RED-ACT Report

Real-time Earthquake Damage Assessment using City-scale Time-history analysis

July 05, M7.1 California Ridgecrest Earthquake (V3)

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Acknowledgments and Disclaimer

The authors are grateful for the data provided by CESMD (CESMD, 2019) and SCSN (SCEDC, 2019). This analysis is for research only. The actual damage resulting from the earthquake should be determined according to the site investigation.

Scientific background of this report can be found at:

http://www.luxinzheng.net/rr.htm

1. Introduction to the earthquake event

At 20:19:52 05 July 2019 (Local Time, UTC -8), an M 7.1 (USGS) earthquake occurred in California Ridgecrest, USA. The epicenter was located at 35.7665N 117.6048W, with a depth of 17.0 km.

2. Recorded ground motions

14 ground motions near to epicenter of this earthquake were analyzed. The names and locations of the stations can be found Table 1. The maximal recorded peak ground acceleration (PGA) is 569 cm/s/s. The corresponding response spectra in comparison with the 8-degree design spectra specified in the Chinese Code for Seismic Design of Buildings are shown in Figure 1.

The waveforms and response spectra of typical ground motions are shown in Appendix.

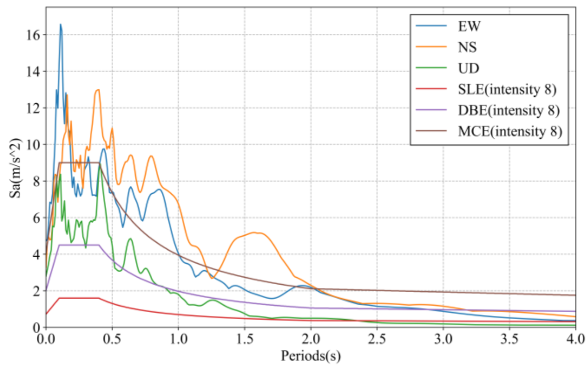


Figure 1 Response spectra of the recorded ground motions with maximal PGA

3. Damage analysis of the target region subjected to the recorded ground motions

Using the real-time ground motions obtained from the strong motion networks and the **city-scale nonlinear time-history analysis,** the damage ratios of buildings located in different places can be obtained. The building damage distribution and the human feeling distribution near to different stations is shown in Figure 2 and Figure 3, respectively. These outcomes can provide a reference for post-earthquake rescue work.

