1. Introduction

1.1. Purpose of Report

This report documents the observations I made while conducting reconnaissance investigations in Durrës following the M6.4 Albania earthquake that occurred on November 26, 2019 (USGS link). My observations were made during walking surveys on November 27th and 28th.

1.2. Links to Photo Album, Map, and Google Earth aerial images

Photos from the two days of my survey can be found in this photo album. They are grouped thematically into the following sections:

(1) Common building types and their damage;
(2) Specific types of damage (e.g. collapse, pounding, etc);
(3) Examples of buildings without observed damage from exterior;
(4) Special use/landmark buildings, such as hospitals, schools, and historic sites;
(5) Emergency shelters and operations;
(6) Buildings under construction & materials;
(7) Miscellaneous

Select photos have been uploaded to Google My Maps, where you can see the locations where the photos were taken. You can view that map here.

Using Google Earth, I put together a few comparisons of the shoreline at Durres between 2002 (first aerial image available) and 2019. See this folder to access the full resolution PDFs of these images.

1.3. Background

At the time of the M6.4 earthquake, I was traveling as a tourist in Ohrid, a town in North Macedonia close to the border with Albania. Sticking to my planned travel schedule, I went to Tirana, Albania on the morning of November 26th, arriving there about ten hours after the main shock. My bus drove through the edge of Durrës, where I observed minor damage from the bus window. I spent the rest of the 26th in downtown Tirana as a tourist, where I did not observe any damage.

I reviewed translated news reports and social media on the evening of November 26th to guide my walking survey of Durrës on November 27th. I was able to identify the location of a couple damaged landmarks, but
unable to identify the exact location of most damaged buildings in the reports. I spent November 27th walking around downtown Durrës to get a sense of the scope and types of damage.

By my visit on November 28th, I had connected with EERI’s Virtual Earthquake Reconnaissance Team (VERT), members of the Learning From Earthquakes (LFE) committee, and staff at the Applied Technology Council (ATC). At the request of individuals in or affiliated with those communities, I spent November 28th investigating possible geotechnical effects, precast buildings, hospitals, and schools. I also attempted to locate the strong motion sensor in downtown Durres, but ultimately did not succeed in locating it.

Dr. Brisid Isufi, a postdoctoral researcher from Albania who is currently at the Universidade NOVA de Lisboa, provided crucial background information that I reference in this report.

I am a structural engineer trained in California.

Figure: Albania map with key locations highlighted. Source: The Guardian (Link)

1.4. Scope of Survey & Limitations of this Report

My observations are limited to downtown Durres and the area along the shore to the southeast of downtown. The map of my geotagged photos gives a sense of the geographical extent of my survey. Due to the lack of detailed information available at the start of my survey, I focused on covering as much territory as possible with the goal of gaining a sense of the scope and types of damage. I did not walk every street...
within this area, nor was I able to visually observe every structure. I did not conduct in depth investigations into any buildings.

I conducted these surveys on my own. For safety, I did not enter buildings with observable damage. Thus, observations are limited to what could be seen easily from the exterior of the buildings. Structural and nonstructural damage visible from the interior are outside the scope of this report.

This report is based on my personal observations. It is not an attempt to summarize all effects of the earthquake. In the interest of completing this report rapidly, I have not attempted to integrate all of the findings of the VERT team or others who have on-the-ground knowledge of conditions. My observations should be reviewed in the context of those other reports.

In several parts of this report, I comment that I did not observe damage of a particular type. I offer this information, because I understand that it can be useful. However, my lack of observations in a certain area should not be interpreted to mean that no damage of this type occurred within the geographical extent of my survey (or outside of it).

I do not speak Albanian, and I did not have a translator. Thus, my communication with residents was limited.

Figure: Map of Durres with photos marking the extents of my survey. (Link)
2. **Building Performance**

2.1. **Summary**

This section summarizes the patterns I observed in damaged buildings and well-performing buildings. Individual cases are described when their behavior was unique or catastrophic. For more photos, see the [photo album](#).

2.2. **Observed Damage Patterns**

2.2.1. **Cracking and falling of hollow clay tile nonstructural walls**

In my survey, the most common damage pattern I observed was shear “X” cracking and out-of-plane failure of hollow clay tile nonstructural walls. This type of damage was especially common in taller (8 to 12 story) buildings, but it was also exhibited in shorter (2 to 7 story) buildings. In my survey, I documented around 45 buildings with this type of damage observable from the exterior.

