EVALUATION OF PRESENT LEGISLATION AND REGULATIONS ON TIRE SIZES, CONFIGURATIONS AND LOAD LIMITS

EXECUTIVE SUMMARY

by

Jay Sharma
Joe P. Mahoney

Prepared by the University of Washington

for the Washington State Transportation Commission
Department of Transportation
and in cooperation with
U.S. Department of Transportation
Federal Highway Administration

WSDOT Contract Y-2292
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>LIST OF FIGURES</td>
<td>ii</td>
</tr>
<tr>
<td>LIST OF TABLES</td>
<td>ii</td>
</tr>
<tr>
<td>Introduction</td>
<td>1</td>
</tr>
<tr>
<td>Study Approach</td>
<td>3</td>
</tr>
<tr>
<td>Comparison of Tire Size Factor with Other States</td>
<td>5</td>
</tr>
<tr>
<td>Conclusions</td>
<td>7</td>
</tr>
<tr>
<td>Recommendations</td>
<td>7</td>
</tr>
<tr>
<td>APPENDIX A: Washington State Patrol Size, Weight and Load-Chapter 46.44</td>
<td>9</td>
</tr>
<tr>
<td>APPENDIX B: Originally Prepared by WSDOT Materials Lab</td>
<td>18</td>
</tr>
<tr>
<td>APPENDIX C: Examples of Overall and Internal Measurements to Determine Gross Weights</td>
<td>24</td>
</tr>
</tbody>
</table>
LIST OF FIGURES

FIGURE NO.  

1. Tire Axle Configuration of the Lime Rock Trucks  2  
2. Study Approach  4  
3. Comparison of the Regulation Requirement for  
   Maximum Tire Loads with the Dual and Single  
   Tire Relationships for Equivalent Fatigue Life.  
   Dual Tire Axle Load Equals 20,000 lb with  
   10 Inch Wide Tires  6  

LIST OF TABLES

TABLE NO.  

1. Comparison of Tire Width Regulations for  
   Various States  8
Introduction

In 1979 as a result of the bankruptcy of the Milwaukee Railroad, transportation of lime rock between a quarry near Kendall, Washington and a cement plant near Bellingham shifted to trucks. A major portion of this haul was made on State Route 542. The carrier (Lynden Transportation Co.) was permitted to increase the gross load from present legal load limit of 80,000 pounds to 105,500 pounds as per state permit regulations, Chapter 46.44 (Appendix A). The carrier is permitted to distribute 105,500 pounds over 8 axles or more as long as any single axle did not exceed 20,000 pounds and any tandem axle did not exceed 34,000 pounds and the maximum load on any tire did not exceed 550 pounds per inch width for tires less than 12 inches wide and 660 pounds per inch width for tires 12 inches wide or greater. The tire and axle configuration selected by the carrier is shown in Figure 1. The carrier elected to use tandem axles with single tires rather than single axles with dual tires because this permitted up to 21,680 pounds on four tires.

This loading was controlled by the 660 pounds per inch of tire. If the carrier had used single axles with dual tires, the maximum load on four tires would have been 20,000 pounds as controlled by the maximum single axle load regulation. Using dual wheel tandem axles would have reduced the payload that could be hauled by the weight of the 8 additional tires and wheels without providing any advantage to the carrier.

The trucks are making approximately 95 to 105 trips per day. The result of this hauling operation has been to increase the pavement and shoulder maintenance costs for this section of highway from an average of approximately $28,000 per year for the years 1977-1979 to approximately $51,000 per year for the years 1980 to 1981.

Based on the experience of SR 542, WSDOT wanted to know if this occurrence was the beginning of a statewide trend and if so how would the highways sustain the increased loads both from a structural and economic point of view. Hence, this study was initiated to look into several aspects of the present laws and regulations governing truck weights and present recommendations for changes, if any, to minimize damage without seriously affecting the local economy.

The principle regulation evaluated was the Revised Code of Washington (RCW) 46.44.042:

"Maximum gross weights - tire factor...it is unlawful to operate any vehicle upon the public highways with a gross weight, including load, upon any tire concentrated upon the surface of the highway in excess of 550 lbs per inch width of such tire, up to a
Figure 1. Tire Axle Configuration of the Lime Rock Trucks.
maximum width of 12 inches and for a tire having a width of 12 inches or more there shall be allowed a 20 percent tolerance above 550 lbs per inch width of such tire."

**Study Approach**

The majority of the pavements in the state can be divided into two categories:

1. Flexible pavement consisting of an asphalt concrete surface layer, gravel base layer and subgrade.

2. Rigid pavement consisting of a portland cement concrete layer, gravel base and subgrade.

As each type of pavement performs differently under the same truck loads and environmental influences, a separate analysis was conducted to study the load carrying capacity of each pavement type.

The study approach is outlined in Figure 2.

The material properties were chosen to represent varying soil types in different parts of the state, climatic changes and other pertinent factors such as a range of layer thicknesses of each type of pavement.

Truck loads were varied to include several axle-tire configurations that are presently being used on the highway network including those that are projected to be used by the American Trucking Industry. Some of the basic assumptions used in this analysis are:

1. That asphalt concrete pavement fails because of repeated applications of heavy truck loads and that the maximum horizontal tensile strain occurs at the bottom of the asphalt concrete layer, and this strain causes cracks to occur in that layer.

