

Activity—Types of Pacific NW Earthquakes & the BOSS Model:

The Violence of Ground Shaking Caused by 3 Types of Earthquakes

Building failure doesn't just have to do with the magnitude of an earthquake.

(See previous BOSS model activity to learn about resonance and buildings during earthquakes.)

The BOSS Model helps students understand that different size and shape buildings have different “resonant frequencies”. In general, small buildings (e.g. single-family homes) will be shaken more violently by short-period ground shaking with the ground oscillating back and forth every one or two

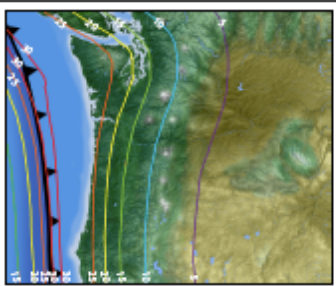
seconds. This short-period ground shaking is a characteristic of earthquakes on crustal faults, like the Seattle or Portland Hills Faults. The ground-shaking maps for these earthquakes show that the ground will shake very violently in areas near the epicenter of a crustal earthquake. Small structures, like single-family

Science Standards (NGSS; pg. 287)

- Motion and Stability—Forces and Interactions: HS-PS2-1, MS-PS2-2
- Energy: MS-PS3-1, MS-PS3-2, HS-PS3-2, MS-PS3-5
- Waves and Their Applications in Technologies for Information Transfer: MS-PS4-1, HS-PS4-1, MS-PS4-2
- Earth's Systems: HS-ESS2-2
- Earth and Human Activity: HS-ESS3-1, MS-ESS3-2
- Engineering Design: HS-ETS1-1, HS-ETS1-3

The Violence of Ground Shaking Caused by 3 Types of Earthquakes

1) Magnitude 9.0, Subduction Zone Earthquake



SEISMIC ZONE QUALITY

Position challenges include: American Cascades fault, Puget Sound earthquake, Seattle fault, Tacoma fault, Olympia fault, Gig Harbor fault, Duwamish fault, Rainier fault, Seattle fault, Tacoma fault, Olympia fault, Gig Harbor fault, Duwamish fault, Rainier fault.

Frequency spectrum: High frequency (1-10 Hz) is dominant. Shaking intensity is high near the epicenter and decreases rapidly with distance.

SEISMIC INTENSITY AND STRUCTURAL DAMAGE

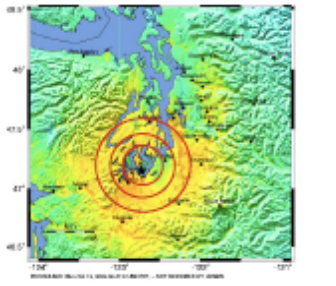
Resonance length: 1 to 10 seconds. Shaking intensity is high near the epicenter and decreases rapidly with distance.

Non-damage risks by building type: Wood-frame houses, brick masonry, masonry chimneys, unreinforced masonry walls, unreinforced concrete walls, unreinforced concrete floors, unreinforced concrete roofs, unreinforced concrete foundations, unreinforced concrete foundations.

Structural damage: Wood-frame house (minor damage), brick masonry (cracked), unreinforced masonry walls (cracked), unreinforced concrete walls (cracked), unreinforced concrete floors (cracked), unreinforced concrete roofs (cracked), unreinforced concrete foundations (cracked).

This map shows average 10% damped acceleration (PGA) for various sizes of the strength of shaking. Specific values may be higher at lower PGA, and significantly more at low damage. Size and building type will affect damage and amount of damage every group has.

2) Magnitude 7, Deep Earthquake



SEISMIC ZONE QUALITY

Position challenges include: Puget Sound earthquake, Seattle fault, Tacoma fault, Olympia fault, Gig Harbor fault, Duwamish fault, Rainier fault, Seattle fault, Tacoma fault, Olympia fault, Gig Harbor fault, Duwamish fault, Rainier fault.

Frequency spectrum: High frequency (1-10 Hz) is dominant. Shaking intensity is high near the epicenter and decreases rapidly with distance.

SEISMIC INTENSITY AND STRUCTURAL DAMAGE

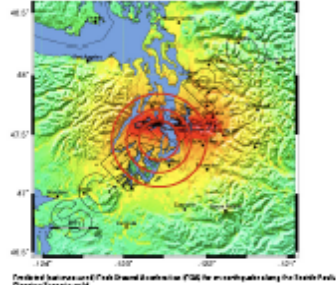
Resonance length: 1 to 10 seconds. Shaking intensity is high near the epicenter and decreases rapidly with distance.

