

September 26, 2007
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TRUCKS AND THEIR IMPACT ON BRIDGES

BRIDGES and BRIDGE Ratings

There are 598,842 bridges in the United States. Of these, 373,982 are over 30 years old (62.4%); 73,764 are structurally deficient (12.3%); and 80,226 are functionally obsolete (13.4%)¹.

Functionally Obsolete Bridges

A functionally obsolete bridge has older design features and, while it is not unsafe for all vehicles, it cannot safely accommodate current traffic volumes, and vehicle sizes and weights. Functional obsolescence results from changing traffic demands on the structure. Facilities, including bridges, are designed to conform to the design standards in place at the time they are designed. Over time, improvements are made to the design requirements. As an example, a bridge designed in the 1930s would have shoulder widths in conformance with the design standards of the 1930s. However, the design standards have changed since the 1930s. Therefore, current design standards are based on different criteria and require wider bridge shoulders to meet current safety standards. The difference between the required, current-day shoulder width and the 1930s designed shoulder width represents a deficiency. The magnitude of these types of deficiencies determines whether the existing conditions cause the bridge to be classified as functionally obsolete.²

Structurally Deficient Bridges

Bridges are considered structurally deficient if significant load carrying elements are found to be in poor or worse condition due to deterioration and/or damage, or the adequacy of the waterway opening provided by the bridge is determined to be extremely insufficient to the point of causing intolerable traffic interruptions. The fact that a bridge is "deficient" does not immediately imply that it is likely to collapse or that it is unsafe³.

A structurally deficient bridge is one that has major deterioration, cracks, or other flaws that reduce its ability to support vehicles. Proper and regularly scheduled reviews of the calculations of all bridges' maximum safe load ratings are important because as a bridge

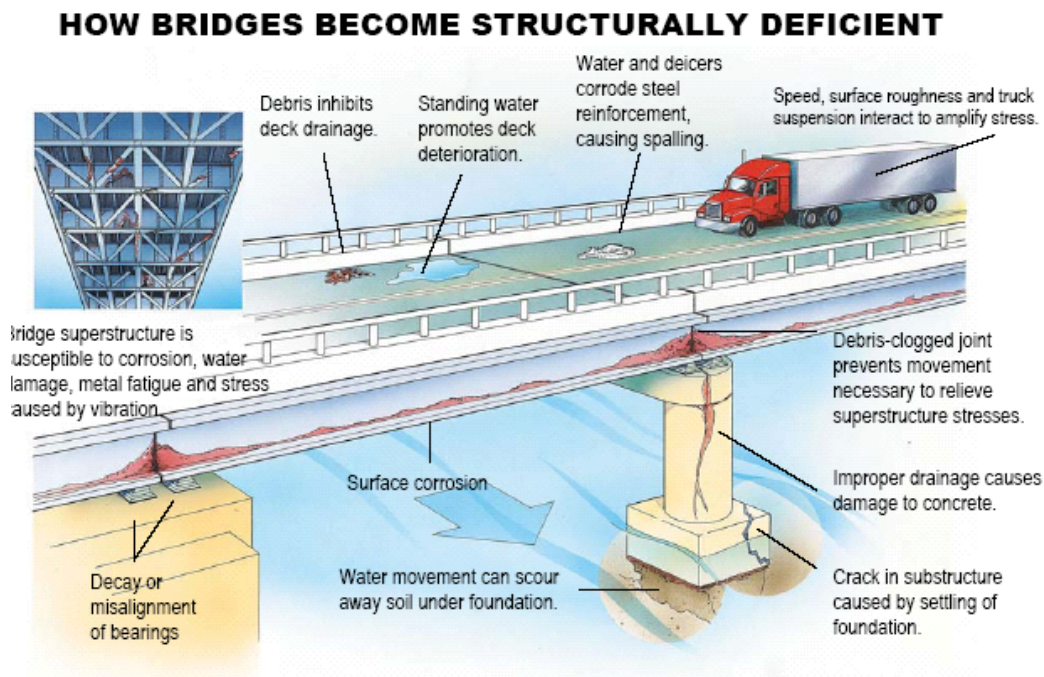
¹ U.S. DOT, FHWA, Tables "Structure Type by Year Built (<http://www.fhwa.dot.gov/bridge/structyr.htm>): Deficient Bridges by State and Highway System, (<http://www.fhwa.dot.gov/bridge/deficient.htm>)