2. That asphalt concrete pavement develops ruts in the wheel paths because of repeated application of heavy truck loads and that the magnitude of rut depth is governed by the quality of subgrade soil and the quality of pavement layers above it.

3. That portland cement concrete pavement fails because of repeated application of heavy truck loads which cause pumping, cracking and eventual deterioration of pavement riding quality. Heavy truck loads in conjunction with varying temperature conditions cause tensile stresses at the bottom edge of the concrete slab to exceed the design strength of the concrete resulting in cracked slabs.

Also refer to Appendix B regarding explanation of magnitude of damage to highway pavements attributable to either truck loading
Portland Cement Concrete Pavements

Calculate maximum flexural stress in concrete slabs resulting from tire loads using a finite element analysis procedure.

Calculate warping stresses in concrete slabs as a result of temperature gradients.

Using fatigue analysis determine the load repetitions to failure for combined load and warping stress.

Develop a relationship between dual and single tires, based on the fatigue analysis.

Asphalt Concrete Pavements

Calculate the maximum horizontal strain at the bottom of the asphalt pavement layer using elastic layer theory.

Using fatigue analysis determine the load repetitions to failure.

Develop a relationship between dual and single tires, based on the fatigue analysis.

Compare With Current Regulations and Recommend Changes if Necessary

Figure 2. Study Approach
or environment, or a combination of these factors.

Using these failure criteria, comparisons were made between single axles with single tires (tire widths ranged from 10 inches to 18 inches) and conventional single axles with dual tires (tire widths of 10 inches each). For flexible pavement, three pavement sections were considered: 3, 6 and 9.5 inches of asphalt concrete. For rigid pavements, a 9 inch thick portland cement concrete pavement over a subgrade with a low to modest strength (k = 100 pci) was considered. The results of these comparisons are plotted in Figure 3.

This figure illustrates the relationship between loads on a single axle with single tires of different widths that will give the same life as a conventional dual tire, single axle weighing 20,000 pounds.

Example

Q. How does the present tire factor law affect the 3 inch asphalt concrete pavement?

A. From Figure 3, 11,500 pounds on a single axle with single tires 11 inches wide will give the same life for 3 inch asphalt concrete pavement as a conventional single axle weighing 20,000 pounds with dual tires 10 inches wide.

Based on the present law, a single axle with a 11 inch wide tire is allowed to carry up to 12,100 pounds (600 pounds more than allowable by the equivalent pavement life approach).

When using 12 inch tires, which is commonly used on milk trucks and other similar combination vehicles, the contractor can legally carry as much as 15,840 pounds on a single axle. This load is likely to cause more damage to pavements less than 9 inches thick, which happens to be the majority of the pavement mileage in this state.

For tires greater than 12 inches wide, the damage to the pavements by single tires far exceeds that done by the dual tires on a single axle.

Comparison of Tire Size Factor with Other States

It appears that 24 states use tire size factors to control loads and range from 450 to 800 pounds per inch width of tire.

Six states including Washington use 550 pounds per inch width or less, the rest allow greater tolerances.
Figure 3. Comparison of the Regulation Requirements for Maximum Tire Loads with the Dual and Single Tire Relationships for Equivalent Fatigue Life. Dual Tire Axle Load Equals 20,000 lb with 10 Inch Wide Tires.
Table 1 summarizes the tire size factors for various states.

Conclusions

1. The pavement section on SR 542 was substantially less than required for the truck traffic it was required to carry. Thus, it is doubtful if any axle configuration would have resulted in a reduction of the maintenance effort required on this section.

2. Lynden Transportation Co. legally arranged their tire and axle configuration as shown in Figure 1 to maximize their haul, but the configuration used was found to do the most pavement damage.

3. A truck survey was conducted to see if the use of single tires is an increasing trend. The survey showed that 9 percent of the trucks exceeded the legal load limit and about 6 percent used single tires on the rear axle and all violated RCW 46.44.042. There were several cases where on dual tired axles, either the tire pressure on the inside tire was very low compared to the outside adjacent tire, or the tire was blown out. In these cases, the analysis shows that there was violation of RCW 46.44.042. Refer to Appendix C for the types of trucks surveyed.

Recommendations

1. It is tentatively advised that the 20 percent tolerance for maximum gross loads on tires 12 inches wide or greater should be deleted from RCW 46.44.042.

