Utah Building Codes and Seismic Resilience

Utah Seismic Safety Commission Meeting
July 6, 2023

HOW BAD WOULD IT BE?

HAZUS ESTIMATES - 7.0 earthquake along the Wasatch Front

3,000+

Fatalities, and additional 7,400-9,300 critically injured

480,000+

Homes without water and 444,000+ homes without power

89,000

Displaced households

EERI, “Scenario for a Magnitude 7.0 Earthquake on the Wasatch Fault—Salt Lake City Segment,” updated based on conversations with FEMA

$75,000,000,000

FEMA ESTIMATE FOR SHORT-TERM ECONOMIC LOSSES

(...so, pretty bad)

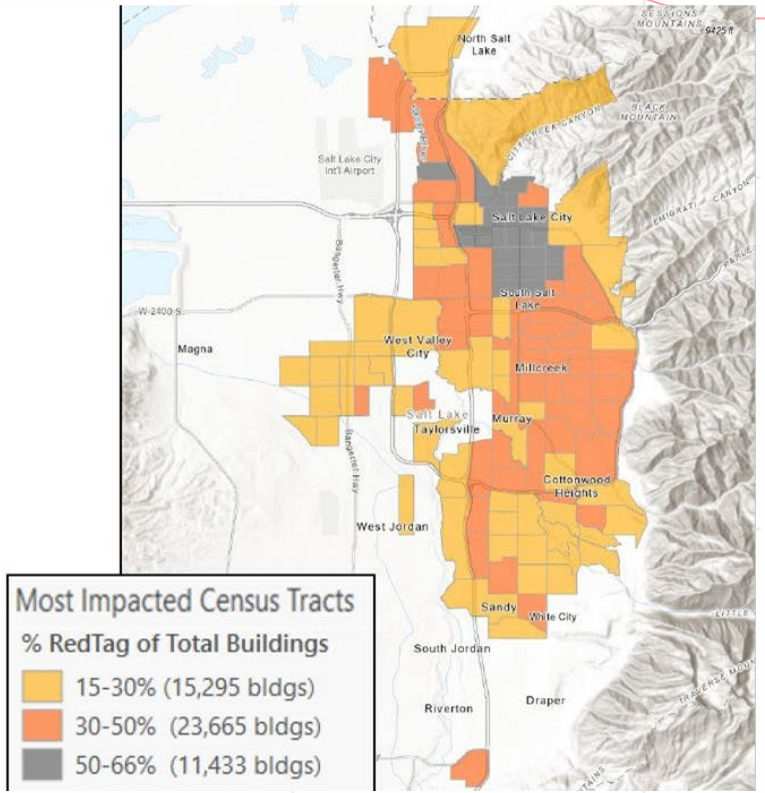
DEM HAZUS modeling of Lifeline Systems Analysis, 2021

Building Damages

Search & Rescue
Building Damages

- **60,664 RedTag (complete damage) Buildings**
  - 57,787 in Salt Lake County (95.2%)
  - 2,280 in Davis County (3.7%)
  - 544 in Utah County (0.8%)
  - 35 in Weber County (0.05%)

- **35,811 YellowTag (extensive damage) Buildings**
  - 29,911 in Salt Lake County (83.5%)
  - 3,251 in Davis County (9%)
  - 2,083 in Utah County (5.8%)
  - 371 in Weber County (1%)



