EVENT BRIEFING

Event:	24 January, 2020 Turkey, Mw 6.7 Earthquake
Region:	West Asia
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Key Lessons

- ❏ Maximum PGA during the earthquake was 0.3g, which was recorded 24 km away from the epicenter. There are several towns and villages in the near-fault area which likely experienced higher accelerations.
- ❏ Typical for earthquakes caused by strike slip faults, measured vertical accelerations were lower than the horizontal accelerations.
- ❏ A number of buildings, including reinforced concrete, masonry and adobe collapsed during the earthquake. Collapsed buildings led to fatalities and injuries. This earthquake once again highlighted the fatal consequences of the inadequate seismic design and construction of these types of buildings.
- ❏ All hospitals remained operational after the earthquake. Base isolation of hospitals is mandated by law in Turkey in seismic regions. This earthquake demonstrated the benefits of base isolation on resilience and functionality of communities and need to encourage the use of base isolation and other protective systems in other buildings.
- ❏ There were no major interruptions in electricity, water, gas and telecommunication services, which indicated a good performance in terms of community resilience.

Introduction

On January 24, 2020, at approximately 8:55 pm local time, a magnitude 6.8 earthquake, with a depth of 8.1 km, struck 9 km NNE of Doganyol, Turkey. The earthquake was felt across a large area of Turkey and several neighboring countries including Syria, Armenia and Georgia (USGS, 2020) and led to 72 collapsed buildings and caused varying levels of damage in other buildings. Objectives of this Event Briefing are 1) to provide details of the 24 January Mw 6.8 Sivrice Earthquake, 2) to describe damage to buildings and disruption to the community in terms of fatalities, downtime, and economic losses, and 3) to list key lessons learned.

Hazard Description

On January 24, 2020, at approximately 8:55 pm local time, a magnitude 6.8 earthquake, with a depth of 8.1 km, struck 9 km NNE of Doganyol, Turkey, Fig. 1 (AFAD, 2020a). The epicenter of the earthquake had coordinates of 38.390°N, 39.081°E. The earthquake was followed by 253 aftershocks with magnitudes ranging between 1.8 and 5.4 within the next two days (IU, 2020).

Figure 1. Epicenter of the Mw 6.8 Sivrice, Turkey earthquake from (left) USGS (2020) and (right) AFAD (2020).

According to the focal mechanism solutions, the earthquake originated from the left lateral strike slip Puturge segment of the East Anatolia fault zone illustrated in Figure 2 (IU, 2020), which caused 299 Mw 4.0+ earthquakes since 1900 and 40 known historical events prior to 1900 (AFAD, 2020a). Aftershocks also aligned with the left-lateral plane.

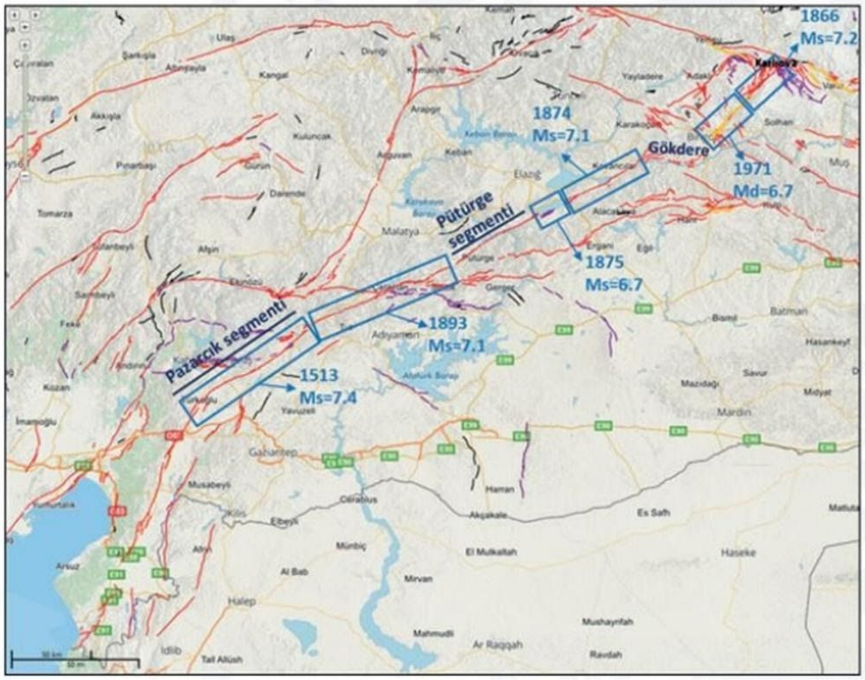

Figure 2. Different segments of the East Anatolia fault zone with significant earthquakes marked on each segment (IU, 2020)

