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KOLEVA Gergana Varbanova

Bulgarian Academy of Science

Central Laboratory for Seismic Mechanics & Earthquake Eng. Acad.

G. Bonchev Str.. Bl. 3 1113

Sofia

BULGARIA

A CONTRIBUTION TO THE ASSESSMENT OF THE SEISMIC VULNERABILITY OF LARGE STRUCTURES IN SOFIA CITY

I. PASKALEVA, G. KOLEVA, F. VACCARI,
D. STEFANOV AND G.F. PANZA

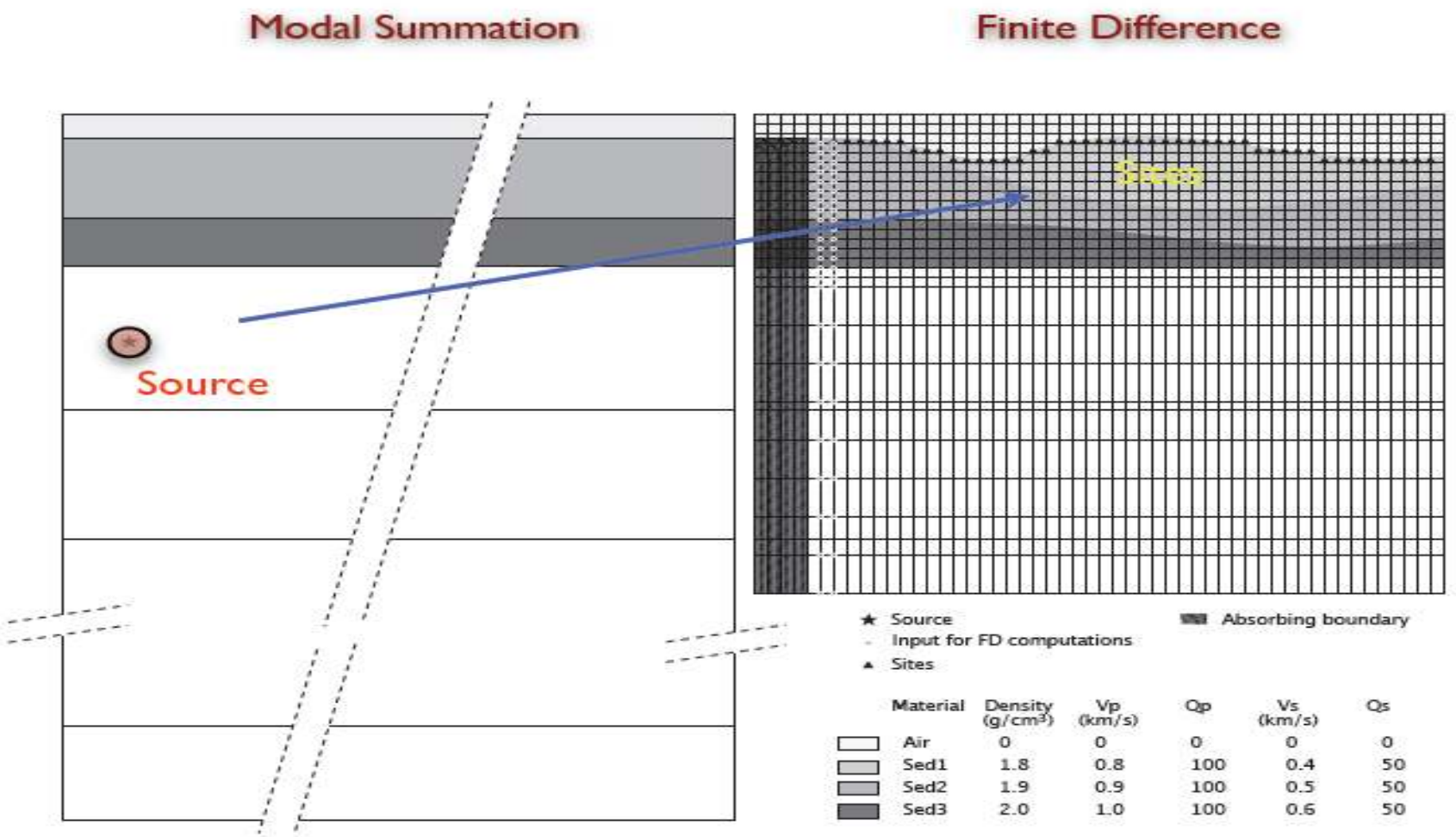
Introduction:

Future trends in earthquake-resistant design of structures can grow benefiting from multi-disciplinary developments of civil engineering.

