

BRIDGE FORMULA WEIGHTS



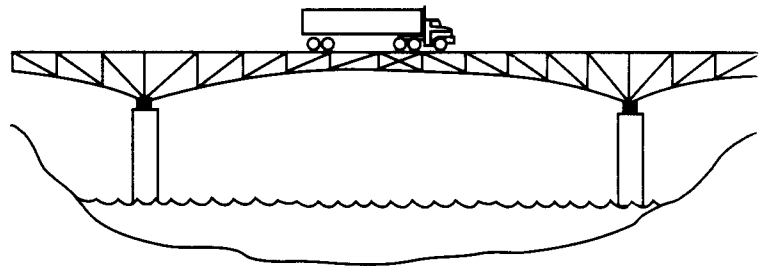
U.S. Department
of Transportation

**Federal Highway
Administration**

January 1994

NOTE- For additional copies contact:
Federal Highway Administration
400 7th Street, SW
Washington, D.C. 20590
(202) 366-2212

$$W = 500 \left[\frac{LN}{N-1} + 12N + 36 \right]$$



Publication No. FHWA-MC-94-007
HIA-20/1(15M)E
HIA-10/R1-96(7.5M)
HIA-20/10-98(10M)

Three questions are addressed by this pamphlet with regard to the Bridge Formula: What is it? Why is it necessary? How is it used?

WHAT IS IT?

$$W = 500 \left[\frac{LN}{N-1} + 12N + 36 \right]$$

W = the maximum weight in pounds that can be carried on a group of two or more axles to the nearest 500 pounds.

L = the distance in feet between the outer axles of any two or more consecutive axles.

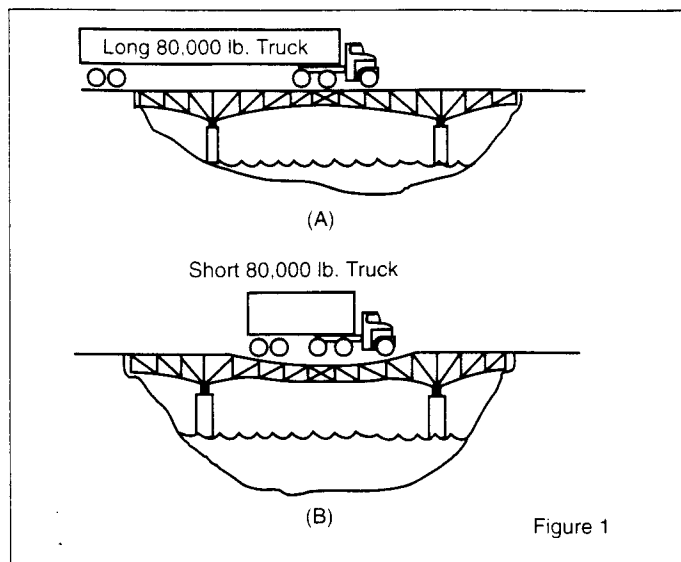
N = the number of axles being considered.

This formula limits the weight on groups of axles in order to reduce the risk of damage to highway bridges. Allowable weight depends on the number of axles a vehicle has and the distance between those axles. However, the single- or tandem-axle weight limits supersede the Bridge Formula limits for all axles not more than 96 inches apart.

WHY IS THE FORMULA NECESSARY?

Bridges on Interstate System highways are used by a wide variety of traffic. They are designed to support expected loadings. However, as trucks grew heavier in the 1950's and 1960's, something had to be done to protect bridges. The solution was to tie allowable weights to the number and spacing of axles.

Axle spacing is as important as axle weight in bridge design. A bridge is analogous to thin ice on a pond. Walking on the ice concentrates a person's weight on the small area covered by the individual's feet, and the ice may break. Lying down, however, spreads the same weight over a much larger area, and the ice is less likely to break. Consider trucks crossing a bridge:



In Figure 1(A), the stress on bridge members as the longer truck rolls across is much less than that caused by the short vehicle in Figure 1 (B), even though both trucks have the same total weight and individual axle weights. The weight of the longer vehicle is spread out, while the shorter vehicle has all of the weight concentrated on a small area.

The Federal-Aid Highway Amendments of 1974 increased the weights allowed on the Interstate System to 20,000 pounds on a single axle, 34,000 pounds on a tandem axle, and 80,000 pounds gross weight (23 U.S.C. 127). But Congress balanced this concession to productivity by enacting the Bridge Formula. The result is that motor vehicles may be loaded to the maximum weight only if each group of axles on the vehicle and their spacing also satisfy the requirements of the Formula. This prevents the vehicle from overstressing bridges in the same way that a person lying down on thin ice would minimize the risk of breaking through.

