REVIEW OF PERMIT LOADS IN OREGON

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Abstract

Oregon's approach to the review of over-dimensional permit loads will be discussed. While our goal is to maintain freight mobility and economic development, we also have the responsibility to protect taxpayer's investment and maintain public safety by making sure the bridges are not damaged by over-dimensional permit loads. This paper will discuss some of the over-dimensional permit loads that are reviewed in Oregon and the increased occurrence of some of these loads as a result of the development of wind turbine energy in Oregon and Washington. The strategies used to minimize the load effects to critical bridge members from these permit vehicles will be described.

Oregon's Permit Load Process

What is an over-dimensional permit? It is a variance permit that allows a trucker to safely move a load that exceeds the maximum size and/or weight limits that are set in Oregon statute. It can be for a single trip or continuous operations. The permit details the route and conditions required for moving the load safely. If the permit isn't strictly followed, then the mishaps like those pictured below can happen.

BRIDGE FAILURES FROM OVER-DIMENSIONAL LOADS

Oregon's Motor Carrier Transportation Division (MCTD) issues single-trip and annual variance permits for overweight, over-height, over-width, over-length, and other unusual truck loads. The permits include routing plans, road restriction information, and other permit conditions. Federal and State Highways are covered by the permits that are issued by MCTD. They can also cover county roads, with county approval, but most

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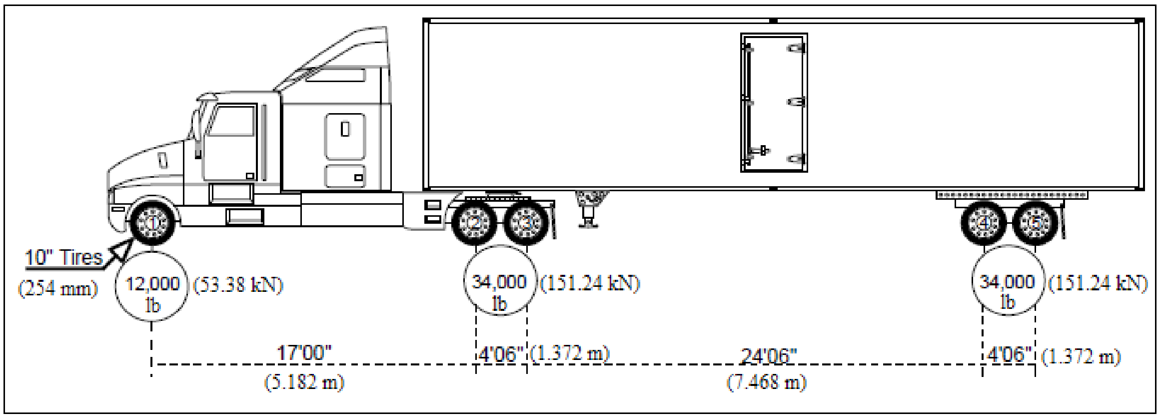
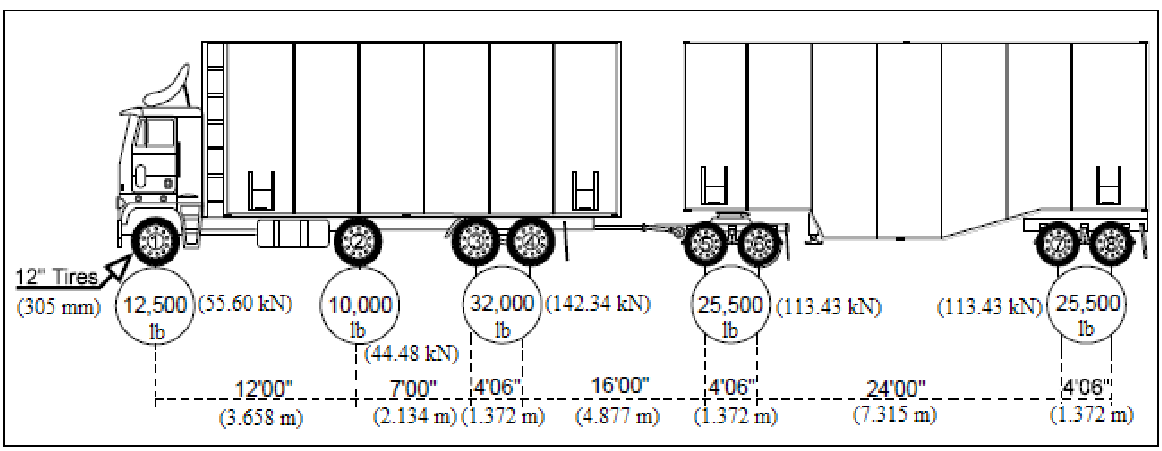
Oregon counties issue their own permits. When a trucker applies for an over-dimensional permit, MCTD or one of its five agents will perform an analysis of the vehicle axle weights and spacing to determine if the vehicle configuration falls within one of the five Weight Tables that are defined by Oregon Statute.

