EFFECT ON BRIDGES OF PROPOSED CHANGES IN PERMISSIBLE TRUCK LOADS

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Restrictions on vehicle loads are placed on the highway system to prolong its useful life and to reduce the costs of maintaining it in serviceable condition. Through the years, legal limits for axle loads and gross loads have been established by each state individually, with only limited coordination between states or attempt at uniformity. However, in the past few years and as a result of the impetus provided by the Federal-Aid Highway Act of 1956 (Interstate Highway Act) technical studies have been made for the establishment of a uniform national policy on maximum dimensions and weights of vehicles permitted to operate on the Federal-Aid Highway Systems. In particular, the technical study carried out by the Committee on Highway Transport of The American Association of State Highway Officials produced recommendations that were officially adopted by the Association in 1964. This study was the basis for House Document No. 354 (88th Congress, 2nd Session) "Maximum Desirable Dimensions and Weights of Vehicles Operated on the Federal-Aid Systems," transmitted by the Secretary of Commerce to the Speaker of the House of Representatives on August 18, 1964. This document is currently before the House for consideration, and six months after the enactment of this legislation a national policy on legal limits for vehicle size and weights will be in effect, with certain additional modifications in the limits to be made on July 1, 1967.

Pertinent limits in this national policy that will influence legal limits in Michigan are as follows:

1. Single axle load limited to 18,000 lb until July 1, 1967.

2. Tandem axle load limited to 32,000 lb until July 1, 1967.

3. Gross load limit to be 73,280 lb until six months after enactment of federal legislation, and then to be as given in Table 1 until July 1, 1967.

The values shown in Table 1 are obtained by the use of the "Bridge Formula" which is

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

where

W = maximum weight in pounds carried on any group of two or more axles.
L = distance in feet between the extremes of any group of two or more consecutive axles.
N = number of axles in the group under consideration.

The maximum overall length of a vehicle, with the exception of car haulers, according to Michigan's current limits is 55 ft. Thus, a practical limit for the distance between extreme axles for a vehicle is approximately 52 ft. For this length, the permissible gross load in accordance with Table 1 is 78,500 lb for five-axle vehicles and 99,000 lb for nine-axle vehicles.

Current Michigan Policy

As you know, Michigan's current legal limits are briefly as follows:

1. Single axle load: 18,000 lb.

2. Tandem axle load: 32,000 lb (one set of tandem axles); 26,000 lb (all other tandem axles).

3. Gross Load Limit: no limit.

It should be pointed out that Michigan is the only state in the nation that does not have a gross load limit. The primary purpose of a gross load limit is to prevent overstressing of bridges. Gross load limits in other states vary from a low of 56,800 lb to a maximum of 88,000 lb. Axle load limits do a reasonably good job of controlling overstressing of bridges, if the number of axles per vehicle is not excessive. However, in Michigan in the past 10 years there has been a rapid increase in the number of axles per vehicle for the tractor, semi-trailer, and trailer type trucks until it appears that with the current permissible length and mechanical limits in truck design, the maximum number is 13. Under Michigan's current laws, such a truck is permitted to carry a gross load of 175,000 lb.

Implications for Michigan Bridges

Studies are continually being carried out by the Department on the design overstress resulting from typical commercial vehicles crossing various bridges in the highway system. Of the total of 2,498 state bridges, either on the trunkline or over the trunkline for grade separation, 28 percent are currently of H 15 design or lower. The H 15 bridge design is for a truck having a gross load of 30,000 lb. On the Federal-Aid Secondary System, one-third of the bridges now being built are designed for the H 15 loading, and on the county road systems approximately one-half are of currently being built for the H 15 loading.

At present, and for the next 30 to 40 years, there will be enough bridges in the state and county systems of H 15 design so that maximum load limits will be a matter of concern in order to preserve their usefulness. In establishing the national policy shown in Table 1, the intent was to limit gross loads so that vehicles will not overstress H 15 bridges by more than 30 percent, and so that H 20 - S 16 bridges (the heaviest current design) by more than 5 percent.