DEM HAZUS modeling of Lifeline Systems Analysis, 2021

Code Performance Expectations

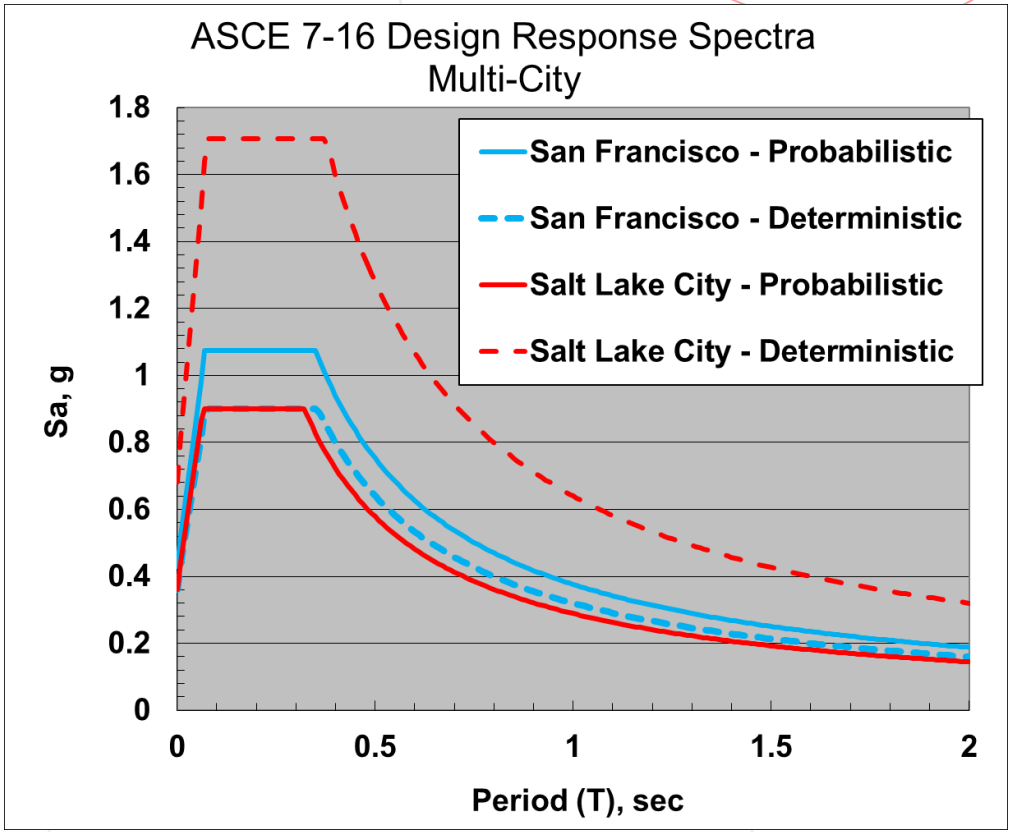
- **Immediate occupancy**: A building can be used after some cleanup occurs and can be occupied during the repairs to fix building damage.
- **Life safety**: A building could have significant structural damage, but it has reserve structural capacity to resist aftershocks. The building may not be able to be occupied until after repairs are made.
- **Collapse prevention**: A building has been pushed to the limits of its strength and stiffness and is on the verge of collapse. Aftershocks may cause the building to collapse.

What Do We Design For?

- Most buildings: **life safety with 2/3 of the code maximum considered ground acceleration**.
  - 10% probability of collapse at maximum ground acceleration.
- More important buildings (high occupancy/critical buildings like fire stations or hospitals): **immediate occupancy** with 2/3 of the code maximum considered ground acceleration.
  - 2.5% probability of collapse at maximum ground acceleration.

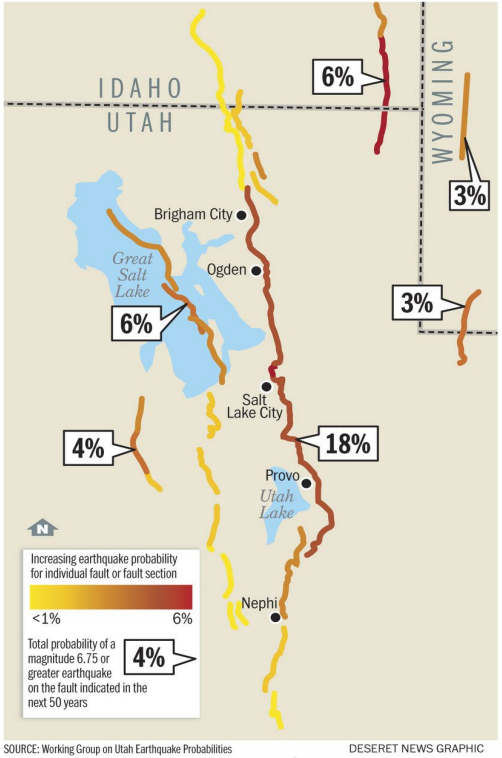
Probabilistic v. Deterministic Ground Motions

- Seismic design is governed by the lesser of probabilistic and deterministic ground motion
- Deterministic=84th percentile ground motion from nearby active faults
- Probabilistic=ground motion that provides a 1% probability of collapse in 50 years.
- On the Wasatch Front, deterministic ground shaking is ≈1.9 X probabilistic ground shaking.



Why is the Wasatch Front's Probabilistic Ground Motion so Much Lower?

