

SEISMIC DESIGN AND RETROFIT - References and Support
12/10/05
(For further information contact Glenn Smith)

The following references and support are available for seismic design / retrofit of bridges.

New Construction (Support of AASHTO specifications)

1. Seismic Design Applications Course (BERGER/ABAM) 1996.
There are videotapes of the 14 one-hour lectures. The two volumes of power point slides to support the lectures are available on the DOT Internet library.

Seismic Bridge Design Applications, 25 April 1996, Part One, FHWA-SA-97-017

Seismic Bridge Design Applications, 25 July 1996, Part Two, FHWA-SA-97-018

<http://isddc.dot.gov/OLPFiles/FHWA/012349.pdf> for FHWA -SA-97-017

<http://isddc.dot.gov/OLPFiles/FHWA/012348.pdf> for FHWA -SA-97-018

Seven volumes of worked Design Examples are available in electronic form.

Seismic Design of Bridges - Design Example No. 1: Two-Span Continuous CIP Concrete Box Bridge FHWA-SA-97-006

Seismic Design of Bridges - Design Example No. 2: Three-Span Continuous Steel Girder Bridge FHWA-SA-97-007

Seismic Design of Bridges - Design Example No. 3: Single Span AASHTO Precast Girder Bridge FHWA-SA-97-008

Seismic Design of Bridges - Design Example No. 4: Three-Span Continuous CIP Concrete Bridge FHWA-SA-97-009

Seismic Design of Bridges - Design Example No. 5: Nine-Span Viaduct Steel Girder Bridge FHWA-SA-97-010

Seismic Design of Bridges - Design Example No. 6: Three-Span Continuous CIP Concrete Box Bridge FHWA-SA-97-011

Seismic Design of Bridges - Design Example No. 7: Twelve Span Viaduct AASHTO Precast Concrete Bridge FHWA-SA-97-012

The examples have not been reprinted because anyone using them should:

1. Investigate the impact of the obsolete Peak Ground Motion Maps used in the Examples.
2. Investigate updating the references to the Standard Specification in the Design Examples to references to the LRFD specification.

New Construction (Support of Guidelines, i. e. MCEER/ATC-49)

2. MCEER/ATC 49, 49-1, and 49-2.

- Volume one is the Guide specification,
- Volume 2 is the Commentary and Appendices. (Note two USGS Ground motion CDs are included with Volume I).
- Comprehensive Liquefaction Study complete with a CD of two investigations.
- Two Design Examples contained in a single volume.

All are available for purchase from MCEER or ATC.

A powerpoint presentation and paper facilitating the use of the Guide Specification as a transition to the Guidelines/ LRFD specification currently under development in NCHRP 20-7 Task – 193 was presented at the 6th International Bridge Engineering Conference in Boston by Glenn Smith.

3. Several states have developed studies / design applications to support implementation of the Guidelines (i.e., IL, VA, NJ).

The T-3 Trial Designs were initially reported as 19 examples, 14 were completed. But, other than the summaries, no further development was undertaken.

New Construction (Future LRFD Seismic Provisions)

3. NCHRP 20-7 Task 193 is tasked with developing a second version of the Guidelines. However, the current effort is directed at developing updated ASSHTO LRFD seismic provisions. The “60% Draft” was distributed at the Bridge Subcommittee meeting in June 2005. The “90% Draft” was distributed to the T-3 Seismic Committee for the meeting December 9, 2005. There was talk of trial designs being

developed this spring and balloting in 2006, but with the absence of a commentary the dates will probably slide.

There are four preliminary reports, i.e.:

- 3/15/05 Draft, Methodology and Suggested Approach, Task F3-5 Report, AASHTO T-3 Support, IMBSEN Road-Map for Recommended LRFD Guidelines for the Seismic Design of Highway Bridges Version 2.
- NCHRP 20-7 Task 193 Task 6 Report for Updating “Recommended LRFD Guidelines for the Seismic Design of Highway Bridges”
- NCHRP 20-7 Task 193 Task 8 Report for Updating “Recommended LRFD Guidelines for the Seismic Design of Highway Bridges” (60% Draft)
- “Recommended LRFD Guidelines for the Seismic Design of Highway Bridges” MM 2005, Roy A. Imbsen (Report prepared by Dennis Mertz) (90% Draft)

These documents are not in public circulation, but should be available from the State Bridge Engineers in the T-3 States.

Note the commentary remains to be done. The USGS Ground Motion Maps have not been provided, but are under development. The two steel bridge design examples are still unavailable.

