M7.1 Anchorage, Alaska Earthquake Reconnaissance Results

Structural and Nonstructural Damage

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Acknowledgement: Janise Rodgers, John Thornley, Chris Motter
Overview

- Minor structural damage (engineered/newer)
- Moderate structural damage (non-engineered/older)
- No collapses, fatalities or serious injuries
- Moderate to heavy non-structural damage
- Widespread piping/equipment and water damage
- Contrast to Christchurch 2011? Have we really been tested?
Building Code Background

- Changes Following 1964 M9.2 Earthquake
- NEHRP 1977
- Seismic details early to mid-eighties (UBC 1979)
- Currently IBC 2012
- Local Alaska Building Code Amendments
- Level of enforcement varies (all building types)
Shaking Overview
Damage Correlation to Shaking Intensity

Credit: MOA
Damage Correlation to Shaking Intensity
Damage Correlation to Shaking Intensity
Damage Correlation to Shaking Intensity

Dec 10, 2018

Jan 30, 2019
Damage Distribution

**MOA Inspection Data**

- **Anchorage:**
  
  Requests: 2228 (2%)

  Inspected: 1298 (1.18%)

  **Red: 28 (0.025%)**

  **Yellow: 606 (0.55%)**

- **North Communities:**
  
  Requests: 1068 (7.43%)

  Inspected: 851 (5.92%)

  **Red: 62 (0.43%) (20 times ANC)**

  **Yellow: 252 (1.75%) (3 times ANC)**
Observed Damage Overview

- **Structural Damage**
  - Single-family residential foundation and foundation related damage
  - Retaining wall shear cracking (mostly above ground)
  - Severe damage/partial collapse: few non-engineered single family residential
  - CMU wall damage (even in post 1980s)
  - Shear cracks in concrete girders and shear walls
  - Out-of-plane masonry wall buckling/deformation
  - CMU wall diagonal cracks
  - CMU connection detachment from floors (especially with no column)
  - Floor joist unseating
Observed Damage Overview

- **Nonstructural Damage**
  - Ceiling grid failure and/or tile fall
  - Glass and façade breakage
  - Masonry veneer cracking/failure
  - Drywall cracking
  - Partition wall damage

- **MEP & Equipment Damage**
  - Water flooding due to firefighting system damage (sprinklers, piping, tanks)
  - Water boilers sliding and connection failure (with severe water flooding)
  - Electric panels, wiring, elevators counterweights
  - Gas lines pipe and connection damage
Observed Damage

Residential

Credit: Wael Hassan

Credit: Chris Motter

Credit: ADN
Observed Damage

Residential Buildings (Mat-Su)

Credit: Chris Motter

Credit: Janise Rodgers
Observed Damage

Residential Wood Buildings (Mat-Su)

Credit: Wael Hassan

Credit: Chris Motter
Observed Damage

Residential Wood Buildings (Mat-Su)

Credit: Janise Rodgers
Credit: Chris Motter
Credit: Chris Motter
Credit: Chris Motter
Observed Damage

Commercial (Anchorage)

Credit: Wael Hassan
Observed Damage

Commercial (Eagle River)

Credit: Chris Motter

Credit: Wael Hassan
Observed Damage

Commercial (Eagle River)

Credit: Chris Motter
Credit: Wael Hassan
Observed Damage

Commercial (Eagle River)

Credit: Wael Hassan
Observed Damage

Office Buildings (Anchorage)

Credit: MOA
Observed Damage

Office Buildings (Anchorage)

Brace Foundation Failure

Credit: Wael Hassan
Observed Damage

High-Rises (Anchorage)

- Concrete girder shear cracking
- Aftershocks effect

Credit: Wael Hassan

Boiler Failure
Observed Damage

Mid-rise Buildings (Anchorage)