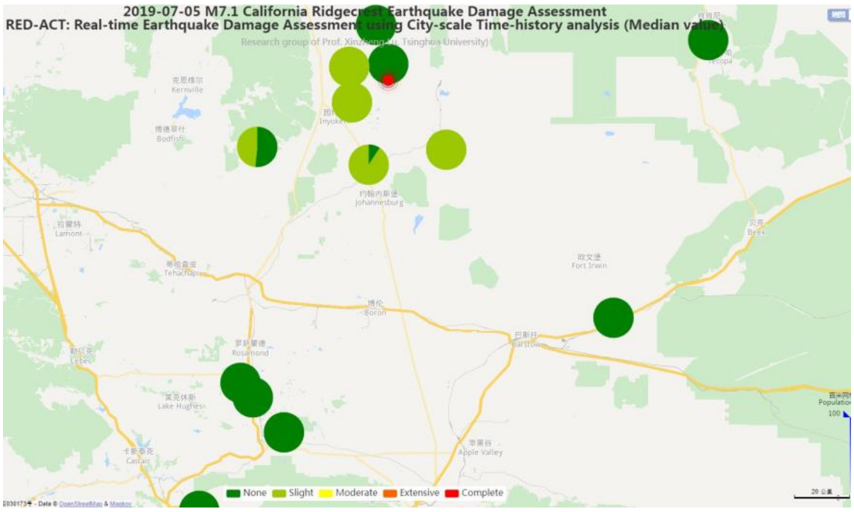


Figure 2 Damage ratio distribution of the buildings near to different stations

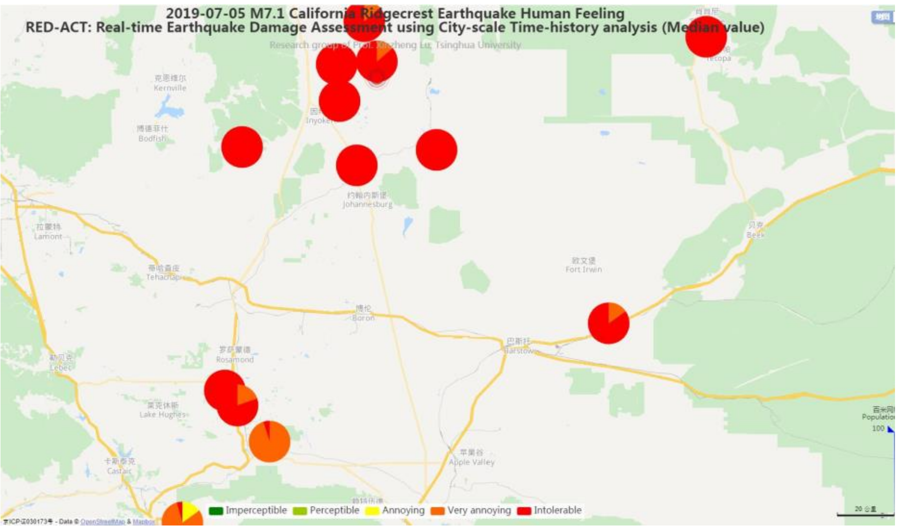


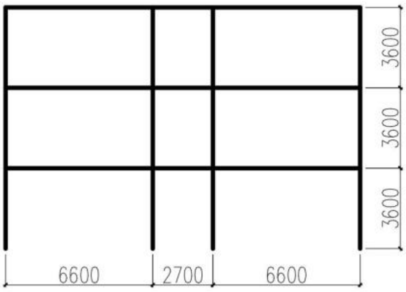
Figure 3 Human feeling distribution near to different stations

3. Damage analysis of typical structures subjected to the recorded ground motions

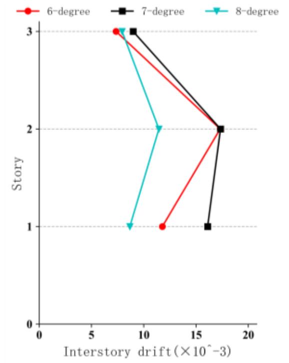
Eight typical structures (two non-engineered masonry buildings, three reinforced concrete frames designed according to Chinese code, and two bridges) are selected as typical structures to check the damage capacity of the recorded ground motions. The numerical models are generated using OpenSees. The results are as follows:

Model 1: 3-story reinforced concrete frame (Thanks Prof. Wang Qi from China Architecture Design & Research Group for providing the model)

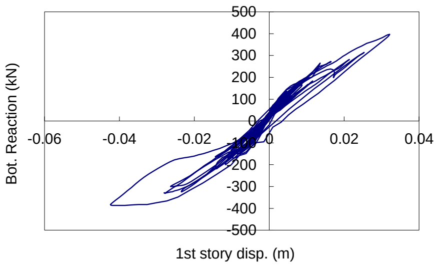
CICCC records are input into three typical 3-story reinforced concrete frames, with the seismic design intensities of 6-, 7-, and 8-degrees (corresponding PGAs for 10%/50y are 0.05g, 0.1g and 0.2g, respectively). The envelope of the inter-story drift ratios obtained from the nonlinear time-history analyses are shown in Figure 4(b). Inter-story force-displacement curves are shown in Figure 4(c) to (e).



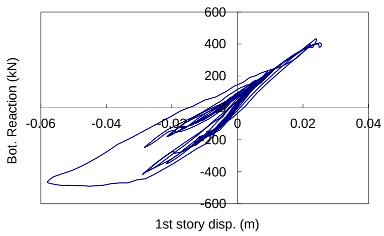
(a) Elevation view (unit: mm)



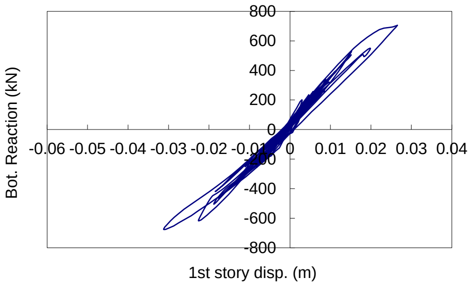
(b) Envelope of the inter-story drift ratios