Weight Table 1 – Legal Weight – No Permit Required. The maximum weight allowed is 600 lb per inch (105.1 N per mm) of tire width, 20,000 lb (88.96 kN) for a single axle, 34,000 lb (151.24 kN) for tandem axles, and 80,000 lb (355.86 kN) gross vehicle weight. The common vehicle types that fall within this table are: solo truck, truck-tractor and semitrailer, truck and trailer, log truck and pole trailer.



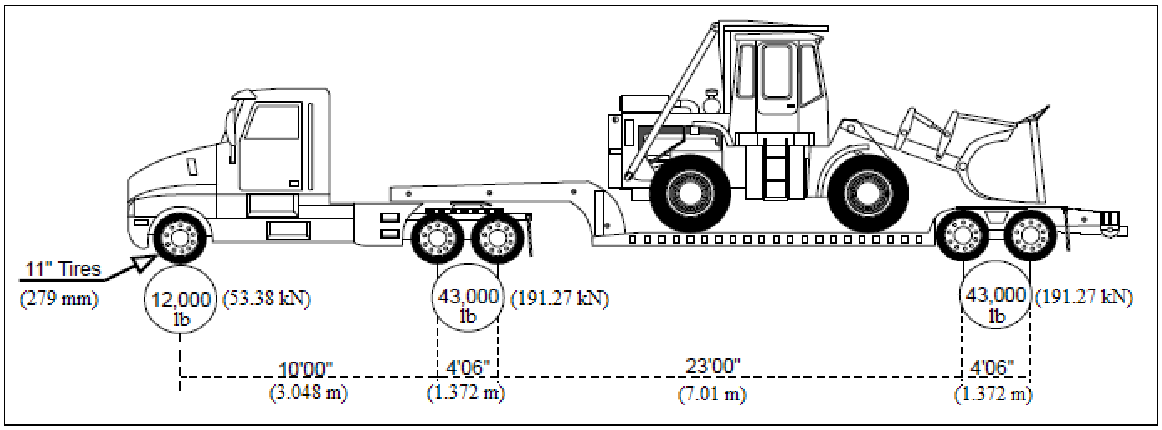
WEIGHT TABLE 1 EXAMPLE

Weight Table 2 – Extended Weight – Permit Required. Permits based on Table 2 allow between 80,000 lb (355.86 kN) and 105,500 lb (469.29 kN) maximum gross vehicle weight while not exceeding legal axle weights. These are divisible loads like gravel, gasoline, and wood-chips. Common vehicle types include: truck-tractor-semitrailer-trailer (aka doubles), triple-trailer combinations, truck-tractor and tri-axle semitrailers.



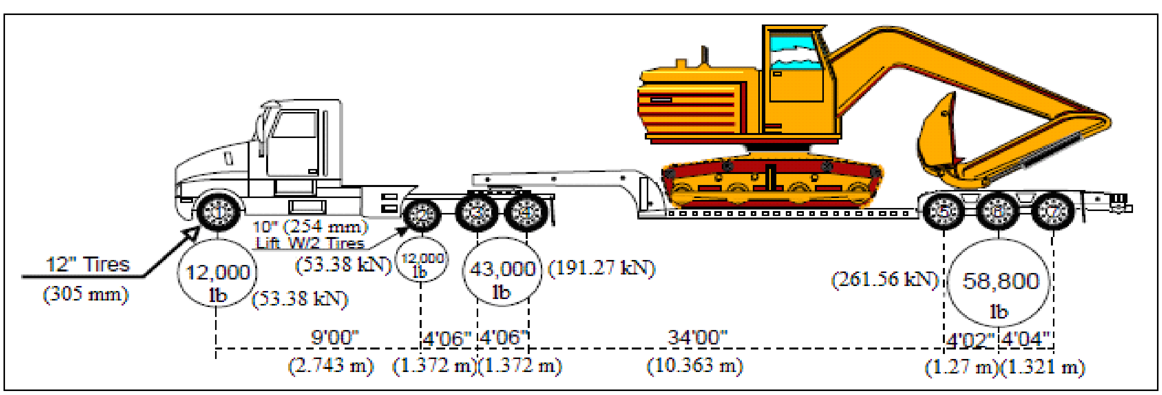
WEIGHT TABLE 2 EXAMPLE

Weight Table 3 – Heavy Haul Weight – Permit Required. Annual, continuous operation permits based on Table 3 will allow up to 98,000 lb (435.93 kN) for non-divisible loads. The maximum weight for single-trip permits is based on the number of axles and wheelbase. Other maximum limitations include: 600 lb per inch (105.1 N per mm) of tire width, 21,500 lb (95.64 kN) per single axle, 43,000 lb (191.27 kN) per tandem axle, the weight shown on the over-dimension permit, and the sum of the permittable axle, tandem axle, or group axle weight, whichever is less. Common vehicle types include: truck-tractor-lowbed semitrailer, truck-tractor-semitrailer and booster.



