	EVENT BRIEFING	
	Event:	21 Sept., 2019 Albania, Mw 5.6; 24 Sept., 2019 Kashmir, Mw 5.6 and 26 Sept., 2019 Turkey, Mw 5.7 Earthquakes
	Region:	Europe / West Asia
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Key Lessons

- These three earthquakes with similar magnitudes and depths led to different levels of ground shaking in urban and rural areas, particularly due to the epicenter locations, leading to differences in damage and loss consequences.
- **Albania and Kashmir:** Relatively large levels of shaking and the consequent damage were due to the shallow nature of the earthquakes. Similar to several previous earthquakes, this highlights the importance of reporting other factors beyond magnitude to the public, such as the focal depth and ground shaking levels, when describing the level of earthquakes.
- **Albania and Turkey:** schools were closed for several days after the earthquake, including those with only minor damage. Most parents hesitated to send their children back to school. This highlights the importance of schools as a pillar of community resilience and the need to ensure the safety and functionality of schools after small and medium earthquakes through the use of protective systems and other methods.
- **Turkey:** The Disaster and Emergency Management Presidency received calls for 473 potentially damaged buildings, most of which had only very minor damage and cracks. This highlights the gap between the safety interpretation of the public and the earthquake engineering community. This also highlights the need to bridge this gap through better education of the public as well as modification of the code objectives to deliver functionality and elimination of damage rather than the conventional life safety objectives.
- **Turkey:** The broken minaret of a mosque and tilting of a building in Istanbul, potentially due to liquefaction after the Turkey earthquake, demonstrated the effect of far field ground motions and ground motion amplification due to local soil conditions, considering that the distance between the epicenter of the earthquake and these structures was around 70 km.
- **Turkey:** Interruption of cell phone services more than half a day, despite no damage to the telecommunication and power supply infrastructure, highlighted the need to evaluate the capacity of cell phone service providers to meet excessive demands after crises in megacities around the world, such as Tokyo, Beijing, Los Angeles, etc.
- These three moderate earthquakes, while not causing extensive damage, were effective in increasing public awareness about seismic risks in their communities.

Earthquake Details

On September 21, 2019, at approximately 3:04 pm local time, a magnitude 5.6 earthquake, with a depth of 10 km, struck 6 km north of Durres, Albania, as shown in Figure 1a (USGS, 2019a). Epicenter of the earthquake was located in Albania 19 miles west of the capital city Tirana, with coordinates of (41.381°N, 19.454°E). The exact faulting mechanism is unclear, and it is possible that this earthquake occurred due to the Calabrian subduction zone.

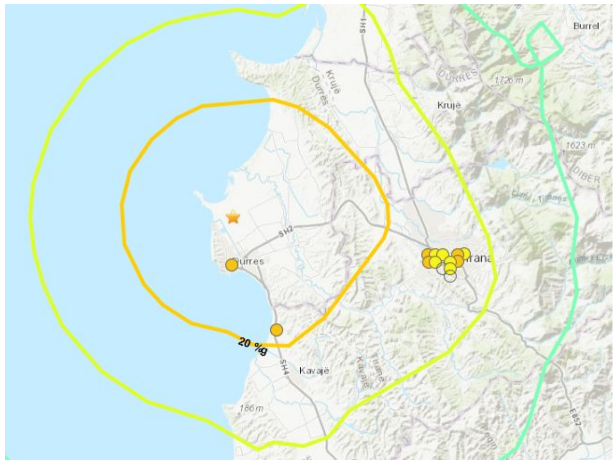
On September 24, 2019, at approximately 4:02 pm local time, a magnitude 5.6 earthquake, with a depth of 10 km, struck 3 km south of New Mirpur, Pakistan, as illustrated in Figure 1b (USGS, 2019b). Epicenter of the earthquake was located 5 km North of Jhelum, Punjab, Pakistan, with coordinates of (33.106°N, 73.766°E). This earthquake likely occurred as the consequence of shallow reverse faulting near the convergent boundary between the India and Eurasia plates. The main fault system is Jhelum Thrust Fault near the epicenter. The nearest fault close to the epicenter is the Dil Jaba thrust fault with the Riwat Fault lying parallel (Government of Pakistan Cabinet Secretariat, 2019).

