2020-05-28

Seismic Hazard Assessment of Oregon: Analysis of Earthquake Resilience within State Wide Infrastructure and the Cost of Retrofitting

Curt Knott
Western Oregon University, cknott16@wou.edu

Seismic Hazard Assessment of Oregon: Analysis of Potential Earthquake Damage Compared to the Cost of Retrofitting

Curt Knott
Western Oregon University
Department of Earth and Physical Science

Western Oregon UNIVERSITY
Geology & Earth Science

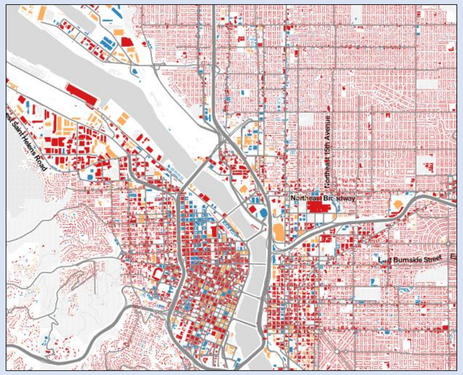
Introduction:

Earthquakes are a imminent threat looming over the Pacific Northwest. Infrastructure within states and cities that reside there must be properly constructed or retrofitted to withstand these potential earthquakes. Oregon and Washington are the 2 state that are at highest risk for a Juan De Fuca subduction zone earthquake. In these regions, many companies have decided to go into earthquake retrofitting, or making infrastructure resistant to earthquakes. However, many earthquake prone areas have neglected to upgrade their buildings or have been otherwise lax on policies that require heightened infrastructure stability.

Portland is one such city. Over 80% of the city was built before the first Seismic building codes where enacted in 1993, and there has been no sign that the older structures have been prepared for such an event. The cost of retrofitting the entire city will be compared to damage estimates if an earthquake occurred now.

Not only buildings, but bridges are also at risk of collapse. According to Oregon State University, 57 of the 60 Bridges within 10km of the coast in Lincoln County will be completely destroyed or damaged in the event of a large earthquake. This doesn't only carry financial issues, this also has the potential to make it impossible for emergency response to assist the people in these isolated areas.

Figure 1.1 (right): A map of Portland showing buildings built before the first state wide seismic building code (orange) and before general state wide building codes (red). Note that this does not include bridges.



Data (Buildings):

For this study, all enterable, enclosed buildings (this excludes archways, fountains, powerlines, etc.). The numbers below where derived from Emporis' data on Portland infrastructure.

Table 1.1 (below): Shows the calculated percentage of buildings built before 1993

Building type	Total buildings	Total before 1993	% before 1993
Skyscrapers	11	7	63.64
High-Rise	156	83	53.21
Low-Rise	887	773	87.15
Other	69	64	92.75
Total	1123	927	80.55

- Cost of Retrofitting (Low-rise) = 3% or $10/ft^2 (Home Advisor)
- Cost of Retrofitting (skyscraper & high) = 3% (Seattle Times)

Data (Bridges):

For bridges, data from Oregon State University's O-Help map program was used to asses all bridges within 10km of the coastline in a single coastal county in Oregon. Lincoln County has one of the longest coastlines in Oregon, and the following was estimated damage for a magnitude 9.0 earthquake.

Bridge Condition	Number of Bridges
Destroyed (unusable)	56
Damaged (unsure)	1
Undamaged (usable)	3
Total	60

Table 1.2 (left): The table shows estimated degree of damage for bridges within 10km of the coast. Note, bridges in Portland are currently considered to be totally unusable after the event,

- Average Cost of Retrofit: 7.34% total cost (ODOT)

Discussion:

With this data, the following information was derived (for exact information, see calculations).

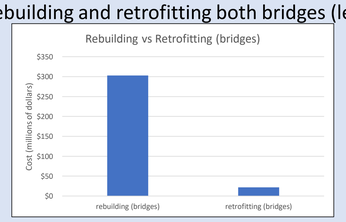
The first thing that comes to everyone's mind is the cost. Well, Portland's current estimated cost of repair is $37 billion (DOGAMI). The estimated cost to retrofit all of Portland's pre 1993 buildings is $866 million. Which means that the cost of retrofitting is almost 50 times less expensive than waiting for an earthquake to hit and fixing the aftermath.