Geotechnical Earthquake Engineering

5. Proceedings of the Workshop on New Approaches to Liquefaction Analysis, Washington, DC, Sunday, January 10, 1999, Annual Meeting of the Transportation Research Board, Special Report Number MCEER-99-SP04. Available at:

<http://mceer.buffalo.edu/publications/workshop/99-SP04/default.asp>

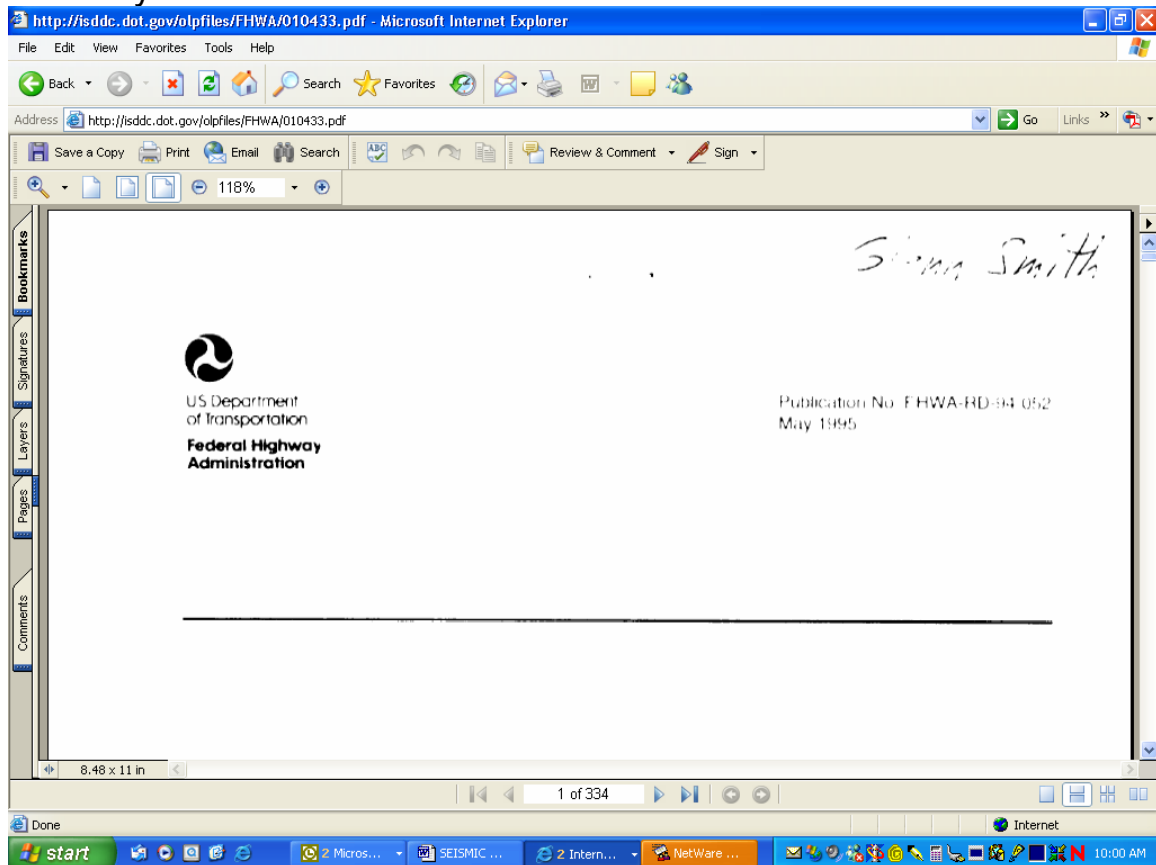
- Introduces the geotechnical and bridge design communities to FHWA Geotechnical Engineering Circular (GEC) No. 3, *Design Guidance: Geotechnical Earthquake Engineering for Highways*,

Volume 1 - Design Principles (Report No. FHWA-SA-97-076)
and *Volume 2 - Design Examples* (Report No. FHWA-SA-97-077)

Note GEC No. 3 is no longer in print because FHWA is committed to updating it, but no timetable is set.

Seismic Retrofit

6. Seismic Retrofitting Manual for Highway Bridges FHWA-RD-94-052 May 1995 is available on the Internet at:



FHWA did not complete development of training to support this “interim” manual. There was a pilot NHI Course held in Nashville in 1998 (Contact Glenn Smith) for details.

Publications by Others

7. EERI Monograph MNO-9

Fundamentals of Seismic Protection for Bridges, 2003

By Mark Yashinsky and M. J. Krashenas

The first third of the book presents an extensive discussion of bridge failures during earthquakes, the second third discusses design specifications and practices (i.e., the LRFD Guidelines and Caltrans work), and the last third describes 42 seismic retrofit applications. The monograph was distributed to all EERI members and may be purchased from the EERI web site.

