AASHTOWare™ BRIDGE
DESIGN AND RATING

Federal Formula B: What this Means for Load Rating/Permitting Today

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2025 Rating and Design User Group Meeting
Boise, ID | August 12-13, 2025

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- BACKGROUND
- "The problem, now and always has been, is how to rationalize design load with safe load carrying capacity or regulatory loading." From *United States Bridge Formula,* Napier and Eicher.
- DESIGN "NOTIONAL" LOADS
- OPERATION OF STATE HIGHWAY SYSTEMS
- STATE LEGAL LOADS
- INTERSTATE HIGHWAY LOADS
- FEDERAL FORMULA B
- DROP OR LIFT AXLES
- CONCLUSION
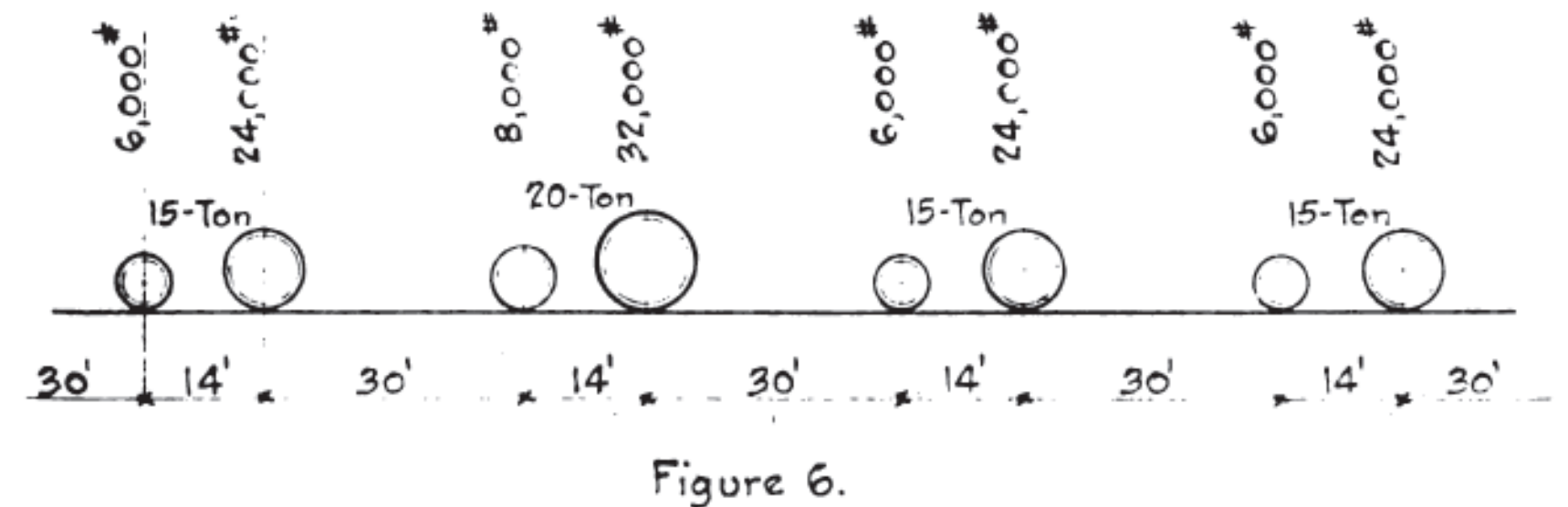
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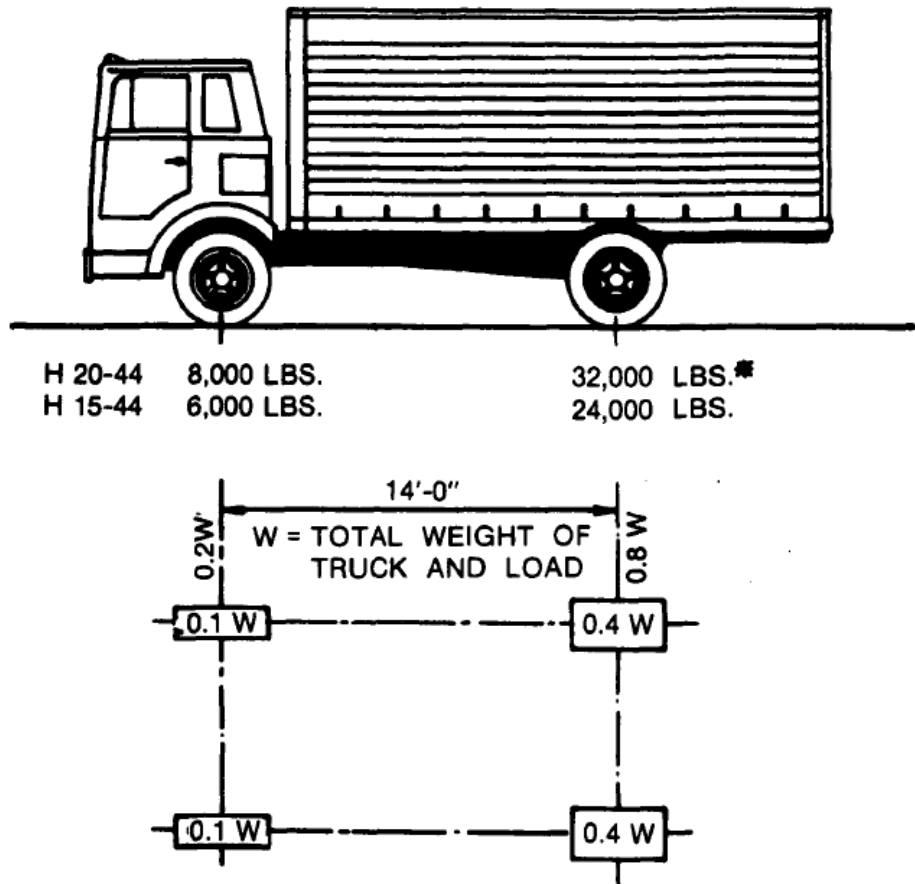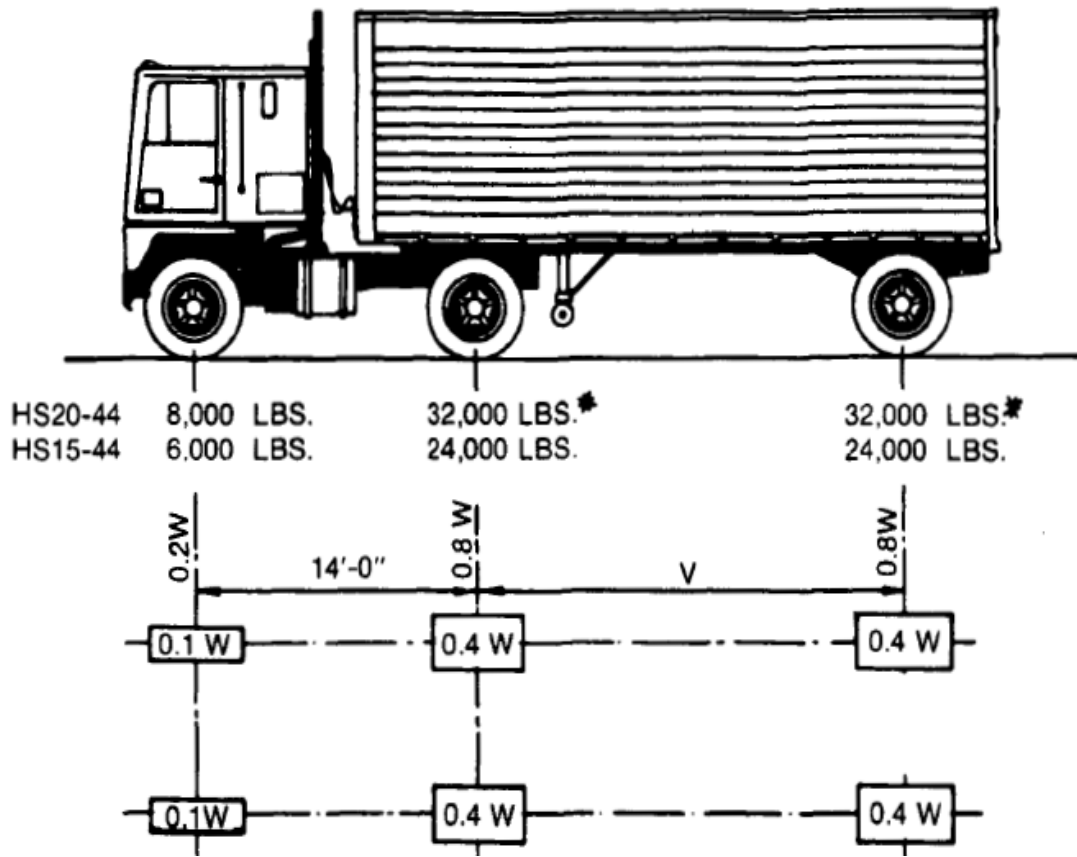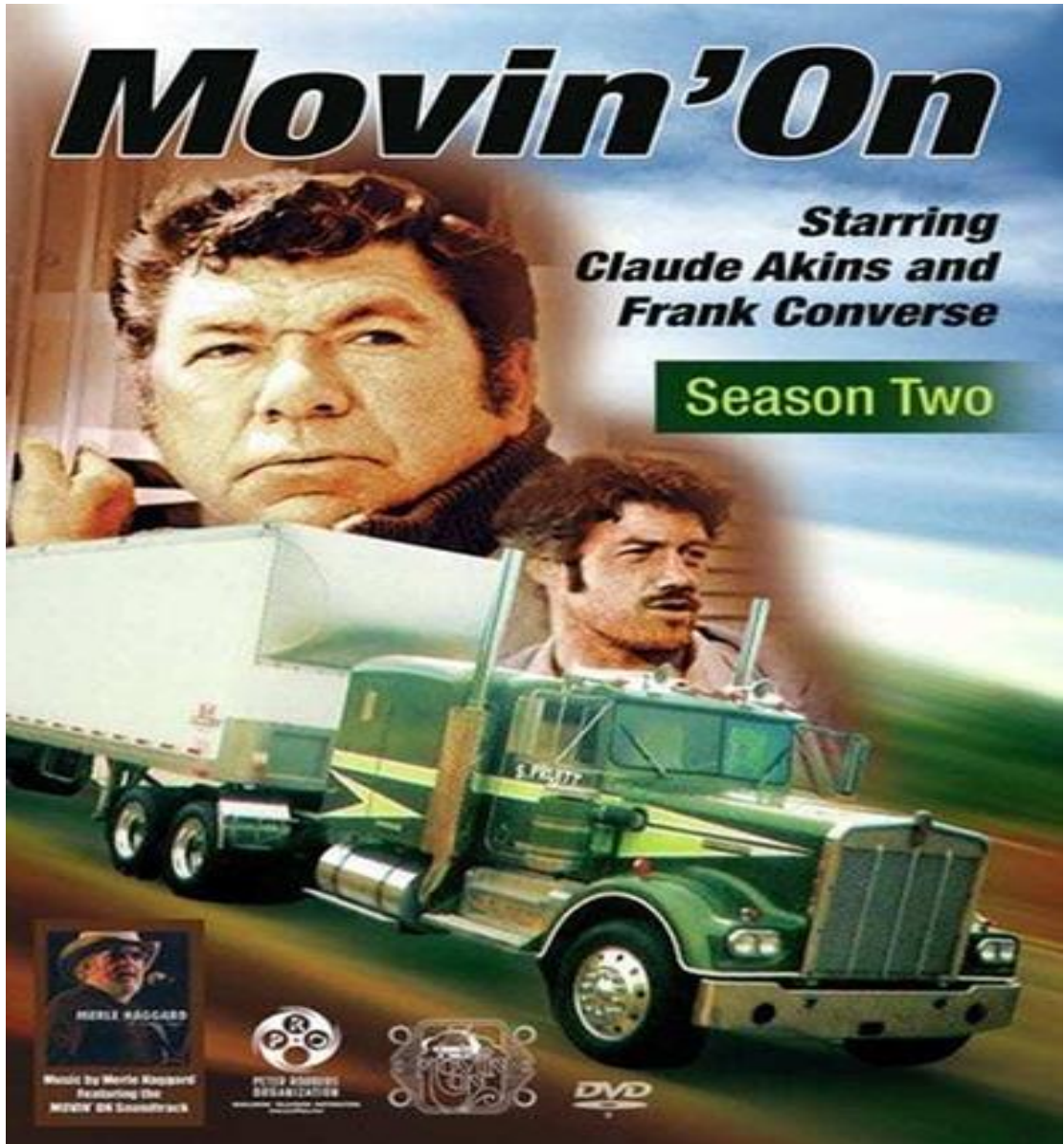
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- **AASHO 1931 Standard Specification for Highway Bridges and Incidental Structures**