- Fewer faults
- Long return between large earthquakes
  - 22 on the Wasatch Fault around 7.0 over the past ~6,000 years, once every 300 years
  - Salt Lake segment: "Big one" every 1300-1500 years



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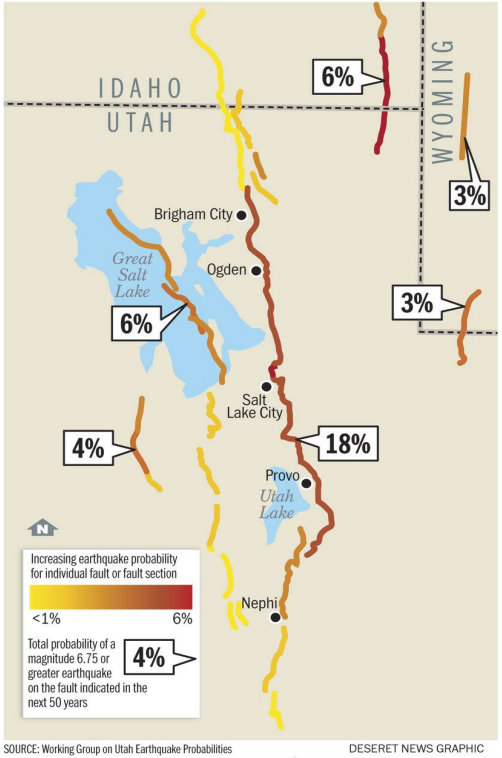
  - 22 on the Wasatch Fault around 7.0 over the past ~6,000 years, once every 300 years **– Last "Big One" was more than 300 years ago**
  - Salt Lake segment: "Big one" every 1300-1500 years **– Last "Big One" was 1400 years ago**

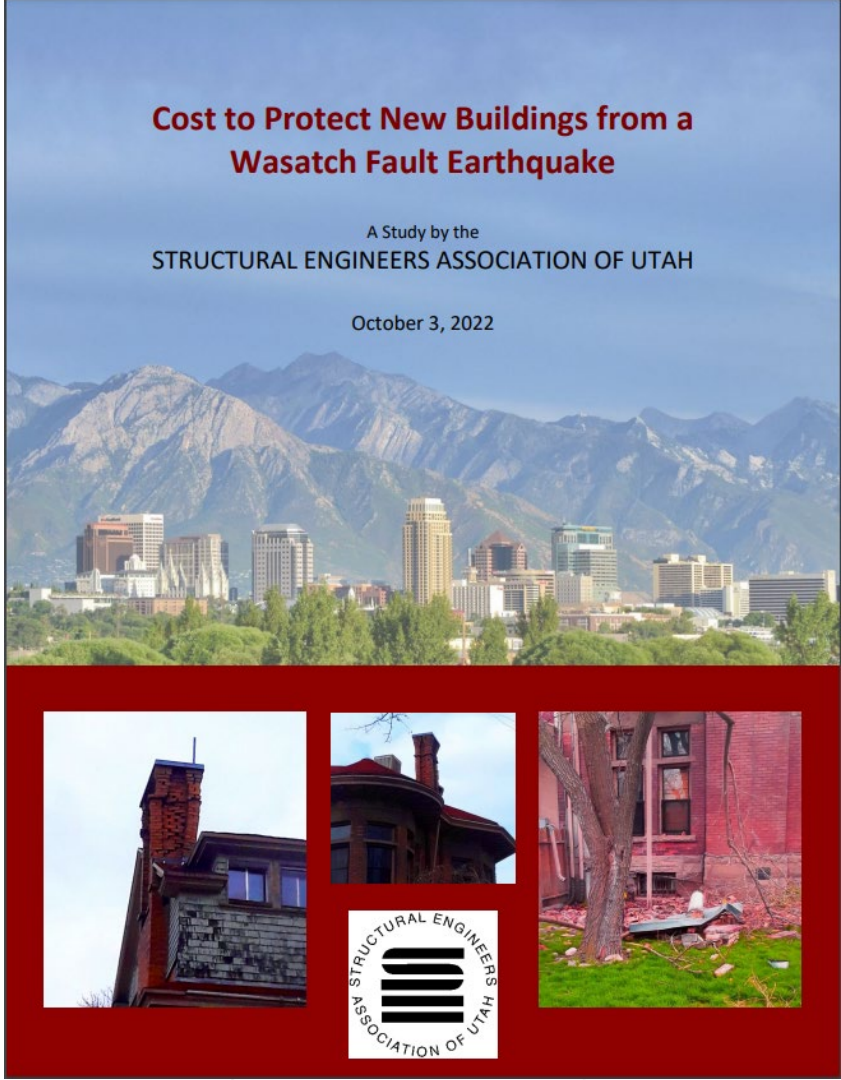


Summary

- We’re constructing buildings to withstand something less than the potential shaking from a nearby “Big One.”
  - 45% probability of collapse at double the code maximum ground shaking.
- Result: danger to occupants and high likelihood that many buildings won’t be useable.