Until 1982, Federal law set only upper limits (or ceilings) on Interstate System weight limits. A few States retained significantly lower weight limits which eventually became barriers to long-distance truck traffic. In 1982, Federal law was amended to make Interstate System weight limits, including the bridge formula limits, both the maximum and the minimum weights (i.e., floors and ceilings) that States must allow on the Interstate System.

HOW IS THE FORMULA USED?

Some definitions are needed to use the Bridge Formula correctly.

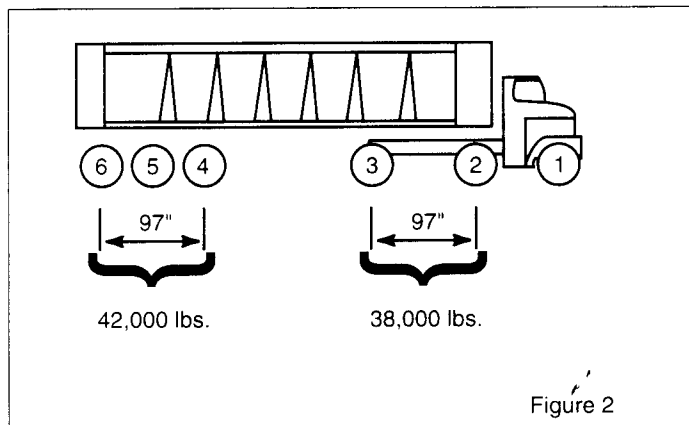
Gross Weight—the weight of a vehicle or vehicle combination and any load thereon. The Federal gross weight limit on the Interstate System is 80,000 pounds.

Single-Axle Weight—The total weight on one or more axles whose centers are not more than 40 inches apart. The Federal single-axle weight limit on the Interstate System is 20,000 pounds.

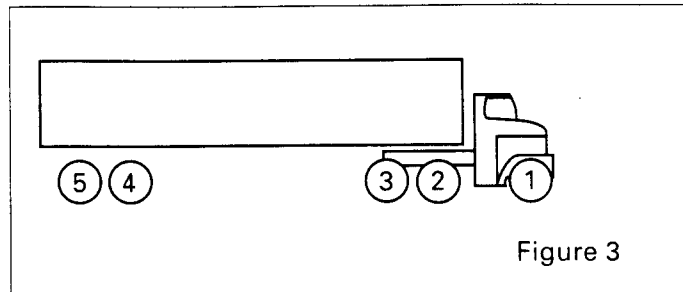
Tandem-Axle Weight—The total weight on two or more consecutive axles more than 40 inches but not more than 96 inches apart. The Federal tandem-axle weight limit on the Interstate System is 34,000 pounds.

Interstate System weight limits in some States may be higher than these figures due to "grandfather" rights. When the Interstate System axle and gross weight limits were adopted in 1956, States were allowed to keep or "grandfather" those which were higher. In 1975, States were also allowed to keep "grandfathered" bridge formula limits which were higher than those established for the Interstate System.

Bridge Formula calculations yield a series of weights (pages 6-7). However, the single-axle weight limit replaces the Bridge Formula weight limit on axles not more than 40 inches apart, and the tandem-axle weight limit replaces the Bridge Formula weight limit for axles over 40 but not more than 96 inches apart. At 97 inches apart, two axles can carry 38,000 pounds and three axles 42,000 pounds, as shown in Figure 2.