An analysis has been made and is shown in Table 2 of the overstress which results in H 15 bridges from some typical commercial vehicles when loaded to legal limits. Typical types for trucks; truck-trailers; tractors, semi-trailers;and tractors, semi-trailers, and trailers are shown with two lengths, the first the shortest practical length and the second the longest practical length. The analysis has been made for each vehicle on the basis of vehicle loads restricted by three limits: 1) Michigan's existing limit, 2) Proposed Change A, and 3) Proposed Change B. These limits are tabulated as follows:

1. Existing Limit:

   Single axle load: 18,000 lb
   Tandem axle load: 32,000 lb (one set of tandem axles), 26,000 lb (all other tandem axles)

2. Proposed Change A:

   Tandem axle load: 32,000 lb (for two sets of tandem axles), 26,000 lb (all other tandem axles)

3. Proposed Change B:

   Tandem axle load: same as Change A
   Gross Load Limit: 105,000 lb

Implications of Proposed Changes

Table 2 shows the overstress on H 15 bridges as a result of trucks loaded according to the existing limits and according to both proposed changes.* In summary these are briefly as follows:

Trucks - A maximum overstress of 16 percent exists and neither Proposed Change affects this vehicle type.

Truck-Trailers - The maximum overstress is currently 43 percent. Proposed Change A would increase this to 48 percent, and the gross load limit of Proposed Change B would not affect this vehicle type.

Tractors, Semi-Trailers - The maximum existing overstress is 31 percent (Type 3S2), Proposed Change A increases this to 36 percent. Proposed Change B with a gross load limit has no effect.

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* The detailing and explanation of the computations which are largely the basis for the overstress values shown in Table 2 are contained in "Practical Bridge Loading Limitations in Relation to Current Commerical Vehicle Types and Bridge Design Practice." Research Laboratory Division Report No. R-414R of the Michigan State Highway Department.

Tractors, Semi-Trailers, and Trailers - The smallest overstress for these vehicles is 30 percent and the largest is 85 percent (Type 4S3-6). Proposed Change A would increase the maximum overstress to 89 percent (Type 4S3-6), while Proposed Change B would limit it to a maximum of 48 percent (Type 2S2-4).

It should be pointed out that the gross load limit of 105,000 lb is most significant for trucks with eight or more axles, while for the heaviest type (4S3-6), it results in reducing the bridge overstress by 37 percent from the existing limit.

Conclusions

The national policy on load limits now before Congress restricts H 15 bridge overstress to a maximum of 30 percent. By imposing a gross load limit of 105,000 lb at this time, the overstress for H 15 bridges in Michigan will be limited to a maximum of about 50 percent. Such a gross load limit will affect only the tractor, semi-trailer and trailer type of vehicle combination, having seven or more axles. If the national load limit policy is approved by Congress, a more drastic limitation of gross loads will be imposed on these heavier vehicles. Allowing for such an eventuality, a gross load limit of 105,000 lb thus becomes simply a desirable interim measure until the national policy is enacted.