On September 26, 2019, at approximately 1:59 pm local time, a magnitude 5.7 earthquake, with a depth of 10 km, struck 20 km South of Silivri, Turkey, as depicted by Figure 1c (USGS, 2019c). Epicenter of the earthquake was located in Marmara Sea, 70 km west of Istanbul, Turkey, with coordinates of (40.890°N, 28.173°E). This earthquake occurred on the strike-slip North Anatolian Fault.

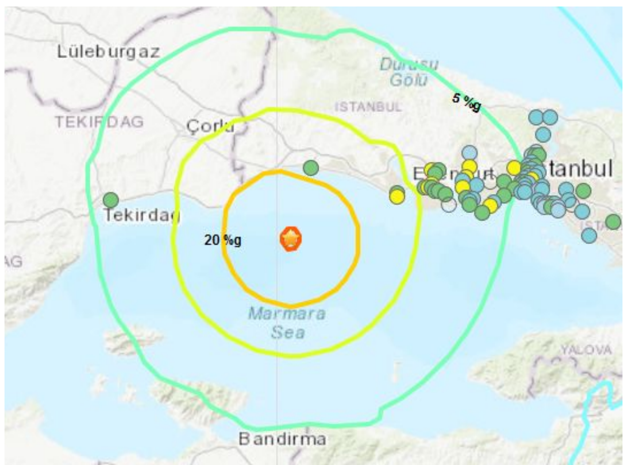
(a) (b) (c)

Figure 1. Epicenter of (a) 9/21 Albania, (b) 9/24 Kashmir, (c) 9/26 Turkey quakes (USGS, 2019)

Although the magnitudes of the three earthquakes were comparable, they differed in the levels of ground shaking. The maximum measured peak ground acceleration in the Turkey earthquake was 0.08g at the Silivri station, which is the closest station to the epicenter (Sucuoglu, 2019). This was somewhat consistent with the accelerations predicted by the ShakeMap in Figure 2b, where the predicted accelerations in Istanbul were between 0.05g and 0.1g. ShakeMaps for Albania and Kashmir earthquakes are shown in Figures 2a and 2c, where the maximum shaking was around 0.2g. This difference was mainly due to the differences of the epicenter locations: in the sea in the case of the Turkey earthquake and inland in the cases of Albania and Kashmir earthquakes. Hazard details of the earthquakes are listed in Table 1.



(a)



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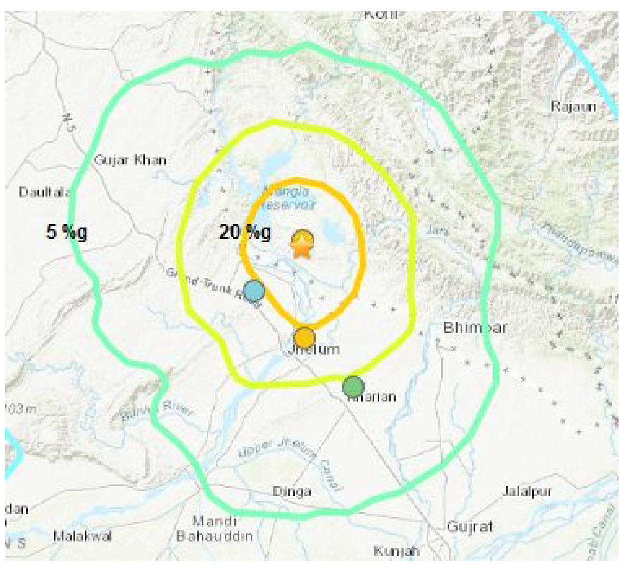

(c)

Figure 2. ShakeMap of (a) 9/21 Albania, (b) 9/24 Kashmir, (c) 9/26 Turkey quakes (USGS, 2019)

Table 1. Hazard details of the earthquakes

Earthquake	Date	Mw	Depth (km)	Fault type	Max. PGA (g)*
Albania	09/21/19	5.6	10	Subduction	0.2
Kashmir	09/24/19	5.6	10	Reverse	0.2
Turkey	09/26/19	5.7	10	Strike-slip	0.08

*For Turkey earthquake, maximum acceleration is based on accelerometer recordings, consistent with ShakeMap accelerations, while the maximum accelerations in Albania and Kashmir earthquakes are based on ShakeMap.

