Earthquakes

How will Seattle's landscape be affected by the next big earthquake?

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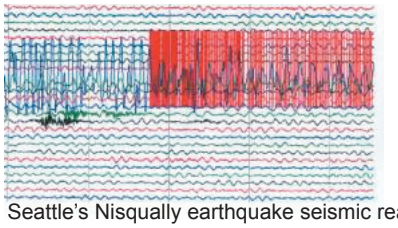


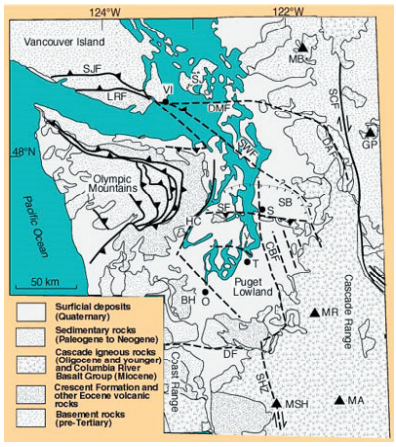
Seattle's Nisqually earthquake seismic readings
http://www.glaciercaves.com

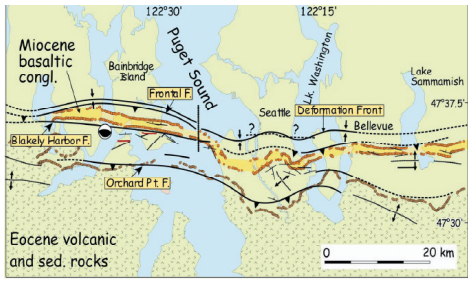
Seattle's dramatic and breathtaking landscapes, from the mudflats and marshlands, to the shoreline bluffs, to the surrounding majestic mountain ranges, are in large part a result of our dynamic underpinnings. Seattle is located at one of the earthquake-hotspots in the already seismically-active Cascade region.

GEOGRAPHY and GEOLOGY

Earthquakes and seismic events in the greater-Seattle region are a result of several separate local processes. These tectonic arrangements cause earthquakes in the Puget Sound region from three primary sources. First, the subducting process at the Cascadia Subduction Zone creates subduction zone quakes. Second, within the subducting Juan de Fuca plate, intraplate quakes may arise. Finally, and perhaps most relevant to the greater-Seattle region, the overriding North American plate is prone to shallow crustal earthquakes. Shallow crustal earthquakes are the most disturbing and dramatic for surface-inhabiting systems and members, as these originate with 20 miles of the surface.

Only recently (summer 2004), it has been found that six separate and parallel shallow fault zones run directly through the heavily urbanized and densifying Seattle region; this is know as the Seattle Fault Zone (SFZ). The last detected major event on the SFZ occurred 1,100 years ago, producing enough surface displacement to generate a tsunami, cause notable landslides, and uplift the southeastern coast of Bainbridge Island by 22 feet. This means that Seattle has the second highest risk of a major earthquake in the United States (behind California), and the question is not IF a major event will occur in the foreseeable future, but rather, WHEN.





Regional map of Cascadia faultlines (above); Seattle Fault Zone (below)
http://seattlescenario.eeri.org/documents.php

KOBE

The M6.9 earthquake to strike Kobe, Japan in 1995 was the first rigorous earthquake to hit the heart of a major city in a highly industrialized country. $200 billion in damage occured; 6,230 deaths; 40,000 injured; 102,000 buildings destroyed; 300 fires destroyed another 7,000 buildings, 300,000 homeless created; 85% of schools (centers for emergency service shelter and service distribution) were severely damaged or collapsed; widespread utility outages; transportation networks severely damaged.

The economic impacts of the disaster in Kobe reach far beyond the date of the disaster. Because of aging infrastructure and standing as a medium sized city, Kobe is still suffering. Before the earthquake, Kobe was the world's 6th largest port; damage to the port and transportation took nearly two years to complete, during which time many small or struggling businesses went under, and those who could afford to move their operations elsewhere did so. As a result Kobe is now the 17th largest port. Also, of the $100 billion in damage to business infrastructure, insurance only covered $1 billion.

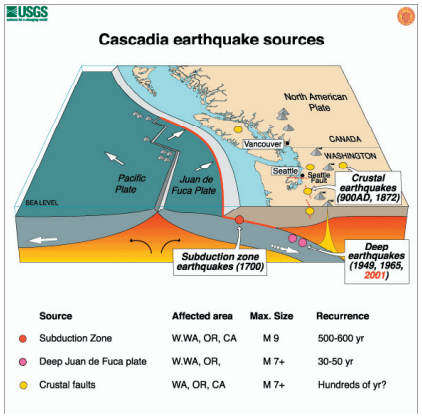
PHYSICAL FOUNDATION

The physical foundation of the city will experience ground failure by the expected earthquake in three primary manners: surface rupture, liquefaction, and landslide.

Surface rupture refers to the displacement of the ground surface when seismic energy is released. Such events cause major surface rupture, possible tsunami (if occurring on the seafloor), and seiching (smaller than a tsunami, refers to rocking of water in a small basin, leading to localized flooding).

Liquefaction occurs in soils and earth strata that are not dense or compacted. Upon large-scale seismic shaking, the particles in the earth quickly settle and densify, causing the ground surface to loose structural integrity, and even migrate laterally. Regions in Seattle most prone to liquefaction are those with a history of fill: the Duamish riverbasin, the waterfront, Union Bay Natural Area, and the Stadium District/International District/Pioneer Square area.