There is a dense array of strong motion recording stations in Turkey (Fig. 3) and ground accelerations were measured in almost all of these stations. PGA (Peak Ground Acceleration) values recorded in five stations closest to the earthquake epicenter are listed in Table 1, where the largest recorded PGA, at 24 km from the epicenter, is 292.8 gals (~0.3g). There are several towns and villages in the near-fault area that likely experienced higher accelerations. The closest city center, Elazig, is 36.5 km away from the epicenter, followed by Malatya and Tunceli with distances of 65.6 and 92.1 km, respectively. Twenty-five buildings collapsed in Malatya, possibly due to any combination of the following: 1) amplification of accelerations beyond the values measured closer to the epicenter, 2) potential forward directivity effects and resulting pulses in ground motions, and 3) lower quality of construction. It is also observed from Table 1 that accelerations are smaller in the vertical direction compared to horizontal accelerations and roughly follow the 2/3 rule.

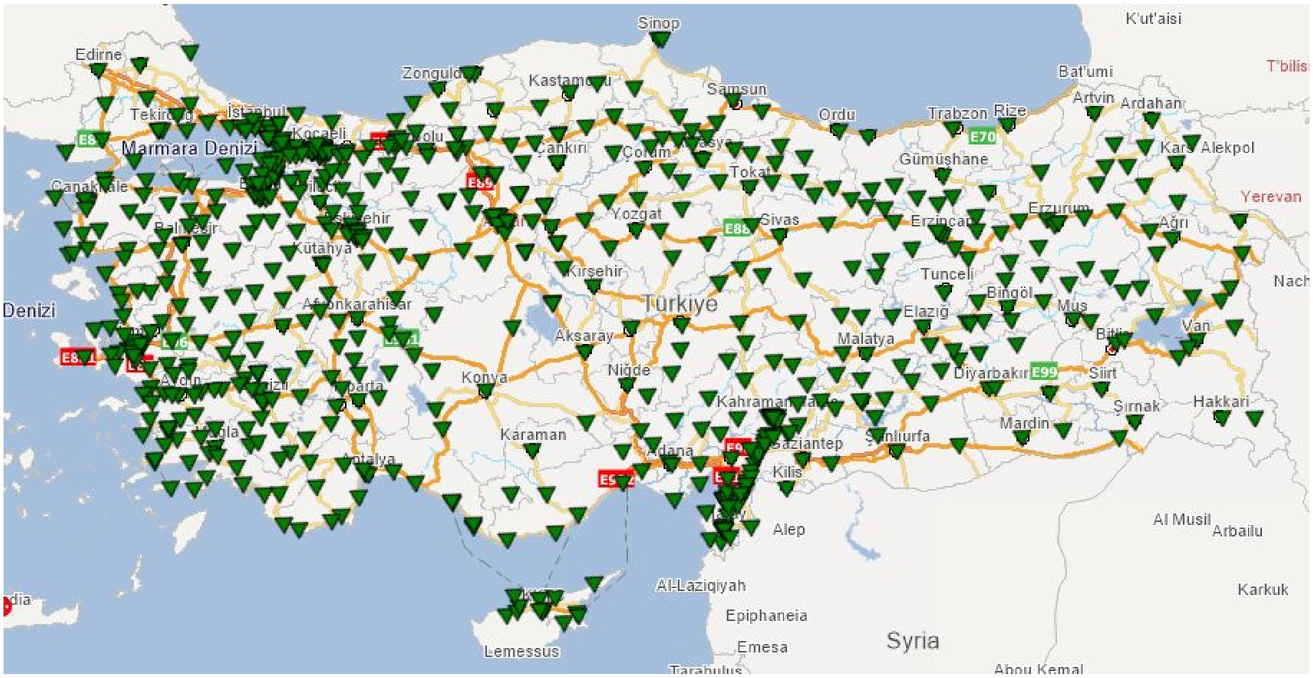

Figure 3. Ground motion stations located in Turkey (AFAD, 2020b.