Patrick Murren

Patrick Murren

EERI
Schools and Educational Buildings

Anchorage Schools
Schools and Educational Buildings

Anchorage School District

- 85 of 97 schools had sort of damage
- Only two schools had moderate to severe structural damage (CMU); still shut down
- 15 schools received thorough structural eval due to minor structural damage, 7 of which in Eagle River
- Schools reopened Dec 10
- Estimated PGA 0.2-0.3g

Mat-Su School District

- Most of 50 schools had sort of damage
- Only two schools had moderate to severe structural damage (CMU); still shut down
- 11 schools suffered minor structural damage
- Schools reopened Dec 2 thru Dec 5
- Estimated PGA 0.2-0.3g

Credit: Rodgers et al 2019
Schools and Educational Buildings

Mat-Su Valley Schools

Credit: Chris Motter
Credit: Bill Noyes
Schools and Educational Buildings

Mat-Su Valley Schools

Credit: Wael Hassan

Credit: Wael Hassan

Credit: Wael Hassan

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Credit: Wael Hassan

Credit: Wael Hassan

Credit: Wael Hassan
Schools and Educational Buildings

Mat-Su Valley Schools

Credit: MSVSD
Schools and Educational Buildings

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Credit: MSVSD
Schools and Educational Buildings

Mat-Su Valley Schools

Credit: Janise Rodgers

Credit: Janise Rodgers
Schools and Educational Buildings

Mat-Su Valley Schools

Credit: Mat-Su School District
Schools and Educational Buildings

Mat-Su Valley Schools

Credit: Janise Rodgers
Schools and Educational Buildings

Eagle River (Anchorage Borough)

Credit: Chris Motter

Credit: Chris Motter

Credit: Chris Motter
Schools and Educational Buildings

Eagle River (Anchorage Borough)

Credit: Chris Motter
Schools and Educational Facilities

University of Alaska, Anchorage Campus

Credit: UAA

Credit: Wael Hassan

Credit: Wael Hassan

Credit: Wael Hassan
Schools and Educational Buildings

University of Alaska, Anchorage (Eagle River Campus)

Photos Credit: Wael Hassan
Hospitals and Healthcare Facilities

Four Major Hospitals in Anchorage Borough & one in Mat-Su:

- Alaska Regional
- Providence Medical Center
- Alaska Heritage
- VA Hospital
- Mat-Su Regional

Questions aside from reporting damage:

- Loss estimation studies for DDD under MCE? **DEMAND?**
- Resilience studies: hospital operation resumption after MCE? **CAPACITY?**
- One emergency room down during MCE? **CAPACITY?**
- Emergency air transport capabilities after MCE? **CAPACITY?**
- Communication network failure in MCE? **CAPACITY?**
- All above D/C ratios in severe winter conditions? **CAPACITY?**
Hospitals and Healthcare Facilities

Concrete Shear Walls

Credit: Wael Hassan
Hospitals and Healthcare Facilities

Concrete Shear Walls

Credit: Wael Hassan
Hospitals and Healthcare Facilities

Water Flooding

Credit: Wael Hassan
Hospitals and Healthcare Facilities

Nonstructural Damage

Photos Credit: Wael Hassan
Hospitals and Healthcare Facilities

Nonstructural Damage

Photos Credit: Wael Hassan
Hospitals and Healthcare Facilities

Nonstructural Damage

Photos Credit: Wael Hassan
Hospitals and Healthcare Facilities

Mat-Su Regional Hospital

Photos Credit: Janise Rodgers
Performance of Instrumented & Tall Buildings

- Atwood Building
- Frontier Building
- BP Building
- EIB Building
- VA Hospital Building
- Hilton Tower
- Port Access Bridge
## Performance of Instrumented Buildings