The gravity system for these buildings consists of reinforced concrete frames. Based on my limited understanding of local design practice, concrete shear walls are commonly used to resist lateral loads in this type of building. However, it is possible that some buildings rely on reinforced concrete frames for lateral resistance instead of, or in addition to, shear walls. Based on my observations of buildings under construction, the shear walls (where present) are typically placed towards the interior of the building, rather than at the exterior.

My access to the interior of damaged buildings was extremely limited, so I am unable to comment on the condition of the gravity or lateral systems in these buildings. In the few locations where I was able to visually observe the reinforced concrete elements, I did not observe structural damage. I did not visually observe the condition of any shear walls. Though we do not have any evidence of structural damage, we also cannot conclude that none occurred. It is important for us to gather information about any possible degradation of the gravity and lateral systems in these buildings, because the existence of structural failures would have even further implications on the seismic deficiencies of this type of building.

This type of building has been built in Albania since 1990, and many of the buildings were built in the last few years. Code enforcement in design and construction was limited during the period in which many of these buildings were constructed. It is a common building type in Albania.

These buildings are typically used as apartments. In most cases, the first story is used as a commercial space, with storefront windows and other large openings at the exterior instead of hollow clay tile walls typical to the floors above. In some cases, the second floor also has a high percentage of glazing. In the buildings where hollow clay tile walls failed, I observed very few cases of glass breaking on these lower floors. I found this to be noteworthy, because it indicates that the glazing was able to accommodate the interstory drift on lower, more flexible stories, but the hollow clay walls on the higher, stiffer floors were not able.
In the buildings I observed, hollow clay tile walls are used in the following ways:

1. to infill reinforced concrete frames at the building exterior (or interior).
2. to construct exterior nonstructural walls at the perimeter of the building, where the exterior wall is in a different plane from the RC frame.
3. to construct interior partitions (nonstructural walls).

I observed examples of in-plane and out-of-plane failures in each of these conditions. Out-of-plane failure is especially dangerous, as it creates a falling hazard when chunks of the wall fall into or out of the building. In-plane failure can cause crushing and spalling of blocks, which is capable of injuring people. In-plane failure makes out-of-plane failure more likely, because the cracking and spalling reduces the out-of-plane integrity of the wall.

The dimensions of the hollow clay tiles vary, though 6 to 8 inch (15 to 20 cm) thick blocks were common in my spot checks. In almost all cases I observed, the walls were one wythe thick, but in at least two damaged buildings, the wall consisted of two wythes of thinner tiles sandwiched around a layer of insulation. In that case, I would estimate the blocks are about 4 inches wide (11 cm). In most cases, the holes in the hollow clay tiles are aligned in the horizontal direction. Typically, there was a thick layer of mortar at the bed (horizontal) joints, but little or no mortar visible at the head (vertical) joints. All walls I observed were unreinforced and installed without any anchorage to structural elements. Most walls have stucco at the exterior and plaster on the interior.

Seismic-resistant nonstructural walls are designed to resist the in-plane and out-of-plane seismic loads associated with their own self-weight and deliver them into the structural system. They are also isolated from the structure so that they are able to accommodate story drifts and so that they do not unintentionally carry seismic load for any other part of the building. Where the nonstructural walls failed, it is unlikely that they were properly designed for seismic resistance.

Where hollow clay tile walls are used as infill for reinforced concrete frames, a seismic-resistant system requires either detailing the system to develop composite behavior between the frame and infill, or it requires creating seismic gaps between the frame and infill to prevent the infill from unintentionally engaging as the frame deforms under seismic loading. Based on my observations, the damaged infills were not isolated from the frames, and it is highly unlikely that the infill was designed to have composite behavior with the frame. The hollow clay tile walls had a brittle and weak response, suggesting that the infill was unable to accommodate the deformation of the frame.

In some cases, the blocks themselves broke apart or shattered. In other cases, the adjacent blocks pulled apart from each other, creating a diagonal crack in the wall along the joints. Once the walls were weakened in-plane and the “X” cracks formed, out-of-plane failure became more likely.

The emergency wing of Durres Regional Hospital, an essential facility, is a two-story building that exhibited shear damage of this type, though to the best of my knowledge there were no out-of-plane failures. Please see section 2.4.1 for more information about that building.

The next pages profile a few buildings with this type of damage. More photos of this type of damage are available Section (1a) of the photo album. A layer of the map is devoted to this type of damage, so you can isolate the locations where this failure was observed by turning off the other map layers.
As these walls were installed in many stairwells, I observed some locations where the wall fell into the stairwell. It is likely that the failure of these walls impeded the ability of people to evacuate the buildings.

