.5	130.7	208.1	70.3	127.1	146.2	227.9	77.2	136.2	136.7	215.6
3S2-4-B Min.	138	63.9	118.5	130.7	208.1	70.3	127.1	146.2	227.9	77.2	136.2	136.7	215.6
3S2-4-A Max.	138					32.7	77.0	91.9	155.6	51.1	101.4	101.8	169.1
3S2-4-B Max.	138					32.7	77.0	91.9	155.6	51.1	101.4	101.8	169.1
3S3-4-A Min.	156	79.0	138.6	152.0	236.5	87.6	150.2	171.3	261.3	96.8	162.4	163.0	250.6
3S3-4-B Min.	160	85.2	146.9	160.8	248.2	93.7	159.3	180.1	273.0	102.8	170.4	171.0	261.3
3S3-4-A Max.	156					47.0	96.0	112.5	183.1	68.3	124.4	124.9	99.8
3S3-4-B Max.	160					52.3	103.1	120.3	193.3	73.7	131.6	132.1	209.5
3S3-5-A Min.	170	95.1	160.1	174.7	266.8	104.5	172.7	195.7	293.8	114.6	186.0	186.7	282.3
3S3-5-B Min.	170	95.1	160.1	174.7	266.8	104.5	172.7	195.7	293.8	114.6	186.0	186.7	282.3
3S3-5-A Max.	170					60.3	113.9	131.9	208.8	83.9	145.2	145.8	227.7
3S3-5-B Max.	170					60.3	113.9	131.9	208.8	83.9	145.2	145.8	227.7

Vehicle Designation	Gross Weight, kips	100 Feet, Percent Overstress for H20-S16	100 Feet H15-S12	100 Feet H-20	100 Feet H-15	125 Feet, Percent Overstress for H20-S16	125 Feet H15-S12	125 Feet H-20	125 Feet H-15	150 Feet, Percent Overstress for H20-S16	150 Feet H15-S12	150 Feet H-20	150 Feet H-15
2S1-4-A Min.	110	43.6	91.4	75.0	133.2	45.7	94.3	58.4	111.2	43.9	91.9	43.9	91.9
2S1-4-B Min.	118	53.8	105.1	87.5	150.0	56.2	108.2	69.8	126.5	54.3	105.8	54.3	105.8
2S1-4-A Max.	110	26.6	68.8	54.3	105.7	32.6	76.8	44.1	92.2	33.5	78.0	33.5	78.0
2S1-4-B Max.	118	35.2	80.2	64.8	119.6	41.7	88.9	54.0	105.4	42.7	90.4	42.7	90.4
2S2-2-A Min.	96	25.1	66.8	52.5	103.2	27.0	69.3	38.1	84.1	25.5	67.3	25.5	67.3
2S2-2-B Min.	108	39.8	86.4	70.4	127.1	42.2	96.0	54.3	106.1	40.6	87.5	40.6	87.5
2S2-2-A Max.	96	13.3	51.1	38.2	84.1	17.9	57.6	28.2	71.0	18.3	57.7	18.3	57.7
2S2-2-B Max.	108	25.9	67.9	53.5	104.6	31.5	75.3	42.9	83.2	32.1	76.1	32.1	76.1
2S2-3-A Min.	110	41.1	88.2	72.1	129.3	43.9	91.8	56.4	108.6	42.5	90.0	42.5	90.0
2S2-3-B Min.	118	51.6	102.2	84.9	146.4	54.5	105.9	67.9	124.0	53.0	104.0	53.0	104.0
2S2-3-A Max.	110	25.6	67.5	53.1	104.1	31.8	75.7	43.3	91.1	32.8	77.2	32.8	77.2
2S2-3-B Max.	118	35.0	80.0	66.2	119.3	41.6	88.8	53.9	105.3	42.7	90.2	42.7	90.2
2S2-4-A Min.	124	60.2	113.6	95.3	160.2	62.9	117.2	77.1	136.2	61.2	115.0	61.2	115.0
2S2-4-B Min.	128	64.6	119.4	100.6	167.4	67.6	123.4	82.2	143.0	65.9	121.2	65.9	121.2
2S2-4-A Max.	124	44.4	92.6	76.1	134.6	50.8	101.0	63.9	118.6	51.5	102.0	51.5	102.0
2S2-4-B Max.	128	47.7	96.9	80.1	140.0	54.5	106.0	68.0	124.0	55.5	107.3	55.5	107.3
3S1-2-A Min.	96	22.8	63.7	49.7	99.5	25.2	67.0	36.1	81.6	24.1	65.5	24.1	65.5
3S1-2-B Min.	108	38.9	85.2	69.4	125.7	41.5	88.6	53.8	105.1	40.1	86.8	40.1	86.8
3S1-2-A Max.	96	8.9	45.1	32.7	76.9	14.5	52.6	24.5	66.0	15.5	54.0	15.5	54.0
3S1-2-B Max.	108	23.9	65.2	51.0	101.3	29.9	73.2	41.2	88.3	30.8	74.5	30.8	74.5
3S1-3-A Min.	110	38.9	86.4	70.5	127.2	42.8	90.4	55.3	107.1	41.7	88.9	41.7	88.9
3S1-3-B Min.	118	51.9	102.5	85.2	146.8	54.7	106.2	68.2	124.2	53.1	104.2	53.1	104.2
3S1-3-A Max.	110	22.3	63.1	49.1	98.7	29.3	72.4	40.6	87.4	30.8	74.5	30.8	74.5
3S1-3-B Max.	118	33.9	78.6	63.3	117.6	40.8	87.7	53.1	104.1	42.0	89.4	42.0	89.4
3S1-4-A Min.	124	60.4	113.8	95.5	160.6	63.1	117.4	77.3	136.4	61.3	115.1	61.3	115.1
3S1-4-B Min.	128	66.1	121.5	102.6	169.9	68.8	125.1	83.5	144.7	66.9	122.6	66.9	122.6
3S1-4-A Max.	124	40.4	87.1	71.1	128.0	47.6	96.8	60.5	114.0	49.0	98.7	49.0	98.7
3S1-4-B Max.	128	46.9	95.9	79.1	138.7	54.0	105.3	67.4	123.2	55.0	106.7	55.0	106.7
3S2-2-A Min.	110	42.4	89.9	73.6	131.3	44.9	93.1	57.5	110.0	43.2	91.0	43.2	91.0
3S2-2-B Min.	118	51.6	102.2	84.9	146.4	54.5	105.9	67.9	124.0	53.0	104.0	53.0	104.0
3S2-2-A Max.	110	28.5	71.3	56.6	108.7	34.1	78.8	45.8	94.4	34.7	79.6	34.7	79.6
3S2-2-B Max.	118	36.2	81.5	66.0	121.2	42.5	90.0	54.9	106.6	43.4	91.2	43.4	91.2
3S2-3-A Min.	124	60.8	114.4	96.1	161.3	53.5	118.0	77.7	137.0	61.7	115.6	61.7	115.6
3S2-3-B Min.	128	66.6	122.1	103.1	170.7	69.2	125.6	84.0	145.3	67.2	123.0	67.2	123.0
3S2-3-A Max.	124	43.0	90.6	74.3	132.3	49.7	99.6	62.8	117.0	50.7	100.9	50.7	100.9
3S2-3-B Max.	128	48.1	97.5	80.6	140.6	54.9	106.6	68.4	124.6	55.8	107.8	55.8	107.8
3S2-4-A Min.	138	80.6	140.9	120.2	193.5	83.3	144.3	99.2	165.7	80.9	141.3	80.9	141.3
3S2-4-B Min.	138	80.6	140.9	120.2	193.5	83.3	144.3	99.2	165.7	80.9	141.3	80.9	141.3
3S2-4-A Max.	138	60.7	114.3	95.9	161.1	67.8	123.7	82.4	143.3	68.6	124.8	68.6	124.8
3S2-4-B Max.	138	60.7	114.3	95.9	161.1	67.8	123.7	82.4	143.3	68.6	124.8	68.6	124.8
3S3-4-A Min.	156	101.6	168.9	145.8	227.6	105.2	173.5	123.0	197.4	102.9	170.6	102.9	170.6
3S3-4-B Min.	160	107.5	176.7	153.0	237.2	111.0	181.3	129.4	205.9	108.6	178.2	108.6	178.2
3S3-4-A Max.	156	79.9	139.8	119.3	192.2	88.3	151.1	104.7	173.0	89.5	152.7	89.5	152.7
3S3-4-B Max.	160	85.2	147.0	125.8	201.0	93.8	158.3	110.6	180.9	94.9	159.9	94.9	159.9
3S3-5-A Min.	170	119.8	193.1	168.0	257.1	123.7	198.2	143.1	224.2	121.2	195.0	121.2	195.0
3S3-5-B Min.	170	119.8	193.1	168.0	257.1	123.7	198.2	143.1	224.2	121.2	195.0	121.2	195.0
3S3-5-A Max.	170	96.4	161.9	139.4	219.1	105.5	174.0	123.4	197.9	106.7	175.7	106.7	175.7
3S3-5-B Max.	170	96.4	161.9	139.4	219.1	105.5	174.0	123.4	197.9	106.7	175.7	106.7	175.7

