M7.1 Anchorage, Alaska Earthquake

Built Environment Structural 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

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 Structural Damage Overview

- Single-family residential foundation and foundation related damage
- Retaining wall shear cracking (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 floor/Joist unseating
Observed Damage

Residential

Credit: Chris Motter

Credit: Wael Hassan

Credit: Chris Motter
Observed Damage

Residential Buildings (Mat-Su)

Credit: Chris Motter

Credit: Janise Rodgers
Observed Damage

Residential Wood Buildings (Mat-Su)

Credit: Janise Rodgers

Credit: Chris Motter

Credit: Chris Motter

Credit: Chris Motter
Observed Damage

Commercial (Eagle River)

Credit: Wael Hassan
Observed Damage

Office Buildings (Anchorage)

Credit: MOA
Observed Damage

Office Buildings (Anchorage)

Credit: Wael Hassan

Brace Foundation Failure

Credit: Wael Hassan
Observed Damage

High-Rises (Anchorage)

Concrete girder shear cracking
Aftershocks effect

Credit: Wael Hassan
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); 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);
- 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
Schools and Educational Buildings

Mat-Su Valley Schools

Credit: Janise Rodgers

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 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?
- Communication network failure in MCE? CAPACITY?
- All above D/C ratios in severe winter condition? 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

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

Frontier Building (Concrete Framing) 1985

Credit: USGS

PGA 0.193g
PRA 0.223g

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
Port of Alaska

Expansion Joint Damage

Credit: Port Authority
### Lifelines

<table>
<thead>
<tr>
<th>Lifeline</th>
<th>Status</th>
</tr>
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<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>
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<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>
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<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>

Credit: Hassan, et al. VERT Report
Lessons Learned (so far)

- Following building codes does help, shouldn’t be optional.
- Don’t get a false feeling of seismic safety because of this event.
- School safety program seems working.
- Geotechnical related damage is overlooked in building and bridge design.
- Pre 1980 buildings and non-engineered buildings, ticking bombs.
- CMU wall connections should be revised/checked.
- MCE loss estimation studies are much needed.
- MCE Resilience studies for essential facilities are much needed.
- Are we really prepared for the big one?
Vision to Improve *(tentative)*

Short term

- New buildings: permit required, code designed and inspected, no exceptions.
- Existing non-engineered public buildings: public safety hazards: immediate structural assessment and either:
  - Retrofit on owner’s expense
  - Or
  - Mandatory visible posting “This building is prone to collapse during a strong earthquake, enter at your own risk”
- Hospital D/C studies.
- School seismic assessment program proposal.
- Article to enforce seismic design of non-structural components and fire-fight systems in essential facilities.
- Geotech report and soil improve. required for all upgrades or new construction
- Code change proposal for seismic restraint of water tanks.
Thank You