Geotechnical Aspects of the August 15, 2007
Mw 8.0 Pisco, Peru Earthquake:
Preliminary Observations

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GEESD IV
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Outline

- General Information
- Ground Motions
- Liquefaction observations
  - Spatial distribution
  - Case histories
- Canchamaná Lateral Spread
- Landslides
Tectonic Setting

Mag ≥ 7.0
- 0 - 69 km
- 70 - 299 km
- 300 - 600 km

Plate Boundaries
- Subduction
- Transform
- Divergent
- Convergent
- Volcanoes

EXPLANATION

North Andes Plate
Nazca Plate
South America Plate
Seismological Information

- Date: August 15, 2007
- Magnitude: Mw = 8.0
- Type: Interface subduction event
- Hypocentral depth = 39 km
- Fault dimensions:
  - 190 km along strike
  - 95 km down dip

Ji and Zeng (USGS)

Overview

- Severe damages in cities of Pisco, Ica, Chincha Alta
  - 519 people were confirmed dead
  - 42 more unaccounted for and 1,874 reported injured
  - 54,926 buildings were destroyed
  - 20,958 buildings were damaged

- Extensive damage to transportation infrastructure
Shaking Intensity

Prompt Assessment of Global Earthquakes for Response (PAGER)

M8.0 NEAR THE COAST OF CENTRAL PERU
S13.32 W76.50 30.2km  Wed Aug 15, 2007 11:40:58 PM GMT

Shaking Intensity

Population per km²

Population exposed to shaking

<table>
<thead>
<tr>
<th>MMI Intensity</th>
<th>Population</th>
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<tbody>
<tr>
<td>VIII</td>
<td>583,000</td>
</tr>
<tr>
<td>VII</td>
<td>846,000</td>
</tr>
<tr>
<td>VI</td>
<td>8,410,000*</td>
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Pisco
Recorded Ground Motions

- 16 Ground motions within 150 km of fault plane
Parcona Record (ICA)

- Distance = 39.4 km
- Instrument on soil
- PGA = .498g
- Duration = 86 s
CERESISIS Record (Lima)

- Distance = 102 km
- Instrument on v. stiff soil
- PGA = .06 g
- Duration = 101 s

Courtesy of IGP
Rimac Record (Gravel)
Callao Record (Soft Soil)
Response Spectra in Lima

Superposición de Espectros de Respuesta de Aceleraciones Absolutas Sismo del 15/08/07 Componente EO

Superposición de Espectros de Respuesta de Aceleraciones Absolutas Sismo del 15/08/07 Componente NS
Liquefaction Observations
Las Lagunas
Liquefaction Observations

- Ventanilla (No Liquefaction)
- Lima
- Villa
- Las Lagunas (Section 3.5)
- Canchamana Lateral Spread (Section 3.3)
- Embankment Failure
- Embankment Failure
- Cracks in Embankment
- Paracas
- Liquefaction in Husacchina Lagoon

No more evidence of liquefaction along Hwy 024A East of this point.
Road embankment failures
Road embankment failures
Liquefaction Observations
Canchamana Landslide Complex

Believed to be the largest lateral spread ever documented

Area ~ several km²

Lateral deformations in the order of 6 m?
CROSS SECTION A-A

BEFORE

Marine Terrace

Non-Liquefiable Layer

Slope ~ 1.6 - 2.1%

Liquefiable Layer

AFTER

Marine Terrace

Crack

Crack

Crack

Crack

Crack

Liquefiable Layer

~ 25m

~ 1km

Ejecta (silty sand and water)

Not to scale
Canchamaná Lateral Spread
Displacements shown are not correct!!!
Liquefaction Observations
Tambo de Mora

0.9 m settlement
Tambo de Mora

- Large settlements over an area of about 4 city blocks
- Well delimited area of settlements: across the street we saw well performing houses
- One case of ejecta of low plasticity clay
Tambo de Mora

$\text{PI} = 16$
General San Martin Port
General San Martin Port

0.8 m settlement
General San Martin Port

0.5 m lateral displacement of wharf deck
Landslides

- Estimated thousands of landslides (disrupted landslides including rock falls, rock slides, soil falls, soil avalanches, and disrupted soil slides)
- Highway department: rockfalls occurred as far as 700 km from the fault plane (small rock falls)
- Culprit of many road closures
Comparison with landslides from other events
Shallow soil slides
Rock slides, falls and avalanches
Disrupted rock/soil slides (rock in soil matrix)
Landslides on natural terrain
Conclusions

- Extensive liquefaction over a widespread area
- Interesting
  - Very large lateral spread
  - Settlement of nearly 1 m of light structures
- Heavy structural damage
  - Mostly to adobe construction
- Recorded time histories
  - Long!
  - Two-phase motion (how does this affect liquefaction?)
Preliminary report:

http://gees.usc.edu/GEER/recent_geotechnical_engineering.htm
THANK YOU
Pisco: structural damage
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