M 6.4 and M 7.1 Ridgecrest, CA Earthquakes

PRELIMINARY VIRTUAL RECONNAISSANCE REPORT (PVRR)

Damaged mobile home in Ridgecrest, CA during the M 6.4 earthquake. Photo by Darla A. Baker / The Californian.

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Executive Summary

A magnitude 6.4 earthquake with a depth of 10.7 km occurred in San Bernardino County, CA on July 4, 2019. The epicenter was located 12 km south west of Searles Valley. On July 5, 2019, a 7.1 magnitude earthquake occurred near the same location and at a depth of 17 km. It is noted that the earthquakes occurred in a fairly remote area in the Mojave Desert region of eastern California. The earthquakes were felt strongly in the China Lake-Ridgecrest area, and more broadly from Los Angeles to Las Vegas. The 6.4 magnitude earthquake was preceded by several foreshocks and followed by hundreds of aftershocks. The maximum Peak Ground Accelerations (PGA) of the 6.4 and 7.1 magnitude earthquakes were 0.38g and 0.48g, respectively. In this report, the PGA residuals are estimated using the ASK14 GMPE in terms of the number of standard deviations with respect to the median model, which correlates to structural response due to earthquake ground motions.

The impact of the two earthquakes on the city of Ridgecrest demonstrated its resiliency as it recovered rapidly where many restaurants and gas stations are back up and running. There was very little structural damage, even from the second stronger earthquake of M 7.1, except for the typically vulnerable buildings (e.g. unreinforced masonry structures and mobile homes). However, there were substantial non-structural and content losses. Fortunately, both earthquakes occurred during a holiday weekend, which meant that schools were not in session and most offices were not operational during the events. If it had not been a holiday and these schools and office spaces would have been fully occupied or the earthquake occurred in a more urban area, fatalities/injuries due to these non-structural damages could have been larger. As a community, we have to be prepared for those scenarios as well. Once again, these two earthquakes have proven the need to improve our regulations when it comes to the design of non-structural components.

Moreover, some utilities for electricity and water distribution suffered from distress. On the other hand, transportation systems and bridges suffered none to minor damage with effective and rapid repair actions.

The other city that was impacted the most is Trona, which did not perform as resilient as Ridgecrest where the city remained dysfunctional up to the time of writing this report. There were more damaged structures, mostly from the effects of ground failure and possibly strong site response related to soft sediments. The town suffered from significant loss of water where its main water pipes fractured due to fault rupture and lateral spreads.

This report overviews the hazard characteristics of the July 4 and 5, 2019 Ridgecrest, California M 6.4 and M 7.1 earthquakes, the regulatory context and emergency response, the impacts of these earthquakes, and current conditions by collocating publicly-reported information. This Preliminary Virtual Reconnaissance Report (P-VRR) represents the first product of StEER's larger coordinated response to this event, informing and supporting other research teams seeking to learn from this disaster.

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Introduction

On July 4, 2019 at approximately 10:33 am PDT, a magnitude 6.4 earthquake with a depth of 10.7 km occurred in a remote area of San Bernardino County, CA. The epicenter was located 12 km south west of Searles Valley at coordinates of 35.71°N and 117.51°W. On July 5, 2019 at 8:19 pm, approximately 34 hours after the first earthquake, a 7.1 magnitude earthquake occurred near the same location, with coordinates of 35.77°N 117.61°W. The 7.1 magnitude earthquake had a depth of 17 km. Since the events were not close to urban areas, the damage experienced by buildings and other infrastructure was not extensive. However, this earthquake sequence is quite important as it includes the two largest earthquakes that occurred in Southern California in the past two decades. It provides many opportunities to learn about the following, among several other useful lessons: a) the earthquake sequence characterized by two large magnitude earthquakes one day apart, and relevantly the large magnitude foreshock scenario, b) the performance and impact of the Earthquake Early Warning and ShakeAlertLA systems, c) the expected performance in future earthquakes of pre-1980 non-ductile reinforced concrete buildings, the pre-1980 soft-first story buildings, the water system infrastructure, and the telecommunications infrastructure, which were identified as four areas of seismic vulnerability by the LA Mayoral Seismic Task Force, d) the efficacy of the adopted retrofit techniques in improving structural response, e) the performance of various structures, including school buildings, hospitals, large industrial facilities, regional airports, and mobile homes, f) the significance of non-structural damage, g) the ground motion characteristics, and h) the community resilience in terms of the duration of power outages, mobile phone network access, infrastructure repairs, etc.

StEER further hopes to use this event to exercise protocols, procedures, policies and workflows that StEER will be developing over the next year in collaboration with the wider hazards community including the Natural Hazards Engineering Research Infrastructure (NHERI) and other members of the Extreme Events Reconnaissance Consortium.

The first product of the StEER response to the 2019 Ridgecrest, California Earthquakes is this **Preliminary Virtual Reconnaissance Report (PVRR)**, which is intended to:

1. provide an overview of the hazard characteristics
2. introduce the regulatory and disaster response context for these events
3. summarize the preliminary reports of damage to wide-ranging infrastructure
4. review StEER's event strategy in response to these earthquakes
5. enhance situational awareness to guide subsequent missions conducted by StEER and the engineering reconnaissance community

It should be emphasized that all results herein are preliminary and based on the rapid assessment of publicly available online data within 3-4 days of these events. Damage assessments discussed herein are based largely on the judgement of the authors without access or with very preliminary and limited access to additional aerial imagery and ground-truthing.

Earthquake Details and Tectonic Summary

On July 4, 2019 at approximately 10:33 am PDT, a magnitude 6.4 earthquake with a depth of 10.7 km occurred in a remote area of San Bernardino County, CA. The epicenter was located 12 km south west of Searles Valley at coordinates of 35.71°N and 117.51°W. On July 5, 2019 at 8:19 pm, approximately 34 hours after the first earthquake, a 7.1 magnitude earthquake occurred near the same location, with coordinates of 35.77°N 117.61°W. The 7.1 magnitude earthquake had a depth of 17 km.

The earthquakes were felt strongly in the China Lake-Ridgecrest area, and more broadly from Los Angeles to Las Vegas. The 6.4 magnitude earthquake was preceded by several foreshocks, and hundreds of aftershocks were detected after the mainshocks. USGS ShakeMap (Figure 1) indicates the maximum Peak Ground Accelerations (PGA) of the 6.4 and 7.1 magnitude earthquakes in the range of 0.2 to 0.3g and 0.7 to 0.8g, respectively. Recorded motions are in a similar range for the 6.4 magnitude earthquake, however for the 7.1 magnitude earthquake, they are on the order of 0.5g, which is less than those predicted by ShakeMap.

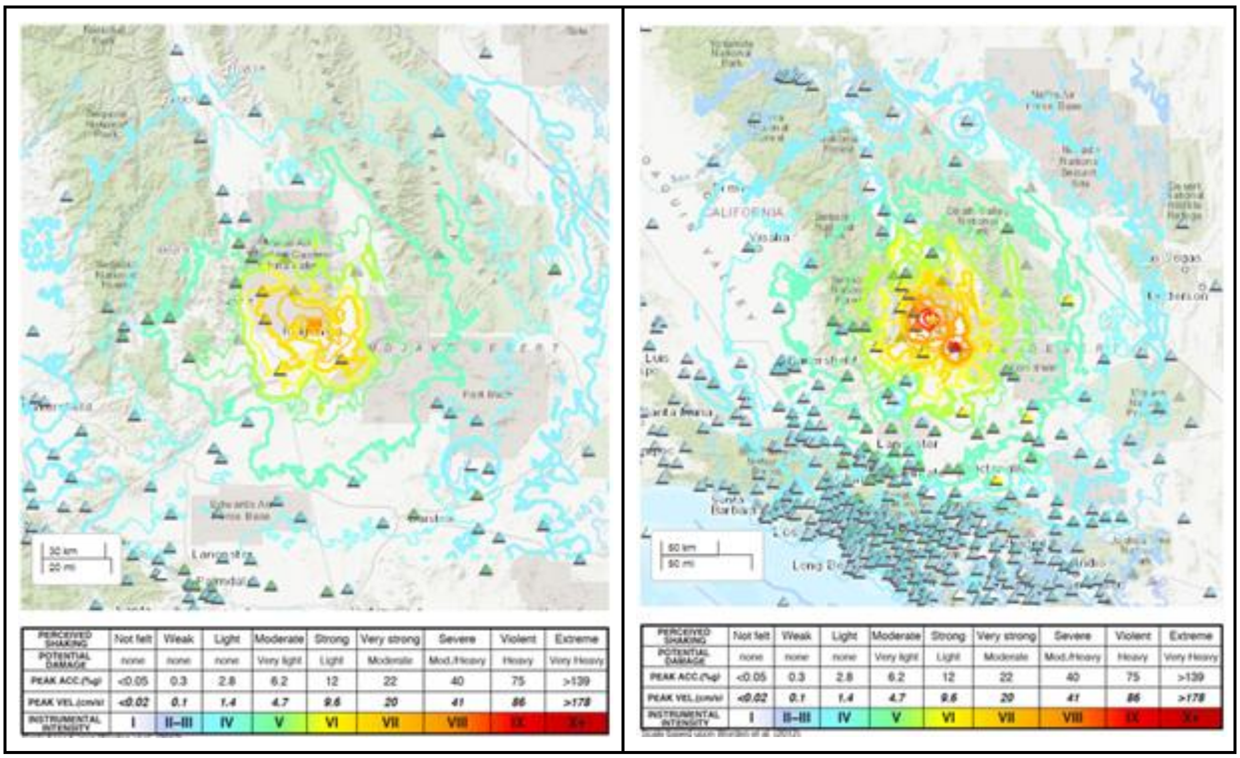

Figure 1. Epicenters of the two Ridgecrest earthquakes and Shakemaps [Left: M 6.4 event and right: M 7.1 event] (USGS, 2019a; USGS, 2019b)

Both earthquakes occurred as the result of shallow strike-slip faulting in the crust of the North America plate. According to the focal mechanism solutions, rupture occurred on a steeply dipping fault as the result of either right lateral (RL) slip on a plane striking NW-SE, or as left lateral (LL) slip on a plane striking SW-NE. The earthquakes were located approximately 150 km northeast of the San Andreas Fault - the major plate boundary in the region. At the locations of the earthquakes, the Pacific plate is moving to the northwest with respect to the North America plate at a rate of approximately 48 mm/yr. The location of the earthquakes falls within the Eastern California shear zone, a region of distributed faulting associated with motion across the Pacific North America plate boundary, and an area of high seismic hazard. More detailed studies will be required to precisely identify the causative fault associated with these events, though seismic activity over the past 2 days has been occurring on two conjugate fault structures in the Airport Lake Fault Zone (USGS, 2019a; USGS, 2019b).

The earthquakes have been followed by numerous aftershocks, the largest of which was a Magnitude 5.4 earthquake 16 hours after the M 6.4 event. Most aftershocks align in a SW-NE trend around the M 6.4 earthquake, though some also align on a NW-SE trend. The M 6.4 event was also preceded by a series of foreshocks over the previous hour, including a magnitude 4.0 event about 30 mins earlier.

Historical Context

This region of eastern California has hosted numerous moderate sized earthquakes. Over the past 40 years, 8 other earthquakes, with magnitudes 5 or larger, have occurred within 50 km of the July 4th, 2019 earthquake. Figure 2 provides a timeline of historical earthquakes in California since 1900. The largest earthquake that took place close to the fault that produced the July 4th and 5th events in the last four decades prior to these two recent events was a magnitude 5.8 event on September 20, 1995, about 13 km to the west-northwest of the July 4th earthquake (USGS, 2019a; USGS, 2019b).

California is a seismically active region that has seen several major earthquakes in recent history. In 1906 The Great San Francisco Earthquake struck the bay area causing great material and human losses. On June 29th, 1925, a M 6.8 earthquake struck in the vicinity of Santa Barbara. As a consequence of this event the Pacific Building Official Conference (currently the International Conference of Building Officials) adopted the Uniform Building Code.

In 1933 the city of Long Beach felt a destructive earthquake, which caused 15 schools in the area to collapse and damaged many more structures. Almost forty years later, in 1971, a M 6.5 earthquake struck the San Fernando Valley. Because of the earthquake, 64 people lost their lives, over 2000 were injured and damage was estimated at $500+ million. The M 6.9 Loma Prieta earthquake on October 17, 1989 led to 63 deaths, 3757 people injured and over $5.6 billion in damage. In 1994, the M 6.7 Northridge earthquake led to 57 deaths, over 8700 people injured and economic losses between $13 and $40 billion.

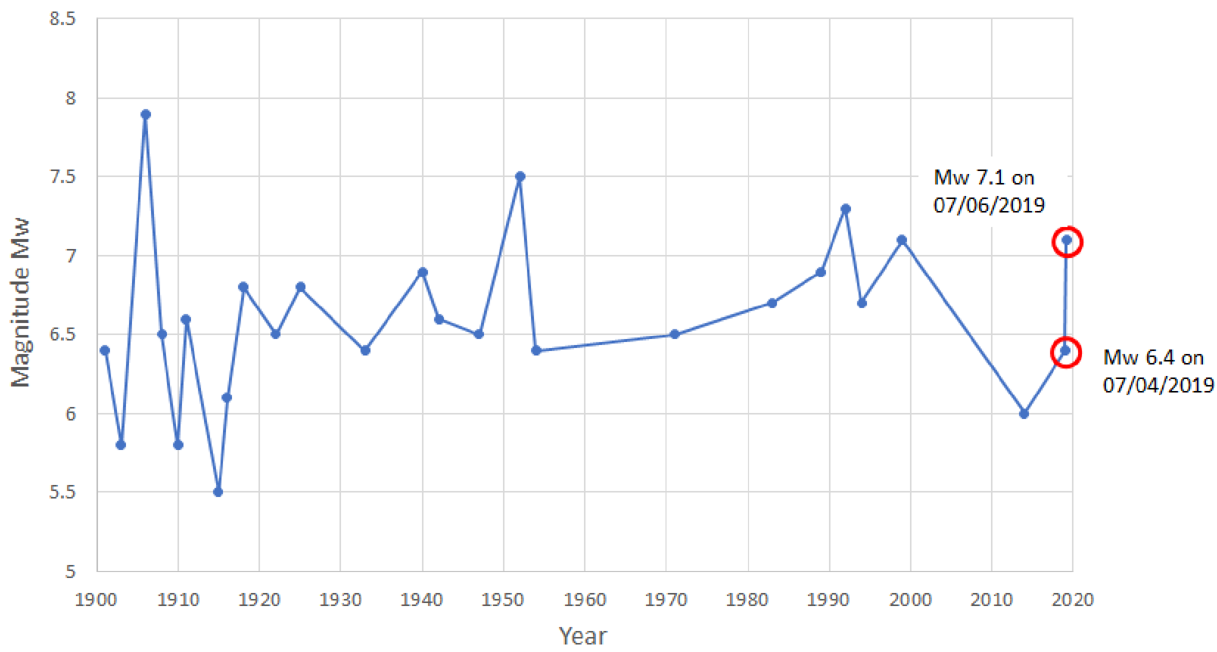

Figure 2. Timeline of major earthquakes in California in the 20th and 21st centuries[1]

Recorded Ground Motions

For both the M 6.4 and M 7.1 events, ground motions were recorded at several stations. In both cases, the maximum recorded Peak Ground Acceleration (PGA) was recorded at the Christmas Canyon China Lake station (code CCC). For the M 6.4 event, the PGA was 369 cm/s^2 (0.38g) and Peak Ground Velocity (PGV) was 27 cm/s according to the Center for Engineering Strong Motion Data (CESMD) database. For the M 7.1 event, the recorded PGA was 470 cm/s^2 (0.48g) and PGV was 55.1 cm/s. Figure 3(a) shows the acceleration time series of the ground motions recorded at the CCC stations for the M 6.4 event and Figure 3(b) shows the same for the M 7.1 event.

[1] https://earthquake.usgs.gov/earthquakes/search/

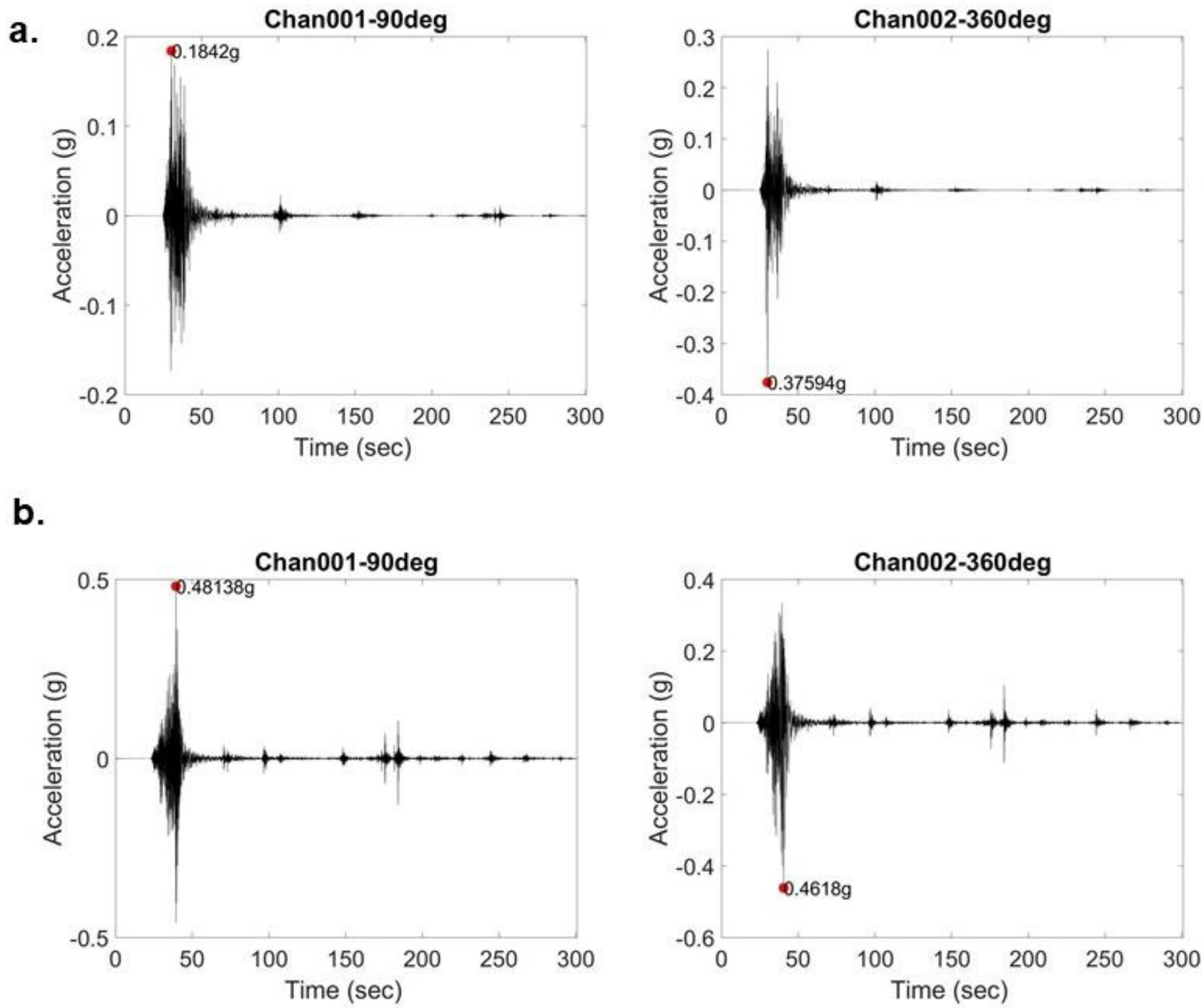

Figure 3. Acceleration time histories recorded at the Christmas Canyon China lake (CCC) station from (a) M 6.4 event and (b) M 7.1 event

Figure 4 shows the PGA vs Distance plots for all the recorded ground motions for both events. The plot shows that beyond a distance of 40 km, the PGA values were less than 0.1g for the foreshock but for the main shock even beyond 100 km, PGA greater than 0.1g has been recorded. In general, higher PGAs were recorded for longer distance for the M 7.1 event. This is consistent with the reports of shaking felt throughout the state.

Response spectra (5% damped) of the two horizontal components and the vertical component of the ground motion with the largest PGA, at the Christmas Canyon China Lake station (code CCC), are shown in Figure 5. The highest spectral acceleration for this station is computed to be 1.17g at about 0.48 sec period for the M 6.4 event, Figure 5(a). For the M 7.1 event, Figure 5(b), the maximum spectral acceleration was computed as 1.69g at about 0.11 sec period. Long period effect was observed in the response spectra of the mainshock.

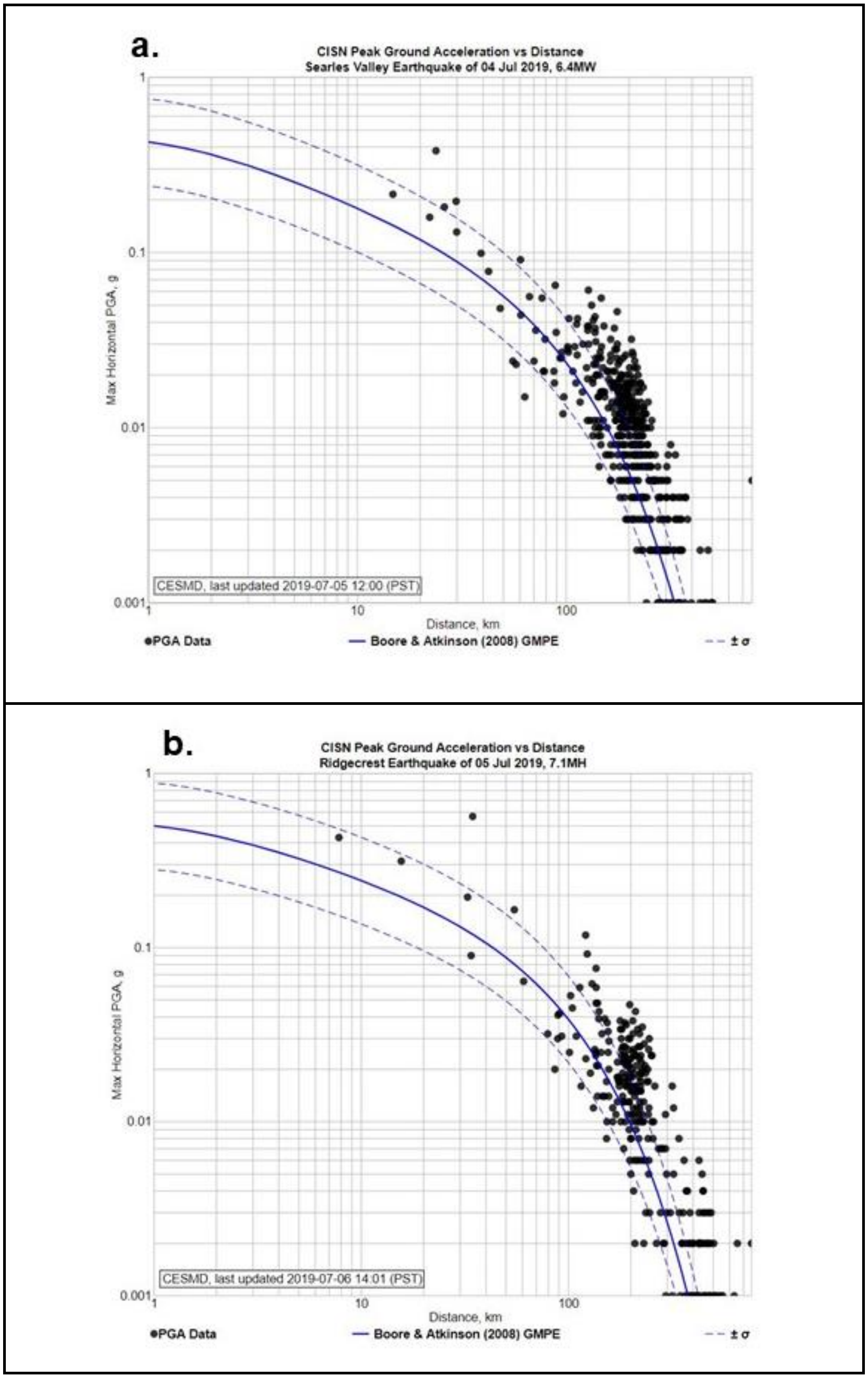

Figure 4. Maximum horizontal ground motion versus distance compared with Boore & Atkinson (2008) Ground Motion Prediction Equation (GMPE) for (a) M 6.4 event and (b) M 7.1 event where distance is fault distance if available, otherwise epicentral distance[2]