2. Washington State RCW 46.44.095 should be revised to require that proposed tire and axle configurations be submitted with the permit application for review and approval prior to receiving an extra tonnage permit. A comparison of the cost of pavement damage versus cost to the carrier should serve as a basis for determining a satisfactory tire-axle configuration. However, in no case should the maximum axle loads for a single axle and 34,000 pounds for a tandem axle or maximum tire load of 550 pounds per inch be exceeded.
<table>
<thead>
<tr>
<th>States</th>
<th>Tire Size Factor (lb/in)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alaska</td>
<td>500</td>
</tr>
<tr>
<td>Connecticut</td>
<td>600</td>
</tr>
<tr>
<td>Florida</td>
<td>550</td>
</tr>
<tr>
<td>Idaho</td>
<td>800</td>
</tr>
<tr>
<td>Indiana</td>
<td>800</td>
</tr>
<tr>
<td>Kentucky</td>
<td>600</td>
</tr>
<tr>
<td>Louisiana</td>
<td>450</td>
</tr>
<tr>
<td>Maine</td>
<td>600</td>
</tr>
<tr>
<td>Massachusetts</td>
<td>800</td>
</tr>
<tr>
<td>Michigan</td>
<td>700</td>
</tr>
<tr>
<td>New Hampshire</td>
<td>600</td>
</tr>
<tr>
<td>New Jersey</td>
<td>800</td>
</tr>
<tr>
<td>New Mexico</td>
<td>600</td>
</tr>
<tr>
<td>New York</td>
<td>800</td>
</tr>
<tr>
<td>North Carolina</td>
<td>600</td>
</tr>
<tr>
<td>North Dakota</td>
<td>550</td>
</tr>
<tr>
<td>Ohio</td>
<td>650</td>
</tr>
<tr>
<td>Oregon</td>
<td>550</td>
</tr>
<tr>
<td>Pennsylvania</td>
<td>800</td>
</tr>
<tr>
<td>South Dakota</td>
<td>600</td>
</tr>
<tr>
<td>Texas</td>
<td>650</td>
</tr>
<tr>
<td>Vermont</td>
<td>600</td>
</tr>
<tr>
<td>Virginia</td>
<td>650</td>
</tr>
<tr>
<td>Washington</td>
<td>550</td>
</tr>
</tbody>
</table>
APPENDIX A

Washington State Patrol Size, Weight, and Load—Chapter 46.44
Outside Width (46.44.010)
Eight Feet (96 inches) inclusive of load for all vehicles

Tolerances:

1. Rear View Mirror - five (5) inches
2. Rubber fenders - two (2) inches
3. Tires (due to expansion) - two (2) inches
4. Safety appliances (clearance lights, rub rails, binder chains) - two (2) inches
5. Appurtenances (door handles, door hinges, and turning signal brackets) - two (2) inches

Maximum Height (46.44.020)
Fourteen (14) feet

Except:

1. Authorized emergency vehicle or repair equipment of a public utility engaged in reasonably necessary operations

Maximum Length (46.44.030)
Single vehicle - forty (40) feet with or without load

Except:

1. The permanent structure of a single vehicle in combination not to exceed forty-five (45) feet; forty-seven (47) feet with monthly, quarterly, or annual special motor vehicle permit.

Exception: Refrigeration units placed on the front of van trailers

Combination of vehicles:

1. The overall length of any combination consisting of a *nonstinger steered tractor and semitrailer shall not exceed sixty-five (65) feet. A *stinger steered tractor and semitrailer shall not exceed sixty-five (65) feet without load and seventy (70) feet with load.

2. The overall length of combination of vehicles consisting of a truck and trailer or any lawful combination of three vehicles shall not exceed sixty-five (65) feet with or without load; seventy-five (75) feet with monthly, quarterly, or annual special motor vehicle permit.

*Stinger steered shall mean a tractor and semitrailer combination, which has the coupling connecting the semitrailer to the tractor located to the rear of the center line of the rear axle of the tractor.
3. These length limitations shall not apply to vehicles transporting poles, pipes, machinery, or other objects of a structural nature that cannot be dismembered, and operated by a public utility when required for emergency repairs of public service facilities or properties.

Maximum Length of Protrusions (46.44.034)

1. Front - Three (3) feet
2. Rear - Fifteen (15) feet beyond last axle

Combination Limits - Two vehicles (46.44.036)

1. Exceptions: (46.44.037)
   a. Truck tractor, semitrailer, and trailer in combination.
   b. Truck tractor, semitrailer, and semitrailer in combination (B train)
      (1) The converter gear (dolly) may be pulled behind a tractor and semitrailer in lieu of a full trailer.
   c. Three trucks or three truck tractors in double saddle-mount position.

Gross Weights - Tire

1. 550 pounds per inch width (46.44.042)
   a. Tire having a width of twelve inches or more shall be allowed a twenty percent tolerance above 550 pounds per inch. (Tire size chart on Page 7 of this pamphlet.)

Excess Weight - logging trucks operating on a permit (46.44.047)

1. Only the three-axle tractor and two-axle pole trailer are allowed to have the permit and are valid only on State primary and secondary highways authorized by the State Department of Transportation.
   a. A map is issued showing the approved routes.

2. An additional six feet of wheelbase is given if the combination is thirty-seven feet or more between the first and last axles.

3. 1,600 pounds tolerance on dual axles.

4. 6,800 pounds tolerance on the combination.

5. Permit may be transferred ($5 fee).

6. Cities and counties may issue a "County Log Tolerance" permit for county roads.
   a. May charge a $5 fee.
   b. Shall designate the routes to be used.
c. Issued on a yearly basis, expiring March 31 of each year.

d. Any person, firm, or corporation using any city street or county road for the purpose of transporting logs with weights authorized by the State highway log tolerance permits, to reach a State highway route, without first obtaining a city or county log tolerance permit when required by the city or county shall be subject to the excess weight penalties.