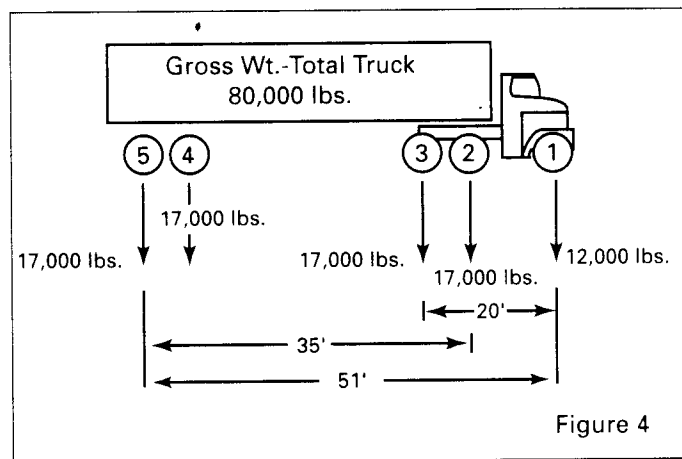


Federal law provides that any two or more consecutive axles may not exceed the weight computed by the Formula even though single axles, tandem axles, and gross weight are within legal limits. In other words, the axle group that includes the entire truck—sometimes called the "outer bridge" group—must comply with the Bridge Formula. But interior combinations of axles, such as the "tractor bridge" (axles 1, 2, and 3) and "trailer bridge" (axles 2, 3, 4, and 5), must also be in compliance with weights computed by the Formula (Figure 3).



The most common vehicle checked for compliance with weight limit requirements is shown in Figure 3. While the Bridge Formula applies to each combination of two or more axles, experience shows that axle combinations 1 through 3, 1 through 5, and 2 through 5 are critical and must be checked. If these combinations are found to be satisfactory, all of the others on this type of vehicle will normally be satisfactory.

The vehicle with weights and axle dimensions as shown in Figure 4 will be used to illustrate a Bridge Formula check. (Continued on page 8.)



PERMISSIBLE GROSS LOADS FOR VEHICLES IN REGULAR OPERATION ¹

Based on weight formula

$$W = 500 \left[\frac{LN}{N-1} + 12N + 36 \right]$$

Distance in feet (L)
between the extremes of
any group of 2 or
more consecutive axles

Maximum load in pounds carried on any group of 2 or more consecutive axles

	N =	2 AXLES	3 AXLES	4 AXLES	5 AXLES	6 AXLES	7 AXLES	8 AXLES	9 AXLES
	4	34,000							
	5	34,000							
	6	34,000							
	7	34,000							
	8 & less	34,000	34,000						
	more than 8	38,000	42,000						
	9	39,000	42,500						
	10	40,000	43,500						
	11		44,000						
	12		45,000	50,000					
	13		45,500	50,500					
	14		46,500	51,500					
	15		47,000	52,000					
	16		48,000	52,500	58,000				
	17		48,500	53,500	58,500				
	18		49,500	54,000	59,000				
	19		50,000	54,500	60,000				
	20		51,000	55,500	60,500	66,000			
	21		51,500	56,000	61,000	66,500			
	22		52,500	56,500	61,500	67,000			
	23		53,000	57,500	62,500	68,000			
	24		54,000	58,000	63,000	68,500	74,000		
	25		54,500	58,500	63,500	69,000	74,500		
	26		55,500	59,500	64,000	69,500	75,000		
	27		56,000	60,000	65,000	70,000	75,500		
	28		57,000	60,500	65,500	71,000	76,500	82,000	
	29		57,500	61,500	66,000	71,500	77,000	82,500	
	30		58,500	62,000	66,500	72,000	77,500	83,000	
	31		59,000	62,500	67,500	72,500	78,000	83,500	
	32		60,000	63,500	68,000	73,000	78,500	84,500	90,000
	33			64,000	68,500	74,000	79,000	85,000	90,500
	34			64,500	69,000	74,500	80,000	85,500	91,000
	35			65,500	70,000	75,000	80,500	86,000	91,500
	36		Exception	66,000	70,500	75,500	81,000	86,500	92,000
	37		(see page 10)	66,500	71,000	76,000	81,500	87,000	93,000
	38			67,500	71,500	77,000	82,000	87,500	93,500
	39			68,000	72,500	77,500	82,500	88,500	94,000
	40			68,500	73,000	78,000	83,500	89,000	94,500
	41			69,500	73,500	78,500	84,000	89,500	95,000
	42			70,000	74,000	79,000	84,500	90,000	95,500
	43			70,500	75,000	80,000	85,000	90,500	96,000
	44			71,500	75,500	80,500	85,500	91,000	96,500
	45			72,000	76,000	81,000	86,000	91,500	97,500
	46			72,500	76,500	81,500	87,000	92,500	98,000
	47			73,500	77,500	82,000	87,500	93,000	98,500
	48			74,000	78,000	83,000	88,000	93,500	99,000
	49			74,500	78,500	83,500	88,500	94,000	99,500
	50			75,500	79,000	84,000	89,000	94,500	100,000
	51			76,000	80,000	84,500	89,500	95,000	100,500
	52			76,500	80,500	85,000	90,500	95,500	101,000
	53			77,500	81,000	86,000	91,000	96,500	102,000
	54			78,000	81,500	86,500	91,500	97,000	102,500
	55			78,500	82,500	87,000	92,000	97,500	103,000
	56			79,500	83,000	87,500	92,500	98,000	103,500
	57		Interstate Gross	80,000	83,500	88,000	93,000	98,500	104,000
	58		Weight Limit		84,000	89,000	94,000	99,000	104,500
	59		(see page 4)		85,000	89,500	94,500	99,500	105,000
	60				85,500	90,000	95,000	100,500	105,500