STANDARD TRUCK
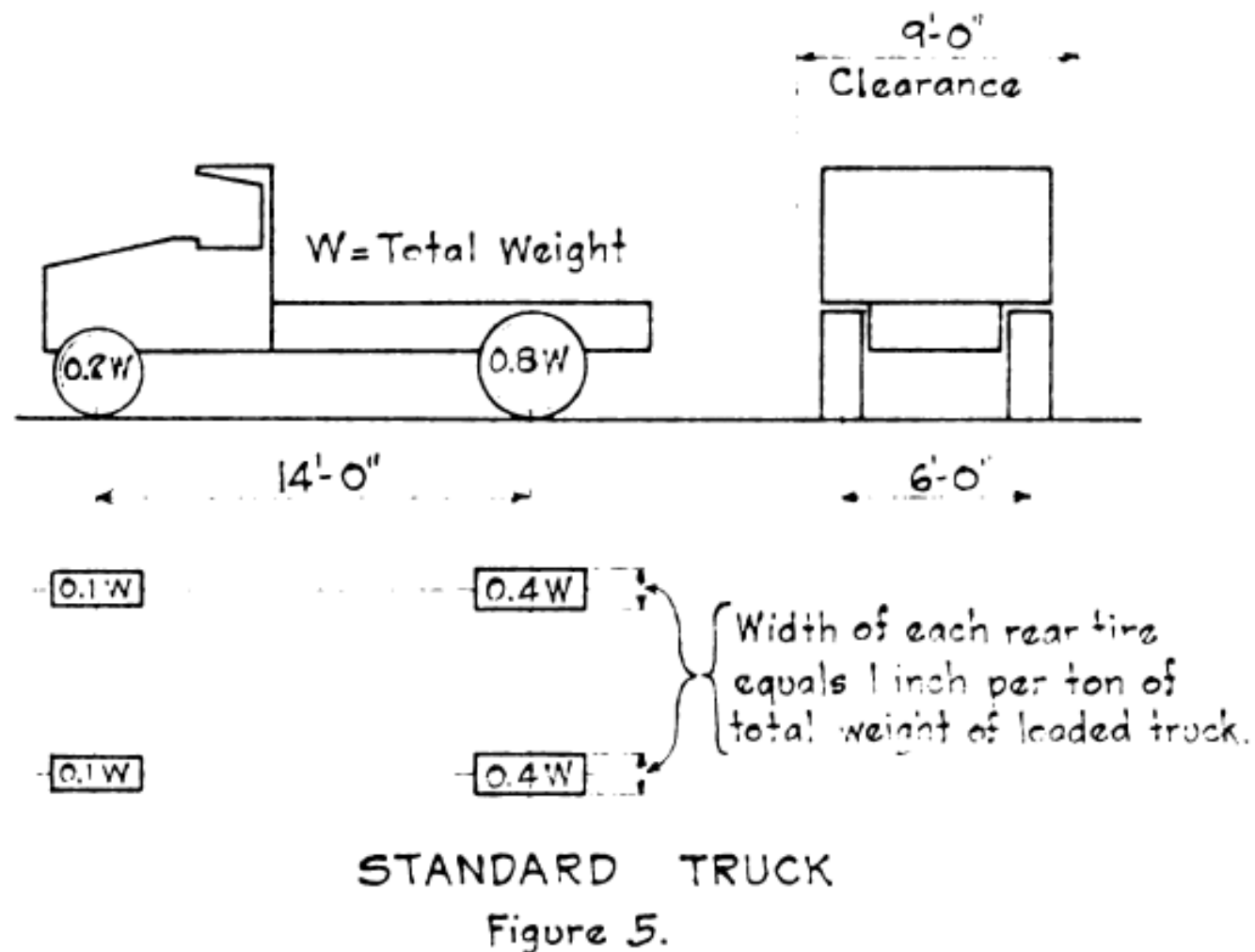
Figure 5.

Figure 6.

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- **US Bureau of Public Roads Specifications, 1919**

Figure 4   15-Ton Truck Loading, B P R Specifications, 1919

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Background: Typical 1920's era trucks

