New Jersey Turnpike Authority
PO Box 5042, Woodbridge, NJ 07095

Document Change Announcement

2007 Design Manual

DCA2012-DM-05

DATE: **November 14, 2012**

Subject: **Revisions to Section 2.2.6 of the Design Manual**

Description of Change

Section 2.2.6 has been revised to clarify intent of rehabilitation design, more clearly define acceptable levels of damage encountered in a seismic event, and to revise the definitions for Essential and Critical bridges to more closely coincide with FHWA and AASHTO design manuals.

Instructions to Designers and Consultants

Effective immediately, the revisions contained in this announcement shall be applied to all projects that have not reached Phase B of design. Contact your NJTA Project Manager for instructions. Attached revision is noted in italics.

Designers may access these revisions in the NJTA Design Manual, which is available on the Authority's Web Page: http://www.state.nj.us/turnpike/professional-services.html.

Information for In-House Staff

The revisions have been incorporated into the Design Manual, which is available on the S drive @ S:\Project Files\Design-Procedure Manual. Please distribute the information to your respective Project Managers and have them direct their consultants appropriately.

Recommended By:

Robert J. Fischer, P.E.
Assistant Chief Engineer, Design

Approved By:

11/16/12

Richard J. Raczynski, P.E.
Chief Engineer

cc: Senior Staff Engineering, Operations & Maintenance Departments, All Prequalified Consultant Firms, File

New Jersey Turnpike Authority

DOCUMENT UPDATE REQUEST

Forward to Assistant Chief Engineer, Design

Initiator	Richard Schaefer	**Submittal Date**	11/7/12
Firm	HNTB Corporation	**Telephone**	973-434-3100

Document (check one)

- ☐ Procedures Manual
- ☒ Design Manual
- ☐ Sample Plans
- ☐ Standard Drawings
- ☐ Standard Specifications

Description of Change

Delete Section 2.2.6 of the Design Manual and replace with the attached document.

Reason for Change

This section has been revised to clarify intent of rehabilitation design, more clearly define acceptable levels of damage encountered in a seismic event, and to revise the definitions for Essential and Critical bridges to more closely coincide with FHWA and AASHTO Design Manuals

2.2.6 Design for Seismic Events

2.2.6.1 Design Specifications

Except as modified below, the seismic evaluation of all bridges shall be governed by the following design codes:

- AASHTO *LRFD Bridge Design Specifications*, 2012 (AASHTO LRFD BDS)
- AASHTO *Guide Specifications for LRFD Seismic Bridge Design*, 2nd Edition, 2011. (AASHTO LRFD SBD)
- FHWA *Seismic Retrofitting Manual for Highway Structures,* Publication No. FHWA-HRT-06-032, January 2006. (FHWA Manual)
- AASHTO *Guide Specifications for Seismic Isolation Design*, 3rd Edition, 2010. (AASHTO GSSID)

The AASHTO *Guide Specifications for LRFD Seismic Bridge Design* offers a displacement-based design alternative to the force-based design methodology presented in the AASHTO LRFD *Bridge Design Specifications*. Displacement-based seismic design has the potential to offer a more economical bridge design, especially in regions of high seismic activity. However, the Turnpike and Parkway facilities are contained within a region of relatively low seismic activity where displacement-based designs have generally proven to offer minimal savings as compared to force-based designs. While the designer is not explicitly discouraged from using a displacement based seismic design, it should be noted that the potential benefits of such a design may be negligible. However, where site specific spectra in problematic soils may arrive at high peak accelerations, a displacement based approach to new bridge design may be warranted.

2.2.6.2 General Considerations

The most common and significant hazard causing earthquake damage is ground shaking. Additional seismic hazards can also include ground failure, liquefaction, lateral spreading, differential settlement and land sliding. All new bridges shall be designed to resist such hazards and all existing bridges which meet the criteria of Section 2.2.6.8 or are otherwise designated by the Authority shall be subjected to a vulnerability analysis and subsequent retrofit design (as required) which considers the above hazards.

2.2.6.3 Seismic Ground Shaking Hazard

For the purposes of both existing bridge vulnerability analysis and new bridge design, the following criteria shall be used when defining the seismic ground shaking hazard. The seismic ground shaking hazard is defined by the design response spectrum.

For the 1,000-year mean return period earthquake, bedrock ground motion parameters shall be taken from the AASHTO LRFD BDS seismic hazard maps and procedures. For the 2,500-year mean return period earthquake, bedrock ground motion parameters for the site shall be taken from the most recent USGS National Seismic Hazard Maps.