¹The permissible loads are computed to the nearest 500 pounds as required by statute.

²The following loaded vehicles must not operate over H15-44 bridges: 3-S2 (5-axle) with wheelbase less than 38 feet; 2-S1-2 (5-axle) with wheelbase less than 45 feet; 3-3 (6-axle) with wheelbase less than 45 feet; and 7- 8- and 9-axle vehicles regardless of wheelbase.

Before checking a vehicle for compliance with the Bridge Formula, its single-axle, tandem-axle, and gross weight should be checked. Here the single axle (number 1) does not exceed 20,000 pounds, tandems 2-3 and 4-5 do not exceed 34,000 pounds each, and the gross weight does not exceed 80,000 pounds. These preliminary requirements are thus satisfied. The first Bridge Formula combination is checked as follows:

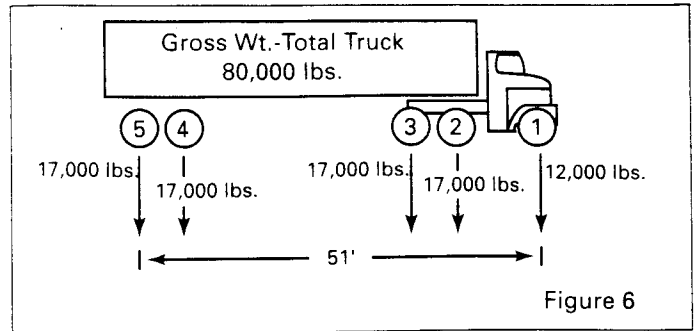


Figure 6

Now check axles 1 thru 5 (Figure 6)

Actual weight = 12,000 + 17,000 + 17,000 + 17,000 + 17,000 = 80,000#.

W maximum, from the Bridge Table for "L" of 51 feet and "N" of 5 = 80,000#.

Therefore, this axle spacing is satisfactory.

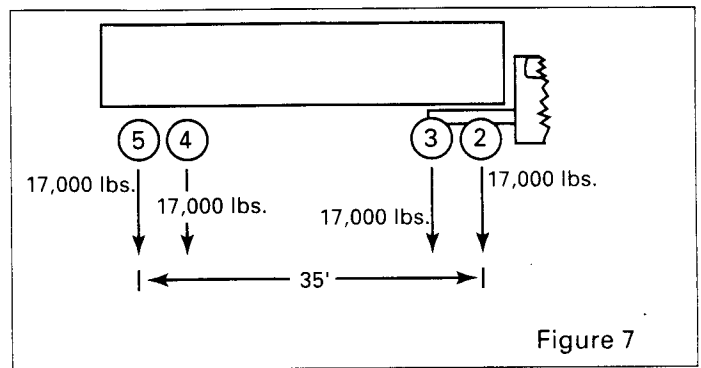


Figure 7

Now check axles 2 thru 5 (Figure 7)

Actual weight = 17,000 + 17,000 + 17,000 + 17,000 = 68,000#.

W maximum, Bridge Table for "L" of 35 feet and "N" of 4 = 65,500#.

This is a violation because the actual weight exceeds the weight allowed by the Bridge Formula. To correct the situation, some load must be removed from the vehicle or the axle spacing (35 feet) must be increased.

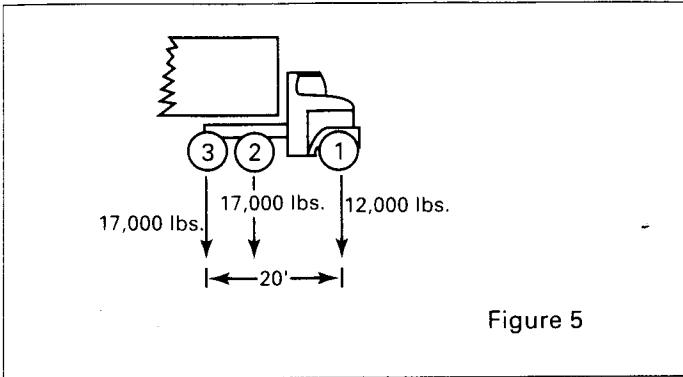


Figure 5

Check of 1 thru 3 (Figure 5)

Actual weight = 12,000 + 17,000 + 17,000 = 46,000 pounds.