[2] https://strongmotioncenter.org/graphtest/?iqrid=ci38443183

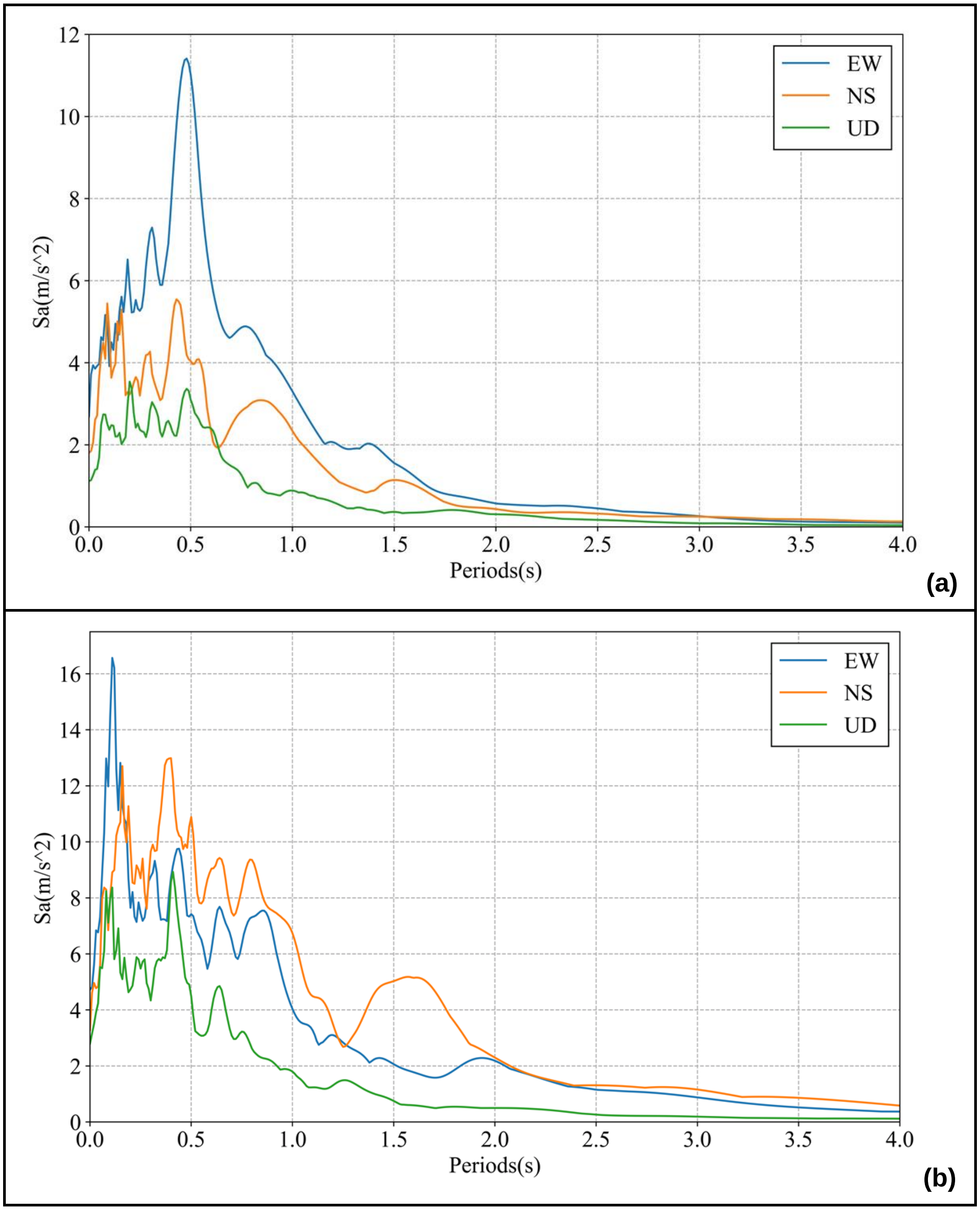

Figure 5. 5% damped response spectra at the CCC station for the (a) M 6.4 event and (b) M 7.1 event (Source: X. Lu, Tsinghua University & also similar to that reported in the CESMD database[3])

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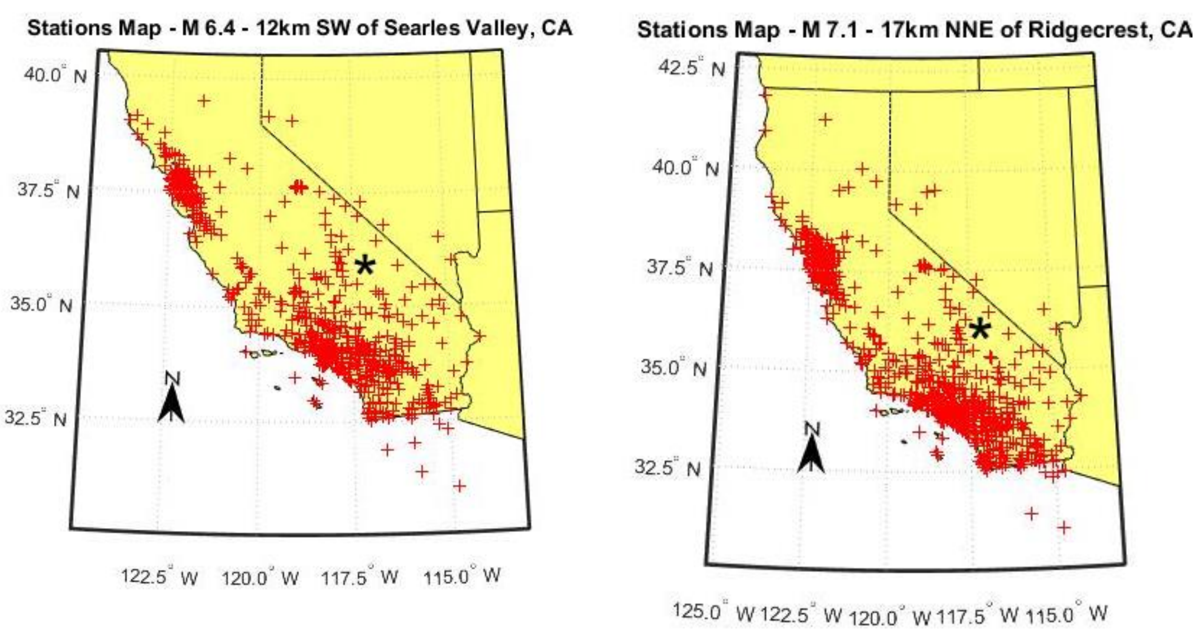
[3] https://strongmotioncenter.org/NCESMD/data/ci38443183/ciccc.gif

PGA Residuals

PGA residuals are estimated using the ASK14 GMPE (Abrahamson *et al.*, 2014), in terms of the number of standard deviations (i.e. epsilon) with respect to the median model. The variable epsilon has been shown to be correlated to structural response for mathematical models subjected to earthquake ground motions (Baker and Cornell, 2008), hence it is deemed appropriate for the purpose of this report. Equation 1 defines the variable epsilon as follows:

$$\varepsilon(T) = \frac{ln(Sa(T)) - ln(\mu(T))}{\sigma ln(T)} \tag{1}$$

where *Sa*(*T*) is the measured spectral acceleration at the structural period *T*, $\mu(T)$ is the median model prediction, and $\sigma ln(T)$ is the GMPE total standard deviation. Data for PGA was obtained from the USGS event pages (USGS, 2019a; USGS, 2019b). According to Equation 1, positive ε-values indicate that the model underpredicts the observations. Figure 6 shows the relative location of the stations (red markers) with respect to the events epicenters (black stars). For the estimation of the median ground motion prediction model, a Vs30 = 360 m/s is selected for this preliminary report. Figure 7 shows the stations superimposed on the slope-based Vs30 map of California.



(a) **(b)**

Figure 6. Stations location of the two Ridgecrest earthquakes and Shakemaps for (a) M 6.4 event and (b) M 7.1 event

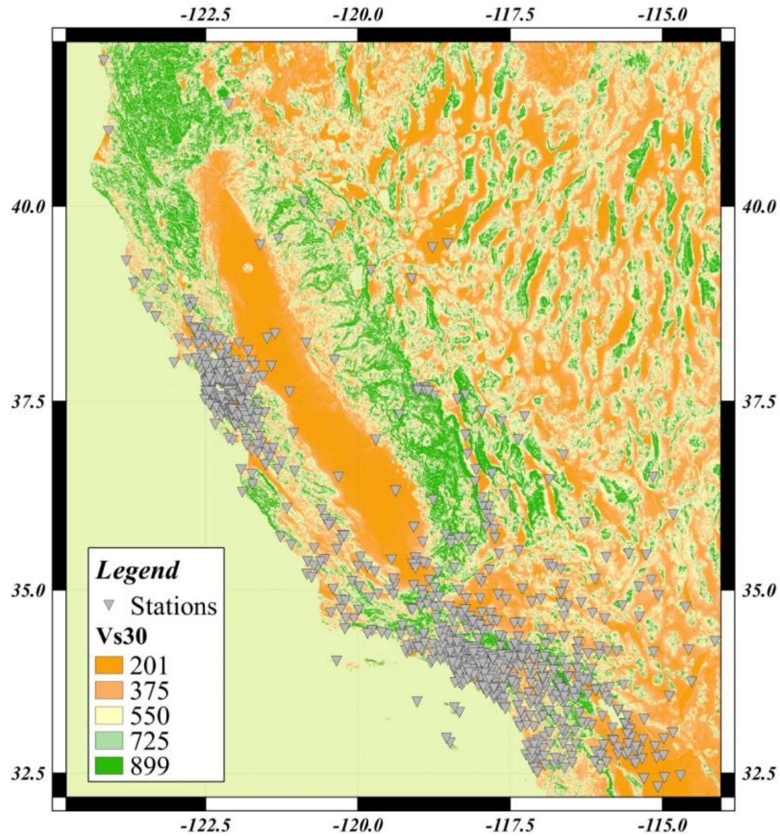


Figure 7. Stations locations superimposed on the slope-based Vs30 map of California

Figure 8 presents epsilon values versus distance for PGA of the two events. At the closer distance range (e.g., R ≤ 50 km), the median PGA is estimated by the GMPE without much bias ($|\varepsilon(T)| \leq 0.1$) for both event magnitudes. In the distance range 100≤ R ≤ 250 km, the median recorded PGA is larger than the median model, but with a small bias ($\varepsilon(T) \leq 0.8$) for the M 6.4 event. On the other hand, for the M 7.1 event, the median model agrees with the median recorded data. For the larger distance range (e.g., R ≥ 400 km), the observations are larger than the median model by approximately one standard deviation, which is consistent with the observations in Figure 4.

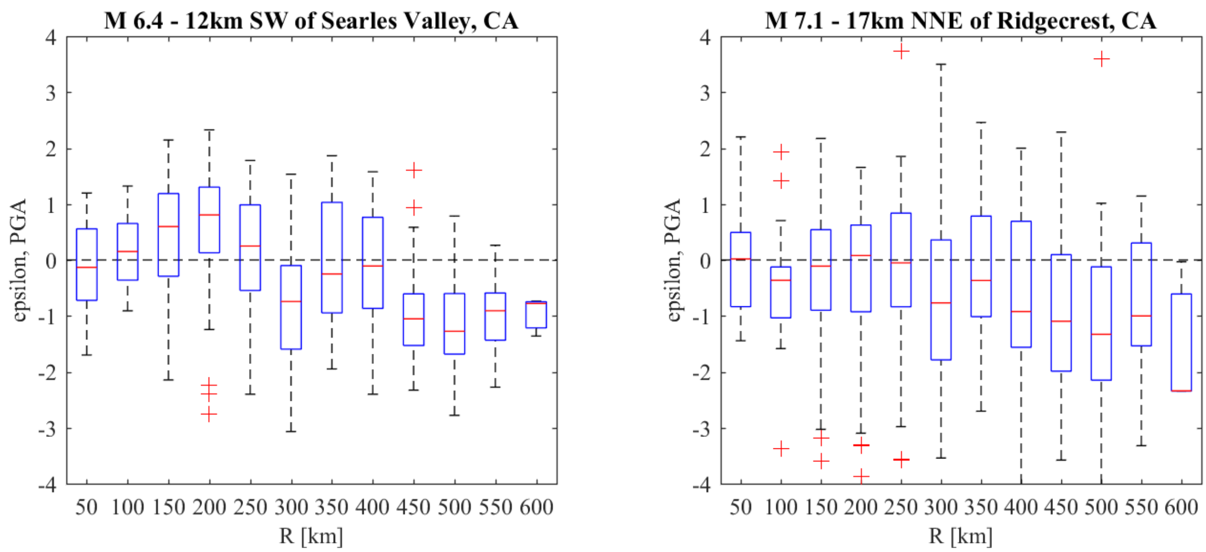


Figure 8. Epsilon of PGA versus distance, based on the ASK14 ground motion model [Left: M 6.4 event and right: M 7.1 event]

Local Codes and Construction Practices

Design of new buildings in California is based on the California Building Code. One of the notable regulations in Southern California is the LA Non-Ductile Reinforced Concrete Ordinance, which requires mandatory retrofits of reinforced concrete construction. A 4-page brochure developed by the Pacific Earthquake Engineering Research (PEER) Center in Collaboration with California Seismic Safety Commission (CSSC) summarizing, in simplified terms, the expected earthquake performance of buildings designed to the California building code can be found in Appendix A of this report.

The California Building Code has seen distinct improvements after each major earthquake. For example, after the 1971 San Fernando earthquake, seismic detailing was introduced for reinforced concrete members to increase ductility and energy dissipation capacity. Similarly, after the 1989 Loma Prieta and 1994 Northridge earthquakes, there were improvements related to soft-story wood frame buildings and welded steel connections. July 4 and 5 earthquakes also have the potential to lead to changes in the code, such as the consideration of large aftershocks and a variety of earthquake consequences in seismic design and reinforcing the ongoing efforts towards changing the code objectives from life safety to community resilience.

Table 1 provides the distribution of housing units by year of construction in San Bernardino County and the city of Ridgecrest, the most heavily impacted areas. This is based on data from the U.S. Census Bureau, 2013-2017 American Community Survey 5-Year Estimates (Bureau, 2018). Such information adds context to building performance relative to code changes. It can be seen from the table that 47.4% and 53.7% of building stock in San Bernardino County and Ridgecrest City, respectively, was constructed prior to 1980; i.e. about half the building stock lacks seismic details. The percentage of seismically retrofitted structures among this deficient building stock is not currently available.

Table 1. Distribution of housing units by year of construction in San Bernardino County and the city of Ridgecrest (U.S. Census Bureau, 2013-2017 American Community Survey 5-Year Estimates (Bureau,2018))

Time Period	San Bernardino County, CA	Ridgecrest, CA
Built 2014 or later	0.50%	0.00%
Built 2010 to 2013	1.50%	1.40%
Built 2000 to 2009	14.80%	5.90%
Built 1990 to 1999	13.10%	8.20%
Built 1980 to 1989	22.80%	30.80%
Built 1970 to 1979	17.50%	29.40%
Built 1960 to 1969	10.70%	10.20%
Built 1950 to 1959	11.50%	10.90%
Built 1940 to 1949	4.00%	1.60%
Built 1939 or earlier	3.70%	1.60%
Total Housing Units	**711,900**	**12,534**

Federal, State and Local Response

Post-earthquake responses by federal, state and municipalities, including Ridgecrest, Trona and Los Angeles, are presented below.

Federal Response

United States President Trump tweeted about the 4th of July 2019 California earthquake. His post on Twitter on the same day of the seismic event expressed that the situation seems to be under control. On July 5th, 2019 Federal Emergency Management Agency delivered a tractor-trailer with water bottles to San Bernardino County due to the damage in the water lines[4].

State Response

- On July 4, 2019 California Governor Gavin Newsom declared a state of emergency for Kern County and expressed that officials are monitoring the aftershocks[5].
- On July 5th, 2019 Gavin Newsom declared a state of emergency for San Bernardino County after the M 7.1 earthquake due to conditions of "extreme peril to the safety of persons and property"[6].
- Mark Ghilarducci, the Director of the California Governor's Office of Emergency Services (Cal OES), said that there were no reported deaths or serious injuries[7].
- The State's Office of Emergency Services (OES), confirmed that the OES would provide fire and rescue resources to the affected region[8].

Local Response

- Ridgecrest's Mayor Peggy Breeden declared a state of emergency. Authorities did not report serious injuries or deaths, but fires, cracked roads, and minor injuries were reported[9].
- Ridgecrest Regional Hospital was evacuated for evaluation by state inspectors and as a preventive measure due to aftershocks[10].
- The Red Cross established evacuation centers in Ridgecrest.
- On July 5th 2019, Los Angeles Department of Water declared that qualified personnel were surveying the aqueduct and reservoirs according to their standard earthquake response protocol. Critical facilities were also being inspected. They declared no damages were reported at that time[11].
- According to the pronouncement of the Chief of San Bernardino County Fire Department,

[4] https://abc7.com/state-of-emergency-in-san-bernardino-co-after-ridgecrest-quake/5381855/

[5] https://abcnews.go.com/US/powerful-aftershocks-shake-southern-california-massive-earthquake-panic/story?id=64147691

[6] https://abc7.com/state-of-emergency-in-san-bernardino-co-after-ridgecrest-quake/5381855/

[7] https://abcnews.go.com/US/powerful-aftershocks-shake-southern-california-massive-earthquake-panic/story?id=64147691

[8] https://www.washingtonpost.com/nation/2019/07/05/aftershocks-rattle-california-after-magnitude-earthquake/?noredirect=on&utm_term=.9c300804d773

[9] https://www.washingtonpost.com/nation/2019/07/05/aftershocks-rattle-california-after-magnitude-earthquake/?noredirect=on&utm_term=.cb2f92d75a8c

[10] https://www.cnn.com/us/live-news/earthquake-california-july-2019/index.html

[11] https://www.latimes.com/local/lanow/la-me-earthquake-california-shake-quake-20190704-story.html

Bill Villarino, most of Trona suffered minor to moderate damage. Typical damage consisted of collapsed chimneys, mobile homes shaken off their supports and some water main breaks, including two main lines. Villarino stated that there were no injuries[12].

- After the M 6.4 earthquake, three important cracks formed across State Route 178 near Trona. They were temporarily repaired soon after the seismic event[13].

[12] https://www.latimes.com/local/lanow/la-me-ln-trona-earthquake-20190705-story.html
[13] https://www.latimes.com/local/lanow/la-me-ln-trona-earthquake-20190705-story.html

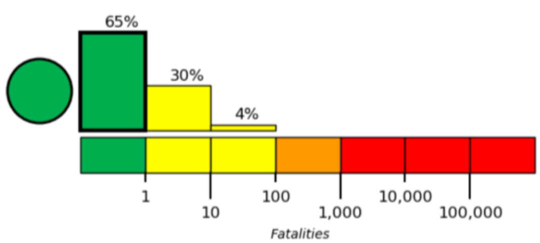
Impacts

Loss of Life and Injuries

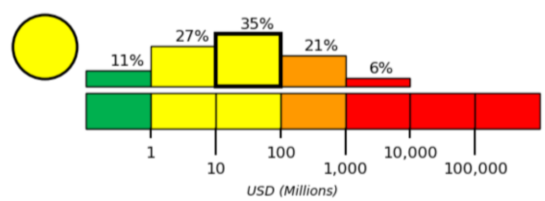
The PAGER (Prompt Assessment of Global Earthquakes for Response) product of the USGS is an automated system that produces content concerning the estimated impact of significant earthquakes around the world, informing emergency responders, government and aid agencies, and the media of the scope of the potential disaster. PAGER rapidly assesses earthquake impacts by comparing the population exposed to each level of shaking intensity with models of economic and fatality losses based on past earthquakes in each country or region of the world (USGS, 2019a & 2019b).

PAGER produces rough estimates of the probability density functions of the number of fatalities and economic losses in U.S. dollars. More specifically, these approximate probability density functions provide estimates of the probabilities of the order of magnitude of the number of fatalities and economic losses by providing probabilities within specific ranges each varying an order of magnitude from the previous one. The number of shaking-related fatalities in this event was projected as relatively low according to the USGS (Figures 9(a) and 10(a)) compared to previous earthquakes with similar magnitude. For both earthquakes, the USGS PAGER tool (Figures 9(b) and 10(b)) estimated no fatalities and 1 to 10 fatalities with probabilities of 65% and 30%, respectively. At the time of the writing of this report, there were no fatalities. For the 6.4 magnitude earthquake, PAGER estimated economic losses due to damage to be between \$1 million and \$10 million, between \$10 million and \$100 million, and between \$100 million and \$1,000 million with probabilities of 27%, 35%, and 21%, respectively. For the 7.1 magnitude earthquake, these probabilities were 23%, 35%, and 25%. Similarity of these two sets of estimates for the two earthquakes despite their significant differences in magnitude is worth exploring. One reason is the low population density in the epicentral region, and the relatively distant location from large urban centers.

PAGER reported that some damage is possible and the impact would be relatively localized. Estimated economic losses are less than 1% of GDP of the United States. Past events with this alert level have required a local or regional level response. It should be noted that these economic loss estimates are characterized by even larger variabilities than those in their estimates of the number of fatalities.

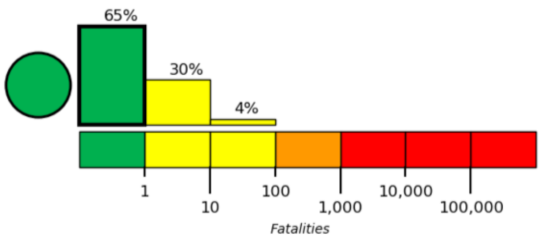


(a)

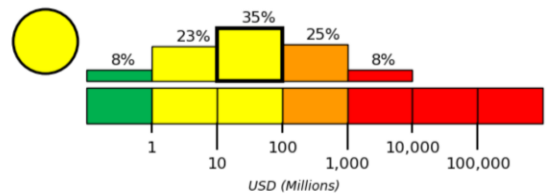


(b)

Figure 9. PAGER Estimated probability of (a) fatalities and (b) economic losses for the July 4th, 2019 Ridgecrest, California Earthquake (USGS, 2019a)



(a)



(b)

Figure 10. PAGER Estimated probability of (a) fatalities and (b) economic losses for the July 5th, 2019 Ridgecrest, California Earthquake (USGS, 2019b)

Buildings

Critical Facilities

Based on most images and reports of damage at Ridgecrest Hospital, it has been evacuated predominantly as a precautionary measure[14]. "Ridgecrest Regional Hospital was evacuated so an engineer could assess whether it had structural damage," according to Ridgecrest police Capt. Justin Dampier. According to OSHPD, they inspected the hospital and did not require evacuation. At the time of authoring this report, Kern County Fire Department (KCFD) reported at least 15 patients were moved to the Ridgecrest High School gymnasium due to "structure" damage at the hospital[15]. Authorities also stated that about 15 patients were moved to other emergency rooms[16]. Those who were evacuated were sheltering in place under shade awnings and trees, while the 15 emergency room patients were taken to Palmdale-Lancaster area. There was no estimate on how many people in total were evacuated from the hospital[17]. "There was some structural damage at the hospital, including leaking sprinklers," a fire battalion chief said at an afternoon news conference. Some reports indicated that a building inspector was examining the damage. The hospital was reported 100% functional again on July 7th.

Commercial Construction

During the two earthquakes, many unsecured objects fell from shelves (Figures 11 to 13). Inside convenience stores aisles were flooded with broken liquor bottles and food items that had fallen off the shelves. There was also light to moderate non-structural component damage, such as collapse of suspended ceilings tiles/grids, concrete, glass and masonry facades, etc. (Figures 14 and 15). As with residential construction covered in the next section, several commercial masonry structures experienced various degrees of damage, Figure 16.