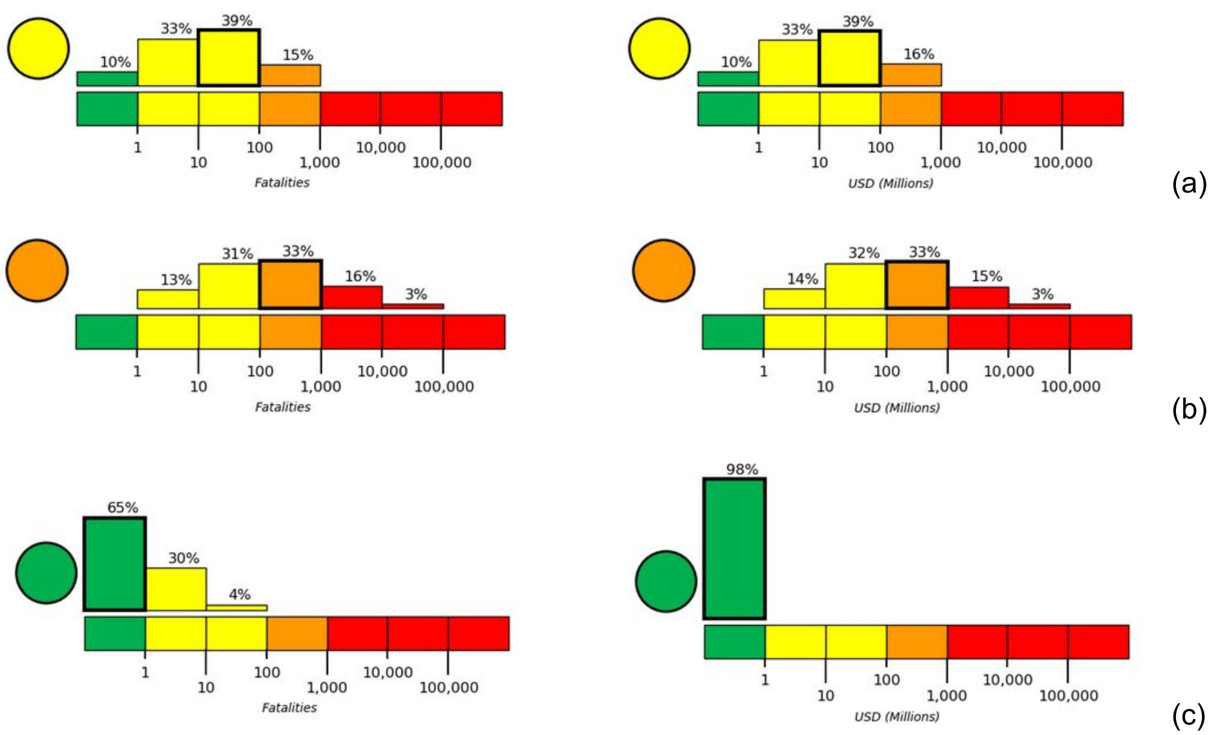

Figure 3. USGS PAGER loss estimates for (a) 9/21 Albania, (b) 9/24 Kashmir, (c) 9/26 Turkey quakes (USGS, 2019) (Left: Estimated Fatalities; Right: Estimated Economic Losses)

For the Albania earthquake, USGS PAGER tool estimated the fatalities to be between 1 and 10, 10 and 100, 100 and 1000, with respective probabilities of 33%, 39%, and 15% (Fig. 3a). No deaths were reported, though there were more than 100 injured. Economic loss and damage were expected to be between $1 and 10 million, between $10 and $100 million, and between $100 and $1000 million with probabilities of 33%, 39%, and 16%, respectively.

For the Kashmir earthquake, USGS PAGER tool estimated the fatalities to be fatalities to be between 1 and 10, 10 and 100, 100 and 1000, with respective probabilities of 13%, 31%, and 33% (Fig. 3b). The actual number of deaths was around 40, with approximately 725 reported injuries.

Economic loss and damage were expected to be between $10 and $100 million, between $100 and $1,000 million, and between $1,000 and $10,000 million with probabilities of 32%, 33%, and 15%, respectively.