Vehicle Designation	Gross Weight, kips	175 Feet, Percent Overstress for H20-S16	175 Feet H15-S12	175 Feet H-20	175 Feet H-15	200 Feet, Percent Overstress for H20-S16	200 Feet H15-S12	200 Feet H-20	200 Feet H-15
2S1-4-A Min.	110	31.2	74.9	31.2	74.9	20.4	60.6	20.4	60.6
2S1-4-B Min.	118	40.6	87.5	40.6	87.5	29.1	72.2	29.1	72.2
2S1-4-A Max.	110	23.1	64.2	23.1	64.2	14.1	52.1	14.1	52.1
2S1-4-B Max.	118	31.8	75.7	31.8	75.7	22.1	62.8	22.1	62.8
2S2-2-A Min.	96	27.0	52.5	27.0	52.5	5.0	40.0	5.0	40.0
2S2-2-B Min.	108	28.2	71.0	28.2	71.0	17.8	57.1	17.8	57.1
2S2-2-A Max.	96	8.9	45.1	8.9	45.1	0.7	34.2	0.7	34.2
2S2-2-B Max.	108	21.7	62.3	21.7	62.3	12.7	50.2	12.7	50.2
2S2-3-A Min.	110	30.0	73.4	30.0	73.4	19.5	59.4	19.5	59.4
2S2-3-B Min.	118	39.6	86.1	39.6	86.1	28.3	71.1	28.3	71.1
2S2-3-A Max.	110	22.7	63.6	22.7	63.6	13.7	51.6	13.7	51.6
2S2-3-B Max.	118	31.7	75.6	31.7	75.6	22.1	62.8	22.1	62.8
2S2-4-A Min.	124	47.1	96.1	47.1	96.1	35.1	80.1	35.1	80.1
2S2-4-B Min.	128	51.4	101.9	51.4	101.9	39.2	85.6	39.2	85.6
2S2-4-A Max.	124	39.6	86.1	39.6	86.1	29.2	72.3	29.2	72.3
2S2-4-B Max.	128	43.5	91.3	43.5	91.3	32.9	77.1	32.9	77.1
3S1-2-A Min.	96	13.3	51.1	13.3	51.1	4.2	38.9	4.2	38.9
3S1-2-B Min.	108	27.8	70.5	27.8	70.5	17.5	56.7	17.5	56.7
3S1-2-A Max.	96	6.8	42.3	6.8	42.3	----	32.0	----	32.0
3S1-2-B Max.	108	20.8	61.0	20.8	61.0	11.9	49.2	11.9	49.2
3S1-3-A Min.	110	29.4	72.6	29.4	72.6	19.0	58.7	19.0	58.7
3S1-3-B Min.	118	39.7	86.3	39.7	86.3	28.4	71.2	28.4	71.2
3S1-3-A Max.	110	21.2	61.6	21.2	61.6	12.5	50.0	12.5	50.0
3S1-3-B Max.	118	31.2	75.0	31.2	75.0	21.7	62.2	21.7	62.2
3S1-4-A Min.	124	47.2	96.2	47.2	96.2	35.2	80.2	35.2	80.2
3S1-4-B Min.	128	52.2	102.9	52.2	102.9	39.8	86.3	39.8	86.3
3S1-4-A Max.	124	37.7	83.6	37.7	83.6	27.7	70.3	27.7	70.3
3S1-4-B Max.	128	43.1	90.8	43.1	90.8	32.6	76.8	32.6	76.8
3S2-2-A Min.	110	30.6	74.2	30.6	74.2	20.0	60.0	20.0	60.0
3S2-2-B Min.	118	39.6	86.1	39.6	86.1	28.3	71.1	28.3	71.1
3S2-2-A Max.	110	24.1	65.5	24.1	65.5	14.8	53.1	14.8	53.1
3S2-2-B Max.	118	32.3	76.4	32.3	76.4	22.5	63.4	22.5	63.4
3S2-3-A Min.	124	47.4	96.5	47.4	96.5	35.4	80.5	35.4	80.5
3S2-3-B Min.	128	52.4	103.3	52.4	103.3	40.0	86.6	40.0	86.6
3S2-3-A Max.	124	39.0	85.3	39.0	85.3	28.8	71.7	28.8	71.7
3S2-3-B Max.	128	43.7	91.6	43.7	91.6	33.1	77.5	33.1	77.5
3S2-4-A Min.	138	64.8	119.8	64.8	119.8	51.3	101.7	51.3	101.7
3S2-4-B Min.	138	64.8	119.8	64.8	119.8	51.3	101.7	51.3	101.7
3S2-4-A Max.	138	55.4	107.2	55.4	107.2	43.8	91.8	43.8	91.8
3S2-4-B Max.	138	55.4	107.2	55.4	107.2	43.8	91.8	43.8	91.8
3S3-4-A Min.	156	85.1	146.8	85.1	146.8	70.1	126.8	70.1	126.8
3S3-4-B Min.	160	90.2	153.6	90.2	153.6	74.7	132.9	74.7	132.9
3S3-4-A Max.	156	74.9	133.2	74.9	133.2	62.0	116.0	62.0	116.0
3S3-4-B Max.	160	79.7	139.6	79.7	139.6	66.4	121.9	66.4	121.9
3S3-5-A Min.	170	101.8	169.1	101.8	169.1	85.4	147.2	85.4	147.2
3S3-5-B Min.	170	101.8	169.1	101.8	169.1	85.4	147.2	85.4	147.2
3S3-5-A Max.	170	90.7	154.3	90.7	154.3	76.6	135.5	76.6	135.5
3S3-5-B Max.	170	90.7	154.3	90.7	154.3	76.6	135.5	76.6	135.5

