THE CENTRAL PERUVIAN EARTHQUAKE OF AUGUST 15, 2007: A PRELIMINARY REPORT
Richard E. Klingner
Structures Seminar The University of Texas at Austin August 29, 2007

The Central Peruvian Earthquake of August 15, 2007: A Preliminary Report
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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
- Peruvian earthquakes are produced by the subduction of the Nazca Plate under the South American Plate
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Basic Seismological Data

- The 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.
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...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

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...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

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...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

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

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

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...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
- **Materials**
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- **Configuration**
  - plan eccentricity
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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
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... problems with walls perpendicular to street only
- building to northeast of main plaza
- note collapsed columns at 2nd story

... problems with walls perpendicular to street only
- insufficient lateral resistance parallel to street
- detailing problems with columns

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

problems with soft 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
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... Damage to social fabric
- troops kept order starting 3 days after earthquake

... Damage to social fabric
- 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

... Damage to social fabric
- many thousands missing

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- massive and widespread damage
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  - 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

Earthquakes don't kill people. Buildings can kill people if they aren't properly designed to resist earthquakes.

We must codify and enforce what we know.