MCEER/ATC-49-1

Liquefaction Study Report

Recommended LRFD Guidelines for the Seismic Design of Highway Bridges

Prepared under

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)

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PREFACE

In 2003 the ATC/MCEER Joint Venture, a partnership of the Applied Technology Council (ATC) and the Multidisciplinary Center for Earthquake Engineering Research (MCEER), University at Buffalo, published the set of documents, *Recommended LRFD Guidelines for the Seismic Design of Highway Bridges, Part I, Specifications,* and *Part II, Commentary and Appendices* (MCEER/ATC-49 Report). These documents are reformatted versions of the seismic design provisions (specifications and commentary) for highway bridges developed under NCHRP (National Cooperative Highway Research Program) Project 12-49, a recently completed project to develop seismic design provisions that would be compatible with the AASHTO *LRFD Bridge Design Specifications.* The reformatting effort, which was carried out to facilitate immediate use of the Project 12-49 provisions by bridge design professionals, was funded as a task under the MCEER Highway Project, which is sponsored by the Federal Highway Administration (FHWA).

NCHRP Project 12-49 also included a companion study to investigate the effects of liquefaction and an effort to develop design examples using the NCHRP 12-49 recommended provisions. The liquefaction study is documented in this MCEER/ATC-49-1 Report, *Liquefaction Study Report*, *Recommended LRFD Guidelines for the Seismic Design of Highway Bridges,* and the design examples are provided in the companion MCEER/ATC-49-2 Report, *Design Examples, Recommended LRFD Guidelines for the Seismic Design of Highway Bridges.*

This special liquefaction study was carried out (1) because liquefaction has been one of the most significant causes of damage to bridge structures during past earthquakes, and (2) because there was concern during the conduct of NCHRP Project 12-49 that that liquefaction hazards under the recommended provisions may prove to be too costly to accommodate in construction. The cause for the latter concern arose because the recommended *Specifications* use ground motions for the Maximum Considered Earthquake (MCE), which have a probability of exceedance of approximately 3 percent in 75 years (which corresponds to a 2,475-year return period), whereas the current American Association of State Highway and Transportation Officials (AASHTO) *Standard Specifications for Highway Bridges* recommend lower amplitude ground motions for design, namely ground motions having a probability of exceedance of approximately 15% in 75 years (which corresponds to a 475-year return period).

A broad array of engineering expertise was engaged by the ATC/MCEER Joint Venture to develop the original NCHRP 12-49 seismic design provisions, companion liquefaction study, and design examples. Ian Friedland of ATC (and formerly MCEER) served as the Project Principal Investigator and Ronald Mayes (Simpson Gumpertz & Heger, Inc.) served as the Project Technical Director. The NCHRP Project 12-49 team consisted of 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 (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, who also served as the Project Administrative Officer. 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.

ATC and MCEER staff provided editorial and desktop publishing services during the preparation of this *Liquefaction Study Report*.

Michel Bruneau, MCEER
Christopher Rojahn, ATC

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* The appendices are provided on the enclosed CD-ROM.