Preliminary Reconnaissance Findings from the 2020 Puerto Rico Earthquake Sequence

Structural Impacts

EDUARDO MIRANDA

JOHN A. BLUME EARTHQUAKE ENGINEERING CENTER
DEPARTMENT OF CIVIL & ENVIRONMENTAL ENGINEERING
STANFORD UNIVERSITY
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EERI, Maggie Ortíz LFE Program

Prof. José Antonio Martínez-Cruzado, UPRM, PRSMP
Dr. Mehmet Celebi, USGS

2020 National Earthquake Conference, March 4-6, 2020, San Diego
Reconnaissance Team

- Jorge Archbold, UC Berkeley
- Armando Messina, Stanford
- Pablo Heresi, Stanford
- Isamar Rosa, Stanford
Main goals

1. To document the performance of instrumented structures;

2. To document the performance of engineered structures close to free field strong motion stations;

3. Document performance of other structures;
The PRSMP/UPRM has now 21 instrumented structures and 114 strong motion stations in five countries.
Examples of some of the buildings instrumented by the UPRM and PRSMP in Puerto Rico

Minillas Bldg., San Juan
Inmaculada Bldg., San Juan
El Castillo Bldg., Mayagüez
Key personnel at PRSMP that deserve the recognition of installing and providing maintenance for so many years are:

1) Prof. José Antonio Martínez-Cruzado (director of the PRSMP);
2) Dr. Carlos I. Huerta-López (seismologist);
3) Jaffet Martínez-Pagán (Engineer since 2003);
4) Erick X. Santana Torres (Specialist in Instrumentation since 2008);
5) Francisco Hernández-Ramírez (Computer specialist since 2018);
6) Glorimer Torres-Batista (Administrative Assistant since 2010);

Personnel at USGS who have provided technical assistance particularly after Hurricane María:

1) Jim Smith
2) David Nget
Comparison of Response Spectra and Design Spectra in Ponce

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Damage to Residential Construction

More than 80 Single Family Houses Collapsed during the Mw 6.4 Jan 7, 2020 Earthquake

More than 8,000 people displaced from their residences

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Damage to Residential Construction
Damage to School Buildings

Agripina Seda school in Guánica (Source: Omar López).

It partially collapsed in the Jan 6th, 2020 foreshock

(Photograph: Omar López)
Damage to School Buildings

Agripina Seda school in Guánica (Source: Omar López).

It partially collapsed in the Jan 6th, 2020 foreshock.

(Photo: Omar López).

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E. Miranda
Damage to School Buildings

Agripina Seda school in Guánica

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Damage to School Buildings

Agripina Seda school in Guánica
Damage to School Buildings
Agripina Seda school in Guánica

#4@4” at the ends

#12s

90° bend

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Damage to School Buildings

Colegio Santísima Trinidad in Ponce
Damage to School Buildings

Colegio Santísima Trinidad in Ponce
Damage to Residential Construction

Ponciana Condominium in Ponce

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Damage to Residential Construction

Ponciana Condominium in Ponce

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Damage to Residential Construction

Parque La Abolición Condominium in Ponce

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Damage to Residential Construction

Parque La Abolición Condominium in Ponce
Damage to Residential Construction

El Sureño Condominium in Ponce
Damage to Residential Construction

El Sureño Condominium in Ponce
Damage to Residential Construction

El Sureño Condominium in Ponce

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Damage to Residential Construction

El Sureño Condominium in Ponce
Damage to Residential Construction
San Jorge Condominium in Ponce
Damage to Residential Construction

San Jorge Condominium in Ponce

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Instrumented bridge on toll highway PR-52 and highway PR-12 in Ponce

PGA about 0.24g
Instrumented bridge on toll highway PR-52 and highway PR-12 in Ponce

PGA about 0.24g
Bridges

Instrumented bridge on toll highway PR-52 and highway PR-12 in Ponce

PGA about 0.24g
Instrumentsed bridge on toll highway PR-52 and highway PR-12 in Ponce