Note: Dashes are used in blanks to indicate no overstress exists. When no symbol is used it indicates that no calculation was made for this blank.

APPENDIX B
ALLOWABLE LOADS FOR ALL VEHICLE TYPES

TRUCKS

2D — MIN LENGTH

	Axle 1	← 11' →	Axle 2	
LEGAL LIMIT A	10K		18K	TOTAL 28K
LEGAL LIMIT B	10K		22K	" 32K
BRIDGE FORMULA	10K		22K	" 32K
H20-S16-44	10K		22K	" 32K
H15-S12-44	10K		22K	" 32K
H20-44	10K		22K	" 32K
H15-44	10K		21K	" 31K

2D — MAX LENGTH

	Axle 1	← 18' →	Axle 2	
LEGAL LIMIT A	10K		18K	TOTAL 28K
LEGAL LIMIT B	10K		22K	" 32K
BRIDGE FORMULA	10K		22K	" 32K
H20-S16-44	10K		22K	" 32K
H15-S12-44	10K		22K	" 32K
H20-44	10K		22K	" 32K
H15-44	10K		22K	" 32K

3 — MIN LENGTH

	Axle 1	← 7' →	Axle 2	← 4' →	Axle 3	
LEGAL LIMIT A	10K		16K		16K	TOTAL 42K
LEGAL LIMIT B	10K		16K		16K	" 42K
BRIDGE FORMULA	10K		16K		16K	" 42K
H20-S16-44	10K		16K		16K	" 42K
H15-S12-44	10K		12K		13K	" 35K
H20-44	10K		15K		16K	" 41K
H15-44	10K		9K		9K	" 28K

3 — MAX LENGTH

	Axle 1	← 14' →	Axle 2	← 4' →	Axle 3	
LEGAL LIMIT A	10K		16K		16K	TOTAL 42K
LEGAL LIMIT B	10K		16K		16K	" 42K
BRIDGE FORMULA	10K		16K		16K	" 42K
H20-S16-44	10K		16K		16K	" 42K
H15-S12-44	10K		14K		15K	" 39K
H20-44	10K		16K		16K	" 42K
H15-44	10K		11K		12K	" 33K

TRACTORS, SEMI – TRAILERS

2S1 — MIN LENGTH

	Axle 1	← 12' →	Axle 2	← 13' →	Axle 3	
LEGAL LIMIT A	10K		18K		18K	TOTAL 46K
LEGAL LIMIT B	10K		22K		22K	" 54K
BRIDGE FORMULA	10K		20K		20K	" 50K
H20-S16-44	10K		22K		22K	" 54K
H15-S12-44	10K		22K		22K	" 54K
H20-44	10K		19K		20K	" 49K
H15-44	10K		13K		14K	" 37K

2S1 — MAX LENGTH

	Axle 1	← 12' →	Axle 2	← 38' →	Axle 3	
LEGAL LIMIT A	10K		18K		18K	TOTAL 46K
LEGAL LIMIT B	10K		22K		22K	" 54K
BRIDGE FORMULA	10K		20K		20K	" 50K
H20-S16-44	10K		22K		22K	" 54K
H15-S12-44	10K		22K		22K	" 54K
H20-44	10K		22K		22K	" 54K
H15-44	10K		21K		22K	" 53K

2S2 — MIN LENGTH

	Axle 1	← 10' →	Axle 2	← 11' →	Axle 3	← 4' →	Axle 4	
LEGAL LIMIT A	10K		18K		16K		16K	TOTAL 60K
LEGAL LIMIT B	10K		22K		16K		16K	" 64K
BRIDGE FORMULA	10K		13K		16K		16K	" 55K
H20-S16-44	10K		22K		16K		16K	" 64K
H15-S12-44	10K		16K		14K		15K	" 55K
H20-44	10K		15K		13K		13K	" 51K
H15-44	10K		11K		9K		9K	" 39K