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[14] https://www.ridgecrestca.com/news/20190705/breeden-declares-state-of-emergency-following-earthquake
[15] https://www.visaliatimesdelta.com/story/news/2019/07/04/earthquake-centered-kern-county-rattles-visalia-tulare/1650393001/
[16] https://www.nbcnews.com/news/us-news/6-4-magnitude-earthquake-shakes-southern-california-n1026621
[17] https://ktla.com/2019/07/04/ridgecrest-hospital-evacuated-after-magnitude-6-4-earthquake-hits-nearby/

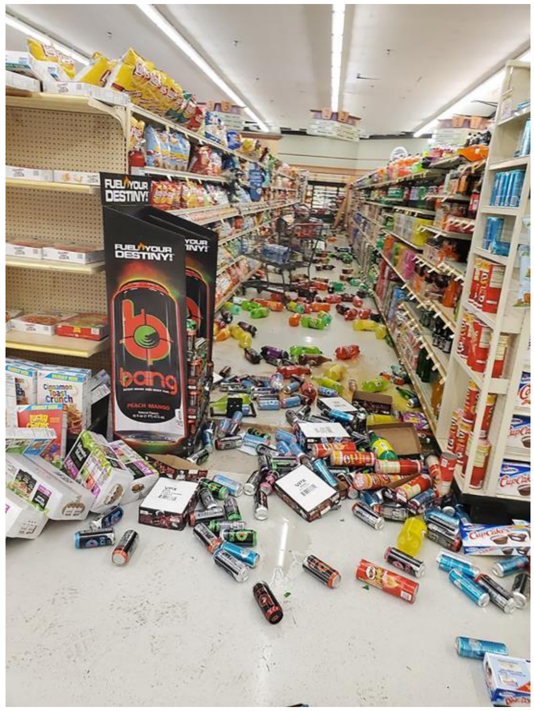


Figure 11. Items knocked from the shelves inside State Bros. Markets in Ridgecrest, California after the M 6.4 event (Source: CNN, 2019)

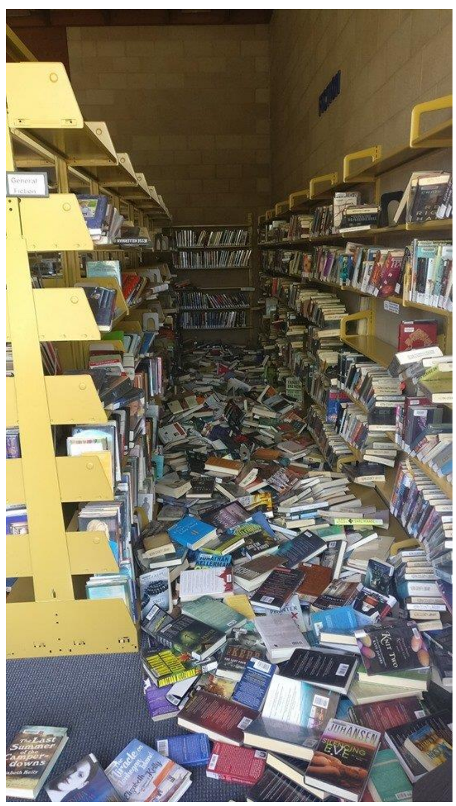


Figure 12. Books cover the floor at a Kern County Library in Ridgecrest after the 6.4 magnitude event (Credit: Richard Wagner, Source: KTLA, 2019)

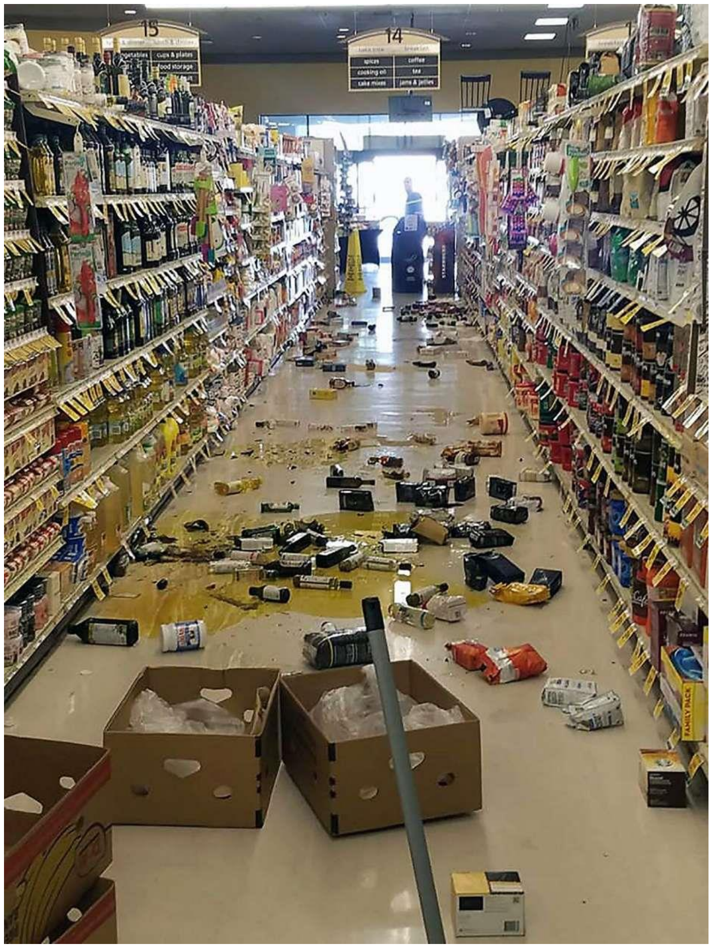
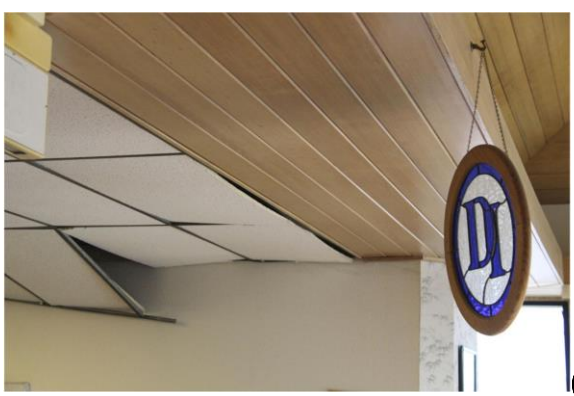


Figure 13. Broken bottles and other goods in a store in Lake Isabella after the magnitude 6.4 earthquake[18]


(a)

(b)

Figure 14. (a) The Daily Independent Newspaper office ceiling damaged during the M 6.4 event (Jessica Watson, AP); (b) Suspended ceiling partial failure at a laundromat in Ridgecrest after the M 6.4 event (Photo by Terry Pierson, The Press-Enterprise/SCNG)

[18] https://www.sfchronicle.com/bayarea/article/6-4-quake-hits-Mojave-Desert-felt-in-Los-Angeles-14071924.php#photo-17804993


(a)

(b)

Figure 15. (a) Fallen concrete panels at a building in North Ridgecrest (Source: Karen Hua via Twitter); (b) Glass facade damage in retail building due to M 6.4 event (Source: AP)

Figure 16. Cracks in masonry walls in Trona following the M 7.1 event (Photo by Christine Goulet, SCEC)

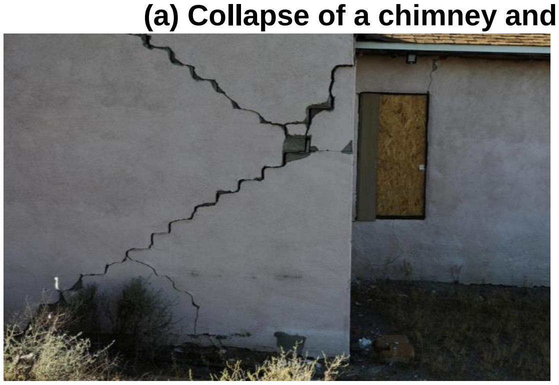
Residential Construction

At least two residential houses in Ridgecrest caught fire after the M 6.4 event most probably due to broken gas pipes. One house on the corner of Sunland Street and East California Avenue had the garage and part of the main roof burnt by fire (Figure 17a). Another house was heavily damaged by fire, after the M 6.4 event (Figure 17b). Figure 18a shows a collapsed chimney and the upper brick layers that fell from a masonry wall. A house was damaged with diagonal and vertical cracks in exterior walls (Figure18b). Other buildings with failed chimneys or damaged walls are shown in Figures 19 to 24. Many unreinforced masonry chimney failures were observed in Trona after the M 7.1 event. Preliminary reports cite significant damage in Trona after the M 7.1, pending more information from field teams. Typical damage to timber framed homes is shown in Figure 22, while damage to items in a cafeteria named "My Enchanted Cottage" at 214 W Ridgecrest Blvd Ridgecrest, CA 93555, are shown in Figure 25.

(a) (b)

Figure 17. Two houses caught fire in Ridgecrest after the M 6.4 event (San Bernandino Sun, 2019; AP News, 2019)

(a) Collapse of a chimney and upper section of a masonry wall



(b) Cracks in exterior walls

(c) Fire damage after M 7.1 event

Figure 18. Damage to masonry structures (Sources: (a) Reuters, 2019; (b) Yahoo, 2019, and (c) themegaagency, Instagram, 2019)

Figure 19. A cinderblock wall partially destroyed in Ridgecrest following the magnitude 7.1 Earthquake (CNN, 2019)

Figure 20. Damage to a masonry house in Trona after the M 7.1 earthquake (Source: [Eytan Wallace]() via Twitter)


(a)


(b)

Figure 21. Damage to a masonry houses in Trona after the M 7.1 earthquake (Sources:a) Rob Mcmillan via Twitter, b) CBS Los Angeles)

(a) (b)

Figure 22. (a) Damaged house in Trona after the M 7.1 event (credit: Mario Tama, AFP); (b) Damaged walls of a home in Trona (Source: @23ABCNews via Twitter)

Figure 23. Collapsed cinder block walls of a masonry house (Source: [Karen Hua]() viaTwitter)

Figure 24. Broken masonry chimney and damaged masonry walls (Source: [Ken O'Doll]() via Twitter)

Figure 25. Contents damage in a cafeteria due to the M 6.4 event (AP News, 2019)

At least two mobile homes were damaged during the M 6.4 event. One is at Trousdale Estates at 210 W. Ward Ave. in Ridgecrest where a woman and her child were inside the building when the earthquake occurred but were unharmed, Figure 26(a). The mobile home appears to have been displaced off its supports, resulting in damage to the skirt surrounding the trailer chassis. Another mobile home also appears to have fallen off its supports resulting in damage to the metal columns supporting the roof over the porch, Figure 26(b). Out of 193 mobile homes in three mobile home parks north of Ridgecrest, eight mobile homes collapsed; none of which were tied down or had seismic braces (Keith Porter from the field.) It appears that most of these collapses were due to the M 7.1 event. According to Jonathan Stewart from the field: there are damaged structures in Trona, in many cases this is from the effects of ground failure. Following the M 7.1 event, Trona seems to be largely abandoned, due to loss of water (it is served by the water pipes ruptured by fault rupture). Only police and utility personnel present in the area. Unlike Trona, Ridgecrest experienced little structural damage except in especially vulnerable structures, significant content and non-structural damage.

(a)

(b)

Figure 26. Damage to mobile homes in Ridgecrest area due to the M 6.4 event (a) Source: Bakersfield News, 2019; (b) Source: Yahoo News, 2019

Schools

At the time of authoring this report, there were no available reports or articles indicating significant damage to local schools. A Fourth of July performance was taking place at Burroughs High School when the M 6.4 earthquake hit, which was documented in a video posted to Twitter (Figure 27, Fox26News, 2019). Since Burroughs High School had back-up generators, they were able to keep the air conditioning operational despite disruption of power elsewhere. Burroughs High School served as a cooling center, allowing people to gather in the gymnasium and stay cool during the day. The American Red Cross later set up an evacuation center at Burroughs High. Ridgecrest High School similarly had individuals temporarily shelter in their gymnasium -- KCFD reported that at least 15 patients from Ridgecrest Regional Hospital were moved there due to potential damage.

Figure 27. Fourth of July performance taking place at Burroughs High School during the M 6.4 earthquake; screen capture from video recorded by Yari Mower (AOL, 2019)

Instrumented Structures

Tables 2 and 3 report the recorded peak structural acceleration (PSA) at the instrumented structures in descending order for the M 6.4 and M 7.1 events, respectively. Stations with PSA greater than 0.05g are listed in the tables. The highest peak acceleration (0.29g) was recorded at a 3-story office building at Lancaster for the M 6.4 event. The same building also recorded significant shaking (PSA = 0.326g) during the M 7.1 event. At the time of writing this report, no information on structural or non-structural damage was available for the above mentioned building. Significant shaking has also been recorded for both events at Hwy 395/Brown Road Bridge at Ridgecrest (0.27g for the M 6.4 and 0.6g for the M 7.1 events). Based on preliminary field investigation[19], no damage was visible from this field assessment after the M 6.4 event. Interestingly, the highest peak structural acceleration for the M 7.1 event was recorded 230 km away from the epicenter at the Port of Long Beach (1.29g). Furthermore, 10 story residential building at Burbank, situated about 180 km away from the epicenter, experienced strong shaking during both events recording 0.22g and 0.30g for M 6.4 and M 7.1 events, respectively.

[19] This field investigation was conducted on July 5th, 2019 by Prof. Farzin Zareian, UCI.

Table 2. Peak acceleration recorded at instrumented structures during the M 6.4 event (Source: CESMD database)

Station Name	Network	Code	Distance (km)	PSA (g)
Lancaster - 3-story Office Bldg.	CGS	24517	127.6	0.291
Lancaster - 5-story Hospital	CGS	24609	127.6	0.275
Ridgecrest - Hwy 395/Brown Road Bridge	CGS	33742	28.6	0.274
Burbank - 10-story Residential Bldg.	CGS	24385	183.8	0.221
Palmdale - 5-story Hospital	CGS	24457	137.4	0.120
Redlands - 1-story Warehouse	CGS	23495	183.8	0.074
San Bernardino - 5-story Hospital	CGS	23634	175.4	0.063
Los Angeles - 9-story Univ Hospital Bldg.	CGS	24260	193.1	0.062
San Bernardino - 6-story Hotel	CGS	23287	183.1	0.057
Los Angeles - 7-story Hospital	CGS	24397	192.2	0.054
Los Angeles - 52-story Office Bldg.	CGS	24602	196.0	0.053
Pasadena; Millikan Library	NSMP	5407	183.0	0.052
Palmdale - Hwy 14/Barrel Springs Bridge	CGS	24706	140.6	0.050
Riverside - 6-story Hospital	CGS	13633	192.2	0.050

Table 3. Peak acceleration recorded at instrumented structures during the M 7.1 event (Source: CESMD database)

Station Name	Network	Code	Distance (km)	PSA (g)
Long Beach - Port of LB Pier T	CGS	14412	230.3	1.290
Ridgecrest - Hwy 395/Brown Road Bridge	CGS	33742	22.1	0.605
Lancaster - 3-story Office Bldg.	CGS	24517	129.9	0.326
Burbank - 10-story Residential Bldg.	CGS	24385	186.7	0.300
Lancaster - Airport Control Tower	CGS	24474	126.8	0.236
Palmdale - 5-story Hospital	CGS	24457	140.2	0.143
San Bernardino - 5-story Hospital	CGS	23634	183.2	0.123
Riverside - 6-story Hospital	CGS	13633	199.7	0.119
San Bernardino - 5-story CSUSB Library	CGS	23285	177.6	0.087
Los Angeles - 8-story County Med Ofc Bld	CGS	24249	197.4	0.077
Palmdale - Hwy 14/Barrel Springs Bridge	CGS	24706	143.6	0.074
Irvine - 6-story Hospital	CGS	13439	234.4	0.071
Los Angeles - 52-story Office Bldg.	CGS	24602	199.5	0.069
Los Angeles - 7-story Hospital	CGS	24397	195.5	0.065
Los Angeles - 9-story Office Bldg.	CGS	24579	200.3	0.065
Los Angeles - 8-story CSULA Admin. Bldg.	CGS	24468	195.5	0.063
Palm Springs - 4-story Hospital	CGS	12299	235.0	0.062
Los Angeles - 19-story Office Bldg.	CGS	24643	203.4	0.054
Pasadena - 9-story Commercial Bldg.	CGS	24571	186.4	0.050
Los Angeles - 9-story Univ Hospital Bldg.	CGS	24260	196.8	0.050

Fire Following Earthquake

M 6.4 Earthquake - July 4, 2019

The M 6.4 earthquake caused two structural fires, a brush fire, and a few vegetation fires. This section will focus on the fires caused in structures. The structural fires occurred in Ridgecrest, CA and in Bakersfield, CA and were reported by the Kern County Fire Department. It is unknown at the time as to the cause of the fires, but multiple gas leaks were also reported after the earthquake. Figure 28(a) shows an active fire in Ridgecrest and Figure 28(b) shows the post-fire condition of the house. Figure 29 shows the Bakersfield Fire Department notification of the active fire in Bakersfield after the M 6.4 event.

(a) (b)

Figure 28. Fire following M 6.4 event in Ridgecrest (a) active fire conditions (ABC, 2019), and (b) post-fire condition (Source: San Bernardino Sun, 2019)

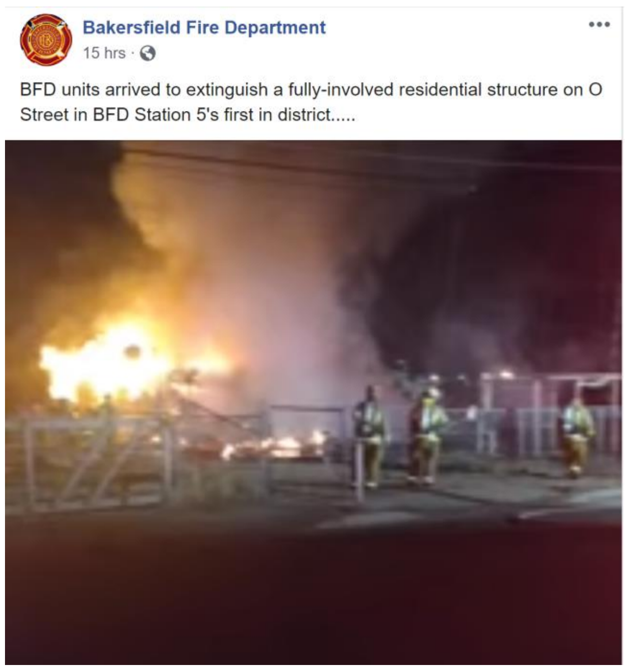
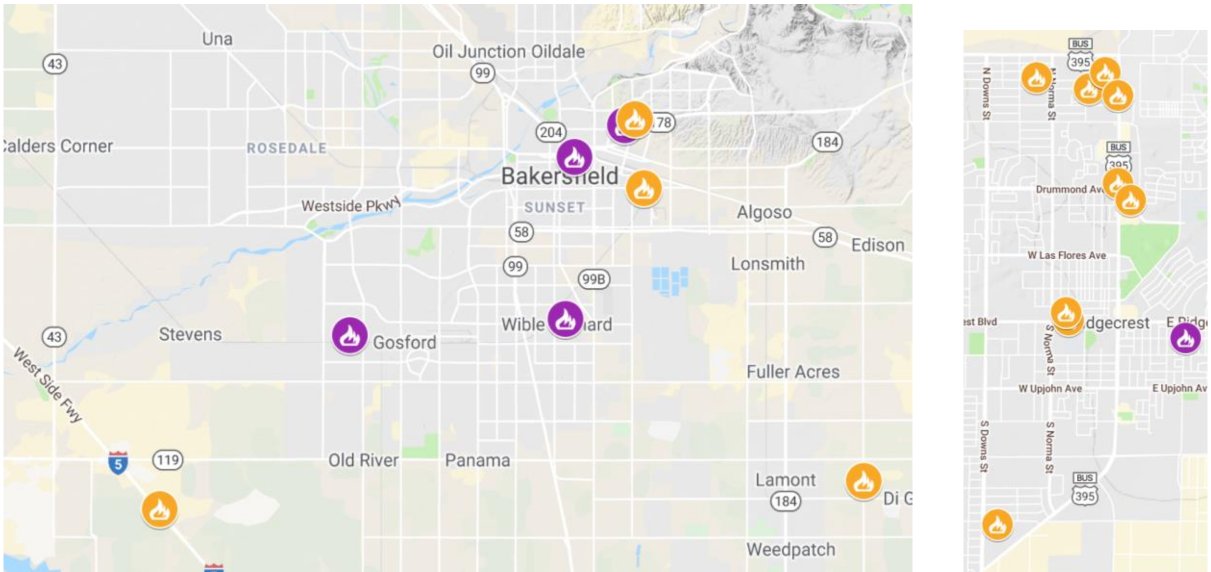


Figure 29. Fire following M 6.4 event in Bakersfield (Source: Bakersfield Fire Department Facebook Page)

Fire departments must respond to all gas leaks with the code of "structural fire." Therefore, through the Kern County Fire Department (KCFD) incident reporter, these locations can be determined. There were three reports of gas leaks in Bakersfield due to the M 6.4 event. These are shown as structural fires and the exact locations are provided in the Earthquake Engineering Research Institute (EERI) Virtual Earthquake Reconnaissance Team (VERT) report that is included in Appendix B of this report.

M 7.1 Earthquake - July 5, 2019

There were 14 structural fire responses by the KCFD within about 12 hours after the earthquake. While all of these may not be earthquake related, these are mapped below, and exact locations are provided in the VERT report included in the appendix of this report. A map of the locations of both the M 6.4 and M 7.1 KCFD responses for structural fires are shown in maps in Figure 30 where these locations were concentrated in Bakersfield and Ridgecrest. A link to the Google Map is provided in the VERT report included in Appendix B of this report.



(a) **(b)**

Figure 30. Distribution of structural fire responses by the KCFD after the two earthquakes; purple indicates M 6.4 responses and orange indicates M 7.1 responses, (a) in Bakersfield, and (b) in Ridgecrest

Lifelines

The M 6.4 Ridgecrest earthquake generated minor damage to lifelines, including some cracks on 178 Highway, localized water breaks, and limited damage to the electric infrastructure. The majority of the damage was quickly repaired by the responsible agencies. The areas affected by lifelines damage were the town of Trona and Ridgecrest. The M 7.1 event created more significant damage than the M 6.4 one, generating several cracks on the SR 178 and rockslides.

Transportation Infrastructure and Bridges

A large crack has formed in a highway near Ridgecrest following the earthquake event on July 4, 2019. The road damage included a 12-inch (305 mm) crack across Highway 178, about two miles west of Trona Road. Moreover, several cracks formed on the SR 178 between Trona and Ridgecrest after the M 7.1 event. The roads have been closed for repairs and were quickly repaired by Caltrans crews (KTLA, 2019, Figures 31 to 33). After the M 6.4 event, highways in San Bernardino County remained open. However, after the M 7.1 event, the SR 178 between Trona and Ridgecrest was closed for repairs. No damage to bridges and airports was reported.

Figure 31. Damage reported in Highway 178 (a) Large crack formed near Trona[20] (b) a motorcyclist rides over a temporarily repaired part of the damaged highway in Ridgecrest one day after the earthquake, demonstrating the rapid response of repair crews; (c) damage reported in Ridgecrest during the M 6.4 event[21]; (d) surface cracks near Ridgecrest following the M 6.4 event[22] (AP Photo/David McNew) (e) Crack length near Ridgecrest after the July 4th event[23]; (f) rockslides cause closure of the highway from the M 7.1 event on Friday night; announced clear Saturday at 1 AM by Kern Country[24]

[20] https://ktla.com/2019/07/04/6-6-earthquake-jolts-southern-california-on-4th-of-july/
[21] https://www.facebook.com/nextquake/photos/rpp.1522642377960072/2878715709019392/?type=3&theater
[22] https://www.reuters.com/article/us-california-quake/big-quake-rattles-area-of-20-million-people-in-california-no-one-killed-idUSKCN1TZ1VB
[23] https://www.facebook.com/USGeologicalSurvey/
[24] https://www.latimes.com/local/lanow/la-me-trona-earthquake-batters-rockslides-ridgecrest-20190705-story.html

Figure 32. A road in Trona slightly damaged during M 6.4 event (AP Photo/M. Hartman[25])

(a) (b) (c) (d)

Figure 33. (a) Several cracks on the SR 178 WS between Trona and Ridgecrest after the M 7.1 event. The road was closed for repairs; (b) Details of the cracks[26]; (c) Other picture of the cracks[27]; (d) Rockfall cleared on SR 178 between Trona and Ridgecrest but route still closed for temporary repair[28]

An assessment of the bridges instrumented for strong motion by the California Department of Transportation. Bridge Number 50-0340 at Brown Road, Figure 34(a), was instrumented for

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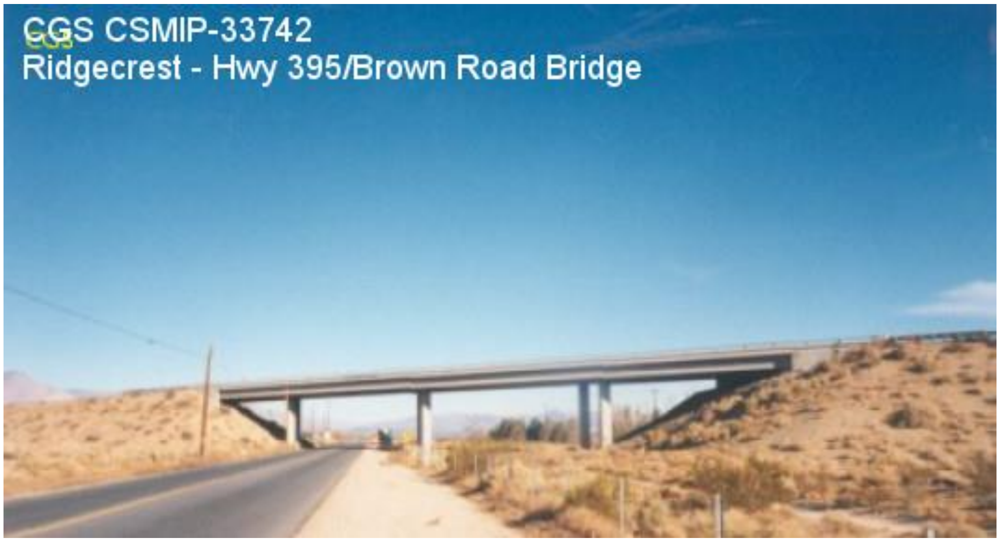
[25] https://www.nbcnews.com/news/us-news/6-4-magnitude-earthquake-shakes-southern-california-n1026621
[26] https://twitter.com/Caltrans8
[27] https://heavy.com/news/2019/07/trona-earthquake-damage-photos/
[28] https://heavy.com/news/2019/07/trona-earthquake-damage-photos/

strong motion and was triggered by this earthquake, Figure 34(b). It is located about 14 miles from the epicenter of this earthquake. The California Geological Survey (CGS) personnel processed the data and send it to Caltrans for emergency use. Typically, a default filter of three seconds is used to filter strong motion records, but with the long period energy associated with this earthquake, a 10 second corner period was utilized. The ground sensors show a peak acceleration of 0.24g and the structure recorded 0.60g (refer to Figure 35). The structure experienced long motions of 116 mm transversely and 152 mm longitudinally (refer to Figure 36). Comparing the wave forms from the top and bottom of the column, they show that they move together and should have no relative deflection. Thus, from this preliminary investigation, no cracks are expected of the columns of this bridge.