Table 1. PGA values recorded in stations closest to the epicenter (AFAD, 2020a)

Station			PGA (gal)			Epicentral Distance (km)
Code	**Latitude (N)**	**Longitude (W)**	**NS**	**EW**	**Vertical**	
2308	38.4506	39.3102	238.0	292.8	190.1	24.0
4404	38.1959	38.8738	206.9	239.2	153.9	28.7
0204	38.0290	39.0347	94.0	110.1	60.8	35.1
2301	38.6704	39.1927	119.6	149.8	68.6	38.0
2302	38.3923	39.6754	26.3	34.0	22.8	46.0

The USGS Shake map (Fig. 4) indicates that the PGA is 0.5g roughly 10 km away from the epicenter and 0.2g roughly 35 km away from the epicenter, consistent with the measured accelerations. Maximum intensity estimated by ShakeMap is VIII, while the intensity predicted by the AFAD preliminary damage estimation tool (AFAD-RED) is MMI IX (AFAD, 2020a).

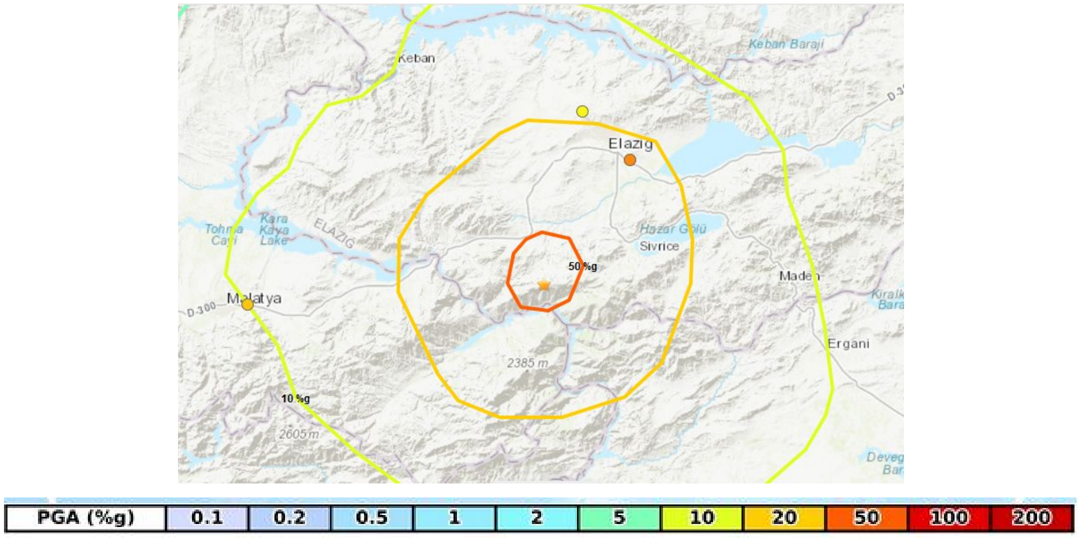

Figure 4. PGA contours estimated from ShakeMap (USGS, 2020).

Damage to Structures

The earthquake led to the collapse of 72 buildings, including reinforced concrete, masonry and adobe construction (Hurriyet, 2020). Collapsed reinforced concrete buildings were low to mid-rise (up to 6 stories), whereas collapsed masonry and adobe buildings were low-rise. Figures 5-7 show photos of three collapsed buildings. Specifically, Figure 5 shows the photo of a 6-story reinforced concrete building in Elazig before the earthquake and the rubble due after the collapse of the building in the earthquake (NTV, 2020). There is no particular plan or elevation irregularity observed from the pre-earthquake photo, except some potential for torsional irregularity. However, information is not available about the structural system, member sizes, reinforcement ratios/detailing, and material characteristics, therefore it is difficult to provide any explanations about the collapse of the building. It is observed from this figure that other buildings around this building are low rise, therefore, there is a chance that the experienced ground motions had larger spectral accelerations at the natural frequency of this collapsed building.