2S2 — MAX LENGTH

	Axle 1	← 12' →	Axle 2	← 34' →	Axle 3	← 4' →	Axle 4	
LEGAL LIMIT A	10K		18K		16K		16K	TOTAL 60K
LEGAL LIMIT B	10K		22K		16K		16K	" 64K
BRIDGE FORMULA	10K		22K		16K		16K	" 64K
H20-S16-44	10K		22K		16K		16K	" 64K
H15-S12-44	10K		22K		15K		15K	" 62K
H20-44	10K		22K		16K		16K	" 64K
H15-44	10K		20K		15K		15K	" 60K

APPENDIX B (cont.)
ALLOWABLE LOADS FOR ALL VEHICLE TYPES

Group	Type	Length	Axle spacing / Load basis	Axle 1	Axle 2	Axle 3	Axle 4	Axle 5	Total
TRACTORS, SEMI-TRAILERS	3S1	MIN LENGTH	10′ – 4′ – 11′						
			LEGAL LIMIT A	10K	16K	16K	18K		TOTAL 60K
			LEGAL LIMIT B	10K	16K	16K	22K		" 64K
			BRIDGE FORMULA	10K	16K	16K	13K		" 55K
			H20-S16-44	10K	16K	16K	22K		" 64K
			H15-S12-44	10K	13K	13K	15K		" 51K
			H20-44	10K	12K	12K	14K		" 48K
			H15-44	10K	8K	8K	10K		" 36K
		MAX LENGTH	12′ – 4′ – 34′						
			LEGAL LIMIT A	10K	16K	16K	18K		TOTAL 60K
			LEGAL LIMIT B	10K	16K	16K	22K		" 64K
			BRIDGE FORMULA	10K	16K	16K	22K		" 64K
			H20-S16-44	10K	16K	16K	22K		" 64K
			H15-S12-44	10K	15K	15K	22K		" 62K
			H20-44	10K	16K	16K	22K		" 64K
			H15-44	10K	12K	12K	18K		" 52K
	3S2	MIN LENGTH	8′ – 4′ – 9′ – 4′						
			LEGAL LIMIT A	10K	16K	16K	16K	16K	TOTAL 74K
			LEGAL LIMIT B	10K	16K	16K	16K	16K	" 74K
			BRIDGE FORMULA	10K	12K	13K	13K	13K	" 61K
			H20-S16-44	10K	15K	15K	15K	15K	" 70K
			H15-S12-44	10K	10K	11K	11K	11K	" 53K
			H20-44	10K	9K	10K	10K	10K	" 49K
			H15-44	10K	6K	7K	7K	7K	" 37K
		MAX LENGTH	12′ – 4′ – 30′ – 4′						
			LEGAL LIMIT A	10K	16K	16K	16K	16K	TOTAL 74K
			LEGAL LIMIT B	10K	16K	16K	16K	16K	" 74K
			BRIDGE FORMULA	10K	16K	16K	16K	16K	" 74K
			H20-S16-44	10K	16K	16K	16K	16K	" 74K
			H15-S12-44	10K	13K	13K	13K	14K	" 63K
			H20-44	10K	15K	16K	16K	16K	" 73K
			H15-44	10K	11K	11K	11K	12K	" 55K
TRUCK-TRAILERS	2-2	MIN LENGTH	12′ – 9′ – 9′						
			LEGAL LIMIT A	10K	18K	18K	18K		TOTAL 64K
			LEGAL LIMIT B	10K	22K	22K	22K		" 76K
			BRIDGE FORMULA	10K	16K	16K	16K		" 58K
			H20-S16-44	10K	20K	21K	21K		" 72K
			H15-S12-44	10K	15K	15K	15K		" 55K
			H20-44	10K	13K	14K	14K		" 51K
			H15-44	10K	10K	10K	10K		" 40K
		MAX LENGTH	12′ – 9′ – 27′						
			LEGAL LIMIT A	10K	18K	18K	18K		TOTAL 64K
			LEGAL LIMIT B	10K	22K	22K	22K		" 76K
			BRIDGE FORMULA	10K	18K	18K	22K		" 68K
			H20-S16-44	10K	22K	22K	22K		" 76K
			H15-S12-44	10K	16K	17K	17K		" 60K
			H20-44	10K	18K	18K	18K		" 64K
			H15-44	10K	13K	13K	14K		" 50K
	2-3	MIN LENGTH	10′ – 8′ – 8′ – 4′						
			LEGAL LIMIT A	10K	18K	18K	16K	16K	TOTAL 78K
			LEGAL LIMIT B	10K	22K	22K	16K	16K	" 86K
			BRIDGE FORMULA	10K	18K	14K	14K	15K	" 71K
			H20-S16-44	10K	16K	17K	15K	15K	" 73K
			H15-S12-44	10K	12K	12K	10K	11K	" 55K
			H20-44	10K	11K	11K	9K	10K	" 51K
			H15-44	10K	8K	8K	6K	7K	" 39K
		MAX LENGTH	12′ – 12′ – 20′ – 4′						
			LEGAL LIMIT A	10K	18K	18K	16K	16K	TOTAL 78K
			LEGAL LIMIT B	10K	22K	22K	16K	16K	" 86K
			BRIDGE FORMULA	10K	16K	16K	16K	16K	" 74K
			H20-S16-44	10K	20K	21K	15K	15K	" 81K
			H15-S12-44	10K	14K	14K	12K	12K	" 62K
			H20-44	10K	15K	15K	14K	14K	" 68K
			H15-44	10K	11K	11K	9K	10K	" 51K

APPENDIX B (cont.)
ALLOWABLE LOADS FOR ALL VEHICLE TYPES

TRUCK - TRAILERS

3-2 — MIN LENGTH

Axle spacing: 10′ – 4′ – 8′ – 8′

	Axle 1	Axle 2	Axle 3	Axle 4	Axle 5	
LEGAL LIMIT A	10K	16K	16K	18K	18K	TOTAL 78K
LEGAL LIMIT B	10K	16K	16K	22K	22K	" 86K
BRIDGE FORMULA	10K	13K	13K	13K	14K	" 63K
H20-S16-44	10K	14K	15K	17K	17K	" 73K
H15-S12-44	10K	10K	10K	12K	12K	" 54K
H20-44	10K	9K	9K	11K	12K	" 51K
H15-44	10K	6K	6K	8K	8K	" 38K