Using the suites of two different earthquake scenarios, structural responses are shown and analyzed for five-storey reinforced concrete building . Two models of the building structure are considered . The first one is with FB (fixed based), therefore the soil conditions under the structure are not taken into consideration . The other considers SSI (soil structure interaction), modeled by springs and dampers.

The structural response for the FB and SSI-structure are computed and the results are compared with those obtained in the free field for two geological profiles and two source mechanism. It is shown how geology and source mechanism affect the acceleration transmitted to the structure along its height during a possible major earthquake in Sofia.

Hybrid method



Input data necessary for simulating ground motion using the hybrid approach

- earthquake source model;
- earthquake scenario;
- regional structural model;
  - Vp are taken from Shanov et al., 1998;
  - Vs=Vp/2;
  - quality factor for P-waves (Qp) for the region was taken from Dziewonski and Anderson, 1981, because no specific information exists ;
  - Qp=2.2*Qs (Stein, S. and Wysession, 2003);
- laterally heterogeneous local model

Scenario earthquake used for the computation

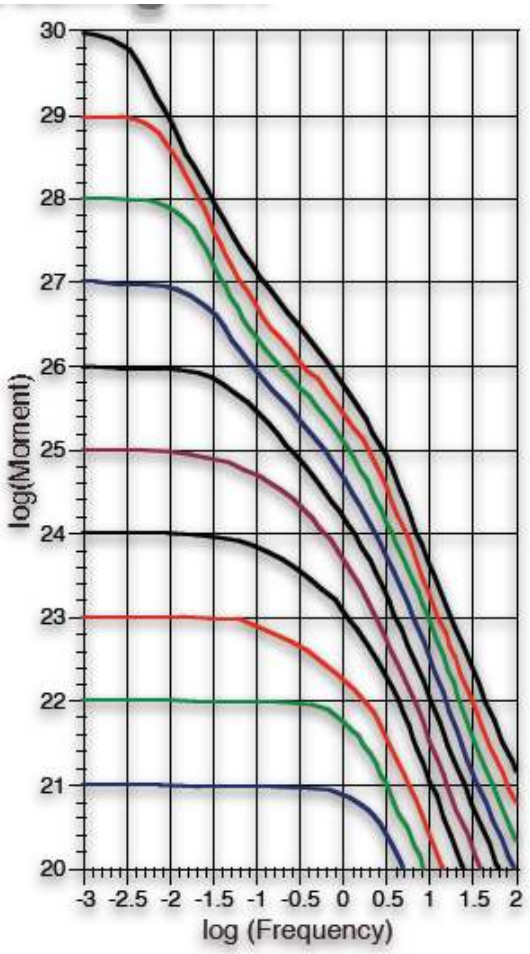
Name of the scenario	Name of the geological profile	Magnitude (M)	Strike angle (°)	Dip angle (°)	Rake angle (°)	Focal depth (km)	Epicentral distance to the nearest profile (km)
Sce3	Sf1-1, Sf3-3	7.0	340	77	285	10	10
Sce3A	Sf3-3	7.0	0	44	309	10	10

Sofia area with the three profiles superimposed ("Sofia 1", "Sofia 2", "Sofia 3")

Earthquake epicenter corresponds to a real seismic event

Regional scale – spectral scaling low

- The moment-magnitude relation by Kanamori (1977) is used
- First synthetic seismograms are computed for a unitary scalar seismic moment
- For such a large event at relatively small distances - simple scaling by Gusev as reported by Aki is not capable of modeling the influence of the rupture process
- Therefore, the algorithm for simulating the source radiation from a fault of finite dimensions named PULSYN25 (PULse-based wide band SYNthesis) was applied



