Earthquake - Seattle Fault

An earthquake is a naturally induced shaking of the ground. Earthquakes are caused by the fracture and sliding of rock within the earth's crust. The earth's crust is divided into eight major pieces (or plates) and many minor plates. These plates are constantly moving, very slowly, over the surface of the globe. As these plates move, stresses are built up in areas where the plates come into contact with each other. Mercer Island can be vulnerable to three types of earthquakes: deep plate from Juan De Fuca (Oceanic) sinking below the shallow North American (Continental) Plate, shallow earthquakes which include the Seattle Fault upon which Mercer Island sits and subduction off the coast (Cascadia).

Deep Earthquakes. **Deep** earthquakes occur within the subducting Juan De Fuca Plate as it bends beneath the continental plate. These deep earthquakes are approximately 25 – 100 kilometers (approximately 30 miles or greater) in depth with magnitudes up to 7.5[1] and could last 15 – 30 seconds of strong shaking. Due to their depth, aftershocks are typically not felt in association with these earthquakes. History indicates that these earthquakes do not occur east of the Cascade Mountains.

Shallow Earthquakes. **Shallow** (crustal) earthquakes occur within the North America plate. This type of earthquake has occurred throughout Washington, and most parts of Oregon. These earthquakes are primarily shallow with depths of less than 30 Kilometers (<15 miles) and less than 8 in magnitude.

Subduction Earthquakes. **Subduction** earthquakes occur along the Cascadia Subduction Zone, as a direct result of the convergence of these two plates. It lies 50 miles offshore and extends from the middle of Vancouver Island in British Columbia in a southerly direction past Washington and Oregon stretching to Northern California. Although no large earthquakes have occurred along the offshore Cascadia Subduction Zone since historic records began in 1790, similar subduction zones worldwide do produce "great" earthquakes – magnitude 8 plus and 20 miles or less in depth. A subduction earthquake would be centered off the coast of Washington and Oregon where the plates converge. Such earthquakes typically have a minute or more of strong ground shaking, and are quickly followed by damaging tsunamis and numerous large aftershocks.

History and Probability of Occurrence. Each year over one thousand earthquakes are recorded in Washington State. Fifteen to twenty of these earthquakes are strong enough to be felt.

Deep earthquakes within the Juan De Fuca plate are believed to occur every 30 years. They generally last 15-30 seconds and have the potential of reaching 7.5 on the Richter scale. Three caused significant damage in western Washington, the 1949 Olympia (magnitude 7.1, 54 km deep), the 1965 Seattle-Tacoma (magnitude 6.5, 57 km deep) and the 2001 Nisqually (magnitude 6.8, 52.4 km)

[1] USGS (www.ess.washington.edu/SEIS/PNSN/Cascadia EQs.pdf)

earthquakes, which occurred within the Juan De Fuca plate. Approximate recurrence intervals for these types of earthquakes of various magnitudes are estimated to be 35 years for magnitude 6.5 and 110 years for magnitude 7.0.[2]

The most recent, the 2001 Nisqually Earthquake measuring 6.8 was a deep earthquake originating thirty miles below the surface of Nisqually National Forest near Olympia. It caused significant damage throughout the King County Region. FEMA records indicate King County had $6.5 million in uninsured home damages alone. The SBA initiated $42.5 million in loans for both home and business owners.[3]

Shallow earthquakes occurred in 1872 (magnitude 6.8 – 7.3) in the North Cascades, 1918 (magnitude 7.0) Vancouver Island, and 1946 (magnitude 7.4) Vancouver Island. Additionally, recent studies have found geologic evidence for large (magnitude 7 or more) shallow earthquakes along the Seattle Fault 1,100 years ago within the central Puget Sound Basin. Massive block landslides into Lake Washington, marsh subsidence and tsunami deposits at West Point in Seattle, tsunami deposits at Cultus Bay on Whidbey Island, and large rock avalanches on the southeastern Olympic Peninsula have all been dated to approximately 1,100 years ago.[4]

Subduction earthquakes are huge "great" quakes magnitude 8 or larger that result when the oceanic and continental plate's rupture, with 1 – 3 minutes shaking expected. These earthquakes occur every 300 – 500 years. In 1700, 300 years ago, the most recent Cascadia Subduction Zone earthquake sent a tsunami as far as Japan. The Alaskan earthquake of 1964 was a 9.2 earthquake and shook for nearly six minutes.

Potential Impact and Vulnerability. Mercer Island I-90 Bridges sit on the Seattle fault. Evidence from high resolution seismic reflection photographs show land course changes under and within 4 km of the I-90 and East Channel bridges. The fault is a surface transversal fault line and spans an area through Seattle, Mercer Island and Bellevue following the I-90 corridor with a width of approximately 5 km. [5] During the 2001 Nisqually Earthquake the bottom of Lake Washington turned over causing the lake to cloud for a period of 20 minutes or more[6].

Time, location, magnitude and depth of an earthquake will greatly affect the vulnerability of cities within the fault area. The portion of land that is soft, including sandy, clay-like and artificial fills makes it susceptible to ground shaking. These areas have potential liquefiable based soil type and ground surface settlement due to earthquake induced ground motions.

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[2] McDonald, Terrance J, "Earthquakes", Seattle: A Hazard Identification and Vulnerability Analysis, Master's Thesis, Cornell University, 1995, p107.
[3] Ten Year State/County Report prepared by SBA through June 24, 2002.
[4] University of Washington Seismology Lab, Earthquake Hazards in Washington and Oregon, May 13, 1994
[5] Cascadia Regional Earthquake Workgroup web site www.crew.org
[6] Mercer Island Marine Patrol

Building materials will greatly affect the impact of an earthquake on a structure; masonry structures that are not reinforced are the most vulnerable while wood frame structures typically perform well in earthquakes. Additionally, individual buildings have different natural frequencies of vibration that depend on their height and structural design, amplification may affect some buildings more than others. Strong shaking is a hazard both near the epicenter of an earthquake and in areas where amplification occurs.

The effects of an earthquake could also vary widely by the buildings and infrastructure first damaged. Damage to buildings that house emergency services such as fire stations, medical clinics and hospitals could lessen emergency response capabilities. Breaks in the street and bridge network can also impair the delivery of emergency services.

The potential coexistence of other secondary disasters with earthquakes, such as fires, hazardous materials releases, ground failures, landslides, liquefaction, tsunamis and seiches add to the difficulty in predicting losses.

Secondary Impacts from Earthquake

Many secondary natural hazards may be triggered by an earthquake, including:

1. Liquefaction and subsidence of soils.
2. Landslides impacting transportation, homes, and public infrastructure.
3. Seiche or sloshing water impacting shoreline developments.
4. Fires from gas pipeline ruptures.
5. Fires from major liquid fuel pipeline ruptures.
6. Flooding from major water pipeline ruptures.

The severity of soil-related natural hazards and ground failure phenomena often depends on status of groundwater, rainy seasons and drought conditions.

Potential manmade hazards related to an earthquake event include:

1. People stranded if transportation or other lifeline networks fail.
2. Chimneys, bricks, unsupported fascia, trees, displacement of buildings, bridges, and non-reinforced structures.
3. Elevated concrete or brick walkways.
4. Cracks in roads could cause accidents and or blockages.

Potential systems vulnerabilities include:

1. Business interruption and resulting losses in sales, wages, and profits.
2. Impacts to local economy if economic processes break down.