Washington State Department of Transportation

Legal Load Limits, Overweight Loads and Pavements and Bridges

June 2006

Washington State follows federal law by placing weight limits on trucks in order to protect pavements and bridges from damage and excessive wear and tear. The Washington State Department of Transportation (WSDOT) often receives requests to increase truck (or axle) weight limits, or to implement programs that would collect additional fees for compensation of overweight loads. There are several reasons for these requests. Hauling larger loads with fewer trucks can help some industries reduce transportation costs and increase efficiency. Competition and changing market conditions continue to put pressure on freight-dependent industries to lower costs and increase service quality. Transportation costs and flexibility for load size can have a significant effect on economic sustainability, particularly for heavy/bulk commodities and highly priced sensitive goods, such as agriculture, lumber/timber, construction, etc.

It's important to us and to the economic vitality of the state that we maintain an efficient freight transportation system and support freight-dependent industries. WSDOT's mission is to keep people and business moving by operating and improving the state's transportation systems vital to taxpayers and communities. To do this, we must manage the resources entrusted to us for the highest possible return of value and to protect the citizens' investment in Washington's transportation infrastructure. It is vital that WSDOT, decision makers and the public understand the trade-offs between economic benefit and increased infrastructure costs that occur when considering increasing load limits.

Photo: I 90

"On major roads, damage caused by overweight trucks – or by more legally loaded trucks than the road was designed for – can take years to show up..."

"Pounding the Pavement"
By Pat Stith, Staff Writer
The News & Observer / newsobserver.com
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What are weight limits and how are they established?

Load limits restrict how much weight can be carried on an axle, a single tire or pair of tires, and on the vehicle or vehicle combination in total. Concerns over the impacts of tire load and gross vehicle weight on a fragile infrastructure were first addressed in the 1913 and 1915 Legislative sessions, respectively. Tire loads began at 400 pounds per inch width of tire and a gross vehicle weight limit was established at 24,000 pounds. In almost every subsequent legislative session, through 1975, load limits have been refined to address changes in infrastructure design and observed effects of vehicle loads.

In 1975, federal laws were implemented to provide protection to the highway infrastructure and uniformity among the states for interstate use. The Washington State Legislature adopted the federal weight limits for all state highways.

Why are weight limits placed on axles and tires?

Tire and axle limits are imposed for a number of reasons; foremost, is to ensure that loads carried by trucks are transported safely. Having defined load limits allows engineers to design pavements that will hold up under anticipated truck traffic with minimal maintenance required for fixing cracks, ruts, and potholes. Load limits are also necessary for protecting bridges from structural weakening or fatigue, preventing unsafe conditions and early replacement of bridge structures. Current information shows that even slight changes in load limits have major impacts on pavement and bridge performance. Both the axle and tire load affect pavements and bridges.

Total axle loads affect large areas of a pavement or a bridge, while tire loads affect smaller, more localized areas. Narrow width tires concentrate the vehicle's weight on a small area, while wider width tires distribute the weight over a larger area and cause less stress on a single spot. As the total load carried by an axle increases, so does the total load on the pavement or bridge. An axle carrying 20,000 pounds puts the same total weight on a bridge or a pavement whether 6-inch wide or 12-inch wide tires are used. The total load may cause damage or failure, even if the local point stresses under the tires are not large.

Photo: SR 153

What are the current tire and axle load limits?

Loads are typically defined according to the type of axle as well as the number of tires per axle. Legal load limits for the various axle configurations in Washington State are shown in Figure 1 and Table 1.

