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# INTERNATIONAL Collaboration in Lifeline Earthquake Engineering 2016

Proceedings of the Seventh China-Japan-US Trilateral Symposium on Lifeline Earthquake Engineering

Shanghai, China • June 1-4, 2016

Edited by Craig Davis, Jie Li, Masakatsu Miyajima, Liping Yan, Xiaogiu Ai, and Haizbong Wang This is a preview. Click here to purchase the full publication.

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# INTERNATIONAL COLLABORATION IN LIFELINE EARTHQUAKE ENGINEERING 2016

### PROCEEDINGS OF THE SEVENTH CHINA-JAPAN-US TRILATERAL SYMPOSIUM ON LIFELINE EARTHQUAKE ENGINEERING

June 1–4, 2016 Shanghai, China

SPONSORED BY Shanghai Institute of Disaster Prevention and Relief Tongji University Beijing University of Technology International Society of Lifeline and Infrastructures Earthquake Engineering Kanazawa University Lifeline Network (LiNK) Japan Ductile Iron Pipe Association Infrastructure Resilience Division of the American Society of Civil Engineers

> EDITED BY Craig Davis Jie Li Masakatsu Miyajima Liping Yan Xiaoqiu Ai Haizhong Wang



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Front cover: Professor Michael O'Rourke

## Preface

The Seventh China-Japan-US Trilateral Symposium on Lifeline Earthquake Engineering (Symposium) was held in Shanghai, China from June 1 to 4, 2016. The Symposium attracted over 83 attendees, many of whom were students, consisting of 10 delegates representing the United States, 13 from Japan, and more than 60 from China. This Symposium included participants from three additional countries - New Zealand, Turkey, and Canada. The Shanghai Institute of Disaster Prevention and Relief, Tongji University, Shanghai, China served as primary organizer and hosted this Symposium and co-organized in collaboration with The International Society of Lifeline and Infrastructure Earthquake Engineering (ISLIEE), Kanazawa University, Japan, and the American Society of Civil Engineers Infrastructure Resilience Division (IRD), USA. Prof. Jie Li of Tongji University took the role of chief organizer, and Prof. Masakatsu Miyajima of Kanazawa University and Dr. Craig A. Davis of Los Angeles Department of Water and Power served as coordinators for Japan and US, respectively. Prof. Xiuli Du of Beijing University of Technology served as coordinator for ISLIEE.

This Symposium was organized in cooperation with the Shanghai Institute of Disaster Prevention and Relief, China, Tongji University; Shanghai, China, Beijing University of Technology, Beijing, China; ISLIEE; Kanazawa University, Japan; Lifeline Network Kansai (LiNK) Japan; Japan Ductile Iron Pipe Association; and the American Society of Civil Engineers IRD, US.

The first China-Japan Symposium on Lifeline Earthquake Engineering was held in 1990 at Beijing, China on the cooperative research between the Central Research Institute of Building and Construction in China and Kobe University in Japan containing wider researchers and engineers in China and Japan who were interested in Lifeline Earthquake Engineering. The second as a trilateral Symposium of China, Japan, and US joint programs was held in 1994 at Xi'an, China under the official US-China protocol program on cooperative earthquake engineering studies. The third, fourth, fifth, and sixth Symposiums were held in 1998 at Kunming, 2002 at Qingdao, 2007 at Haikou, China, and 2013 at Chengdu, China, respectively.

The objective of this seventh Symposium was to provide a forum for professional lifeline earthquake engineers and researchers in China, Japan, United States, and elsewhere for mutual exchange of recent results of main investigations on lifeline earthquake engineering, including water, wastewater, gas and liquid fuels, electric power, telecommunication, and transportation systems. Transportation includes roads and highways, ports (sea and air) and harbors, rail, and other transport systems and critical components in which communities are dependent upon. Recent severe earthquakes including 2008 China, 2009 Indonesia, 2010 Haiti, 2010 Chile, 2010-2011 New Zealand sequence, the 2011 and 2016 Japan, and 2015 Nepal earthquakes caused not only the direct losses of damaged lifeline facilities, but also severe indirect losses and community impacts caused by the interruption and long-term restoration of lifeline system functions. Seismic resilience incorporates the systemic loss and temporal recovery and is therefore a very important issue for managing community impacts and the physical and functional damages related to lifelines. The issue of seismic resilience for lifelines was emphasized in this seventh Symposium.