Non-damage risks by building type: Wood-frame houses, brick masonry, masonry chimneys, unreinforced masonry walls, unreinforced concrete walls, unreinforced concrete floors, unreinforced concrete roofs, unreinforced concrete foundations, unreinforced concrete foundations.

Structural damage: Wood-frame house (minor damage), brick masonry (cracked), unreinforced masonry walls (cracked), unreinforced concrete walls (cracked), unreinforced concrete floors (cracked), unreinforced concrete roofs (cracked), unreinforced concrete foundations (cracked).

Let your 10% damped acceleration (PGA) for various sizes of the strength of shaking. Specific values may be higher at lower PGA, and significantly more at low damage. Size and building type will affect damage and amount of damage every group has.

3) Magnitude 7, Shallow Crustal Earthquake



SEISMIC ZONE QUALITY

Position challenges include: Puget Sound earthquake, Seattle fault, Tacoma fault, Olympia fault, Gig Harbor fault, Duwamish fault, Rainier fault, Seattle fault, Tacoma fault, Olympia fault, Gig Harbor fault, Duwamish fault, Rainier fault.

Frequency spectrum: High frequency (1-10 Hz) is dominant. Shaking intensity is high near the epicenter and decreases rapidly with distance.

SEISMIC INTENSITY AND STRUCTURAL DAMAGE

Resonance length: 1 to 10 seconds. Shaking intensity is high near the epicenter and decreases rapidly with distance.

Non-damage risks by building type: Wood-frame houses, brick masonry, masonry chimneys, unreinforced masonry walls, unreinforced concrete walls, unreinforced concrete floors, unreinforced concrete roofs, unreinforced concrete foundations, unreinforced concrete foundations.

Structural damage: Wood-frame house (minor damage), brick masonry (cracked), unreinforced masonry walls (cracked), unreinforced concrete walls (cracked), unreinforced concrete floors (cracked), unreinforced concrete roofs (cracked), unreinforced concrete foundations (cracked).

Crustal faults are not Puget Sound distribution (PGA) for an earthquake along the Seattle fault. Shaking intensity is high near the epicenter and decreases rapidly with distance.

EXPLANATION FOR COLORS ON THE MAPS

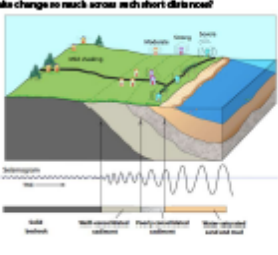
MAP 1: High (red) to low (purple) peak ground accelerations (PGA)

MAP 2 & 3: Same as MAP 1

What is acceleration? You are held to the Earth with a force that is equal to your mass times the acceleration of gravity. The number 100 (not shown here) indicates ground shaking that can produce acceleration exceeding the Earth's gravity. This would mean that stones and people can be thrown into the air.

Why does the intensity of an earthquake change so much across such short distances?

How seismic waves shake the ground during an earthquake depends on the geologic layering. The figure below shows how an earthquake wave going through solid bedrock has high frequency and low amplitude. When the waves go through weaker material, they oscillate with higher amplitude but lower frequency. Imagine dropping a rock on concrete and recording the vibration compared to dropping a rock on a trampoline or a mattress.



This poster is on this DVD in the folder called:

5. Maps & Posters

> **EarthquakeScenarioPoster_SeattleNisqually.pdf**

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homes, would sustain significant damage, if located near the epicenter. Thus single-family houses are analogous to the short block of the BOSS model.

An additional important characteristic of earthquakes on crustal faults is that ground shaking will last for only about 10 to 20 seconds. Generally speaking, this short duration of ground shaking means large structures will not oscillate nearly as much as they would if the ground shaking lasts for a longer time interval. Thus, large structures are analogous to the tall block of the BOSS model that does not oscillate very much when you shake the BOSS model so that the short block oscillates in large swings. Larger buildings (e.g. sky scrapers and bridges) will be shaken more violently by long-period ground shaking in which the ground oscillates back-and-forth every ten or twenty seconds.

Surface waves from a great Cascadia Subduction Zone earthquake will oscillate the ground with periods of 10 to 20 seconds. *PLUS*, the duration of ground shaking will be four to six minutes! Thus large structures experiencing ground oscillations produced by a great Cascadia Subduction Zone earthquake are analogous to the tall block of the BOSS model. The combination of long-period and long-duration ground shaking caused by a great Cascadia Subduction Zone earthquake will excite even very large structures into violent shaking that will last for several minutes. Large amplitude oscillations lasting several minutes are bad news for large structures. Engineering bridges and large buildings to withstand such ground shaking is a major engineering challenge!