MCEER/ATC-49

Recommended LRFD Guidelines for the Seismic Design of Highway Bridges Part I: Specifications

Based on
NCHRP Project 12-49, FY '98
"Comprehensive Specification for the Seismic Design of Bridges"
National Cooperative Highway Research Program

Prepared by
ATC/MCEER JOINT VENTURE
A partnership of the
Applied Technology Council
(www.ATCouncil.org)
and the
Multidisciplinary Center for Earthquake Engineering Research
(http://mceer.buffalo.edu)

Prepared under the MCEER Highway Project
Project 094, Task F3-1
Federal Highway Administration

NCHRP 12-49 PROJECT PARTICIPANTS

Project Team

Ian Friedland, Principal Investigator
Ronald Mayes, Technical Director
Donald Anderson
Michel Bruneau
Gregory Fenves
John Kulicki
John Mander
Lee Marsh
Geoffrey Martin
Andrzej Nowak
Richard Nutt
Maurice Power
Andrei Reinhorn

Project Engineering Panel

Ian Buckle, Co-Chair
Christopher Rojahn, Co-Chair
Serafim Arzoumanidis
Mark Capron
Ignatius Po Lam
Paul Liles
Brian Maroney
Joseph Nicoletti
Charles Roeder
Frieder Seible
Theodore Zoli

2003

PREFACE

The 1971 San Fernando earthquake was a major turning point in the development of seismic design criteria for bridges in the United States. Prior to 1971, the American Association of State Highway and Transportation Officials (AASHTO) specifications for the seismic design of bridges were based in part on the lateral forces requirements for buildings that had been developed by the Structural Engineers Association of California. In 1973, the California Department of Transportation (Caltrans) introduced new seismic design criteria for bridges, which included the relationship of the site to active faults, the seismic response of the soils at the site and the dynamic response characteristics of the bridge. AASHTO adopted Interim Specifications in 1975 which were a slightly modified version of the 1973 Caltrans provisions, and made them applicable to all regions of the United States. In addition to these code changes, the 1971 San Fernando earthquake stimulated research activity on seismic problems related to bridges.

In the light of these research findings, the Federal Highway Administration awarded a contract in 1978 to the Applied Technology Council (ATC) to evaluate current criteria used for seismic design of highway bridges, review available seismic research findings for design applicability and use in new specifications, develop new and improved seismic design guidelines for highway bridges applicable to all regions of the United States, and to evaluate the impact of these guidelines and modify them as appropriate. The guidelines from this ATC project, known as ATC-6, *Seismic Design Guidelines for Highway Bridges* (ATC, 1981), were first adopted by AASHTO as a Guide Specification in 1983. They were later adopted as seismic provisions within the AASHTO *Standard Specifications for Highway Bridges* as Division I-A in 1991.

After damaging earthquakes occurred in California (1989), Costa Rica (1991) and the Philippines (1991), AASHTO requested the Transportation Research Board to review these criteria and prepare revised specifications as appropriate. Funded through the AASHTO-sponsored National Cooperative Highway Research Program (NCHRP) under NCHRP Project 20-7, Task 45, the Multidisciplinary Center for Earthquake Engineering Research (MCEER, formerly known as NCEER) prepared an updated set of seismic design provisions which closely followed the previous criteria but removed ambiguities, corrected technical omissions, and introduced limited new material that was based on field experience and new research findings. The updated provisions were adopted into both the AASHTO *Standard Specifications* and the first and second editions of the AASHTO *LRFD Bridge Design Specifications*. However, the technical basis for the updated provisions was essentially the same as that of the ATC-6 provisions which were initially published in 1981.