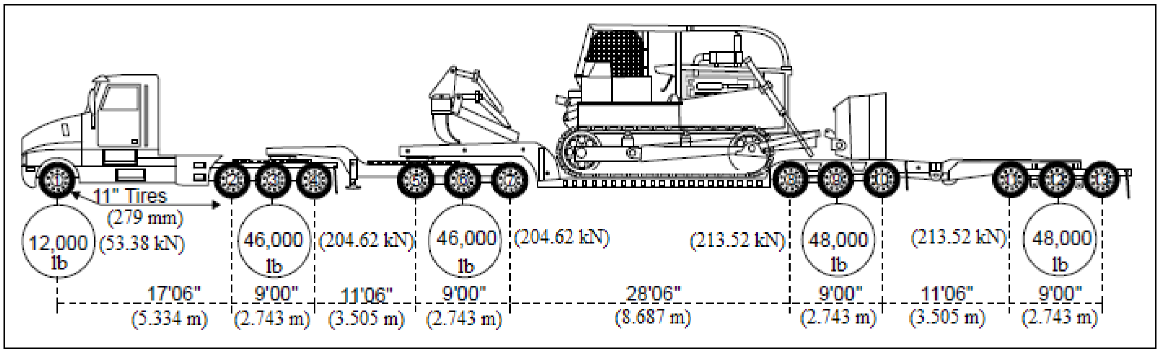
WEIGHT TABLE 3 EXAMPLE

Weight Table 4 – Heavy Haul Weight – Permit Required. The maximum weight for Table 4 permits is based on the number of axles and wheelbase. Table 4 allows for more weight using a shorter wheelbase than that authorized by Table 3. Other maximums limitations include: 600 lb per inch (105.1 N per mm) of tire width, 21,500 lb (95.64 kN) per single axle, 43,000 lb (191.27 kN) per tandem axle, the weight shown on the over-dimension permit and the sum of the permittable axle, tandem axle, or group axle weight, whichever is less. Common vehicle types include: self-propelled crane, truck-tractor-lowbed semitrailer, truck-tractor with jeep & semitrailer, truck-tractor with semitrailer & booster.



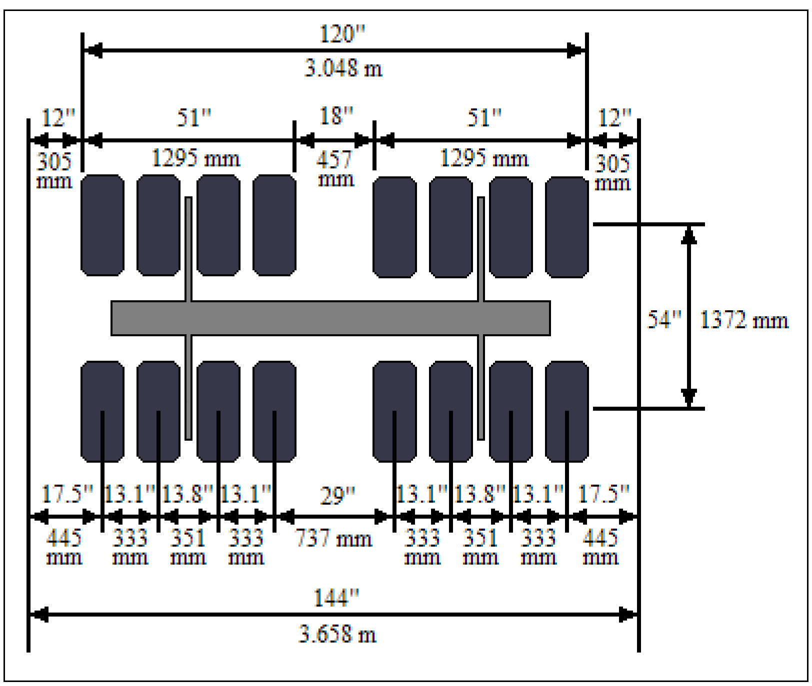
WEIGHT TABLE 4 EXAMPLE

Weight Table 5 – Heavy Haul Weight – Permit Required. Weight Table 5 is for certain specific vehicle configurations only. It provides for up to 48,000 lb (213.52 kN) per tandem axle if the combination of vehicles has at least 9 axles, with a steer axle followed by four consecutive tandem axles which are 8' (2.438 m) wide (standard). Ten percent more weight may be allowed when the combination has 10' (3.048 m) wide axles with 4 tires per axle. Instead of 48,000 lb (213.52 kN) per tandem, this allows up to 52,800 lb (234.87 kN).



WEIGHT TABLE 5 EXAMPLE

Weight Table 5 also allows an additional "bonus" weight (25% more) when the combination has 10' (3.048 m) wide axles with 8 tires per axle. Instead of 48,000 lb (213.52 kN) per tandem, this 25% "bonus" weight will allow up to 60,000 lb (266.89 kN) per tandem. This type of tandem axle configuration is called a "trunnion axle".