3-2 — MAX LENGTH

Axle spacing: 12′ – 4′ – 14′ – 18′

	Axle 1	Axle 2	Axle 3	Axle 4	Axle 5	
LEGAL LIMIT A	10K	16K	16K	18K	18K	TOTAL 78K
LEGAL LIMIT B	10K	16K	16K	22K	22K	" 86K
BRIDGE FORMULA	10K	16K	16K	15K	17K	" 74K
H20-S16-44	10K	14K	15K	21K	21K	" 81K
H15-S12-44	10K	11K	12K	14K	14K	" 61K
H20-44	10K	13K	13K	16K	16K	" 68K
H15-44	10K	9K	9K	11K	12K	" 51K

3-3 — MIN LENGTH

Axle spacing: 8′ – 4′ – 7′ – 7′ – 4′

	Axle 1	Axle 2	Axle 3	Axle 4	Axle 5	Axle 6	
LEGAL LIMIT A	10K	16K	16K	18K	16K	16K	TOTAL 92K
LEGAL LIMIT B	10K	16K	16K	22K	16K	16K	" 96K
BRIDGE FORMULA	10K	12K	12K	12K	12K	12K	" 70K
H20-S16-44	10K	12K	12K	14K	12K	13K	" 73K
H15-S12-44	10K	8K	8K	11K	9K	9K	" 55K
H20-44	10K	7K	8K	10K	8K	8K	" 51K
H15-44	10K	5K	5K	7K	6K	6K	" 39K

3-3 — MAX LENGTH

Axle spacing: 12′ – 4′ – 14′ – 14′ – 4′

	Axle 1	Axle 2	Axle 3	Axle 4	Axle 5	Axle 6	
LEGAL LIMIT A	10K	16K	16K	18K	16K	16K	TOTAL 92K
LEGAL LIMIT B	10K	16K	16K	22K	16K	16K	" 96K
BRIDGE FORMULA	10K	14K	14K	14K	14K	15K	" 81K
H20-S16-44	10K	14K	14K	16K	14K	14K	" 82K
H15-S12-44	10K	9K	10K	12K	10K	10K	" 61K
H20-44	10K	11K	11K	13K	11K	11K	" 67K
H15-44	10K	7K	8K	10K	8K	8K	" 51K

TRACTORS, SEMI-TRAILERS AND TRAILERS

2S1-2 — MIN LENGTH

Axle spacing: 10′ – 12′ – 8′ – 10′

	Axle 1	Axle 2	Axle 3	Axle 4	Axle 5	
LEGAL LIMIT A	10K	18K	18K	18K	18K	TOTAL 82K
LEGAL LIMIT B	10K	22K	22K	22K	22K	" 98K
BRIDGE FORMULA	10K	15K	15K	15K	15K	" 70K
H20-S16-44	10K	16K	17K	17K	17K	" 77K
H15-S12-44	10K	12K	12K	12K	12K	" 58K
H20-44	10K	12K	12K	12K	13K	" 59K
H15-44	10K	8K	8K	9K	9K	" 44K

2S1-2 — MAX LENGTH

Axle spacing: 12′ – 16′ – 12′ – 16′

	Axle 1	Axle 2	Axle 3	Axle 4	Axle 5	
LEGAL LIMIT A	10K	18K	18K	18K	18K	TOTAL 82K
LEGAL LIMIT B	10K	22K	22K	22K	22K	" 98K
BRIDGE FORMULA	10K	18K	17K	17K	17K	" 79K
H20-S16-44	10K	18K	18K	18K	18K	" 82K
H15-S12-44	10K	13K	13K	13K	14K	" 63K
H20-44	10K	15K	15K	16K	16K	" 72K
H15-44	10K	11K	11K	11K	11K	" 54K

2S1-3 — MIN LENGTH

Axle spacing: 10′ – 10′ – 8′ – 8′ – 4′

	Axle 1	Axle 2	Axle 3	Axle 4	Axle 5	Axle 6	
LEGAL LIMIT A	10K	18K	16K	18K	16K	16K	TOTAL 96K
LEGAL LIMIT B	10K	22K	22K	22K	16K	16K	" 108K
BRIDGE FORMULA	10K	13K	13K	13K	13K	12K	" 74K
H20-S16-44	10K	14K	14K	14K	12K	13K	" 77K
H15-S12-44	10K	10K	10K	10K	9K	9K	" 58K
H20-44	10K	10K	10K	11K	9K	9K	" 59K
H15-44	10K	7K	8K	8K	6K	6K	" 45K

2S1-3 — MAX LENGTH

Axle spacing: 12′ – 15′ – 10′ – 15′ – 4′

	Axle 1	Axle 2	Axle 3	Axle 4	Axle 5	Axle 6	
LEGAL LIMIT A	10K	18K	18K	18K	16K	16K	TOTAL 96K
LEGAL LIMIT B	10K	22K	22K	22K	16K	16K	" 108K
BRIDGE FORMULA	10K	14K	15K	14K	15K	15K	" 83K
H20-S16-44	10K	15K	15K	15K	15K	14K	" 84K
H15-S12-44	10K	11K	11K	11K	10K	10K	" 63K
H20-44	10K	13K	13K	13K	11K	12K	" 72K
H15-44	10K	9K	9K	10K	8K	8K	" 54K

APPENDIX B (cont.)
ALLOWABLE LOADS FOR ALL VEHICLE TYPES

TRACTORS, SEMI-TRAILERS AND TRAILERS

2S1-4 — MIN LENGTH

Axle spacing: 10′ – 8′ – 7′ – 4′ – 7′ – 4′

LEGAL LIMIT A	10K	18K	18K	16K	16K	16K	16K	TOTAL 110K
LEGAL LIMIT B	10K	22K	22K	16K	16K	16K	16K	" 118K
BRIDGE FORMULA	10K	12K	12K	12K	12K	11K	11K	" 80K
H20-S16-44	10K	12K	12K	10K	10K	11K	11K	" 76K
H15-S12-44	10K	9K	9K	7K	7K	7K	8K	" 57K
H20-44	10K	9K	9K	7K	7K	7K	8K	" 57K
H15-44	10K	6K	6K	5K	5K	5K	5K	" 42K

2S1-4 — MAX LENGTH

Axle spacing: 12′ – 12′ – 12′ – 4′ – 12′ – 4′

LEGAL LIMIT A	10K	18K	18K	16K	16K	16K	16K	TOTAL 110K
LEGAL LIMIT B	10K	22K	22K	16K	16K	16K	16K	" 118K
BRIDGE FORMULA	10K	13K	13K	12K	12K	12K	13K	" 85K
H20-S16-44	10K	13K	13K	11K	11K	12K	12K	" 82K
H15-S12-44	10K	10K	10K	8K	8K	8K	8K	" 62K
H20-44	10K	11K	11K	9K	9K	10K	10K	" 70K
H15-44	10K	8K	8K	6K	6K	7K	7K	" 52K

