StEER STRUCTURAL EXTREME EVENTS RECONNAISSANCE		**EVENT BRIEFING**	
		Event:	26 November, 2019 Albania, Mw 6.4 Earthquake
		Region:	Europe
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Key Lessons

- ❏ The Mw 6.4 earthquake that occurred on 11/26/19 was the second earthquake to hit the region within three months and the strongest to hit Albania in more than 40 years. It is considered the deadliest earthquake in Albania in the past 99 years and the world's deadliest earthquake in 2019.
- ❏ The earthquake caused the collapse and severe damage of reinforced concrete (RC) and masonry buildings; a large number of fatalities and injuries are attributed to the strong shaking, reaching 0.5g PGA, low quality of construction, and presence of buildings with many seismic vulnerabilities.
- ❏ Construction that does not comply with current codes and standards as well as corruption in Albania's burgeoning building industry were mentioned by the authorities as the main reasons for low-quality construction.
- ❏ Photos of damaged RC buildings clearly show the presence of non-ductile features in collapsed RC buildings, such as lack of transverse reinforcement, strong-beam/weak-column proportions, lack of confinement at member ends, and weak/soft stories.
- ❏ Multicell clay blocks, which are not only very brittle, but also afford no option to reinforce or grout, were a noted vulnerability in masonry buildings and infill walls in RC buildings. The use of such brittle material should be outlawed in all earthquake-prone areas, including Albania and other countries around the region.
- ❏ This earthquake once again demonstrated that there can be fatal consequences if the principles of earthquake-resistant design are not followed; unfortunately, the presence of earthquake provisions in building codes are not enough unless they are executed properly.

Introduction

On November 26, 2019, at approximately 3:54 am local time, a magnitude 6.4 earthquake, with a depth of 20 km, struck 12 km WSW of Mamurras, Albania. It was the second earthquake to hit the region within three months and the strongest to hit Albania in more than 40 years. It is considered the earthquake (in terms of casualties) in Albania in the past 99 years and the world's deadliest earthquake in 2019 (Wikipedia, 2019). The objectives of this briefing are: 1) to provide details of the 26 November Mw 6.4 Albania Earthquake, 2) to describe damage to buildings and other infrastructure as well as disruption to the community, in terms of downtime and economic losses, 3) to list key lessons learned, and 4) to demonstrate the use of Natural Language Processing (NLP) for rapidly generating brief reconnaissance reports making use of news and social media.

Hazard Description

On November 26, 2019, at approximately 3:54 am local time, a magnitude 6.4 earthquake, with a depth of 13 miles, struck 8 miles WSW of Mamurras, Albania, as shown in Figure 1 (USGS, 2019). The epicenter of the earthquake was 19 miles northwest of the capital city of Tirana, with coordinates of 41.521°N 19.559°E. There have been more than 500 aftershocks, some with a magnitude of larger than 5.0 (Al Jazeera, 2019).

The earthquake occurred as the result of thrust faulting near the convergent boundary of the African and Eurasia plates, where the two plates converge at a rate of 73 mm/year. USGS focal mechanism solutions indicate reverse slip on a shallow or steeply dipping fault, consistent with the tectonics of the region. Large earthquakes are common in this region and seven Mw 6.0 or larger events have occurred within 150 km of the November 26th earthquake's epicenter over the past 100 years. The largest of these historical earthquakes was an Mw 6.9 on April 15, 1979, 70 km to the north-northeast of the November 26th earthquake epicenter, killing 100 people in Montenegro and 35 in Albania, leaving another 100,000 people homeless. An Mw 6.7 earthquake on November 30, 1967, 80 km to the east of the November 26th earthquake epicenter, resulted in 19 fatalities and significant damage in the surrounding region.

According to the USGS ShakeMap in Figure 2, significant levels of ground shaking, with as large as 0.5g peak ground acceleration (PGA), are estimated (USGS, 2019).

Figure 1. Epicenter of the Mw 6.4 Albania earthquake (USGS, 2019)

