JERSEY DOT'S
"Turning Problems into Solutions"
Tech Brief

SEISMIC ANALYSIS OF RETAINING WALLS, BURIED STRUCTURES, EMBANKMENTS, AND INTEGRAL ABUTMENTS

FHWA/NJ-2005-002 August 2005

WHY WE ARE DOING THIS…

In recent years, several major bridges have collapsed during earthquakes. The 1989 Loma Prieta earthquake in San Francisco; the 1994 Northridge earthquake in Los Angeles, and the 1995 Kobe earthquake in Japan all have caused major damage and collapse of bridges and its components that were designed and detailed based on existing seismic design provisions. In 2003, newly recommended seismic design guidelines for AASHTO LRFD were proposed based on the NCHRP 12-49 Report. These guidelines included major changes in the seismic design, among them, an increase in the seismic hazard levels in the eastern United States which resulted in much higher design earthquake accelerations and soil factors This increase in earthquake level (the proposed 2500 year event versus the current 500 year event) will impact the seismic design of bridges in New Jersey. Is the 2500 years event justified for New Jersey? Should we use the (2/3) of the 2500 years event, the 1000 years event, or the 1500 years event? What is the impact on the seismic design, cost, retrofit, etc..? Furthermore, the current LRFD specifications and the newly recommended guidelines do not address seismic design of integral abutments, retaining walls, buried structures, and embankments.

Embankment damage from the 2001 Plattsburg earthquake in NY State

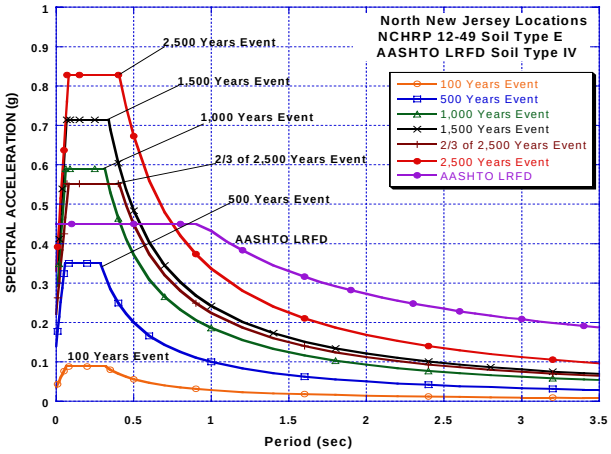

Bridge damage from the 1994 earthquake in Northridge, CA

HERE IS WHAT WE DID…

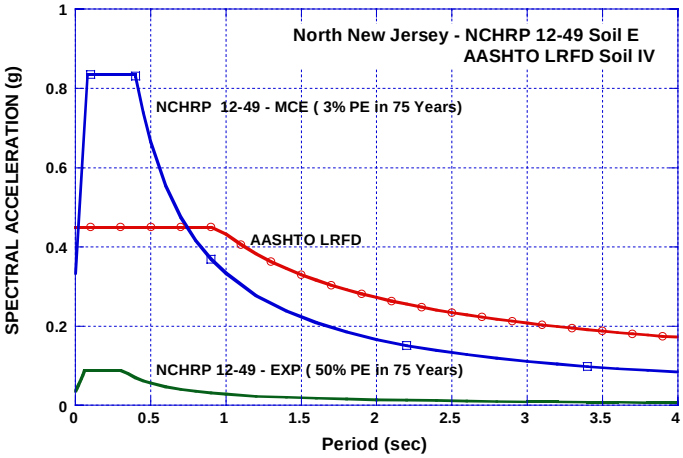
- We performed a comprehensive review of the newly recommended seismic design guidelines from the NCHRP 12-49 report and compared them to the current guidelines of AASHTO LRFD specifications.

- We prepared two examples of typical bridges in New Jersey and designed them based on the NCHRP 12-49 guidelines and current AASHTO LRFD specifications.

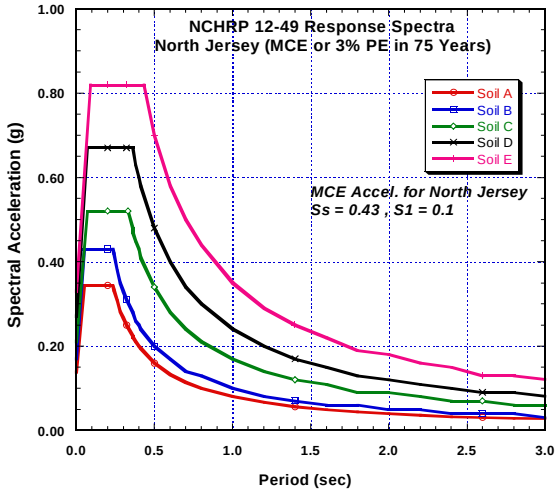
- We compared the impact of soil site factors on Central and South Jersey. The small earthquake accelerations in these regions increased significantly in soft soils.