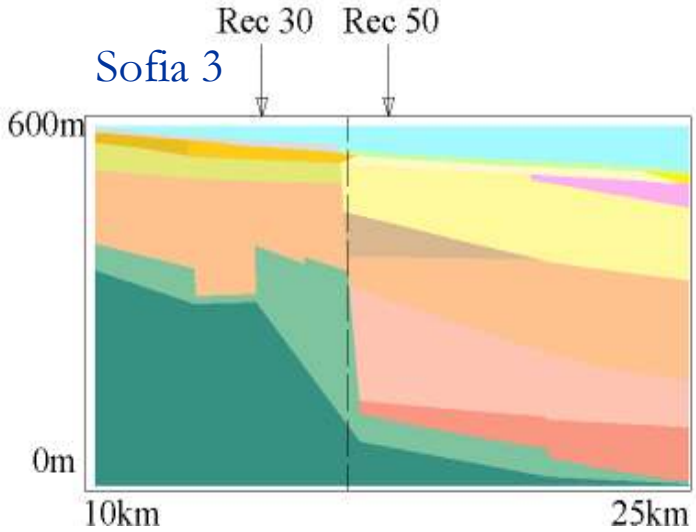
PULse-based wide band SYNthesis

- The source was modeled as a rectangular fault plane with a grid of point sub-sources;
- Using random parameters like the spatial distribution of slip and rupture velocity, the program PULSYN25 generates a source (phase and amplitude) spectrum that is close in amplitude to Gusev's (1983).
- To compute the synthetic seismogram at a specific site, the PULSYN25 spectra were used to scale the seismograms generated by the hybrid method. This approach produces broadband signals that reproduce directivity effects and the rupture process of the source.

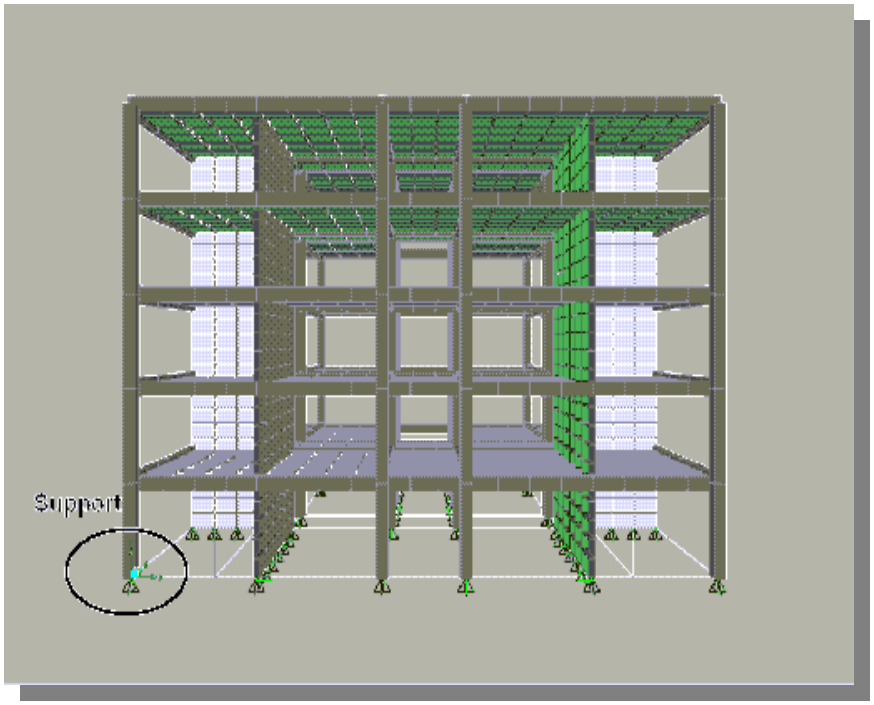
PULse-based wide band SYNthesis

- Realistic synthetic seismograms
  - geotechnical properties of the site
  - position and the geometry of the seismic source
  - mechanical properties of the propagation medium
- Time histories
  - for all components - transversal, radial and vertical