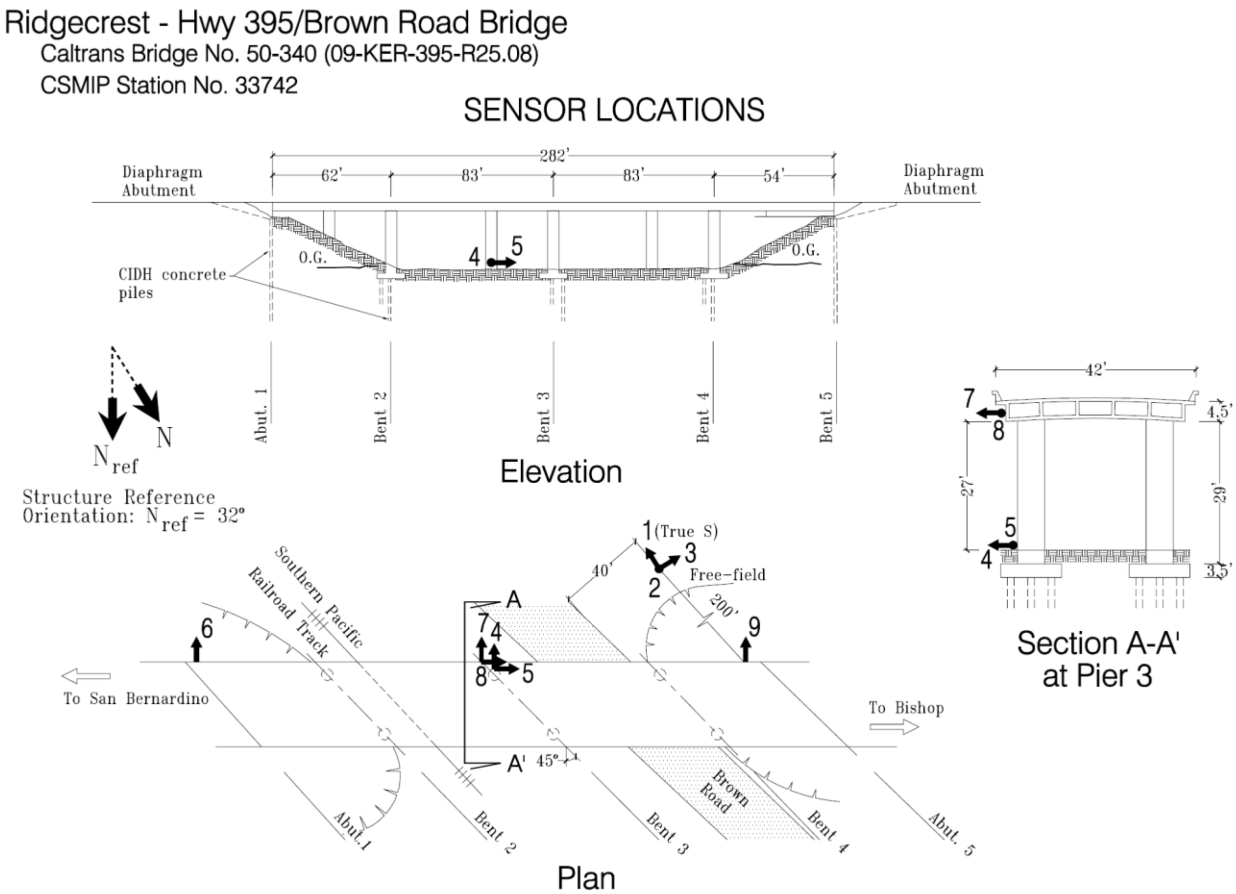
A structure having a long period of natural vibration (e.g. 6 sec) such as a tall building or large bridge (e.g. Vincent Thomas) would have experienced great motion (harmonic vibration). Since this bridge structure of Brown Road and the local buildings have a high natural frequency of vibration, they basically moved with the ground. If this epicenter was under a large city, many structures would experience greater displacements. It is indeed fortunate that these two big events occurred in a rural area.

Another interesting observation is that the free field vertical spectral acceleration (Sa) is almost 4g at 0.4 seconds (refer to Figure 37). Because of the magnitude of the two events, many ground stations, bridges, buildings and geotechnical downhole arrays were triggered and data is available[29].

[29] https://strongmotioncenter.org/cgi-bin/CESMD/iqr_dist_DM2.pl?ID=ci38457511



(a)



(b)

Figure 34. Caltrans Bridge No. 50-340 of Brown Road (a) Photograph of the bridge; (b) Bridge layout and instrumentation by CSMIP

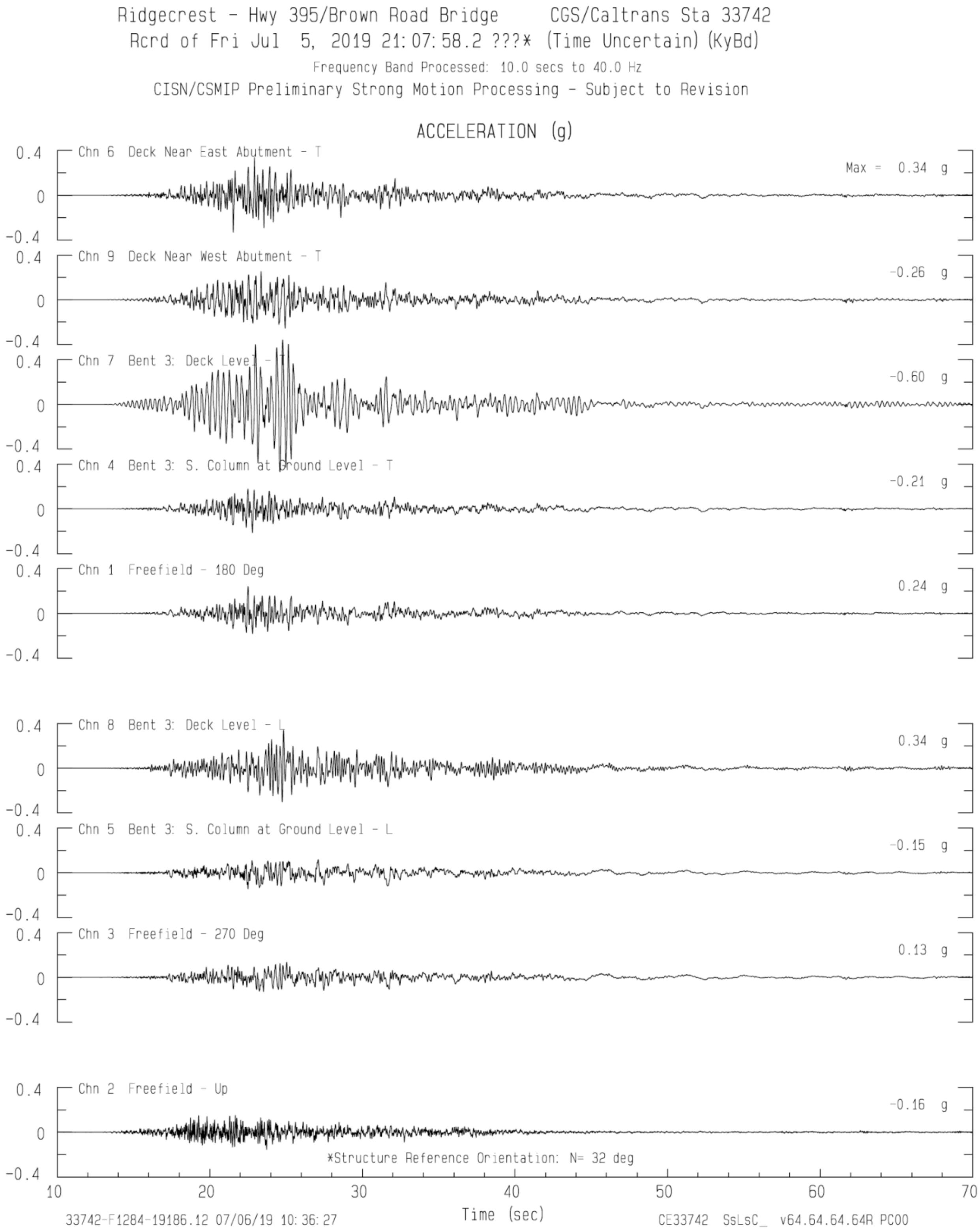


Figure 35. Measured accelerations of Bridge No. 50-340 of Brown Road during M 7.1 event (for Channel numbers, refer to Figure 34(b))

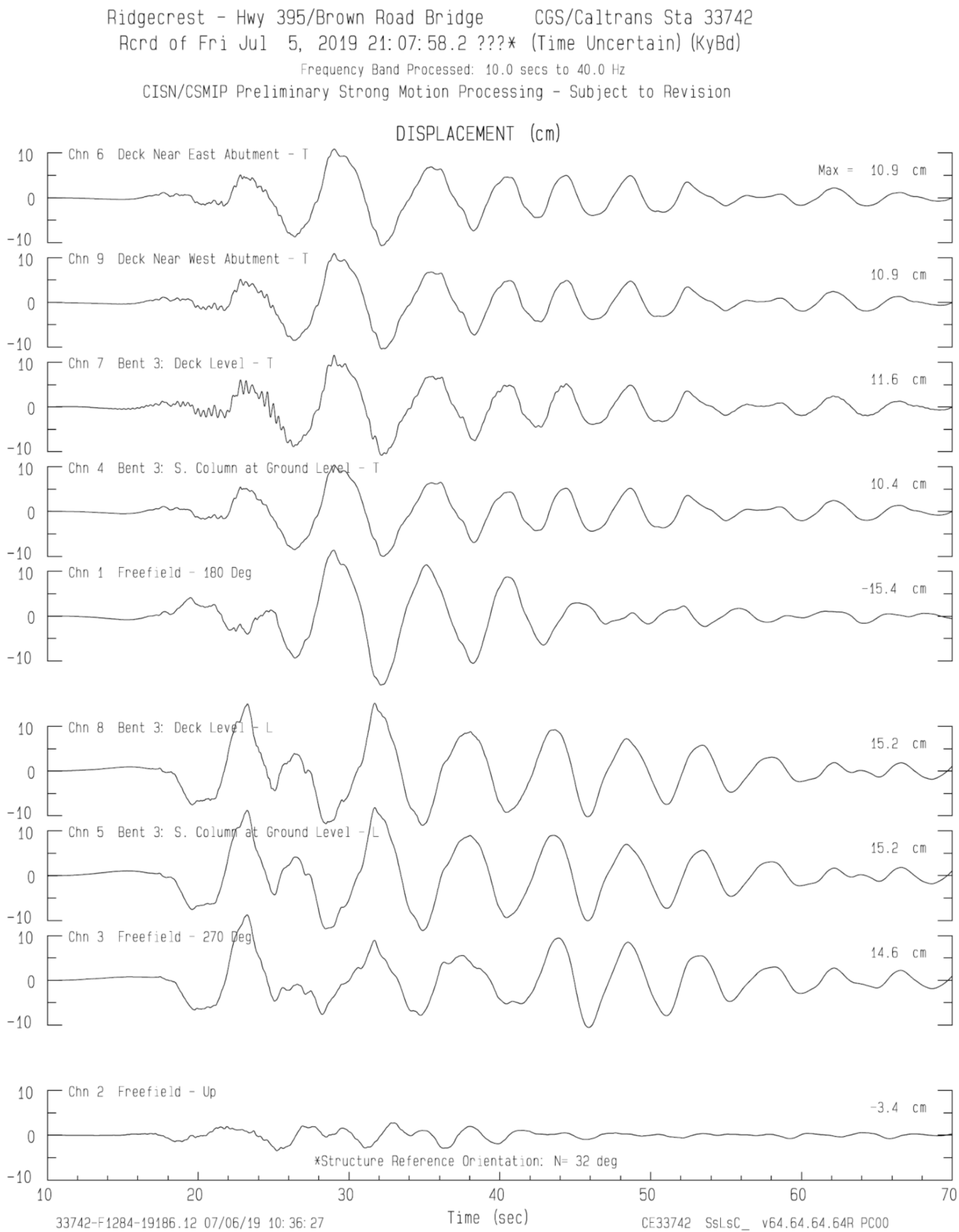


Figure 36. Computed displacement from measured accelerations of Bridge No. 50-340 of Brown Road during M 7.1 event (for Channel numbers, refer to Figure 34(b))

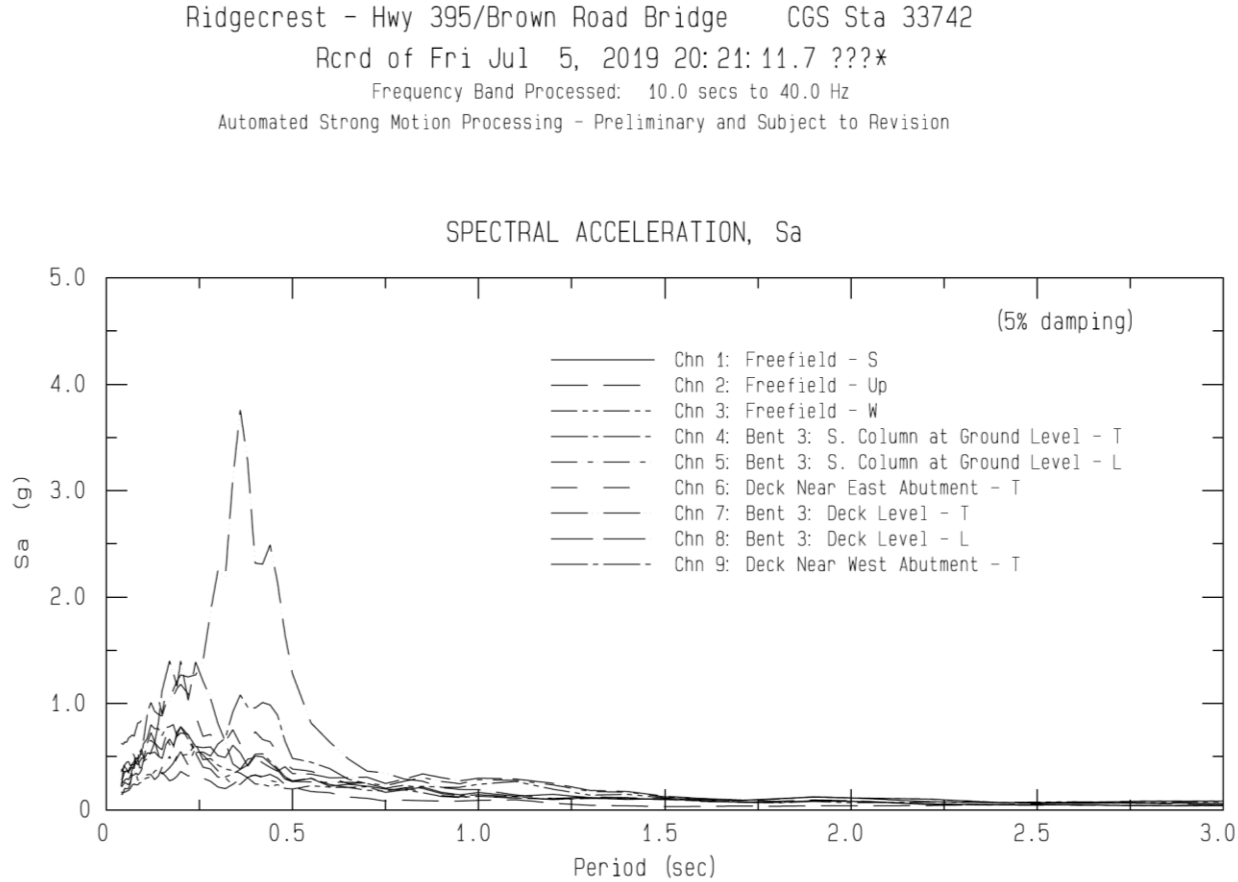


Figure 37. Computed 5% damped spectral accelerations from measured accelerations of Bridge No. 50-340 of Brown Road during M 7.1 event (for Channel numbers, refer to Figure 34(b))

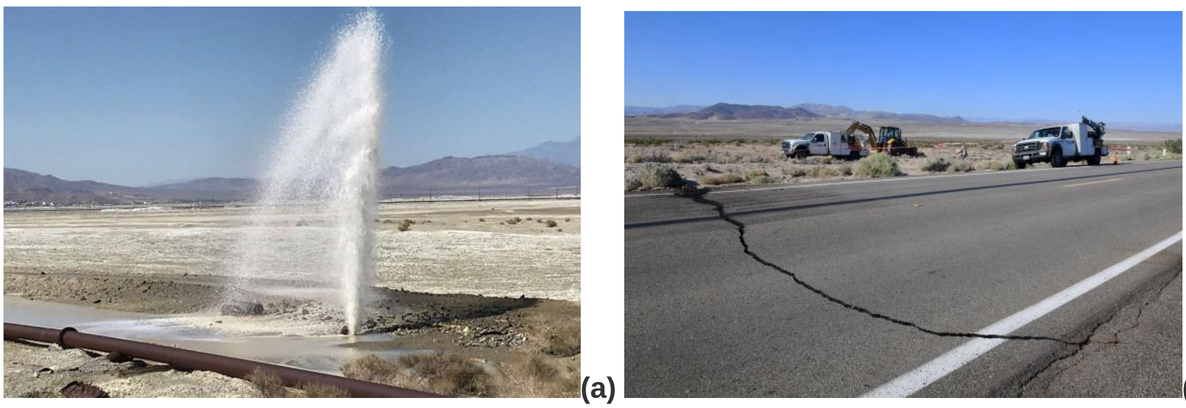
Utilities for Electricity and Water Distribution

Power was knocked out in Trona, Figure 38, a small town closest to the epicenter, located about 25 miles north of Ridgecrest. In addition, residents reported water main breaks and gas line breaks[30]. It was reported that 2,000 customers in Kern County and another 3,000 in San Bernardino and Inyo lost power after the M 7.1 event. Service had been restored quickly[31]. Some water pipes were damaged during the M 6.4 event. Refer to Figures 39 and 40.

30 https://losangeles.cbslocal.com/2019/07/04/6-6m-quake-strikes-near-ridgecrest-in-kern-county/
31 https://www.washingtonpost.com/nation/2019/07/06/california-earthquake/?utm_term=.60923781a92e

(a) (b)

Figure 38. (a) A utility pole in Trona was damaged during the earthquake[32]; (b) Workers repair damaged utility lines in Trona, CA (AP Photo/Mario Tama | Getty Images[33]



(a) (b)

Figure 39. (a) Water spews from pipes in Trona damaged by the M 6.4 event (AP Photo/Matt Hartman[34]; (b) A crack on Highway 178 seen during fixing a broken water line south of Trona (Source: AP Photo/F.J. BROWN | AFP/GETTY IMAGES[35]

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32 https://www.chron.com/bayarea/article/6-6-earthquake-southern-California-san-bernardino-14071882.php#photo-17806022

33 https://www.mprnews.org/story/2019/07/05/strongest-earthquake-in-20-years-rattles-southern-california

34 https://www.sfchronicle.com/bayarea/article/6-4-quake-hits-Mojave-Desert-felt-in-Los-Angeles-14071924.php#photo-17806048

35 https://www.wknofm.org/post/64-magnitude-earthquake-hits-southern-california-rattling-large-swath-state

(a) (b)

Figure 40. (a) Exploded water pipe reported during the M 6.4 event, consequently forming a crater near Ridgecrest (Source: AP Photo/Etienne Laurent, EPA-EFE[36]; (b) Crews dealing with a water main that ruptured during the earthquake[37]

Non-Structural Damage

This event caused significant damage to non-structural elements such as infill walls, partition walls (usually built of masonry), ceilings and veneers and various types of building contents. In addition to the equipment damage shown with photographs in previous sections, there was damage to suspended ceilings, Figure 41.

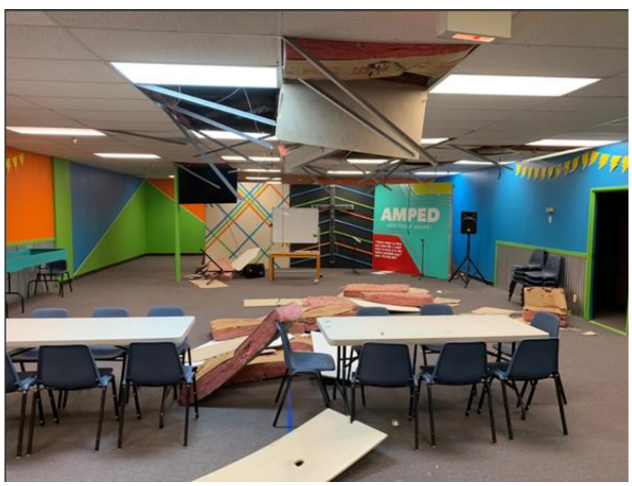


Figure 41. Suspended ceiling damage at Baptist Church in Ridgecrest[38]

[36] https://www.desertsun.com/story/news/local/2019/07/04/6-6-magnitude-earthquake-rattles-parts-southern-california/1650319001/

[37] https://www.msn.com/en-us/weather/weathertopstories/64-magnitude-earthquake-hits-southern-california/ss-AADRIAr?ocid=msn360#image=16

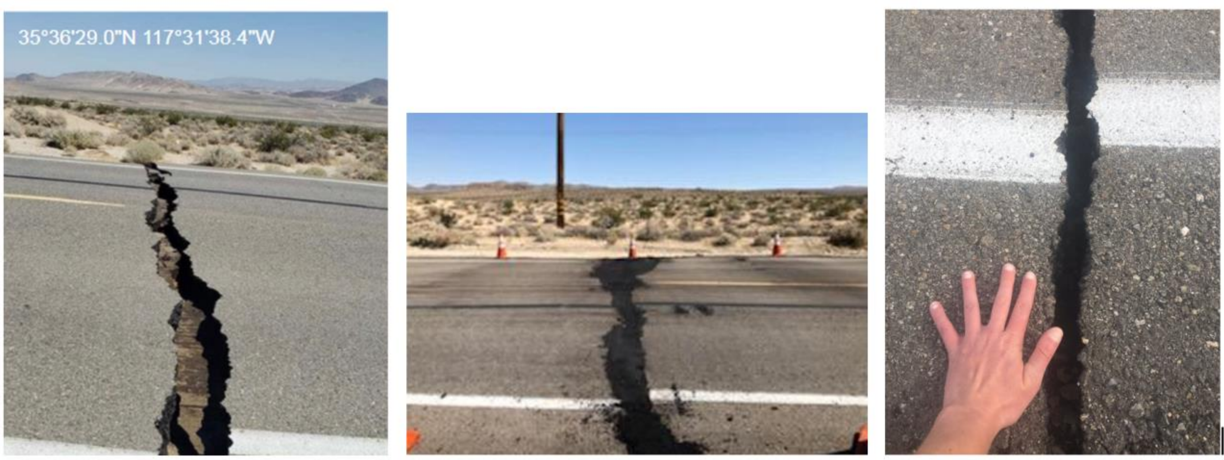
[38] http://www.bpnews.net/53239/calif-quakes-prompt-southern-baptist-response

Geotechnical Failures

M6.4 Earthquake - July 4, 2019

The M 6.4 earthquake caused geotechnical damage in the form of surface fault rupture, ground separation, and ground fissures. An approximately 12" (305 mm) wide crack was formed across Trona Road about 2.5 miles South of State Route 178 (see VERT report included in Appendix B). Another large crack was formed across State Route 178 about 2 miles West of Trona Road. Several other cracks along State Route 178 were reported by the Caltrans District 8 Twitter page; according to the same source these cracks were repaired by the Caltrans District 9 Maintenance crews within an hour after the event. According to the USnews, California Highway Patrol announced that overpasses and underpasses were not damaged and these cracks were primarily in the county roads.

Several traces of fault rupture and ground fissure were also reported near Ridgecrest after the earthquake. Satellite images reflected subtle left-lateral fault rupture after the M 6.4 Ridgecrest earthquake.



(a) (b) (c)

Figure 42. Geotechnical damage following M6.4 Ridgecrest (a) 12"(305 mm) wide crack across Trona road[39], (b) Caltrans District 9 Maintenance crews make repairs to cracks along SR 178 near Trona (Source: Caltrans District 8 Twitter page[40]), and (c) ground separation and offset (photo by Emily Guerin[41]). All images reported in the VERT report, Appendix B.

[39] https://heavy.com/news/2019/07/california-earthquake-today-map-damage-magnitude/

[40] https://twitter.com/Caltrans8

[41] https://twitter.com/guerinemily

Figure 43. 100 ft (30.48 m) wide zone of parallel ruptures showing left lateral (LL) and some dilation along the Ridgecrest surface rupture reported by Danielle Verdugo Madugo[42]

(a) (b) (c)

Figure 44. Surface Fault Rupture following M 6.4 Ridgecrest earthquake (a) Off the road rupture (reported by Emily Guerin[43]), (b) Ground crack near Ridgecrest[44], (c) fault rupture across Randsburg Wash Road to the south of State Route 178, measured offset of approximately 1.5 feet (457 mm) (Source: Brian Olson Twitter page[45]). All images reported in the VERT report, Appendix B.

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42 https://twitter.com/DanielleVerdugo

43 https://twitter.com/guerinemily

44 https://www.newsweek.com/california-earthquake-viral-videos-panic-chaos-tremor-aftershock-1447699

45 https://twitter.com/mrbrianolson

(a) (b)

Figure 45. (a) Lateral displacement of about 100 cm; and (b) Wide distributed shears[46]

M7.1 Earthquake - July 5, 2019

The M 7.1 earthquake caused geotechnical damage in the form of surface fault rupture (e.g. offset, ground fissures etc.), rockfalls, and liquefaction-induced failures (e.g. lateral spreading). A North-West trending fault rupture measured up to 6 feet (1.83 m) of right-lateral offset on the China Lake NWAS base[47]. A right-lateral offset of about 6.5 feet (1.98 m) and a vertical offset of about 3 feet (0.91 m) were reported[48]. A surface rupture across State Route 178 caused a right-lateral offset, likely related to the North-West trending conjugate fault[49], photo taken from the VERT report, Appendix B. Fault rupture also bended railroad tracks and caused damage to the nearby road; a 3-feet (0.91 m) right lateral offset was reported[50].

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46 https://twitter.com/ChupikColin/status/1147558794148245504
47 https://twitter.com/mrbrianolson
48 https://twitter.com/mrbrianolson
49 https://twitter.com/mrbrianolson
50 https://twitter.com/neotectonic

Figure 46. (a) Aerial view of the faulted road on the China Lake NWAS base, about 6.5 feet (1.83 m) right lateral (RL) and 3 feet (0.91 m) vertical offset[51], (b) North-West trending fault rupture measuring 6 feet (1.83 m) of right-lateral offset on the China Lake NWAS base[52], and (c) Bent railroad track due to the fault rupture , close to 3 feet (0.91 m) of RL offset[53]

Multiple ground cracks along State Route 178 near Post Mile 8.5 were patched before opening the road to traffic (the duration of closure is now known at this time). According to the Caltrans District 8 Twitter page, Caltrans started permanent construction repairs on State Route 178 approximately six miles east of Ridgecrest. The repairs were done in three separate areas within four mile stretch along the State Route 178. All bridges and highway structures have been evaluated by Caltrans engineers and they have been determined safe for normal operations[54].