1922 MACK AB

1924 KENWORTH

1920 FORD Dump Truck

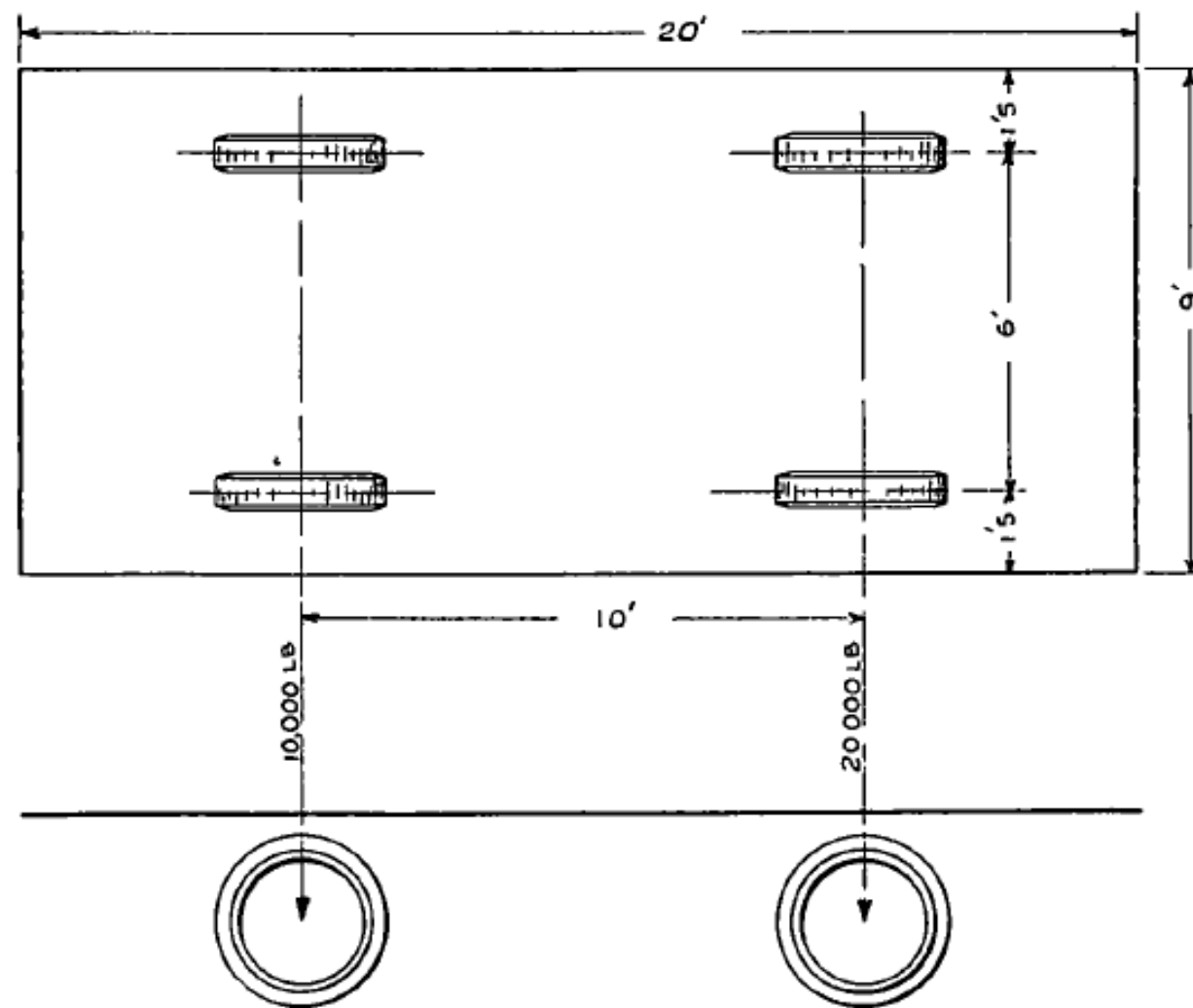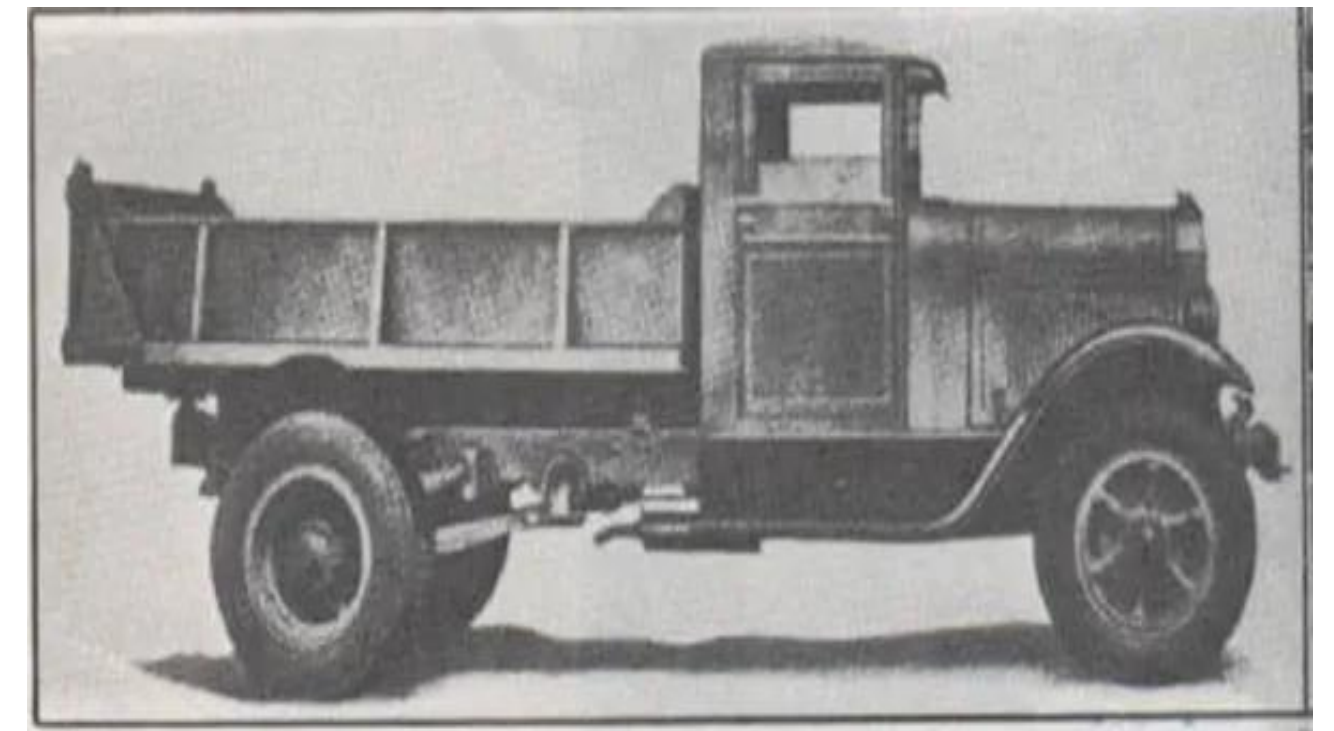# Federal Formula B: What this Means for Load Rating/Permitting Today

- AASHO pre 1946 Formula

- Operationally, many State Legislatures codified this design vehicle into their truck size and weight laws that they established to be able to control the size of trucks on their highways, so as to minimize bridge failures. Some states specified and limited a load per inch of tire width, a maximum single axle weight, and Allowable Gross Loads for vehicles.

