Global Risk Miyamoto

L'Aquila, Italy Earthquake Journal

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Preface

On April 6th, 2009 at 3:32 am, while most were sleeping, a magnitude 6.3 earthquake struck the Abruzzo region of central Italy. The epicenter is located approximately 7 km northwest of L'Aquila, approximately 85 km northeast of Rome. L'Aquila is comprised of a blend of modern and Baroque and Renaissance era architecture.

Kit Miyamoto of Miyamoto International, Peter Yanev and Ilbe Salvaterra of Global Risk Miyamoto, traveled to the site to collect data on earthquake effects related to historical and modern buildings, investigate damage to industrial facilities for our clients, and to gather information to promote impactful changes to engineering practices in high earthquake risk communities worldwide.

We believe that we can make a positive impact to minimize the human and financial losses from earthquakes. Please allow us to share the personal journal entries from Mr. Miyamoto. Building awareness is the first step...

Journal Entry #4

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April 16, 2009, 7:30 am - The Journey to the Epicenter

We checked out of the hotel early this morning. Today, we are planning to drive through the high altitude mountain range by Highway 5 and then back to the L'Aquila epicentral area.

9:35 am - The Power Plant

We stopped at a 1999-built combined cycle, 180 MW power plant with three sets of boilers in the town of Celano, which is about 30km from the epicenter. The plant manager gladly gave us a tour of the plant. He wanted us to point out any earthquake damage and weaknesses that can be improved for future earthquakes.

The plant buildings and structures were well engineered steel structures that appeared undamaged. These were the only steel framed buildings that we have observed so far. Some of the equipment, particularly the generation related equipment was anchored properly. Much of the other equipment, however was not anchored properly for earthquakes. We pointed out some of the weaknesses in equipment systems. The emergency battery racks was not braced and the batteries were not protected against falling off their racks. Batteries seem so trivial, but are crucial for turbine operations after an earthquake triggered stoppage.

The ground motion at the plant, was weak and did not cause any damage. Absolutely nothing fell in the earthquake, not even books from shelves. We also did not observe any damage to conventional buildings around the power plant.

The plant substation is owned by the national transmission company. The substation equipment had no earthquake design to speak of. Most of the various ceramics were interconnected with rigid busses instead of flexible connections and would have quickly failed had the earthquake been stronger. When the ground starts to shake, ceramic insulators move independently of each other, and if restrained, the differential movement will break the brittle ceramics. Power doesn't flow when ceramics fail. The transformers in the station were also not anchored. All that will result in business interruptions in future earthquake. Fortunately, there are many seismic options and procedures. We went over some of these with the plant manager, who was very grateful. I think he will implement many of our suggestions to improve the reliability of this plant for future large earthquakes.

12:35 pm - Ghost Towns and Blue Tents

Highway 5 north reached 1,500 meters and placed us in an alpine meadow surrounded by snow capped mountains. This scene was dotted with ancient villages. We drove through several and found them to be strangely deserted. No people and all businesses were closed. There wasn't any apparent damage to the buildings. In one village, we found a cluster of government issued blue tents at the edge of town. That's where all the people went. They were really scared of the buildings and didn't want to stay in them.

I saw this same problem in China last year. There was no formal post-earthquake engineering inspection program to assess building damage and to let people know if they can safely reoccupy their homes and businesses. Not doing so increases the homeless problem, adds cost and slows overall recovery. We are fortunate in Japan and California where thousands of pre-trained volunteered engineers will inspect buildings and give them red, yellow or green tags. Green is for safe entry. Red is unsafe to enter.

1:08 pm - Ruined Treasure

We approached the town of San Panfilo d'Ocre. Ilbe spotted a ruined 10th century castle on a nearby hilltop. From a distance, we can see that the top of ancient walls had collapsed. It is sad to see such heritage lost, but this will happen without retrofit. We continued on through the deserted but undamaged village, and finally met the villagers at the end of the road, in a blue-tent refugee center. We tried to get to the castle for a closer look, but were stopped by a road block.

1:30 pm - Collapsed Industrial Building

As we entered L'Aquila valley, about 10 km from the epicenter, we spotted a heavily damaged, newly constructed industrial building. It was a precast concrete building and the structural system was very similar to the one we investigated yesterday. The concrete walls were peeled off by the earthquake and crumbled to the ground. The concrete frame shifted in the earthquake and dropped the concrete roof planks to the ground. Upon closer inspection, we saw only two small steel connections tying the walls to the roof. Obviously, these were not strong enough to resist the earthquake forces. This new industrial building was in a neighborhood of older residential buildings that had no damage. As noted yesterday, buildings of this type have very little earthquake resistance.

2:40 pm - Young Family

From the L'Aquila valley, we drove up to the medieval town of Fossa; which has a 13th century church at the town entrance. There was a large gash at the wall corner and major damage to the bell tower. This was similar to the damage we witnessed in L'Aquila's old city center. An Italian TV crewed approach and asked about our findings. We gave them a short commentary and continued on with our investigation.

At the city center entrance, we met a crew of police and firemen. This, like other heavily damaged areas, was well secured. The crew was very organized and helpful. A middle aged fireman, Fabrizio, volunteered to guide us through the deserted town center. We found collapsed houses and damaged churches. At one location, Fabrizio told us that four people were killed there, including a young mother and her daughters. Images of my wife and three kids flashed through my mind.

4:00 pm - A Collapsed Bridge

Soon we were in the L'Aquila valley near Poggio Picenze, not far from the epicenter. We spotted a large industrial complex in the distance and decided to investigate. As we drove through a country road toward Poggio Picenze, our progress was suddenly stopped by a collapsed bridge over a small river. It was a strange sight. The concrete bridge had pancaked and rested on the river, with its deck twisted in agony. The bridge's columns had punched through the deck. Peter quickly climbed down the fallen bridge to study the damage close up. He was promptly asked to leave by a fireman who was guarding the bridge. Peter is 62 years old. I greatly respect his passion for engineering.