(c) Inter-story force-displacement of 6-degree frame



(d) Inter-story force-displacement of 7-degree frame



(c) Inter-story force-displacement of 8-degree frame

Figure 4 Three typical 3-story RC frames

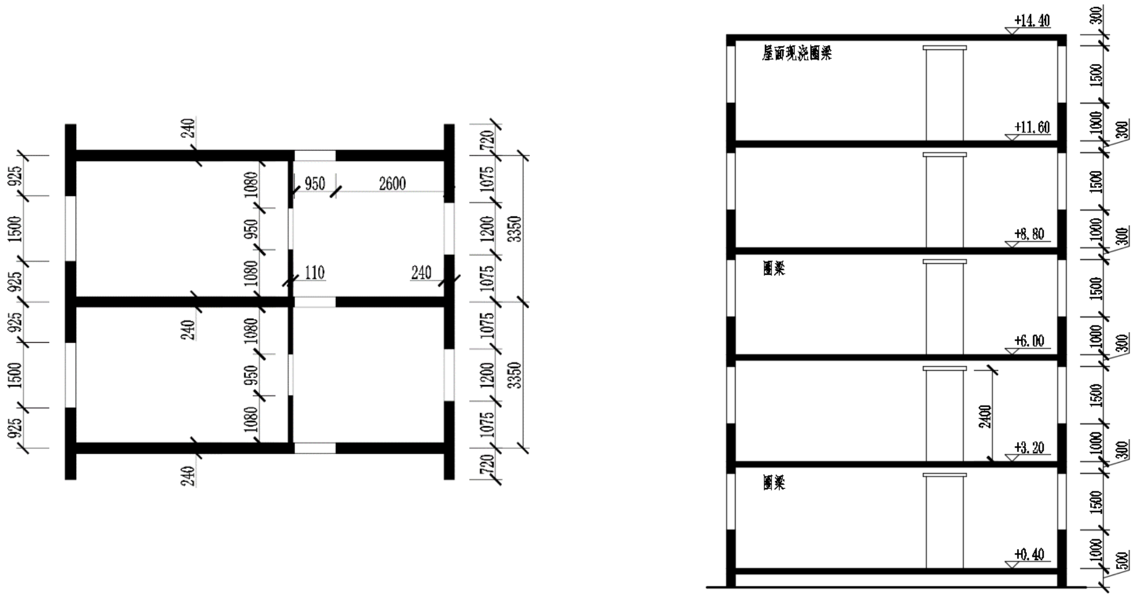
Model 2: Single story unreinforced masonry

CICCC records are input into a single story unreinforced masonry building in Figure 5. The damage state of the structure is **severe damage**. (Ji X D, et al. Shaking table test of unretrofitted and retrofitted brick-wood structures representative of existing rural buildings in Beijing. Journal of Building Structures, 2012, 11, 53-61.)

Figure 5 A single story unreinforced brick-wood residential building

Model 3: five-story simple masonry

CICCC records are input into a five-story simple masonry in Figure 6. The damage state of the structure is **moderate damage**. (Zhu B L, et al. Seismic resistance capacity analysis of a five-story masonry test building in Shanghai, Journal of Tongji University, 1981,4,7-14.)



(a) Plan view (b) Section view

Figure 6 A five-story simple masonry building

Model 4: Highway bridge built in 1980s (Thanks Prof. Gu Yin from Fuzhou University)

CICCC records are input into a highway bridge built in 1980s in Figure 7. The damage state of the bridge is **severe damage**.

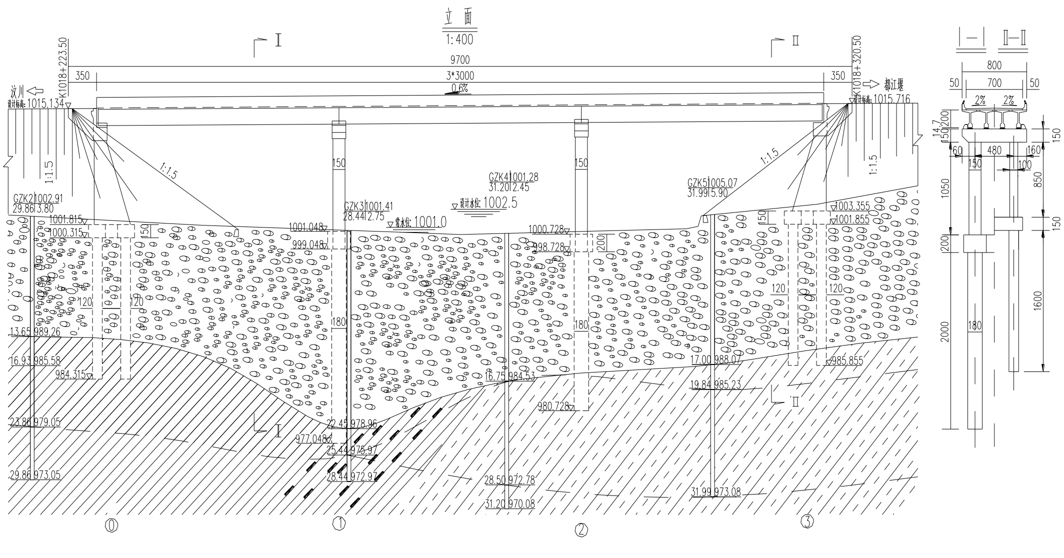


Figure 7 A highway bridge built in 1980s

Model 5: Approach bridge of a super long bridge (Thanks Prof. Gu Yin from Fuzhou University)

CICCC records are input into the approach bridge of a super long bridge in Figure 8. The damage state of the bridge is **moderate damage**.