[51] https://twitter.com/mrbrianolson
[52] https://twitter.com/mrbrianolson
[53] https://twitter.com/neotectonic
[54] https://twitter.com/Caltrans8

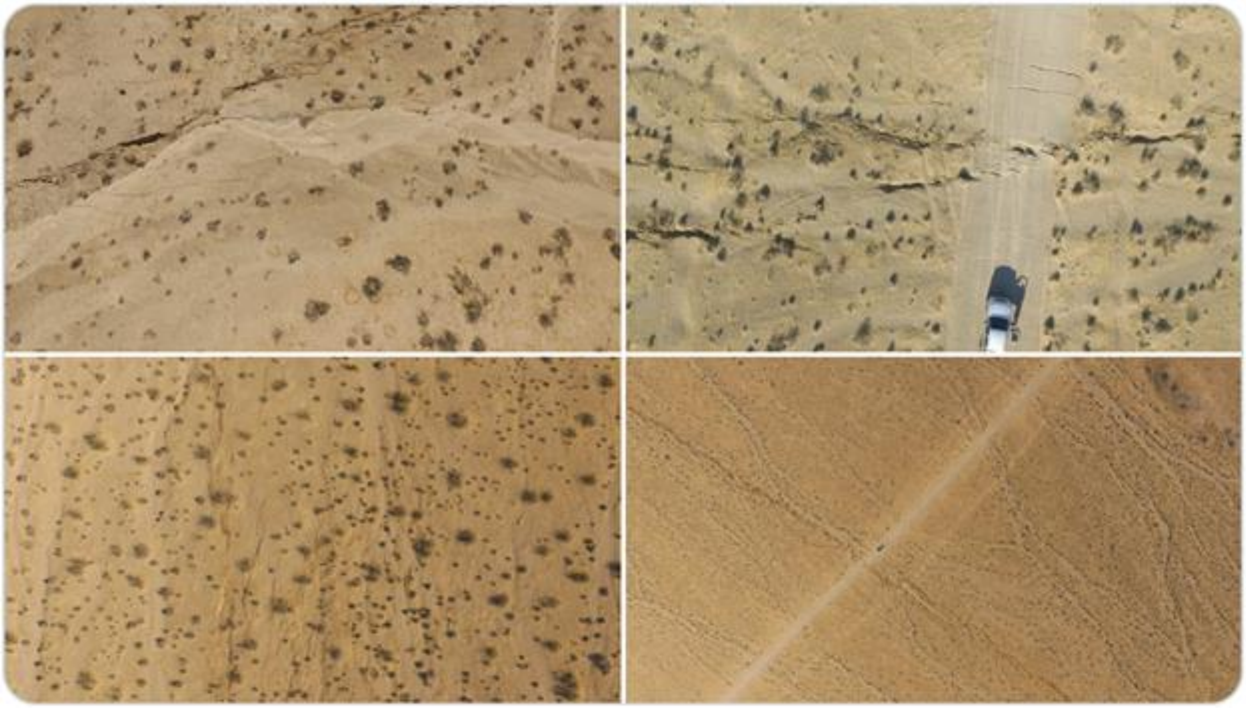


Figure 47. Aerial views of ground failure indicating left-stepping and right-stepping lateral faults reported by Ian Pierce[55]

Figure 48. Multiple ground cracks along SR 178 (Source: Caltrans8 Twitter page[56], taken from the VERT report, Appendix B)

55 https://twitter.com/neotectonic
56 https://twitter.com/Caltrans8

Figure 49. SR 178 near PM (post mile mark) 8.5 Caltrans crews making repairs to patch road before open to traffic[57] (picture taken 12:53am 07/06/2019)

Rockfall caused road closure in State Route 178 between Bakersfield and Lake Isabella. This road was later opened to traffic. Rockfall in State Route 178 between Trona and Ridgecrest caused traffic closure; the rockfall was later cleared. Rockfall was also reported from State Route 190 Townes Pass and State Route 127 near the Tecopas Hot Springs turnoff[58].

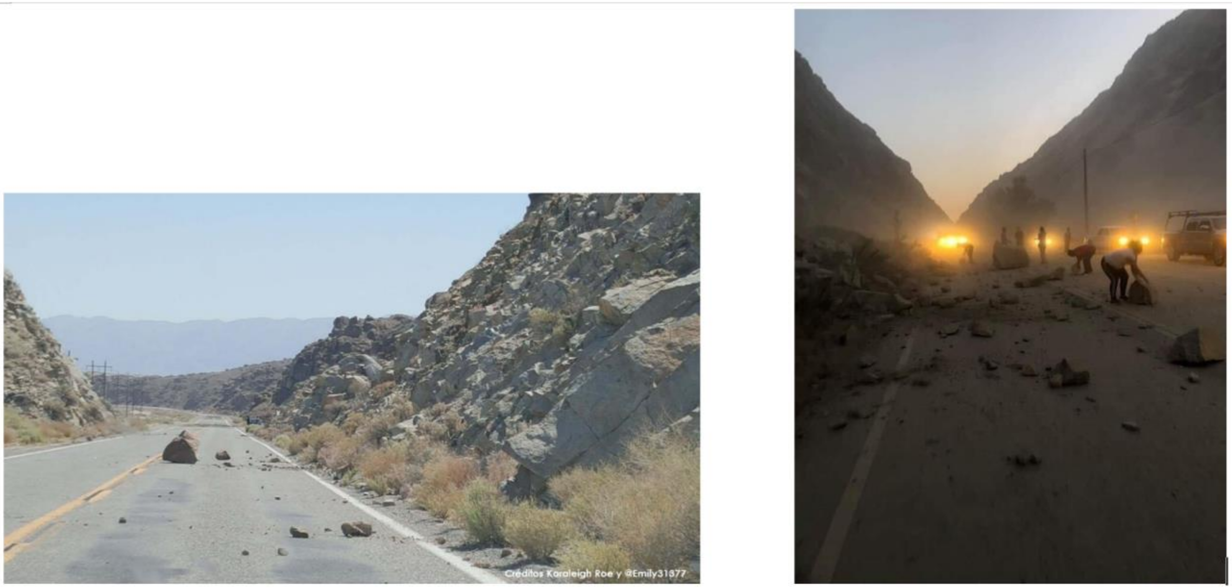


Figure 50. Rockfall damages in Ridgecrest[59] (left) and Trona[60] (right). All images reported in the VERT report, Appendix B.

Significant geotechnical damage in Trona resulted from at depth liquefaction (Ken Hudson, personal communication) leading to lateral spreading at the surface. Few sand boils were also

57 https://twitter.com/Caltrans8
58 https://twitter.com/Caltrans8
59 https://twitter.com/neotectonic
60 https://www.latimes.com/local/lanow/la-me-trona-earthquake-batters-rockslides-ridgecres

observed. Photos below were collected by EERI members performing field investigation after the M7.1 earthquake and shared by Kenneth Hudson (one of the EERI team members). The groundwater table in this area is reported to be fairly shallow (~1.5 ft (457 mm) according to http://wdl.water.ca.gov/waterdatalibrary/ and nearby well data). The combination of heavy rainfall during the past winter with the lakebed could justify these observations as well as the occurrence of liquefaction (Ken Hudson, personal communication).

Figure 51. Liquefaction induced lateral spreading and sand boils causing damage to the roadway, and infrastructure in the Trona area (source for all: courtesy of Kenneth Hudson, one of EERI field investigation team members) [clockwise from top left: Esparza restaurant commercial building distance from – closest distance to Searles Lake 0.6 mile; US Post Office Building – closest distance to Searles Lake 1.0 mile; corner of California Street and Argus Avenue; Shell gas station – closest distance to Searles Lake 1.0 mile].

Figure 52. Closer look at ground failure observed at underground storage tank at Shell gas station on Trona Road (Source: courtesy of Kenneth Hudson, one of EERI field investigation team members).

Current Conditions, Access Restrictions and Recommendations

There have been access restrictions to some hospitals. The Ridgecrest Regional Hospital has now reopened after being closed for a few days after both earthquake events[61]. As of this report, the authors are not aware of any unusual access restrictions in place.

Recommendations for further investigation may include the following:

1. Effect of the accumulated damage from the M 6.4 earthquake on the response during the M 7.1 earthquake,
2. Evaluation of the accuracy of regional scale simulations (those of NHERI SimCenter and X. Lu Tsinghua group) by comparing their results against the observed damage,
3. Investigation of the current status of ShakeAlertLA. Does it require revisions, change of thresholds, etc.?
4. Current status of earthquake insurance in California,
5. Reasons behind the relatively poor performance of the water supply network despite the ongoing efforts for its improvement around the Los Angeles area, and
6. Further investigation of performance of non-structural components including mobile homes.

[61] https://twitter.com/FlavioLacayo/status/1148011491984998400?s=20

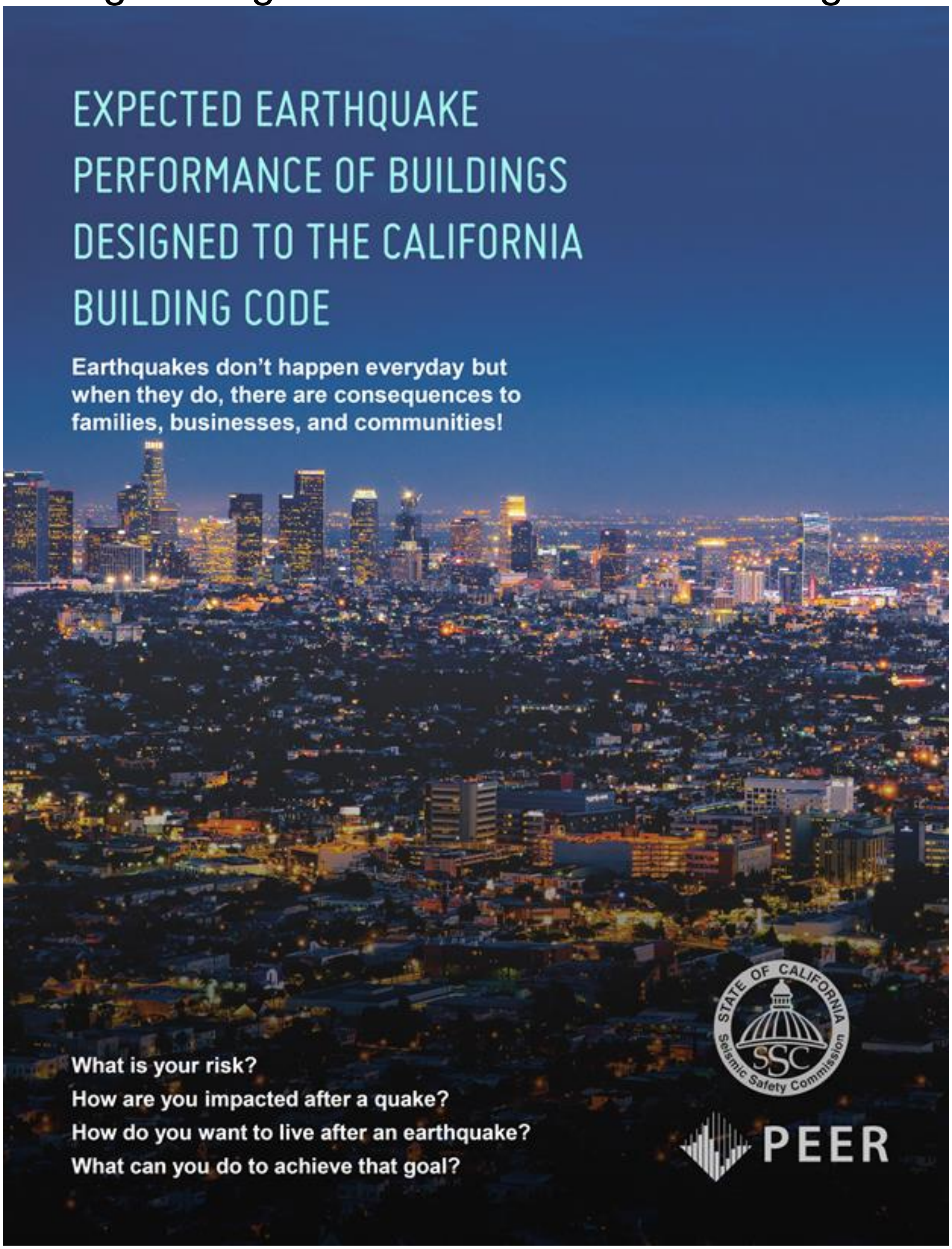
StEER Response Strategy

Based on prior event experience and preferences, StEER volunteers are generally offered positions on two types of StEER Teams:

- **Virtual Assessment Structural Teams (VASTs)** were formed to assemble data on the event from public sources and lead authorship of two reports: The Preliminary Virtual Assessment Structural Team (P-VAST) Report and The Early Access Reconnaissance Report (EARR) based on the data from FAST-1. VASTs also work to enrich FAST data with other information gleaned from inventory and high-resolution imagery and participate in quality assurance and data cataloging processes.
- **Field Assessment Structural Teams (FASTs)** were formed by invitations to individuals with prior field experience and expertise relevant to this type of event. FASTs were used to rapidly gather essential data only visible on the ground, with the understanding that these will be enriched with additional sources of data through aligned StEER efforts.

Given the magnitude of the two Ridgecrest earthquakes, StEER deployed the VAST who produced this report. However, the observed limited structural damage discussed in this report does not warrant the need to deploy a FAST at this stage. StEER will continue to monitor the situation and work with local field reconnaissance teams in case the situation changes and necessitates deploring a FAST. In this case a FAST drawn from regional expertise with prior earthquake reconnaissance experience will be sought. Typically, a FAST will gather samples of damage to buildings and other infrastructure using a combination of door-to-door (D2D) damage assessments, unmanned aerial surveys (UASs) and StreetView imagery. VAST will review damage reports and data from FAST as swiftly as possible, as well as other public data from this event, as conducted in this report. This will be used to generate an Early Action Reconnaissance Report (EARR) to be released on DesignSafe. The findings of FAST will then inform subsequent FASTs that may deploy to the affected regions.

Appendix A: Expected Earthquake Performance of Buildings Designed to the California Building Code[62]



[62] Brochure developed by Grace Kang of PEER and several co-authors of this report for the CSSC.

EXPECTED CODE PERFORMANCE

The California Building Code is a *minimum requirement* intended to protect *life safety* and *prevent collapse*. It *allows damage*, which means buildings may not be habitable or functional after a moderate or large earthquake.

THE BUILDING CODE...

HAS LIFE SAFETY INTENT
the building may remain standing so you can evacuate

ALLOWS DAMAGE
you might not be allowed to re-enter a damaged building

IS A MINIMUM REQUIREMENT
you can choose to have your building designed or retrofitted for less damage

EARTHQUAKES & CODE IMPROVEMENTS

1971 **SAN FERNANDO**
Magnitude 6.5: 64 died, 2543 injured, $553M damage
Code improvement: Concrete detailing

1989 **LOMA PRIETA**
Magnitude 6.9: 63 died, 3757 injured, $5.6-$6B damage
Code improvements: Wood frame soft story issues

1994 **NORTHRIDGE**
Magnitude 6.7: 57 died, 8700 injured, $13B-$40B damage
Code improvement: Welded steel frame detailing

EXPECTED PERFORMANCE OF CODE-DESIGNED NEW BUILDINGS IN EARTHQUAKES

ESSENTIAL BUILDINGS

Examples: Hospitals, Fire Stations

ORDINARY BUILDINGS

Examples: Houses, Apartments, Stores, Offices, Schools

		Collapse Prevention	Life Safety	Immediate Occupancy	Operational
ESSENTIAL BUILDINGS	**Extreme Shaking** Maximum Considered Earthquake	Likely	Likely	Unlikely	Unlikely
ESSENTIAL BUILDINGS	**Strong Shaking** Design Level Earthquake	Likely	Likely	Possibly	Unlikely
ORDINARY BUILDINGS	**Extreme Shaking** Maximum Considered Earthquake	Likely	Possibly	Unlikely	Unlikely
ORDINARY BUILDINGS	**Strong Shaking** Design Level Earthquake	Likely	Likely	Unlikely	Unlikely

POSSIBLE CONSEQUENCES AND YOUR RISK

MYTHS	REALITY & RISKS
I occupy a new building, so I will be fine.	The California Building Code establishes a minimum standard intended to protect life safety. Even a new building, following an earthquake, may have damage and be unusable.
My building was retrofitted last year, so I will be fine.	Most retrofitted buildings are not required to be fully compliant with the current California Building Code. Even a retrofitted building may have damage and be unusable after an earthquake.
Only buildings that are compliant to current code can be occupied or sold.	Even as the California Building Code develops and improves, communities may not be able to require existing buildings to comply with current code.
My home and workplace are not located next to a fault, so I will be fine.	Different soil and site conditions can result in strong shaking far from faults. In 1989, severe damage and collapses occurred in San Francisco and Oakland, 60 miles away from the epicenter of the Loma Prieta Earthquake.
I am located in a lower hazard area, so I will be fine.	In lower hazard areas, infrequent earthquakes can still cause strong shaking.
Damage to the building's structure is the most costly type of damage in earthquakes.	Most costs are typically from non-structural repairs, replacement of high-value components, and lost revenue from business disruption.
I cannot afford to mitigate and prepare now.	Bracing and anchoring building contents can be part of regular maintenance tasks. There are programs designed to partially subsidize home mitigation efforts. Taking action now can reduce damage and disruption later.

EARTHQUAKE HAZARD IN CALIFORNIA

CONSEQUENCES

FAMILY
- injury from falling items
- expensive repairs
- isolation and stress
- displacement

BUSINESS
- loss of inventory
- supply chain broken
- loss of income
- relocation

COMMUNITY
- limited supplies & services
- emergency services overloaded
- fragmentation

Life Safety Level of Damage for an Ordinary Building after a Large Earthquake

THINGS YOU CAN DO

Preparedness will determine the quality of life in the weeks and months that follow a major earthquake.

FAMILY

- Secure your space: brace and restrain heavy and important items such as water heaters and bookcases.
- In addition to a short-term emergency and communication plan, develop a longer-term recovery plan that includes personal and financial security.
- Assess age and earthquake safety of home. Consider retrofitting measures including chimney bracing.

RESOURCES

California Earthquake Authority – Residential Earthquake Insurance and Mitigation
https://www.earthquakeauthority.com
"Homeowner's Guide to Earthquake Safety"
https://ssc.ca.gov/forms_pubs/hog.html
"Staying Safe Where the Earth Shakes"
https://www.earthquakecountry.org/stayingsafe/
"MyHazards" Online Tool: Risks and Recommended Actions
http://myhazards.caloes.ca.gov/

BUSINESS

- Develop a short-term emergency plan as well as a longer-term continuity and recovery plan that includes employees, inventory, and financial security.
- Incorporate equipment and inventory restraint with operational maintenance plans.
- Confer with experts to identify risks and how to maintain operational functions by designing beyond the minimum code level.

RESOURCES

California Resilient Business Challenge
https://outsmartdisaster.com/be-resilient/at-work/resilient-business-challenge/
"Commercial Property Owner's Guide to Earthquake Safety"
https://ssc.ca.gov/forms_pubs/cog.html
"7 Steps to an Earthquake Resilient Business"
https://www.earthquakecountry.org/library/7StepsBusiness2008.pdf

COMMUNITY

- Engage, inform, and train neighborhoods about mitigating the consequences of major earthquakes, including short-term emergency response and longer-term recovery measures.
- Determine which facilities are at risk and their impact on the public.
- For each public building, define its post-earthquake role in the community, complete a structural and non-structural assessment, and implement needed upgrades.

RESOURCES

Federal Emergency Management Agency (FEMA) Earthquake Publications
https://www.fema.gov/earthquake-publications
"Natural Hazard Mitigation Saves - 2018 Interim Report" and Fact Sheets
https://www.nibs.org/page/mitigationsaves

Expected Earthquake Performance of Buildings Designed to the California Building Code was initiated and is published by the California Alfred E. Alquist Seismic Safety Commission ("Seismic Safety Commission"). The guide was developed and prepared for publication by PEER - Pacific Earthquake Engineering Research Center, headquartered at the University of California, Berkeley.

The Seismic Safety Commission and PEER gratefully acknowledge the assistance of the following public and private entities for information, expertise and images: Association of Bay Area Governments / Metropolitan Transportation Commission (ABAG / MTC); California Business, Consumer Services and Housing Agency; California Earthquake Authority (CEA); City of Los Angeles Resilience by Design Program; City of San Francisco Earthquake Safety Implementation Program; Earthquake Country Alliance; Federal Emergency Management Agency (FEMA); Structural Engineers Association of California (SEAOC), Northern California (SEAONC) and Southern California (SEAOSC) member organizations; U.S. Geological Survey (USGS); U.S. Resiliency Council (USRC).

Image Credits - Cover: *https://www.goodfreephotos.com/united-states/california/los-angeles/night-lights-in-los-angeles-california-cityscape.jpg.php*
Page 2: NISEE-PEER Library. Page 3: *http://www.conservation.ca.gov/cgs/ Documents/MS-48.pdf. Joe Pugliese/Copyright © 2018. Los Angeles Times. Used with Permission.*

Appendix B: EERI VERT Report

Virtual Earthquake Reconnaissance Team (VERT):
Phase 1 Response to M6.4 & M7.1 Searles Valley Earthquakes
07/04 & 7/05/2019

By: Mohammad Shafiqual Alam, Yolanda Alberto, Chrysl Aranha, Sahar Derakhshan, Wilfrid Djima, Erica Fischer, William Greenwood, Gabriela Haro, Wael Hassan, Kenneth Hudson, Manny Hakhamaneshi, Alex Julius, Lucas Laughery, Xin Ma, Walker Maddalozzo, Harish Mulchandani, Tonatiuh Rodriguez-Nikl, Yi Tyan Tsai, Mehmet Unal, Jenna Wong, David Yoo, Katerina Ziotopoulou

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Erica Fischer (erica.fischer@oregonstate.edu)
Manny Hakhamaneshi (manny.hakhamaneshi@dot.ca.gov)

Topic: Earthquake Characteristics

VERT Phase 1 Response for:
Searles Valley M6.4 & M7.1 Earthquakes

Earthquake Characteristics
M6.4 Earthquake

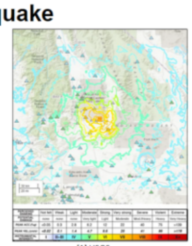
Date: 07-04-2019,17:33:49 (UTC)

Magnitude: Mw 6.4 [1]

Location:
- Epicenter located 115 miles from Los Angeles
- 35.705°N and 117.506°W

Depth: 10.7 km depth [1]

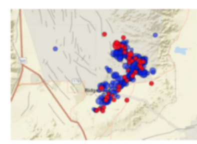
Max Intensity:
- Severe shaking
- Mild damage



[1] USGS

Summary of Location, Fatalities, Fault Mechanism, and other Statistical Data
M6.4 Earthquake

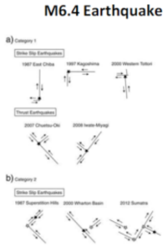
Fault Mechanism:
- The earthquake resulted from shallow strike slip faulting in the crust of North America plate [1].
- Based on its aftershocks, appears that two orthogonal faults have ruptured together, one right-lateral, and the other left lateral [2]
- Possible that the NE fault moved first, pulling away from and destabilizing the NW fault [3]
- Pablo Ampuero pointed out "conjugate faulting" [10]



Map of aftershocks over faults [3]

Summary of Location, Fatalities, Fault Mechanism, and other Statistical Data
M6.4 Earthquake

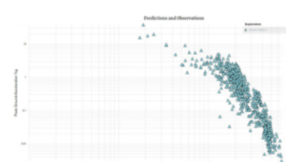
Conjugate Fault Categories:



[9]

Summary of Location, Fatalities, Fault Mechanism, and other Statistical Data
M6.4 Earthquake

USGS ShakeMap
- updated 2019-07-05 05:38:21 (UTC)
- PGA vs. RUpture Distance



USGS ShakeMap Analysis [7]

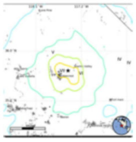
Summary of Location, Fatalities, Fault Mechanism, and other Statistical Data
M6.4 Earthquake

Impact on human safety:

- 0 fatalities reported as of July 5, 2019 [5]
- Unknown number of injuries reported as of July 5, 2019, primarily from fallen glass [5]

Impact on society:

- 1 house fire with 50% damage [5]
- $10 million to $100 million worth of estimated damage [6]



USGS Population per ~1 sq. km. from LandScan [8]

Summary of Location, Fatalities, Fault Mechanism, and other Statistical Data
M7.1 Earthquake

Date: 07-06-2019,03:19:52 (UTC)

Magnitude: Mw 7.1

Location:

- Epicenter located 10.6 miles from Ridgecrest
- 35.733°N 117.605°W

Depth: 17.0 km

- Vertical displacements of up to 12 ft and lateral displacements of up to 6 ft (measured by reconnaissance team)

[1] USGS

Summary of Location, Fatalities, Fault Mechanism, and other Statistical Data
M7.1 Earthquake

Fault Mechanism:

- The earthquake resulted from shallow strike slip faulting in the crust of the North American plate [7].
- Rupture occurred on a steeply dipping fault as the result of either right lateral slip on a plane striking NW-SE, or as left lateral slip on a plane striking SW-NE [8]

References

1 https://earthquake.usgs.gov/earthquakes/eventpage/ci38443183/executive
2http://temblor.net/earthquake-insights/southern-california-m-6-4-earthquake-stressed-by-two-large-historic-ruptures-8976/
3 https://twitter.com/DrLucyJones/status/1146919334930874368
4 https://earthquake.usgs.gov/earthquakes/eventpage/ci38443183/shakemap/intensity
5 Kern County Fire Department https://twitter.com/kerncountyfire/status/1146903900676485121
6 https://www.usgs.gov/news/update-magnitude-64-earthquake-southern-california
7 https://earthquake.usgs.gov/earthquakes/eventpage/ci38443183/shakemap/analysis
8https://earthquake.usgs.gov/earthquakes/eventpage/ci38457511/executive
[9] https://link.springer.com/article/10.1186/s40623-015-0207-1
[10] https://twitter.com/DocTerremoto

Topic: Aftershocks

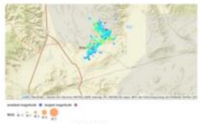
VERT Phase Response for:
Searles Valley M6.4 & M7.1 Earthquakes

Summary of Aftershocks
M6.4 Searles Valley Earthquake

- According to the USGS forecast issued 07/05/2019 06:22:01 UTC, the chance of more aftershocks estimate as follows: Within the next 1 Week until 2019-07-12 06:30:00 (UTC):
  - The chance of an earthquake of magnitude 3 or higher is > 99 %, and it is most likely that as few as 57 or as many as 110 such earthquakes may occur in the case that the sequence is re-invigorated by a larger aftershock.
  - The chance of an earthquake of magnitude 5 or higher is 55 %, and it is most likely that as few as 0 or as many as 4 such earthquakes may occur.
  - The chance of an earthquake of magnitude 6 or higher is 8 %, and it is most likely that as few as 0 or as many as 2 such earthquakes may occur.
  - The chance of an earthquake of magnitude 7 or higher is 1 in 100, such an earthquake is possible but with a low probability. [1]

Summary of Aftershocks
M6.4 Searles Valley Earthquake

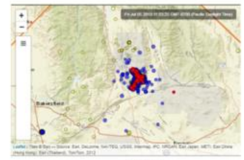
- As of 07/05/2019 06:22 UTC, there have been 76 magnitude 3 or higher earthquakes, which are strong enough to be felt, and 0 magnitude 5 or higher earthquakes, which are large enough to do damage. [1]
- According to our USGS forecast, over the next 1 Week there is a 3 % chance of one or more aftershocks that are larger than magnitude 6.4. It is likely that there will be smaller earthquakes over the next 1 Week, with 57 to 110 magnitude 3 or higher aftershocks. [1]



[2] SCSN.org

Summary of Aftershocks
M6.4 Searles Valley Earthquake

On 07/05/2019 at 11:07:53 (UTC) a Magnitude 5.4 earthquake occurred at a depth of 7km.



