Lushan, Sichuan Province, China, Earthquake of 2013

Lifeline Performance

PREPARED BY
Earthquake Investigation Committee of the Technical Council of Lifeline Earthquake Engineering

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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.

As the grand challenge of lifeline resilience is taking a strong hold in the United States, Japan, and New Zealand, the monographs documenting lessons learned are the basis of establishing best practices and engineering guidelines to advance lifeline resilience.

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1 INTRODUCTION

The Lushan earthquake occurred at 8:02 am local time, April 20, 2013. This earthquake is the result of a rupture on a nearby/adjacent fault segment to the great M 8.0 Wenchuan earthquake of May 12, 2008. The ruptured fault segment in 2013 was located south of the southern end of the rupture in the 2008 event. The distance between the Lushan (卢山) EQ epicenter is about 83 km SSW of the Wenchuan EQ epicenter.

While the USGS lists the earthquake as moment magnitude (M) 6.6, various other Japanese and Chinese agencies list the earthquake as surface wave magnitudes between 6.9 and 7.0.

The following highlights the findings from the ASCE/TCLEE/EIC team members John Eidinger, Alex Tang, and Craig Davis, who visited the epicentral area on May 27, 28 and 31, 2013 as well as interviewed local individuals who had been to the area. This report places a special emphasis on the "lessons learned and implemented" since the 2008 earthquake.

This report primarily covers the Lushan City and towns/villages within 50 km of Lushan City. Lushan City has a population about 25,000 people.

Within Lushan City, the estimated ground motions were generally between PGA = 0.25g and 0.35g, soils generally being firm. Although there were some localized liquefaction effects, and there were no landslides within the main city area. Outside of Lushan City, ground motions were locally higher (closer to the epicenter), and there were many landslides and rockfalls in steep canyon areas.

1.1 Key Findings

This earthquake can be considered a subsequent earthquake of the 2008 M 8.0 event. The 2008 event placed additional stress on nearby faults and accelerated the time these nearby faults would break. Given that the 5-year interval of time between the two events (2008 to 2013) was long enough to implement some mitigation measures, the purposes for the ASCE team investigation had these three goals:

- First, document the damage or resilience of lifelines.
- Second, describe the "lessons learned" in this area of China with respect to the difference in earthquake hazard mitigation in the 5 intervening years. This includes both emergency response, as well as seismic design and construction practices.
- Third, describe the implications of the good performance and failures in the Lushan earthquake, and how these might be considered in US practice.

The following section highlights the key findings.

Table 1-1. Comparison of the Two Earthquakes.

	2008	2013
Magnitude, M	8.0 M	6.6 M (USGS)
Epicenter	31.0367N 103.3329E	30.277N 102.937E
Fault Type	Reverse Thrust	Reverse Thrust
Depth, km	19	14 (12.9)
Rupture Area, km^2	330x25	20x25
Azimuth	--	218° (223.5°)
Dip	--	39° (80°)
Maximum MMI Intensity	XI	IX
Affected area	Large	Small
Fatalities	87,000	196
Economic Loss	Large	Small

Note: Values in parenthesis are from non-Chinese sources

Comparison of the 2008 and 2013 Earthquakes

Table 1-1 lists some parameters that compare the 2008 and 2013 earthquakes.

Damage to Lifelines

There was widespread damage to critical lifelines. We observed no seismic design practices for buried lifelines built pre-2008 or during the 2008 and 2013 time period; they suffered substantial damage, resulting in widespread and locally lengthy service outages. Additionally, we observed no seismic provisions for high-voltage electrical equipment, and there was extensive damage at the Jinhua (金 花) 110 kV substation.

Lessons Learned

The emergency response was generally good in the 2013 Lushan event. Rapid mobilization by nearly 10,000 emergency responders helped reduce the impacts of the earthquake. The response was faster and more comprehensive than in the 2008 earthquake, reflecting both lessons learned as well as the relatively smaller affected areas in the 2013 event.

The seismic code for this part of China was increased from "Zone VI (pre-2008)" to "Zone VII (post-2008)". The implications are that at Zone VI there are essentially no seismic design provisions for lateral loads, but for Zone VII the regular building stock is designed for PGA = 0.1g. Given the high seismic activity and hazard for this region of China, and following US practice, the minimum upgrade could have been for PGA = 0.3g