In some buildings, hollow clay tiles failure occurred at the corners of buildings, where the nonstructural walls intersected with one another. In other cases, the effects of building pounding were exacerbated by the brittle and weak hollow clay tiles.

Figures: (Top left) Failure along the block joints; (Top right) Failure of block elements; (Bottom left) Example of wall with two wythes & insulation; (Bottom right) Failure through block cells
Figures: 12 story building @ 41.323850, 19.454856
Figures: 10 story building @ 41.314596, 19.475817
Constructed around 2016 based on Google Street View
Figures: Out-of-plane failure of hollow clay tile nonstructural exterior walls in short (7 or fewer stories) buildings
Figures: (Left) Collapse of hollow clay tile wall and exit stairs; (Right) Collapse of hollow clay tile balcony

Figures: (Left) Cracked hollow clay tile interior partition; (Right) Hollow clay tile corner damage


2.2.2. **Collapse and severe observable structural damage**

In my survey I observed four collapses, though there were other collapsed buildings in Durres that I did not observe. I also observed one building with severe structural damage. See Sections (2a) and (2b) of the [photo album](#) for additional photos of these buildings.

2.2.2.1. **Total collapse: Building at 41.320039, 19.460023**

This six story building had a large height-to-width ratio and was located adjacent to a 6-story solid brick masonry building (no damage observed). The building was located at a street corner, with open storefronts on the two sides facing the street. The other two sides were mostly solid, which would have increased torsional forces, in addition to the soft story behavior caused by the storefronts. The building had reinforced concrete slabs and frames. The walls appear to have been made from hollow clay tiles.

I visited this collapse around 36 hours after earthquake. The top two stories were overturned, while the lower floors collapsed while staying upright. The building fell away from the neighboring building and into the street. Unless the rubble was moved during rescue efforts that occurred before I arrived, this positioning would suggest that the top two floors overturned, and the lower four stories collapsed downward.

Figures: (Left) Google Street View 2016 image of building (pink and yellow); (Right) Collapsed building
Figures: Collapsed building at 41.320039, 19.460023
2.2.2.2. Total collapse: Hotel Bar Restaurant Mira Mare

This five story building, Hotel Mire Mare, appears to have had reinforced concrete frames and slabs, with hollow clay tile walls. The two lower stories had large openings which may have created soft stories. Additionally, some walls on the upper three stories do not appear to line up with the lower two, creating a vertical irregularity which could have disrupted the load path for seismic loads from the upper stories to the ground. Based on Google Earth historical imagery, the building was built before 2002. Hotel Mira Mare is in close geographical proximity (600 ft or 200 m) of two other collapses: Vila Verde and Hotel Lubjana (See 2.2.2.6).

When I visited the site on November 28th, search teams were still working to retrieve victims from the rubble.

Figures: (Top) Google Street View 2016 image of building; (Bottom) Collapsed building
2.2.2.3. Collapse of two lower stories & connected restaurant pavilion: Vila Verde Hotel

Vila Verde was a five story building, and its lower two floors collapsed in the earthquake. Google Earth historical imagery shows that the building was constructed sometime before 2002 (year of first available aerial image), and that the large wraparound restaurant canopy was added in a renovation sometime after 2002. The canopy also collapsed in the earthquake. Vila Verde Hotel is in close geographical proximity (600 ft or 200 m) of two other collapses: Hotel Lubjana and Mira Mare (See 2.2.2.6).

Figures: (Top) Google Maps image of building; (Bottom) Building after earthquake
2.2.2.4. Collapse of first story & tilting of entire building: Hotel Lubjana

Hotel Lubjana was a six story building. In the earthquake, the first floor collapsed and the entire building tilted backward, away from the street. Based on Google Street View from 2016, which does not show this building, the hotel was built within the last three years. Hotel Lubjana is in close geographical proximity (600 ft or 200 m) of two other collapses: Mira Mare and Vila Verde (See 2.2.2.6).

Figures: (Top) Image of building from Booking.com; (Bottom) Building after earthquake
Figures: Hotel Lubjana after earthquake
2.2.2.5. **Severe structural damage: Building@ 41.311322, 19.481608**

This six story building had severe structural damage, as well as significant nonstructural damage. The building has reinforced concrete frames and hollow clay tile walls. The lower two stories have large open storefronts and exhibited soft story failure. Two columns visible from the street had spalling that exposed the reinforcement. At least one column was severely deformed, impairing both the gravity and lateral systems. Displacements at the lower “soft” floors caused damage to glazing on the second floor, and a hollow clay tile wall collapsed on exit stairs.