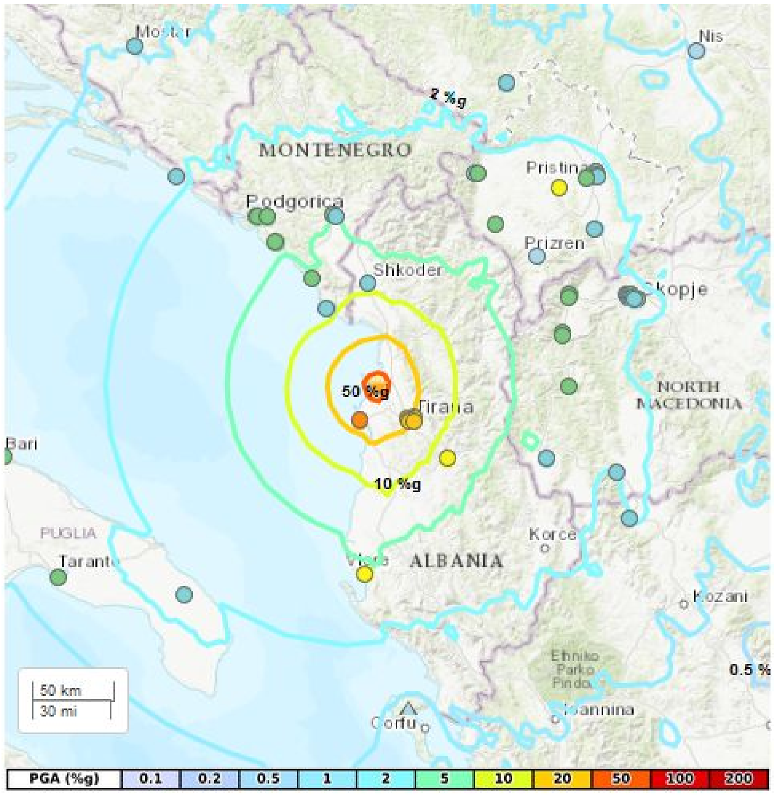

Figure 2. PGA contours estimated from ShakeMap (USGS, 2019)

Damage to Structures

Damage was very severe in the large port city of Durres and the town of Thumane, which are respectively 15 miles SSW and 6 miles E of the epicenter (Wikipedia, 2019). Severe damage and collapses are attributed to the large levels of shaking reaching 0.5g PGA and a number of seismically vulnerable buildings. In fact, construction that does not comply with codes and standards, as well as corruption in Albania's burgeoning building industry, were mentioned as the main reasons for low-quality construction in the affected areas. After the earthquake, a new law has been drafted that will imprison investors, architects and supervisors for 7-15 years for any violation of construction norms (Al Jazeera, 2019). This earthquake once again demonstrated that there can be fatal consequences if the principles of earthquake-resistant design are not followed. Unfortunately, the presence of earthquake provisions in building codes are not enough unless they are executed properly.

Buildings

Albanian Prime Minister Edi Rama indicated that more than 1,465 buildings in Tirana and about 900 in the nearby city Durres had been seriously damaged (Deutsche Welle, 2019). Many reinforced concrete (RC) and masonry buildings experienced collapse and severe damage (Figs. 3-5). Two hotels and two apartment blocks collapsed in Durres. Four buildings, including a five-story apartment block, collapsed in Thumane. At the time this briefing was authored, many people were still trapped in the remains of the ruined buildings (Wikipedia, 2019). An illustration of insufficient detailing from a collapsed RC building is provided by Figure 6: the exposed vertical element shows a lack of transverse reinforcement and failure in a diagonal plane associated with shear damage; the horizontal element in this figure is observed to have adequately anchored transverse reinforcement with only 90-degree hooks in place of the 135-degree seismic hooks necessary for confinement. These and other non-ductile features such as the presence of strong-beam/weak-column proportions, lack of confinement at member ends and connections and weak/soft stories (Fig. 7) potentially contributed to the observed collapses. One of the commonly observed damage types of RC buildings in this earthquake is the In-Plane (IP)/Out-of-Plane (OOP) failures of infill walls (Fig. 8). Fortunately, the damage in these photos was limited to the infill failures and did not result in the formation of weak and soft stories and consequent story collapses. However, infill wall failures may have contributed to other building collapses, similar to those observed during previous earthquakes in Europe (Mosalam and Günay, 2015). Infill wall failures also present a high risk of injury or death due to falling masonry rubble.

Figure 3. Collapsed reinforced concrete buildings (CNN, 2019)

Figure 4. Collapsed masonry building in Thumane with the doorframe standing (CNN, 2019)

Related to the damage in masonry buildings, photos in Figure 5 show the presence of multicell clay blocks. These blocks are not only very brittle but they afford no options for reinforcing or grouting the cells to increase the wall strength and ductility. The use of such brittle material should be outlawed in all earthquake-prone areas, including Albania and other countries around the region.

Figure 5. Heavily damaged multicell clay blocks in masonry buildings and infill walls in RC buildings (Twitter, 2019)

Figure 6. Lack of transverse reinforcement and failure in a diagonal plane associated with shear damage of the vertical element and lack of adequately anchored confining reinforcement in the horizontal element (CNN, 2019)

Figure 7. A soft/weak story collapse observed in Durres (CSEM, 2019)

Figure 8. In-plane (IP) / Out-of-Plane (OOP) failures of infill walls (CSEM, 2019)

Other Infrastructure

Because the earthquake caused significant building damage, collapses and consequent fatalities, almost all of the preliminary information is on buildings. At the time this briefing was authored, there was not much information available related to the damage of other infrastructure, though the photo in Figure 9 shows significant road damage in the capital city Tirana.