2S2-2 — MIN LENGTH

Axle spacing: 10′ – 10′ – 4′ – 8′ – 8′

LEGAL LIMIT A	10K	18K	16K	16K	18K	18K	TOTAL 96K
LEGAL LIMIT B	10K	22K	16K	16K	22K	22K	" 108K
BRIDGE FORMULA	10K	13K	13K	13K	13K	12K	" 74K
H20-S16-44	10K	14K	12K	12K	14K	14K	" 76K
H15-S12-44	10K	10K	8K	8K	10K	11K	" 57K
H20-44	10K	10K	8K	8K	10K	11K	" 57K
H15-44	10K	7K	5K	5K	8K	8K	" 43K

2S2-2 — MAX LENGTH

Axle spacing: 12′ – 15′ – 4′ – 10′ – 15′

LEGAL LIMIT A	10K	18K	16K	16K	18K	18K	TOTAL 96K
LEGAL LIMIT B	10K	22K	16K	16K	22K	22K	" 108K
BRIDGE FORMULA	10K	15K	14K	15K	14K	15K	" 83K
H20-S16-44	10K	15K	13K	13K	15K	16K	" 82K
H15-S12-44	10K	11K	9K	9K	11K	11K	" 61K
H20-44	10K	12K	10K	10K	13K	13K	" 68K
H15-44	10K	9K	7K	7K	9K	9K	" 51K

2S2-3 — MIN LENGTH

Axle spacing: 8′ – 8′ – 4′ – 8′ – 8′ – 4′

LEGAL LIMIT A	10K	18K	16K	16K	18K	16K	16K	TOTAL 110K
LEGAL LIMIT B	10K	22K	16K	16K	22K	16K	16K	" 118K
BRIDGE FORMULA	10K	12K	12K	12K	12K	12K	11K	" 81K
H20-S16-44	10K	12K	10K	10K	12K	11K	11K	" 76K
H15-S12-44	10K	9K	7K	7K	9K	7K	8K	" 57K
H20-44	10K	9K	7K	7K	9K	8K	8K	" 58K
H15-44	10K	7K	5K	5K	7K	5K	5K	" 44K

2S2-3 — MAX LENGTH

Axle spacing: 12′ – 12′ – 4′ – 12′ – 12′ – 4′

LEGAL LIMIT A	10K	18K	16K	16K	18K	16K	16K	TOTAL 110K
LEGAL LIMIT B	10K	22K	16K	16K	22K	16K	16K	" 118K
BRIDGE FORMULA	10K	13K	13K	13K	13K	13K	13K	" 88K
H20-S16-44	10K	13K	11K	11K	14K	12K	12K	" 83K
H15-S12-44	10K	10K	8K	8K	10K	8K	8K	" 62K
H20-44	10K	12K	10K	10K	8K	10K	10K	" 70K
H15-44	10K	8K	6K	6K	9K	7K	7K	" 53K

2S2-4 — MIN LENGTH

Axle spacing: 8′ – 6′ – 4′ – 7′ – 4′ – 7′ – 4′

LEGAL LIMIT A	10K	18K	16K	16K	16K	16K	16K	16K	TOTAL 124K
LEGAL LIMIT B	10K	22K	16K	16K	16K	16K	16K	16K	" 128K
BRIDGE FORMULA	10K	11K	11K	11K	11K	11K	11K	10K	" 86K
H20-S16-44	10K	11K	9K	9K	9K	9K	9K	10K	" 76K
H15-S12-44	10K	8K	6K	6K	6K	7K	7K	7K	" 57K
H20-44	10K	8K	6K	6K	7K	7K	7K	7K	" 58K
H15-44	10K	6K	4K	4K	4K	5K	5K	5K	" 43K

2S2-4 — MAX LENGTH

Axle spacing: 12′ – 11′ – 4′ – 10′ – 4′ – 11′ – 4′

LEGAL LIMIT A	10K	18K	16K	16K	16K	16K	16K	16K	TOTAL 124K
LEGAL LIMIT B	10K	22K	16K	16K	16K	16K	16K	16K	" 128K
BRIDGE FORMULA	10K	12K	11K	12K	12K	12K	12K	12K	" 93K
H20-S16-44	10K	12K	10K	10K	10K	10K	10K	10K	" 82K
H15-S12-44	10K	8K	7K	7K	7K	7K	8K	8K	" 62K
H20-44	10K	10K	8K	8K	8K	8K	8K	9K	" 69K
H15-44	10K	7K	5K	6K	6K	6K	6K	6K	" 52K

APPENDIX B (cont.)
ALLOWABLE LOADS FOR ALL VEHICLE TYPES

TRACTORS, SEMI-TRAILERS AND TRAILERS

3S1-2

MIN LENGTH

Axle spacing: 9' – 4' – 9' – 9' – 9'

	Axle 1	Axle 2	Axle 3	Axle 4	Axle 5	Axle 6	TOTAL
LEGAL LIMIT A	10K	16K	16K	18K	18K	18K	96K
LEGAL LIMIT B	10K	16K	16K	22K	22K	22K	108K
BRIDGE FORMULA	10K	13K	13K	13K	13K	13K	75K
H20-S16-44	10K	9K	9K	16K	16K	16K	76K
H15-S12-44	10K	5K	6K	12K	12K	12K	57K
H20-44	10K	6K	6K	12K	12K	12K	58K
H15-44	10K	3K	3K	9K	9K	10K	44K

MAX LENGTH

Axle spacing: 12' – 4' – 15' – 10' – 15'

	Axle 1	Axle 2	Axle 3	Axle 4	Axle 5	Axle 6	TOTAL
LEGAL LIMIT A	10K	16K	16K	18K	18K	18K	96K
LEGAL LIMIT B	10K	16K	16K	22K	22K	22K	108K
BRIDGE FORMULA	10K	15K	15K	15K	14K	14K	83K
H20-S16-44	10K	11K	11K	17K	17K	17K	83K
H15-S12-44	10K	6K	7K	13K	13K	13K	62K
H20-44	10K	8K	8K	14K	15K	15K	70K
H15-44	10K	4K	5K	11K	11K	11K	52K