TRUNNION AXLE CONFIGURATION

For every bridge that is load rated, the Oregon Department of Transportation (ODOT) requires the application of a standard suite of additional permit vehicles that represent the different Weight Tables to be analyzed as part of the load rating. If a particular bridge has low rating factors for one or more of these standard permit vehicles, ODOT will include the bridge in its "Weight-Restricted Bridges on Major State Routes" list with additional information regarding the maximum Weight Table vehicle that can use the bridge. Oregon's Motor Carrier Transportation Division (MCTD) then refers to this list when it approves an over-dimensional permit for a specific route.

Since ODOT's Bridge Engineering Section maintains the "Weight-Restricted Bridges on Major State Routes" list and keeps it current, when a trucker applies for an over-dimensional permit that falls within one of the Weight Tables, MCTD can approve the permit without having ODOT's Bridge Engineering Section perform a review. Otherwise, if the over-dimensional permit exceeds the limits of the Weight Tables, then ODOT's Bridge Load Rating Unit will perform an analysis of the vehicle configuration (axle weights and spacing) for all of the State owned bridges on the requested route.

In 2011, Oregon's Motor Carrier Transportation Division issued 175,000 continuous trip permits and 110,000 single trip permits. Of the 110,000 single trip permits that were issued, only 153 of them exceeded the Weight Tables and required a review of the bridges on the requested route by ODOT's Bridge Load Rating Unit.

Permit Review by ODOT's Bridge Load Rating Unit

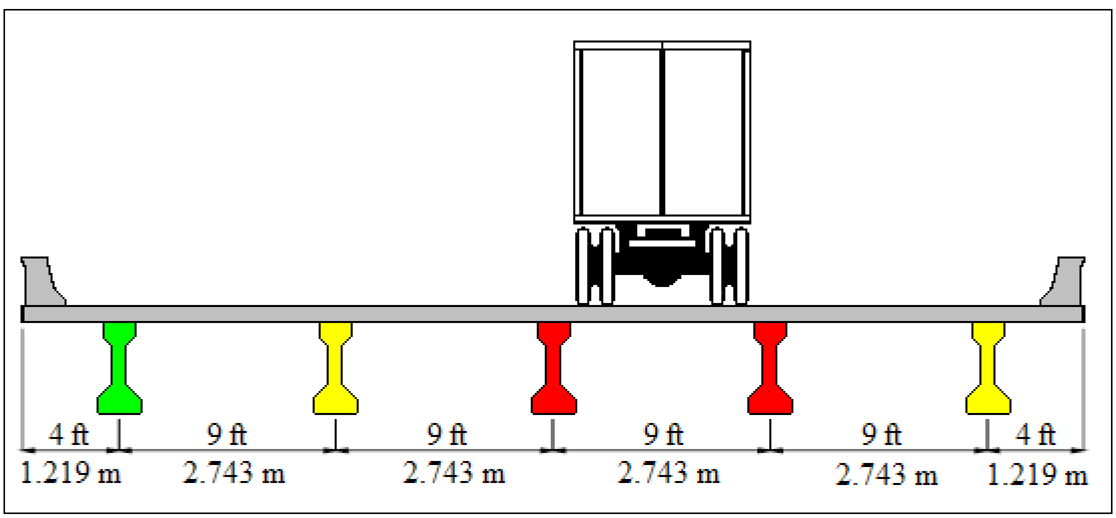
When an over-dimension permit vehicle configuration exceeds the limits of the Weight Tables, Oregon's Motor Carrier Transportation Division will forward information from the permit application to ODOT's Bridge Load Rating Unit. The information that is needed by the Load Rating Unit is the route that the trucker is requesting to take, which includes the highway number and mile point range for each leg of the requested route. A diagram of the proposed vehicle configuration is also needed, which includes the axle weights, spacing, and axle widths.

The information about the proposed route is used to perform a database query to retrieve a list of every State owned bridge that the vehicle will drive across. This list will include the bridge number, bridge name, span configuration, highway number, mile point location, year built, design load, latest inspection conditions, and load rating factors for legal and standard permit vehicles (if the bridge has been load rated). This list is used to help identify which bridges on the route that might have trouble carrying the proposed vehicle. Some routes are relatively short and may have a handful of bridges that will be crossed, where others pass through the entire state and will cross several hundred bridges.

ODOT's Bridge Load Rating Unit uses BRASS-GIRDER software to perform the load rating analysis for the majority of its bridges. The BRASS software was developed and is maintained by the Wyoming Department of Transportation. BRASS stands for Bridge Rating and Analysis of Structural Systems. The software utilizes finite element theory of analysis and current AASHTO specifications to compute moments, shears, axial forces, deflections, and rotations caused by dead loads, live loads, settlements and temperature change.