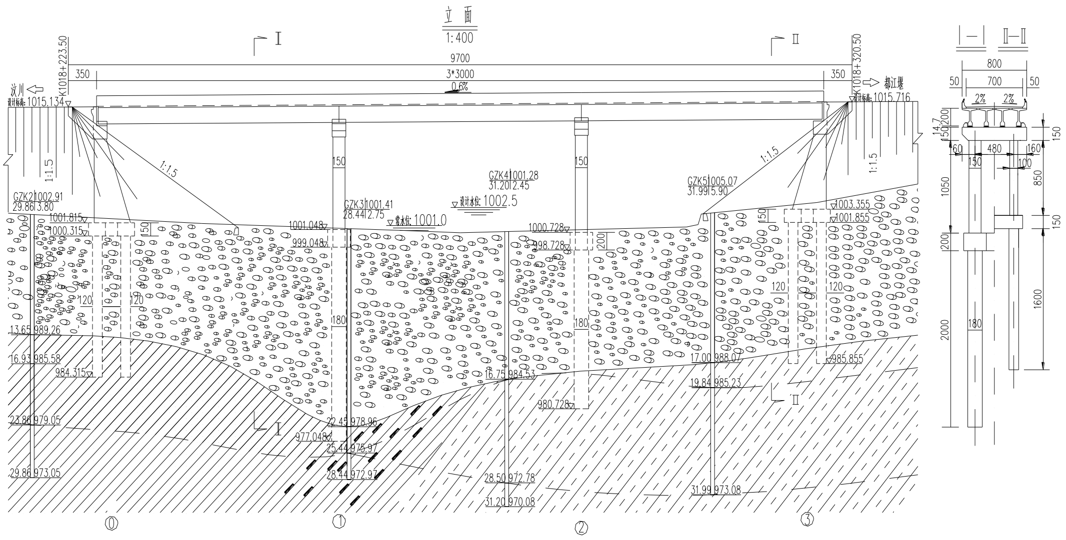


Figure 8 The approach bridge of a super long bridge

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Table 1 Names and locations of the strong motion stations

No.	Station Name	Longitude	Latitude
1	CE22519	-116.67	34.961
2	CE24088	-118.376	34.296
3	CE24474	-118.215	34.739
4	CE24517	-118.158	34.687
5	CE24661	-118.16	34.687
6	CE24965	-118.03	34.57
7	CICCC	-117.365	35.525
8	CICLC	-117.598	35.816
9	CILRL	-117.682	35.48
10	CISHO	-116.275	35.9
11	CISRT	-117.751	35.692
12	CITOW	-117.765	35.809
13	CIWBS	-118.14	35.537
14	CIWRC	-117.65	35.948