The buildings in Figures 6 and 7 have several surrounding buildings with a similar number of stories and structural systems that remained intact, though experiencing damage; therefore observed collapses could be due to several deficiencies, low construction quality and any damage experienced in a prior earthquake. It is known that there is a very narrow boundary between collapse and survival for non-ductile reinforced concrete buildings, which could potentially explain why only a few of these possibly non-ductile buildings collapsed and others remained standing. However, information is not available about the seismic detailing of these buildings at the time this briefing was authored. Other than the collapsed buildings, there are buildings that experienced varying levels of damage, including severe damage in Doganyol, which is 9 km away from the epicenter.

Figure 5. Collapsed six-story building in Elazig (right) along with a photo of the building before the earthquake (left) (NTV, 2020).

Figure 6. Collapsed reinforced concrete building among a block of buildings in Mustafa Pasa neighborhood of Elazig (Anadolu Agency, 2020).

Figure 7. Collapsed reinforced concrete building in Sursuru neighborhood of Elazig with similar intact buildings around (NTV, 2020).

All hospitals in the epicentral area remained operational after the earthquake (BBC, 2020). Base isolation of hospitals is required by law in Turkey in seismic regions. This earthquake demonstrated the benefits of this practice for resilience and functionality of essential services; it is hoped this encourages the greater adoption of base isolation and other protective systems beyond hospitals.

Resilience Aspects and Effects on Community

USGS PAGER tool estimated the fatalities to be between 1 and 10, between 10 and 100, and between 100 and 1000 with probabilities of 22%, 47%, and 25%, respectively (Fig. 8). There were 29 casualties at the time this briefing was authored, with over 1000 more were injured. Economic loss was expected to be between $1 million and $10 million, between $10 million and $100 million, between $100 million and $1,000 million, and between $1,000 million and $10,000 million with probabilities of 5%, 28%, 43%, and 20%, respectively.

There were no major interruptions to electricity, water, gas, and telecommunication services, which indicated good performance in terms of community resilience. However, rescue operations and building inspections, including school buildings, are still under way and expected to take some time to complete. Therefore, recovery is from this event is expected to follow a short to medium timeline.

StEER Response Strategy

StEER's present response to this earthquake consists of this Event Briefing, compiling information from various websites, news channels and USGS. The briefing does not include detailed field investigations. StEER will continue to engage its Virtual Assessment Structural Team (VAST) to collect and process additional public data relating to this earthquake. StEER is also coordinating with researchers at several universities in Turkey, including Middle East Technical University, Bursa Technical University and Ankara Yildirim Beyazit University who may be conducting preliminary on-site assessments to determine next steps in response to this event. StEER is also monitoring the response of other organizations including GEER, PEER, EERI, SEER, GHI and Build Change, to determine if they may be able to share on-site data for this event. Data from any of these efforts may be used to develop a more detailed report that will augment this preliminary briefing.

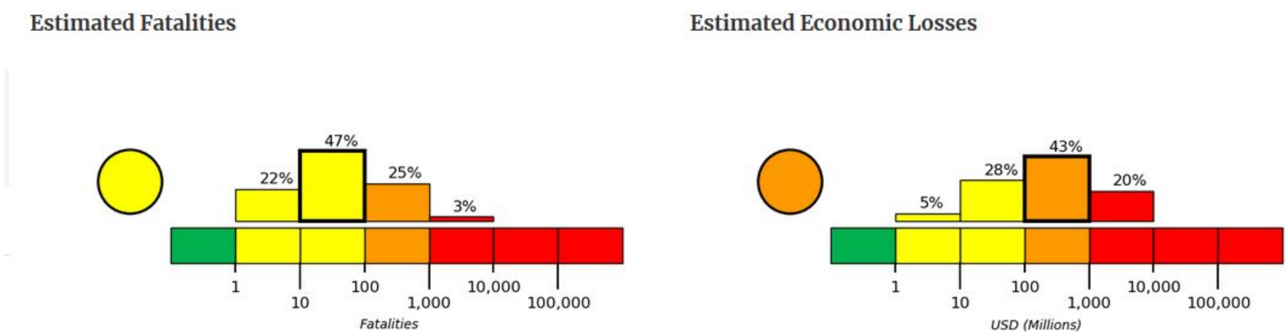

Figure 8. USGS PAGER estimated fatalities (left) and economic losses (right) (USGS, 2020).

References

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