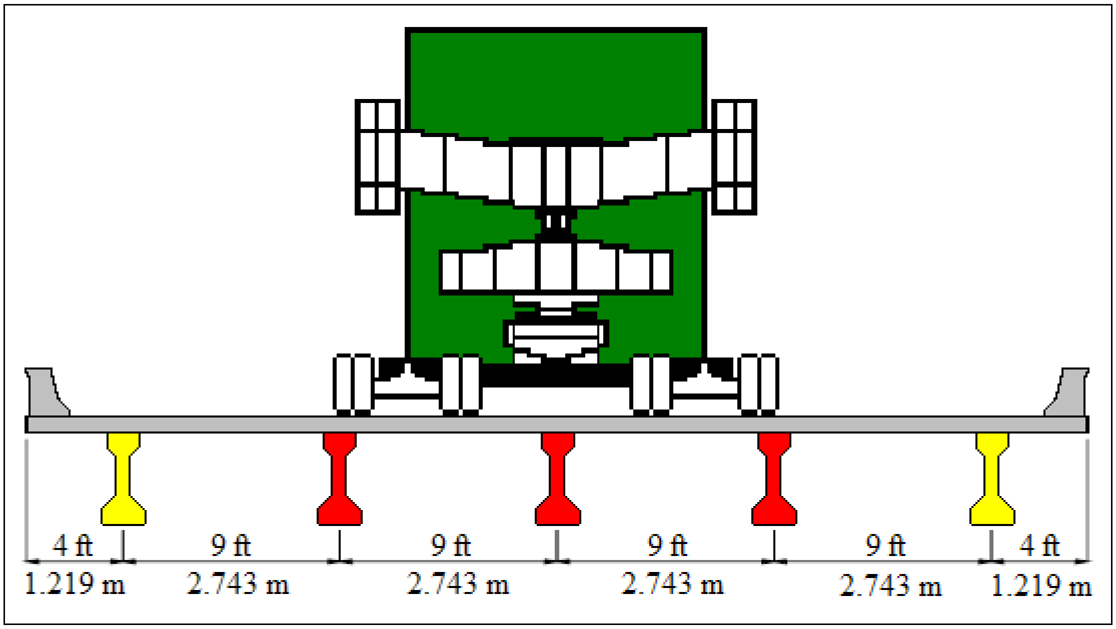
The proposed vehicle configuration is entered into BRASS and a quick analysis is performed on four sample bridges that are routinely used to compare the load effects (shear and moment forces) from the proposed over-dimensional permit vehicle and the standard load rating permit vehicles. The four bridges consist of the following span layouts: 50 ft (15.24 m) – 83 ft (25.30 m) – 46 ft (14.02 m) continuous span bridge, 164 ft (49.99 m) simple span bridge, 80 ft (24.38 m) simple span bridge, and 40 ft (12.19 m) simple span bridge. Knowing how the proposed vehicle's load effects compare to the standard permit loads for the different span lengths helps identify which bridges on the route list need to be analyzed with the proposed vehicle.

When reviewing the vehicle configuration, it is important to note the out-to-out axle widths of the primary load carrying axles. The standard out-to-out axle width of a normal commercial vehicle is 8 ft (2.438 m). For beam-slab bridges, the concrete deck and diaphragms will distribute a percentage of the load to the other beams in the bridge. The beams that are directly under the vehicle will resist the majority of the load and the beams that are farther out will help resist a smaller percentage. In the figure below, the red girders will have the largest distribution factor applied to them as they are resisting the majority of the load. The other girders that are a greater distance from the vehicle contribute less to resisting load effects from the vehicle, as illustrated by the yellow and green girders.



LOAD DISTRIBUTION FOR STANDARD VEHICLE WIDTH

Over-dimensional permit vehicle widths can vary. Many use standard axle widths, but some very large/heavy permit vehicles can have out-to-out axle widths as much as 20 ft (6.096 m). For most bridges, the more that the vehicle can spread the load out transversely, the more girder lines will share the majority of the load. With more girder lines sharing the load, the magnitude of the load that each girder has to resist is less.



LOAD DISTRIBUTION FOR LARGE PERMIT VEHICLE WIDTH

Since the load rating software that ODOT uses can only analyze vehicles with standard axle widths, when a permit vehicle has out-to-out axles widths of 16 ft (4.877 m) or greater only half of the axle load will be entered and the AASHTO multiple lane distribution factors will be used in the analysis. Depending on how the permit vehicle is rating out for a particular bridge, sometimes a linear interpolation will be performed for a percentage of the axle loads that will be used in the analysis when the out-to-out axle widths are 12 ft (3.658 m) or 14 ft (4.267 m).

If a particular bridge member is having trouble safely resisting the forces for an over-dimensional permit vehicle, ODOT's load rating engineers will analyze the structure with the vehicle placed at different locations transversely across the structure. For example, some older bridges may have been widened during their history. The original girders may have poor reinforcing details or lower capacity than the newer girders within the widened portion of the bridge. If the analysis shows that the newer widened girders perform better at resisting the forces from the proposed vehicle, the load rating engineer will specify that the trucker needs to drive in the shoulder as close as they can to the barrier so that the load is carried by the stronger portion of the bridge. Depending on the controlling bridge members, the engineer may stipulate that the permit vehicle be driven at different transverse positions for some of the various bridges on a given route. Sometimes the engineer will require the load to center over a substructure column or support on the right or left side of the bridge, or they may require the vehicle to center the load down the middle of the structure so the that load is evenly distributed over the girders, between truss lines, or centered on floorbeams.