Appendix: Typical ground motions

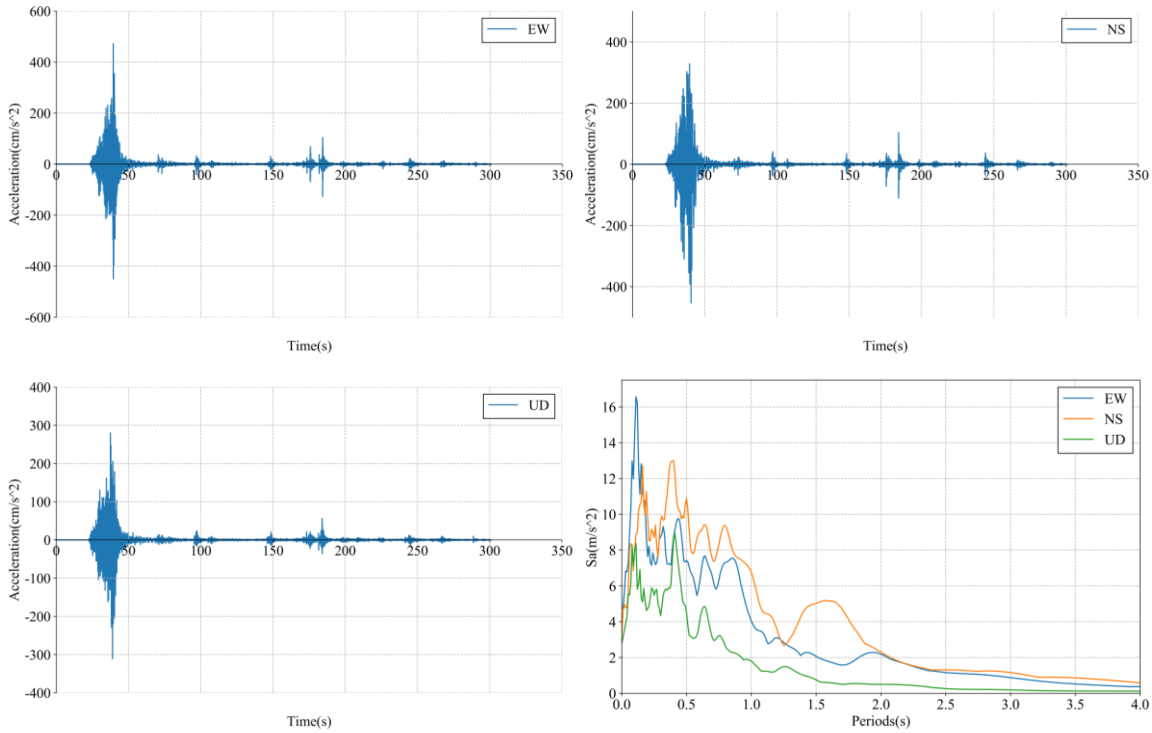

Figure A Station CI.CCC (Data from CESMD, 2019)

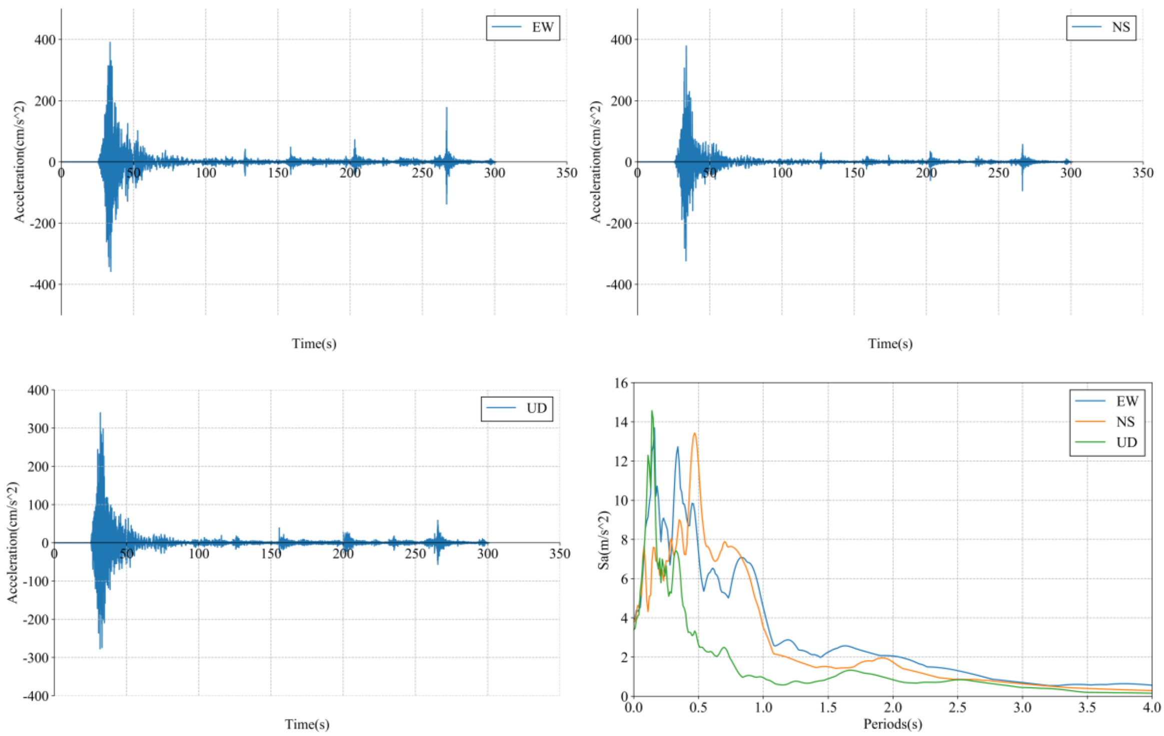

Figure B Station CI.TOW2 (Data from CESMD, 2019)

References

CESMD, 2019. https://strongmotioncenter.org/

SCEDC, 2019. http://service.scedc.caltech.edu/