The Central Peruvian Earthquake of August 15, 2007: A Preliminary Report

Prof. Richard E. Klingner
The University of Texas at Austin
Member, Reconnaissance Team
Peru-Japan Disaster Mitigation Center
klingner@mail.utexas.edu
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Objectives of Presentation
- Why we study the performance of structures, soils, and lifelines in earthquakes
- How we achieve those goals through post-earthquake reconnaissance
- Preliminary observations from a one-day reconnaissance after the Central Peruvian Earthquake
- Further information at www.eeri.org

We study the performance of infrastructure and institutions in earthquakes for several reasons
- Document “crash and bash”
- Maintain and improve the performance of structures, soils, and lifelines in earthquakes
- Maintain and improve institutional response to earthquakes
- Apply lessons learned in extreme loadings, to maintain and improve performance in ordinary loadings

Key issues, Central Peruvian Earthquake
- Old lessons repeated
- Massive and widespread damage
  - Damage to infrastructure from geotechnical failures (Pan-American Highway)
  - Damage to structures (widespread strong ground shaking, so damage was differentiated by construction type)
  - Lack of coherence in governmental response
  - Damage to social fabric

- We must codify and enforce what we know

Basic seismological data...
- The Central Peruvian Earthquake of August 15, 2007 took place on the west coast of South America

...basic seismological data
- Peruvian earthquakes are produced by the subduction of the Nazca Plate under the South American Plate
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basic seismological data
- Epicenter was about 145 km SSE of the capital city of Lima.
- Nearby towns were Pisco and Ica.

Wednesday August 15, 2007
- 6:40:57 pm local time
- Moment magnitude ($M_w$) 8.0
  - Measures energy released; rupture of hundreds of kilometers, movement of more than 10 m.
- Two strong-motion stations within 50 km, but strong-motion records not yet available.
- Estimated peak ground acceleration at least 0.5 g.

Sunday August 19: we drove from Lima down the coast to Pisco
- The area is coastal desert, with little rainfall.

Our 250-km journey was complicated by earthquake damage to the Pan-American Highway
- Some families were walking toward Lima in search of food and water.

Along the way, many isolated communities were cut off from food and water
- Some groups of survivors were asking passing vehicles for help.

Along the way, geotechnical damage was evident...
- Gross lateral movement of highway due to ground shifting.
along the way, geotechnical damage was evident
- overturned utility poles, probably due to liquefaction

along the way, geotechnical damage was evident
- settlement of highway slopes

along the way, geotechnical damage was evident
- sand boils, showing crystallized salts from low coastal water table

along the way, structural damage was also evident
- damage to adobe church

We turned west from the Pan-American Highway and entered Pisco

Pisco was badly damaged
- Pisco has a population of about 120,000
- about half of the buildings in Pisco were destroyed
Hierarchy of Structural Vulnerability

- **Materials**
  - (no steel structures)
  - a few reinforced concrete structures
  - reinforced or confined masonry
  - adobe

- **Configuration**
  - plan eccentricity
  - insufficient wall density in both principal plan directions
  - soft stories, captive columns

-reinforced concrete structures had widely variable performance

- **problems with non-ductile detailing**
- **potential problems with configuration**
  - plan eccentricity
  - insufficient wall density in both principal plan directions
  - soft stories and captive columns

...problems with non-ductile detailing of concrete structures

- **Embassy Hotel**
- in one part, two lower floors collapsed

...problems with non-ductile detailing of concrete structures

- insufficient reinforcement
- no continuity of reinforcement
- insufficient confinement

...contrast with excellent performance of other reinforced concrete structures

- modern annex to San Juan de Dios Hospital
- only working hospital in Pisco

...reinforced (confined) masonry structures generally performed better than adobe

- **problems with detailing**
- **potential problems with configuration**
  - plan eccentricity
  - insufficient wall density in both principal plan directions
  - soft stories and captive columns
. . . reinforced (confined) masonry structures generally performed better than adobe
- confined masonry has reinforcement in concrete elements within masonry

. . . adobe structures generally collapsed
- this is typical of damage in Pisco
- about half the city’s buildings, most of adobe, collapsed

Hierarchy of Structural Vulnerability
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problems with plan eccentricity...
- plan eccentricity increases deformation demand on elements far from center of rigidity

. . . problems with plan eccentricity
- Embassy Hotel
- corner building

problems with walls perpendicular to street only...
- building to west of main plaza
- decent detailing, note damage to infills
... problems with walls perpendicular to street only
- building to northeast of main plaza
- note collapsed columns at 2nd story

... problems with soft stories...
- deformations from lateral displacement are concentrated in one story, and can exceed available deformation capacity in that story

... problems withsoft stories
- openings on ground floor create soft story there
- this building is about to collapse

problems with captive columns...
- for a given flexural capacity, shear demand on column increases as column height decreases

... problems with captive columns
- note partial infill of right-hand building
... problems with captive columns
- Captive column created by partial infill has collapsed

Lack of coherence of governmental response to earthquake...
- Pisco and other towns were not easily reached
- Initial aid (water, food, shelter) was slow to arrive and poorly coordinated
- Volunteer firefighters from Spanish-speaking countries throughout the world were the most visible and comforting symbol of governmental support

... governmental response
- Volunteer firefighters (search and rescue)

Damage to social fabric...
- No water, electricity or phones
- Local police were quickly overwhelmed by widespread looting
- Troops were not posted until 3 days after earthquake
- Church of San Clemente collapsed, killing 150 during mass
- More than 500 dead in total
- Many thousands missing

... Damage to social fabric
- Some phone lines worked, but many didn’t
- Cell phones couldn’t be charged

... Damage to social fabric
- Widespread looting
Damage to social fabric
- troops kept order starting 3 days after earthquake
- Church of San Clemente collapsed during mass, killing 150 (nave is gone)

Damage to social fabric
- more than 500 dead
- medical facilities almost totally destroyed
- many thousands missing

Key issues, Central Peruvian Earthquake
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  - lack of coherence in governmental response
  - damage to social fabric
- We must codify and enforce what we know

“Earthquakes don’t kill people. Buildings can kill people if they aren’t properly designed to resist earthquakes.”
- Prof. Javier Pique de Pozo, President of Peruvian Society of Engineers