² U.S. Department of Transportation, Federal Highway Administration and Federal Transit Administration, *2006 Status of the Nation's Highways, Bridges, and Transit: Conditions and Performance* (Washington, DC, 2007), chapter 3, at [<http://www.fhwa.dot.gov/policy/2006cpr/index.htm>]

³ U.S. Department of Transportation, Federal Highway Administration and Federal Transit Administration, *2006 Status of the Nation's Highways, Bridges, and Transit: Conditions and Performance* (Washington, DC, 2007), chapter 2, at [<http://www.fhwa.dot.gov/policy/2006cpr/index.htm>]

ages, corrosion and decay can decrease its capacity to support vehicles. Some bridges are weakened to the point that signs must be posted to bar vehicles heavier than the calculated maximum load. A structurally deficient bridge can suffer partial failures that further decrease its capacity and can pose a risk to public safety. In the worst-case scenario, corrosion and decay of bridge structures can weaken a bridge to the point of collapse⁴.

Most Federal bridge safety standards were created in 1968 in response to just such a catastrophe—an Ohio River bridge collapse, caused by corrosion, that killed 46 people in 1967. Despite the creation of new standards, four more major bridge failures in Connecticut, New York, Tennessee, and California from 1983 to 1995 killed a total of 28 people. All five of these major bridge failures were caused at least in part by structural deficiencies (*see Figure 1*). These failures have made it clear that regular inspections that check for corrosion, decay, and a reduction in weight capacity are important tools for ensuring that bridges are safe⁵.



Source: Illustration by Jana Brenning. Copyright Jana Brenning. Reprinted with permission. Illustration first appeared in *Scientific American*, March 1993.

Figure 1. Water, salt, stress, and corrosion can make a bridge structurally deficient, decrease its load rating, and create the need for a weight limit.

6

Heavy Vehicles Affect Bridges

⁴ U.S. Department of Transportation, Office of the Secretary of Transportation, Office of Inspector General “Audit of Oversight of Load Ratings and Postings on Structurally Deficient Bridges on the National Highway System,” Report No. MH-2006-043, March 21, 2006

⁵ *Ibid.*

⁶ *Ibid.*

Over half the bridges in the national inventory are over 30 years old⁷, which explains why so many are deficient. While truck weights have increased over the decades, funds for bridge inspection, maintenance, repair, and rehabilitation have not kept pace. Despite inadequate funding levels, bridges have maintained high safety levels with very few collapses. This safety record has been achieved because bridge engineers traditionally use very conservative methods of proportioning the sizes of bridge components, and there is often a high strength reserve. According the Transportation Research Board, increased truck weight and significant increases in truck traffic are eroding this reserve⁸.

There are two bridge responses that must be considered in evaluating the effect of heavy vehicles: overstress and fatigue. Overstress concerns the possibility of severe damage and possible collapse caused by a single extreme loading event. Fatigue concerns the cumulative damage caused by millions of truckload passages, which can cause cracks or rupture of key elements of the bridge.⁹

Overstress

In overstress, the loading of the bridge that governs bridge capacity in most instances is two or more heavy trucks on the bridge at the same time. The probability of occurrence of a multiple-presence event can be evaluated by simulation and depends on the frequency of occurrence of heavy vehicles. As the number of heavy trucks increase (due to permits, new legal configurations, volume, and illegal overloads), there is a higher likelihood of a critical load event in which several heavy vehicles are on the bridge simultaneously. Additionally, dynamic impacts, which vary with the speed, roadway roughness, vehicle suspension system, and truck position, affect bridge response. Typically, bridge engineers plan for the rare loading event and design the bridge accordingly with considerable safety factors.¹⁰

Fatigue

Bridge engineers are also concerned with fatigue life considerations caused by repetitive loading. Each truck crossing produces one or more stress cycles, which use up a portion of the bridge's total fatigue life. The occurrence of a fatigue failure is identified by cracks developing at points of high stress. The magnitude of stress depends on the vehicle weight and the size of the bridge section.