Special Permits for Oversize or Overweight Vehicles (46.44.090)

1. Issued by Department of Transportation for State highways--by local authorities with respect to the public highways under their jurisdiction.

Gross weight Limits of Special Permits (46.44.091)

1. 22,000 pounds on a single axle.

2. 43,000 pounds on any group of axles more than 3 feet 6 inches apart and less than 7 feet apart.

3. Weight limits may be exceeded on highways designated for greater weight.

4. Construction equipment may exceed the above with large pneumatic tires.

Special Permit Width Limits (46.44.092)

1. 14 feet on a two-lane highway

2. 32 feet on a multiple-lane highway: Except multiple-lane highways with physical barrier serving as a median divider not in excess of 20 feet.

3. Exceptions:

   a. May be exceeded on highways designed and constructed for greater widths.

   b. May be rescinded during an emergency.

   c. 16 feet on a two-lane highway during daylight hours when the weight does not exceed 45,000 pounds.

   d. Buildings in excess of 14 feet may be moved not to exceed five miles.

Oversize Permits - Fees (46.44.0941)

1. Annual permit for 75 feet in length - $60.

   a. Permits are not restricted to hours or days.

Gross Weights (46.44.041)

1. Single axle - 20,000 pounds
2. Single drive axle garbage trucks - 22,000 pounds with additional tonnage permit
   a. Not valid on interstate system

3. Tandem axles - 34,000 pounds
   a. Axles spaced less than 7 feet must oscillate

4. Three-axle vehicle - 40,000 pounds
   a. Weight in excess of 40,000 pounds, allowed by additional tonnage permit, determined by tire size and wheelbase table.

5. Vehicle combinations - 80,000 pounds
   a. Weight in excess of 80,000 pounds, allowed by additional tonnage permit, determined by tire size and wheelbase table, using overall and internal spacing.

Wheelbase Table (46.44.041)

1. Overall measurement is from the center of the front axle on a vehicle or combination of vehicles to the center of the last axle on vehicles or combinations of vehicles.

2. Internal measurement will include groups of axles, and groups of two consecutive sets of tandem axles.
   a. Tandem axles will not be split when measuring internal spacing.

3. Minimum wheelbase - three feet, six inches, except axles spaced less than three feet, six inches may not exceed the maximum weight allowed for a single axle (46.44.050).

4. When inches are involved in wheelbase measurements, under six (6) take lower, six (6) inches or over, take the higher weight.

5. Steering axle weights are determined by tire size (46.44.042).

6. No enforcement tolerance will be allowed.

7. To determine license gross weight and additional tonnage weight, follow the examples of overall and internal measurements. Apply the total number of axles in the overall or internal measurement and apply this to the appropriate columns on the table for gross weights.

8. Establishes a grandfather provision for vehicle or combination of vehicles in operation on January 4, 1975, to operate with weights on two consecutive sets of dual axles in effect by law on that date. This provision will allow 32,000 pounds on a tandem axle and a combined gross weight of 73,280 pounds for certain combinations.
Combinations operating under the grandfather provision will be required to purchase a license gross weight tonnage of 74,000 pounds. A five axle combination with a minimum overall wheelbase measurement of 44' 6" would be allowed 73,280 pounds. Combinations with less than 44' 6" wheelbase, their weights will be determined by the enclosed vehicle loading chart. As in the past, we will not measure internal wheelbase on vehicles operating within the weights allowed by the grandfather provision. No tolerance will be allowed over these weights.

Additional Tonnage Permits (46.44.095)

1. Issued by the Department of Transportation.

2. Permits are issued annually with fees reduced by 1/12 or monthly instead of quarterly ($37.50 per thousand pounds).
   a. Permits may be transferred - fee $5.
   b. Seasonal vehicles may purchase permits quarterly. Must purchase a minimum of 6,000 pounds.

3. Temporary additional tonnage permits may be purchased for a minimum of five days at $1 per day for each 7,000 pounds.

4. Violated permits to be sent to the Department of Transportation upon third conviction.

Additional Tonnage Permits - Cities and Counties (46.44.0941)

1. Cities and counties may issue permits for operation on roads or streets under their jurisdiction.

2. Allowed on state roads by endorsement.

Mandatory Fines for Overloading (New Section--Chapter 46.44)

1. Penalties apply to tires (46.44.042), log tolerance permits (46.44.047), special motor vehicle permits (46.44.090 and 46.44.091), additional tonnage permits, axles, wheelbase, vehicles and combinations of vehicles (46.44.095), failure to obtain, display, or misrepresentation of permits (46.44.090 and 46.44.095).

2. Violation is a misdemeanor and is punishable as follows:
   a. Basic fine:
      (1) First violation - not less than $50.
      (2) Second violation - not less than $75. In addition, the court may suspend the license registration.
      (3) Third violation - not less than $100. In addition, the court shall suspend the license registration.
      (4) For license registration suspension purposes, first, second, and third violations are within any twelve-month period.
(5) In no case may the basic fine be suspended.

b. Poundage penalty (in addition to basic fine)

(1) Three cents per pound, provided that upon the first violation within a calendar year, the court may suspend 500 pounds on each axle, up to a maximum of 2,000 pounds on any combination of vehicles.

c. For license suspension purposes, bail forfeitures are given the same effect as convictions.

d. Convictions are figured on a calendar year and must be on the same vehicle or combination of vehicles.

e. Penalties for violation of a posted limitation (winter restrictions)

(1) First violation - not less than $150

(2) Second and subsequent violations - not less than $150 and, in addition, the court shall suspend the license registration for not less than 30 days.

f. Vehicles or combinations of vehicles of which the owner or operator represent as being disabled or otherwise unable to submit to immediate weighing will be sealed or marked. Removal of the seals, markings, or any part of the load prior to weighing will be punishable by a fine of not less than $500 and suspension of the license registration for not less than 30 days.