TABLE 1
PERMISSIBLE GROSS LOADS
FOR VEHICLES IN REGULAR OPERATION

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	41,000						
10		41,500						
11		42,000						
12		43,000	46,000					
13		44,000	49,000					
14		44,500	49,500					
15		45,000	50,000					
16		46,000	50,500	56,000				
17		47,000	51,500	56,500				
18		47,500	52,000	57,000				
19		48,000	52,500	58,000				
20		49,000	53,500	58,500	64,000			
21		50,000	54,000	59,000	64,500			
22		50,500	54,500	60,000	65,000			
23		51,000	55,500	60,500	66,000			
24		52,000	56,000	61,000	66,500	72,000		
25		53,000	56,500	61,500	67,000	72,500		
26		53,500	57,500	62,000	67,500	73,000		
27		54,000	58,000	63,000	68,000	74,000		
28		55,000	58,500	63,500	69,000	74,500	80,000	
29			59,500	64,000	69,500	75,000	80,500	
30			60,000	65,000	70,000	75,500	81,000	
31			60,500	65,500	70,500	76,000	81,500	
32			61,500	66,000	71,000	76,500	82,500	88,000
33			62,000	66,500	72,000	77,000	83,000	88,500
34			62,500	67,000	72,500	78,000	83,500	89,000
35			63,500	68,000	73,000	78,500	84,000	89,500
36			64,000	68,500	73,500	79,000	84,500	90,000
37			64,500	69,000	74,000	79,500	85,000	91,000
38			65,500	70,000	75,000	80,000	85,500	91,500
39			66,000	70,500	75,500	81,000	86,500	92,000
40			66,500	71,000	76,000	81,500	87,000	92,500
41			67,500	71,500	76,500	82,000	87,500	93,000
42			68,000	72,000	77,000	82,500	88,000	93,500
43			68,500	73,000	78,000	83,000	88,500	94,000
44			69,500	73,500	78,500	83,500	89,000	95,000
45			70,000	74,000	79,000	84,000	89,500	95,500
46			70,500	75,000	79,500	85,000	90,500	96,000
47			71,500	75,500	80,000	85,500	91,000	96,500
48			72,000	76,000	81,000	86,000	91,500	97,000
49			72,500	76,500	81,500	86,500	92,000	97,500
50				77,000	82,000	87,000	92,500	98,000
51				78,000	82,500	88,000	93,000	98,500
52				78,500	83,000	88,500	93,500	99,000
53				79,000	84,000	89,000	94,500	100,000
54				80,000	84,500	89,500	95,000	100,500
55				80,500	85,000	90,000	95,500	101,000
56				81,000	85,500	90,500	96,000	101,500
57				81,500	86,000	91,000	96,500	102,000
58				82,000	87,000	92,000	97,000	102,500
59				83,000	87,500	92,500	97,500	103,000
60				83,500	88,000	93,000	98,500	104,000

The maximum load on any single axle is limited to 18,000 lb, and on any tandem axle to 32,000 lb, when the distance between extreme axles of any such group is not less than 40 in. or more than 8 ft.

Loaded vehicles of type 3-S2 (5 axle) with wheelbase less than 35 feet must not operate over H15-44 bridges.

Loaded vehicles of type 2-S1-2 (5 axle) with wheelbase less than 42 feet must not operate over H15-44 bridges.

Loaded vehicles of type 3-3 (6 axle) with wheelbase less than 44 feet must not operate over H15-44 bridges.

Loaded vehicles of 7, 8, or 9 axles regardless of type and of wheelbase must not operate over H15-44 bridges.

TABLE 2

MAXIMUM OVERSTRESS FOR H 15 BRIDGES
FOR TYPICAL TRUCKS WITH EXISTING LEGAL LIMITS
AND EFFECT OF TWO PROPOSED CHANGES
(For bridge spans from 20 to 200 ft in length)