This building was demolished around December 3rd ([Youtube link](https://www.youtube.com/watch?v=dQw4w9WgXcQ)).

*Figures: Building with severe structural and nonstructural damage (note deformed columns in photo on right)*
2.2.2.6. Geographical proximity of collapsed buildings in shoreline area: historical comparison

Figure: Google Earth satellite image from 2002 of shoreline in the vicinity of three collapses (locations labeled with pins). Compare with image on next page. (Link to high resolution images [here](#)) Hotel Lubjana and the wraparound pavilion on Vila Verde do not appear, because they were not yet built.
Figure: Google Earth satellite image from 2019 of shoreline in the vicinity of three collapses (locations labeled with pins). Compare with image on previous page. (Link to high resolution images [here])
2.2.3. **Pounding**

There were several examples of pounding between adjacent buildings. Pounding results from insufficient gaps being provided between adjacent buildings.

*Figure: Examples of pounding damage*
2.2.4. **Nonstructural damage observable from exterior**

Aside from the hollow clay tile wall failures, the most common type of nonstructural damage I observed was the cracking and falling of stucco and plaster. I also observed a few examples of glazing damage.

*Top row: Fallen stucco; Bottom row: Glazing damage*
Figures: Cracked plaster in a 5 story solid brick building
Figures: Severe nonstructural damage of Building at @ 41.317597, 19.467245;
(Top left) Out-of-plane hollow clay tile wall failure; (Top right) Damage to exit stairs;
(Bottom left) Front view of building with two soft stories; (Bottom right) Damage to partitions and glazing
2.3. **Performance of other common building types**

2.3.1. **Precast panel buildings**

Building of five to six stories constructed with precast concrete panels are common in Durrës. These buildings were likely built in the 1960s to 1980s. I observed many of these buildings from the exterior. I did not observe significant structural or nonstructural damage.

*Figures: Typical precast panel building*
2.3.2. **Solid brick masonry buildings**

Buildings of two to six stories constructed with solid brick masonry walls are common in Durrës. These buildings were most commonly built in the 1960s to 1980s. These buildings have reinforced concrete slabs. I observed many of these buildings from the exterior. The most serious damage I observed was cracking of plaster and stucco. I did not observe any severe cracking of brick walls in my survey (aside from the Old City Wall described in 2.4.4.1).

However, there is a documented partial collapse of a solid brick building in Durrës. (I did not observe this building in my survey.) Two lower stories of that building collapsed. The first floor of the building had been renovated to have large openings, which may have created a soft story condition. Another engineer who observed the building suggests that geotechnical effects may have also played a role in that collapse.
2.4. **Performance of special use buildings and landmarks**

2.4.1. **Hospitals**

The emergency wing of Durrës Regional Hospital sustained significant damage in the main shock on November 26th. The damage was exacerbated in an aftershock on November 28th. To the best of my knowledge, there was no discontinuity of hospital service, but the main entrance to the emergency wing was closed after the aftershock. After the emergency entrance closure, emergency patients started to use another hospital entrance.

This two story building with a canopy at the entrance had significant cracking concentrated in the hollow clay tile piers between openings. Hollow clay tile partition walls also cracked. The cracking had visibly degraded the out-of-plane integrity of the walls and piers, making out-of-plane failure more likely in aftershocks. At the building corners, vertical cracks had also formed.

Characteristics are similar to the buildings described in Section 2.2.1. I do not know if there was any damage to the structural elements, and more investigation is needed. Ronny Moses of the Swiss Agency for Development and Cooperation, a structural engineer I spoke with who had investigated the building more closely, reported that he did not see evidence of damage to the reinforced concrete elements. However, his survey was limited and thus does not rule out the possibility of structural damage. There were no reports of significant nonstructural damage inside the hospital, but more investigation is recommended.

*Figure: Emergency wing of Durres Regional Hospital*
Figure: Exterior damage to Durres Regional Hospital
Figures: Front entrance of Emergency Wing of Durres Regional Hospital on Nov-27 (top) and Nov-28 (bottom). Cracks widened during an aftershock on the morning on Nov-28.
Figures: Cracked hollow clay tile nonstructural wall
(Photo taken by Ronny Moses of Swiss Agency for Development and Cooperation)

Figure: Lobby of Durres Regional Hospital (no observed nonstructural damage)
I walked by the front side of American Medical Center and did not notice any damage. Operations appeared to be normal.