If the bridge inspection report indicates that the approach roadway is rough or has settled to create a ramping mechanism that has the effect of launching vehicles onto the bridge, which has the result of increasing the dynamic impact loading from the vehicle, the engineer may request that the trucker slow their speed while crossing the bridge. With a reduced vehicle speed, the load rating engineer will use a 10% Dynamic Impact Factor applied to the live load forces instead of the 33% Dynamic Impact Factor as specified by the AASHTO LRFD Bridge Design Specifications. Requesting that the permit vehicle cross a bridge at a reduced speed tends to create more of a hazard for the traveling public since the majority of drivers will become frustrated by the reduced speed and begin driving more aggressively to attempt to pass the permit vehicle. Therefore this option is only used as a last resort for extremely heavy loads (which usually can not drive at normal highway speeds anyway) when the engineer needs to reduce the load effects slightly to allow the vehicle to cross the structure.

When the load rating engineer includes special instructions for the trucker to cross a bridge, whether it is driving the truck in a specific position or reducing the speed, Oregon’s Motor Carrier Transportation Division (MCTD) will include the engineer’s special instructions as part of the trucker’s permit. MCTD will also require one or more pilot cars to escort the vehicle so that they can perform traffic control and create a safety buffer between the permit vehicle and other traffic while it performs the required maneuvers as it crosses the bridges.

If the load rating engineer is unable to get the analysis to show that the proposed vehicle can safely cross every bridge on the requested route, they will send their recommendation to MCTD that the permit be denied. MCTD will then work with the carrier to either modify their route if there are specific bridges that are causing the rejection, or they will inform the trucker that they need to modify their vehicle configuration to better distribute the loads. Often times the trucker will attempt to shift their load, which will slightly change their axle weights. In some instances this will make enough of a difference to reduce the overall load effect on the bridges, especially if the original configuration had a concentrated grouping of very heavy axles. Or the trucker may be able to add additional axles and devices that will spread the load longitudinally, which will often reduce the other axle weights that are sharing the load.

The longer the distance over which the permit vehicle can spread the load, the less are the load effects that are applied to most bridges. This is because for most bridge spans a group of axles will be exiting the span before another group of axles begin crossing it. Therefore, a given span will never “see” the entire load of the permit vehicle at one time. This can be seen in the following picture of an electrical transformer being transported across a bridge consisting of multiple simple precast concrete spans. If this bridge had been comprised of spans acting continuous for liveload, the load rating engineer would also have to check the negative moment at interior supports.

A LONG PERMIT VEHICLE DISTRIBUTING THE LOAD OVER SEVERAL SPANS

Most truckers try to avoid making their vehicle configuration any longer or wider than necessary. This is because the longer and/or wider their vehicle is, the more difficult it is to maneuver and make the needed turning movements to get to their destination. Sometimes a trucker will submit a revised vehicle configuration after they have already received approval for their permit, because they discovered during their trip preparations that they cannot make a required turning movement with their original vehicle configuration.

AN OVER-DIMENSIONAL PERMIT VEHICLE NEGOTIATING A TURNING MOVEMENT

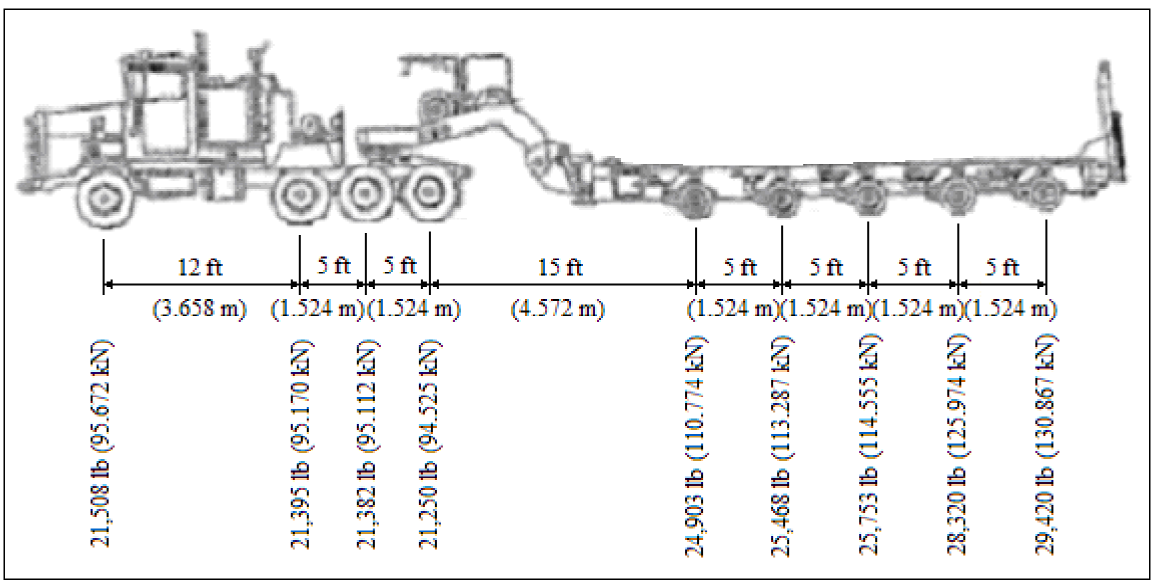
Ultimately, if a trucker is unable to provide a vehicle configuration that the load rating engineer can confirm will not overload any of the bridges on their requested route, their permit will be denied. Some truckers have then gone on to obtain other equipment that will better distribute their loads. Or they have used other modes of transportation such as railroad or barge to get the item as close as possible to its destination. They were then able to bypass most of the problem bridges. Some truckers have hired an engineering consultant to provide a shoring design to temporarily support problem bridges, or even designed temporary structures for their vehicle to use.