- **W = C x (L + 40) ------- (pre-1946)**

- **W = the Allowable Gross Load of a vehicle**

- **Where C is a coefficient (700-850), AASHO suggested that 700 be used.**

- **L = the distance between the outmost axles**

- By observation it appears that AASHO derived this formula by comparing moments produced by the H15 and H20 design trucks to moments produced by trucks that conformed to the Bridge Formula [W = C x (L + 40)].

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- AASHO pre 1946 Formula

- The AASHO pre 1946 Formula was also know as the Gemeny Formula

HIGHWAY RESEARCH BOARD

GEMENY—LOAD LIMITATIONS

LOAD LIMITATIONS ON HIGHWAYS

ALBIN L GEMENY

Senior Structural Engineer, U S Bureau of Public Roads

- Published in 1932, Gemeny was concerned about inconsistencies between legal loads independently established by the various States. He developed the paper for discussion with AASHO.
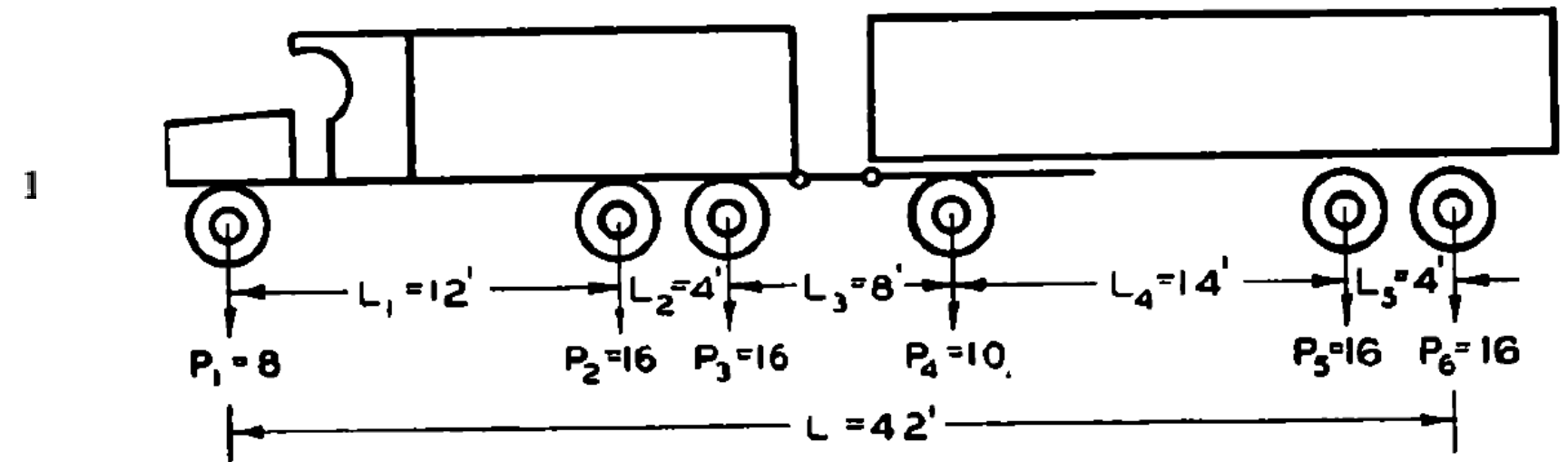
Figure 13   Type I—6-Wheel Truck and Trailer

Value of " P " in Thousands of Pounds

Maximum Permissible

Axle Load = 18,000 Lbs.
Gross Load = 1,000 (L + 40) = 82,000 Lbs.

Permissible Loads Are for Bridges Designed for A A S H O — H15 Loading Plus 100% Overload

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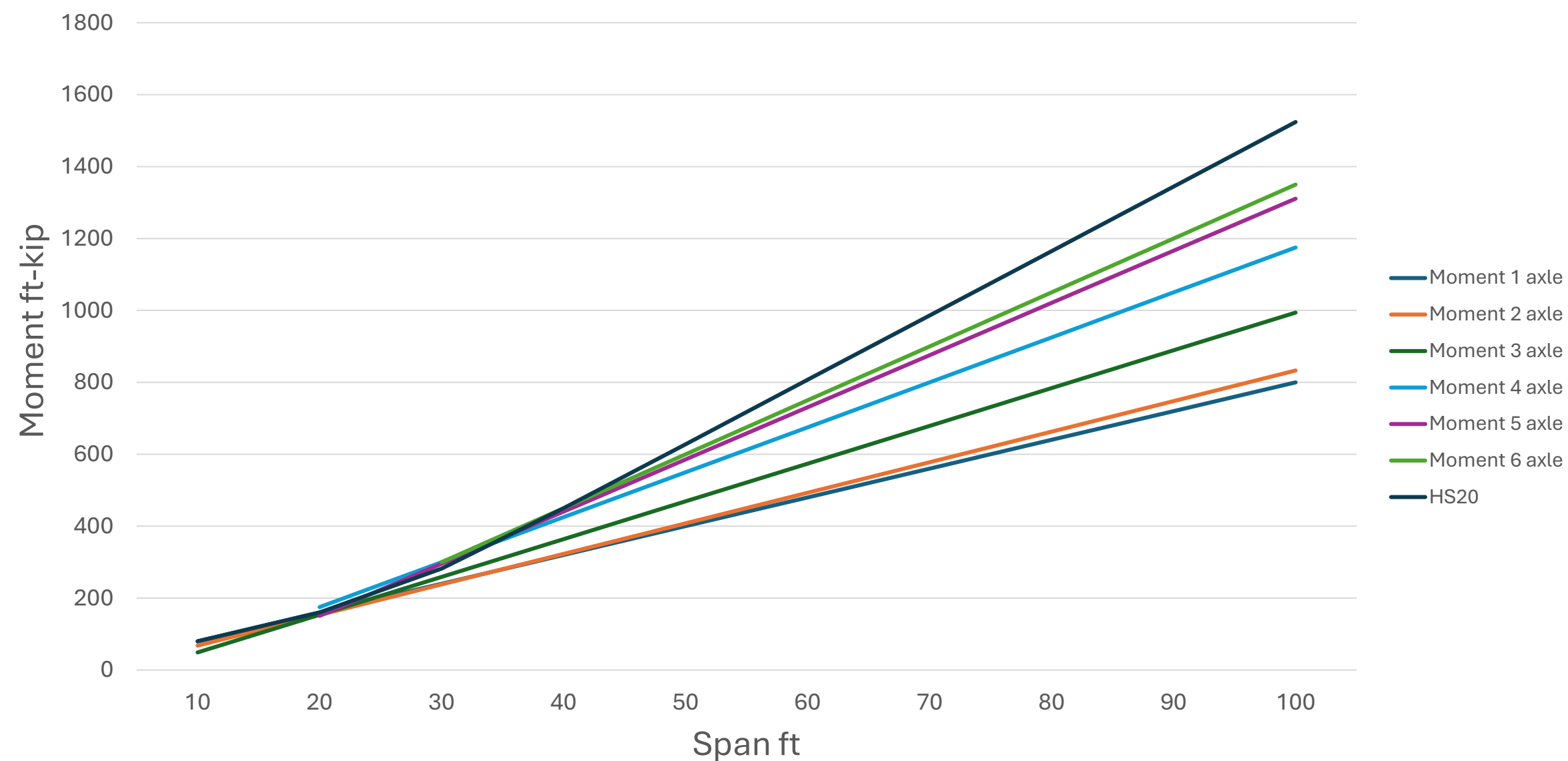
MOMENT COMPARISONS