Figure 1. Tire-axle combinations

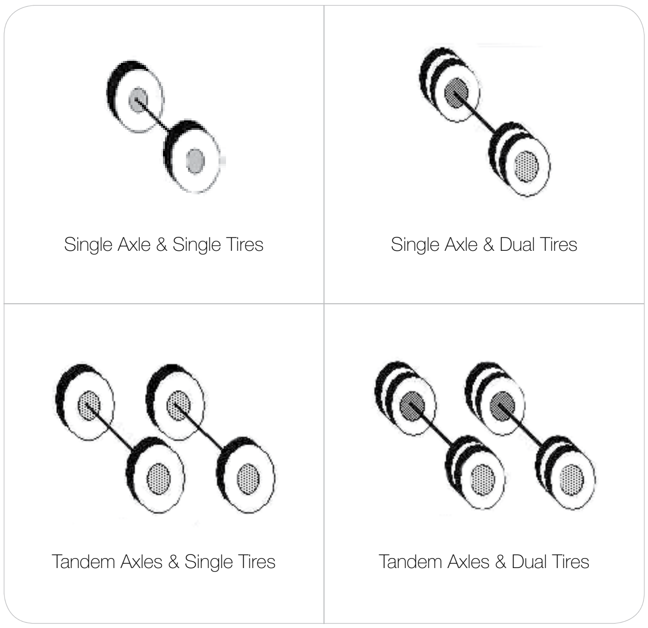

Table 1. Current Washington State tire and axle load limits

Tire / Axle	Limit
Tire Load	600 lb/inch of tire width
Single Axle	20,000 lbs
Single Axle with two tires (carrying more than 10,000 lbs)	500 lb/inch of tire width
Tandem Axle	34,000 lbs
Gross Vehicle Weight	105,500 lbs

Most of the current state highway system, and all new state highways, are designed using these load limits. Some of the older highways were not built to current design standards and require work to upgrade to today's standards. As designed, these highways can withstand current legal loads without damaging the pavement structure.

Maintenance varies by pavement type:

- The surface of asphalt pavements wears out and needs to be replaced on a regular cycle, about every 15 years, but the pavement below the worn surface remains. Replacing just the surface is much less expensive than replacing the full depth of the pavement structure.
- Concrete pavements are designed to handle the weight of legal loads and last for up to 50 years. These pavements need to be "ground" smooth about every 25 years to remove wear caused by studded tires. This is much less expensive than replacing cracked and broken concrete.

Washington State has an inventory of 2,975 bridges that have a length of 20 feet or more:

- 16 percent are designed for trucks (H10, H15, H20) weighing 20 tons (40,000 lbs) or less.
- 6 percent are designed for trucks (HS15) weighing 27 tons (54,000 lbs).
- 70 percent are designed for trucks (HS20) weighing 36 tons (72,000 lbs).
- 8 percent are designed for trucks (HS25 or HL93) weighing more than 36 tons (72,000 lbs).

Note: The American Association of State and Highway Transportation Officials (AASHTO) designates standard truck loadings for designing highway structures. Type "H" is for Highway Truck, "HS" for Highway semi-trailer and "HL" for Highway Lane loading.

What happens to pavements exposed to loads they were not designed to handle?

Repeated overweight loads, or an increased number of legal loads, damage asphalt pavements by overstressing the pavement structure, causing cracking and eventually potholes. Concrete pavements also break and crack under repeated overweight loads, or an increased number of legal loads, making them rough and decreasing the life of the pavement.

The relationship between axle weight and pavement damage is not linear, but exponential. For example, a single axle loaded to 40,000 lbs (twice the legal load) causes 16 times more damage than a single axle legally loaded to 20,000 lbs.

Many highway pavements around the state do not have sufficient thickness to carry heavy loads and without load restrictions would suffer pavement failures, as shown in Figure 2 and Figure 3. Unlike bridges, a single overloaded truck rarely causes a spectacular pavement failure. Many repetitions of trucks beyond the current legal load limit, or above the original estimated number of trucks, must occur before you see damage in the form of extensive pavement cracking or potholes. Unfortunately, by the time this damage is visible the pavement structure may have been damaged to the point where it must be replaced – which is an expensive and time consuming process.

Figure 2. Cracking due to Heavy Loads (SR-532 near I-5)

Figure 3. Rutting due to Heavy Loads (I-90, Spokane, Weigh Scale)

What are the choices and related costs for pavements?

For asphalt pavements, which constitute the majority of roadways in Washington State, WSDOT calculates that the increased pavement depth needed to handle larger truckloads are as shown in Figure 4 (dual single axle) and Figure 5 (dual tandem axle).