Landslides occur when sheets of earth break with their structural connection to surrounding parcels. There were 100s of detected earthquakes resulting from the Nisqually earthquake; however, as it had been fairly dry in the weeks preceeding Nisqually, the situation would have been much amplified in both magnitude and frequency of events had the ground been heavy and saturated from recent precipitation.



http://geology.wr.usgs.gov

BUILT STRUCTURES: SYSTEMS AND STRUCTURES

ROADWAYS

Due to Seattle's geography and topography, most major transportation corridors run in a north-south direction, and all have heavy and aging infrastructural components (including trenched sections, elevated portions, bridges over waterways, etc). All six major roadways (Interstates 5, 405, and 90; state routes 99, 167, 520) will experience damage and partial closures from structural failure of both the built forms and underlying earth, lasting a few weeks to a few years.

The Alaska Way Viaduct is a particularly sensitive component. Constructed in 1953 and currently carrying twice its designed capacity, it nearly collapsed in Nisqually. Additionally, the Viaduct is structurally dependant on the aging seawall and sits on liquefiable soils. As major roadways will be at least partially impassable, smaller roadways will be forced to take on an increased load, and are expected to rapidly deteriorate under heightened intensity of use.

The Seattle Fault and Bainbridge Island uplift
http://seattlescenario.eeri.org/documents.php

The M6.9 earthquake to strike Kobe, Japan in 1995 was the first major earthquake to hit the heart of a major city in a highly industrialized country.

Damage from Kobe earthquake
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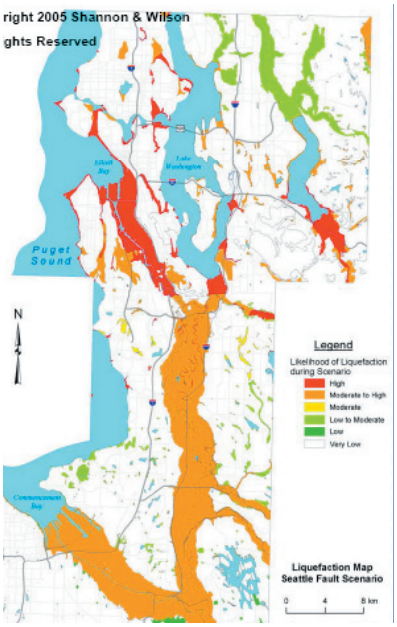
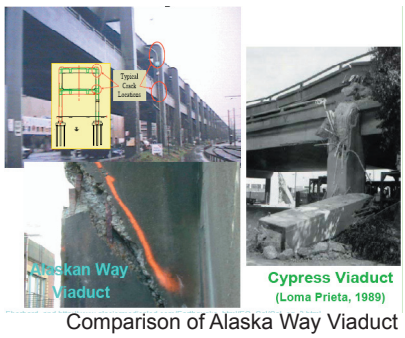


Map of Seattle's Liquifaction Zones
http://seattlescenario.eeri.org



Comparison of Alaska Way Viaduct consntruction and collapsed Cypress Viaduct in Northridge, California
http://seattlescenario.eeri.org

LIFELINES

The so-called 'life-lines' of Seattle are expected to suffer certain and possibly lasting damage. Life-lines include electricity, drinking water, wastewater, fuel transmission, and communications networks. Though with utilities generation and sources are generally located outside our immediate region, it is transmission of all life-lines that will be disrupted by the expected earthquake event. Many life-lines are dependant upon electricity (water pumping systems, mobile-phone towers, etc), and though the transmission network is described as robust, damage to sub-stations and transmission lines could prove significant. Of particular note is, again, the Alaska Way Viaduct. Much of the electricity for downtown Seattle is transmitted by infrastructure embedded in the Viaduct; the collapse of the Viaduct will disrupt transmission of electricity to one of the most densely populated portions of the city for up to several weeks.

BUILDINGS

In a projection of a M6.7 shallow surface crustal earthquake running through the heart of Seattle, conducted by Earthquake Engineering Research Institute and the Washington Military Department Emergency Management Division, it was found that half or more businesses in SODO, the International District, Pioneer Square, and the Elliot Bay Waterfront would be rendered uninhabitable, 20 percent of single and multi-family housing would experience moderate to extensive damage, 46,000 households will be displaced, and the Duamish Industrial region would experience devastating damage.

These figures are a result of both the structure of the underlying soils, and also the building stock. Unreinforced masonry (i.e. brick) structures are vulnerable due to lack of reinforcement and lack of adequate connections; this building form defined much of the historic Pioneer Square and International District neighborhoods. Reinforced concrete tilt-up structures, prevalent in the industrial Duamish region, often have missing or inadequate roof-wall ties, thus are quite prone to roof failure.

EMERGENCY RESPONSE

Emergency services following the next earthquake will be dependant on those structures that are likely the most damaged by the quake: transportation and lifelines. First responders must be able to organize, communicate, and move around the city to respond to the crisis. Communication, electricity, and structurally sound buildings will be important to dispense emergency services and shelter displaced and injured people. Harborview is the Seattle region's only level one trauma center; the southern gulf region's only one level-one trauma center is unable to reopen due to damage, and with half of the other medical facilities in operation, the dire medical situation is being exacerbated by decreased capacity for care.

HUMAN LAYER

The impact of this event will be enormous. The Seattle region is home to half the population of Washington State. Though many people think that Nisqually was "the big one," the risk of an event of much greater magnitude and impact is real. Also, the recent impact of Hurricane Katrina makes real the potential human impact when citizens and emergency responders are crippled.

In summary, this situation, though devastating and frightening, will likely become a reality for Seattle. It will be a disastrous event for the residents, businesses, and networks of this region, the impacts and recovery of which will be lasting. Our outdated networks of transportation and lifelines will cripple the city in function, response, and recovery. However, this leveling-event will also present great opportunities in the rebuilding efforts. Our heightened knowledge of appropriate construction methods and recognized need for more logically designed systems will be more easily implemented when done by necessity and need.

Resources

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