Moment Comparisons	
1 axle – 32 kip	↓
Tandem 4 ft apart – 34 kip	↓ ↓
Tridem axle 4 ft apart – 42 kip	↓ ↓ ↓
Quad axle 4 ft apart – 50 kip	↓ ↓ ↓ ↓
5 axles 4 ft apart -58 kip	↓ ↓ ↓ ↓ ↓
6 axles 4 ft apart – 60 kip	↓ ↓ ↓ ↓ ↓ ↓
HS20	↓ ↓ ↓

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- **In 1944 AASHO proposed the H20-S16-44 design truck commonly referred to as HS20 design truck**

- **How do States operate their Highways?**

- **AASHO 1946 Formula**

- $W = 1025 (L+24) - 3L^2$ -------------- (AASHO 1946 Policy)

  L = the distance between the outmost axles.

  along with

  Single Axle load = 18,000 pounds

  Tandem axle (under 8 ft, spacing) = See table, 32,000 pounds

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- The 1946 AASHO Policy proposed the following table to illustrate the formula-

Distance in feet between the extremes of any group of axles	1946 AASHO Maximum load in pounds carried on any group of axles Single Axle = 18,000 lbs	Idaho 1949 Statutes Single Axle =18,000 lbs. Allowable Load in Pounds	Idaho 1955 Statutes Single Axle =18,000 lbs. Allowable Load in Pounds	Idaho 1955 Statutes Engaged in the transportation of logs, pulp wood, stull, poles or piling; ores, concentrate, sand and gravel, aggregates, unprocessed agricultural commodities; Single Axle = 18,900 lbs. Tandem axle 37,800 lbs.	
				Vehicles with Three or Four Axles	Vehicles with Five or More Axles
3		30,500	30,500	37,800	37,800
4	32,000	32,000	32,000	37,800	37,800
5	32,000	32,000	32,000	37,800	37,800
6	32,000	32,000	32,200	37,800	37,800
7	32,000	32,000	32,900	37,800	37,800

2025 R

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Background: Typical 1950's era trucks

1950 KENWORTH

1950's WHITE FREIGHTLINER

1955 PETERBILT 281 TANKER
(Star of the Steven Spielberg movie DUEL)

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1956 Interstate System

- First significant federal legislation concerning truck weights   was contained in the Federal Aid High way Act of 1956.

- This bill provided that no funds would be used for the Inter state system in any state that allowed vehicles with a single axle weighing more than 18,000 lbs. (a tandem axle of 32,000 lbs.), and a gross weight of 73,280 lbs. However, a "grandfather clause" provided that any vehicle that operated legally within a state before the passage of the law could continue to operate legally afterwards.

- No specific truck weight tables were included

Interstate Bill signed by President Eisenhower on June 29, 1956

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- **In 1962 the Texas Transportation Institute and the Bureau of Public Roads did a research study titled "Truck Weight Trends Related to Highway Structures" and produced a generalized bridge formula**

$$W = A \{f(NL) + BN + C\}$$

W = maximum load in pounds carried on any group of two or more consecutive axles.
L = distance in feet between the extremes of any group of two or more consecutive axles.
N = number of axles in group under consideration.
A, B & C are constants which depend upon quality of highway and bridge provision & desired level of heavy vehicle operation.
f = some function involving "N" and "L"

Federal Formula B: What this Means for Load Rating/Permitting Today

In **1964** the Highway Research Board prepared and submitted
to Congress, via the Secretary of Commerce,
House Document 354.

Several Bridge Formulas were considered based on the 1962 TTI Research.

$$W = 500 \left(\frac{LN}{N-1} + 12N + 32 \right) \quad \textit{(Federal Formula A)}$$

$$W = 500 \left(\frac{LN}{N-1} + 12N + 36 \right) \quad \textit{(Federal Formula B)}$$

$$W = 500 \left(\frac{LN}{N-1} + 12N + 40 \right) \quad \textit{(Federal Formula C)}$$