Laterally varying 2D models

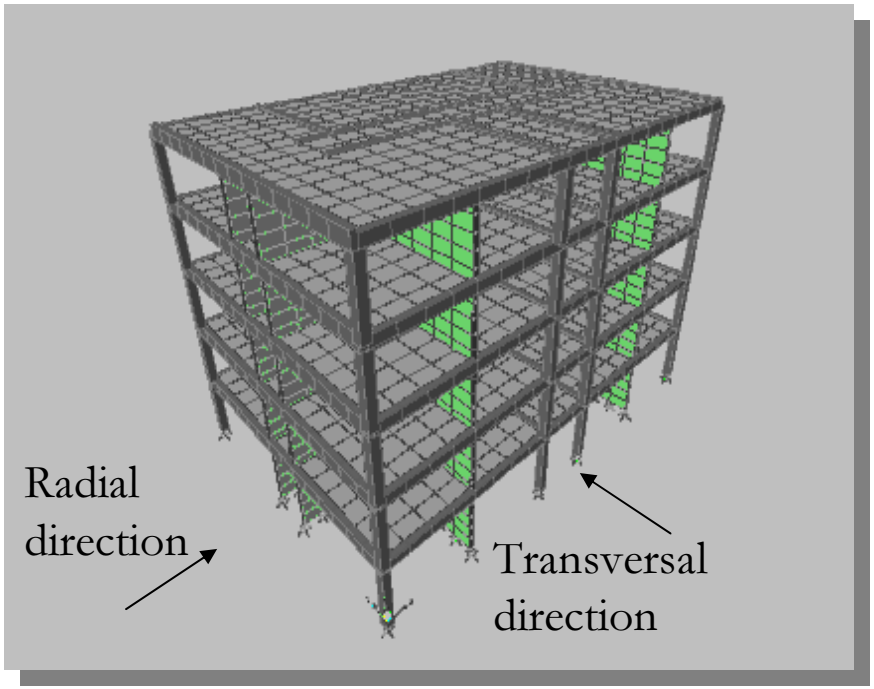


Finite elements building model



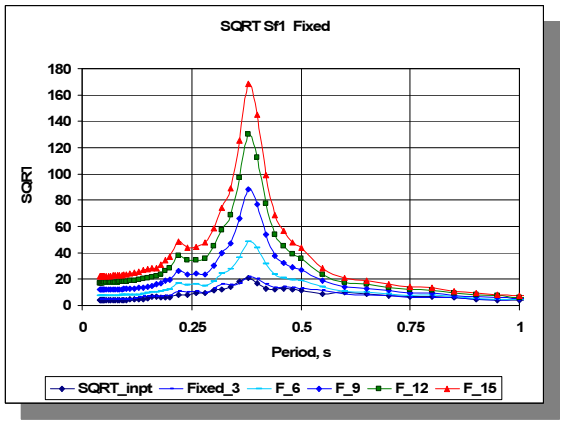
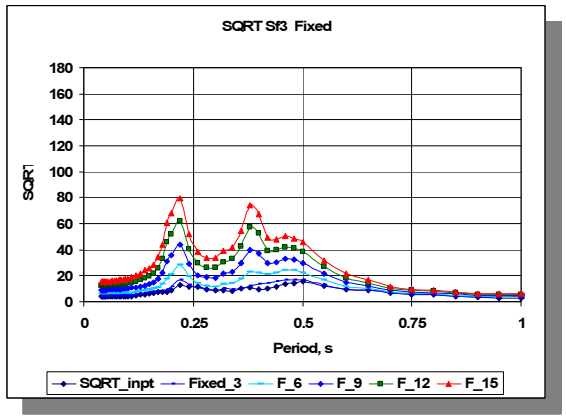
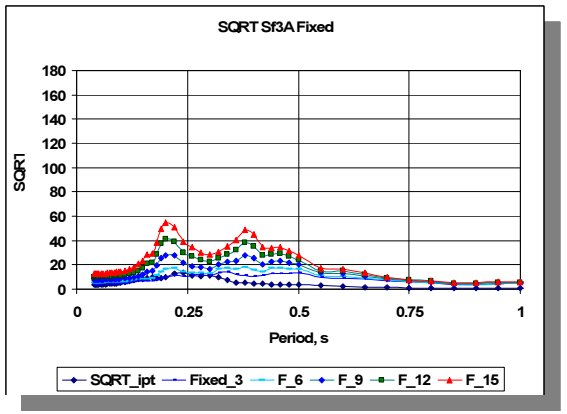
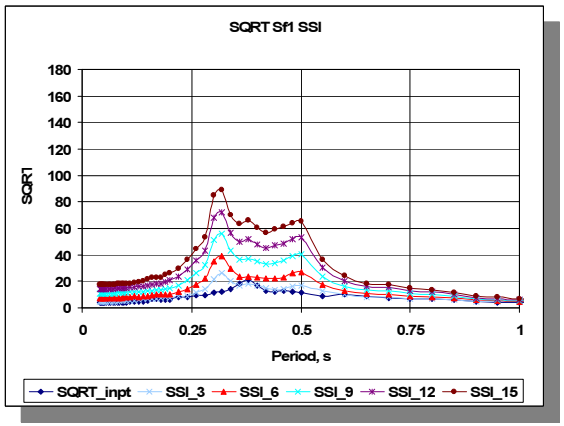
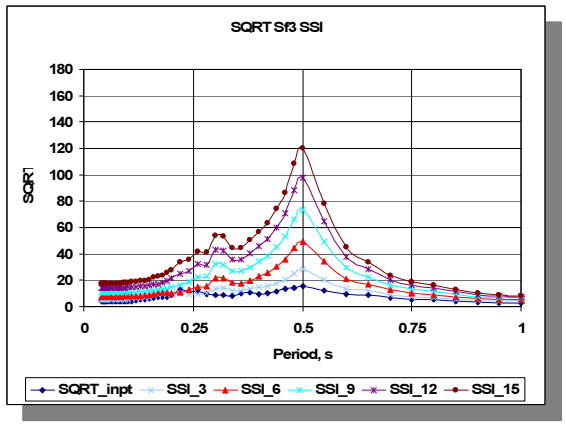
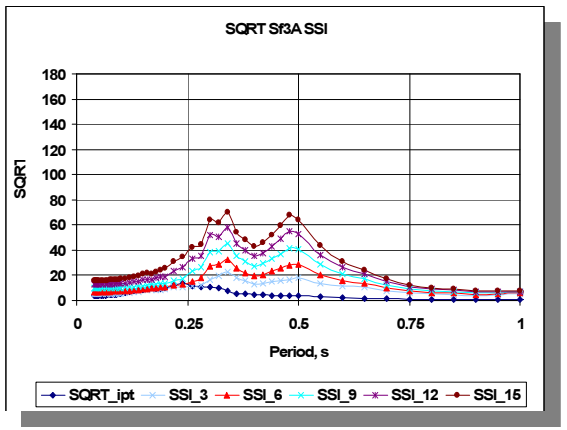
- Modeling and calculation: SAP 2000
- Derived values for the support nodes:
  - Kx, Ky, Kz – translational stiffness in global X, Y, Z directions
  - Kxx, Kyy, Kzz – rotational stiffness around global X, Y, Z directions
  - Constant damping
- T_1=0,394s (FB Model)
- T_1=0,49s (SSI Model)

Finite elements building model



- Analysis case
  - Linear modal Time History applied as acceleration TH:
    - Radial direction
    - Transversal direction
- TH normalized to:
  - Maximum of the accelerograms
  - Bulgarian code 1987
    - PGA=2.7m/s^2

The influence of the geological conditions on the building behaviour - Horizontal resultant of the response spectra calculated as square root (SQRT) along the structure height for the FB/SSI Models on the geological profiles Sofia 1, 3, 3a.