For both the 1,000-year and 2,500-year mean return period earthquakes, the design response spectrum shall be computed following the provisions of AASHTO LRFD BDS Article 3.10.4.

The Site Specific Procedure may be used for any bridge, but shall be mandatory for the following situations:

- Bridges 1000 feet or greater in length.
- Bridges with a deck area exceeding 50,000 square feet.
- Bridges designated by the Authority as "Critical".
- Anywhere a time history response analysis will be performed as part of the overall design / retrofit scheme.

2.2.6.4 Bridge Importance Classification

For the seismic design of new bridges as well as the seismic vulnerability assessment and retrofit design of existing bridges, all bridges shall be classified as "Essential" bridges unless designated otherwise by the Authority. If the Authority elects to assign "Critical" importance classification to a bridge, the designation will be clearly stated in the project scope of work.

2.2.6.5 Seismic Performance Criteria

The following seismic performance criteria shall apply for the design of new bridges as well as for seismic vulnerability assessment and retrofit design of existing bridges. These criteria expand upon and supersede definitions in the AASHTO LRFD BDS and the FHWA Manual.

Bridge Classification	Considered Seismic Event	Mean Return Period	Probability of Exceedance	Acceptable Damage Level	Access Level
Essential	Single Level	1000 years	7% in 75 years	Minimal	Immediate
Critical	Upper Level	2500 years	3% in 75 years	Repairable	Limited
	Lower Level	1000 years	7% in 75 years	Minimal	Immediate

Post-seismic event acceptable damage levels are defined as follows:

- "Minimal" damage means that the bridge should have "essentially elastic" response, meaning minor inelastic response could take place. In reinforced concrete elements, post-earthquake damage should be limited to light flexural cracking. Permanent deformations are not allowed for primary structural members. Minor damage and permanent deformations are permitted in secondary members. No damage to expansion joints is permitted, except for the sealing gland, which may be considered sacrificial for the purposes of seismic performance evaluation.

- "Repairable" damage means that the bridge can be restored to its pre-earthquake condition without replacement of primary structural members. Inelastic response is permitted and may result in concrete cracking, concrete cover spalling, and yielding of reinforcement in concrete members. Where spalling or loss of concrete cover is anticipated, consideration shall be given to where loosened concrete may fall. Falling concrete over active roadways or populated areas will not be considered acceptable. Loosened concrete which may fall over median areas or in roadway shoulders will be considered acceptable. Limited damage will be considered acceptable in secondary members and non-structural components including expansion joints provided that such damage will not significantly damage attaching primary members or allow the secondary members to fall free of the bridge. Permanent post-event deformations shall be small and no collapse will be permitted. Repairs, where required, shall be possible without completely closing the bridge to traffic, i.e., repairs can be performed with limited lane and shoulder closures. As a part of the Phase A report, the consultant shall present their detailed seismic design criteria including an inventory of bridge members which are anticipated to receive damage, and the anticipated extent of the damage with a conceptual repair scheme, a preliminary estimate of repair costs, and an anticipated construction schedule or time frame in which the repairs can be completed to the point that all active traffic lanes on the bridge can be restored to full service.

Post-earthquake access levels are defined as follows:

- Immediate access means that full service for all vehicles will be available within 72 hours following a design seismic event allowing for inspection and clearance of debris.

- Limited access means that service for emergency vehicles will be available within 72 hours following a design seismic event allowing for inspection and clearance of debris, i.e. steel plates may be required to span over failed joint areas or damaged deck areas. Full service to general traffic for all lanes shall be able to be restored within a matter of three months unless longer timeframes are permitted by the Authority.

2.2.6.6 Analysis for Earthquake Loads

Analysis requirements for earthquake loads presented herein apply to new bridge design as well as existing bridge seismic vulnerability assessment / retrofit design.

Single Mode or Uniform Load analyses are permitted for all Essential bridges which will not be classified as "Irregular bridges". Multi-mode analyses shall be used for all Irregular bridges. In addition to the provisions noted in the AASHTO LRFD BDS Sections 4.7.4.3, the following bridge types shall be considered to be "Irregular bridges":

- Bridges with any span curved in plan, where the definition of curvature is as described in Section 4.6.1.2.4b of the AASHTO LRFD BDS.
- Bridges designed with transverse box girder elements.
- All bridges designated as "Critical" by the Authority.