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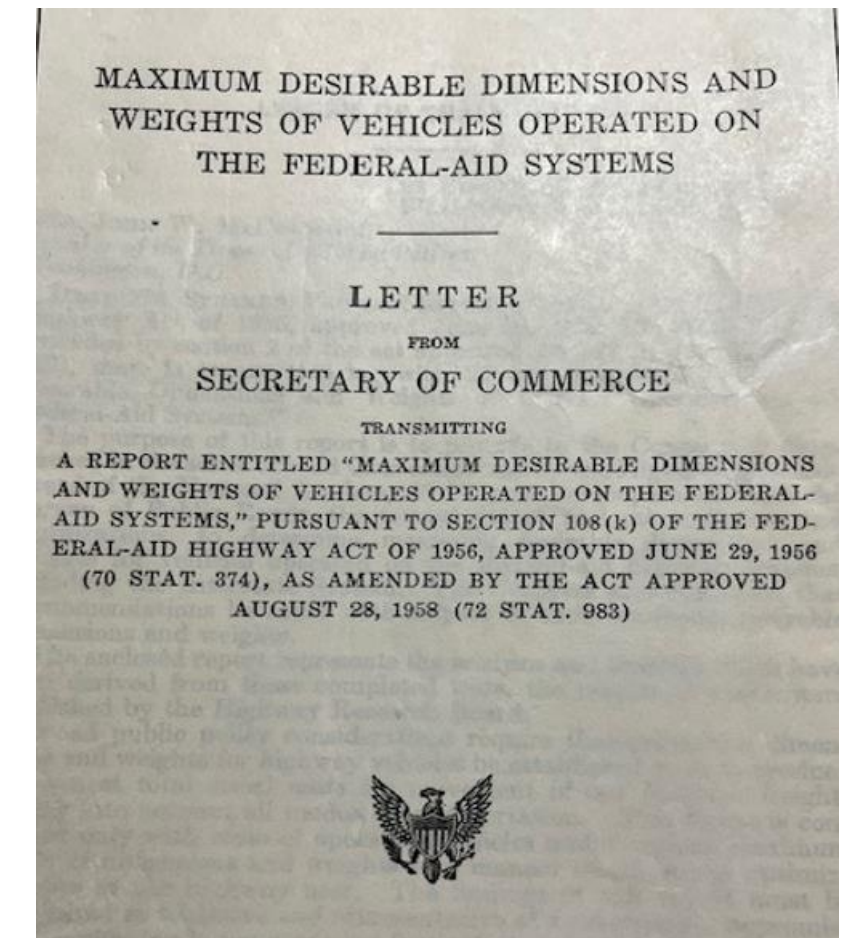
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In 1964, it was recommended to Congress that using

$$W = 500 \left(\frac{LN}{N-1} + 12N + 36 \right) \quad \textit{(Federal Formula B)}$$

W = maximum load in pounds carried on any group of two or more consecutive axles.

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

N = number of axles in group under consideration.

Single axle limit = 20,000 lbs

Tandem axle limit = 34,000 lbs

Would not overstress HS-20 designed bridge by more than 5% and H-15 designed bridges by more than 30% provided they are well maintained. They were advised that in no case should loaded vehicles with more than six axles be allowed over H-15 designed bridges.

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- **The Federal-aid Highway Amendments of 1974 increased the maximum permissible weight limits for the Interstate System and adopted Federal Formula B.** The maximum allowable single and tandem weights were raised to 20,000 and 34,000 pounds respectively, and gross vehicle weights were controlled by Bridge Formula B to a maximum of 80,000 pounds.

- **If a State was using previous AASHTO bridge formula they could retain lower limits. So some States were barrier States for interstate travel.**

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

(Federal Formula B)
Single Axle load = 20,000 pounds
Maximum Tandem axle = 34,000 pounds

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The legislation referred to as the Surface Transportation Assistance Act of 1982 unified Interstate travel and eliminated lower minimums for some States.

VEHICLE WEIGHT, LENGTH, AND WIDTH LIMITATIONS

Sec, 133. (a) Section 127 of title 23 of the United States Code is amended to read:

[Section] 172. Vehicle weight limitations-- Interstate System

...However, the maximum gross weight to be allowed by any State for vehicles using the National System of Interstate and Defense Highways shall be twenty thousand pounds carried on one axle, including enforcement tolerances, and a tandem axle weight of thirty-four thousand pounds, on a group of two or more consecutive axles produced by application of the following formula:

$$W = 500 \left(\frac{LN}{N-1} + 12N + 36 \right) \quad \textit{(Federal Formula B)}$$

where W equals overall gross weight on any group of two or more consecutive axles to the nearest five hundred pounds, L equals distance in feet between the extreme of any group of two or more consecutive axles, and N equals number of axles in group under consideration,

Single Axle load = 20,000 pounds

Maximum Tandem axle = 34,000 pounds

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- **Operationally in Idaho, the Idaho Legislature in 1972** still limited vehicles to the 1955 Idaho Statutes, but enacted provisions for Federal Formula B loads on the Interstate Highways. Allowing 105,500 lbs. vehicles with 9 axles up to 60' between the extremes of the 1st and last axle.

- **In 1974 the Idaho Legislature clarified the tabular form of Federal Formula B** allowing a variety of axle spacing and distances between extreme axles to operate at 105,500 lbs.

- **In 1986 the Idaho Legislature** enacted legislation that provided the maximum single axle gross weight shall be 20,000 lbs. and that the maximum gross vehicle weight shall by 105,500 lbs. on all State Highways except that travel on the Interstate Highways would require an excess weight fee and permit above 80,000 lbs.

- **In 1993 the Idaho Legislature introduced definitions and limitations for "Variable Load Suspension Axles"** otherwise known as (lift axles, drop axles, tag axles to name a few), "Variable load suspension axle" means an axle or axles designed to support a part of the vehicle and load and which can be regulated to vary the amount of load supported by such an axle or axles and which can be deployed or lifted by the operator of the vehicle."

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- **In 1993 the Idaho Legislature introduced definitions and limitations for "Variable Load Suspension Axles"** otherwise known as (lift axles, drop axles, tag axles to name a few), "Variable load suspension axle" means an axle or axles designed to support a part of the vehicle and load and which can be regulated to vary the amount of load supported by such an axle or axles and which can be deployed or lifted by the operator of the vehicle."

- (10) Variable load suspension axles shall meet the following criteria in order to be included in the computation of gross vehicle or axle weight limits for vehicles under the provisions of this section:

   (a) The deployment control switch for such axles may be located inside of the driver's compartment but the pressure regulator valve for the operation of pressure on the pavement shall be located outside of and inaccessible to the driver's compartment.

   (e) Variable load suspension axles must be fully deployed or fully raised. For applicable definitions, see sections 49-117 and 49-123, Idaho Code.

- (11) Any person who operates motor vehicle with a variable load suspension axle in violation of the provisions of this section shall be subject to the penalties provided in section 49-1013, Idaho Code.