[1] USGS

Summary of Aftershocks
M6.4 Searles Valley Earthquake

The **probability of at least one aftershock** of at least magnitude M within the given time frame. Forecast starting 07/05/2019 06:30:00 UTC [1]

Magnitude	1 Day	1 Week	1 Month	1 Year
M >= 3	> 99%	> 99%	> 99%	> 99%
M >= 5	26%	55%	72%	89%
M >= 6	3%	8%	12%	20%
M >= 7	< 1%	< 1%	1%	2%

Summary of Aftershocks
M6.4 Searles Valley Earthquake

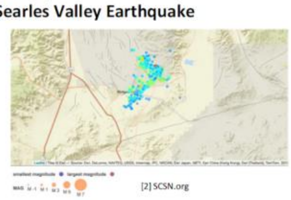
The likely **number of aftershock** of at least magnitude M within the given time frame. Forecast starting 07/05/2019 06:30:00 UTC [1]

Magnitude	1 Day	1 Week	1 Month	1 Year
M >= 3	19 to 44	57 to 110	94 to 170	179 to 290
M >= 5	0 to 2	0 to 4	0 to 5	0 to 6
M >= 6	*	0 to 2	0 to 2	0 to 2
M >= 7	*	*	*	*

* Earthquake possible but with a low probability.

Summary of Aftershocks
M6.4 Searles Valley Earthquake

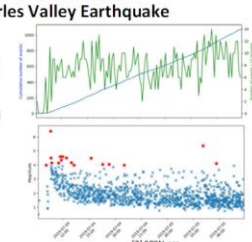
Map showing the current events in the Ridgecrest earthquake sequence. Events are shown colour-scaled by time and size-scaled by magnitude according to the scales shown at the bottom of the figure.



[2] SCSN.org

Summary of Aftershocks
M6.4 Searles Valley Earthquake

Time series of the Ridgecrest earthquake sequence. The upper plot shows the cumulative number of events (blue), as well as the number of earthquakes per 20 minutes (green). The lower plot shows earthquake magnitudes through time, with events of M≥4 marked as red stars.



[2] SCSN.org

Summary of Aftershocks
M7.1 Earthquake

According to the USGS forecast issued 2019-07-06 03:19:52 (UTC) over the next 1 Week there is a 3 % chance of one or more aftershocks that are larger than magnitude 7.1. It is likely that there will be smaller earthquakes over the next 1 Week, with 240 to 410 magnitude 3 or higher aftershocks. Magnitude 3 and above are large enough to be felt near the epicenter. The number of aftershocks will drop off over time, but a large aftershock can increase the numbers again, temporarily.

Summary of Aftershocks
M7.1 Earthquake

The USGS estimates the chance of more aftershocks as follows: Within the next 1 Week until 2019-07-13 15:00:00 (UTC):

- The chance of an earthquake of magnitude 3 or higher is > 99 %, and it is most likely that as few as 240 or as many as 410 such earthquakes may occur in the case that the sequence is re-invigorated by a larger aftershock.
- The chance of an earthquake of magnitude 5 or higher is 96 %, and it is most likely that as few as 0 or as many as 8 such earthquakes may occur.
- The chance of an earthquake of magnitude 6 or higher is 27 %, and it is most likely that as few as 0 or as many as 2 such earthquakes may occur.
- The chance of an earthquake of magnitude 7 or higher is 3 %, such an earthquake is possible but with a low probability.

Summary of Aftershocks
M7.1 Earthquake

The **probability of at least one aftershock** of at least magnitude M within the given time frame. Forecast starting 07/06/2019 15:00:00 UTC [1]

Magnitude	1 Day	1 Week	1 Month	1 Year
M >= 3	> 99%	> 99%	> 99%	> 99%
M >= 5	71%	96%	>99%	>99%
M >= 6	12%	27%	40%	59%
M >= 7	1%	3%	5%	8%

Summary of Aftershocks
M7.1 Earthquake

The likely **number of aftershock** of at least magnitude M within the given time frame. Forecast starting 07/06/2019 15:00:00 UTC [1]

Magnitude	1 Day	1 Week	1 Month	1 Year
M >= 3	91 to 170	57 to 110	94 to 170	690 to 1,200
M >= 5	0 to 4	0 to 8	2 to 11	4 to 6
M >= 6	0 to 2	0 to 2	0 to 3	0 to 4
M >= 7	*	*	0 to 2	0 to 3

* Earthquake possible but with a low probability.

References

1 USGS https://earthquake.usgs.gov/earthquakes/eventpage/ci38443183/oaf/commentary
2Southern California Seismic Network http://www.scsn.org/index.php/2019/07/04/07-04-2019-m6-4-near-searles-valley/index.html

Topic: Hospitals

VERT Phase 1 Response for:
Searles Valley M6.4 & M7.1 Earthquakes

Summary of Hospitals

<u>Ridgecrest Regional Hospital:</u>
July 4, 2019:
- Patients evacuated to be cautious [1]
- 15 patients transferred to other hospitals while engineers repaired broken pipes [1]. At least five were helicoptered out [4]
  - Patients sent to three hospitals (Bakersfield, Lancaster, Palm Field)
- Broken sprinklers at hospital [2]
- **No structural damage to hospital**
- No one was in surgery at the time of the quake. [4]

Summary of Hospitals

<u>Ridgecrest Regional Hospital (RRH):</u>
July 5, 2019
- Due to aftershocks, Ridgecrest Regional Hospital is only providing ER services to locals in need, all other patients have been transferred out of the hospital [4].
- OSHPD inspected hospital and green tagged the hospital. There was a water leak that caused closure of the hospital (reported during EERI Clearinghouse).
- Emergency room remains closed, but emergency department is open for triage walk-in patients [3].
- Hospital is encouraging anyone in active labor to still come to the hospital for delivery. They note that they have OBs and nurses on site and are confidently set-up for natural and c-section delivery [3].
- The following are closed until further notice: Urgent Care; Lab; Radiology; Dental; Rehab; Medical Records / Health Information Management (HIM); OPP (with the exception of patients scheduled for minor procedures and who have been notified) [3].

Summary of Hospitals

<u>Ridgecrest Regional Hospital (RRH):</u>
July 6, 2019
- **RRH suffered more damage in the new impatient tower** [5]
- Hospital is still closed, with the exception of Walk-In Emergencies and Active Labor [5]
- Clinics expected to be open on Monday and full reopening of the hospital this week [5]

July 7, 2019: RRH resumes normal operations (reported during EERI Clearinghouse)

References

1 https://www.latimes.com/local/lanow/la-me-earthquake-california-shake-quake-20190704-story.html
2 https://ktla.com/2019/07/04/ridgecrest-hospital-evacuated-after-magnitude-6-4-earthquake-hits-nearby/
3 https://www.rrh.org/news-updates/2019/july/latest-update-following-yesterday-s-earthquake/
4 http://www.foxla.com/news/local-news/ridgecrest-regional-hospital-evacuated-after-64-earthquake-rattles-california
5 https://www.facebook.com/RidgecrestRegionalHospital/
6 Instagram - @streetmedic72
7 Instagram - @mercy_air

Topic: Other building damage

VERT Phase 1 Response for:
Searles Valley M6.4 & M7.1 Earthquakes

Summary of other building damage
M6.4 Searles Valley Earthquake

- San Bernardino Fire Department reports there are multiple buildings with minor cracks [1]
- House fires reported in Ridgecrest [2]
- Damage to some mobile homes [3,4]

(a) (b)
Red Tagged mobile home (a) Irfan Khan / LA Times [3], and (b) James Quigg / AP [5]

Summary of other building damage
M6.4 Searles Valley Earthquake

- Reports of yellow-tagged mobile home in Ridgecrest that had shifted on its foundation, as well as red-tagged mobile homes in Trousdale Estates, Ridgecrest [3]
- Reports of collapsed fireplace, fallen ceilings, shattered windows in home in Trona [3]
- Ridgecrest home “practically collapse upon itself” [3]
- Damage to Naval Air Weapons Station China Lake [3]

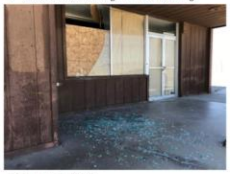
Summary of other building damage
M6.4 Searles Valley Earthquake

- Ceiling tiles and grid non-structural damage


Daily Independent Newspaper office damage [6]
Credit: Jessica Weston (AP)

Summary of other building damage

- Glass facades damage in retail buildings



Mark Hartman / AP [7]

Summary of other building damage
M6.4 Searles Valley Earthquake

Contents on shelves fallen

Adam Graehl / AP [7]

Vons in Lake Isabella, CA [8]
Rex Emerson

Summary of other building damage
M6.4 Searles Valley Earthquake

Displaced books, Ridgecrest Branch Library

Richard Wagner / AP [9]

Richard Wagner / AP [9]

Summary of other building damage
M7.1 Searles Valley Earthquake

CMU wall damage reported in Trona

James Quigg / AP (operational) [6]

Instagram - @eatwithredasmr [10]

Summary of other building damage
M7.1 Searles Valley Earthquake

Searles Valley Minerals - Instagram @teton022 [11]

Instagram [12]

Summary of other building damage
M7.1 Searles Valley Earthquake

Instagram [13]

References

1 https://twitter.com/SBCOUNTYFIRE/status/1146848797189783552
2 https://time.com/5620756/southern-california-earthquake-what-to-know/
3https://www.latimes.com/local/lanow/la-me-earthquakesa-earthquake-50-quake-reported-near-ridgecrest-calif-dpgw-20190705-story.html
4https://www.npr.org/2019/07/04/738791698/a-6-4-magnitude-earthquake-hits-southern-california-rattling-a-large-swath-of-st
5https://www.salemnews.com/news/national_news/california-towns-survey-quake-damage-amid-more-aftershocks/article_ceb2c8c1-d696-5e83-89ca-f3937ee663bf.html
6https://www.deseretnews.com/article/900078424/california-towns-survey-quake-damage-amid-more-aftershocks.html
7https://www.desertsun.com/media/cinematic/gallery/1663470001/photos-71-magnitude-earthquake-damages-structures-sparks-fires-in-southern-california/
8 https://twitter.com/Rex_Emerson/status/1146854374229987328

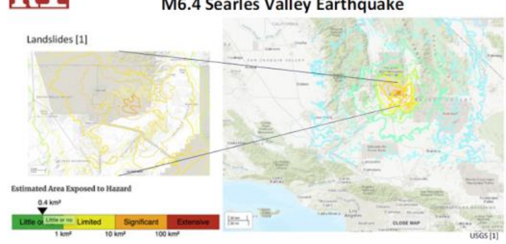
References

9 https://www.facebook.com/ridgecrestbranchlibrary/posts/10156602398037169?__tn__=-R
10 https://www.instagram.com/p/BzmKFSxHVXM/
11 https://www.instagram.com/p/Bzm0VWrgiUn/
12 https://www.instagram.com/p/Bzl4rGznniX/
13 https://www.instagram.com/p/Bzno2pRIOUL/

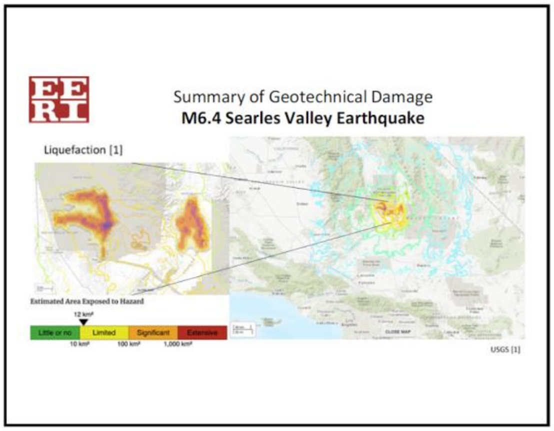
Topic #7: Geotechnical Damage

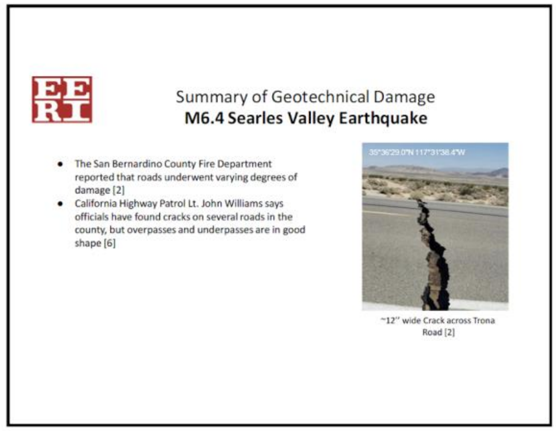
VERT Phase 1 Response for:
Searles Valley M6.4 & M7.1 Earthquakes

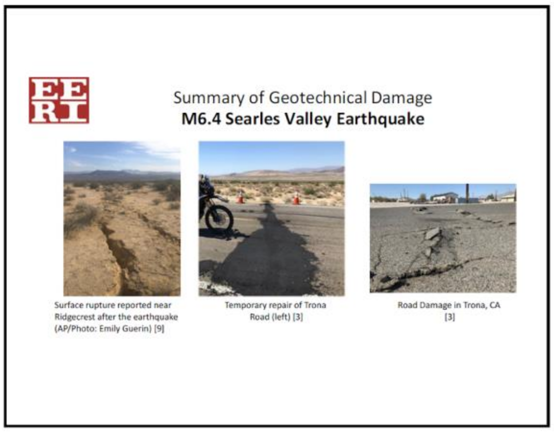
Summary of Geotechnical Damage
M6.4 Searles Valley Earthquake

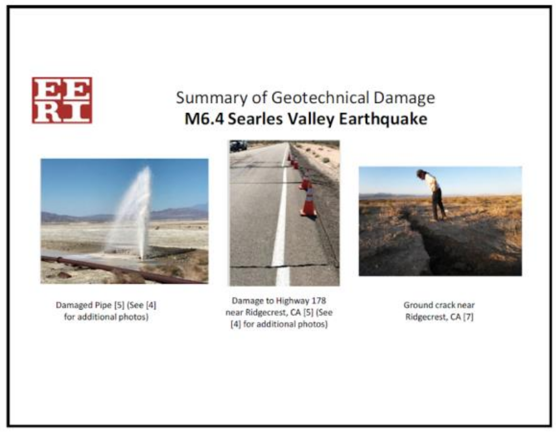


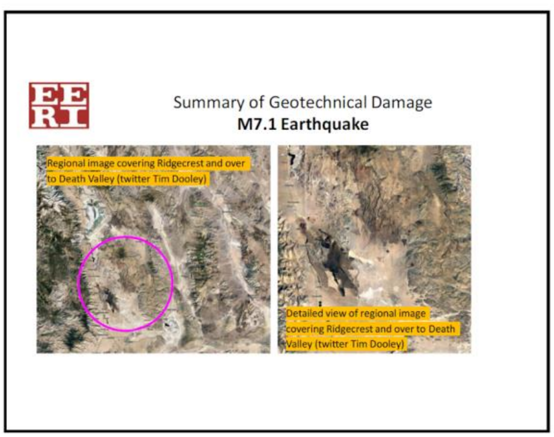
USGS [1]

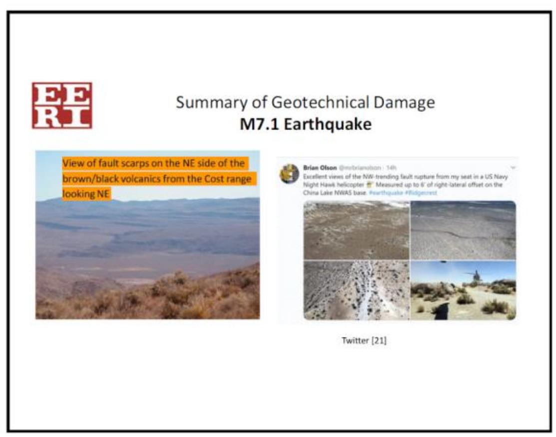

Summary of Geotechnical Damage
M6.4 Searles Valley Earthquake
Liquefaction [1]
Estimated Area Exposed to Hazard
12 km²
Little or no
Limited
Significant
Extensive
10 km²
100 km²
1,000 km²
USGS [1]

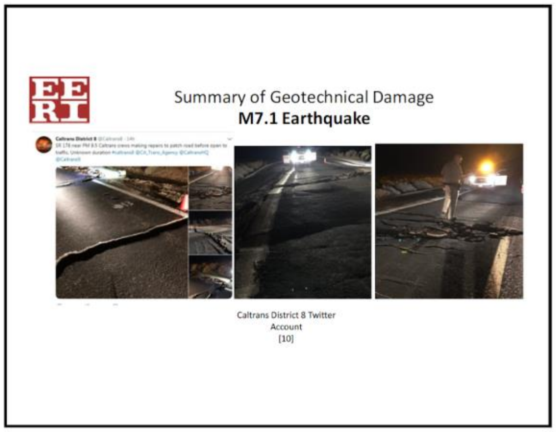

Summary of Geotechnical Damage
M6.4 Searles Valley Earthquake
• The San Bernardino County Fire Department reported that roads underwent varying degrees of damage [2]
• California Highway Patrol Lt. John Williams says officials have found cracks on several roads in the county, but overpasses and underpasses are in good shape [6]
~12'' wide Crack across Trona Road [2]


Summary of Geotechnical Damage
M6.4 Searles Valley Earthquake
Surface rupture reported near Ridgecrest after the earthquake (AP/Photo: Emily Guerin) [9]
Temporary repair of Trona Road (left) [3]
Road Damage in Trona, CA [3]


Summary of Geotechnical Damage
M6.4 Searles Valley Earthquake
Damaged Pipe [5] (See [4] for additional photos)
Damage to Highway 178 near Ridgecrest, CA [5] (See [4] for additional photos)
Ground crack near Ridgecrest, CA [7]

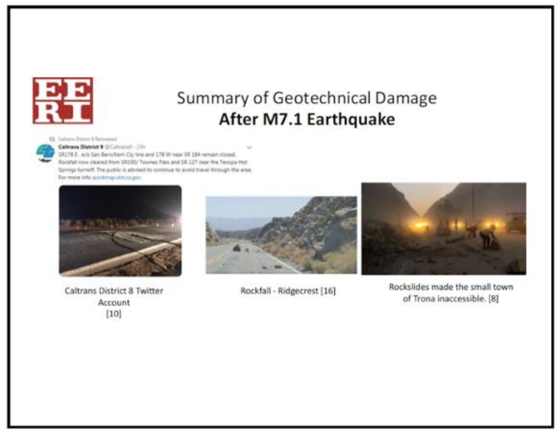

Summary of Geotechnical Damage
M7.1 Earthquake
Regional image covering Ridgecrest and over to Death Valley (twitter Tim Dooley)
Detailed view of regional image covering Ridgecrest and over to Death Valley (twitter Tim Dooley)

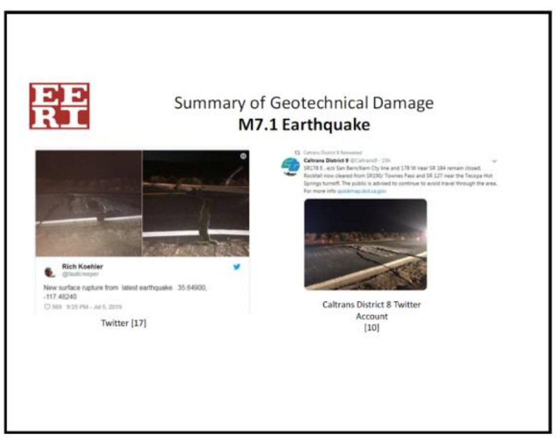

Summary of Geotechnical Damage
M7.1 Earthquake
View of fault scarps on the NE side of the brown/black volcanics from the Cost range looking NE
Brian Olson
Twitter [21]


EERI
Summary of Geotechnical Damage
M7.1 Earthquake
Caltrans District 8 Twitter Account [10]

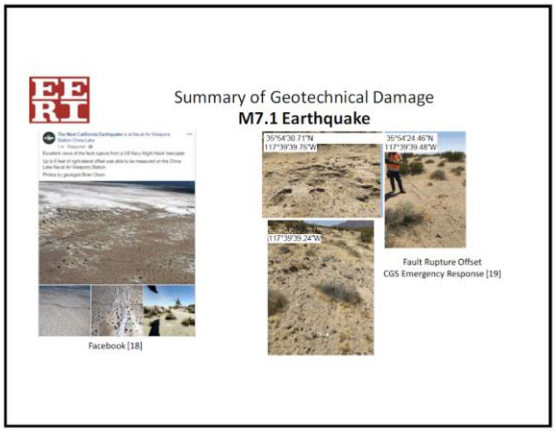

EERI
Summary of Geotechnical Damage
After M7.1 Earthquake
Highway 178 southwest of Trona is closed due to damage. [12]
NBCLA Twitter Account [11]
Caltrans District 8 Twitter Account [10]

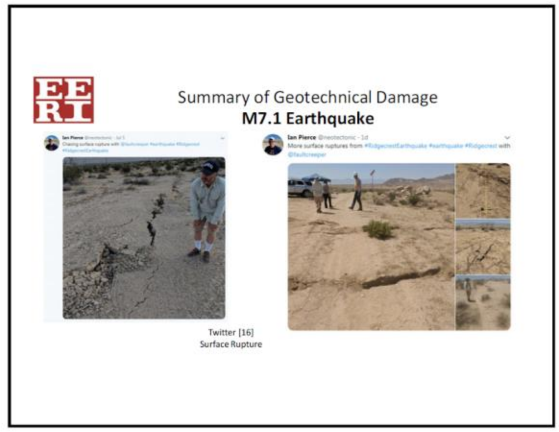

EERI
Summary of Geotechnical Damage
M7.1 Earthquake
Pictures from #Trona show damage. A portion of SR178 has buckled near the railroad track. David Surles who sent the photos says residents are fleeing the area in wake of the 7.1M quake. The entire town lost power again. #RidgecrestEarthquake Stay tuned to @ABC7 #abc7eyewitness
ABC7 Twitter [13]
Bent railroad tracks and damaged road where the fault crossed them. Close to 1 meter (3 feet) of right lateral offset.
Neat Trona pinnacles, Photos by Ian Pierce. [14]
35.5943658, -117.4003630

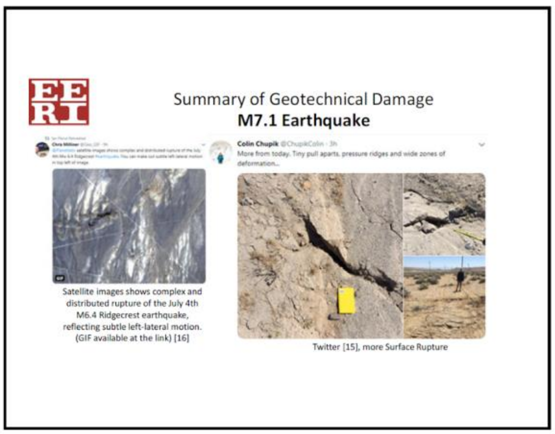

EERI
Summary of Geotechnical Damage
After M7.1 Earthquake
Caltrans District 8 Twitter Account [10]
Rockfall - Ridgecrest [16]
Rockslides made the small town of Trona inaccessible. [8]

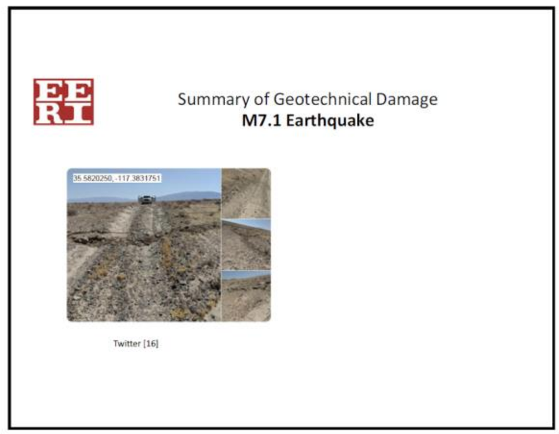

EERI
Summary of Geotechnical Damage
M7.1 Earthquake
Rich Koehler
Twitter [17]
Caltrans District 8 Twitter Account [10]

