

WENCHUAN, SICHUAN PROVINCE, CHINA, EARTHQUAKE OF 2008

Lifeline Performance

Edited by
Alex K. Tang, P.E., P.Eng., C.Eng.



Technical Council on Lifeline Earthquake Engineering
Monograph No. 39

ASCE

This is a preview. [Click here to purchase the full publication.](#)

Wenchuan, Sichuan Province, China, Earthquake of 2008

Lifeline Performance

PREPARED BY

Earthquake Investigation Committee of the
Technical Council on Lifeline Earthquake Engineering

EDITED BY

Alex K. Tang, P.E., P.Eng., C.Eng.

Technical Council on Lifeline Earthquake Engineering
Monograph No. 39



Published by the American Society of Civil Engineers

This is a preview. [Click here to purchase the full publication.](#)

Library of Congress Cataloging-in-Publication Data

Wenchuan, Sichuan Province, China, earthquake of 2008 : lifeline performance / prepared by Earthquake Investigation Committee of the Technical Council on Lifeline Earthquake Engineering ; edited by Alex K. Tang, P.E., P.Eng. ; Technical Council on Lifeline Earthquake Engineering.

pages cm. — (Monograph ; no. 39)

Includes bibliographical references and index.

ISBN 978-0-7844-1333-3 (print : alk. paper)—ISBN 978-0-7844-7864-6 (ebook) 1. Buildings--Earthquake effects—China—Wenchuan Xian. 2. Lifeline earthquake engineering—China--Wenchuan Xian. 3. Earthquake damage—China—Wenchuan Xian. 4. Wenchuan Xian (Sichuan Sheng, China)—Buildings, structures, etc. I. Tang, Alex, editor. II. American Society of Civil Engineers. Earthquake Investigation Committee.

TH1095.W465 2014

693.8'52095138—dc23

2014023610

Published by American Society of Civil Engineers

1801 Alexander Bell Drive

Reston, Virginia, 20191-4382

www.asce.org/bookstore | ascelibrary.org

Any statements expressed in these materials are those of the individual authors and do not necessarily represent the views of ASCE, which takes no responsibility for any statement made herein. No reference made in this publication to any specific method, product, process, or service constitutes or implies an endorsement, recommendation, or warranty thereof by ASCE. The materials are for general information only and do not represent a standard of ASCE, nor are they intended as a reference in purchase specifications, contracts, regulations, statutes, or any other legal document. ASCE makes no representation or warranty of any kind, whether express or implied, concerning the accuracy, completeness, suitability, or utility of any information, apparatus, product, or process discussed in this publication, and assumes no liability therefor. The information contained in these materials should not be used without first securing competent advice with respect to its suitability for any general or specific application. Anyone utilizing such information assumes all liability arising from such use, including but not limited to infringement of any patent or patents.

ASCE and American Society of Civil Engineers—Registered in U.S. Patent and Trademark Office.

Photocopies and permissions. Permission to photocopy or reproduce material from ASCE publications can be requested by sending an e-mail to permissions@asce.org or by locating a title in ASCE's Civil Engineering Database (<http://cedb.asce.org>) or ASCE Library (<http://ascelibrary.org>) and using the “Permissions” link.

Errata: Errata, if any, can be found at <http://dx.doi.org/10.1061/9780784413333>.

Copyright © 2014 by the American Society of Civil Engineers.

All Rights Reserved.

ISBN 978-0-7844-1333-3 (paper)

ISBN 978-0-7844-7864-6 (PDF)

Manufactured in the United States of America.

Cover photo credits: top left: David Lee; top right: Conrad Felice; bottom left: John Eidinger; bottom right: Alex Tang

TCLEE Monographs

Since 1990, the Technical Council on Lifeline Earthquake Engineering (TCLEE) has published reports in the TCLEE Monograph Series. TCLEE Monographs further the Council's goal of advancing the state-of-the-art and -practice in lifeline engineering for earthquakes, hurricanes, and other extreme events.

More information about TCLEE is available at <http://www.asce.org/tclee/>.

A list of available TCLEE Monographs may be found at <http://www.asce.org/bookstore>. Digital versions may be found in the ASCE Library, <http://ascelibrary.org/r/tclee>.

