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Project Summary Report 1713-S2
Project 0-1713: Evaluation of the AASHTO 18-Kip Load Equivalency Concept
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PROJECT SUMMARY REPORT

SUMMARY OF FINDINGS ON THE RELATIVE IMPACT OF TRIDEM AND TRUNNION AXLES ON PAVEMENTS AND BRIDGES

What We Did ...

The trunnion axle configuration has gained favor with many carriers of oversized and overweight loads. As a result, the frequency of interstate hauling of these specialized loads is increasing. Compared with conventional axle configurations, the trunnion axle configuration allows for placement of more wheels in the transverse direction, an arrangement that may be more or less favorable to preventing premature load-induced damage on highway pavements and structures. Currently, the load allowances on multiple axle groups are non-uniform, which makes them disruptive to interstate commerce. In particular, load allowances for permitting overweight vehicles with triple axle (tridem) groups and trunnion axle groups differ considerably between California and Texas. For example, while California provides routine overload permits to vehicles with trunnion axle groups but not to vehicles with tridem axles, Texas is issuing routine overload permits to vehicles with tridem axles but not to those with trunnion axles. Differences in state permitting policy can cause delays in obtaining specialized long-haul permits – delays that result in added expense in administrative

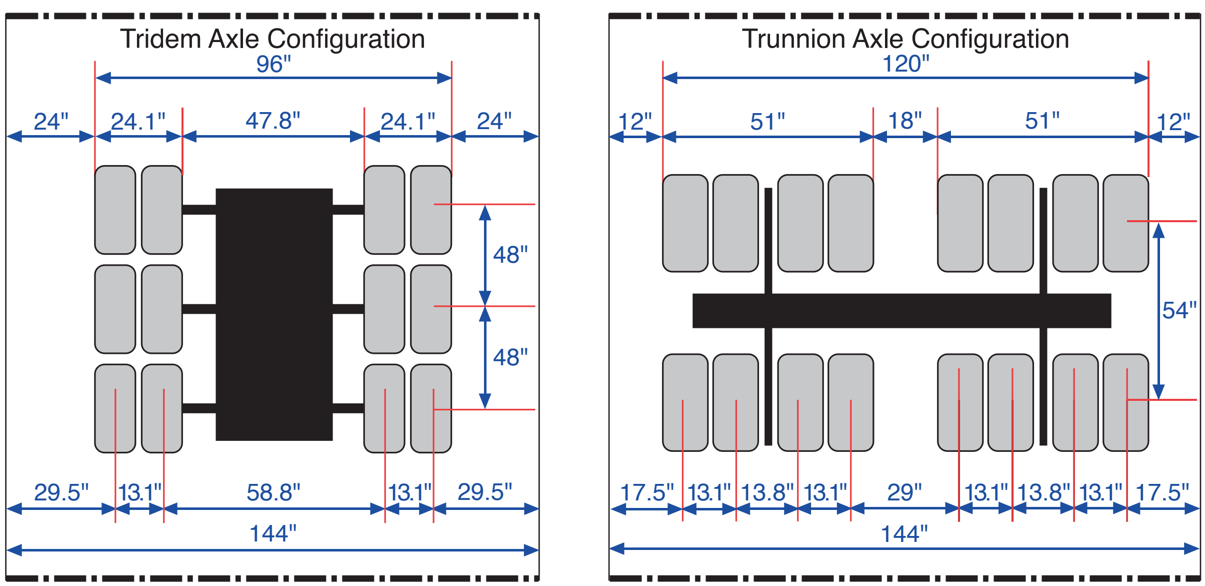

Figure 1: Illustration of Tridem and Trunnion Axle Configurations

time lost and the possibility of trans-loading en route.

In order to determine whether comparable overload limits can be endorsed for routine permitting of these two axle configurations in Texas, and to work toward uniformity of permitting practices in neighboring states, it is essential that one understand the relationship between the impact of trunnion axle loading and the consequent premature pavement damage. A project sponsored by the Texas Department of Transportation (TxDOT) was therefore carried out at The University of Texas at Austin to determine the impact of trunnion axle loadings on the premature damage of both flexible and rigid pavements, relative to a standard tridem axle configuration.

Configuration of Tridem and Trunnion Axles

The illustrations in Figure 1 show the typical configuration of tridem and trunnion axles (dimensions are labeled in inches). The major differences between tridem and trunnion axles that indicate potential impact on the damage to pavements include:

- The trunnion configuration has two axles, while a tridem configuration has three axles.
- There are a total of sixteen tires in a trunnion configuration, while there are twelve tires in a tridem configuration.
- The trunnion axle configuration allows for placement of more wheels in the transverse direction than does the tridem axle configuration.
- The trunnion axle is generally 10 feet in width, while a tridem axle's typical width is 8 feet.