N = 3 axles.

L = 20 feet.

$$W = 500 \left[\frac{LN}{N-1} + 12N + 36 \right]$$

$$W = 500 \left[\frac{(20 \times 3)}{(3 - 1)} + (12 \times 3) + 36 \right] = 51,000\#$$

W maximum = 51,000#, which is more than the actual weight of 46,000#, so the Bridge Formula requirement is satisfied.

Example—From the Bridge Table (pages 6 & 7)

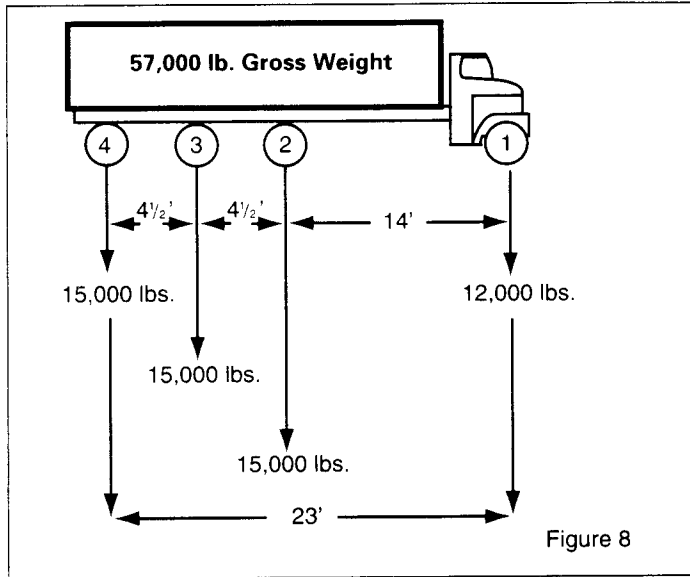
This same number (51,000#) could have been obtained from the Bridge Table by reading down the left side to L = 20 and across to the right where N = 3.

EXCEPTION TO FORMULA AND BRIDGE TABLE

Federal law (23 U.S.C.127) includes one exception to the Bridge Formula and the Bridge Table—two consecutive sets of tandem axles may carry 34,000 pounds each if the overall distance between the first and last axles of these tandems is 36 feet or more. For example, a five-axle tractor-semitrailer combination may carry 34,000 pounds both on the tractor tandem (axles 2 and 3) and the trailer tandem (axles 4 and 5), provided axles 2 and 5 are spaced at least 36 feet apart. Without this exception, the Bridge Formula would allow an actual weight of only 66,000 to 67,500 pounds on tandems spaced 36 to 38 feet apart.

BRIDGE FORMULA APPLICATION TO SINGLE UNIT TRUCKS

The procedure described above can be used to check any axle combinations, but several closely spaced axles usually produce the most critical situation.



The truck in Figure 8 satisfies the single axle weight limit (12,000# is less than 20,000#), the tandem axle limit (30,000# is less than 34,000#) and gross weight limit (57,000# is less than 80,000#). With these restrictions satisfied, a check will be made for Bridge Formula requirements, axles 1 through 4.

Actual weight = 12,000 + 15,000 + 15,000 + 15,000 = 57,000#.

W maximum for "N" of 4 and "L" of 23 feet = 57,500 from the Bridge Table.

Since axles 1 thru 4 are satisfactory, check axles 2 thru 4:

W (actual) = 15,000 + 15,000 + 15,000 = 45,000#.

W maximum for "N" of 3 and "L" of 9 feet = 42,500# (From the Bridge Table).

This is a violation. The load would have to be reduced, axles added, or spacing increased, to comply with the Bridge Formula .

CAUTION

This pamphlet paraphrases the actual provision in 23 U.S.C. 127 and 23 CFR 658 for the sake of clarity. In case of a dispute, the statute and regulations will govern.

Previous editions of this pamphlet released under the title "Bridge Gross Weight Formula", dated April 1984, remain valid. Neither the Formula nor any resulting maximum gross weight values (table entries) have been changed.