<u>Vehicle Configurations that Exceeded Oregon Weight Tables</u>

Vehicle configurations that exceed the Weight Tables are large pieces of equipment or items that cannot be divided into multiple smaller loads. These loads can range from construction equipment such as excavators and large cranes to fabricated components such as a bridge girder, submarine propeller, or electrical transformer.

Some permit loads are relatively light, but may not have many axles to distribute the load. For example a 34,000 lb (151.24 kN) empty bus on 2 axles that was manufactured outside of Oregon and was being delivered to a city within the State exceeded the Weight Tables. Buses are exempt from having to meet the legal axle weights when operating within their local jurisdiction. But since it was in transit to be delivered, the owner had to apply for a permit for it to drive on the Oregon Highways.

Other permits can be fairly heavy and compact. A recent permit application that ODOT's Load Rating Engineers recommended to be denied was for the National Guard to transport a piece of military equipment to different armories within Oregon. The proposed vehicle configuration as provided by the National Guard is shown below.



PROPOSED VEHICLE CONFIGURATION TO TRANSPORT MILITARY EQUIPMENT

The National Guard wanted to use their own apparatus to transport the military equipment, but the proposed vehicle configuration is too compact for the amount of load that they want to move. Axles 5 through 9 are only spaced at 5ft (1.524 m) centers and carry a load of 133,864 lb (595.457 kN). This vehicle produces load effects that are up to 43% greater than the heaviest standard permit vehicles that Oregon uses in bridge load ratings. A different vehicle configuration, with more axles spread over a longer distance, will be required for the National Guard to transport their equipment on Oregon's Highways.

In 2005 Oregon started receiving permit applications to move components to build the first of many wind turbine farms in Eastern Oregon and Washington. For most wind farms that are being built in Oregon and Washington, the components are manufactured in another country and are shipped to ports in Longview and Vancouver Washington. The components then have to be loaded onto trucks and are transported on Oregon Highways through the Columbia River Corridor to Eastern Oregon and Washington.

The trucking company that was awarded the contract for this first wind farm had 85 days to deliver 83 complete wind turbines to the project site that was 291 miles (468.3 km) from the port. Each completed wind turbine required 9 separate truck loads to deliver the components. Most of the components are able to be transported on equipment that meets the weight tables, thus requiring over-dimensional permits due to their size only.

One of the wind turbine components is very heavy and exceeds the Weight Tables, which in turn requires the bridges on the route to be analyzed by a load rating engineer. The component is a nacelle that houses all of the generating components in a wind turbine, including the generator, gearbox, drive train, and break assembly. Depending on the equipment being used to transport the nacelle, the vehicle configuration can weigh anywhere between 245,000 lb (1,089.8 kN) to 420,000 lb (1,868.3 kN) and have from 9 to 19 axles. The photo below shows a nacelle being loaded on a vehicle.

WIND TURBINE NACELLE BEING LOADED ON A VEHICLE

Since there are so many of these loads travelling on the same route, Oregon Motor