In the Symposium, three keynote lectures, six invited presentations, and 82 technical papers were presented. The keynote lectures were given by Professor Shiro Takada, Professor Emeritus, Kobe University, Professor Jean-Pierre Bardet, Dean of the College of Engineering University of Miami, and Prof. Hong-Nan Li, Chair Professor of Infrastructure Engineering, Dalian University of Technology. The invited presentations were given by Professor Hui Li, Harbin Institute of Technology, Professor Yasuko Kuwata, Kobe University, Professor Yoshihisa Maruyama, Chiba University, Professor Jianwen Liang, Tianjin University, Alex Tang, President, L&T Consulting, and Dr. Endi Zhai Chief Engineer for Civil Works and Director of Chief Engineer's Office, China Three Gorges Corporation.

Many papers were presented by younger practitioners, researchers, and students, showing how interest in lifeline earthquake engineering practice and research continues to grow. These proceedings contain 77 papers, including those presented at the Symposium. The papers cover a wide variety of topics relevant to lifeline earthquake engineering including: seismicity, ground motions, and site effects; seismic performance, modeling, evaluation, and design of water supply, sewage, electric power, gas and liquid fuel, telecommunication, and transportation systems and their components; seismic reliability and post-earthquake serviceability, recovery and resilience of lifeline systems; lifeline interactions; tunnels and underground structures; geotechnical and structural earthquake behavior related to lifelines; seismic testing and analysis for lifeline components and foundations (e.g., pipes, bridges, etc.); tsunami impacts, and a special session on bridge impact loads.

The purpose of these proceedings is to publish the high quality work that is being undertaken internationally in lifeline earthquake engineering and presented at the Symposium. The papers were first intended to initiate and foster discussion and intellectual exchange during the Symposium. Following the Symposium these proceedings are intended to make the papers available to others. This is the second time the proceedings from this series of lifeline earthquake engineering Symposiums has been formally published and engineering indexed. To ensure high caliber papers, each paper submitted underwent a stringent review for technical, grammatical, and format aspects. Each paper underwent at least two levels of review. The papers were screened by members of the Technical Committee from their respective countries to ensure each was original, pertinent to the Symposium, understandable and written in good English, and had good technical quality providing an important contribution to lifeline earthquake engineering. The papers from China were also reviewed and edited by English language technical editors. The resulting works provided a high quality experience for Symposium attendees and helped foster a good discussion and exchange of practice, experiment, and theoretical knowledge.

The ISLIEE was formed to enhance the international collaboration and development in lifeline and infrastructure engineering research and practice, including the coordination of this series of symposiums. The eighth symposium is currently being planned for 2018 at Shenyang Jianzhu University, China. The eighth symposium will encourage greater participation from other countries and younger members. This is intended to enhance the international collaboration and development in lifeline and infrastructure engineering research and practice.

The contributions of numerous individuals and participants from the participating countries are acknowledged. The outstanding efforts of Dr. Xiaoqiu Ai of Tongji University, for performing the primary coordinating duties and accomplishing successful Symposium are gratefully acknowledged.

Editors

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June 2016

## Contents

## Bridge Analysis

Numerical Synthesis Method of Ground Motions for Seismic Design of Near-Fault Bridge Engineering	
Bridge Collision	
<b>Evaluation of Large-Scale Composite Bumper System for Bridge Piers9</b> Lu Zhu, Hai Fang, and Weiqing Liu	
Index of Bending Performance for RC Columns under Impact Loadings14 Yanchen Song, Junjie Wang, and Junsheng Su	
Research on the Reasonable Stiffness of Bridge Anti-Collision Devices	
Simplified Impact Force Time History Model of Barge Pier Collisions	
Finite Element Analysis of the Nonlinear Collision between 300k DWT VLCC and Bridge Pier	
Experimental Study on the Behavior of Hot-Rolled Square Tubular T-Joints under Impact Loadings	
Time Variation Characteristics of Impact Force in Collision of Heavy Vehicle to the Bridge Pier	
<b>Design Method of Steel Plate-Rubber Energy Absorption Ring60</b> Lingfeng Tu, Junjie Wang, Zheng Zhu, and Yanchen Song	
Experimental Study on Flexural Behavior of Impact-Damaged Reinforced Concrete Beams	
Bridges	
Fiber-Based Damage Analysis of Circular RC Bridge Columns	