Weighing and Lightening

1. May require the operator to stop and submit to being weighed by portable scales or directed to the nearest public scales.

2. May require the load to be reduced to legal limits.

Liability for Overloading (46.44.120)

1. Owner, operator, and any person knowingly and intentionally participating in creating any unlawful condition of use shall also be subject to the penalties provided in this chapter.

Overloading Licensed Capacity - Additional License (46.16.140)

1. It is a misdemeanor to operate a vehicle in excess of the licensed gross weight.

a. Any person who operates a vehicle with a gross weight in excess of the licensed gross weight shall be deemed to have established a new gross weight and in addition to any other penalties shall be required to purchase a new tonnage license covering the new maximum gross weight.
(1) Failure to secure such new license shall be a misdemeanor.

(2) No such person shall be permitted or required to purchase additional gross weight which would exceed the gross weight allowed by law—increasing beyond the legal limits of tires or axles or vehicles.

Overloading Licensed Capacity--Penalties (46.16.145)

1. Establishes statutory fines and penalties for operating vehicles in excess of the licensed gross weight.
   a. First conviction $25 to $50 fine.
   b. Second conviction $50 to $100 fine and the court may suspend the registration.
   c. Third conviction $100 to $200 fine and the court shall suspend the registration for not less than thirty days.

Movement of Farm Implements (46.44.130)

Farm implements of less than 45,000 pounds gross weight and a total outside width of less than 20 feet may move over State highways while patrolled, flagged, lighted, signed, and at a time of day in accordance to rules to be adopted by the Department of Transportation under terms of a special permit to be issued by the Department of Transportation for a quarterly or annual period.

TIRE SIZE TABLE

Subject to the maximum gross weight for axle, axles, and vehicles.

<table>
<thead>
<tr>
<th>Tire Size</th>
<th>Single Tire</th>
<th>2 Tires (1 Axle)</th>
<th>4 Tires (1 Axle)</th>
<th>8 Tires (2-Axle Duals)</th>
<th>10 Tires (3-Axle Veh.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>8:25</td>
<td>4537.5</td>
<td>9075</td>
<td>18150</td>
<td>36300</td>
<td>45375</td>
</tr>
<tr>
<td>9:00</td>
<td>4950</td>
<td>9900</td>
<td>19800</td>
<td>39600</td>
<td>49500</td>
</tr>
<tr>
<td>10:00</td>
<td>5500</td>
<td>11000</td>
<td>22000</td>
<td>44000</td>
<td>55000</td>
</tr>
<tr>
<td>11:00</td>
<td>6050</td>
<td>12100</td>
<td>24200</td>
<td>48400</td>
<td>60500</td>
</tr>
<tr>
<td>12:00</td>
<td>7920</td>
<td>15840</td>
<td>31680</td>
<td>63360</td>
<td>79200</td>
</tr>
<tr>
<td>18:00</td>
<td>11880</td>
<td>23760</td>
<td>47520</td>
<td>(Flotation Type – Used Singly on Drive Axles)</td>
<td></td>
</tr>
</tbody>
</table>

16
WASHING STATE HIGHWAY COMMISSION
DEPARTMENT OF HIGHWAYS

VEHICLE WEIGHT TABLE

Drawn in accordance with Chapter 398, Session Laws of 1977
as last amended by Chapter 45-44 Session Laws of 1977
MARCH 1977

No vehicle or combination of vehicles shall operate upon the public highways of this state with a gross load on any single axle in excess of twenty thousand pounds, or upon any group of axles in excess of that weight in the following table, except that two consecutive sets of tandem axles may carry a gross load of thirty-four thousand pounds each, if the overall distance between the last and first axles of such consecutive sets of tandem axles is thirty-six feet or more.