For the Turkey earthquake, USGS PAGER tool estimated the fatalities to be fatalities to less than 1, between 1 and 10, between 10 and 100, with respective probabilities of 65%, 30%, and 4% (Fig. 3c). No deaths were reported, and the number of injuries was less than 30. Economic loss and damage were expected to be less than $1 million with a probability of 98%.

Highlights

Kashmir Earthquake

The Kashmir earthquake resulted in a significant amount of damage for a moderate level earthquake. A total of 454 houses were damaged, 135 of which were severe and the remaining light to moderate (National Disaster Management Authority, 2019). Some houses were reported to have collapsed in Mirpur following the earthquake. The reason for these collapses is potentially the aftershocks following the mainshock. This highlights the importance of considering aftershocks for the seismic assessment of existing buildings, especially those that have collapse symptoms, such as unreinforced masonry or non-ductile concrete buildings.

Two bridges were reported damaged and parts of several roads were severely affected (Fig. 4). Pakistan's major water reservoir Mangla Dam located near Mirpur remained safe (the Hindu, 2019). However, the officials indicated that Mangla dam power house has been closed, cutting off 900 MW power supply to the national grid. Upper Jhelum canal was damaged and water inundated various villages. Pakistan-occupied Information Minister indicated that the breach in the Upper Jhelum Canal was fixed due to timely intervention of officials (the Hindu, 2019). Mobile phone towers, and electricity poles in the area were damaged interrupting communications and power supply (the Guardian, 2019).

Figure 4. Damage to roads in Kashmir earthquake

There are two potential reasons for the relatively large extent of damage experienced in a moderate earthquake. The first is the inadequate quality of construction and lack of earthquake resistant design in the damaged houses and bridges. This earthquake occurred in the intensity zone with maximum Peak Ground Acceleration (PGA) in the range of 0.35g (Government of Pakistan Cabinet

Secretariat, 2019). Therefore, if the structures were designed according to the seismic code, they should not have experienced significant damage in this earthquake. The second reason is the shallow nature of the earthquake leading to increased levels of shaking. This highlights the importance of reporting other factors to the public, such as the focal depth, and ground shaking levels (as compared to using only earthquake magnitude) to describe the level of earthquakes.

Albania Earthquake

Although only 5.6 in magnitude, the Albania earthquake was the strongest earthquake in the country in the last 30 years (Japan Times, 2019). In the region of Tirana, 48 houses and three apartment buildings experienced cracks (Fig. 5), while in Durres region, 42 houses and four apartment buildings were damaged, along with 20 buildings damaged in other areas (Euro News, 2019). One apartment building in Durres was heavily damaged (Fig. 6), with a crack running down it from the sixth floor all the way to the ground (Euro News, 2019; AP News, 2019). As shown in Figure 6, Debris falling from the collapsed roof of a building crushed several cars (Euro News, 2019).

In Durres, residents afraid of going back into their homes and apartments, spent days outside of their homes (AP News, 2019). Schools were closed for several days after the earthquake, with 98 schools experiencing damage. Although only two schools were declared unsafe, most parents hesitated to send their children back to school. After small and medium earthquakes, safety and functionality of schools, which are a pillar of community resilience, should be ensured such that students can continue their education without interruption and with full confidence. One way to achieve this is through the increased usage of protective systems in school buildings.

Figure 5. Severely damaged houses in a village near Tirana, Albania quake (AP News, 2019)

Figure 6. Heavily damaged building with a big crack running all along the height (left); Cars crushed by debris fallen from the collapsed roof a building; Albania quake (Euro News, 2019)

Turkey Earthquake

Due to the low level of accelerations in urban areas (< 0.1g), there was not significant damage experienced in the Turkey earthquake. The most significant damage was the broken minaret of a mosque in the Avcilar district of Istanbul, shown in Figure 7 (USA Today). This damage is probably due to some structural deficiency of this minaret, considering the one next to it did not experience any damage (Figure 7). Regardless, this damage demonstrates the effect of far field ground motions and the ground motion amplification due to local soil conditions, considering that the distance between the epicenter of the earthquake and Avcilar is around 70 km.