What Would It Cost to Increase the Seismic Standard in the Code?

"The purpose of this study is to identify the percentage cost increase for buildings if the buildings were designed for the higher deterministic acceleration"



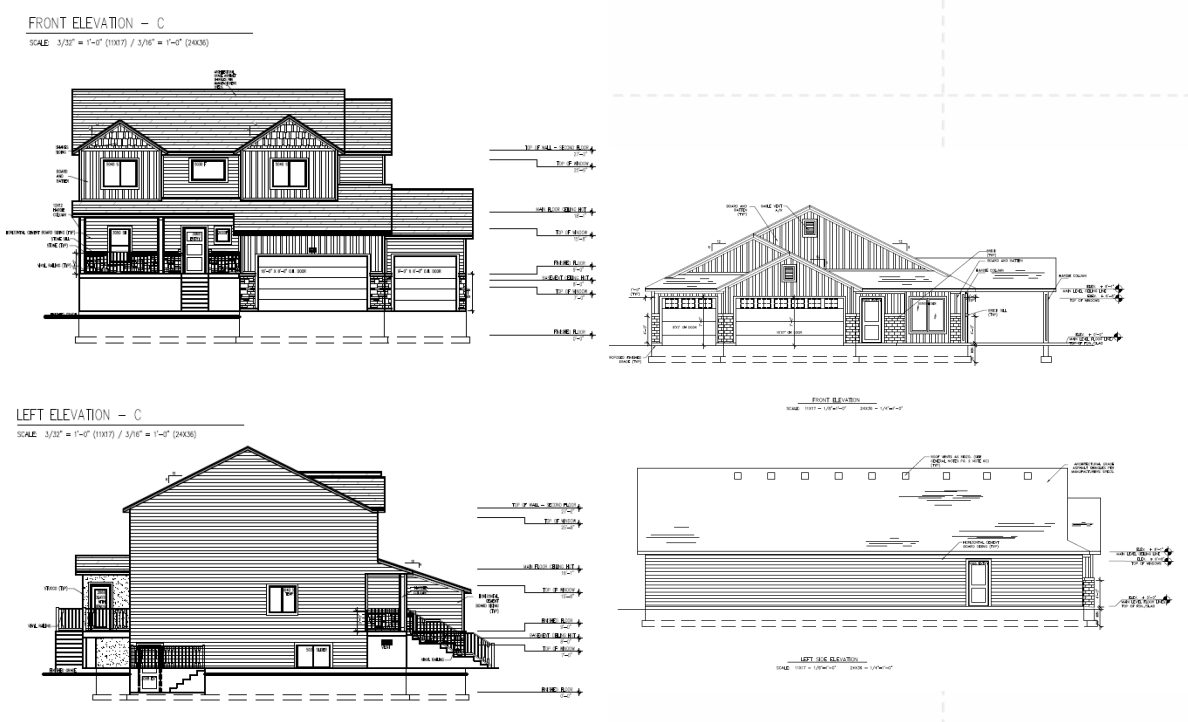
System	Cost increase compared to the total construction cost
Single-family residential (Single-story, wood frame)	0.26%
Multi-family residential (3-story, wood frame)	0.12%
Warehouse (Single-story, steel braced frame – ordinary concentric braced frame)	2.5%
Office building (4-story, steel moment frame)	2.9%
Office/warehouse (Single-story precast concrete shear wall and buckling restrained braced frame)	5.3%
Office building (5-story, buckling restrained braced frame)	0.76%
Car wash/storage (Single-story, reinforced masonry)	0.27%

$1,311

$1,175

Ensign Analysis

- 1-story and 2-story single-family home
- 1.5 x typical standard
- Cost: $100-$300 per home



Impacts of Increased Standard

- Lower risk of deaths
- More businesses able to remain open
- More people able to stay in their homes
- **More resilient community**

Open Questions

- Do we increase the standard for all buildings or just the ones with lowest cost?
- What's the cost for a 4-6 story apartment complex (wood construction over concrete podium)?
- What should the standard be?
- How do we quantify the benefits?