In 1998, the NCHRP initiated a subsequent study under NCHRP Project 12-49 to develop a new set of seismic design provisions for highway bridges, compatible with the AASHTO *LRFD Bridge Design Specifications*. NCHRP Project 12-49, which was conducted by a joint venture of the Applied Technology Council and the Multidisciplinary Center for Earthquake Engineering Research (the ATC/MCEER Joint Venture), had as its primary objective the development of seismic design provisions that reflected the latest design philosophies and design approaches that would result in highway bridges with a high level of seismic performance. The results of NCHRP Project 12-49 have been reformatted into a stand-alone set of provisions that can be more readily used for seismic design. The provisions contained herein are the results of that effort.

Development of the original NCHRP Project 12-49 provisions (from which this document was generated) was done by the ATC/MCEER Joint Venture. Ian Friedland of ATC (and formerly MCEER) was the Project Principal Investigator and Ronald Mayes was the Project Technical Director. Christopher Rojahn of ATC was the Project Administrative Officer on behalf of the ATC/MCEER Joint Venture. The NCHRP Project 12-49 Project Team included Donald Anderson (CH2M Hill, Inc.), Michel Bruneau (University at Buffalo), Gregory Fenves (University of California at Berkeley), John Kulicki (Modjeski and Masters, Inc.), John Mander (University of Canterbury, formerly University at Buffalo), Lee Marsh (BERGER/ABAM Engineers), Ronald Mayes

(Simpson, Gumpertz & Heger, Inc.), Geoffrey Martin (University of Southern California), Andrzej Nowak (University of Michigan), Richard Nutt (bridge consultant), Maurice Power (Geomatrix Consultants, Inc.), and Andrei Reinhorn (University at Buffalo).

The project also included an advisory Project Engineering Panel; Ian Buckle, of the University of Nevada at Reno, co-chaired this committee with Christopher Rojahn of ATC. Other members included Serafim Arzoumanidis (Steinman Engineers), Mark Capron (Sverdrup Civil Inc.), Ignatius Po Lam (Earth Mechanics), Paul Liles (Georgia DOT), Brian Maroney (California DOT), Joseph Nicoletti (URS Greiner Woodward Clyde), Charles Roeder (University of Washington), Frieder Seible (University of California at San Diego), and Theodore Zoli (HNTB Corporation).

NCHRP Project Panel C12-49, under the direction of NCHRP Senior Program Officer David Beal and chaired by Harry Capers of the New Jersey Department of Transportation (DOT), also provided a significant amount of input and guidance during the conduct of the project. The other members of the NCHRP Project Panel were D.W. Dearasaugh (Transportation Research Board), Gongkang Fu (Wayne State University), C. Stewart Gloyd (Parsons Brinckerhoff), Manoucher Karshenas (Illinois DOT), Richard Land (California DOT), Bryan Millar (Montana DOT), Amir Mirmirman (University of Central Florida), Charles Ruth (Washington State DOT), Steven Starkey (Oregon DOT), and Phillip Yen (FHWA).

Three drafts of the Project 12-49 specifications and commentary were prepared and reviewed by the ATC Project Engineering Panel, NCHRP Project Panel 12-49, and the AASHTO Highway Subcommittee on Bridges and Structures seismic design technical committee (T-3), which was chaired by James Roberts of Caltrans.

The development of this document, and the companion *Commentary* and *Appendices* (Part II), was conducted as a task in the FHWA-sponsored MCEER Highway project following completion of the original NCHRP 12-49 project. A subset of the original NCHRP Project 12-49 team, consisting of Donald Anderson, Michel Bruneau, Ronald Mayes, Lee Marsh, Richard Nutt, and Maurice Power, condensed the original draft specifications prepared by the Project Team to this two-volume document, *Recommended LRFD Guidelines for the Seismic Design of Highway Bridges*. In addition to making the document more amenable for design, the two volumes address issues identified during final project review and provide additional commentary for some of the studies that were carried out in support of the original specification development.

ATC and MCEER staff provided editorial and desktop publishing services during the preparation of this Guide Specification.

Michel Bruneau, MCEER
Christopher Rojahn, ATC

TABLE OF CONTENTS