The Federal Bridge Formula

The federal bridge formula was derived to limit stresses on bridges caused by trucks. The formula provides a standard to control the spacing of truck axles on vehicles that use highway bridges. The current federal bridge formula was derived from assumptions about the extent to which legal vehicles should be allowed to exceed the stresses assumed

⁷ U.S. DOT, FHWA, Tables "Structure Type by Year Built (<http://www.fhwa.dot.gov/bridge/structyr.htm>)

⁸ TRB Special Report 225, "Truck Weight Limits, Issues and Options, dated 1990, Chapter 5 Bridges, page 91.

⁹ Ibid.

¹⁰ TRB Special Report 225, "Truck Weight Limits, Issues and Options, dated 1990, Chapter 5 Bridges, page 92.

in bridge design. Specifically, the formula was designed to avoid overstressing HS-20 bridges by more than 5 percent and H-15 bridges by more than 30 percent. HS-20 is the minimum design load recommended by AASHTO for an Interstate highway, and H-15 is a much lighter design load that has been used for many bridges on non-Interstate highways¹¹. The current federal bridge formula is an overly cautious limit on weights for shorter trucks when applied strictly to the Interstate system because fewer than 1,000 of the 50,000 bridges on the Interstate have a design load of H-15 or less.¹²

ANSWERS TO SOME ANTICIPATED QUESTIONS

Do trucks cause bridges to collapse? No. Trucks do contribute to bridge deterioration and the eventually need for replacement. However, to date, a truck has never been shown to be the primary cause of a bridge collapse.

Has truck weight increased since the Interstate bridges were built? Yes. In 1956 federal law set the maximum truck weight at 73,280 pounds for trucks operating on the Interstate Highway System, and also provided “grandfather rights” for states allowing higher truck weight before July 1, 1956. In 1974, federal law was changed so that states could allow trucks operating on the Interstate System to have a maximum weight of 80,000 pounds.

Do trucks pay their fair share? Yes, trucks constitute 13 percent of the vehicle-miles-traveled, 11 percent of all registered vehicles and pay 34.4 percent of the highway users’ fee revenue. Since the vast majority of vehicles on the road during peak periods are passenger vehicles, trucks’ responsibility for these costs is very low in comparison.

Aren't there a lot of overweight trucks that damage bridges? Less than 10 percent of truck miles are at weights above the federal legal Interstate weight limit of 80,000 pounds.¹³ While heavier trucks have a disproportionately greater impact on bridges, their overall contribution to bridge damage is relatively small.

Should we reduce the weight of trucks so they don’t damage bridges? The negative impacts of lowering truck weight should also be considered before deciding the answer to this question. Reducing the weight of trucks means that more trucks will be needed to haul freight. This means more crashes, more air and noise pollution, more traffic congestion and higher freight transportation costs, which increases costs to consumers and makes American businesses less competitive in global markets. The savings generated by less bridge wear are likely to pale in comparison with the added costs.

Have states been lax in weight enforcement? No. Last year state enforcement personnel stopped and weighed over 179 million trucks. They issued 507,146 citations to

¹¹ Ibid.

¹² Ibid.

¹³ Federal Highway Administration, “Federal Highway Cost Allocation Study,” August 1997.

overweight trucks.¹⁴ Trucks were in compliance with federal and state weight laws 99.97%. That is an outstanding record.

Hasn't there been an increase in the number of over-weight trucks operating on these bridges? In fact, the number of overweight vehicles has decreased, at least by the number of weight citations issues. In 2000, 653,720 overweight citations were issued nationally, again a compliance rate of 99.7%. In 2003 there were 515,587 overweight citations.¹⁵

¹⁴ FHWA, http://ops.fhwa.dot.gov/freight/sw/violation_report.htm

¹⁵ Ibid.