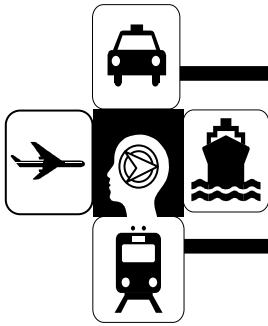


# JERSEY DOT'S

"Turning Problems into Solutions"



## *Tech Brief*

### Seismic Design Considerations

Need a solution?  
Think Jersey DOT

FHWA-NJ-2010-006

July 2010

#### BACKGROUND

Guidelines for the seismic design and retrofit of highway bridge structures in New Jersey are presented in Section 38 of New Jersey Department of Transportation Design Manual for Bridges and Structures, 5<sup>th</sup> Edition. This manual recommends using "2008 AASHTO Guide Specifications for LRFD Seismic Bridge Design" for the design of new bridges. FHWA publication titled "2006 Seismic Retrofitting Manual for Highway Structures: Part 1 – Bridges" has been adopted by the NJDOT for the seismic retrofit of existing bridges.

#### HERE'S THE PROBLEM

- AASHTO Guide Specifications for Bridge Seismic Design (AASHTO-SGS) don't provide any specific guidelines for the design and classification of critical bridges. A majority of bridges in New Jersey may be critical.
- AASHTO-SGS present displacement based approach, which is significantly different than the force-based approach used before the adoption of the AASHTO-SGS. There are very few examples illustrating the use of AASHTO-SGS.
- New Jersey Department of Transportation has an extensive electronic database of soil boring logs for sites across the state. This database can be used to develop a site class map for the state that can be used for a preliminary seismic design and a rapid seismic hazard evaluation for the entire state or for a network of bridges in the state.
- Liquefaction analysis is generally carried out during different NJDOT projects, although New Jersey is a region of low seismicity. AASHTO-SGS also recommend liquefaction analysis for Seismic Design Category B. Many of the critical bridges in New Jersey are likely to fall into this category. Currently, there is no liquefaction hazard map for the state of New Jersey to determine liquefaction potential at a particular bridge site during the preliminary design phase.

- Finally, existing bridges in New Jersey are retrofitted using the 2006 FHWA manual on “Seismic Retrofitting Manual for Highway Structures: Part 1 – Bridges”. It has been observed that analysis requirements for seismic retrofit of existing bridges are significantly more complicated than those for new bridges.

AND, HERE’S THE SOLUTION...

A seismic guideline for New Jersey that presents unified approach for new and existing bridges that are classified as standard and critical; zip-code based seismic site class maps, seismic design category maps and liquefaction hazard maps; procedure and tool on site specific design spectra; and examples illustrating applications of AASHTO-SGS for different types of bridges classified as standard and critical.

THESE ARE OBJECTIVES...

The focus of this project has been to resolve numerous issues towards practical implementation of AASHTO Guide Specifications on Bridge Seismic Design and the 2006 FHWA Seismic Retrofitting Manual for Highway Structures. Specific objectives have been to

- a. Develop criteria for classification and design of critical bridges in New Jersey.
- b. Develop a procedure for the development of site-specific design spectra for critical bridges.
- c. Develop examples illustrating applications of AASHTO Guide Specifications on Bridge Seismic Design for the design of different types of bridges.
- d. Develop seismic soil site, seismic design category and liquefaction hazard maps for the entire state of New Jersey for a preliminary seismic design for both critical and essential bridges.

HERE IS WHAT WE DID...

A seismic design considerations guideline that addresses all objectives described above has been developed for engineers in New Jersey. The guideline can be used for seismic design of new and existing bridges and for training of engineers about the provisions of AASHTO-SGS.

For the design of new critical bridges, a factor of 1.5 has been proposed to be multiplied to zip-code based spectra corresponding to 1000 Yr return period earthquake recommended in AASHTO-SGS. All new critical bridges have been recommended to be designed for essentially elastic behavior using the 1000 Yr spectra multiplied by a factor of 1.5. This factor has been the basis of reducing the seismic demand from 2500 Yr return period to 1000 Yr return period in the AASHTO-SGS for standard bridges designed for life safety performance. Existing critical bridges have been proposed to be designed for essentially elastic behavior for 1000 Yr return period spectra. Modified design criteria for existing bridges that align with guidelines presented in AASHTO-SGS for new bridges have also been proposed. These proposed guidelines for existing bridges either meet or exceed guidelines recommended in the 2006 FHWA manual for seismic retrofitting of bridges. Guidelines on classification of bridges into standard and critical categories have also been developed.

NJDOT has extensive electronic database of soil boring logs across the state. More than 12,000 selected boring logs from this database have been used to develop seismic site class map for the state of New Jersey. Seismic Design Category (SDC) maps for standard and critical bridges have been developed for the state of New Jersey based on this seismic site class map. Further extensive analysis using soil boring logs has been done to develop liquefaction hazard maps for the entire state of New Jersey. These maps can be used to determine the need for further detailed analysis for liquefaction, thereby further economizing any seismic design / retrofit project.

Nine examples of bridges of different span lengths and material types have been developed to illustrate applications of provisions of the AASHTO-SGS for the design of new bridges. Six of these examples illustrate the design of bridges in seismic design category (SDC) B, while three examples illustrate the design in SDC A category.

AASHTO-SGS require the design of bridges using site specific spectra. This analysis is generally done by consultants, adding to costs of seismic design / retrofit projects in New Jersey. A semi-automatic computer tool and procedure using freely available software has been developed so that NJDOT engineers can carry out the development of site-specific spectra in-house. Usage of this tool and procedure is expected to result in significant cost savings in seismic design / retrofit projects, while improving the reliability and consistency of design of critical bridges.

## CONCLUSION:

The guideline on seismic design considerations for New Jersey presents comprehensive guidelines on all aspects important for the implementation of AASHTO Guide Specifications on Bridge Seismic Design and 2006 FHWA manual for seismic retrofitting in the state of New Jersey. Design examples presented in the guideline will serve as very useful resource for engineers not only in New Jersey, but for most of Northeastern United States. Successful and effective implementation of the guideline will certainly standardize and economize the seismic design / retrofit of bridges in the state of New Jersey.

## WHAT IS THE NEXT STEP?

Seismic design guidelines for New Jersey for new and existing bridge structures are implemented through Section 38 of the New Jersey Department of Transportation Design Manual for Bridges and Structures, 5<sup>th</sup> Edition. Provisions in Section 38 of the Design Manual for Bridges and Structures need to be updated on the basis of this report for an effective implementation of research outcome of this project.

The guideline doesn't include examples illustrating design of various approaches for seismic retrofit of bridges, including limitations, advantages and cost effectiveness of these approaches. These examples will provide training to engineers and standardize the seismic retrofit process, resulting in significant cost savings to NJDOT.

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

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

Report Title:

NJDOT Research Report No: FHWA-NJ-2010-006