

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

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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

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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

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Basic seismological data . . .

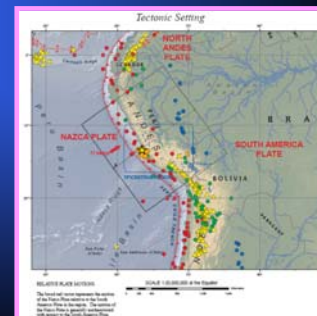
- The Central Peruvian Earthquake of August 15, 2007 took place on the west coast of South America



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. . . 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

- The epicenter was about 145 km SSE of the capital city of Lima
- Nearby towns were Pisco and Ica



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... basic seismological data

- 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

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Sunday August 19: we drove from Lima down the coast to Pisco


- The area is coastal desert, with little rainfall



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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



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Along the way, many isolated communities were cut off from food and water


- some groups of survivors were asking passing vehicles for help



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Along the way, geotechnical damage was evident...


- gross lateral movement of highway due to ground shifting



12

... along the way, geotechnical damage was evident

- *overturned utility poles, probably due to liquefaction*



13

A photograph showing a utility pole that has been completely overturned and lies on the ground. The background shows a dry, hilly landscape under a cloudy sky.

... along the way, geotechnical damage was evident

- *settlement of highway slopes*



14

A photograph of a paved road with a significant crack running down the center. A person is standing on the shoulder of the road for scale. The background shows a dry, open landscape.

... along the way, geotechnical damage was evident

- *sand boils, showing crystallized salts from low coastal water table*




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A close-up photograph of the ground surface showing irregular, light-colored patches of soil, identified as sand boils with crystallized salts. A white marker is placed on the ground for scale.

... along the way, structural damage was also evident

- *damage to adobe church*



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A photograph of a traditional adobe church building that has suffered significant structural damage, with its roof partially collapsed and walls crumbling. A yellow taxi is parked in front of the building.

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




17

A photograph showing a person wearing a red shirt and a yellow cap riding a bicycle on a street in Pisco. The street is lined with buildings and utility poles.

Pisco was badly damaged

- *Pisco has a population of about 120,000*
- *about half of the buildings in Pisco were destroyed*



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A photograph of a street in Pisco showing extensive destruction. Debris is piled up on the sidewalks, and many buildings appear to be partially destroyed or completely ruined. A white car is driving down the street.

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**



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... 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

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

- confined masonry has reinforcement in concrete elements within masonry



confined masonry in back , collapsed adobe in front

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... adobe structures generally collapsed

- this is typical of damage in Pisco
- about half the city's buildings , most of adobe , collapsed



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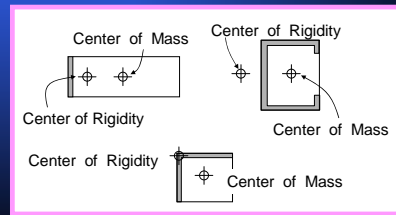
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problems with plan eccentricity ...

- plan eccentricity increases deformation demand on elements far from center of rigidity



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... problems with plan eccentricity

- Embassy Hotel
- corner building



29

problems with walls perpendicular to street only ...


- building to west of main plaza
- decent detailing , note damage to infills



30

... problems with walls perpendicular to street only


- building to northeast of main plaza
- note collapsed columns at 2nd story



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... problems with walls perpendicular to street only

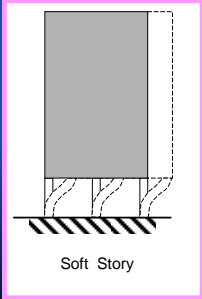
- insufficient lateral resistance parallel to street
- detailing problems with columns



32

problems with soft stories ...

- deformations from lateral displacement are concentrated in one story, and can exceed available deformation capacity in that story



Soft Story

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... problems with soft stories

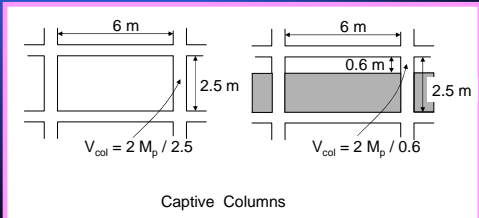
- openings on ground floor create soft story there
- this building is about to collapse



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problems with captive columns ...

- for a given flexural capacity, shear demand on column increases as column height decreases




Captive Columns

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... problems with captive columns


- note partial infill of right-hand building



36

... problems with captive columns

- captive column created by partial infill has collapsed



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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

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... governmental response

- volunteer firefighters (search and rescue)

Church of San Clemente, main plaza



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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

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... Damage to social fabric

- some phone lines worked, but many didn't
- cell phones couldn't be charged



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... Damage to social fabric

- widespread looting



42

... Damage to social fabric

- troops kept order starting 3 days after earthquake



43

... Damage to social fabric

- Church of San Clemente collapsed during mass, killing 150


nave is gone



44

... Damage to social fabric

- more than 500 dead
- medical facilities almost totally destroyed



45

... Damage to social fabric

- many thousands missing



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47

“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



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