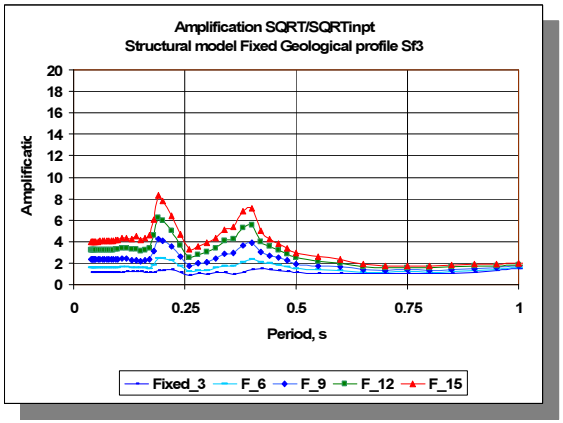
	Model: Sofia 1	Model: Sofia 3	Model: Sofia 3a
FB Model			
SSI Model			

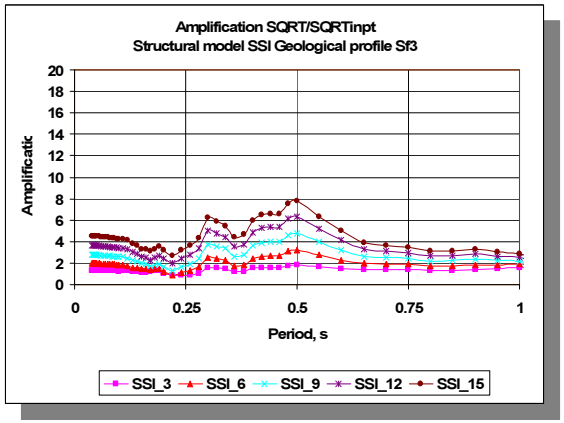
The influence of the earthquake mechanism on the amplification - Amplification along the structural height as ratio SQRTSAi/SQRTSAinp for FB/SSI Model on the geological profiles Sofia 3, 3a.

Model: Sofia 3

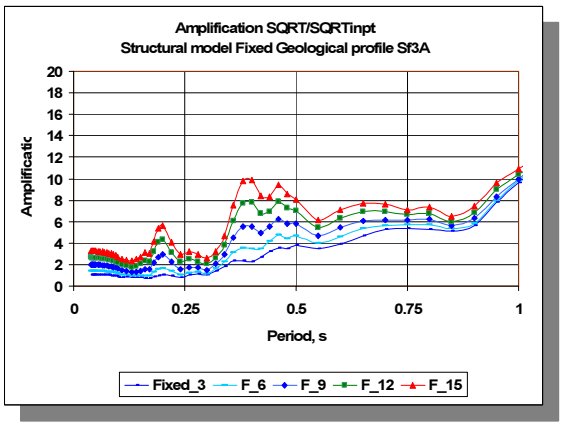
Model: Sofia 3a

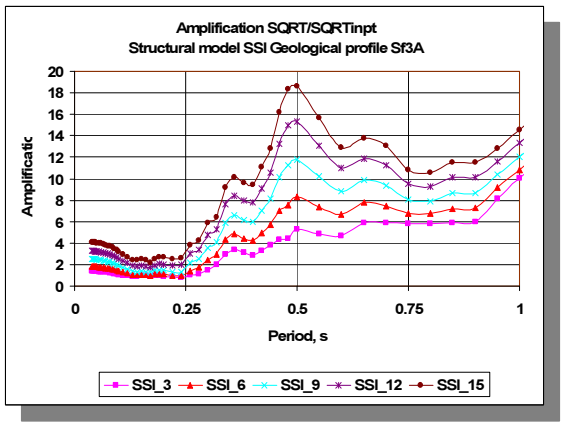
FB Model





SSI Model





Conclusion:

- The study shows how local geology and source mechanism affects the acceleration transmitted to the entire structure height during a possible major earthquake in Sofia.
- The analysis show that site geology effect cannot fully overshadows the influence of seismic source mechanism since the near-fault motions are dominated by the source characteristics.
- Local governments must require site-specific seismic hazard evaluations to validate the hazard level to allow appropriate recommendations for mitigation.

Acknowledgement

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Thank you for the attention!