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# Protecting Bridges from Earthquake Damage

Peter Dusicka
*Portland State University*

OTREC
OREGON TRANSPORTATION RESEARCH AND EDUCATION CONSORTIUM

P.O. Box 751
Portland, OR 97207-0751
Phone: (503) 725-2843
Web site: http://otrec.us
Email: askotrec@otrec.us

# PROTECTING BRIDGES FROM EARTHQUAKE DAMAGE

*Research helps develop bridge retrofit strategies for the Oregon Department of Transportation, to minimize costly damage in the event of an earthquake.*

## The Issue

Earthquake damage to bridges can have serious effects on a transportation network. When a bridge is out, the damage can go well beyond what is immediately visible: in addition to the cost of repairing it, the state must deal with short-term and long-term interruptions to traffic. These interruptions can delay repair and construction, as well as impacting post-earthquake emergency response and causing the loss of valuable time for commuters and freight. To prevent this situation, older bridges (ones that are past an average construction life of about 50 years) should be retrofitted with stronger materials, especially in earthquake-prone areas. The problem facing researchers was how to determine which bridges in Oregon should be retrofitted first.

## The Research

The goal of the study, led by Peter Dusicka of Portland State University, was to come up with an intelligent way to know which bridges to retrofit first: how they should be prioritized to minimize damage and cost. The research team's task was to identify which bridges were the most strategically important (if certain key bridges were out, it would be especially disastrous because there are no alternate routes to handle their traffic) and which were most vulnerable to earthquake damage (some are in areas of higher seismic activity than others).

Their efforts were part of an ongoing endeavor known as Seismic Risk Analysis (SRA). SRA is performed all over the world by earth scientists, geotechnical and structural earthquake engineers, transportation engineers and planners, and economists. The practice is designed to help anticipate the consequences of future earthquakes, and to form plans and strategies for reducing risk.

SRA has been developed and refined since the 1970's, and the scope of it continues to get larger as new methods are created to address specific needs. The Federal Emergency Management Agency (FEMA) and the Federal Highway Administration (FHWA) have developed

### THE ISSUE
The Cascadia Subduction Zone presents an earthquake threat. The Oregon Department of Transportation, or ODOT, must use its resources to effectively maintain bridges against seismic activity.

### THE RESEARCH
This project focuses on the development of a virtual model of Oregon's highways. The model:

- Digitally replicates Oregon's system of highways and bridges;
- Can be used to test the effects of varying levels of earthquakes on those structures;
- Was developed for the purpose of helping ODOT prioritize the retrofitting of its bridges.

### THE IMPLICATIONS
Good retrofit strategies can minimize the impact of earthquake damage by helping to assure that vulnerable bridges are reinforced before the highway is likely to be disrupted.

*Photo: Bridge that is a candidate for seismic retrofitting.*

software for using SRA to assess highway systems. They use a geographic information system (GIS) to visually manipulate and display a model of the roads and bridges in any given area, and to simulate the effects of various types of earthquakes.

The software that Dusicka and his team used in this study, developed by the FHWA, was REDARS2: Risk for Earthquake Damage to Roadway Systems. In 2008, Dusicka used the software to create a GIS model of Oregon's state highway and bridge network. In this project, several improvements were made to that research and a more complete model was developed. This computerized GIS model allowed researchers to test the impact of different types of earthquakes upon the functionality of the road network.

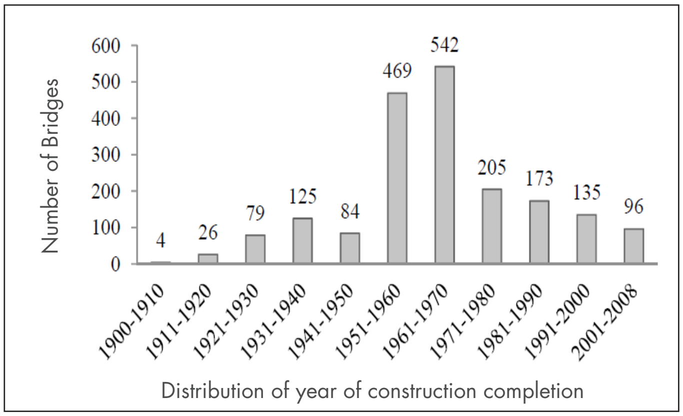
The risk associated with earthquake hazards on highway systems is largely dependent on the complexity and redundancy of a network in providing smooth traffic flow. It is important to understand how the system works as a whole, in order to predict how severe earthquake repercussions will be. Identifying which bridges were the most important and how the transportation grid would function without them was the primary objective of using this method.

## Implications

The Oregon Department of Transportation, or ODOT, owns and maintains just over 2,600 bridges. Approximately one-fifth of them are beyond the 50-year construction life. This project focused on developing a computer model, using seismic risk assessment software, to help ODOT determine which of its bridges were under the largest threats from earthquake damage.

The model was then used to analyze Oregon's highway network, resulting in recommendations toward bridge retrofit strategies for ODOT. The next step in model development will be to include a more enhanced transportation network beyond highways, to include county-owned bridges, and eventually to encompass the entire state of Oregon.

Having access to the predicted effects of various types of earthquakes upon specific bridges, based on each bridge's structural information and its position within the highway grid, stands to help ODOT make informed decisions about how to proactively reinforce the bridges on Oregon's highways.




**Graph showing how many bridges were completed during each decade.**

As shown here, 787 of Oregon's bridges were completed prior to 1960. This puts them beyond the ideal 50-year construction life, meaning they are due for a retrofit. It is important to prioritize the retrofitting according to need.

**PROJECT INFORMATION**

TITLE: Seismic Hazard Assessment of Oregon Highways

INVESTIGATORS: Peter Dusicka, Ph.D., Portland State University; John Gliebe, Ph.D., Portland State University

PROJECT NUMBER: 2009-270

CONTACT:
Justin Carinci, 503-725-2843
carinci@otrec.us

MORE INFORMATION
*http://otrec.us/project/270*