The loading characteristics of trunnion and tridem axles used for the analysis are summarized in Table 1. When both these configurations have the same magnitude of axle load, the load per tire for a trunnion axle is less than that for a tridem axle. For example, if the axle load is 60 kips, the load per tire for a trunnion axle would be 3.75 kips, compared to 5 kips for a tridem axle.

What We Found ...

The relative impact of tridem and trunnion axles on highway pavements and bridges is summarized in Tables 2 and 3, respectively. While the impact for pavements is expressed as the 18-kip load equivalency factors (LEFs), the impact for bridges is measured in terms of the change of maximum moments in the bridges.

Based on the research findings, the following conclusions can be drawn:

1. For flexible pavements, tridem axles are more damaging than trunnion axles. For a typical flexible pavement with a 3-inch AC surface, tridem axles are about 3.4 times more damaging than trunnion axles; for a typical flexible pavement with a 6-inch AC surface, tridem axles are about 3.1 times more damaging than trunnion axles.
2. For rigid pavements, trunnion axles are more damaging than tridem axles. For a typical rigid pavement with an 8-inch PCC surface, trunnion axles are 1.27 times more damaging than tridem axles; for a typical rigid pavement with a 12-inch PCC surface, trunnion axles are about 1.29 times more

Table 1: Loading Characteristics

	Tridem Axle	Trunnion Axle
Axle load	60 kips	60 kips
Number of tires	12	16
Load per tire	5 kips	3.75 kips
Tire pressure	115 psi	115 psi

Table 2: Relative Impact of Tridem and Trunnion Axles on Pavements

Pavement Type	Pavement Thickness	Load Equivalency Factors (LEFs)		
		18-kip Axle	Trunnion Axle	Tridem Axle
Flexible	3 inch	1	1.84	6.25
	6 inch	1	1.55	4.85
Rigid	6 inch	1	3.78	2.97
	8 inch	1	5.87	4.56

damaging than tridem axles.

3. Clearly, the thickness of either the AC layer for flexible pavements or the PCC slab for rigid pavements does not play a significant role in the relative damage of tridem and trunnion axles on pavements.
4. The relatively higher damaging impact of trunnion axles compared to tridem axles on rigid pavements is partially due to the fact that trunnion axles are wider than tridem axles; consequently, there is a higher probability that the outermost tires of a trunnion vehicle will be closer to the edge of the slab.
5. The potential of a trunnion truck to damage highway bridges does not significantly differ from that of a tridem truck.

The Researchers Recommend ...

The results of the analyses clearly indicate that trunnion axles are generally not as damaging as tridem axles. It is recommended that TxDOT's Motor Carrier Division and the Pavements Section of the Construction Division take this finding into consideration in formulating a modified permitting policy for heavy vehicles having trunnion or tridem axles.

Table 3: Relative Impact of Tridem and Trunnion Axles on Bridges

	55-ft bridge with diaphragms		55-ft bridge without diaphragms		25-ft bridge without diaphragms	
Tridem Axle	372.79	1.38%	451.13	-1.21%	162.43	0.99%
Trunnion Axle	377.93		492.40		164.04	
Tridem and Tandem Axle	401.08	1.28%	492.40	-1.14%	212.75	0.76%
Trunnion and Tandem Axle	406.21		486.78		214.36	
Tridem Axle (plus dead load of bridge)	600.11	0.85%	556.45	1.87%		
Trunnion Axle (plus dead load of bridge)	605.24		566.85		N/A	
Tridem + Tandem Axles (+ dead load of bridge)	628.39	0.82%	590.86	1.87%	N/A	

For More Details...

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The research is documented in the following reports:

1713-1 *Evaluation of the AASHTO 18-kip Load Equivalency Concept* Draft, April 1999

1713-2 *Impact of Changing Traffic Characteristics and Environmental Conditions on Performance of Pavements* Draft, August 2003

1713-3 *Impact of Trunnion Axle Groups on the Performance of Highway Infrastructure* March 2001

To obtain copies of a report: CTR Library, Center for Transportation Research, (512) 232-3138, email: ctrlib@uts.cc.utexas.edu

TxDOT Implementation Status July 2003

The primary application of the new Load Equivalence Factors (LEFs), developed in this study, is in the calculation of 18-kip equivalent single axle load data used in the structural design of pavements. TxDOT is in the process of implementing the use of total axle load spectra for structural pavement design along the lines of the new AASHTO 2002 Pavement Design Guide. Therefore, TxDOT will not implement the finding of this project for structural pavement design. However the LEFs developed here could be used in the research field to compare with designs made using the total axle load spectra.

Contact Dr. German Claros, P.E., Research and Technology Implementation office, (512) 467-3881, gclaros@dot.state.tx.us, for further information.

Your Involvement Is Welcome!

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