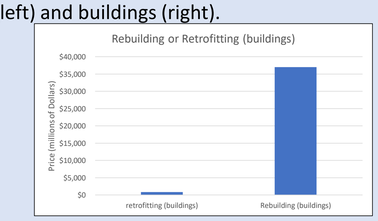
The next question is how long it would take to complete the retrofitting project. This was calculated to take about 4-6 years (see calculations). There is no data for how long it would take to recover Portland from an earthquake. But given that many of its buildings are not earthquake safe, it is likely that it could take decades.

Bridges showed a similar trend. The retrofitting of bridges costs significantly less than the cost of rebuilding. Lincoln counties bridges have a total reconstruction cost is estimated to be $303,000,000 (OHELP). Retrofitting estimates are at almost a tenth of that, totaling $22,240,200.

Total reconstruction of bridges in Lincoln county would take a very long time, and might not even be possible if access is hindered. Not only that, the 3 major highways that lead inland all have bridges that would be destroyed on the, making it impossible to drive inland for safety. However, the time it takes to secure the bridges from earthquakes is only 2-3 years.

Figure 1.2 (below): The two graphics below show the difference in cost between rebuilding and retrofitting both bridges (left) and buildings (right).





Calculations:

- Total cost of retrofitting (bridges) = .0734 x Total cost of bridges = $22,240,200
- Time for retrofitting (bridges) = 2 weeks x Total number of bridges = 120 weeks
- Average height of buildings in Portland was derived from the line of best fit of figure 1.3. This height was added together and divided by the total number of buildings to give an average building size (91 ft). This was then divided by the average height for a floor to find the average number of floors for the buildings in Portland. This was then multiplied by the average ft^2 for ground area (16,670ft^2). This gave average ft^2 of Portland's buildings. (100,400ft^2).

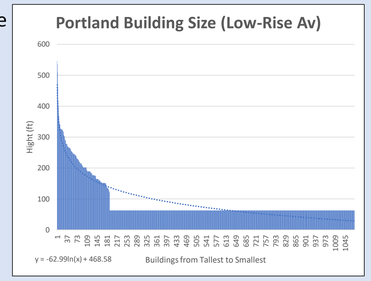


Figure 1.3 (top right): The High-rise, Skyscrapers, and low-rise buildings (average) plotted from largest (left) to smallest (right). The line of best fit is a logarithmic formula that has an R^2 of .8138. Formula bottom left of the figure.

Conclusion:

The cost of reconstruction completely overwhelms the cost of retrofitting. As such, it is far more economically friendly to retrofit the structures. Not only that, but it is far safer for people living in those areas to have infrastructure that is safe to use and reside in. This is doubly so for the coastal regions that will be hit by not only the earthquake, but also a subsequent tsunami. The bridge failure issue has been talked about for a long time, and so has the Portland structure issue. These issues must be resolved, or potentially thousands to tens of thousands could perish in the aftermath of the next major Cascadia Subduction Zone earthquake.

References:

Doughton, S. (2018, December 21). What if the megaquake happens when you're in a Seattle high-rise? New study predicts stronger shaking. Retrieved May 27, 2020, from https://www.seattletimes.com/seattle-news/science/how-safe-are-seattles-high-rises-new-study-predicts-stronger-earthquake-shaking/

GmbH, E. (n.d.). Portland, OR. Retrieved May 27, 2020, from https://www.emporis.com/city/101329/portland-or-usa

HELP. (n.d.). Retrieved May 27, 2020, from http://ohelp.oregonstate.edu/

https://www.oregon.gov/ODOT/Programs/ResearchDocuments/SRS500_480_FinalReport.pd

Learn how much it costs to Earthquake Retrofit a Home. (n.d.). Retrieved from https://www.homeadvisor.com/cost/environmental-safety/earthquake-retrofit-a-home/