**Atwood Building 20 Story, Steel Frame/Shear Wall (1982)**

<table>
<thead>
<tr>
<th>Floor</th>
<th>HNN-East</th>
<th>HNE-East</th>
</tr>
</thead>
<tbody>
<tr>
<td>Street Level</td>
<td>0.23g</td>
<td>0.22g</td>
</tr>
<tr>
<td>2nd</td>
<td>0.26g</td>
<td>0.26g</td>
</tr>
<tr>
<td>7th</td>
<td>0.28g</td>
<td>0.31g</td>
</tr>
<tr>
<td>8th</td>
<td>0.28g</td>
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<tr>
<td>13th</td>
<td>0.18g</td>
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<tr>
<td>14th</td>
<td>0.18g</td>
<td>0.23g</td>
</tr>
<tr>
<td>19th</td>
<td>0.17g</td>
<td>0.23g</td>
</tr>
<tr>
<td>EM</td>
<td>-</td>
<td>0.33g</td>
</tr>
<tr>
<td>Roof</td>
<td>0.41g</td>
<td>0.44g</td>
</tr>
</tbody>
</table>

Credit: M. Celebi
Performance of Instrumented Buildings

Atwood Building 20 Story, Steel Frame/Shear Wall

Credit: Wael Hassan

Credit: Wael Hassan

Credit: Wael Hassan

Credit: Unknown
Performance of Instrumented Buildings

Frontier Building (Concrete Framing) 1985

PGA 0.193g
PRA 0.223g

Credit: USGS
Credit: Wael Hassan
Performance of Instrumented Buildings

Frontier Building (Concrete Frame) 1985

Credit: Wael Hassan

Credit: Wael Hassan
Performance of Instrumented Buildings

BP Building 14 Story (1984)

Credit: BP

Credit: BP

Credit: Wael Hassan
Bridges

- 245 bridge structures
- 20 bridges with light to moderate structural damage
Bridges

Anchor Bolts

Credit: Nick Murray/Ben Still
Bridges

Wing and Hider Wall Cracks

Credit: Nick Murray/Ben Still

Credit: Nick Murray/Ben Still
Bridges

Abutments

Credit: Jesse Escamilla/Ben Fetterhoff
Lifelines

Bridge Bearing

Credit: Nick Murray/Ben Still
Bridges

Shear Keys

Credit: Sara Manning/Fred Paulsen

Credit: Sara Manning/Fred Paulsen
Bridges

Bridge Displacement

Transverse

Credit: Nick Murray/Ben Still

Longitudinal

Credit: Jesse Escamilla/Ben Fetterhoff
## Lifelines

**VERT Report (Hassan et. al, 2018), StEER Report 2018, EERI LFE Report (Hassan et. al Aug 2019)**

<table>
<thead>
<tr>
<th>Lifeline</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electric power</td>
<td>Significant initial disruption (≈80,000 customers, 70-85% of customers for some suppliers); mostly restored within 24hr</td>
</tr>
<tr>
<td>Gas</td>
<td>1-2 gas line breaks reported but repaired within 36hr; 700+ reports of potential gas leaks</td>
</tr>
<tr>
<td>Water</td>
<td>Water main breaks reported, causing some flooding; precautionary boil advisories lifted in most areas</td>
</tr>
<tr>
<td>Telecommunications/Internet</td>
<td>No known reports of disruption or damage; some entities advised to use text or social media to avoid clogging phone lines</td>
</tr>
<tr>
<td>Airport</td>
<td>Some damage within airport (ANC) terminal, but no damage to runways; Fully operational by 3:18PM Friday</td>
</tr>
<tr>
<td>Port</td>
<td>Minor damage; No disruption of service</td>
</tr>
<tr>
<td>Trans-Alaska Pipeline/Fuel</td>
<td>No damage found; Seven hour shutdown</td>
</tr>
<tr>
<td>Public Transit</td>
<td>Bus service in Anchorage (Anchorage People Mover) was disrupted on Friday; resumed Saturday/Sunday offering free rides</td>
</tr>
</tbody>
</table>
Acknowledgements

- MOA
- AK DOT
- Utpal Dutta
- UAA
- PEER
- Anchorage Mayor
- Facility Management teams at AWWU, UAA, Hospitals, BP, Frontier, School Districts

More information available at:
http://learningfromearthquakes.org/2018-11-30-anchorage-alaska/
Thank You