Damage observed in the Ground Zero Zone of Portoviejo

April 16, 2016 Ecuador Earthquake
EERI Learning from Earthquakes Briefing Webinar

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Portoviejo - Outline

• Introduction

• Damage on Reinforced Concrete Buildings
  • Residential and Commercial Buildings
  • Churches

• Conclusions
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Introduction - Portoviejo

- Population: 250,000
- Province: Manabí
- Area: 373.6 mi²
Introduction - Portoviejo

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Portoviejo
Post-earthquake damage assessment

Portoviejo
Reinforced concrete frame buildings with URM infills
Portoviejo
Palace of Justice of Portoviejo - “Palacio de Justicia de Portoviejo”

**Construction System:** 9-story RC frame building

**Year of construction:** 2002

**Damage:**
- Seismic joints
- Contents
- Infill walls
- Tile system
Portoviejo
Damage to infill walls

Arturo E. Schultz (University of Minnesota)
Ana Gabriela Haro (North Carolina State University)
Portoviejo
"Mutualista Pichincha"; 10-story RC frame building

Partial collapse: general view
Partial collapse: close view

Short column and poor detailing
Leaning direction

Arturo E. Schultz (University of Minnesota)
Portoviejo
"Centro Comercial Municipal "; 9-story RC frame building

Before the 2016 earthquake

Arturo E. Schultz (University of Minnesota)

After the 2016 earthquake

Arturo E. Schultz (University of Minnesota)

Partial collapse

Damage on infill walls
Portoviejo
"Banco Comercial de Manabí"; 6-story RC frame building

Damage during the April 16, 2016 earthquake

Damage during the May 18, 2016 aftershocks

Courtesy of Diego Aguirre Burneo (Ecuadoran Inspector)
Portoviejo
Pounding between buildings

"Contraloría General del Estado" building affected by two adjacent structures

Adjacent slabs at different heights

Restricted differential movement

Ana Gabriela Haro (North Carolina State University)

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Arturo E. Schultz (University of Minnesota)
Portoviejo

Structural damage on an RC 3-story building

General view of the structure

Column failure

Joint failure and beam detail

Attempt to prevent total collapse
Portoviejo
Plastic hinges evidenced in a 5-story RC building
Portoviejo
Cases of structural alterations

Ana Gabriela Haro (North Carolina State University)
Portoviejo
Cathedral "Jesús del Buen Pastor"

Arturo E. Schultz (University of Minnesota)
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The failure modes observed in the Ground Zero - Portoviejo zone revealed the necessity of enforcing design and construction codes to improve the seismic structural performance of new and existing buildings to prevent future catastrophes.

Main causes of damage:

- Extremely flexible RC frame buildings
- Heavy and brittle infill walls
- Lack of robustness and redundancy
- Poor reinforcement detailing
- Poor quality of materials
- Lack of control during construction