3S1-3

MIN LENGTH

Axle spacing: 8' – 4' – 8' – 8' – 8' – 4'

	Axle 1	Axle 2	Axle 3	Axle 4	Axle 5	Axle 6	Axle 7	TOTAL
LEGAL LIMIT A	10K	16K	16K	18K	18K	16K	16K	110K
LEGAL LIMIT B	10K	16K	16K	22K	22K	16K	16K	118K
BRIDGE FORMULA	10K	12K	12K	12K	12K	12K	11K	81K
H20-S16-44	10K	9K	9K	15K	15K	9K	10K	77K
H15-S12-44	10K	6K	6K	12K	12K	6K	6K	58K
H20-44	10K	6K	6K	12K	12K	6K	7K	59K
H15-44	10K	3K	4K	10K	10K	4K	4K	45K

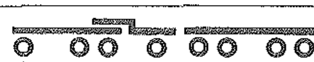
MAX LENGTH

Axle spacing: 12' – 4' – 12' – 12' – 12' – 4'

	Axle 1	Axle 2	Axle 3	Axle 4	Axle 5	Axle 6	Axle 7	TOTAL
LEGAL LIMIT A	10K	16K	16K	18K	18K	16K	16K	110K
LEGAL LIMIT B	10K	16K	16K	22K	22K	16K	16K	118K
BRIDGE FORMULA	10K	13K	13K	13K	13K	13K	13K	88K
H20-S16-44	10K	10K	10K	16K	16K	10K	11K	83K
H15-S12-44	10K	6K	6K	13K	13K	7K	7K	62K
H20-44	10K	8K	8K	14K	14K	9K	9K	72K
H15-44	10K	5K	5K	11K	11K	6K	6K	54K

3S1-4

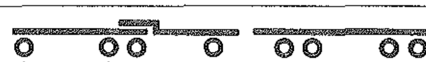
MIN LENGTH



Axle spacing: 8' – 4' – 7' – 6' – 4' – 7' – 4'

	Axle 1	Axle 2	Axle 3	Axle 4	Axle 5	Axle 6	Axle 7	Axle 8	TOTAL
LEGAL LIMIT A	10K	16K	16K	18K	16K	16K	16K	16K	124K
LEGAL LIMIT B	10K	16K	16K	22K	16K	16K	16K	16K	128K
BRIDGE FORMULA	10K	11K	11K	11K	11K	11K	11K	10K	86K
H20-S16-44	10K	8K	8K	14K	9K	9K	9K	9K	76K
H15-S12-44	10K	5K	6K	12K	6K	6K	6K	6K	57K
H20-44	10K	5K	6K	12K	6K	6K	6K	6K	57K
H15-44	10K	3K	4K	10K	4K	4K	4K	4K	43K

MAX LENGTH

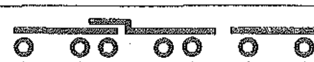


Axle spacing: 12' – 4' – 11' – 10' – 4' – 11' – 4'

	Axle 1	Axle 2	Axle 3	Axle 4	Axle 5	Axle 6	Axle 7	Axle 8	TOTAL
LEGAL LIMIT A	10K	16K	16K	18K	16K	16K	16K	16K	124K
LEGAL LIMIT B	10K	16K	16K	22K	16K	16K	16K	16K	128K
BRIDGE FORMULA	10K	12K	12K	12K	12K	12K	12K	11K	93K
H20-S16-44	10K	10K	10K	12K	10K	10K	10K	11K	83K
H15-S12-44	10K	7K	7K	9K	7K	7K	7K	8K	62K
H20-44	10K	8K	8K	10K	8K	8K	9K	9K	70K
H15-44	10K	5K	5K	8K	6K	6K	6K	6K	52K

3S2-2

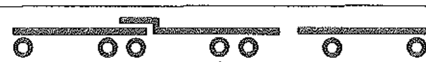
MIN LENGTH



Axle spacing: 8' – 4' – 8' – 4' – 8' – 8'

	Axle 1	Axle 2	Axle 3	Axle 4	Axle 5	Axle 6	Axle 7	TOTAL
LEGAL LIMIT A	10K	16K	16K	16K	16K	18K	18K	110K
LEGAL LIMIT B	10K	16K	16K	16K	16K	22K	22K	118K
BRIDGE FORMULA	10K	12K	12K	12K	12K	12K	11K	81K
H20-S16-44	10K	10K	10K	10K	10K	13K	13K	76K
H15-S12-44	10K	7K	7K	7K	7K	9K	10K	57K
H20-44	10K	7K	7K	7K	7K	10K	10K	58K
H15-44	10K	5K	5K	5K	5K	7K	7K	44K

MAX LENGTH



Axle spacing: 12' – 4' – 12' – 4' – 12' – 12'

	Axle 1	Axle 2	Axle 3	Axle 4	Axle 5	Axle 6	Axle 7	TOTAL
LEGAL LIMIT A	10K	16K	16K	16K	16K	18K	18K	110K
LEGAL LIMIT B	10K	16K	16K	16K	16K	22K	22K	118K
BRIDGE FORMULA	10K	13K	13K	13K	13K	13K	13K	88K
H20-S16-44	10K	10K	10K	10K	10K	16K	16K	82K
H15-S12-44	10K	6K	6K	7K	7K	13K	13K	62K
H20-44	10K	7K	8K	8K	8K	14K	14K	69K
H15-44	10K	5K	5K	5K	5K	11K	11K	52K

APPENDIX B (cont.)
ALLOWABLE LOADS FOR ALL VEHICLE TYPES

TRACTORS, SEMI-TRAILERS AND TRAILERS

3S2-3

MIN LENGTH

Axle spacing: 8' – 4' – 7' – 4' – 6' – 7' – 4'

LEGAL LIMIT A	10K	16K	16K	16K	16K	18K	16K	16K	TOTAL 124K
LEGAL LIMIT B	10K	16K	16K	16K	16K	22K	16K	16K	" 128K
BRIDGE FORMULA	10K	11K	11K	11K	11K	11K	11K	10K	" 86K
H20-S16-44	10K	8K	8K	9K	9K	15K	9K	9K	" 77K
H15-S12-44	10K	5K	6K	6K	6K	12K	6K	6K	" 57K
H20-44	10K	5K	6K	6K	6K	12K	6K	6K	" 57K
H15-44	10K	3K	4K	4K	4K	10K	4K	4K	" 43K

