Ground Response Overview and Foundation Failure of Pile-Supported Building

Martin B. Hudson, Ph.D.
SEAOSC
Wood PLC (fka Amec Foster Wheeler)
From Los Angeles Times
Sept 19 event is an Extensional (normal faulting) earthquake at ~58km depth. It is likely an intraslab rupture breaking the Cocos oceanic lithosphere. It happened in Mexico’s flat slab region, close to sharp kink in the slab between flat part and deeper steeply dipping part.

From Garini and Gazetas – National Technical University of Athens, Greece
Ground Response

Shaded areas saw strong shaking, enough to move heavy furniture.

Darker red areas saw more intense shaking, enough to collapse buildings.

MEXICO CITY:

Peak Ground Acceleration estimated by UNAM

From Garini and Gazetas – National Technical University of Athens, Greece
Spectral response for 0.2 s estimated by UNAM

From Garini and Gazetas – National Technical University of Athens, Greece
Spectral response for 1 s period estimated by UNAM

From Garini and Gazetas – National Technical University of Athens, Greece
Spectral response for 2 s period estimated by UNAM

From Garini and Gazetas – National Technical University of Athens, Greece
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Lakebed Clay Amplification

Garini and Gazetas calculated the thickness of underlying clay which would result in highest spectral response in range that would impact 5 to 10 story buildings most – this thickness is about 20 to 30 meters of clay, highlighted in yellow below.

From Garini and Gazetas – National Technical University of Athens, Greece
Subject Building – Foundation Failure

Prior to Earthquake
August 2017, Google Earth

After Earthquake
Oct. 12 2017, SEAOSC Safer Cities
Subject Building – Foundation Failure

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Roughly 12 inches settlement of building versus pre-earthquake building elevation
Subject Building – Foundation Failure

Prior to Earthquake
August 2017, Google Earth

After Earthquake
Oct. 12 2017, SEAOSC Safer Cities
Structural Information

6 stories
Structural damage observed:
  - Infill (In-Plane)
  - Infill (Out-of-Plane)
  - Non ductile concrete detailing
Tilting of Building Toward Left
Splitting of Building due to Differential Settlement
Crack Through Middle of Building
Split of Building at Roof
Failure Mechanism – 2 Phases

- Rock
- Clay
- Downdrag forces

- Reduced F.S. of piles due to downdrag loads
- Failure of piles in earthquake, with differential settlement

Final condition at driveway
Conclusion

Downdrag forces adjacent to pile foundations may be resisted under static conditions, but adding seismic forces can then cause failure of compromised piles.
Acknowledgements

- More information available at:
  http://learningfromearthquakes.org/2017-09-19-puebla-mexico/