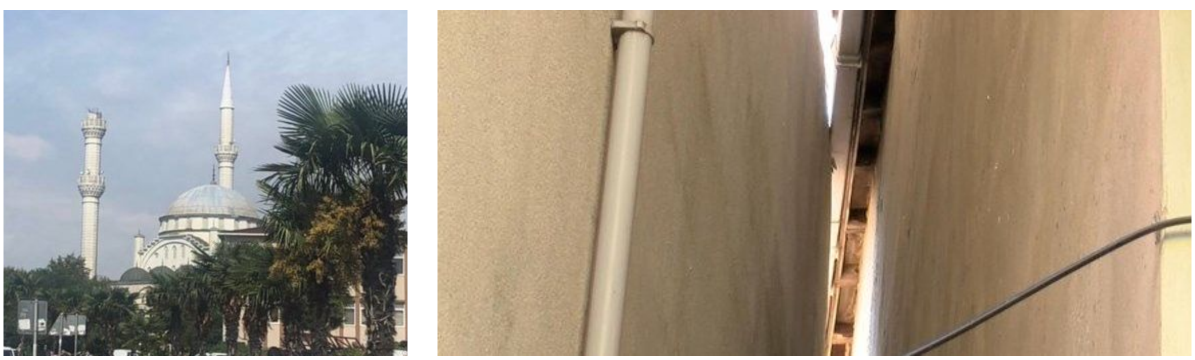

Figure 7. Broken minaret of a mosque in Avcilar, Istanbul (left), building in Istanbul leaning on the adjacent building due to tilting (right) (NTV, 2019a)

Another important case study is a building in Istanbul that tilted and is leaning on an adjacent building (NTV, 2019a), possibly attributed to soil liquefaction underneath the building. This tilting also demonstrates the effect of far field ground motions and the ground motion amplification due to local soil conditions.

The Disaster and Emergency Management Presidency of Turkey received calls for 473 potentially damaged buildings, most of which had only very minor damage and cracks. This highlights the gap between the safety interpretation of the public and the earthquake engineering community including the seismic codes. There is a need to bridge this gap through better education of the public as well as modification of the code objectives to functionality and elimination of damage rather than the conventional life safety objectives. In order to evaluate the condition of these structures, teams of engineers need to inspect these buildings in a short amount of time. In order to use the available resources more efficiently and increase the efficiency and effectiveness of the preliminary post-disaster damage assessment process, tools of Artificial Intelligence (AI), such as automated identification of damage from images (Gao and Mosalam, 2018), can be considered.

Similar to the Albania earthquake, education was interrupted in several schools, including those that had only minor damage (NTV, 2019b). This again demonstrates the need to provide complete school safety and resiliency, potentially through more use of protective systems.

One of the negative consequences of the Turkey earthquake was the interruption of the cell phone services that lasted up to half a day not only near the epicenter of the earthquake, but in the whole country (Haberturk, 2019), although there was not any damage in the power supply or telecommunications infrastructure. The reason for the service interruption was the sudden increase in the calls after the earthquake, particularly in Istanbul, with a population of 15 million. This highlights the need to evaluate the capacity of cell phone service providers to meet excessive demands after crises in megacities around the world, such as Tokyo, Beijing, Los Angeles, etc.

Since the return periods of big earthquakes are generally long, it may be difficult to maintain earthquake awareness until the big earthquake occurs. One of the benefits of the Turkey earthquake was to increase earthquake awareness among the general public without causing big negative consequences. Furthermore, it provided valuable data on the seismic response of various structures from sensors and from visual inspection (Sucuoglu, 2019).

StEER Response Strategy

Objectives of this event briefing were (1) to provide details of the three moderate intensity earthquakes, namely 21 September 2019 Mw 5.6 Albania, 24 September 2019 Mw 5.6 Kashmir, and 26 September 2019 Mw 5.7 Turkey earthquakes, (2) to describe damage to buildings and other infrastructure as well as the disruption to the community in terms of downtime and economic losses, and (3) list key lessons learned. Information provided here is based on various websites, news channels and USGS, therefore does not include detailed field investigations. StEER may continue to engage its Virtual Structural Assessment Team (VAST) to collect and process additional public data relating to these earthquakes. These data may be used to develop a more detailed VAST reports to augment this preliminary briefing. StEER does not anticipate mobilizing any Field Assessment Structural Teams (FAST) in response to these events.

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