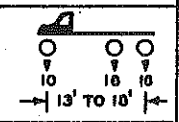
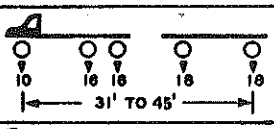
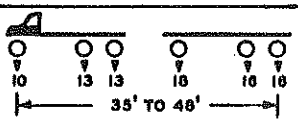
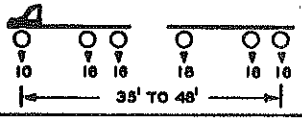
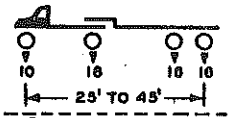
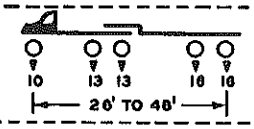
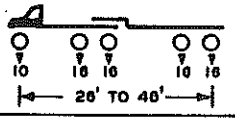
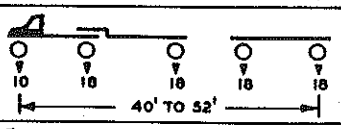
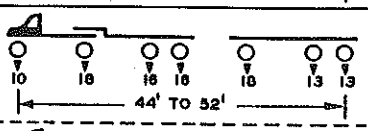
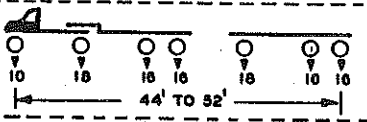
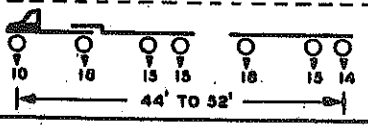
	Truck Types	Total Load, kips	Wheelbase, ft	Overstress, percent
Trucks	Type 3	42	13	16
	Existing Limits 	42	18	10
Trucks, Trailers	Type 3-2	78	31	36
	Existing Limits 	78	45	21
	Type 3-3	86	35	43
	Existing Limits 	86	48	47
	Type 3-3	92	35	48
	Change A 	92	48	31
Tractors, Semi-Trailers	Type 2S2	60	25	18
	Existing Limits 	60	45	8
	Type 3S2	68	26	31
	Existing Limits 	68	48	11
	Type 3S2	74	26	36
	Change A 	74	48	14
Tractors, Semi-Trailers, and Trailers	Type 2S1-2	82	40	30
	Existing Limits 	82	52	21
	Type 2S2-3	104	44	44
	Existing Limits 	104	52	37
	Type 2S2-3	110	44	48
	Change A 	110	52	41
	Type 2S2-3	105	44	45
	Change B 	105	52	38

TABLE 2 (cont.)

MAXIMUM OVERSTRESS FOR H 15 BRIDGES
FOR TYPICAL TRUCKS WITH EXISTING LEGAL LIMITS
AND EFFECT OF TWO PROPOSED CHANGES
(For bridge spans from 20 to 200 ft in length)

	Truck Types	Total Load, kips	Wheelbase, ft	Overstress, percent
Tractors, Semi-Trailers, and Trailers (cont.)	Type 2S2-4	112	42	53
	Existing Limits (10 16 16 16 13 13 13 13; 42' TO 52')	112	52	44
	Type 2S2-4	118	42	58
	Change A (10 16 16 16 16 16 13 13; 42' TO 52')	118	52	48
	Type 2S2-4	105	42	48
	Change B (10 16 14 13 13 13 13 13; 42' TO 52')	105	52	39
	Type 3S2-4	120	42	63
	Existing Limits (10 13 13 16 16 13 13 13 13; 42' TO 52')	120	52	49
	Type 3S2-4	126	42	67
	Change A (10 13 13 16 16 13 13 16 16; 42' TO 52')	126	52	53
	Type 3S2-4	105	42	51
	Change B (10 12 12 12 12 12 12 12 11; 42' TO 52')	105	52	40
	Type 3S3-5	146	46	75
	Existing Limits (10 13 13 13 13 13 16 16 13 13 13; 46' TO 52')	140	52	66
	Type 3S3-5	152	46	81
	Change A (10 10 16 13 13 13 16 16 13 13 13; 46' TO 52')	152	52	70
	Type 3S3-5	105	46	46
	Change B (10 10 10 10 10 10 9 9 9 9 9; 46' TO 52')	105	52	40
	Type 4S3-6	175	52	86
	Existing Limits (13 16 16 13 13 13 13 13 13 13 13 13; 52')			
	Type 4S3-6	181	52	89
	Change A (13 16 16 13 16 16 13 13 13 13 13 13; 52')			
	Type 4S3-6	105	52	30
	Change B (8 8 8 8 8 8 8 8 8 8 8 8; 52')			

NOTE: The legal axle load limits are shown except for the steering axle which is 10 kips (Type 4S3-6 is an exception) a 10 kip limit on the steering axle appears to be a practical limit rather than a legal one.