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- **In the 2010 Edition of the AASHTO MBE, Specialized Hauling Vehicles (SHV) were introduced for load rating purposes. These vehicles are considered legal loads as they meet the requirements of Federal Formula B.**
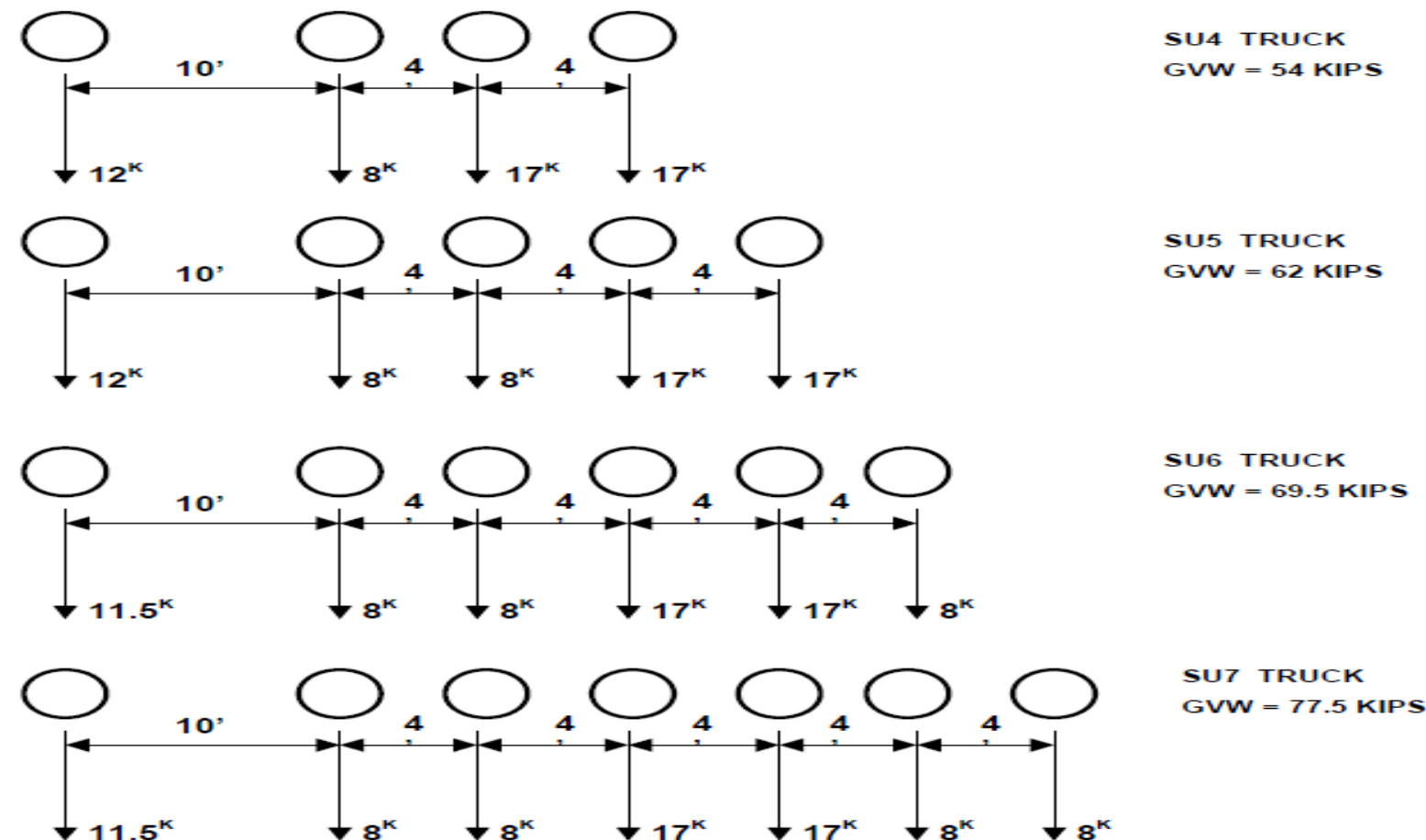

Figure D6A-7—Bridge Posting Loads for Single-Unit SHVs that Meet Federal Bridge Formula B

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- **As noted in AASHTO MBE C6A.4.4.2.1b –**

- The vehicles referred to as specialized hauling vehicles (SHV) are legal single-unit, short-wheelbase, multiple-axle trucks commonly used in the construction, waste management, bulk cargo, and commodities hauling industries.

- Since the adoption of the AASHTO family of three legal loads, the trucking industry has introduced specialized single-unit trucks with closely spaced multiple axles that make it possible for these short-wheelbase trucks to carry the maximum load of up to 80,000 lb and still meet Formula B.

- Variable load suspension axles have been around in the trucking industry since the late 1940's and early 1950's. Initially they used mechanical means to lift or drop the axle. Now a days all variable load suspension axles deploy by compressed air or hydraulics.

- In essence, in the last 30 to 40 years the trucking industry capitalized on the use of variable load suspension axles to maximize the allowable gross weight or vehicles to conform to Federal Formula B.

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FHWA and TTI sponsored research done in about 1986 called "Bridge Formula Development" proposed a new bridge formula a more rational formula independent of the number of axles. Single a tandem axles were unchanged from Federal Formula B. The proposed formula assures that HS 20 bridges will be not be loaded to more than 1.05 times design stresses, and H15 bridges will not be loaded to 1.30 times design stresses.

The formula reduces the maximum weight allowed on four or more closely paced axles. However, for most practical lengths, the formula is less restrictive than Federal Formula B.

Transportation Research Record 1072

Bridge Formula Development

JAMES S. NOEL, RAY W. JAMES, HOWARD L. FURR, FRANCISCO E. BONILLA, and LLOYD R. CAYES

$$W = (34 + L)\ 1{,}000\ \text{lb} \qquad 8\ \text{ft} \le L \le 56\ \text{ft}$$
$$W = (62 + L/2)\ 1{,}000\ \text{lb} \qquad 56\ \text{ft} \le L$$

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

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- Conclusion –

- "Bridge Formula's" are an effective way for the State Legislatures to establish legal loads that strive to not produce stresses greater than design stresses.

- Federal Formula B was and is an effective way for FHWA to establish uniformity of legal loads amongst the States.

- What's Next? – Truck Platooning Issues and

  uniformity between States.

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