8. Seismic Prioritization of Highway Bridges in Canada, Zhu Liu, March 2001. This Masters Thesis submitted to McGill University contains a comparison of nine seismic retrofit prioritization procedures (six from the United States). He then selects a procedure and applies it to a population of 28 bridges in Montreal, Canada.

9. Seismic Behavior and Retrofit of Bridge Knee Joint Systems, David McLean and Nasim Shattarat, July 2005. Research Report WA-RD 601.1 was provided to the Washington State DOT by Washington State University. Experimental tests were conducted on outrigger bents and retrofitted bents. Design and detailing guidelines for retrofitting outrigger bents are provided.

10. Improved Seismic Design Procedure for Concrete Bridge Joints, Sri Sritharan
Strut-and-Tie Analysis of Bridge Tee Joints Subjected to Seismic Actions, Sri Sritharan
September 2005 ASCE Journal of Structural Engineering
The first paper describes why the widely publicized joint design method is inadequate. The second paper presents an improved design procedure.

11. State-of-the-Art Summary of Seismic Evaluation and Retrofit Techniques for Concrete Bridges, ACI Committee 341. Submitted for TAC review, Spring 2005.
ACI 341.XR addresses the three primary phases of a retrofit program: seismic vulnerability evaluation, evaluation of seismic demands and capacities, and the selection and design of retrofit measures.

Provides general descriptions of appropriate linear and non-linear analysis methods to evaluate the seismic response of an existing bridge. Describes retrofit measures to improve the seismic response

of the bridge components. Provides conceptual level information, but, relies on references for detailed descriptions of the design methods. This level of technical content is similar to what is being developed in the FHWA retrofit manual for other structures (i.e., Retaining Structures, Slopes, Tunnels, Culverts and Roadways).

12. Several states have their own seismic design criteria. Much of this material is posted on the Internet on the state DOT web sites, i.e., California, New York, Oregon, South Carolina, and Washington state. There have been recent updates.

13. There is an NCHRP Project to develop seismic ground motion in the New Madrid Region with the lead by the Mid-America Earthquake Center (MAE). No reports have been published.

FUTURE DEVELOPMENTS IN SEISMIC DESIGN SUPPORT

FHWA research programs at MCEER products expected within twelve months:

- FHWA Seismic Retrofitting Manual For Highway Structures: Part I – Bridges;

- FHWA Seismic Retrofitting Manual For Highway Structures: Part 2 – Retaining Structures, Slopes, Tunnels, Culverts and Roadways;

- Seismic Isolation of Highway Bridges

- Seismic Retrofitting Manual For Highway Truss Bridges.

Parts 1 and 2 have been under review since 2000. February 2005 was the latest draft of Part one, however, “Seismic Retrofit of Highway Bridges, A Pilot Training Course / Workshop” was held by MCEER and hosted by the Oregon DOT on December 5-7, 2005 in Portland Oregon. The session was video taped and hopefully the notebook, working draft and video will be available for a larger audience soon. The Working Draft of Part I (dated December 5, 2005) was distributed.

Papers addressing the content of Part 1 were presented at the New York City Bridge Conference in September 2005 and Caltrans Seismic Research Workshop in October 2005. The first Chapter or overview had been shared at TRB Workshops in January 2004 and 2005.

August 2004 is the latest draft of Part Two. A paper addressing the content was presented at the New York City Bridge Conference in September 2005 by Glenn Smith.

The Isolation and Truss manuals were reviewed by MCEER's Highway Seismic Research Council (HSRC) in September 2004.

An expanded draft of the Truss manual was provided in the spring of 2005 to the reviewers. The author's from T.Y.Lin have developed examples to support the work. "Seismic Retrofit of Truss Bridges, A Pilot Training Course / Workshop" will be held by MCEER on December 12-14, 2005 in St. Louis, MO.

Over the next year the Office of Bridge Technology is committed to major efforts to implement seismic design using LRFD, developing design examples, and resources to support retrofit design.

American Concrete Institute (ACI)

The ACI Fall Convention was held in Kansas City, MO, November 5-9, 2005. The ACI 341 Earthquake Resistant Concrete Bridges Technical Committee has eight subcommittees. The following met:

- A – Columns
 - C – Retrofit
 - B – Pier Walls
 - D – Performance Based Seismic Design
- and the full committee.

There are several lengthy documents under development. I have since received chapters of the Column document. The Retrofit document is complete but more input has been incorporated and it will be reballoted. An isolation document while incomplete is already 112 pages in length.

The ACI 374 Seismic Design Committee, while primarily about buildings, parallels the issues under consideration with ACI 341. In

several respects, their work appears more advanced. They are working on columns, ground motion, pushover analysis, and isolation.

The Innovative Technology Group ITG-4 High-Strength Concrete for Seismic Applications was resolving ballot comments on their document. A published report is expected soon.

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