BRIEF OVERVIEW OF
SEISMIC HAZARDS FOR THE
ST. LOUIS METROPOLITAN AREA
for
New Madrid Chapter
Earthquake Engineering Research Institute
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Active Midwest Seismic Zones

- New Madrid Seismic Zone rediscovered in 1973 NRC study of West Memphis power plant
- Wabash Valley Seismic Zone generated M 5+ quakes in 1968 and 1987; initially suspected in 1993 and accepted in 2004
- South Central Illinois spawned a M 5+ quakes in 1838, 1857, and 1891. Initially recognized in 1999
The 1895 M6.0 Charleston, MO earthquake affected an area 20X greater than an equivalent magnitude quake in California.
SHAKING INTENSITY versus DISTANCE

Midwest quakes are less frequent, but much more lethal than California quakes because there is less damping of seismic energy.

Conclusion: Don’t use charts generated with seismic data taken from California!
# Recurrence Intervals for New Madrid Earthquake Events

<table>
<thead>
<tr>
<th>Magnitude</th>
<th>Recurrence Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.0</td>
<td>14 Months</td>
</tr>
<tr>
<td>5.0</td>
<td>10 – 12 Years</td>
</tr>
<tr>
<td>6.0</td>
<td>70 – 90 Years</td>
</tr>
<tr>
<td>7.0</td>
<td>254 – 500 Years</td>
</tr>
<tr>
<td>8.0</td>
<td>550 – 1200 Years</td>
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* based on existing data; always subject to update and revision
In our lifetimes, the most likely earthquake to impact St. Louis would be something similar to the Magnitude 6.0 Charleston, MO quake of 1895, which has a recurrence frequency of 70+/- 15 years (overdue since 1980).

It could emanate from either the New Madrid Zone or the Wabash Valley Fault Zone, or from South Central Illinois.
What is Site Response?

The type, depth and size of fault, combined with physical properties of crust and geophysical properties of overlying surficial soils combine to affect site response.
Site response is used to describe the fundamental period of vibration and lateral forces generated by a typical earthquake at any particular site.
Effect of Soil Thickness on Peak Ground Acceleration (PGA)

Magnitude 6.8 quake emanating from South Central Illinois at 110 km
Effect of Soil Thickness on RESPONSE SPECTRA

Soil Thickness: 28 m
Peak SA = 0.28 g
Peak Period = 0.62 sec

Soil Thickness: 25 m
Peak SA = 0.35 g
Peak Period = 0.51 sec

Soil Thickness: 22 m
Peak SA = 0.28 g
Peak Period = 0.45 sec

Soil Thickness: 39 m
Peak SA = 0.26 g
Peak Period = 0.87 sec
Magnitude 6.0 event at a distance of 110 km

The spectral acceleration is highest when the soil thickness is close to 25 m for M 6.0 quake at 110 km.

But, the spectral acceleration increases when the soil thickness drops to 21 m for a M 6.8 quake at the same distance.

From these figures it can be appreciated that the soil thickness may have a significant effect on both the peak accelerations and periods.

Magnitude 6.8 event at a distance of 110 km
Seismic site response varies markedly with the thickness of late Quaternary cover.

Effect of sediment cover thickness on the peak spectral accelerations for Creve Coeur Bridge Site for M 6.0 to 6.8 events at 210 km.

Effect of sediment cover thickness on the peak period for Creve Coeur Bridge Site for M 6.0 to 6.8 events at 210 km.
Rock Spectral Accelerations increase as magnitude increases.

Ground Surface spectral accelerations increase as magnitude increases.

Site amplification is the ratio of the response spectra of a soil site to the response spectra of the underlying bedrock.
What Causes Amplification of Ground Motion?

- **Resonance** within the soil column overlying much stiffer basement rocks
- **Impedance Ratio** between the rigid basement rock and the unconsolidated soils lying over them
- **Conservation of energy** of the incoming seismic wave train (e.g. wave energy arriving at a much higher rate than can be propagated through the soft soil cover)
We can estimate the fundamental site period with some basic data. The period will change with location in a parabolic shaped channel.

\[ T_s = \frac{4 \times D}{V_{Sf}} \]

where

- \( D \) = depth of channel fill
- \( V_{Sf} \) = shear wave velocity of channel fill

**FUNDAMENTAL PERIOD of SAND-FILLED BEDROCK CHANNEL**

**SEISMIC WAVE TRAIN**

\( T_m = \) Input Foundation Motion
Site amplification is a function of the Impedance Ratio between the valley fill and the underlying basement rock. Impedance Ratios in Midwestern US channels are among the most excessive examples identified anywhere in the world.
AMPLIFICATION at 110 km distance

Amplification Spectra for Creve Coeur Bridge M 6.0
event at 110 km South Central Illinois

- 8.2 x
- Peak Period = 0.75 sec

Amplification Spectra for Creve Coeur Bridge M 6.3
event at 110 km South Central Illinois

- 8.6 X
- Peak Period = 0.8 sec

Amplification Spectra for Creve Coeur Bridge M 6.5
event at 110 km South Central Illinois

- 7.3 x
- Peak Period = 0.8 sec

Amplification Spectra for Creve Coeur Bridge M 6.8
event at 110 km South Central Illinois

- 6.2x
- Peak Period = 1.2 sec
The amplification of seismic energy through soil cover is greater in lower magnitude earthquakes because the weaker ground motions are of insufficient amplitude to trigger an inelastic response (nonlinear soil effect), which causes substantive damping of incoming seismic energy.

This phenomenon results in greater percent amplification of incoming seismic energy for smaller magnitude events.
Recent sand blows dot the landscape surrounding New Madrid, MO, testifying to massive liquefaction.
Liquefaction is a failure mechanism by which cohesionless materials (sand and silt) lose shear strength when the pore pressure equals the effective confining stress. It is usually limited to the upper 50 feet and typically occurs in silt, sand and fine gravel.
Liquefaction is predicted in the Missouri River Flood Plain for an earthquake magnitude 6.8 event from South Central Illinois and Wabash Valley Seismic Zones.

Liquefaction to depths of 18 m predicted for quake Magnitudes > 6.5
Thank You

This presentation will be posted in .pdf format at www.umr.edu/~rogersda