<table>
<thead>
<tr>
<th>Distance in feet between the extremes of any group of 2 or more consecutive axles</th>
<th>2 axles</th>
<th>3 axles</th>
<th>4 axles</th>
<th>5 axles</th>
<th>6 axles</th>
<th>7 axles</th>
<th>8 axles</th>
<th>9 axles</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>34,000</td>
<td>34,000</td>
<td>34,000</td>
<td>34,000</td>
<td>34,000</td>
<td>34,000</td>
<td>34,000</td>
<td>34,000</td>
</tr>
<tr>
<td>5</td>
<td>36,000</td>
<td>36,000</td>
<td>36,000</td>
<td>36,000</td>
<td>36,000</td>
<td>36,000</td>
<td>36,000</td>
<td>36,000</td>
</tr>
<tr>
<td>6</td>
<td>38,000</td>
<td>38,000</td>
<td>38,000</td>
<td>38,000</td>
<td>38,000</td>
<td>38,000</td>
<td>38,000</td>
<td>38,000</td>
</tr>
<tr>
<td>7</td>
<td>40,000</td>
<td>40,000</td>
<td>40,000</td>
<td>40,000</td>
<td>40,000</td>
<td>40,000</td>
<td>40,000</td>
<td>40,000</td>
</tr>
<tr>
<td>8</td>
<td>42,000</td>
<td>42,000</td>
<td>42,000</td>
<td>42,000</td>
<td>42,000</td>
<td>42,000</td>
<td>42,000</td>
<td>42,000</td>
</tr>
<tr>
<td>9</td>
<td>44,000</td>
<td>44,000</td>
<td>44,000</td>
<td>44,000</td>
<td>44,000</td>
<td>44,000</td>
<td>44,000</td>
<td>44,000</td>
</tr>
<tr>
<td>10</td>
<td>46,000</td>
<td>46,000</td>
<td>46,000</td>
<td>46,000</td>
<td>46,000</td>
<td>46,000</td>
<td>46,000</td>
<td>46,000</td>
</tr>
<tr>
<td>11</td>
<td>48,000</td>
<td>48,000</td>
<td>48,000</td>
<td>48,000</td>
<td>48,000</td>
<td>48,000</td>
<td>48,000</td>
<td>48,000</td>
</tr>
<tr>
<td>12</td>
<td>50,000</td>
<td>50,000</td>
<td>50,000</td>
<td>50,000</td>
<td>50,000</td>
<td>50,000</td>
<td>50,000</td>
<td>50,000</td>
</tr>
<tr>
<td>13</td>
<td>52,000</td>
<td>52,000</td>
<td>52,000</td>
<td>52,000</td>
<td>52,000</td>
<td>52,000</td>
<td>52,000</td>
<td>52,000</td>
</tr>
<tr>
<td>14</td>
<td>54,000</td>
<td>54,000</td>
<td>54,000</td>
<td>54,000</td>
<td>54,000</td>
<td>54,000</td>
<td>54,000</td>
<td>54,000</td>
</tr>
<tr>
<td>15</td>
<td>56,000</td>
<td>56,000</td>
<td>56,000</td>
<td>56,000</td>
<td>56,000</td>
<td>56,000</td>
<td>56,000</td>
<td>56,000</td>
</tr>
<tr>
<td>16</td>
<td>58,000</td>
<td>58,000</td>
<td>58,000</td>
<td>58,000</td>
<td>58,000</td>
<td>58,000</td>
<td>58,000</td>
<td>58,000</td>
</tr>
<tr>
<td>17</td>
<td>60,000</td>
<td>60,000</td>
<td>60,000</td>
<td>60,000</td>
<td>60,000</td>
<td>60,000</td>
<td>60,000</td>
<td>60,000</td>
</tr>
<tr>
<td>18</td>
<td>62,000</td>
<td>62,000</td>
<td>62,000</td>
<td>62,000</td>
<td>62,000</td>
<td>62,000</td>
<td>62,000</td>
<td>62,000</td>
</tr>
<tr>
<td>19</td>
<td>64,000</td>
<td>64,000</td>
<td>64,000</td>
<td>64,000</td>
<td>64,000</td>
<td>64,000</td>
<td>64,000</td>
<td>64,000</td>
</tr>
<tr>
<td>20</td>
<td>66,000</td>
<td>66,000</td>
<td>66,000</td>
<td>66,000</td>
<td>66,000</td>
<td>66,000</td>
<td>66,000</td>
<td>66,000</td>
</tr>
<tr>
<td>21</td>
<td>68,000</td>
<td>68,000</td>
<td>68,000</td>
<td>68,000</td>
<td>68,000</td>
<td>68,000</td>
<td>68,000</td>
<td>68,000</td>
</tr>
<tr>
<td>22</td>
<td>70,000</td>
<td>70,000</td>
<td>70,000</td>
<td>70,000</td>
<td>70,000</td>
<td>70,000</td>
<td>70,000</td>
<td>70,000</td>
</tr>
<tr>
<td>23</td>
<td>72,000</td>
<td>72,000</td>
<td>72,000</td>
<td>72,000</td>
<td>72,000</td>
<td>72,000</td>
<td>72,000</td>
<td>72,000</td>
</tr>
<tr>
<td>24</td>
<td>74,000</td>
<td>74,000</td>
<td>74,000</td>
<td>74,000</td>
<td>74,000</td>
<td>74,000</td>
<td>74,000</td>
<td>74,000</td>
</tr>
<tr>
<td>25</td>
<td>76,000</td>
<td>76,000</td>
<td>76,000</td>
<td>76,000</td>
<td>76,000</td>
<td>76,000</td>
<td>76,000</td>
<td>76,000</td>
</tr>
<tr>
<td>26</td>
<td>78,000</td>
<td>78,000</td>
<td>78,000</td>
<td>78,000</td>
<td>78,000</td>
<td>78,000</td>
<td>78,000</td>
<td>78,000</td>
</tr>
<tr>
<td>27</td>
<td>80,000</td>
<td>80,000</td>
<td>80,000</td>
<td>80,000</td>
<td>80,000</td>
<td>80,000</td>
<td>80,000</td>
<td>80,000</td>
</tr>
<tr>
<td>28</td>
<td>82,000</td>
<td>82,000</td>
<td>82,000</td>
<td>82,000</td>
<td>82,000</td>
<td>82,000</td>
<td>82,000</td>
<td>82,000</td>
</tr>
<tr>
<td>29</td>
<td>84,000</td>
<td>84,000</td>
<td>84,000</td>
<td>84,000</td>
<td>84,000</td>
<td>84,000</td>
<td>84,000</td>
<td>84,000</td>
</tr>
</tbody>
</table>

The Gross Weight of any tire and load shall not exceed 550 lbs. per inch width of tire.

