Understanding Earthquake Hazard and Earthquake Mitigation Strategies

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What is an earthquake?

Plate tectonics and other geologic processes cause pressure in the rock. Rock cracks and slips to relieve pressure in the rock. The movement on the fault creates vibrational (seismic) waves that radiate in all directions.

The crack starts at the earthquake focus. The final crack surface is the earthquake fault.
Where do earthquakes occur?

Most of the Earth’s earthquakes take place at the boundaries between the surface tectonic plates.
However, there are some earthquakes that take place within the middle of the plates, away from the plate boundaries.

1980 - 2001 (NEIC, m≥5)
Where do earthquakes occur in the U.S.?

Most U.S. earthquakes occur along the western plate boundary. However, some take place in the middle of the plate.

It takes in New England about 100-150 years of earthquake activity to equal the number of earthquakes in California in 1 year.
Earthquakes in the central and eastern U.S. are felt over a much larger area than earthquakes of the same magnitude in the western U.S. Similarly, there is a potential for damage over a much larger area in the central and eastern U.S.

Even though the seismicity rate in California is 100-150 times greater than in New England, the seismic hazard rate (probability of strong ground shaking per location) is only about 30 times greater in Los Angeles than in Boston.
On average, about 6 small earthquakes of $M \leq 3.5$ are felt in New England each year. Several thousand earthquakes have been recorded in New England and vicinity since 1975, the largest being $M 5.9$ in Quebec.
## Boston Earthquake Probabilities

<table>
<thead>
<tr>
<th>Magnitude</th>
<th>Mean Repeat Time (Years)</th>
<th>Date of Last EQ</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.0 or greater</td>
<td>53</td>
<td>1791?</td>
</tr>
<tr>
<td>5.5 or greater</td>
<td>142</td>
<td>1755</td>
</tr>
<tr>
<td>6.0 or greater</td>
<td>381</td>
<td>1755</td>
</tr>
<tr>
<td>6.5 or greater</td>
<td>1024</td>
<td>1638?</td>
</tr>
<tr>
<td>7.0 or greater</td>
<td>2752</td>
<td>????</td>
</tr>
</tbody>
</table>

These are the mean repeat times of an earthquake with an epicenter within about 200 km of downtown Boston.
The above plots show draft seismic hazard maps of the ground motion level that has a 2% chance of being exceeded in 50 years (2475-year mean repeat time).
What would happen in Boston if a large earthquake occurs?

Much of Boston and nearby areas are built on man-made land.

Soft soils (river and ocean sands and muds, landfill, etc.) can amplify the ground motions relative to nearby bedrock areas.
HAZUS ANALYSES OF ELEVEN SCENARIO EARTHQUAKES IN NEW ENGLAND

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Summary of Expected Losses

Economic: $3.4 billion
Injuries (fatalities): 245 (1)
Displaced households: 149
Households with no power: 29,038

1755 EQ estimated M 6.2 (Ebel, 2005)
Sample Plots: M5.8 Newburyport, MA Scenario

Estimated Building Inspection Needs and Ground Shaking Intensity

Earthquake Scenario: Magnitude 5.8
Date: May 2011 (USGS and FEMA)

- Red Tag (Complete Damage)
- Yellow Tag (Extensive Damage)
- Green Tag (Slight/Moderate Damage)
- 1 Dot = 25 Buildings (by census tract)

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Estimated Concrete, Steel Debris and Highway Damage and Ground Shaking Intensity

Earthquake Scenario: Magnitude 5.8
Date: May 2011 (USGS and FEMA)

1 dot = 1 thousand tons of Concrete and Steel Debris

Highway Damage

Instrumental Intensity

- Strong
- Moderate
- Small

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Estimated Building Economic Loss by Census Tract and Ground Shaking Intensity

Earthquake Scenario: Magnitude 5.8
Date: May 2011 (USGS and FEMA)

- 1 Dot = $500 Million

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Injuries Requiring Hospital Treatment 2 p.m. and Impaired Hospitals

Earthquake Scenario: Magnitude 5.8
Date: May 2011 (USGS and FEMA)

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Earthquake prediction is currently impossible. In all parts of the world, strong earthquakes occur without any recognizable precursory warning.

However, once an earthquake does occur, there is time for sensors near the epicenter to send warnings to localities farther away. These early-warning systems are now in development in Japan and California.