MAX LENGTH

Axle spacing: 12' – 4' – 10' – 4' – 11' – 11' – 4'

LEGAL LIMIT A	10K	16K	16K	16K	16K	18K	16K	16K	TOTAL 124K
LEGAL LIMIT B	10K	16K	16K	16K	16K	22K	16K	16K	" 128K
BRIDGE FORMULA	10K	12K	12K	12K	12K	12K	12K	11K	" 93K
H20-S16-44	10K	9K	9K	9K	9K	16K	10K	10K	" 82K
H15-S12-44	10K	6K	6K	6K	7K	13K	7K	7K	" 62K
H20-44	10K	7K	7K	7K	8K	14K	8K	8K	" 69K
H15-44	10K	5K	5K	5K	5K	11K	5K	6K	" 52K

3S2-4

MIN LENGTH

Axle spacing: 8' – 4' – 5' – 4' – 5' – 4' – 6' – 4'

LEGAL LIMIT A	10K	16K	16K	16K	16K	16K	16K	16K	16K	TOTAL 138K
LEGAL LIMIT B	10K	16K	16K	16K	16K	16K	16K	16K	16K	" 138K
BRIDGE FORMULA	10K	11K	11K	10K	10K	10K	10K	10K	10K	" 92K
H20-S16-44	10K	8K	6K	8K	8K	9K	8K	9K	9K	" 75K
H15-S12-44	10K	5K	6K	6K	6K	6K	6K	6K	6K	" 57K
H20-44	10K	5K	5K	6K	6K	6K	6K	6K	6K	" 56K
H15-44	10K	4K	4K	4K	4K	4K	4K	4K	4K	" 42K

MAX LENGTH

Axle spacing: 12' – 4' – 8' – 4' – 10' – 4' – 10' – 4'

LEGAL LIMIT A	10K	16K	16K	16K	16K	16K	16K	16K	16K	TOTAL 138K
LEGAL LIMIT B	10K	16K	16K	16K	16K	16K	16K	16K	16K	" 138K
BRIDGE FORMULA	10K	11K	11K	12K	11K	11K	11K	11K	11K	" 99K
H20-S16-44	10K	9K	9K	9K	9K	9K	9K	9K	9K	" 82K
H15-S12-44	10K	6K	6K	6K	6K	6K	7K	7K	7K	" 61K
H20-44	10K	7K	7K	7K	7K	7K	7K	8K	8K	" 68K
H15-44	10K	5K	5K	5K	5K	5K	5K	5K	6K	" 51K

3S3-4

MIN LENGTH

Axle spacing: 5' – 4' – 5' – 4' – 4' – 5' – 5' – 4' – 4'

LEGAL LIMIT A	10K	16K	16K	16K	16K	16K	18K	16K	16K	16K	TOTAL 156K
LEGAL LIMIT B	10K	16K	16K	16K	16K	16K	22K	16K	16K	16K	" 160K
BRIDGE FORMULA	10K	10K	9K	9K	9K	9K	9K	9K	9K	9K	" 92K
H20-S16-44	10K	6K	6K	6K	7K	7K	13K	7K	7K	7K	" 76K
H15-S12-44	10K	4K	4K	4K	4K	5K	11K	5K	5K	5K	" 57K
H20-44	10K	4K	4K	4K	4K	5K	11K	5K	5K	5K	" 57K
H15-44	10K	3K	3K	3K	3K	3K	9K	3K	3K	3K	" 43K

MAX LENGTH

Axle spacing: 9' – 4' – 9' – 4' – 4' – 9' – 9' – 4' – 4'

LEGAL LIMIT A	10K	16K	16K	16K	16K	16K	18K	16K	16K	16K	TOTAL 156K
LEGAL LIMIT B	10K	16K	16K	16K	16K	16K	22K	16K	16K	16K	" 160K
BRIDGE FORMULA	10K	11K	10K	10K	10K	10K	10K	10K	10K	10K	" 101K
H20-S16-44	10K	7K	7K	7K	7K	7K	13K	8K	8K	8K	" 82K
H15-S12-44	10K	5K	5K	5K	5K	5K	11K	5K	5K	6K	" 62K
H20-44	10K	5K	6K	6K	6K	6K	12K	6K	6K	6K	" 69K
H15-44	10K	4K	4K	4K	4K	4K	10K	4K	4K	4K	" 52K

3S3-5

MIN LENGTH

Axle spacing: 4' – 4' – 4' – 4' – 4' – 4' – 4' – 4' – 4' – 4'

LEGAL LIMIT A	10K	16K	16K	16K	16K	16K	16K	16K	16K	16K	16K	TOTAL 170K
LEGAL LIMIT B	10K	16K	16K	16K	16K	16K	16K	16K	16K	16K	16K	" 170K
BRIDGE FORMULA	10K	9K	9K	8K	8K	8K	8K	8K	8K	8K	8K	" 92K
H20-S16-44	10K	6K	6K	6K	6K	7K	7K	7K	7K	7K	7K	" 76K
H15-S12-44	10K	4K	4K	4K	5K	5K	5K	5K	5K	5K	5K	" 57K
H20-44	10K	4K	4K	4K	5K	5K	5K	5K	5K	5K	5K	" 57K
H15-44	10K	3K	3K	3K	3K	3K	3K	3K	4K	4K	4K	" 43K

MAX LENGTH

Axle spacing: 8' – 4' – 8' – 4' – 4' – 8' – 4' – 8' – 4' – 4'

LEGAL LIMIT A	10K	16K	16K	16K	16K	16K	16K	16K	16K	16K	16K	TOTAL 170K
LEGAL LIMIT B	10K	16K	16K	16K	16K	16K	16K	16K	16K	16K	16K	" 170K
BRIDGE FORMULA	10K	10K	9K	9K	9K	9K	9K	9K	9K	9K	9K	" 101K
H20-S16-44	10K	7K	7K	7K	7K	7K	7K	7K	7K	8K	8K	" 82K
H15-S12-44	10K	5K	5K	5K	5K	5K	5K	5K	5K	5K	6K	" 61K
H20-44	10K	6K	6K	6K	6K	6K	6K	6K	6K	6K	5K	" 69K
H15-44	10K	4K	4K	4K	4K	4K	4K	4K	4K	5K	5K	" 52K