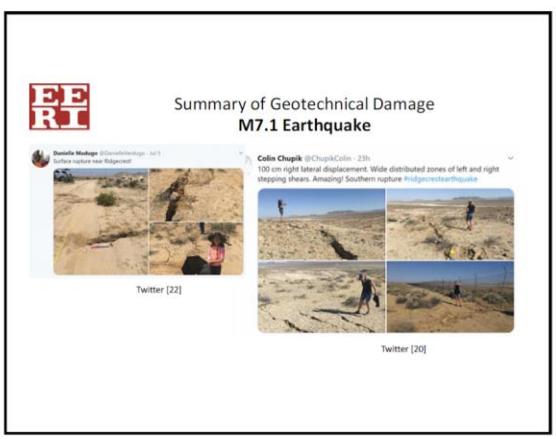

EERI
Summary of Geotechnical Damage
M7.1 Earthquake
Twitter [17], more Surface Rupture
Twitter [16]

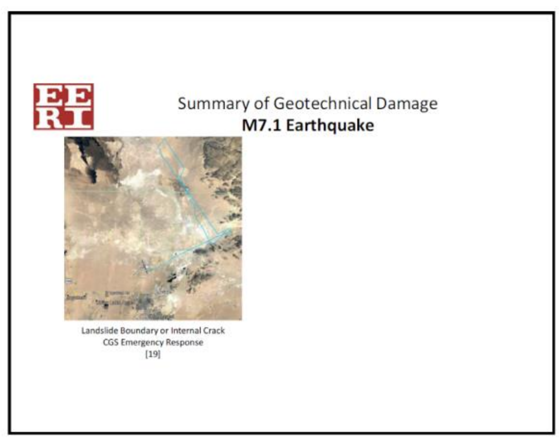

EE RI
Summary of Geotechnical Damage
M7.1 Earthquake
35°54'30.71"N 117°39'39.75"W
35°54'24.46"N 117°39'39.48"W
117°39'39.24"W
Fault Rupture Offset
CGS Emergency Response [19]
Facebook [18]


EE RI
Summary of Geotechnical Damage
M7.1 Earthquake
Ian Pierce
Twitter [16]
Surface Rupture


EE RI
Summary of Geotechnical Damage
M7.1 Earthquake
Colin Chupik
More from today. Tiny pull aparts, pressure ridges and wide zones of deformation...
Satellite images shows complex and distributed rupture of the July 4th M6.4 Ridgecrest earthquake, reflecting subtle left-lateral motion. (GIF available at the link) [16]
Twitter [15], more Surface Rupture


EE RI
Summary of Geotechnical Damage
M7.1 Earthquake
Twitter [16]


EE RI
Summary of Geotechnical Damage
M7.1 Earthquake
Danielle Madugo
Surface rupture near Ridgecrest!
Colin Chupik
100 cm right lateral displacement. Wide distributed zones of left and right stepping shears. Amazing! Southern rupture #ridgecrestearthquake
Twitter [22]
Twitter [20]


EE RI
Summary of Geotechnical Damage
M7.1 Earthquake
Landslide Boundary or Internal Crack
CGS Emergency Response
[19]

Summary of Geotechnical Damage
M7.1 Earthquake

Instagram
[23]

Instagram
[24]

References

1USGS (2019). M6.4 - 12 km SW of Searles Valley, CA. Latest Earthquakes. Ground Failure. https://earthquake.usgs.gov/earthquakes/eventpage/ci38443183/ground-failure/summary
2Heavy News (2019). California Earthquake Today, 6.4 Magnitude: Map & Damage, Jul. 4, 2019. https://heavy.com/news/2019/07/california-earthquake-today-map-damage-magnitude/
3Antczak, J., and Rodriguez, O. R. (2019). "Strongest Earthquake in 20 Years Rattles Southern California." https://www.apnews.com/60fe39042bb64733ab283abab8b228f8
4Shorealone Films. (2019). "Ridgecrest / Trona Earthquake 6.4 , 07-04-19." https://www.flickr.com/photos/81789298@N05/sets/72157709440732412/
5ABC 7 News (2019). "Ridgecrest, California, Earthquake Aftermath: Photos." https://abc7.com/ridgecrest-earthquake-aftermath-photos/5378789/
6 US News https://www.usnews.com/news/us/articles/2019-07-04/the-latest-66-quake-rattles-southern-california-nevada
7 https://www.newsweek.com/california-earthquake-viral-videos-panic-chaos-tremor-aftershock-1447699
8 Los Angeles Times https://www.latimes.com/local/lanow/la-me-trona-earthquake-batters-rockslides-ridgecrest-20190705-story.html
9Next Quake Facebook Page https://www.facebook.com/nextquake/photos/ms.c.eJwlyLkRwEAIBLCObmAfWPpvzIEVCtkTs~;I01374YwSkRDwTcbPKwaVeCDQzpXNx3m4greArTH~_ngBCA.bps./2879438642280432/?type=3&theater

References

[10] https://twitter.com/Caltrans8/status/1147413732772892672/photo/1?ref_src=twsrc%5Etfw%7Ctwcamp%5Etweetembed%7Ctwterm%5E1147413732772892672&ref_url=https%3A%2F%2Fheavy.com%2Fnews%2F2019%2F07%2Ftrona-earthquake-damage-photos%2F
11 https://twitter.com/MekahloNBCLA
12USGS Facebook Page https://www.facebook.com/USGeologicalSurvey/
[13] https://twitter.com/ABC7Leticia/status/1147358633929216005/photo/1?ref_src=twsrc%5Etfw%7Ctwcamp%5Etweetembed%7Ctwterm%5E1147358633929216005&ref_url=https%3A%2F%2Fheavy.com%2Fnews%2F2019%2F07%2Ftrona-earthquake-damage-photos%2F
[14] The Next California Earthquake page in Facebook https://www.facebook.com/nextquake/?__tn__=kC-R&eid=ARC9R2KETgAUELXci3uBI44ZemeRk54oYMZ9ogTXOXh9-rePwhNlp89ZVtN6Dk4CjwCpONHVsssYrB8G&hc_ref=ARTw-TvUg24QfxLanwYTPh7pOvr3rVuH1pgy-P-bpD7z9wgJRmwVtv1oL7NcDyEus0o&__xts__[0]=68.ARDI4kJikMdARwzsFnVmL5tH_PnPcQMsIwtEI-vifcAT9dn7xvwCVNrVP6jaXFb-diEhQps04WA7FB4NewjfWXubO2wT4qJcR0Jb6s82x3uAR1IfXzjyZiAf8g5Td3lkUePlbDAPGo1_vLg_lWa4g-kLKugyW8VnQGD8t_7mzp9i4_cQUzMjOCWrOXxnQAVwpecAkeb_YXV0xokr5aGqTKhFD8dj2hkIiVaty4kY433yZ1exfLQK4dRCi-NTLpNvSeHYNTLcubtyNto93ae0V2GHrrM17X27F9itfYLYJKpjujOlK31wo5aqqifHqX79ib4RZUCR-

References

14 The Next California Earthquake page in Facebook https://www.facebook.com/nextquake/?__tn__=kC-R&eid=ARC9R2KETgAUELXci3uBI44ZemeRk54oYMZ9ogTXOXh9-rePwhNlp89ZVtN6Dk4CjwCpONHVsssYrB8G&hc_ref=ARTw-TvUg24QfxLanwYTPh7pOvr3rVuH1pgy-P-bpD7z9wgJRmwVtv1oL7NcDyEus0o&__xts__[0]=68.ARDI4kJikMdARwzsFnVmL5tH_PnPcQMsIwtEI-vifcAT9dn7xvwCVNrVP6jaXFb-diEhQps04WA7FB4NewjfWXubO2wT4qJcR0Jb6s82x3uAR1IfXzjyZiAf8g5Td3lkUePlbDAPGo1_vLg_lWa4g-kLKugyW8VnQGD8t_7mzp9i4_cQUzMjOCWrOXxnQAVwpecAkeb_YXV0xokr5aGqTKhFD8dj2hkIiVaty4kY433yZ1exfLQK4dRCi-NTLpNvSeHYNTLcubtyNto93ae0V2GHrrM17X27F9itfYLYJKpjujOlK31wo5aqqifHqX79ib4RZUCR-4eiOuQlXMjPs62XzpY5mWz8me2-W69OgnNiUaa5yT4zV8kHe3RbtVCuJqZ82qaZXGCDJdn1fxsd7W86p_DvlkL8feYKV-vvCKiWEJ6FPyqjXnIJtksVfbjnYmuYgaOz_L84hSQE
15 https://twitter.com/ChupikColin/status/1147558794148245504
16 https://twitter.com/neotectonic
17 https://twitter.com/faultcreeper

References

18The Next California Facebook Page https://www.facebook.com/nextquake/?__tn__=kC-R&eid=ARCOpk-NvrkY_dmhns4jKfYX0BEI47uMkH2Qi_G7v1sOn34RPy_lHT8ina-OxOyxHDPxUBIV2uGKPQVc&hc_ref=ARQGIYMMbq7FSd53VOm8H4_pF3NYtauhL6rKxZq3Vp73zEG9On1fbeBnNyo_7qSbQoY&__xts__[0]=68.ARBVKkYasmAlm-MEaoaOfEyy4gOWQZeG8b-OPmMEmoL_SuEF7Enf_0DQhwiQwuRlYr-TN8_cdNUvBp610c7hgqM9Z8vK_Xg8V-58oZe3eefT_VFyibLhyOg01IYsPFX4nwDRAkzXpZ63EoQhLM76z7nARZ6J30uVdNju2XHX6_JiOZ8fhnnY95gwUhlkZ_6sbRTBu3ZbVKbLgPbKaeeWx2UiNehhC6CTwg7gZi90LvyLlyQ1rx7OSMdaxz87ElzHKXKaUSdEEd9PDOdmSu92GCupIWKt3riP0B1cU3BvpeykUlFLwPqdq-buXpzWDRJo3oW5Q2uDc35Hcr5NFS3_l2rBDyuDnPlUVVDjRWohJ5iyKfvOiq-NNhHsO3c
19 http://gmw.conservation.ca.gov
20 https://twitter.com/ChupikColin
21 https://twitter.com/mrbrianolson
22 https://twitter.com/DanielleVerdugo
23 https://www.instagram.com/p/Bzm0g3yg-lX/
24 https://www.instagram.com/p/BziiwfADF0R/

Topic: Lifelines

VERT Phase 1 Response for:
Searles Valley M6.4 & M7.1 Earthquakes

Lifelines
M6.4 Searles Valley Earthquake

Town of Trona: [1]
- Power outage
- Water outage

San Bernardino: [2] & [4]
- Water main break
- Downed power lines were reported, and a massive house fire was captured on cell phone video (possible gas line break).

July 5
Town of Trona: [4]
- Power restored, still no gas and water

Lifelines
M6.4 Searles Valley Earthquake

- Southern California Edison working on power outages throughout Southern CA. Tracking outages through website.

Power outages over the 24 hours [6]

Lifelines
M6.4 Searles Valley Earthquake

Utility pole damage
[5]

Overview & and how it affected various regions
M6.4 Searles Valley Earthquake

Lifeline	Status
Electric power	1,800 people without power in Trona [10] 6,900 outages affecting tens of thousands of people as reported by Southern California Edison (https://www.sce.com/outage-center/check-outage-status)
Gas	5 gas line breaks reported [3]
Water	Water main break in San Bernardino county Water was out in Trona Co.
Telecommunications/Internet	None
Oil	N/A
Airport	No damage to airports
Port	N/A
Public Transit	Metrolink shut down for inspections, resumed normal operation afterwards [11]

Lifelines
After M7.1 Earthquake

- About 3000 people lost power in Ridgecrest after the earthquake, but most of it recovered on July, 6 [7]
- More damage (fires, blazes, gas leaks) than in the previous earthquake, reported by the San Bernardino County Fire [7]
- In Trona, there were intermittent blackouts and disrupted water service. A boiling order was in place [8]
- Local power outage in Encino/Valley Glen affecting around 1000 customers [9]

References

1 https://news.yahoo.com/power-water-trona-following-m6-013754888.html
2https://fox5sandiego.com/2019/07/04/san-bernardino-officials-battling-water-main-breaks-downed-power-lines-and-rock-slides-after-6-4-magnitude-earthquake/
3https://www.mcall.com/news/nation-world/mc-nws-california-earthquake-20190704-h6zvd2ekgjdhvaxgpptqhbb6ty-story.html
4 https://losangeles.cbslocal.com/2019/07/05/the-latest-6-4-magnitude-earthquake-strikes-southern-california/
5https://www.sbsun.com/2019/07/04/6-6-magnitude-earthquake-southwest-of-searles-valley-in-san-bernardino-county-is-felt-throughout-the-southland/
6 https://downdetector.com/status/sce
7BBC News, California earthquake: Power 'restored to most' after 7.1-magnitude quake https://www.bbc.com/news/world-us-canada-48891511
8Washington Post, California had its largest earthquake in years-then an even bigger one hit https://www.washingtonpost.com/nation/2019/07/06/california-earthquake/?utm_term=.615b4cb7e0f4
9 https://twitter.com/LADWP/status/1147357008657448961

References

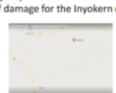
10 https://heavy.com/news/2019/07/california-earthquake-today-map-damage-magnitude/
11 http://www.foxla.com/news/local-news/several-power-outages-reported-following-major-71-quake-in-socal

Topic: Transportation Networks (including roads)

VERT Phase 1 Response for:
Searles Valley M6.4 & M7.1 Earthquakes

Overview of Transportation Networks
M6.4 Earthquake

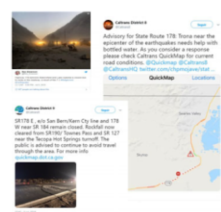
- Crack in road was observed (see photo right), and CalTrans reported that the road was repaired within an hour [1]
- Metrolink trains were temporarily halted [3]
- Large boulders fell onto US395; cleared within an hour [2]
- No damage reported at LAX. Web searches produced no reports of damage for the Inyokern or Trona airports.



Location of earthquake damage on Trona Rd [8]

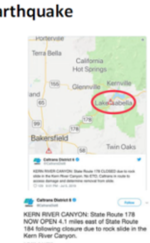
Overview of Transportation Networks
M7.1 Earthquake

- Road closures affecting emergency response - Trona in need of bottled water. Access road from the south is closed [22:19 Jul 5]
- CaLTrans reports KERN river canyon state route 178 closed due to rock slide near lake ISABELLA after the 7.1 earthquake. [4]
- SR178 E , e/o San Bern/Kern Cty line and 178 W near SR 184 remain closed. Rockfall now cleared from SR190/ Townes Pass and SR 127 near the Tecopa Hot Springs turnoff. The public is advised to continue to avoid travel through the area. [23:42 July 5]
- A 5-foot wide fissure was reported in the roadway near Highway 178 and South Richmond Road in Ridgecrest, according to the Kern County Fire Department. [6]



Major road closures
M7.1 Earthquake

The California Transportation Agency said all repairs have been made and all roads are now open - July 6, 7:30 am [9]

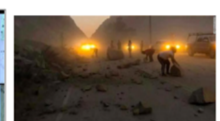


SR 178 closed due to rock slide [7]

SR 178 open [7]

Overview of Transportation Networks
M7.1 Earthquake

Rupture in route 178



SR 178 closed due to rock slide [5]

Earthquake damage on Trona Rd [8]

References

1 https://www.nytimes.com/2019/07/04/us/earthquake-california.html
2https://www.latimes.com/local/lanow/la-me-ridgecrest-earthquake-damage-emergency-20190704-story.html
[3]https://www.sbsun.com/2019/07/04/6-6-magnitude-earthquake-southwest-of-searles-valley-in-san-bernardino-county-is-felt-throughout-the-southland/
[4]https://twitter.com/CaltransDist6?ref_src=twsrc%5Etfw%7Ctwcamp%5Etweetembed%7Ctwterm%5E1147354863606460416&ref_url=https%3A%2F%2Fktla.com%2F2019%2F07%2F05%2Fpowerful-7-1-quake-closes-highway-in-kern-county-scattered-reports-of-damage-in-ridgecrest-region%2F
5 https://edition.cnn.com/2019/07/05/us/california-earthquake/index.html
6https://www.desertsun.com/story/weather/2019/07/05/magnitude-earthquake-felt-palm-springs-area/1662857001/
7 https://twitter.com/CaltransDist6
8https://www.facebook.com/FDIncidentsSB/photos/a.1048903341820083/2368418936535177/?type=3&theater
[9]https://ksby.com/news/2019/07/06/aftershocks-expected-after-fridays-7-1-magnitude-earthquake-damaging-homes-infrastructure-and-injuries

Topic: Business Impacts

VERT Phase 1 Response for:
Searles Valley M6.4 & M7.1 Earthquakes

Summary of Business Impacts
M6.4 Earthquake

- Disneyland rides were temporarily closed for inspection. Rides are back up and running by 3:15 pm on 7/4 [1]
- Walmart in San Bernardino was closed, this was used as a location to hand out water and drinks to those without electricity/AC [2]
- Eastridge Liquor says they lost thousands of dollars of merchandise [2]

Summary of Business Impacts
M6.4 Earthquake

Damage at Eastridge Market Liquor [3]

Thrifty Wash ceiling damage [3]

Stater Brother in Ridgecrest [3]

Summary of Business Impacts
M6.4 Earthquake

Damage at the Ridgecrest library [4]

NBA Summer League postponed in Las Vegas after 6.9 (7.1?) EQ [5]

Summary of Business Impacts
M6.4 Earthquake

Nonstructural damage at McCarran Airport in Vegas [6]

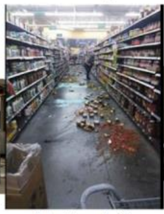
Restaurant Fire at Casa Corona [7]

Summary of Business Impacts
M6.4 Earthquake

Following 6.4 EQ, inspections and assessments were being conducted on Friday and the facility was closed at Naval Air Weapons Station China Lake [8]

Summary of Business Impacts
M7.1 Earthquake

Albertson's grocery in Ridgecrest, July 6
AP Photo/ Marcio Jose Sanchez



Walmart Yucca valley [9]

Bottles and debris on the floor of a liquor store
AP Photo

References

1 https://www.cnn.com/2019/07/04/us/disneyland-rides-closed-after-earthquake-trnd/index.html
2 https://abc7news.com/ridgecrest-earthquake-64-quake-strikes-mojave-desert/5378584/
3 https://www.sbsun.com/2019/07/04/6-6-magnitude-earthquake-southwest-of-searles-valley-in-san-bernardino-county-is-felt-throughout-the-southland/
4 https://www.latimes.com/local/lanow/la-me-earthquakesa-earthquake-50-quake-reported-near-ridgecrest-calif-dpgw-20190705-story.html
5 https://www.espn.com/nba/story/_/id/27129031/vegas-summer-league-postponed-69-quake
6 https://twitter.com/nielslesniewski?ref_src=twsrc%5Egoogle%7Ctwcamp%5Eserp%7Ctwgr%5Eauthor
7 https://www.foxnews.com/us/magnitude-6-9-earthquake-hits-southern-california-1-day-after-largest-in-decades
8 https://www.foxnews.com/us/naval-weapons-base-near-quakes-epicenter-closed-for-safety-inspections
9 https://www.kesq.com/news/photos-food-falls-from-yucca-valley-walmart-shelves-during-powerful-quake/1092584952

Topic: Emergency Response

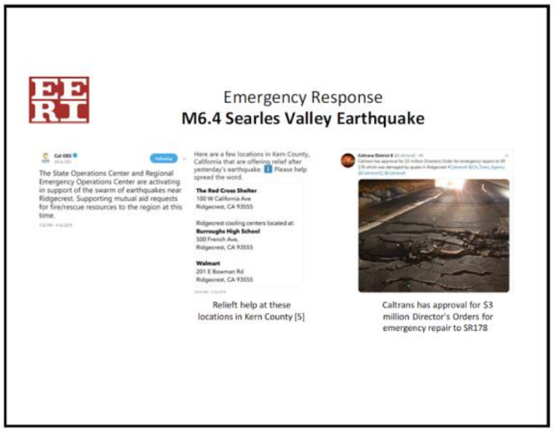
VERT Phase 1 Response for:
Searles Valley M6.4 & M7.1 Earthquakes

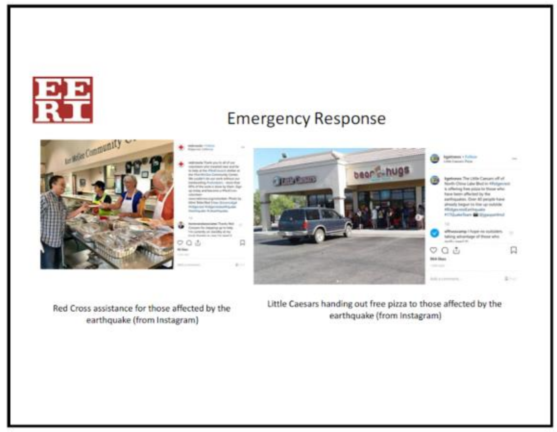
Emergency Response
M6.4 Searles Valley Earthquake

- Governor Newsom issued an emergency proclamation activating both state and region CalOES
- Two emergency shelter locations opened, but only a handful of people arrive [1]
- Most emergency calls were from Ridgecrest [1]
- Firefighters and first responders from surrounding areas came to help out in Kern Co.
- Red Cross opened a shelter at Kerr McGee Community Center [2]
- Along with shelter, the Red Cross is providing warm meals and emotional support [3]
- An evacuation center is being set up by the Red Cross at Burroughs High School [3]
- Police and fire officials say they have enough resources so far to meet needs in the wake of a magnitude 6.4 earthquake that hit Kern County [4]

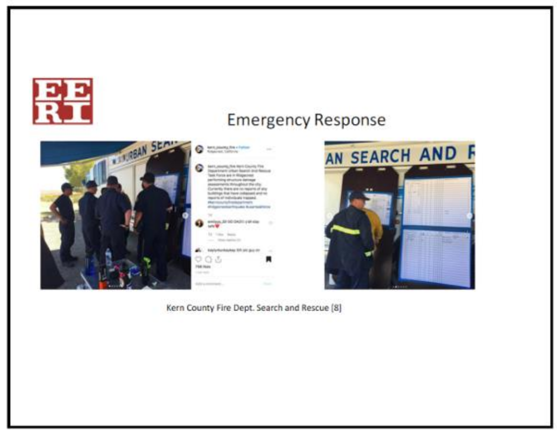
Emergency Response
M6.4 Searles Valley Earthquake

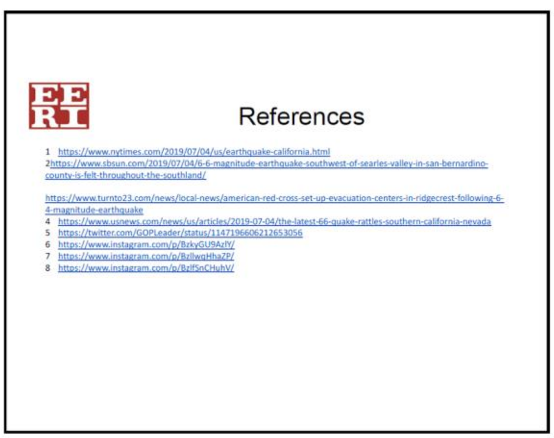
- Kern County Fire Chief David Witt says emergency crews are also dealing with small vegetation fires, cracks on some roads and gas leaks that were reported after the quake [4]
- The Kern County Fire Department says it is sending search and rescue teams to the town of 28,000 people [4]
- Pets had to be evacuated from Socks & Paws Animal Rescue in Ridgecrest. They were evacuated to Marleys Mutts.
- Little Caesars in Ridgecrest was handing out free pizza to those affected by the earthquake


Emergency Response
M6.4 Searles Valley Earthquake
The State Operations Center and Regional Emergency Operations Center are activating in support of the swarm of earthquakes near Ridgecrest. Supporting mutual aid requests for fire/rescue resources to the region at this time.
Here are a few locations in Kern County, California that are offering relief after yesterday's earthquake. Please help spread the word.
The Red Cross Shelter
100 W California Ave
Ridgecrest, CA 93555
Ridgecrest cooling centers located at:
Burroughs High School
500 French Ave,
Ridgecrest, CA 93555
Walmart
201 E Bowman Rd
Ridgecrest, CA 93555
Relieft help at these locations in Kern County [5]
Caltrans has approval for $3 million Director's Orders for emergency repair to SR178

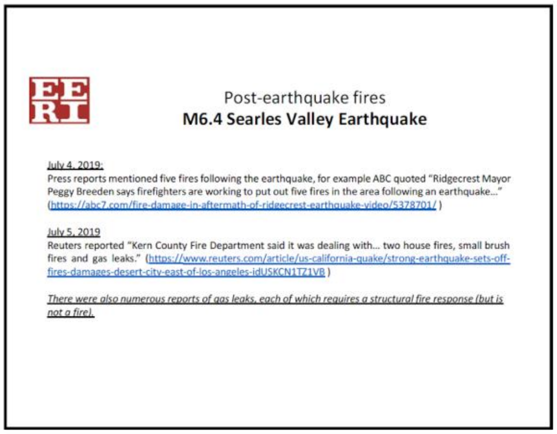

Emergency Response
Red Cross assistance for those affected by the earthquake (from Instagram)
Little Caesars handing out free pizza to those affected by the earthquake (from Instagram)


Emergency Response
Movement of Nurses to Red Cross Sites [6]
Evacuation Response [7]