Junsheng Su and Junjie Wang

Seismic Response Analysis of High-Speed Operating Train-Bridge Coupling System
Multiple Hazard Bridge Design
Seismic Response Analysis of Yokohama-Bay Bridge Considering Pounding between Wind-Tongue and Wind-Shoe and Safety Evaluation during the 2011 Great East Japan Earthquake
Effectiveness of Rubber Cushion to Mitigate Pounding between Girders and Blocks of Curved Bridge Subjected to Strong Ground Motion107 Bo Song, Jing-Xia Cheng, and Yan-Xu Wang
<b>The Earthquake Response Analysis of the Niulanjiang Bridge</b> <b>during the 2014 Ludian Earthquake in China</b> 115 Yong Huang, Liang Zhang, Haidong Qiao, Rui Li, and Weijie Le
<b>Influence of Pounding on the Girder Unseating Potential of Skewed Bridges122</b> C. Kun and N. Chouw
Study on Seismic Alarm Threshold Value for High Speed Train on Bridge Considering Train-Bridge Coupling Effect
<b>Study on Dynamic Response Characteristics of a Bridge in Beijing136</b> Fei Wang, Hongkui Ge, and Xiandong Kang
Routine Health Monitoring of a Long-Span Suspension Bridge Based on Strong Motion Monitoring System
Field Testing and Analysis of a Maglev Guideway PC Girder with Unbonded Post-Tensioning Curvilinear Tendons
Seismic Damage Analysis of Concrete Girder Bridges Subjected to Near-Fault Ground Motions
Correlation Definition of Bridge Seismic Performance by Numerical Approach

## **Buried Reservoirs**

A Centrifuge Study: Influence of Site Response on the Seismic Performance of Buried Reservoir Structures	
Communications	
Study on the Whiplash Effect of Communication Tower Fixed on the Top of Buildings	
A. W. Liu, Y. D. Wang, and B. W. Hou	
Cooling Towers	
Study on the Application of Base Isolation for the Ultra Large Cooling Tower Structure	
Yongbin Liu, Guofang Zeng, Junwu Dai, and Yongqiang Yang	
Damping Equipment	
<b>Experimental Studies of the Mechanism of Particle Dampers Based</b> <b>on an SDOF Structure under Harmonic Excitation194</b> Jin Wang, Weiming Yan, and Weibing Xu	
Electric Power	
Seismic Damage Investigation and Analysis of Electric Power System in Nepal Ms 8.1 Earthquake201 Jin-Long Liu and Yong Huang	
Seismic Fragility of Power Distribution Systems	
Electrical Equipment	
Seismic Protection of Porcelain Cylindrical Electrical Equipment Based on MTMD	
Energy and Power Systems	
Assessment of Tsunami Inundation Exposure of Energy-Related Base Facilities Caused by Anticipated Nankai Megathrust Earthquakes	
Effect of Initial Geometrical Imperfections on Buckling Strength and Design of Offshore Wind Turbine Tower234 Nu Nu Lwin and Bo Song	

Dynamic Nonlinear Time-History Analysis of Nuclear Power Plant under Near-Fault Ground Motion with Velocity Pulse242 Qiumei He, Xiaojun Li, Yaqi Li, Aiwen Liu, and Jiangwei Zhang
Interdependencies
Lifeline Interrelation during the Tohoku Earthquake: Analysis through Text Mining250 Yasuko Kuwata
Isolation Systems
Parameters Optimization and Energy Analysis of Inter-Story Isolation System
Liquefaction
The Development of Software for Deterministic Assessment of Seismic Soil Liquefaction
Oil and Gas
Rapid Seismic Disaster Assessment of Oil and Gas Pipeline Basedon the ShakemapA. W. Liu, B. W. Hou, J. Liu, and Y. D. Wang
Pavement
Numerical Simulation on the Composited Pavement Slab Subjected to Multiple Drop Weight Impact
Pile Foundations
An Investigation on the Parameter Study of Soil-Pile Spring Model of Seismic Bridge
Effect of Pile Diameter on the Seismic Performance of Pile Foundation
Pipeline Networks
Seismic Reliability Evaluation of Pipeline Networks under Spatially Correlated Ground Motions