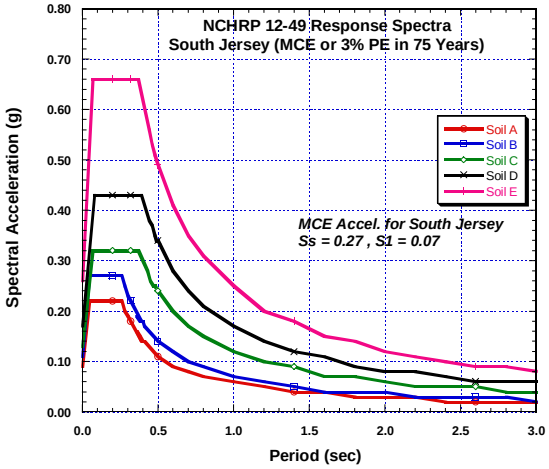
Design response spectra for various return periods in soft soils.



Comparison between the NCHRP 12-49 design spectra and the current AASHTO LRFD.



Design response spectra for NCHRP 12-49 MCE earthquake for various soil conditions in Northern Jersey.



Design response spectra for NCHRP 12-49 MCE earthquake for various soil conditions in Southern Jersey.

- We provided seismic hazards and performance objectives for New Jersey consistent with the new NCHRP 12-49 guidelines, NYCDOT, NYSDOT, and SCDOT seismic hazard and performance criteria.

Proposed Earthquake Hazard and Seismic Performance Levels for bridges in New Jersey

Ground Motion Level	Performance Level	Critical Bridges	Other Bridges
Extreme Earthquake ***(EE)***	**Earthquake**	***MCE (2500 Years Event)***	***(2/3) of MCE (2500 Years Event)***
	Service	Maintained	Impaired
	Damage	Repairable (No Collapse)	Significant (No Collapse)
Functional Earthquake ***(FE)***	**Earthquake**	***10% PE in 50 Years (500 Years Event)***	***EXP (108 Years Event)***
	Service	Immediate	Immediate
	Damage	Minimal to None	Minimal

- We provided seismic design criteria and guidelines for integral abutments, retaining walls, embankments, and buried structures consistent with the newly recommended guidelines.

FINDINGS……

- Seismic hazard and performance levels based on NCHRP 12-49 ground motions should be considered for New Jersey with the following modifications: Safety Level design for 'critical bridges' shall be based on the MCE event, while Operational Level design shall be based on the 500-year event. Safety level design for 'non-critical bridges' (Other bridges) shall be based on 2/3 of the MCE. Minimum seat width at abutments and expansion piers shall be based on the MCE rather than 2/3 of the MCE. The Operational Level design for "other bridges" will be based on the EXP earthquake in NHCRP 12-49.

- Soil site factors have increased dramatically for soft soils subjected small ground motions. These factors will have a major impact on the design response spectra and the selection of the seismic hazard level in Central and South Jersey.

- Transverse column reinforcement in plastic hinge zones is significantly affected by the longitudinal steel ratio. This reinforcement is independent of the longitudinal steel in the existing provisions. For column diameters between 3 ft and 6 ft with 1 and 2 percent longitudinal steel, the existing specifications require more transverse reinforcement. For column diameters between 5 ft and 6 ft with 3 percent steel or more, the new NCHRP 12-49 provisions require more transverse reinforcement.

- The minimum seat width required in NCHRP 12-49 is higher than those in AASHTO LRFD. This means that wider abutment walls are needed according to the NCHRP 12-49 provisions. The design examples showed that the NCHRP 12-49 minimum seat widths were about 60 to 70 percent higher than those required in the current AASHTO LRFD specifications.

- There is a need for research to predict large, infrequent earthquakes or extreme earthquake events and to prepare seismic hazard maps for seismic design in New Jersey. Also, there is a need to re-evaluate soil-site factors proposed by NCHRP 12-49 for New Jersey and the northeastern United States. This is a large undertaking and it may require the formation of a consortium of universities, agencies, and organizations in the northeast with expertise in seismology, geology, soil dynamics, risk analysis and management, and seismic design. Currently, the NYCDOT, the NYSDOT, and the FHWA are funding a project to evaluate the effects of local soils on the ground motions. A similar project is recommended for New Jersey.

- Current service and damage levels adopted in NCHRP 12-49, current AASHTO LRFD, SCDOT, and NYCDOT are qualitative and are open to interpretation on what constitutes minimal damage, significant damage, etc…. Quantitative assessments similar to those available in the SEAOC Bluebook [9] for buildings, which use the concepts of capacity and demand, and the ratios between, would provide a more objective approach for evaluating service and damage levels.

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A final report is available online at
http://www.state.nj.us/transportation/refdata/research/

If you would like a copy of the full report, please FAX the NJDOT, Bureau of Research, and Technology Transfer Group at (609) 530-3722 or send an e-mail to Research.Bureau@dot.state.nj.us and ask for:

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