4:15 pm - Destroyed Town of Sant'Eusanio Forconese

We just drove through an abandoned town named Sant'Eusanio Forconese. Its town center was on a hill top and was totally destroyed. The scene reminded me of a World War II movie. It looked like a bomb had ripped through the main street. I don't know how many people died here since there was no one to ask.

5:05 pm - Father and Son

At Fiume Aterno, we surveyed an industrial building at the east end of town. I found the corners of the precast walls had torn away from the building and fell to the ground. The owner came out from the building and looked very annoyed initially, but soon warmed when Ilbe told him that we were engineers from United States. We learned that this was a family owned factory and manufactured construction materials ranging from wood beams to steel rebar. He invited us into the building and introduced us to his son Scimia, who recently graduated from engineering school. Scimia spoke English and was covered with white dust. He told us that he had been repairing concrete cracks in the building and asked us to examine his work; which looked fine. They really appreciated our advice. As we were leaving, his father told us that the large precast plant next door was shut down for one week because of extensive damage to inventory. We bid them farewell and moved on.

5:55 pm - Hospital

We reached a large hospital on the west side of L’Aquila. It is a 3-story modern hospital that seem undamaged from a distance. But once we got to the entrance, we can see that the walls at the top level had collapsed onto the emergency entrance area, knocking down the large “emergency” sign. This scene reminded us of the emergency canopy collapse at the Olive View Hospital in the 1971 M6.7 San Fernando, California earthquake; which heightened earthquake awareness in California engineers and pioneered the development of today’s seismic codes.

With exterior walls gone, the concrete beams and columns were exposed. These walls were masonry infill walls similar to those that we saw at the college on day one. The hospital was dark and totally deserted. The ground motion here was not strong enough to collapse the structural system, but the unanchored masonry walls didn’t have a chance. Interestingly, other buildings nearby didn’t have much damage—a testament to the low ground motions.

Emergency hospital operations were moved to an outside tented area in the rear parking lot. We talked to a neurology doctor about the situation and he was told that the damage was superficial and they were hoping to move back to the hospital.

7:10 pm - Onna

Onna is a small village in a valley near a river. I couldn't believe my eyes when we got there. Many buildings were either totally collapsed or are

about to collapse. Soft soils in this river meadow area may have contributed to the higher ground acceleration and destruction. Earthquake motions tend to increase in soft soil areas. These residential buildings were made of unreinforced brick and concrete floors, one of the most dangerous building types. This same system killed many of 100,000 in China last year. The lesson is repeated here. We spoke with some police officers who explained that over 40 people were killed in this village of 300. We saw a 3-story building completely leveled to the ground. This type of collapse doesn't allow people any chance to escape. I smelled the familiar sweet scent of crushed buildings, dust and belongings.

Dusk is setting in and hundreds of firefighters and emergency personnel are wrapping up another day of search and rescue work. They walk quietly and respectfully around the destroyed buildings—a large grave yard in a beautiful meadow...

April 17, 2:50 am

The familiar Black Berry alarm clock woke me up from a short sleep. I rushed to catch a plane back to California this morning. I have decided to leave a day ahead of schedule. My work was done here. My thoughts drifted to the dead mother and her daughters in Fossa. I needed to see my family.

End Journal Entry #4

Postscript

The April 6, 2009, M6.3 L'Aquila, Italy earthquake is considered a moderate size event. But it killed 300 people in an area with a population of 100,000, and destroyed many modern and ancient buildings. The direct damage is currently estimated at $16 billion.

Damage was wide spread but sporadic. We found much damage on hill tops, where strong ground motions focused, and soft soil areas where ground motions were amplified. From a structural engineering perspective, we did not discover any new failure modes. Even though this was a moderate size earthquake, damage was observed in buildings with non-ductile concrete, soft story, unreinforced masonry, and new precast construction. The risk was increased by heavy concrete floors. Non-structural elements such as suspended ceilings and infill brick walls failed if they were not properly braced or anchored. This failure mode shut down operations at a large modern hospital - when the community needed it most. Falling infill walls and ceilings would have killed many college students in the hill-top engineering school we visited. Many new precast buildings failed in this earthquake. The buildings simply had poor seismic design. If the earthquake had been a little stronger, many of this building type would have collapsed. For historical structures, churches were the most dangerous because of their high masonry walls, large interior spaces, bell towers and domes.

The Italian Building Code rates this area Zone 2 (an area of moderate earthquake risk) even though the L'Aquila area is known to be seismically active and has had a long history of large earthquakes, including events in 1315, 1349, 1452, 1501, 1646, 1703 and 1706. The 1706 event destroyed the town and killed much of the population of 5000 people.

I would like to emphasize that the structural deficiencies identified for both new and historical structures in our survey are found worldwide. We have experienced and will continue to experience similar structural failures even in advanced earthquake engineering countries like the United States and Japan. There are many pre-1980 non-ductile concrete structures, older unreinforced masonry buildings, facilities with un-braced non-structural elements, and inadequate earthquake engineering. Historical structures should be strengthened to protect our heritage and culture. Strengthening is so much more cost effective than post earthquake repair. It also saves lives. Public and private sector earthquake risk reduction is essential to reduce both human and financial catastrophes.

About Global Risk Miyamoto (GRM)

Global Risk Miyamoto was formed specifically to provide the risk management community with accurately quantified site-specific risk identification and loss expectancies resulting from natural hazard perils such as earthquakes, windstorms, hurricanes, typhoons, and floods.

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