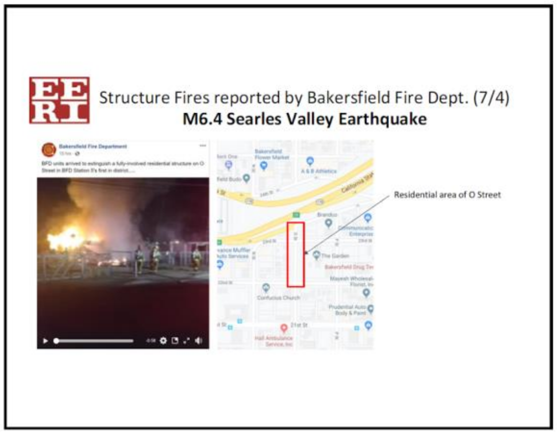

Emergency Response
AN SEARCH AND
Kern County Fire Dept. Search and Rescue [8]

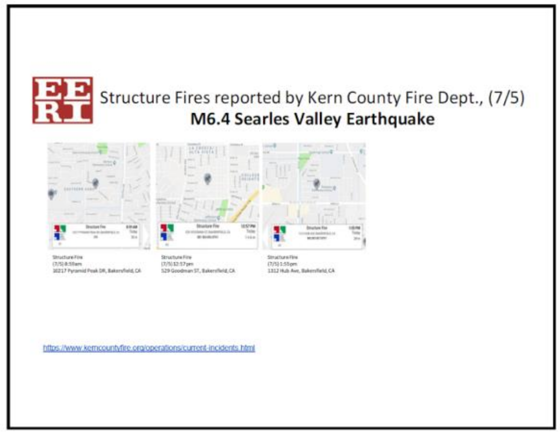

References
1 https://www.nytimes.com/2019/07/04/us/earthquake-california.html
2https://www.sbsun.com/2019/07/04/6-6-magnitude-earthquake-southwest-of-searles-valley-in-san-bernardino-county-is-felt-throughout-the-southland/
https://www.turnto23.com/news/local-news/american-red-cross-set-up-evacuation-centers-in-ridgecrest-following-6-4-magnitude-earthquake
4 https://www.usnews.com/news/us/articles/2019-07-04/the-latest-66-quake-rattles-southern-california-nevada
5 https://twitter.com/GOPLeader/status/1147196606212653056
6 https://www.instagram.com/p/BzkyGU9AzlY/
7 https://www.instagram.com/p/BzllwqHhaZP/
8 https://www.instagram.com/p/BzlfSnCHuhV/

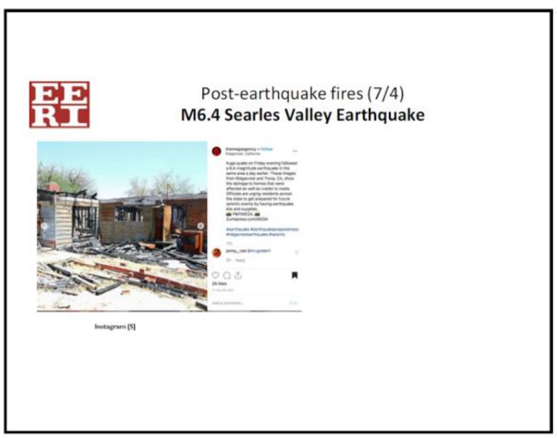

Topic: Post-earthquake fires
VERT Phase 1 Response for:
Searles Valley M6.4 & M7.1 Earthquakes
All locations shown in:
https://drive.google.com/open?id=1sc1MWZbA-H64HLPZYQubBPuB4YRcc4TG&usp=sharing

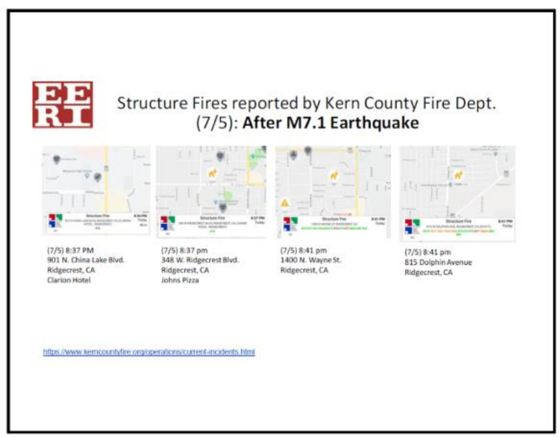

Post-earthquake fires
M6.4 Searles Valley Earthquake
July 4, 2019:
Press reports mentioned five fires following the earthquake, for example ABC quoted "Ridgecrest Mayor Peggy Breeden says firefighters are working to put out five fires in the area following an earthquake..." (https://abc7.com/fire-damage-in-aftermath-of-ridgecrest-earthquake-video/5378701/)
July 5, 2019
Reuters reported "Kern County Fire Department said it was dealing with... two house fires, small brush fires and gas leaks." (https://www.reuters.com/article/us-california-quake/strong-earthquake-sets-off-fires-damages-desert-city-east-of-los-angeles-idUSKCN1TZ1VB)
There were also numerous reports of gas leaks, each of which requires a structural fire response (but is not a fire).

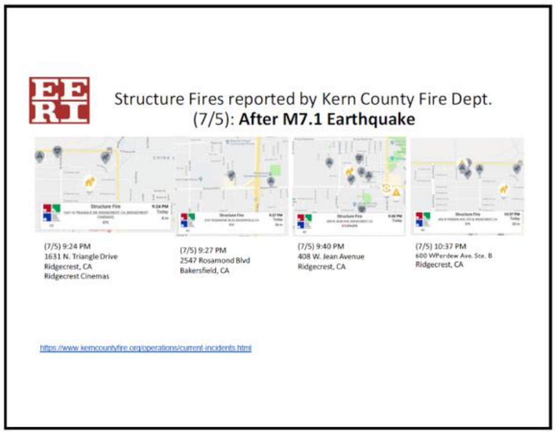

Post-earthquake fires (7/4)
M6.4 Searles Valley Earthquake
Fire in house after earthquake [1]
Fire after an earthquake in Ridgecrest, Calif. [3]
Partial damage to home due to fire [2] in Ridgecrest


Structure Fires reported by Bakersfield Fire Dept. (7/4)
M6.4 Searles Valley Earthquake
Bakersfield Fire Department
Residential area of O Street

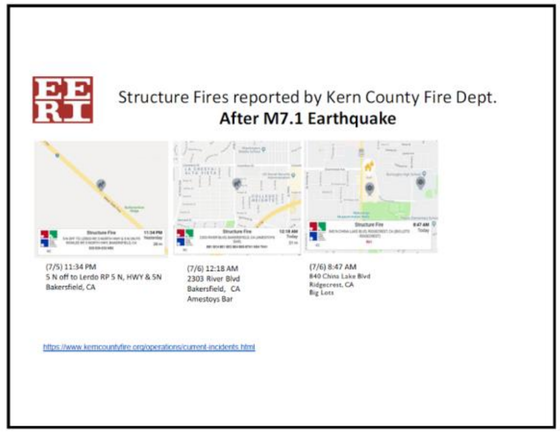

Structure Fires reported by Kern County Fire Dept., (7/5)
M6.4 Searles Valley Earthquake
Structure Fire
(7/5) 8:59am
10217 Pyramid Peak DR, Bakersfield, CA
Structure Fire
(7/5) 12:57pm
529 Goodman ST., Bakersfield, CA
Structure Fire
(7/5) 1:55pm
1312 Hub Ave, Bakersfield, CA
https://www.kerncountyfire.org/operations/current-incidents.html


Post-earthquake fires (7/4)
M6.4 Searles Valley Earthquake
Instagram [5]

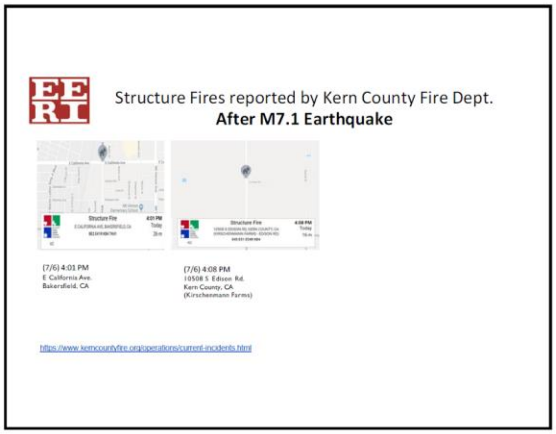

Structure Fires reported by Kern County Fire Dept.
(7/5): After M7.1 Earthquake
(7/5) 8:37 PM
901 N. China Lake Blvd.
Ridgecrest, CA
Clarion Hotel
(7/5) 8:37 pm
348 W. Ridgecrest Blvd.
Ridgecrest, CA
Johns Pizza
(7/5) 8:41 pm
1400 N. Wayne St.
Ridgecrest, CA
(7/5) 8:41 pm
815 Dolphin Avenue
Ridgecrest, CA
https://www.kerncountyfire.org/operations/current-incidents.html



EERI
Structure Fires reported by Kern County Fire Dept.
(7/5): After M7.1 Earthquake
(7/5) 9:24 PM
1631 N. Triangle Drive
Ridgecrest, CA
Ridgecrest Cinemas
(7/5) 9:27 PM
2547 Rosamond Blvd
Bakersfield, CA
(7/5) 9:40 PM
408 W. Jean Avenue
Ridgecrest, CA
(7/5) 10:37 PM
600 WPerdew Ave. Ste. B
Ridgecrest, CA
https://www.kerncountyfire.org/operations/current-incidents.html

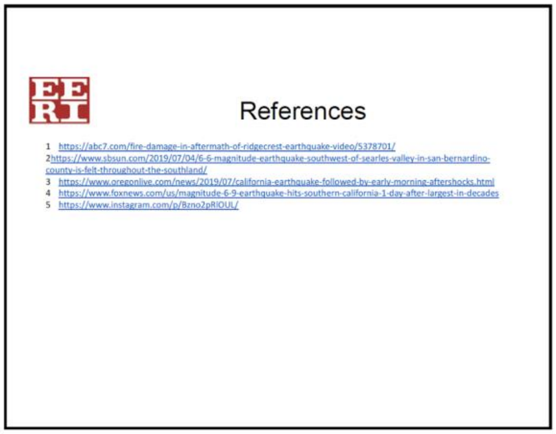


EERI
Structure Fires reported by Kern County Fire Dept.
After M7.1 Earthquake
(7/5) 11:34 PM
5 N off to Lerdo RP 5 N, HWY & 5N
Bakersfield, CA
(7/6) 12:18 AM
2303 River Blvd
Bakersfield, CA
Amestoys Bar
(7/6) 8:47 AM
840 China Lake Blvd
Ridgecrest, CA
Big Lots
https://www.kerncountyfire.org/operations/current-incidents.html



EERI
Structure Fires reported by Kern County Fire Dept.
After M7.1 Earthquake
(7/6) 4:01 PM
E California Ave.
Bakersfield, CA
(7/6) 4:08 PM
10508 S Edison Rd.
Kern County, CA
(Kirschenmann Farms)
https://www.kerncountyfire.org/operations/current-incidents.html

EERI
Structure Fires reported by Bakersfield Fire Dept.
After M7.1 Earthquake
[4] Smoke rises from a fire that broke out behind the Casa Corona restaurant following an earthquake in Ridgecrest, Calif., Friday, July 5, 2019. (Associated Press)
https://www.google.com/maps/place/Casa+Corona/@35.6490994,-117.6723923,467m/data=!3m1!1e3!4m8!1m2!2m1!1scasa+corona!3m4!1s0x0:0xbcc420826052a8bd!8m2!3d35.6471835!4d-117.6700974



EERI
References
1 https://abc7.com/fire-damage-in-aftermath-of-ridgecrest-earthquake-video/5378701/
2https://www.sbsun.com/2019/07/04/6-6-magnitude-earthquake-southwest-of-searles-valley-in-san-bernardino-county-is-felt-throughout-the-southland/
3 https://www.oregonlive.com/news/2019/07/california-earthquake-followed-by-early-morning-aftershocks.html
4 https://www.foxnews.com/us/magnitude-6-9-earthquake-hits-southern-california-1-day-after-largest-in-decades
5 https://www.instagram.com/p/Bzno2pRIOUL/

References

The following sources were consulted in the authorship of this report:

Abrahamson, N. A., Silva, W. J., and Kamai, R. (2014). Summary of the ASK14 Ground Motion Relations for Active Crustal Regions. Earthquake Spectra, 30(3), 1025-1055. doi:10.1193/070913eqs198m

Baker, J. W., and Cornell, C. A. (2008). Vector-valued Intensity Measures Incorporating Spectral Shape For Prediction of Structural Response. Journal of Earthquake Engineering, 12(4), 534-554. doi:10.1080/13632460701673076

Bureau, C. (2018). American Community Survey 2013-2017 5-year Data Release. Retrieved from https://www.census.gov/newsroom/press-kits/2018/acs-5year.html

David M. Boore and Gail M. Atkinson (2008) Ground-Motion Prediction Equations for the Average Horizontal Component of PGA, PGV, and 5%-Damped PSA at Spectral Periods between 0.01 s and 10.0 s. Earthquake Spectra: February 2008, Vol. 24, No. 1, pp. 99-138.

Ross S. Stein, Tiegan Hobbs, Chris Rollins, Geoffrey Ely, Volkan Sevilgen, and Shinji Toda, (2019), Magnitude 7.1 earthquake rips northwest from the M 6.4 just 34 hours later, Temblor, http://doi.org/10.32858/temblor.037

USGS (2019a), Latest Earthquakes M 6.4 - 12km SW of Searles Valley, CA, Last accessed July 7, 2019. https://earthquake.usgs.gov/earthquakes/eventpage/ci38443183/executive

USGS (2019b), Latest Earthquakes M 7.1 - 17km NNE of Ridgecrest, CA, Last accessed July 7, 2019. https://earthquake.usgs.gov/earthquakes/eventpage/ci38457511/executive

Acknowledgements

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StEER team appreciates the collaboration with the Earthquake Engineering Research Institute (EERI) and its Virtual Earthquake Reconnaissance Team (VERT). We thank Professor X. Lu, Tsinghua University, and his research group for the technical assistance on the response spectra shown in Figure 5 of this report. We also thank Professors J. Stewart, UCLA, and his GEER team and F. Zareian, UCI, for sharing their first-hand preliminary field observations.

The discussion about the performance of Bridge Number 50-0340 instrumented by CGS has been shared by Mr. Pat Hibley, Office of Earthquake Engineering, Caltrans. The authors acknowledge Mr. Hibley for his contributions of this discussion and also of Figures 34 to 37.

The sharing of videos, damage reports and briefings via DesignSafe-CI's Slack channel was tremendously helpful and much appreciated. These collaborations and exchanges of critical data in the landfall stages benefited greatly from the work of the DesignSafe CI team who continuously supported and responded to StEER's emerging needs.

About StEER

The National Science Foundation (NSF) awarded a 2-year EAGER grant (CMMI 1841667) to a consortium of universities to form the Structural Extreme Events Reconnaissance (StEER) Network. StEER's mission is to deepen the structural natural hazards engineering (NHE) community's capacity for reliable post-event reconnaissance by: (1) promoting community-driven standards, best practices, and training for RAPID field work; (2) coordinating official event responses in collaboration with other stakeholders and reconnaissance groups; and (3) representing structural engineering within the wider extreme events reconnaissance (EER) consortium in geotechnical engineering (GEER) and social sciences (SSEER) to foster greater potentials for truly interdisciplinary reconnaissance. StEER also works closely with the NSF-supported Natural Hazards Engineering Research Infrastructure (NHERI) RAPID facility and cyberinfrastructure Reconnaissance Portal to more effectively leverage these resources to benefit StEER missions.

StEER relies upon the engagement of the broad NHE community, including creating institutional linkages with dedicated liaisons to existing post-event communities and partnerships with other key stakeholders. While the network currently consists of the three primary nodes located at the University of Notre Dame (Coordinating Node), University of Florida (Atlantic/Gulf Regional Node), and University of California, Berkeley (Pacific Regional Node), StEER aspires to build a network of regional nodes worldwide to enable swift and high quality responses to major disasters globally.

StEER's founding organizational structure includes a governance layer comprised of core leadership with Associate Directors for the two primary hazards as well as cross-cutting areas of Assessment Technologies and Data Standards, led by the following individuals:

- **Tracy Kijewski-Correa (PI),** University of Notre Dame, serves as StEER Director responsible with overseeing the design and operationalization of the network.
- **Khalid Mosalam (co-PI),** University of California, Berkeley, serves as StEER Associate Director for Seismic Hazards, leading StEER's Pacific Regional node and serving as primary liaison to the Earthquake Engineering community.
- **David O. Prevatt (co-PI),** University of Florida, serves as StEER Associate Director for Wind Hazards, leading StEER's Atlantic/Gulf Regional node and serving as primary liaison to the Wind Engineering community.
- **Ian Robertson (co-PI),** University of Hawai'i at Manoa, serves as StEER Associate Director for Assessment Technologies, guiding StEER's development of a robust approach to damage assessment across the hazards.
- **David Roueche (co-PI),** Auburn University, serves as StEER Associate Director for Data Standards, ensuring StEER processes deliver reliable and standardized reconnaissance data.

StEER's response to the 2019 Ridgecrest Earthquakes preceded the formation of its official policies, protocols and membership, which are still in active development. All policies, procedures and protocols described in this report should be considered preliminary and will be refined with community input as part of StEER's operationalization in 2019.

StEER Event Report Library

Lu, X. Gunay, S. Kijewski-Correa, T. Robertson, I. Mosalam, K. Prevatt, D. Roueche, D.(2019-06-22) "StEER - 17 June, 2019 Yibin City, Sichuan, China Earthquake: Event Briefing." DesignSafe-CI. https://doi.org/10.17603/ds2-2117-1565.

Sutley, E. Lequesne, R. Li, J. Kirkham, W. Chen, Z. Al-Sabawy, A. Daniel, L. Enderami, S. Kim, J. Mudaliar, T. Taher, S. Sharma, P. Roueche, D. (2019-06-12) "StEER - 28 MAY 2019 LINWOOD, KS EF4 TORNADO: FIELD ASSESSMENT STRUCTURAL TEAM (FAST) EARLY ACCESS RECONNAISSANCE REPORT (EARR)." DesignSafe-CI. https://doi.org/10.17603/ds2-xz1j-nm14.

Yan, G. Zhang, X. Elgawady, M. Han, D. Li, T. Li, Z. Zhao, Y. Honerkamp, R. Zhao, J. Ramadan, A. Esswein, E. Barner, T. Roueche, D. (2019-06-11) "StEER - 22 May 2019 JEFFERSON CITY, MO TORNADO: FIELD ASSESSMENT STRUCTURAL TEAM 1 (FAST-1) EARLY ACCESS RECONNAISSANCE REPORT (EARR)." DesignSafe-CI. https://doi.org/10.17603/ds2-qa2b-wz63.

Miranda, E., Acosta, A., Ceferino, L., Davalos, H., Galvis, F., Gunay, S., Heresi, P., Macedo, J., Miranda, S., Ramos, J., Rojas, P., Ruiz-Garcia, J., Vera, X., Mosalam, K., Robertson, I., Roueche, D., (2019-06-04) "StEER - 26 MAY 2019 LAGUNA PERU EARTHQUAKE: PRELIMINARY VIRTUAL ASSESSMENT STRUCTURAL TEAM (P-VAST) REPORT." DesignSafe-CI. https://doi.org/10.17603/ds2-cbff-4878.

Gunay, S. Mosalam, K. Kijewski-Correa, T. Prevatt, D. Robertson, I. Roueche, D. (2019-06-04) "StEER - 22/23 April, 2019 Philippines Earthquakes: Event Briefing." DesignSafe-CI. https://doi.org/10.17603/ds2-6my9-yz67.

Roueche, D., Cleary, J., Barnes, R., Davis, B., Marshall, J., Rittelmeyer, B., Smallegan, S., Guo, Y., Hodges, C., Kijewski-Correa, T., Salman, A., Turner, K., Merschman, E., mulchandani, H., Prevatt, D., Robertson, I., Mosalam, K., (2019-06-04) "StEER - 3 March 2019 Tornadoes in the Southeastern US: Field Assessment Structural Team (FAST) Early Access Reconnaissance Report (EARR)." DesignSafe-CI. https://doi.org/10.17603/ds2-qav0-t570.

Roueche, David; Davis, Brett; Hodges, Courtney; Rittelmeyer, Brandon; Turner, Kelly; Kijewski-Correa, Tracy; Prevatt, David; Robertson, Ian; Mosalam, Khalid (2019-01-30) , "StEER - 19 JANUARY 2019 TORNADOES IN THE SOUTHEASTERN US: FIELD ASSESSMENT TEAM EARLY ACCESS RECONNAISSANCE REPORT (EARR)", DesignSafe-CI [publisher], Dataset, doi:10.17603/ds2-eb6e-tr31 [DOI: https://doi.org/10.17603/ds2-eb6e-tr31]

Robertson, Ian; Esteban, Miguel; Stolle, Jacob; Takabatake, Tomoyuki; mulchandani, Harish; Kijewski-Correa, Tracy; Prevatt, David; Roueche, David; Mosalam, Khalid (2019-01-15), "StEER - PALU EARTHQUAKE AND TSUNAMI, SULAWESI, INDONESIA: FIELD ASSESSMENT TEAM 1 (FAT-1) EARLY ACCESS RECONNAISSANCE REPORT (EARR)", DesignSafe-CI [publisher], Dataset, doi:10.17603/DS2JD7T [DOI: https://doi.org/10.17603/DS2JD7T]

Robertson, Ian; Head, Monique; Roueche, David; Wibowo, Hartanto; Kijewski-Correa, Tracy; Mosalam, Khalid; Prevatt, David (2018-12-31), "StEER - SUNDA STRAIT TSUNAMI (INDONESIA): PRELIMINARY VIRTUAL ASSESSMENT TEAM (P-VAT) REPORT" DesignSafe-CI [publisher], Dataset, doi:10.17603/DS2Q98T [DOI: https://doi.org/10.17603/DS2Q98T]

Mosalam, Khalid; Kijewski-Correa, Tracy; Hassan, Wael; Archbold, Jorge; Marshall, Justin; Mavroeidis, George; Muin, Sifat; mulchandani, Harish; Peng, Han; Pretell Ductram, Anthony Renmin; Prevatt, David; Robertson, Ian; Roueche, David (2018-12-06), "StEER - EERI ALASKA EARTHQUAKE: PRELIMINARY VIRTUAL ASSESSMENT TEAM (P-VAT) JOINT REPORT" DesignSafe-CI [publisher], Dataset, doi:10.17603/DS2MQ38 [DOI: https://doi.org/10.17603/DS2MQ38]

Roueche, David; Cleary, John; Gurley, Kurtis; Marshall, Justin; Pinelli, Jean-Paul; Prevatt, David; Smith, Daniel; Alipour, Alice; Angeles, Karen; Davis, Brett; Gonzalez, Camila; Lenjani, Ali; mulchandani, Harish; Musetich, Matthew; Salman, Abdullahi; Kijewski-Correa, Tracy; Robertson, Ian; Mosalam, Khalid, (2018-10-25), "StEER - HURRICANE MICHAEL: FIELD ASSESSMENT TEAM 1 (FAT-1) EARLY ACCESS RECONNAISSANCE REPORT (EARR)" , DesignSafe-CI [publisher], Dataset, doi:10.17603/DS2G41M [DOI: https://ezid.cdlib.org/id/doi:10.17603/DS2G41M]

Alipour, Alice; Aly, Aly Mousaad; Davis, Brett; Gutierrez Soto, Mariantonieta; Kijewski-Correa, Tracy; Lenjani, Ali; Lichty, Benjamin; Miner, Nathan; Roueche, David; Salman, Abdullahi; Smith, Daniel; Sutley, Elaina; Mosalam, Khalid; Prevatt, David; Robertson, Ian, (2018-10-19), "STEER - HURRICANE MICHAEL: PRELIMINARY VIRTUAL ASSESSMENT TEAM (P-VAT) REPORT" , DesignSafe-CI [publisher], Dataset, doi:10.17603/DS2RH71 [DOI: https://ezid.cdlib.org/id/doi:10.17603/DS2RH71]

Hu, Fan; Robertson, Ian; Mosalam, Khalid; Gunay, Selim; Kijewski-Correa, Tracy; Peng, Han; Prevatt, David; Cohen, Jade, (2018-10-11), "StEER - 2018 HAITI EARTHQUAKE: PRELIMINARY VIRTUAL ASSESSMENT TEAM (P-VAT) REPORT" , DesignSafe-CI [publisher], Dataset, doi:10.17603/DS2Z69H [DOI: https://ezid.cdlib.org/id/doi:10.17603/DS2Z69H]

Robertson, Ian; Kijewski-Correa, Tracy; Roueche, David; Prevatt, David, (2018-10-04), "PALU EARTHQUAKE AND TSUNAMI, SUWALESI, INDONESIA PRELIMINARY VIRTUAL ASSESSMENT TEAM (PVAT) REPORT" , DesignSafe-CI [publisher], Dataset, doi:10.17603/DS2XD5S [DOI: https://ezid.cdlib.org/id/doi:10.17603/DS2XD5S]

Barnes, Robert; Lytle, Blake; Rogers, Spencer; Pei, Weichiang; Kijewski-Correa, Tracy; Gonzalez, Camila; u, Fan; Musetich, Matthew; Peng, Han; Prevatt, David; Roueche, David; Salman,Abdullahi; Mosalam, Khalid; Robertson, Ian, (2018-09-25), "HURRICANE FLORENCE: FIELD ASSESSMENT TEAM 1 (FAT-1) EARLY ACCESS RECONNAISSANCE REPORT (EARR)", DesignSafe-CI [publisher], Dataset, doi:10.17603/DS2TT3G [DOI: https://ezid.cdlib.org/id/doi:10.17603/DS2TT3G]