Note: dynamic analysis is not required for single span bridges. This exception does not apply to viaduct bridges composed of a series of single span superstructures.

Extreme Event I Load Combination in Table 3.4.1-1 of the AASHTO LRFD BDS shall consider a Live Load Factor (g_{EQ}) of 0.50. Similarly, 50% of live load forces shall be considered simultaneously with dead load and seismic effects when the design and/or analysis is performed in accordance with AASHTO LRFD SBD or the FHWA Manual. Note that the inertial effects of the live load shall not be included in the dynamic analysis.

2.2.6.7 Design of New Bridges

All new bridges shall be designed to incorporate minimum support lengths, connection designs, and column design / ductility details required for Zone 2 criteria, as per the provisions of the AASHTO BDS. New bridges designed using AASHTO LRFD SBD shall follow, at a minimum, the design and detailing requirements of Seismic Design Category B. Single-span bridges shall be designed in accordance with Article 3.10.9.1 of the AASHTO LRFD BDS.

New bridges designated as "Critical" shall be designed to resist both the lower level and upper level events while maintaining the post-earthquake acceptable damage levels and access levels as defined in subsection 2.2.6.5.

These general considerations provide for a rational approach to bridge designs that allows the use of simplified analysis methods for the majority of bridges in the Turnpike and Parkway inventories, but requires the inclusion of code mandatory detailing that offers significant increases in seismic performance, ductility, and redundancy at a relatively incidental increase to the bridge construction cost.

2.2.6.8 Vulnerability Assessment and Retrofit Design

The FHWA Manual shall be used as a guide regarding evaluation procedures and upgrade measures for retrofitting existing seismically deficient highway bridges.

Unless directed otherwise by the Authority, a seismic retrofit shall be considered for all existing bridge rehabilitation projects which meet the following criteria:

- Anticipated project work includes increasing the bridge deck area by more than 25% and/or replacing the entire bridge deck.

- Anticipated project work includes replacing or repairing more than 25% of the superstructure bearings.

When the estimated cost of the proposed seismic retrofit strategy exceeds 25% of the estimated replacement cost of the bridge, replacement of the bridge shall be considered.

In addition to the above criteria, the designer is responsible for rational consideration of all existing bridges within a project for seismic retrofit eligibility. Development of a retrofit scheme should be considered where the anticipated scale and type of work to an existing bridge offers the opportunity to include cost effective seismic retrofitting measures into the project.

When an existing bridge has been determined to be a candidate for seismic retrofitting, a conceptual retrofit strategy shall be included as part of the Phase A submission. When the estimated cost of the proposed retrofit strategy indicates that a full bridge replacement may be warranted, the Authority shall be contacted prior to the Phase A submission.

When existing bridges designated by the Authority as "Critical" are investigated for retrofit design, they shall be analyzed to resist both the lower level event and upper level events for maintaining the post-earthquake acceptable damage levels and access levels as defined in subsection 2.2.6.5. Retrofit strategies shall be prepared for both the lower level event and the upper level event, including a cost estimate for each strategy. Both strategies and their corresponding cost estimates shall be presented as part of the Phase A report and shall include a recommendation to retrofit the structure to either the lower level or the higher level event.

The majority of existing bridges should not be expected to meet the force and ductile detailing requirements set forth in the AASHTO LRFD codes noted above, as many of these existing bridges were designed with little or no provision for resistance to seismic hazards. The existing bridges within the NJTA inventory generally have limited ductility and are incapable of sustaining stable inelastic cyclic response, which is the basis of current seismic design provisions for new bridges.

For existing bridge seismic retrofit evaluation, Method C: Component Capacity/Demand Method as described in Section 5.4 for Seismic Retrofit Category C and D, and Appendix D of the Retrofitting Manual shall be used, at a minimum.

Nonlinear static and/or dynamic analyses are recommended, but not required, where bridges with ductile details are to be evaluated, or where member strengthening and/or ductility enhancement are considered as part of the retrofitting concept.

Seismic retrofitting of existing bridges constitutes a substantial structural alteration. The design engineer shall perform a complete LRFR load rating analysis of the as-retrofitted bridge in accordance with the NJTA Load Rating Manual unless directed otherwise by the Authority's project engineer.

Isolation strategies, if employed, shall be designed in accordance with the AASHTO GSSID. This document is explicitly intended to function in concert with the AASHTO LRFD BDS and the AASHTO LRFD SBD. The use of Load Factor Design or Allowable Stress Design methodologies in concert with these specifications is not permitted.