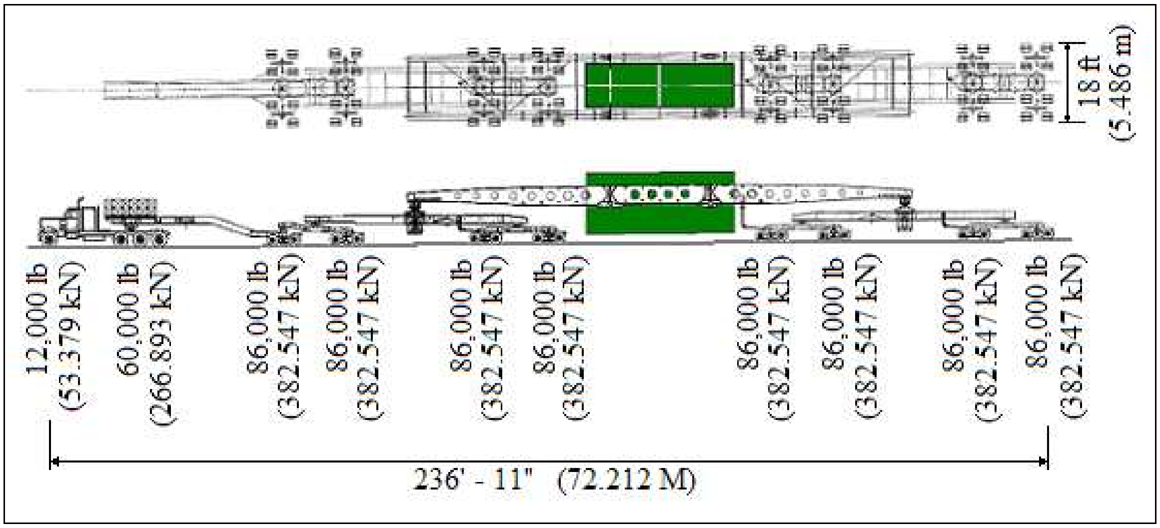
Carrier Transportation Division will issue several Single Trip Permits based on the same bridge analysis as long as the vehicle configuration (axle weights and spacing) and the route are the same. If either the route or the vehicle configuration changes slightly, ODOT's Bridge Load Rating Unit is required to perform a review of all of the bridges on the specified route for the proposed vehicle configuration.

Wind power accounted for 8.2% of total electricity generated in Oregon during 2011. Wind power capacity in Oregon has seen large growth in recent years and Oregon now ranks among the top ten states with the most wind power installed. In 2009 General Electric was awarded a $1.48 billion contract to build the Shepherds Flat Wind Farm. The 845-megawatt project will use over 300 turbines and will spread across 30 square miles (78 km^2) in north-central Oregon ("Wind power in Oregon", 2012).

STAGING AREA FOR WIND FARM CONSTRUCTION

With the continued construction of wind farms in Oregon, there has been an increase in permit loads with the nacelles and other wind turbine components, but there has also been an increase in permit loads to transport other items that are a result of the wind farms. ODOT's Load Rating Unit has had to perform permit reviews to haul large cranes and earth moving equipment to and from the wind farms sites. There has also been a large increase in the delivery of electrical transformers near the wind farm sites to connect the power generated to the electrical grid.

Electrical transformers are the heaviest of all over-dimensional permit loads that the ODOT Load Rating Unit has had to review. On average, the vehicle configurations for these loads have a gross vehicle weight of 490,000 lb (2179.6 kN) and use between 9 and 24 axles depending on the weight. The heaviest transformer load that Oregon has reviewed had a gross vehicle weight of 864,708 lb (3846.4 kN) on 22 axles. The following illustration shows a common vehicle configuration that is used to transport an electrical transformer.



VEHICLE CONFIGURATION FOR AN ELECTRICAL TRANSFORMER

The following table shows the number of electrical transformer permit reviews that ODOT's Load Rating Unit has performed since 2001. A correlation can be seen between the increase in the number of transformer moves per year and the growth in wind turbine farms.

TRANSFORMER PERMIT REVIEWS PER YEAR

Year	Number of Transformer Loads
2001	7
2002	1
2003	0
2004	0
2005	1
2006	3
2007	19
2008	14
2009	15
2010	22
2011	34

Conclusion

Bridge Load Rating plays an important part in Oregon's over-dimensional permitting process. By including routine legal and permit vehicles in the load rating analysis for every bridge, the Oregon Department of Transportation can maintain a

“Restricted Bridge List” that Oregon’s Motor Carrier Transportation Division uses to approve thousands of permit applications that meet the Oregon Weight Tables. When a permit application exceeds the Oregon Weight Tables, the vehicle configuration (axle weights and spacing) and requested route information are sent to ODOT’s Bridge Load Rating Unit were the proposed vehicle is analyzed for every bridge on the requested route.

There are different tools that the bridge load raters use to help determine which bridges on the requested route may provide problems for the proposed vehicle. The bridge load rating engineer has different strategies available to use to minimize the load effects from the proposed vehicle on a given bridge. These strategies range from modifying the distribution of load based on the out-to-out axle spacing of the vehicle, requiring the truck to drive in a specific location while crossing the bridge, and reducing the vehicle speed.

The frequency of permit reviews that exceed the Oregon Weight Tables appears to be increasing at a yearly rate. The development and growth of the wind turbine industry in Oregon and Washington is just one factor that is driving the increase in over-dimensional permit loads in Oregon.

As stated in the beginning of this paper, while our goal is to maintain freight mobility and economic development, we also have the responsibility to protect taxpayer’s investment and maintain public safety by making sure our bridges are not damaged by over-dimensional permit loads.

References

Wind power in Oregon. (2012). Retrieved September 12, 2012, from http://en.wikipedia.org/wiki/Wind_power_in_Oregon