The Overall Width of vehicle and load shall not exceed 8 feet.

The Overall Length of vehicle and load shall not exceed 14 feet.

The Overall Height of any vehicle shall not exceed 10 feet 4 inches. Violation of any combination of vehicles, with or without load, shall not exceed 8 feet. Semi-trailers shall not exceed 42 feet.

(Combination of vehicles allowed 75 feet which may contain a 47 ft. semi-trailer by special permit - RCW 46.64.0411.)
APPENDIX B

Originally Prepared by WSDOT Materials Lab
A Review of Two Reports Prepared for
the American Trucking Association

"Causes of Pavement Damage on Interstate Highways"
by Counsel Trans, Inc.

"Effects of Truck Weights on Pavement Deterioration"
by Texas Transportation Institute

The major emphasis on both of these reports was to estimate the proportion
of damage to our highway pavements attributable to either truck loading or
environment, or a combination of these factors. In general, both reports
conclude that all states experience less distress attributable directly to
load than to other causes. Our experience in the State of Washington does
not support these findings. The following are our concerns with the data
presented in both reports.

"Causes of Pavement Damage on Interstate Highways"

The Counsel Trans report is based on an inventory conducted in six states on
selected interstate pavements at least eight years old. The defects rated
in the inventory were those normally used, or at least accepted, by most
states. A determination was then made as to whether the distress was
"...primarily caused by loading..." or "...primarily caused by factors other
than loading..." There was no consideration for the effect that load may
ultimately have on defects initially caused by environmental factors.

Many of our pavements experience non-load-related defects early in their
service life, such as reflective cracking or thermal cracking. These defects
are usually of minor severity and have negligible effect on the serviceability
of the roadway. In time, the accumulated effect of load causes the severity
of these defects to increase to the extent that serviceability is affected.
We believe greater consideration should have been given in the report to the
effect of load on environmentally induced defects.

Most of our asphalt concrete pavements last 10 to 12 years before they require
some form of rehabilitation. In their report, Counsel Trans inventoried
select interstate pavements eight years of age or older. It would seem that
an inventory collected on pavements in this part of their life cycle, as
Counsel Trans has done, would tend to be biased toward non-load-related dis-
tresses. It would be more pertinent to conduct an inventory on only those
projects which have been identified as requiring rehabilitation or resurfacing
in the very near future. An inventory of these sections would indicate what
defects are actually present when we make the final decision as to which pro-
jects we should spend our all-too-limited funds on.

A review of the inventory data for all of our interstate AC pavement sections
requiring rehabilitation or resurfacing in the next biennium indicates that
we do in fact experience a much higher proportion of load-related distress
than that indicated by Counsel Trans. The following is a rough comparison
of our interstate ACP sections which require action to the Counsel Trans study.
Some of the defect categories used in the report were combined to fit our defect
categories.
The Counsel Trans findings, as stated in their report, are:

"Pavement damage reasonably ascribable to vehicular loading, on
The National System of Interstate and Defense Highways, is between
35 and 41 percent of the damage attributable to all causes."

Considering data from our own inventory as well as our personal experience, we cannot support these findings. They vastly overstate the effect of non-load-related distress, while under-estimating the effect of load-related distress on pavements requiring rehabilitation.

"Effects of Truck Weights on Pavement Deterioration"

The second report, prepared by the Texas Transportation Institute, also studies the damage which occurs to pavement due to various causes. In their report they have classified the causes into three categories: traffic loads, climate, and a combination of the two. Though they do consider a combined category, they also do not acknowledge the effect load has on increasing the severity of climatically induced defects. There are several defect classifications included in the report which we find questionable. Specifically, we do not consider either non-reflective longitudinal cracking or ravelling as climatically caused distresses. Longitudinal cracking often occurs in the wheel path before alligator cracking. We consider both cracking types load-related. Our experience also indicates ravelling is more dependent upon quality of construction and heavy traffic load than on climate.

To analyze the amount of damage attributable to each cause, TTI used an inventory of metropolitan highways in Minnesota, as well as performance curves for flexible pavements developed in Texas, for composite pavements developed in Minnesota and rigid pavements developed in Illinois. Relative damage functions developed in several different states were then applied to determine perceived effect of the different distresses.