*Figure: American Medical Center*
2.4.2. **Schools**

I observed five schools from the exterior. One appeared to have some glazing damage, but I did not observe any damage of the other four schools.

![Figure: Naim Frashëri High School has a few broken windows](image)

*Figures: I did not observe damage of these four schools from the exterior*
2.4.3. **Museums**

Durrës Archaeological Museum is the largest archaeology museum in Albania. I observed damage at the top floor piers, which have cracked at each of the corners I was able to see. I was unable to investigate the construction of the wall pier.

On November 27th, when I visited, the museum was closed to visitors.

Figure: Durrës Archaeological Museum with cracking at the piers in the top floor
Figures: Damage was evident at each corner of the top floor of Durrës Archaeological Museum.
2.4.4. **Historic structures**

Durrës is home to several historic structures.

2.4.4.1. **Old City Wall**

The Old City Wall runs a length of about 250 meters (800 ft), with three towers along its length. The 4.5 meter high (15 ft) wall is made from masonry. It was originally built around 500 AD, though parts have been repaired and reconstructed since then. One tower of the Old City Wall collapsed into the street during the earthquake. I did not observe damage at other parts along this wall.

*Figures: (Top) Google Street View 2016 image of the tower; (Bottom) Collapsed tower*
Figures: Section of Old City Wall that collapsed into the street
Figures: I did not observe damage on other sections of the Old City Wall. In the bottom photo, note the steel “belts” installed to tie the intersecting walls of the tower together. This may have helped prevent this tower from damage.
2.4.4.2. Venetian Tower, Roman Amphitheater, Roman Forum

I did not observe significant damage to the Venetian Tower, Roman Amphitheater, or Roman Forum.

Figures: (left) Venetian tower; (right) Roman Forum

2.4.5. Other landmark buildings

To see photos of other landmarks buildings please see Section 4 of the photo album.
3. **Other Topics**

3.1. **Geotechnical effects**

I did not observe anything I could comfortably classify as a geotechnical effect in my survey. Most of the survey area was flat. Much of it was in close proximity to the shoreline.

Based on available aerial imagery, there has been considerable development along the shoreline in Durrës since 2002.

As mentioned in 2.2.2.6, the proximity of several severely damaged structures in close proximity to one another may suggest that site effects could have contributed to the behavior.

3.2. **Business continuity; Infrastructure; Lifelines**

To the best of my knowledge, transportation between Durrës and Tirana was not interrupted at any point. I did not observe any significant damage to roads I walked on or travelled on. I also did not observe loss of electricity or utilities in the locations I walked in Durrës.

With the exception of businesses housed in buildings with severe damage, many businesses in Durrës were open the day after the earthquake. School was cancelled in the days following the earthquake. As previously stated, the Archaeology Museum was also closed when I visited the day after the earthquake. I have no information about the operations of the port.

I saw many residents of buildings with hollow clay tile wall failure going into their apartments to retrieve valuables, such as televisions, furnishings, doors, appliances, and sentimental items.

*Figures: (Left) Many businesses were open the day after the earthquake; (Right) Residents of a building with fallen blocks retrieving possessions from their apartment*
3.3. Temporary shelters and emergency operations

Temporary shelters and emergency operations were set up near Niko Dovano stadium. Tents and emergency operations were up-and-running by the time I arrived the day after the earthquake.

Figures: Temporary shelters and emergency supplies near Niko Dovano Stadium

3.4. Strong Motion Station DURR in downtown Durres (not located)

I spent some time trying to locate strong motion station DURR, which is documented as being located in downtown Durrës at coordinates 41.31990, 19.45730. I approached the GPS location from three different directions without success. After I mentioned that I couldn't find the station to Dr. Brisid Isufi on the EERI VERT team, he asked one of his colleagues to look for it. The colleague followed up that access is not open to the public and that there is no one there.
4. **Next steps**

If you have any comments or questions about anything in this report, please add it as a comment to the [Google Doc version](#). If substantial changes result based on questions or comments, I will reissue the report with the revisions/additions.

Based on my observations, I would recommend additional investigation into the following topics:

1. If buildings with nonstructural hollow clay tile wall failures have any observable structural damage.
2. If the Archaeology Museum has any structural damage, nonstructural damage, or contents loss.
3. If there are any common denominators in the three collapses that occurred in close proximity to each other.
4. How the damage to Durres Regional Hospital impacted hospital operations.
5. How low rise housing performed.