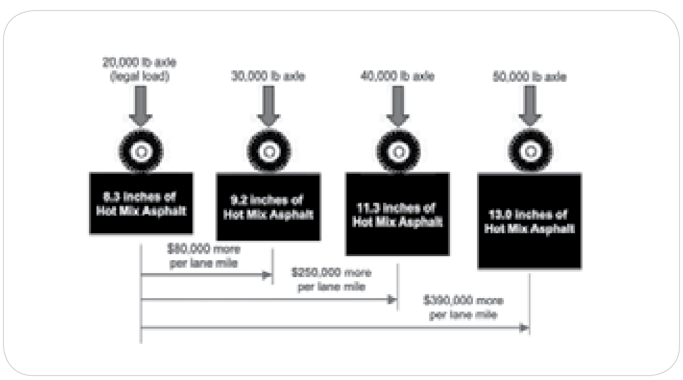

Figure 4. Impact of Single Dual Axle Load Increase on Pavement Thickness

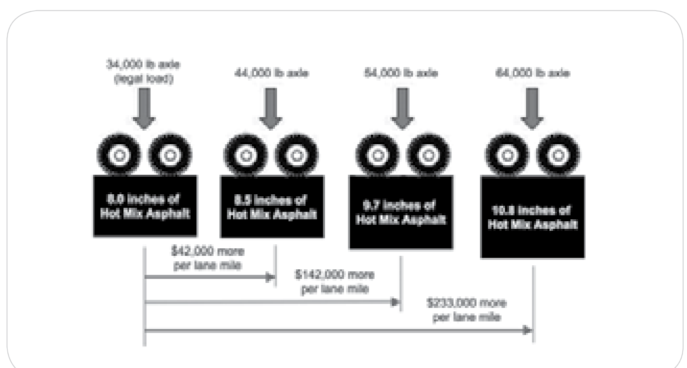

Figure 5. Impact of Tandem Dual Axle Load Increase on Pavement Thickness

If legal load limits are increased, there are two basic choices for preserving current pavement infrastructure:

- Spend more money to handle the increased load by increasing the pavement thickness of existing roadways and changing designs for new pavement, or
- Spend more money repairing the damage caused by the increased loads.

Increasing the axle load on a dual single tire axle by 10,000 pounds would result in an immediate need of $900 million to ensure additional pavement damage does not occur. Under the same scenario, an increase of 10,000 pounds on the dual tandem axle would require just under $500 million. There would also be associated societal costs and inconveniences due to the closure of highways for repairs or upgrades.

What happens to bridges exposed to loads that they were not designed to handle?

Concrete and structural steel bridges exposed to overweight loads, or increased legal load limits, most often suffer from fatigue. Fatigue results from repetitive stress, much like bending a paper clip back and forth repeatedly, eventually the metal fatigues and breaks. Structural steel fatigue cracks continue until the carrying capacity of the affected structure is reduced to the point that it will no longer support a load. In steel reinforced concrete bridges, fatigue cracks the concrete and allows water or other contaminants to affect the steel reinforcing bars. The bars corrode and cause expansion, which breaks off the concrete cover and creates more exposure for corrosion. This process continues until the carrying capacity is reduced to the point that the bridge can no longer support a load. The heavier and more frequent the loads, the faster these fatigue cracks will grow in size and length.

Bridges consist of several different structural elements, combining together to form the complete bridge. Loads greater than the current legal loads affect these structural elements in different ways. Bridge decks must transfer the wheel load to the main support beams, which in turn transfer the load to the foundation supports. Each of these elements can experience fatigue and fatigue damage from larger than legal loads (Figures 6, 7 and 8).