Contents

Preface.....	ix
Contributors	x
Acknowledgments.....	xi
 Chapter 1: Introduction	 1
Executive Summary	1
Lessons Learned.....	4
Investigation Team.....	5
Chapter Authors	6
Maps, Place Names, and Locations	6
Abbreviations.....	
 Chapter 2: Seismology and Geotechnical Considerations	 8
Seismic Setting.....	8
Seismic Hazard Zonation.....	16
Ground Motions	18
Landslide Failures.....	27
Surface Faulting.....	27
Site Classification in Chinese Code GB50011	33
Acknowledgement	35
 Chapter 3: Transportation Systems	 36
Executive Summary	36
Performance of Roads.....	37
Retaining Walls.....	50
Bridges	52
Tunnels.....	81
Rail System	89
Recommendations.....	89
Acknowledgment	92
References.....	93
 Chapter 4: Electric Power System.....	 94
Overview.....	94
Electric Power Generation	96
Transmission System	100
Transmission Towers.....	133
Distribution System	141

Lessons Learned and Recommendations	144
Acknowledgment	149
Reference	150
Chapter 5: Potable Water Systems	151
Overview of the Existing Water Systems	151
Water Pipes	151
Water Facilities	158
Water Emergency Response and Recovery	163
Dujiangyan Water Diversion System.....	166
Lessons Learned and Recommendations	168
Acknowledgment	171
Chapter 6: Telecommunications.....	172
Executive Summary	172
Description of System.....	172
Performance of the Cellular (Wireless) Network	173
Performance of the Landline Network.....	188
Lessons Learned and Recommendations	204
Acknowledgment	204
Reference	204
Chapter 7: Airports	205
Executive Summary	205
Airports	205
Chapter 8: Dams	206
Executive Summary	206
Overview of System Performance	207
Performance of Sichuan Dams and Reservoirs.....	209
China's Dam Safety Program	216
Conclusions and Recommendations	220
Acknowledgment	221
Reference	221
Chapter 9: Damage to Schools and General Building Stock	222
Executive Summary	222
Schools.....	227
Beichuan (北川) Town	236
Hongkou (虹口) Area	246
Dujiangyan.....	255

Yingxiu	262
Mianyang	266
Chengdu	267
Shifang	270
Nanba (南坝) and Hejiaba (何家坝).....	275
Lessons Learned and Recommendations	280
Acknowledgment	281
Chapter 10: Emergency Response.....	282
Executive Summary	282
Government Response	282
Non-Government Organization (NGO) Response.....	287
Continuing Efforts by the Chinese Government.....	289
Long-Term Reconstruction Efforts.....	289
Conclusions	290
Acknowledgment	290
Index	291

Preface

The Earthquake Investigation Committee of the Technical Council of Lifeline Earthquake Engineering (TCLEE), American Society of Civil Engineers (ASCE), was established to initiate, organize, train for, coordinate, and evaluate the performance of lifelines following earthquakes. Members of the committee are employees of lifeline industries, consulting engineers, and academics from the United States and Canada. Committee members provide services on a voluntary basis. For some earthquake investigations, participants' companies do not require their employees to take vacation time for the investigation and may provide some support for expenses. ASCE also provides support to reimburse expenses. In addition to the time associated with the reconnaissance trip, the substantial effort by each individual to prepare a short report for the TCLEE Web page and the full report for the monograph series is all done on a voluntary basis. The cost of this effort is substantially more than the support provided by ASCE.

Individuals participating in the investigation need not be members of the committee or members of ASCE, but they are expected to follow the committee's earthquake investigation practices as described in the ASCE publication, TCLEE Monograph 11, *Guide to Post-Earthquake Investigation of Lifelines*. Members of the investigation team coordinate with other groups and may participate in groups organized by other organizations. They gather both good and poor performance data from domestic and foreign earthquakes to provide information for practitioners to improve the performance of the lifeline systems. Foreign earthquakes that have been investigated include the 1985 Chile, 1988 Soviet Armenia, 1990 Philippines, 1991 Costa Rica, 1992 Kocaeli (Turkey), 1994 Kobe (Japan), 1999 Kocaeli (Turkey), 1999 Chi-Chi (Taiwan), 2001 Gujarat (India), 2002 Atico (Peru), 2004 Zemmouri (Algeria), 2004 Sumatra, 2007 Kashiwazaki (Japan), and 2008 Pisco (Peru). Domestic earthquakes that have been investigated include 1989 Loma Prieta, 1992 Landers, 1994 Northridge, 2000 Napa, 2001 Nisqually, 2002 Denali, 2003 Paso Robles, and 2008 Alum Rock.

The Kobe earthquake report, Monograph 14, was the first foreign earthquake investigation report published by ASCE as a TCLEE monograph. The first domestic earthquake investigation report published by ASCE as a TCLEE monograph, Number 8, was for the Northridge earthquake. Prior to this time, TCLEE prepared a lifeline report that was published by the Earthquake Engineering Research Institute (EERI). The Earthquake Investigation Committee continues to cooperate with EERI to provide an abbreviated version of lifeline performance in Earthquake Spectra (EERI publication). TCLEE publishes brief preliminary reports on the ASCE/TCLEE Web page.

Alex Tang, PE, F. ASCE
June 2010