Figure 9. Significant road damage in Tirana (CSEM, 2019)

Resilience Aspects and Effects on Community

USGS PAGER tool estimated the fatalities to be between 1 and 10 with a probability of 12%, between 10 and 100 with a probability of 37%, between 100 and 1,000 with a probability of 37% and between 1,000 and 10,000 with a probability of 12% (Fig. 10). At the time this briefing was authored, the number of deaths as a consequence of the earthquake was reported as 51 and there were approximately 2,000 injuries. Damages were expected 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 8%, 25% and 36%, respectively. Furthermore, there were probabilities of 22% and 6% of the economic loss to be between $1,000 million and $10,000 million and between $10,000 million and $100,000 million, respectively.

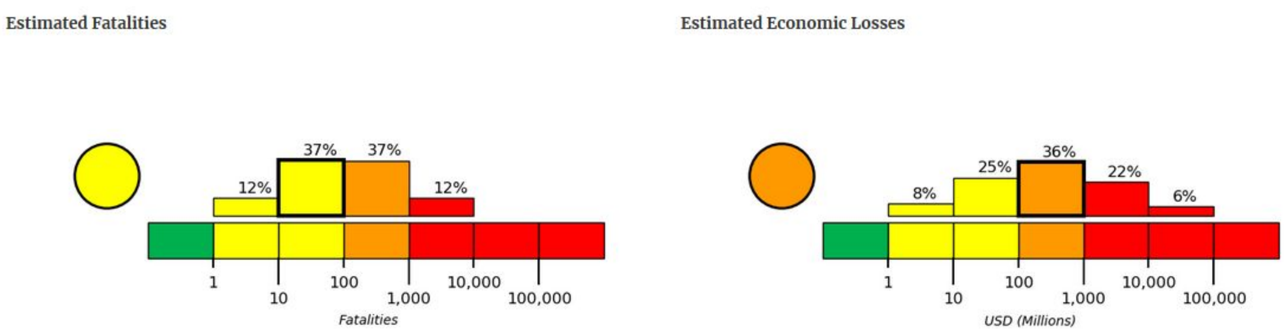

Figure 10. USGS PAGER loss estimates (USGS, 2019)

Given the severity of the situation, Albanian Prime Minister Edi Rama declared a state of emergency in Tirana and Durres during December. Recovery efforts are currently continuing in the rubble of collapsed buildings, where residents and emergency crews in cities across the country rescued 45 people from some of the collapsed buildings. Considering the state of emergency and current situation, the recovery and reconstruction process after this earthquake is likely to be lengthy.

The earthquake left around 4,000 people homeless (Al Jazeera, 2019). Similar to many previous earthquakes, even the residents of houses and buildings that were still standing, which performed well, remained outside after the earthquake. One of the residents in the capital Tirana indicated he did not know where he would live and described his apartment as “uninhabitable.” An estimated 2,500 people have been displaced by the earthquake and are temporarily being sheltered either in the Niko Dovana Stadium of Durres in tents or in hotels (Wikipedia, 2019).

Natural Language Processing: StEER Pilot for Proof-of-Concept

Natural language processing (NLP) is a subfield of linguistics, computer science, and artificial intelligence concerned with the interactions between computers and human (natural) languages, with the objective of processing and analyzing large amounts of natural language data. In the context of reconnaissance for earthquakes and other natural hazards, it is used here as a tool to automatically generate summaries of information from news websites. The steps followed in this process are as follows: 1) collect text from different news sites related to the earthquake (using the Nexis Uni database, 2019), 2) compile this information in a csv file as input, 3) run the NLP algorithm as a Python code, and 4) generate a summary of all the information (a process referred to as summarization). In the summarization, the text is converted to a matrix and the summary text is converted to another matrix that is a transformation of the original matrix. The summarization algorithm aims at minimizing the norm of the difference of the matrices that correspond to the original and summary texts. The summary text is defined as a percentage of the complete text, with a 20% summary used for this earthquake briefing.

This pilot by StEER demonstrated that NLP has great potential to initiate reconnaissance reports in a rapid manner. It not only decreases the time to generate a report, but also increases the accuracy and abundance of information by facilitating access to many identified resources that can be missed in conventional manual report preparation. Future StEER briefings are expected to encourage the use of NLP to improve the efficiency of briefing generation.

StEER Response Strategy

StEER’s present response to this earthquake is constituted by this Event Briefing, compiling information from various websites, news channels and USGS, therefore it does not include detailed field investigations. At present, StEER will not form a Virtual Assessment Structural Team (VAST) or formal Field Assessment Structural Team (FAST) in response to this event, but is in communication with teams deploying from the University of Bristol and the Hellenic Association for Earthquake Engineering. StEER anticipates engaging a Virtual Assessment Structural Team (VAST) to assist in processing and disseminating the information collected by these teams. StEER is also exchanging information with other organizations including GEER, PEER, EERI, SEER, GHI, Build Change, to determine how best to collect on-site data for this and future events.

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