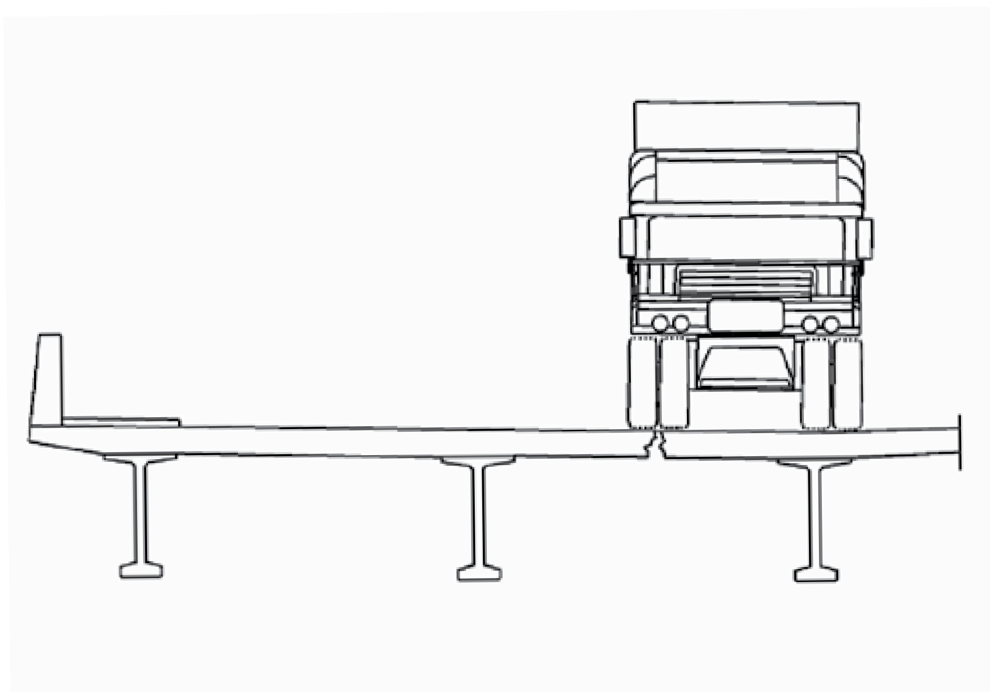

Figure 6. Concrete Roadway Deck Section and Fatigue Location

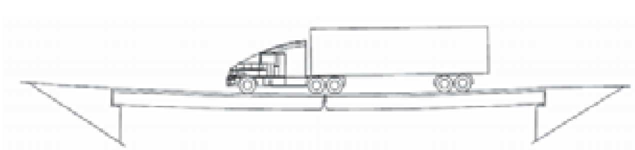

Figure 7. Beam "Bending" Failure

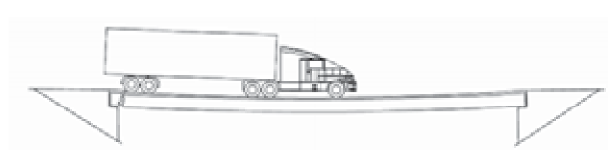

Figure 8. Beam Shear Failure

Allowable load limits have increased over the years and bridges designed for lighter loads have not been strengthened. Partly because of repeated heavy loads, many bridges are showing signs of structural distress. Signs of distress include fatigue cracking of structural steel (Figure 9) and corrosion of the reinforcing steel in concrete members (Figure 10). This can lead to bridge closure or collapse (Figures 11 and Figure 12).

Figure 9. Fatigue Crack in Structural Steel Beam
(I-5, Nisqually River Bridge)

Figure 10. Corroding Reinforcing Steel Bars in Concrete Beam
(SR-2, Ebey Island Viaduct)

What are the choices and related costs for bridges?

To maintain safe bridges for everyone, WSDOT engineers need to reduce allowable loads as bridges suffer from fatigue damage. A bridge with fatigue damage may first be "load restricted", making it illegal for any overloaded truck to use the bridge. As the fatigue damage progresses, the bridge's capacity to carry heavy loads decreases and the bridge is "load posted". This restricts the allowable weight of trucks below typical legal weight limits. The final step for a seriously fatigued bridge is total closure.

Since bridges have a limited load capacity, increasing the maximum allowable load would accelerate the need for load restrictions on affected bridges as they become fatigued. These bridges could also need to be entirely closed, decreasing mobility of people and business. Alternatively, the bridges would need to be strengthened to accommodate heavier loads or replaced before the expected life of the structure; both would require significant costs dependent on the affected structure.

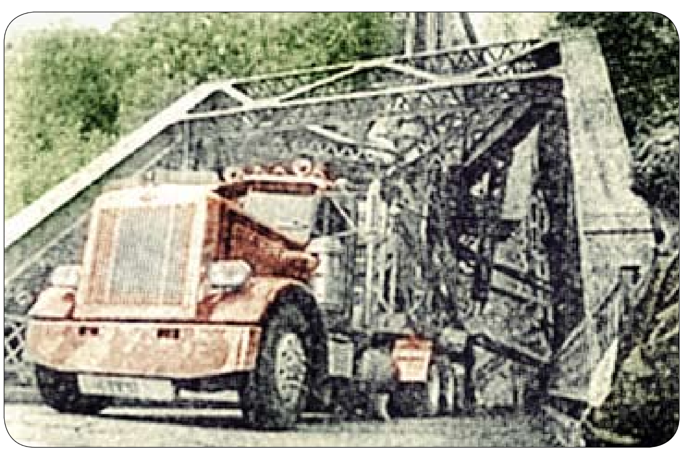

Figure 11. Bridge Failure due to Truck Loading
(old SR-106, Skokomish River, circa 1984)

Figure 12. Bridge Failure due to Truck Loading
(old SR-106, Skokomish River, circa 1984)

For more information contact: This briefing paper provides a brief overview of weight restrictions in Washington State and the associated costs of increasing load limits. For more information, please contact:

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