Example of observed damage
Bridges

Bridge on highway PR-12 and highway PR-133 in Ponce

PGA about 0.2g
Bridges

Joints at every bent/support

PGA about 0.2g
Bridges

PGA about 0.2g
Example of observed damage to shear keys

PGA about 0.2g
Example of observed damage to shear keys
Example of observed damage to shear keys
Bridge on highway PR-127 and highway PR-2 near Guayanilla
Bridges

Bridge on highway PR-127 and highway PR-2 near Guayanilla
Bridges

Bridge on highway PR-127 and highway PR-2 near Guayanilla
Example of observed damage to abutments due to impact
Example of near failure (instability) in rocker bearings
Bridges

Bridge No. 2401 in Guayanilla
Example of damage in shear keys
Bridges

Bridge No. 2401 in Guayanilla

Example of damage from pounding
Bridges

Bridge No. 2401 in Guayanilla

Example of plastic hinges in piers
Bridges

Viaduct in Mayagüez

OLD

NEWER

PGA = 0.2g

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Viaduct in Mayagüez

OLD

NEWER

PGA about 0.2g
Shear failures observed in several piers
Bridges

Damage lead to many bridge closures and traffic disruption.
Learning from Instrumented Structures

Collaboration between

Blume Center
Stanford

USGS
science for a changing world

Prof. José Antonio Martínez-Cruzado, UPRM, PRSMP
Dr. Mehmet Celebi, USGS

El Castillo
Mayagüez

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Sensor Location
Minillas Government
Building (B01L)

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Summary and Conclusions

- The foreshocks in the sequence provided warning and many structures were not inhabited at the time of the main shock (Mw 6.4) resulting in an fortunate outlier in the statistics of collapse to fatality ratios;

- The efforts of the PRSN and PRSMP resulted a very valuable set of ground motion records and in instrumented structures;

- By far the largest impact was on residential construction. The earthquake highlighted the importance of raising the design target to improved performance such as shelter in place;

- The earthquake showed once again how relatively small amount of damage can lead to the closure of many highway bridges leading to traffic disruption;

- The earthquake highlighted the need of adequate planning to initiate structural evaluations ASAP;
Two Reports are Now Available

Puerto Rico M6.4 Earthquake
7 January 2020

StEER Structural Engineering Risk Assessment
Prepared for: NHERI DesignSafe
Project ID: PRJ-2670

Preliminary Virtual Reconnaissance Report (PVRR)

Virtual Assessment Structural Team (VAST) Lead:
Eduardo Miranda, Stanford University

Virtual Assessment Structural Team (VAST) Authors:
(in alphabetical order)
- Andrés Acosta, Stanford University
- Luis Apointe, U Puerto Rico Mayagüez
- Jorge Archbold, UC Berkeley
- Ao Du, Rice University
- María Contos, U Puerto Rico Mayagüez
- Selim Gunay, UC Berkeley
- Wael Hassan, University of Alaska, Anchorage
- Pablo Heresi, Stanford University

Virtual Assessment Structural Team (VAST) Editors:
(in alphabetical order)
- Tracy Kijewski-Correa, University of Notre Dame
- Khalid M. Mosalam, UC Berkeley
- Dadi O. Prevatt, University of Florida
- Ian Robertson, University of Hawaii
- David Rouche, Auburn University

Puerto Rico Earthquake Sequence Dec 2019 to Jan 2020

StEER Structural Engineering Risk Assessment
Prepared for: NHERI DesignSafe
Project ID: PRJ-2712

Early Access Reconnaissance Report (EARR)

Field Assessment Structural Team (FAST) Lead:
Eduardo Miranda, Stanford University

Field Assessment Structural Team (FAST) Members:
(in alphabetical order)
- Jorge Archbold, UC Berkeley
- Pablo Heresi, Stanford University
- Armando Messina, Stanford University
- Isamar Rosa, Stanford University

Virtual Assessment Structural Team (VAST) Editors:
(in alphabetical order)
- Ian Roberston, University of Hawaii
- David Rouche, Auburn University

Available from STEER's, NHERI's DesignSafe and Stanford's Blume Center websites and soon in the EERI's clearinghouse for this event.

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Thank you for your attention!