We do not think it prudent to apply damage functions developed in one state to another which may have totally different design and construction requirements. The use of damage equations developed in Washington to analyze pavement performance from Illinois, as was done in the report, is a good example. The rigid pavement equation developed for Illinois is based predominantly on pavements which are reinforced--jointed at 70-ft spacing with dowels used for load support across each joint. In the State of Washington, damage equations were developed based on our own PCC pavements which are almost all unreinforced with joint spacing of 15 ft or less with no load transfer devices. One should expect a significant difference in the occurrence of the various distress categories between unique pavement designs. The difference in experience must
also extend to distress categories. In their report, TTI interpreted one of our distress categories as D-cracking to (we assume) better fit their experience. This was a total misapplication of our weightings as we do not even experience D-cracking. This distress is associated with certain types of rock seldom found in this state and never used as aggregate in our pavements. It would seem reasonable that similar discrepancies between states can apply to the other pavement types. We doubt that specific damage functions can be developed that will accurately represent the performance of either rigid or flexible pavements in all states.

The pavement inventory used in the TTI report was from Minnesota. It was based on selected sections from two districts which apparently control most metropolitan highway routes within the state. One would expect the condition of these pavements to be quite dependent upon the general policies of the State Highway Department. The policies of the State of Minnesota as stated in the report are as follows:

"The departments felt that the rate of crack deterioration into multiple cracking was dependent on the quality of the subgrade soils, the traffic loading, and environmental conditions. They stated that multiple cracking usually deteriorates to alligating if left untreated. Therefore the departments would prefer to usually overlay once multiple cracking has occurred rather than risk a greater expenditure at a later date."

One would also not expect to find much load-associated cracking in an area where the stated policy was to resurface the pavement in anticipation of the onset of this type of cracking. The data from Minnesota are not too surprising then when it shows very little load-associated cracking on average.

Again, our experience in the State of Washington indicates a much higher proportion of load-associated cracking on projects selected for rehabilitation than that indicated in the TTI report. The following direct comparison can be made between those projects identified for rehabilitation in our state and a sample of 20 flexible pavement sections inventoried just prior to maintenance in the TTI report:

<table>
<thead>
<tr>
<th>TTI Summary</th>
<th>WSDOT Summary</th>
</tr>
</thead>
<tbody>
<tr>
<td>20 Flexible Pavements from Minnesota</td>
<td>Interstate Flexible Pavements Requiring Rehabilitation</td>
</tr>
<tr>
<td>Transverse Cracking</td>
<td>87.95%</td>
</tr>
<tr>
<td>Longitudinal Cracking</td>
<td>16.48%</td>
</tr>
<tr>
<td>Multiple Cracking</td>
<td>11.92%</td>
</tr>
<tr>
<td>Alligator Cracking</td>
<td>1.61%</td>
</tr>
<tr>
<td>Rutting</td>
<td>3.97%</td>
</tr>
<tr>
<td>Patching</td>
<td>11.29%</td>
</tr>
</tbody>
</table>

*In Washington, multiple cracking is coded as transverse and longitudinal cracking.

**This value also includes flushing.

As can be seen, we experience a much greater amount of longitudinal and alligator cracking which we consider to be load-associated.
In their conclusions, authors of the TTI report make the following observations relative to all states:

"As shown in this report, the damage that results in a decision to maintain or rehabilitate a pavement is not ascribable to load alone but in some cases is entirely dependent upon climatic influences and in other cases is the result of the combined effect of these two..."

"...It is also apparent that at the present time there is no consensus among the states about what types of distress should be considered or how heavily each should be weighted in determining a decision criterion for maintenance and rehabilitation activities. But despite the lack of consensus, it is evident that in the estimation of all of the states, climatically caused distress figures heavily in their decision-making in developing a pavement maintenance and rehabilitation program for the state highway networks."

As stated before, considering data from our own inventory as well as our personal experience, we do not agree with these findings. They overstate the effect of non-load-related distress while underestimating the effect of load on pavements requiring rehabilitation. With regard to this report, we specifically feel that more consideration should have been given to the differences between performance models in all states, commensurate with the variation in design and construction practices.
APPENDIX C

Examples of Overall and Internal Measurements to Determine Gross Weight
EXAMPLES OF OVERALL AND INTERNAL MEASUREMENTS TO DETERMINE GROSS WEIGHTS

1. 2 axle solo truck

2. 3 Axle combination truck tractor-semi trailer

3. 4 Axle combination truck tractor-semi trailer

4. 4 Axle Combination Truck

5. 5 Axle Combination Truck
6. 3 Axle Truck

7. 4 Axle Combination
   Truck Tractor-Semi Trailer

8. 5 Axle Combination
   Truck Tractor-Semi Trailer

Overall wheelbase of 51' allows 80,000 lbs determined by tire size steering axle

Overall

9. 5 Axle Combination
   Truck
   Trailer

*Indicates the critical measurements

Example: 24' wheelbase from axle 2 to 4 allows by table (3 axle column) 54,000 lbs. 10' wheelbase from axle 4 to 5 allows 40,000 lbs. These two examples for gross weight purposes would be determined by the internal wheelbase from axle 2 to 5. Take the total wheelbase measurement from axle 2 to 5. This would be the critical measurement as 34' from axle 2 to 5 applied to the 4 axle column would allow a gross weight of 63,500 lbs.
Vehicles towing a dolly axle not designed to support an appreciable part of the load will not be included in the wheelbase measurement for gross combination weight purposes.